Sectoral Risk Briefings:
Insights for Financial Institutions

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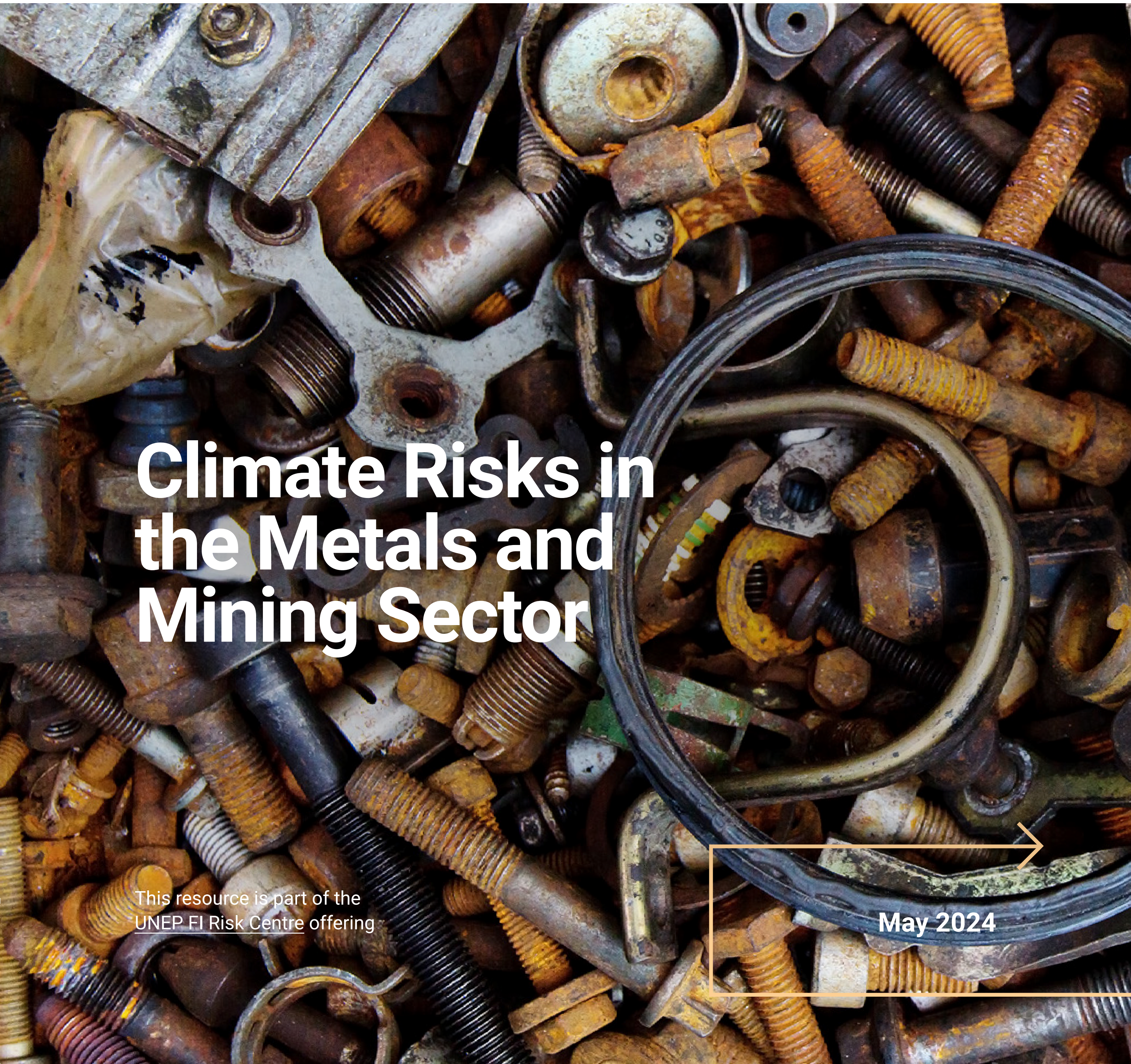

Climate Risks in the Metals and Mining Sector

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May 2024

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Purpose of this document

This detailed briefing note explores relevant climate risks for the sector, supported by illustrative examples from firms in the form of case studies featured in the main text. These case studies showcase how firms in the sector are recognising and confronting climate risks through disclosure examples from their annual reports.

It is important to note that this brief specifically delves into the potential impacts of climate change on the sector. Therefore, exploring the reverse—how the sector impacts climate change—is not the primary purpose of this document. Additionally, the scope of this brief is narrowed to focus solely on climate risks, excluding a broader examination of potential environmental and social risks for the sector. A future series may incorporate these other important risks and considerations of double materiality.

This brief also provides guidance and recommendations aimed at assisting financial institutions in effectively managing both their own risks and those of their clients, with the aim of accelerating a sustainable financial and economic system.

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Introduction

In the past few years, the global economy has been lashed by the COVID-19 pandemic,- geopolitical conflict, supply chain disruptions, an energy crisis, and high inflation. These challenges are occurring against the backdrop of the mounting planetary emergency of climate change. Climate change can exacerbate all other challenges, increasing geopolitical conflicts over resources, crippling infrastructure and supply chains, extending the range of dangerous pathogens, and collapsing the natural systems upon which we depend. As the US Pentagon presciently stated: "climate change is a threat multiplier." While the transition to a sustainable, net-zero future is critical, it demands fundamental shifts in nearly all economic sectors. These shifts are not without risk for the companies and communities impacted by them.

Financial institutions face an array of risks from this rapidly changing, and often chaotic, world. Their clients are exposed to physical hazards as well as transition risks, which can have major credit, market, and operational implications. The prudent financial institution will explore these climate-related risks and prepare strategies to meet them. Future resiliency and success are contingent on thoughtful planning and good decisions today. UNEP FI has been working at the intersection of sustainability and finance for over 30 years. Its programs for financial institutions develop the tools and practices necessary to positively address the most pressing environmental challenges of our time. UNEP FI's Climate Risk and TCFD Program has worked with over 100 financial institutions to explore physical and transition risks posed by climate change. Through this work, a need has been identified to provide financial institutions with a baseline understanding of climate-related risks and their manifestations across different sectors.

This brief is part of a series of notes that cover major economic sectors and their associated climate risks.[1] Each brief also provides specific guidance and recommendations for financial institutions to more effectively manage their risks and those of their clients. UNEP FI intends for the resources and perspectives included within these notes to empower financial colleagues to communicate these risks throughout their institutions and across the financial sector more generally. The hope is that the communication process will not only enhance awareness of climate risks, but also begin conversations that will lead to tangible changes in strategy and operations. It is the integration of the insights that will be the truest test of the effectiveness of this series. This particular brief covers the physical and transition risks facing the metals and mining sector.

1 Previously published climate risk sector briefs by UNEP FI cover Agriculture, Real Estate, Oil & Gas and Industrials.

Sector overview

Growing demand for electronics and other modern goods has led to a rising level of mining and to an increase in the production of metals and minerals. The flipside of this growth is that mining and metals comprise of the world's most carbon-intensive sectors. For example, estimates suggest that steel, aluminium, gold and copper are responsible for 11%, 3%, 0.4%, and 0.2% of global carbon dioxide emissions, respectively (Carbon Brief, 2021; International Aluminium Institute, 2023; World Gold Council, 2020; International Copper Alliance, 2022).

For this sector risk brief, the scope for the metals and mining sector includes the mining and quarrying of minerals occurring naturally as solids (coal and ores). The brief does not include liquids (petroleum) or gases (natural gas). Mining activities considered in this report are in line with the divisions classified by the Nomenclature of Economic Activities (NACE) of the sector (Open Risk Manual, n.d.) and include:[2]

- Mining of coal and lignite
- Mining and preparation of metal ores, such as aluminium (bauxite), copper, lead, zinc, tin, manganese, chrome, nickel, cobalt, molybdenum, tantalum, and vanadium
- Mining and preparation of precious metals, such as gold, silver, and platinum
- Mining support service activities

Machinery used for mining, processing and transporting metals and minerals is currently reliant on fossil fuels as a source of fuel and electricity (Azadi et al., 2020), resulting in the sector being highly carbon-intensive. The sector is also responsible for emitting non-carbon dioxide (CO_2) greenhouse gas (GHG) emissions. A large proportion of these emissions originate from fugitive coal-bed methane released during coal mining (Zheng et al., 2019). For different minerals, the mining process has varying levels of carbon emissions intensity. Ore extraction and processing currently account for 40% of the mining sector's energy use, for instance (MIT Climate Portal, 2020). A study has estimated that global mining and resource extraction (including extraction of fossil fuels) can cause up to USD 3 trillion in environmental damage globally per year. Most of this can be attributed to GHG emissions. The metals and minerals that contribute the most to environmental damage caused by climate change include iron, coal, magnesium, aluminium and manganese (Arendt et al., 2022). For some countries, these costs can outweigh the economic gains from mining. Besides its contribution to global emissions, mining can have various other damaging environmental and social impacts. These impacts include high water consumption for operations, environmental pollution caused by leakages of

2 Extraction of crude petroleum and natural gas is not within the scope of this report. More information on climate risks for oil and gas can be found in the sector brief here.

mining tailings,[3] and land use for drilling, excavating and developing nearby infrastructure (Earth.org, 2022), involuntary resettlement of local communities and impacts on indigenous land (Oxfam, n.d.).

As the transition to a low-carbon economy accelerates, the metals and mining sector faces significant transition risks and opportunities. Due to the carbon-intensive practices that characterise most mining processes, the sector is exposed to heightened risk from the implementation of carbon prices across the globe, as well as additional regulatory restrictions on mining. Demand shift from high-emission technology towards clean technology, coupled with technological advancements, will increase market shares of certain metals and minerals. This will create potential business disruptions and asset stranding. As awareness of climate change grows, metals and mining firms are also at increasing risk from reputational damage.

The metals and mining sector is dependent on physical conditions to be able to operate effectively around the world. As the global temperature rises, the frequency and severity of extreme weather events is set to increase. This will make firms in the sector progressively more vulnerable to the physical impacts of climate change. Businesses could face substantial supply chain and mining disruptions, as well as interruptions of energy for refinement. Such impacts emphasise the need for the sector to address its climate risks. Below, we explore the key physical and transition risks faced by the metals and mining sector in depth (Table 1).

The metals and mining sector has a crucial role to play in the transition to a low-carbon global economy. The supply of raw materials from the sector will be at the centre of the global decarbonisation and electrification efforts across other sectors, as raw materials crucial for technologies such as electric vehicles and solar PVs. Therefore, the climate risks faced by the metals and mining sector can prevent other sectors from reaching net zero.

3 Materials left following material extraction that are not economically valuable

Table 1: Key climate risks for the metals and mining sector

Risk		Summary
Transition risks	**Increasing carbon prices**	As a carbon-intensive sector, the implementation of carbon prices will raise the cost of mining operations, thereby increasing overall expenses and impacting company profits.
	Public policy restrictions	Governments are implementing numerous policies with the aim of reducing emissions and environmental and social impacts. Such restrictions may affect mining methods currently in use across a variety of markets.
	Shifts in market preferences	Shifts in market preferences between metals and minerals due to the transition to the low-carbon economy will force changes in market shares, prices, and demand. These economic changes can pose challenges for individual firms in the sector.
	Technology and the rise of low-carbon alternatives	Advancements in low-carbon technologies will increase demand for specific types of metals and minerals. At the same time, the rise in new mining technologies and new mine locations can also threaten incumbent firms.
	Rising reputational risk	The mining sector is subject to public campaigns due to the contribution of mining to climate change and pollution and for its impacts on communities.
	Emerging legal risk	Firms in the sector face increased exposure to legal risks due to their greenhouse gas emissions and other forms of pollution, as well as due to their impacts on land and communities.
	Growing investor action	As investors increasingly consider climate risks and commit to decarbonization, many are shifting away from carbon-intensive sectors such as mining and pushing portfolio companies to reduce their emissions footprint.

Risk		Summary
Physical Risks	Intensifying storms and flooding	Increased frequency and severity of storms and floods due to climate change threaten mining operations and can damage expensive infrastructure.
	Sea level rise	Rising sea-levels can disrupt operations such as drilling, imperil site expeditions, and cause infrastructural damage. Shipping and other supply chain activities face growing risks from rising seas.
	Water-related issues (droughts and water scarcity)	The metals and mining sector is highly reliant on water. As climate change impacts worsen, water stress is likely to intensify. Water scarcity can reduce the productivity of water-intensive activities and in some cases halt them entirely.
	Shifting permafrost	As global temperatures rise, shifting permafrost will negatively impact the metals and mining sector by creating flooding and damaging infrastructure. Mining waste released from thawing permafrost can also pose environmental and legal hazards.
	Rising temperatures and heat stress	Higher temperatures can intensify the occurrence of wildfires. Wildfires can damage mining facilities and create dangerous working conditions, and even halt mining operations, resulting in higher costs and losses for firms.

SECTION A:
Transition risks

As global economies transition to a low-carbon future, the carbon intensity of the metals and mining sector will make it increasingly vulnerable to transition risks. Such risks include the implementation of stringent climate policies and growing regulatory expectations. Carbon prices will increase the costs of carbon-intensive mining operations, on the one hand, but will drive the advancement and adoption of low-carbon technologies in the sector, on the other. Decarbonisation of other sectors will drive a massive shift in market preferences for metals and minerals as demand for clean technology rises. If businesses in the sector do not take assertive action, they are set to face growing transition risks. The impact of such transition risks could be particularly pronounced in countries whose economies rely on mining activities. Two illustrative examples are Mongolia and Botswana, where mining contributes 80–90% of all exports (Ericsson and Lof, 2019).

In addition, the transition risks facing the metals and mining sector pose risks for workers and communities who rely on the sector for jobs and income. It is therefore important to align transition financing with a just transition approach that considers the needs of groups at impacted by changes in the mining sector, including workers, Indigenous Peoples and local communities.

1. Increasing carbon prices

Governments are increasingly implementing carbon prices to reduce CO_2 emissions in an effort to reach their net zero climate goals by 2050. Carbon pricing raises the price of fossil fuels based on their carbon content or their emissions when burned. Carbon pricing can be implemented in different forms, such as through an emission fee or through incentives for emissions reductions. As of 2023, 39 national and 33 subnational carbon pricing initiatives have been implemented globally. Together, these initiatives cover 23% of global GHG emissions. Carbon prices ranged from as low as USD 1 per tonne of CO_2 equivalent (tCO_2e) to USD 156/tCO_2e (World Bank, 2023). Although most current pricing schemes exclude mining due to its economic importance, this is likely to change in the coming years as policies grow in strength and the high carbon intensity of the sector is considered.

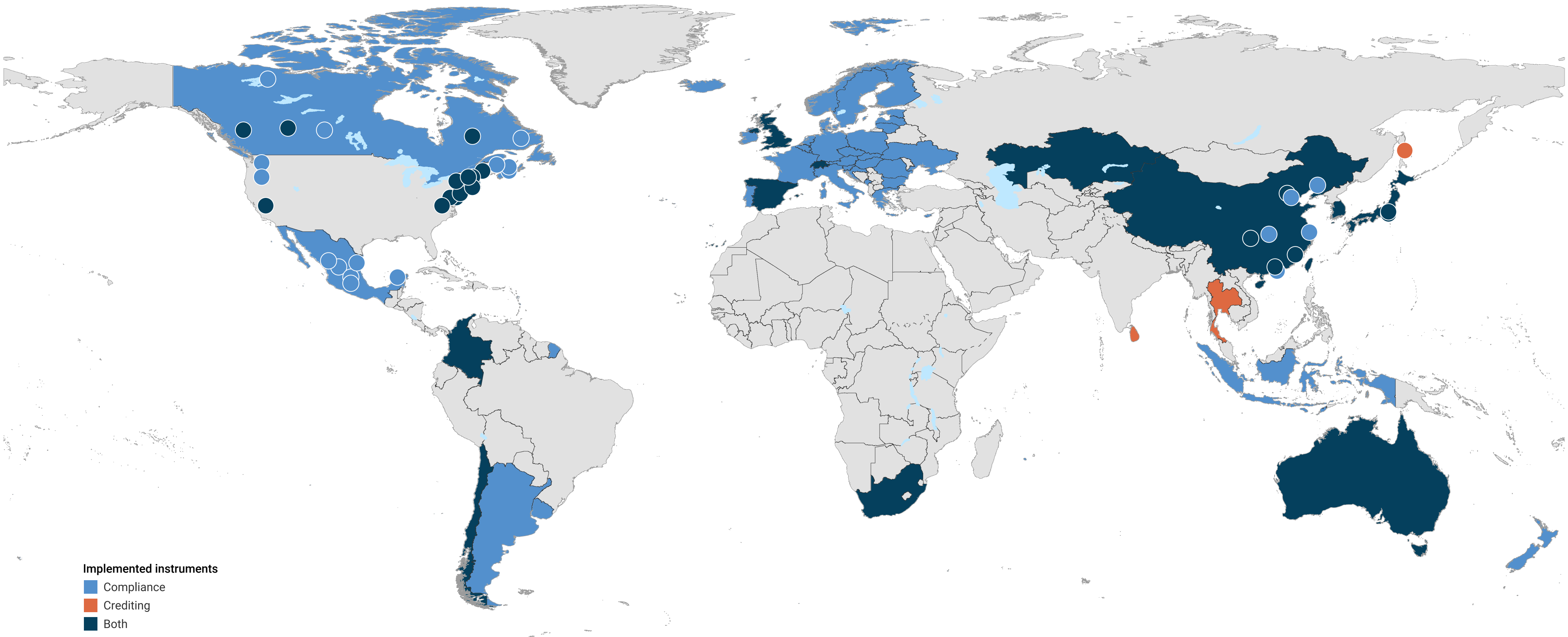


Figure 1: Map of carbon pricing initiatives globally (World Bank, 2023)

An Emissions Trading System (ETS), described as a cap-and-trade initiative, requires companies to obtain allowances for their emissions or the carbon content of the fossil fuels used. Governments that implement such schemes control the supply of emissions allowances and the trading of these allowances at a carbon price. As of 2023, 36 ETSs are operational (World Bank, 2023). Switzerland's ETS, which dates back to 2008, had an average auction price of USD 80 in 2022 (ICAP, n.d.). For its part, China launched a national carbon market in 2021 with an average emission allowance price of USD 9.11/tCO_2e (S&P Global, 2022b). Austria also launched a national ETS recently. The scheme, which came into force in 2022, set the carbon price of coal at EUR 45 by 2024 (Government of Austria, 2022). One of the latest mandatory national ETSs—launched in 2023—operates in Indonesia (ICAP, 2023). Most of these schemes follow on the heels of the European Union's (EU) ETS, which comprised the first international ETS when it was established back in 2005 (European Commission, n.d.). Now in its fourth phase, the EU ETS imposes a limit on the maximum amount of GHG emissions that regulated entities can emit. The cap is regulated through European Union Allowances (EUAs) that grant the holder the right to emit one tonne of CO_2 within a year. Companies can receive, buy, or trade these EUAs (European Commission, n.d), which in 2023 reached a price of EUR 100 (Reuters, 2023a).

A carbon tax is a direct tax on the carbon content of fossil fuels. A wide range of countries have already announced the implementation of a carbon tax, often with plans for raising it in the coming years. For example, South Africa has announced its intention to increase its carbon tax from around USD 10/tCO_2e to USD 20/tCO_2e by 2026, then USD 30/tCO_2e by 2030, and USD 120/tCO_2e beyond 2050. Canada also plans to raise its carbon tax by USD 12 [CAD 15] /tCO_2e annually, reaching USD 136 [CAD 170] /tCO_2e by 2030 (World Bank, 2022b). Denmark has announced the implementation of a new carbon tax on firms starting in 2025. The tax will apply to all firms whether they are in the EU ETS or not. For firms outside the EU ETS, the tax will be set at USD 51/tCO_2 in 2025 and will increase to USD 109/tCO_2 by 2030. For firms related to mineralogical processes, the tax will be USD 14.6/tCO_2 in 2025 (World Bank, 2022a).

Data and ratings agency S&P recently analysed the financial impacts on mining companies if countries were to implement policies to limit warming to below 2°C. The analysis found that about a third of the 1,400 mines assessed across 56 countries could be exposed to a carbon price of USD 100 by 2030 (S&P, 2020). Firms in the sector could face higher costs from carbon prices through the emissions they produce or through emission intensive inputs, such as cement, steel, and electricity for mining procedures (Minerals Council South Africa, n.d.). Mined metals follow commodities pricing, which means that their prices are determined by supply and demand in the market and not by a single company. Commodities are also traded using future contracts with a predetermined price. Given the limited differentiation across products, individual firms generally have little ability to pass along increased costs to consumers if competitors offer lower prices. As carbon pricing varies from country to country, firms in geographies exposed to higher carbon prices will face higher production costs than those subject to lower carbon prices. As a result, the former face a more significant decrease in profits.

The impact of a carbon price on a firm will depend on the carbon intensity[4] of the metal or mineral (Figure 2) that it mines. For example, metals such as copper and zinc would see minor changes to a firm's marginal costs even under extreme carbon pricing scenarios due to their lower carbon intensity (Figure 3). Under the different carbon pricing scenarios, the marginal costs for copper and zinc only change by 4% and 5%, respectively. This is due to their lower carbon intensity compared to other metals. By comparison, aluminium could witness marginal costs increasing by 118% (Wood MacKenzie, 2021). The impact of a carbon tax on a mining firm will also depend on the value of the commodity (Figure 4). For example, USD 9,400 worth of iron ore mined will emit the same levels of CO_2 as USD 100 worth of coal. Therefore, implementing a carbon tax of USD 150t/CO_2 will represent less than 5% of an iron ore's value but 240% of the value of the coal mined (Cox et al., 2022; UBC, 2022).

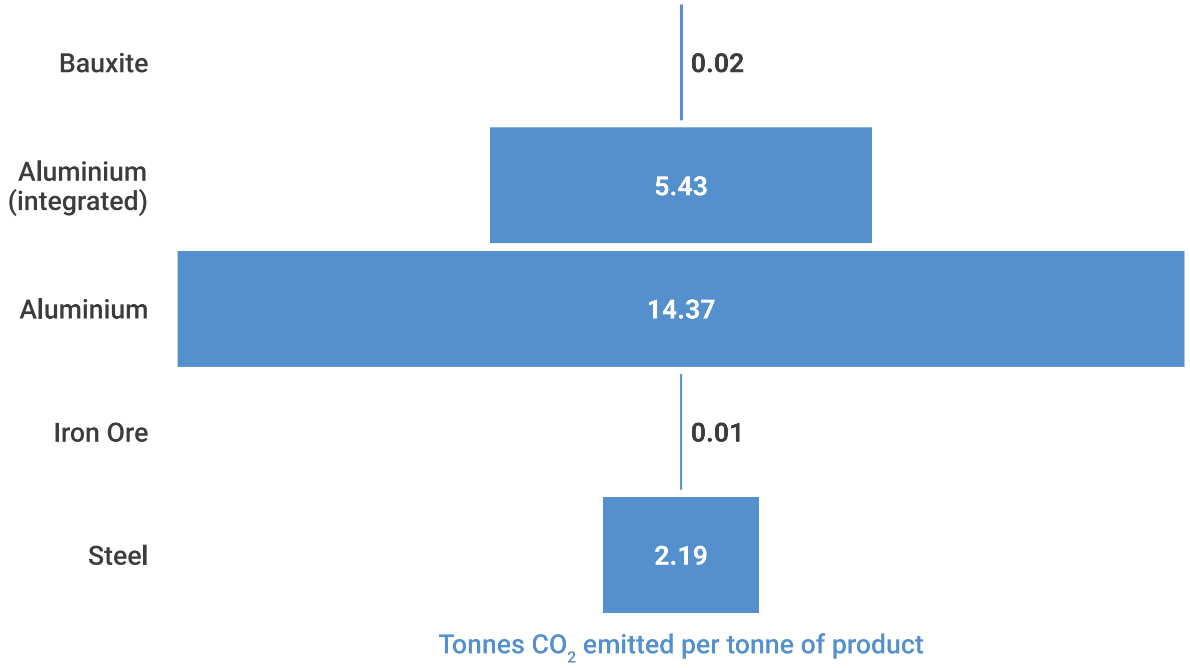
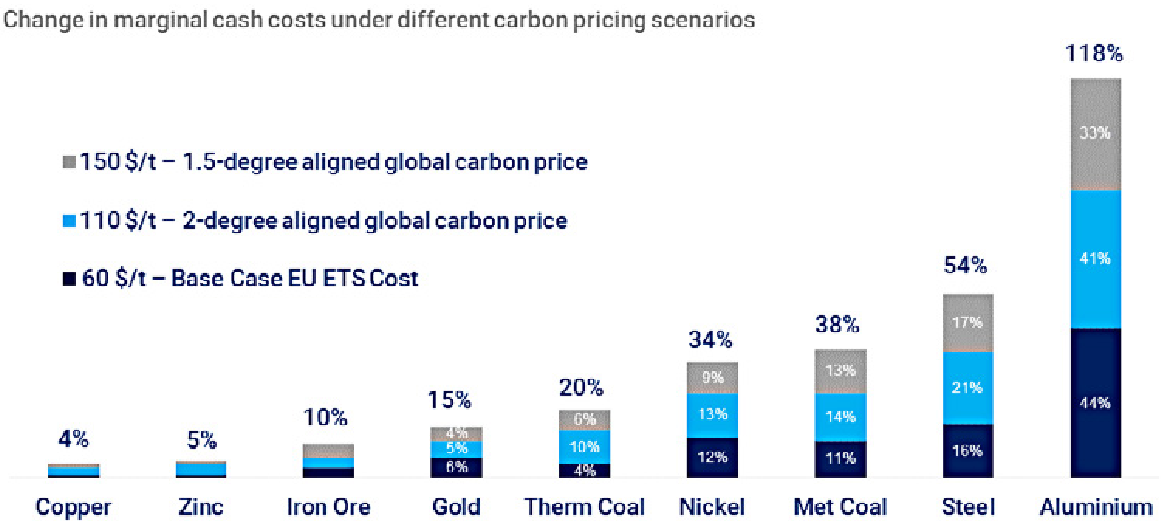


Figure 2: CO_2 emitted per tonne of raw mineral and final metal production (Cox et al., 2022)

4 The carbon intensity of a metal is determined by the amount of energy used for extraction and refinement.



Source: Wood Mackenzie Emissions Benchmarking Tool, Metals and Mining Cost Services

Figure 3: Estimated changes in marginal costs for mining commodities under different carbon pricing scenarios (Wood MacKenzie, 2021)

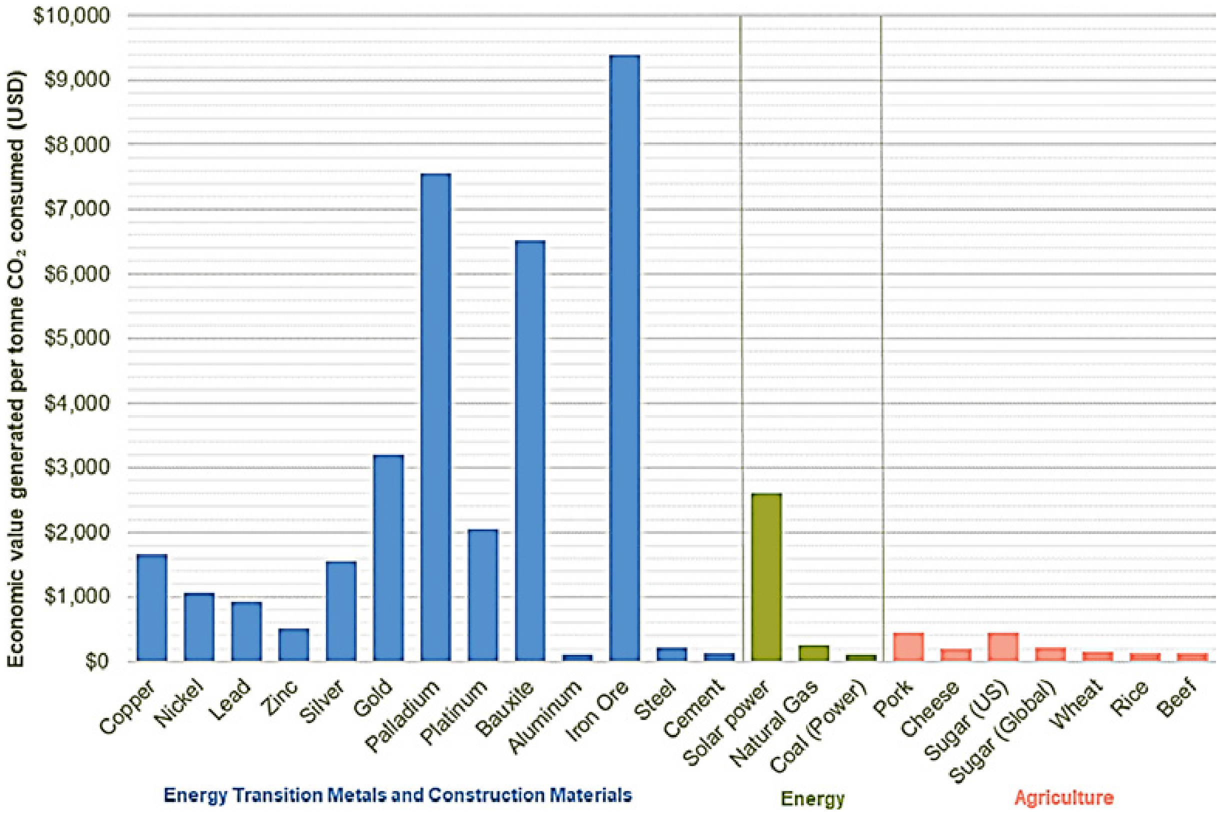


Figure 4: Economic value of commodities, including selected metals, per tonne of CO_2 emitted (Cox et al., 2022)

As carbon pricing increases the costs of mining commodities, less carbon-intensive metals will be able to out-compete metals with higher carbon intensity that are used as raw materials for the same purposes. For example, copper and aluminium are good conductors. As such, wires made from these two materials are commonly used for power transmissions. However, given the lower carbon intensity of copper, wires from this material will be able to out-compete those made from aluminium (Wood MacKenzie, 2021).

The impact of a carbon price on a firm in the sector also depends on the areas where it operates. The GHG intensity of a mining asset can vary, with mining being more emissions-intensive in some countries than others. For example, South Africa, has one of the highest GHG intensity per unit of ore treated. The GHG intensity of gold mines, meanwhile, are three times higher than those in Russia and 23 times higher than those in the United States. This is because gold mines in South Africa are powered directly by the grid through coal as opposed to a range of other sources (Figure 5) (Australian Resources and Investment, 2021; S&P, 2020). A study looking at the impact of two carbon prices on the cost of gold mining in different countries found that under a USD 50t/CO_2 carbon price, production costs ranged from USD 6.50 per ounce (oz) to USD 137.7/oz. Under a USD 100t/CO_2 production, meanwhile, costs ranged from USD 12.90/oz to USD 275.4/oz (Figure 6). In this second carbon price scenario, the world's leading gold producers—i.e. Australia, China, Russian Federation and the United States—become less cost competitive; however, Canada becomes more cost competitive. This is because countries with gold mines powered by fossil fuels instead of renewables will face higher cost increases when a carbon price is implemented. In Australia, for examples, 85% of the country's electricity came from fossil fuels in 2017, with mines not connected to the grid relying on fossil fuel-driven generation. By contrast, 80% of Canada's electricity at this time was sourced from less carbon-intensive alternatives, with hydroelectric representing the lion's share (S&P, 2022a).

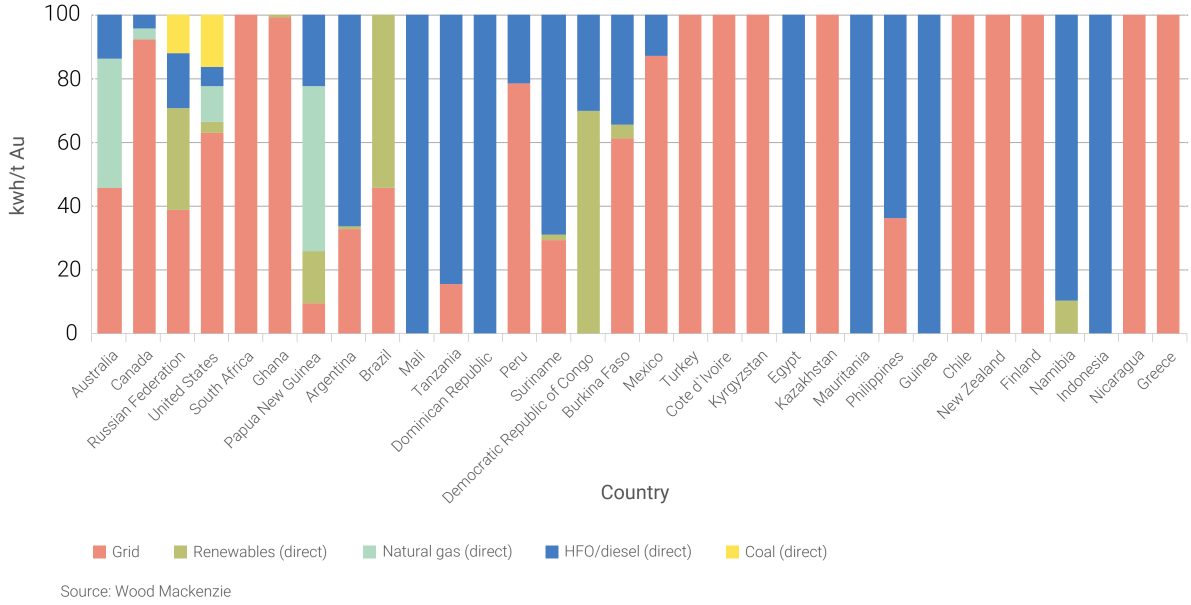


Figure 5: Share of power sources for gold production by country in 2019 (World Gold Council, 2020)

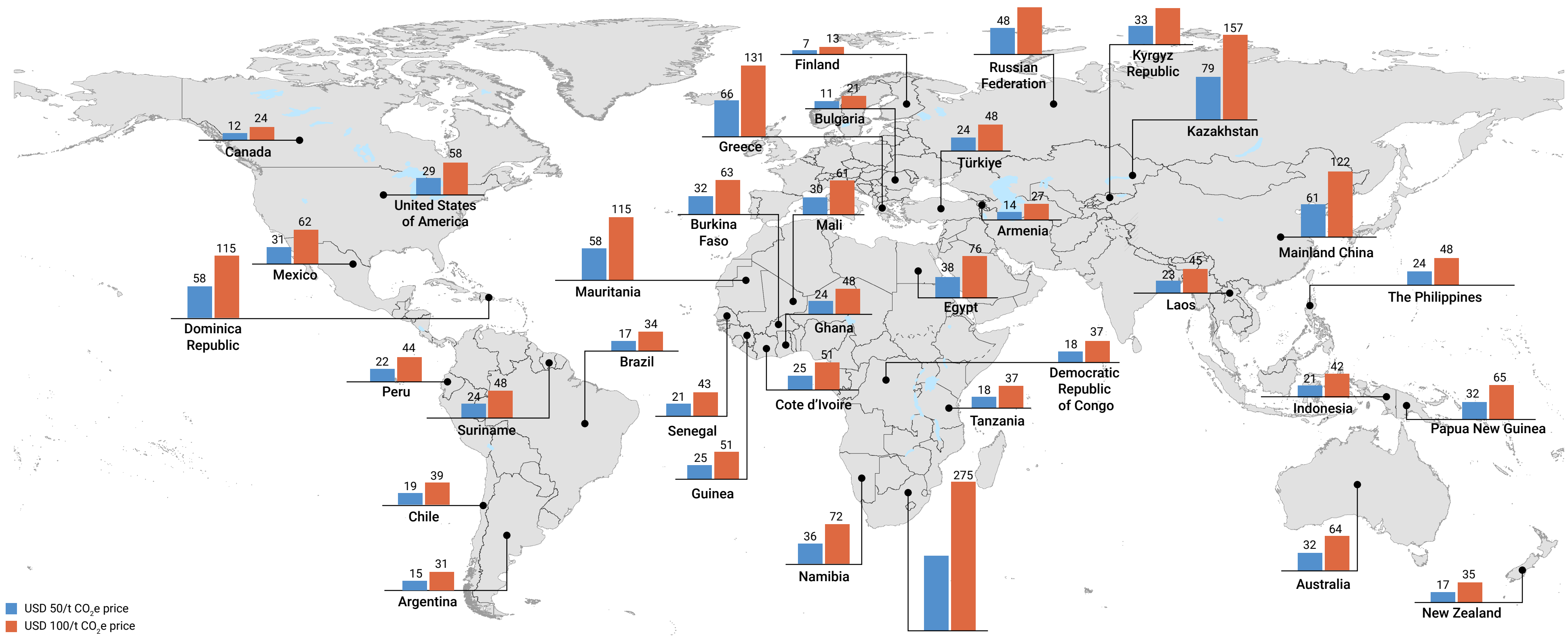


Figure 6: Impact of global carbon price on production costs of gold (S&P, 2022)

The Australian Prudential Regulation Authority (APRA)'s Climate Vulnerability Assessment (CVA) showed the impact of carbon pricing under a transition scenario on financial institutions and their portfolios, including mining. The exercise used a Delayed Transition Scenario where reductions in GHG emissions occur after 2030 to limit warming below 2°C, resulting in high transition risks. Results revealed an aggregate increase in lending losses from the mining sector under the Delayed Transition Scenario, accounting for 4% of business lending exposures. In the CVA's projection for 2050, the mining sector was shown to have the highest loss rates in business lending among all the sectors assessed (Figure 7). Participating banks in the exercise explored potential responses to the increase in lending losses. One option was to change the composition of their business lending portfolio so as to substantially reduce exposures within the mining sector, including a 90% reduction in their exposure to coal miners (APRA, 2022).

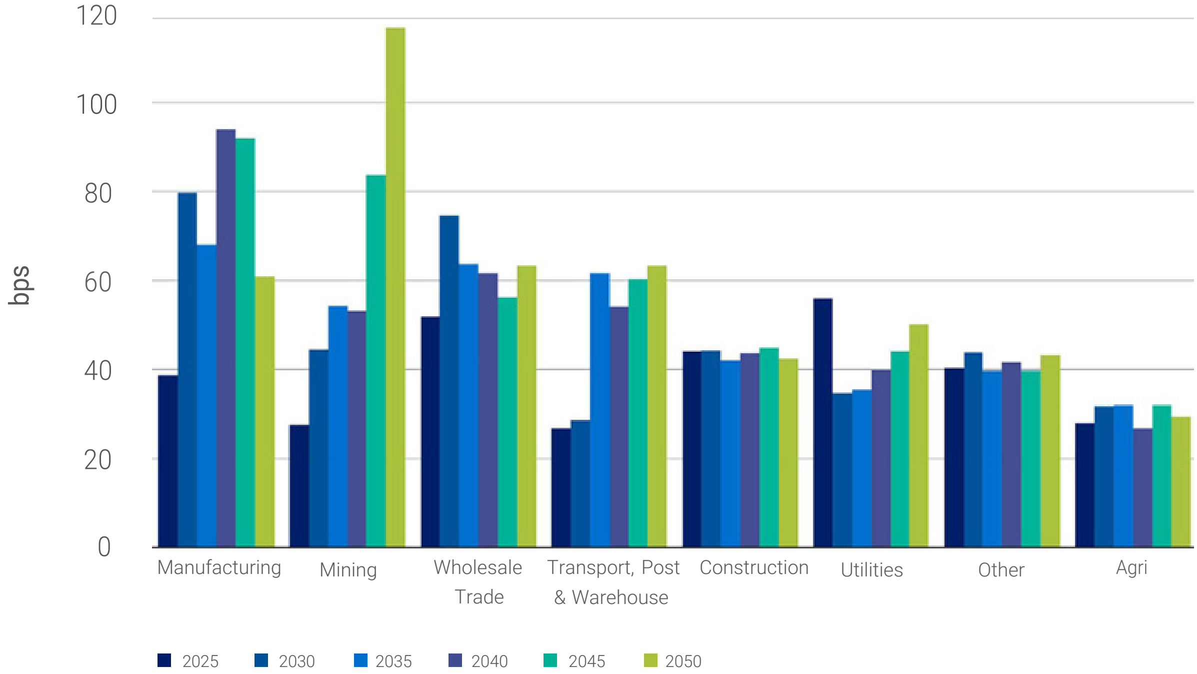


Figure 7: Results of APRA's CVA showing annualised loss rates in business lending under a delayed transition scenario (APRA, 2022)

Case Study 1: Carbon pricing risk

Harmony Gold Mining TCFD Report 2022

South African gold mining company

Transition risk identification
We identified several climate-related risks to our operations. Key transitional risks include Harmony's dependency on South Africa's fossil fuel-based electricity grid and potential carbon tax increases. The South African government plans to change the carbon tax legislation to make Eskom (South Africa's national power utility) liable to pay carbon tax from January 2026 onwards. This will result in a pass-through cost on electricity from January 2026. We are assessing the potential impacts on our operating costs. We are engaging with the government on this issue through the Minerals Council of South Africa.

GHG emissions target setting and implementation
In FY16, Harmony set two 10-year GHG emissions intensity targets, through to FY26 using an FY14 base year. The first target relates to tonnes CO_2/tonne ore milled and the second to tonnes CO_2/kg of gold produced. As of FY22, Harmony has now also introduced our net zero by 2045 target, which involves net reduction of total emissions by 206ktCO_2e/year, against an FY21 base year. Progress on our 10-year target to date includes a 39% decrease in emissions intensity per tonne of ore milled against an FY14 baseline. This decrease was largely due to our energy efficiency programme and portfolio rebalancing to focus on fewer energy-intensive resources.

2. Public policy restrictions

Along with carbon pricing, governments are increasingly considering the implementation of other types of regulatory restrictions on metals and mining operations to reduce emissions. This can create transition risks for the sector. A case in point is the Australian parliament's recent decision to pass a law mandating coal mines to reduce emissions by 5% annually (Al Jazeera, 2023).

Mining companies need to adapt to environmental protection laws of the jurisdictions where they operate. Examples range from requiring mining companies to pay for public resources to complete bans on mining activities. Similar restrictions are likely to be introduced to decarbonise the sector. For example, the United States government recently announced its intention to impose a 20 year ban on any new mining activity in parts of northern Minnesota to protect the state's waterways (Inside Climate News, 2023). Likewise, in 2022, Honduras cancelled environmental permits for metal and non-metal mining due to the impact of mining on natural resources and the availability of clean water (Reuters, 2022a). As of 2023, meanwhile, mining firms operating in the Australian province of New South Wales will have to start paying for the removal and use of water from the Sydney water basin (Sydney Morning Herald, 2023). The measure comes in response to uncontrolled water use by companies in the sector. As climate change adds further pressure on water availability in countries, such regulations for the metals and mining sector are expected to become more frequent.

Regulation related to coal mining

Global concern over climate change is leading more governments to commit to the phase-out of coal. In 2015, the United Kingdom became the first country to announce such a measure. The following year, Belgium went one step further and became coal-free. In 2017, France brought forward its plan to phase out coal by 2022 and enacted it under its energy and climate law in 2019 (Beyond Fossil Fuels, 2022). At COP 26, more than 40 countries agreed to phase out coal-fired power, including major coal-using countries like Canada, South Korea, Indonesia and Vietnam. At the same time, a group of major financial institutions agreed to end overseas finance for all fossil fuels (COP, 2021; The Guardian, 2021). By 2022, 23 European countries had announced targets to phase out coal (Beyond Fossil Fuels, 2022). As more governments shift away from coal use globally, mining companies primarily focused on coal mining could be vulnerable to a significant decrease in demand for mined coal, leading to a drop in their profits.

It is estimated that government subsidies for coal, oil, and natural gas reached USD 5.9 trillion globally in 2020, roughly USD 11 million for every minute (IMF, 2021). As a result of these subsidies, 99% of coal is priced at less than half it's true value (Yale, 2021). At present, two-thirds of all global fossil fuel subsidies are provided by just five countries; China, the United States, Russia, India, and Japan (Yale, 2021). Other countries with high fossil fuel subsidies include Canada, which was giving at least USD 3.6 billion annually in subsidies in the last 2010s (IISD, 2020), and Australia, which provided USD 11.6 billion in subsidies between 2021 and 2022 (Australia Institute, 2022). It is estimated that 52 countries (representing 90% of fossil fuel supplies worldwide) gave an average of USD 555 billion in subsidies annually from 2017 to 2019. This figure fell to USD 345 billion in 2020, but only because of economic losses linked to the COVID-19 pandemic (Timperley, 2021). Global subsidies for coal also include subsidies for coal mining, such as producer subsidies to reduce the cost of production. Examples of subsidies for coal mining can consist of cash handouts, the construction of energy infrastructures, funds for the development and rehabilitation of former mines, and tax exemption (CAN Europe, 2015; Kim and Pathak, 2019).

Similar to carbon pricing, the removal of coal subsidies is being increasingly discussed as an instrument to reduce CO_2 emissions. About 20 countries have already pledged to stop public financing for overseas fossil fuel projects, including coal (Reuters, 2021a). The Group of 20 called for the phase out of inefficient fossil fuel subsidies in 2009 and again in 2012. At COP 26 in 2021, 197 countries agreed to renew efforts to decrease the use of fossil fuel subsidies (IMF, 2021). According to the Global Subsidies Initiative (GSI), a research group in Geneva, Switzerland, at least 53 countries reformed their fossil fuel subsidy policies between 2015 and 2020 (Nature, 2021). In Egypt, for example, the government reduced subsidies from 7% of GDP in 2013 to 2.7% in the 2016–17 budget (Nature, 2021). Meanwhile, a study looking at the removal of fossil fuel production subsidies in Ireland found that the removal of the subsidy would increase the production costs and the retail prices of these commodities, causing energy prices to increase by 10% in 2030 (Bruin and Yakut, 2023). A similar study considered the implications of removing production coal subsidies in the G7 countries: i.e. Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. It found that the removal of the production subsidy could lead to an increase in the market price of coal and a decrease in the output quantity for large coal exporters such as the United States (Kim and Pathak, 2019).

Coal mines are also at risk of closure due to government policies. Researchers recently carried out a case study review of four regions that either have closed coal production facilities or that are in the process of doing so. Their analysis showed that changing economic and political circumstances made the coal mines less competitive and inefficient. For example, one of the regions in question—Romania's Jiu Valley—had fifteen mines operating in the early 1990s; today, this figure has reduced to four due to their inability to compete with global prices and their dependency on subsidies to survive. The mine closures led to the loss of over 20,000 jobs in the Jiu Valley (European Commission, 2021).

Case study 2: Public policy restrictions

Glencore Climate Report 2022

Swiss mining and trading group

Policy and legal risks
Our ability to operate or develop industrial assets can be affected by regulatory and policy developments, such as carbon and corporate taxes, project approvals (or lack thereof or delays to project approvals), emissions caps or limits on emissions intensity, energy regulation, carbon trading and use of carbon offsets. In addition, changing regulations may increase operating costs and reduce profitability, impacting operational viability and future investments.

There are increasing moves to introduce carbon import taxes, such as the European Union's Carbon Border Adjustment Mechanism. These have the potential to affect our products' export markets and trade flows. We also anticipate evolving regulation relating to energy intensity reduction for industrial emitters as countries put in place measures to meet their nationally determined contributions (NDCs).

Pricing carbon, either through direct taxes, emission trading schemes, or leakage avoidance mechanisms (such as border taxes) may create additional costs through the value chain, as well as provide opportunities to promote low-carbon products. Variations in carbon pricing mechanisms between multiple jurisdictions can affect both the cost and the importation of our products.

There has been a significant increase in litigation (including class actions), in which climate change and its impacts are a contributing or key consideration, including administrative law cases, human rights claims, tortious cases and claims brought by investors. In particular, a number of lawsuits have been brought against companies with fossil fuel operations in various jurisdictions seeking damages related to climate change. A number of regulators have also increased their scrutiny of companies' actions in respect of climate change, including through investigating claims related to inaccurate or misleading disclosure ('greenwashing').

Mitigation measures
We track and respond to regulatory and technology developments, as well as customer demand. We anticipate increased demand for our products that have lower embedded carbon content.

We are working internally and with relevant industry organisations on developing life cycle analyses to aid the calculation of our specific commodities' emissions. We play an active and constructive role in public policy development on carbon and energy issues, both directly and through participation in industry organisations. Through developing life cycle analysis tailored to our commodities and production processes, we identify optimisation potential, carbon reduction opportunities and energy efficiencies within our operations. We expect that technology will in time enable us to enhance reporting of our emissions throughout our value chain and to work with our stakeholders to reduce emissions.

We operate successfully in multiple jurisdictions that have direct and indirect carbon pricing or regulations. During 2022, we used actual carbon prices, and carbon prices consistent with the IEA's NZE 2021 scenario (as the scenario available at the time of our planning process) to assess the likelihood and impact of rising carbon price.

We have identified some parts of our business that would likely experience financial stress in a high carbon price environment. However, our analysis of the impact of carbon pricing on operational costs has found that our business overall is likely to remain resilient. We consider local regulation and carbon price sensitivities as part of our ongoing business planning for existing industrial assets and new investments.

We have assessed that increasing demand for our transition metals commodities is likely to drive higher prices for those products in turn offsetting increases to processing costs arising from the implementation of carbon pricing instruments.

We seek to correct inaccurate or misinformation that we identify in the public domain and reiterate our position on key issues related to our climate change strategy and in relation to our corporate reputation.

Case study 3: Insights gained from the economic transformation of coal-dependent economies in the past decades (Oei et al., 2019)

Hard coal production in Germany ended in 2018 after the country ended its coal subsidies. Policies over the years had already led Germany's largest hard coal mining areas, the Ruhr area and Saarland, to phase out coal and diversify their economic reliance on other sectors. Table 2 summarises the key characteristics of both regions.

As both regions transitioned away from coal mining in the previous decades, the transition journey for the Ruhr area and Saarland were quite different. The phase-out of coal mining in the Ruhr area was met with resistance from mining firms, politicians and unions. The area remained reliant on the mining and steel industry instead of looking for new economic possibilities, while key stakeholders were focused on modernising existing structures. Mining firms refused to sell areas of owned land to new firms due to the fear of increased competition from new companies and workers switching jobs. As a result, the transition away from coal was complicated and took many years to occur.

The phase-out of coal mining in Saarland was met with less resistance due to the state and federal government's public ownership of the mining company. The Saarland government offered incentives to mining companies to sell their land to other companies, profiting from the sale to other sectors. As a result, hundreds of companies were able to settle, creating replacing many coal mining jobs. The automotive industry was a key industry to replace coal mining in the area and, in 2016 collected revenue of about EUR 10 billion.

As countries implement stringent climate policies to phase out coal, the transition of cities to replace coal mining with other industries will depend on the implementation of the right types of policies and considerations of a just transition.

Table 2: Summary of characteristics of the Ruhr area and Saarland

		Ruhr area	Saarland
Main characteristics of the region			
Size		4,400 km^2	2,600 km^2
Location		Close to the border with the Netherlands	At the border with Luxembourg and France
Population	1961	5,674,223	1,083,012
	Min	5,045,784 (2013)	989,035 (2014)
	Max	5,756,623 (1965)	1,132,127 (1966)
	2017	5,113,487	994,187
Population density (2017)		1,150/km^2	380/km^2
Integration to Federal Republic Germany		From the beginning in 1949	1957
Political/Spatial level		Loose regional conglomerate of cities	Federal state
Regional competition		Several, similarly large cities within close vicinity compete with each other and create (inefficient) redundant structures	Concentration on few cities
Political/administrative representation		Organized as a regional entity within NRW with only limited responsibilities	Own federal government
Overall economy within the region			
GDP (per capita) in million € (real)	1991	102,340 (*p.c.*: 44,444)	21,269 (*p.c.*: 40,055)
	2016	160,150 (*p.c.*: 66,924)	34,602 (*p.c.*: 59,346)
Homogeneity of GDP in region		In the 1990s strong differences, recently weaker cities were able to catch up	Higher GDP/capita in the cities compared to rural area
Gross value added in mill. € 2018 (share of total regional GDP)[9]	Agriculture, Forestation, Fishing	2,846 (0.4%)	62 (0.2%)
	Production industry	178,365 (25.3%)	11,066 (30.8%)
	Services	454,554 (64.5%)	21,298 (59.2%)
Mining specifications including employment			
Main energy carrier		Hard coal	Hard coal
Type of mining		Deep mines	Deep mines
Number of mines in 1957		138	17
Employees	1957	~600,000	~65,000
	1967	~290,000	~32,500
	1977	~190,000	~22,000
	2017	~4,500	~139
Ownership		Private	Public
End of operation		2018	2012

3. Shifts in market demand

With the transition to a green economy accelerating, the metals and mining sector could witness a monumental shift in its market conditions. As sectors move from carbon-intensive practices towards cleaner alternatives in the coming years, demand for specific metals and minerals as raw materials are set to change. Companies centered around coal and other traditional mining portfolios, will become increasingly exposed to changing market conditions, while other companies will witness a rise in demand. For example, mineral production is predicted to increase by over 450% by 2050 to match the rising demand for clean energy technology (World Bank, 2020).

As market conditions change, companies focused on traditionally mined metals will also face greater market competition from companies that reform their portfolios around rising market demand. The critical driver of change in market share is the use of minerals in energy technologies. Figure 8 below shows how the global market value for coal and energy transition metals will change from 2020 to 2050. Under the International Energy Agency's (IEA) Sustainable Development Scenario (which limits warming to below 1.8°C), the market value of coal is expected to decline exponentially due to the transition to clean energy. On the other hand, materials such as cobalt, nickel, and lithium are projected to witness a significant rise. As for revenue from coal production, this is expected to decrease from USD 431 billion in 2020 to USD 175 billion in 2050. In comparison, revenue from selected metals needed for the clean energy transition is estimated to increase from USD 39 billion in 2020 to USD 264 billion in 2050 (IEA, 2021a).

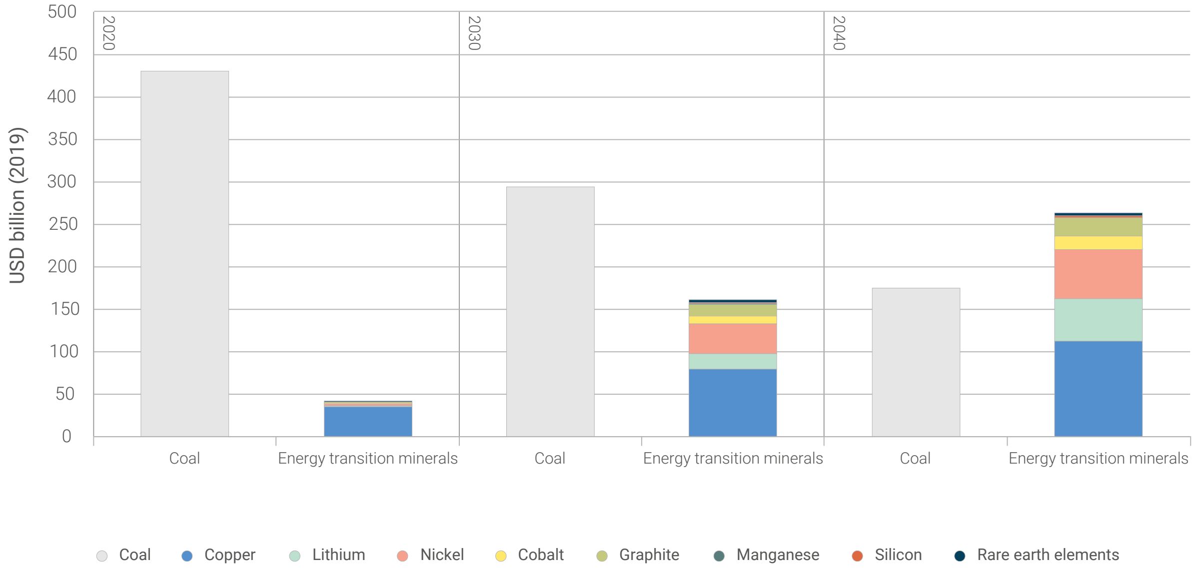


Figure 8: Revenue from production of coal compared to crucial energy transition materials from 2020 to 2050 (IEA, 2021a)

Shift in demand for mining of metal ores and precious metals

Clean technologies, such as solar photovoltaic (PV), wind turbines and electric vehicles (EVs) need more metals and minerals as materials in comparison to their carbon-intensive alternatives. For example, an EV needs six times more minerals on average than an internal combustion engine car. Similarly, an onshore wind plant needs nine times more minerals than a gas-powered equivalent. The type of metals and minerals used also vary by the technology type. Lithium, nickel, cobalt and manganese are needed for batteries, for instance, while rare earth elements are used in wind turbines and EV motors. As for copper and aluminium, these are needed for electricity networks. In their role as strong drivers of future demand, therefore, the energy and transportation sectors are set to exert a significant influence on the market for the metals and mining sector. Under the IEA's Sustainable Development Scenario, mineral demand for clean energy technology is four times higher in 2040 than in 2020. Under the IEA's net zero scenario, meanwhile, mineral demand increases by six times from 2020 to 2040 due to a more rapid transition (Figure 9) (IEA, 2021b). Table 3 illustrates the projected change in demand from energy technologies for a range of metals in 2050, compared to 2018 levels. Cobalt, lithium and graphite are estimated to witness the greatest increase in demand (World Bank, 2020).

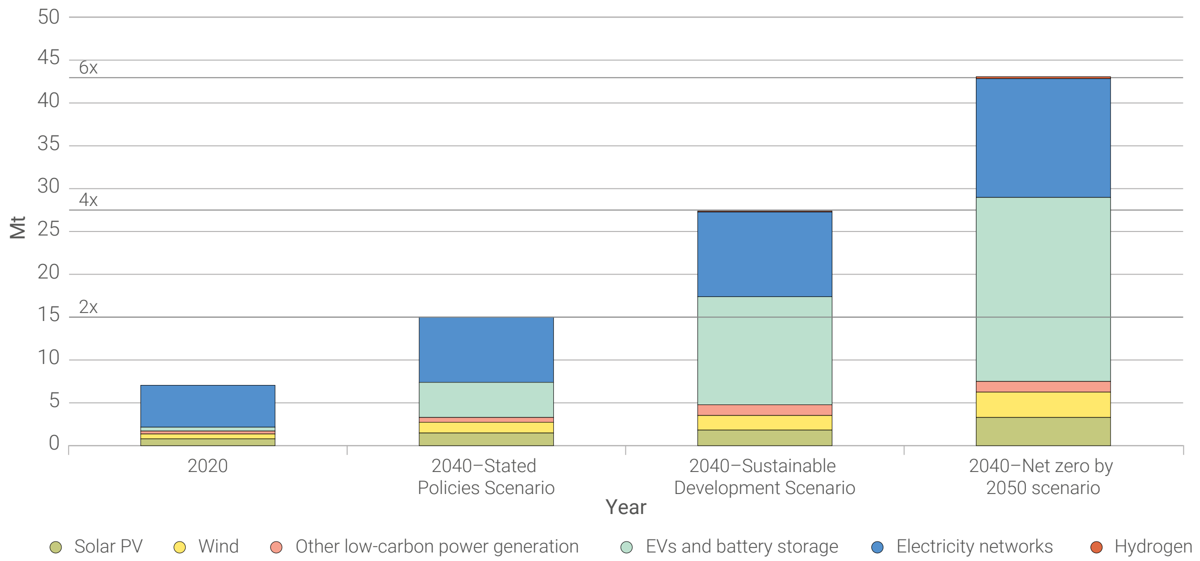


Figure 9: Total mineral demand for clean energy technologies from 2020 to 2040 by scenario (IEA, 2021b)

Table 3: Projected change in demand from energy technologies for a range of metals and minerals (World Bank, 2020)

Mineral	2018 annual production (Tons, thousands)	2050 projected annual demand from energy technologies (Tons, thousands)	2050 projected annual demand from energy technologies as percent of 2018 annual production
Aluminum	60,000	5,583	9%
Chromium	36,000	366	1%
Cobalt	140	644	460%
Copper	21,000	1,378	7%
Graphite	930	4,590	494%
Indium	0.75	1.73	231%
Iron	1,200,000	7,584	1%
Lead	4,400	781	18%
Lithium	85	415	488%
Manganese	18,000	694	4%
Molybdenum	300	33	11%
Neodymium	23[b]	8.4	37%
Nickel	2,300	2,268	99%
Silver	27	15	56%
Titanium	6,100	3.44	0%
Vanadium	73	138	189%

Fluctuations in demand for low-carbon technologies in the near-term can exert uncertainty on prices for specific metals and minerals. A rise in lithium prices has already been observed (Figure 10), for example, indicating growing demand. This rise is primarily due to the boom in EV sales, which helped send lithium prices skyrocket in 2022—increasing by 550% in March 2022 compared to the previous year (McKinsey, 2022). However, following a rapid rise in the total spot value of lithium from USD 3 billion in 2020 to USD 35 billion in 2022, lithium prices crashed in 2023. The decrease in prices was attributed to lower EV demand in China than expected. In 2022, sales of EVs and plug-in hybrids had grown by 90%, however, in 2023, sales only grew by 6.3%. Meanwhile, supply of lithium is expected to increase substantially in 2023, outcompeting demand. Forecasts suggest that lithium production could increase by 22 to 42% (International Banker, 2023).

However, in the coming years, demand for lithium is expected to exceed supply, with BMI, a research unit of Fitch Solutions, estimating that a lithium shortage could occur by 2025 due to high demand for the metal from China (CNBC, 2023). S&P Global estimates that the demand for lithium batteries is set to grow annually by 22% until 2030 (S&P Global, 2023). If the supply cannot keep pace with the rate of demand, lithium prices may experience a substantial increase, similar to what was observed in 2022. Companies operating in this industry that have such metals in their portfolios could benefit from these rising prices. For instance, in 2022, when lithium prices reached a record high, Albemarle, the largest global provider of lithium for electric vehicle (EV) batteries, reported a surge in net sales from USD 894 million in the previous year to USD 2.6 billion. The company attributed this increase to the high lithium prices (Albemarle, 2023). However, high prices could lead to increased costs for companies that rely on these metals as raw materials. For example, in August 2022, EV prices, on average, rose by 15.6% compared to the previous year, in line with the upward trend in lithium prices (Axios, 2022).

Monthly global weighted average per metric ton; January 2020 to August 2022

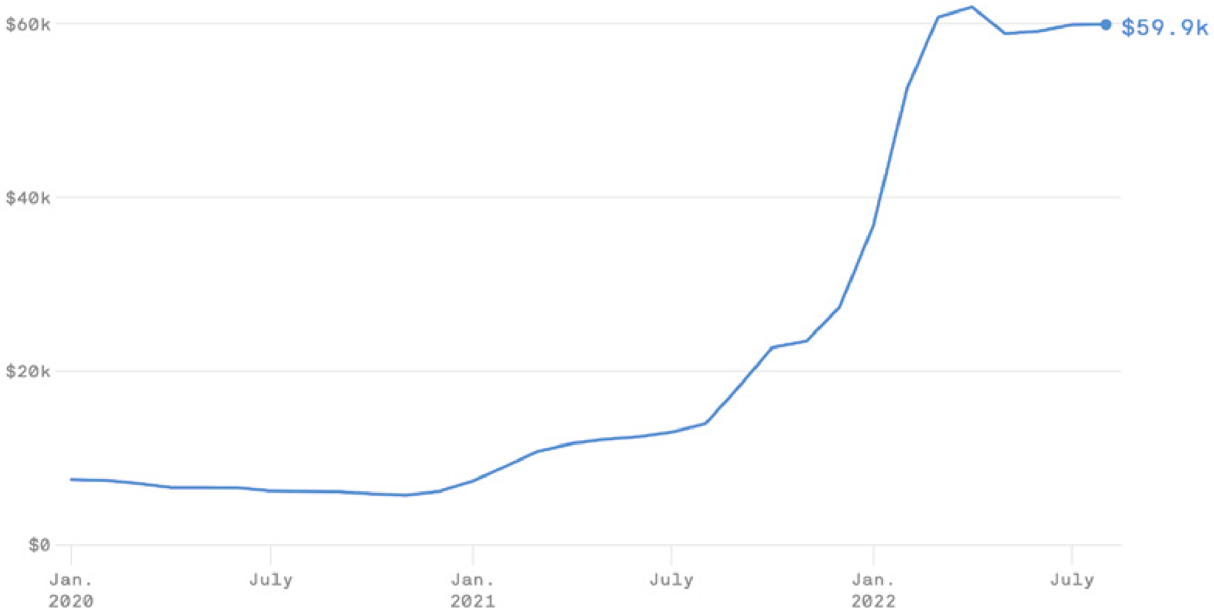


Figure 10: Increase in market price of lithium (Axios, 2022)

In the metals and mining sector, some firms have already started considering how to seize potential opportunities of a low-carbon transition by increasing their exposure to certain metals through acquisitions of projects and exploration of deposit sites. These firms expect that demand for these metals will rise as countries increase their net-zero ambitions. At the same time, supply could become constrained over the long-term due to there being a limited number of projects underway and increasing obstacles to mining practices at specific sites (such as difficulties in obtaining relevant licenses and operating permits). To succeed in the transition, financial institutions and their mining-sector clients must determine whether the current high prices observed for certain metal represent a short term phenomenon or whether they will continue in the long-run due to demand exceeding supply for these metals. The former would raise doubts about the sector's future returns, while the latter points to the creation of potentially lucrative market opportunities (Financial Times, n.d.).

Shift in market demand for coal mining

Research shows that 80% of global coal resources must remain underground and unused to limit global warming to 1.5°C (McGlade & Etkins, 2015). This creates the risk of stranded assets for coal mining firms due to reduced investments and early retirements of existing mines. The United States, Russian and Australia are just some of the countries that could be at risk of stranded assets. Auger *et al.* (2021) assessed the impact of the phase-out of coal on coal mining using the IEA's Sustainable Development Scenario. Under the scenario, the study showed that coal prices decline significantly due to a reduction in demand and oversupply of coal, causing the least efficient mines to retire. In the scenario, steam coal prices decrease by an average of 3% annually up to 2040. The scenario also envisages declines in global trade. Australian coal exports decrease by 60% between 2017 and 2030, for example, while over the same period exports from Indonesia and Latin America fall by 40% and 20%, respectively. The study found that by 2040, one-third of global mining capacity will be at risk of becoming stranded due to a rapid decline in demand, causing coal mines to shut down before the end of their lifetime. To limit warming to below 2°C, between 1.5% to 2.5% of coal mines need to be decommissioned annually. This will result in 25% of global mining to become stranded during the course of the next decade alone (Figure 11). It is estimated that the early closure of mines will cost over 2.2 million jobs by 2040 (Auger et al., 2021).

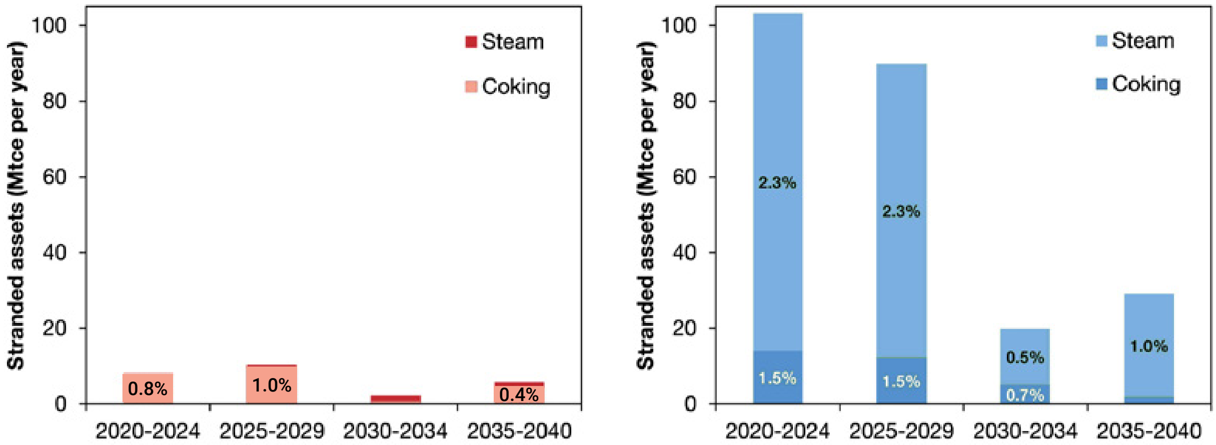


Figure 11: Projected decommissioning of financially unviable hard coal mining capacity in SDS compared to business as usual (Auger et al., 2021)

4. Technology and the rise of low-carbon alternatives

Traditional firms with carbon-intensive operations in the metals and mining sector face increasing competition from firms that integrate advancing low-emissions technologies, such as renewables and the electrification of machinery and vehicles. For example, the predominant phases in the production of aluminum alumina refining, anode manufacturing, and aluminum smelting contribute to nearly 85% of the direct CO_2 emissions associated with aluminum production. The remaining emissions come from processes related to recycled production and semi-finishing. These direct emissions can be mitigated through the adoption of low carbon technologies (IEA, 2022). A survey of miners and mining equipment manufacturers by professional services firm EY, together with the University of Queensland and the University of British Columbia, found that electrification of mines can result in reduced operational and capital costs whilst also improving energy efficiency. Notably, for example, diesel engines can be replaced with electrification and renewable power. The incorporation of low-carbon technology alternatives also reduces the need for ventilation shafts in underground mines and improves working conditions for miners. Further, the use of advanced technologies could also result in less of a need for maintenance (EY, 2019).

As technological advancements reduce the costs of low-carbon alternatives (especially renewable energy) and as fossil fuels become more expensive due to carbon pricing, mining operations that do not adopt low-emissions technology could face higher costs than firms that quickly incorporate such technologies. For example, data from the United States showed that the complete cost per MWh of the cheapest renewable was already at least three times more affordable than 75% of the country's coal capacity (Energy Innovation, 2023). This can create a risk for companies relying on traditional fuels rather than on low-carbon alternatives for their operations because higher costs could result in lower profits.

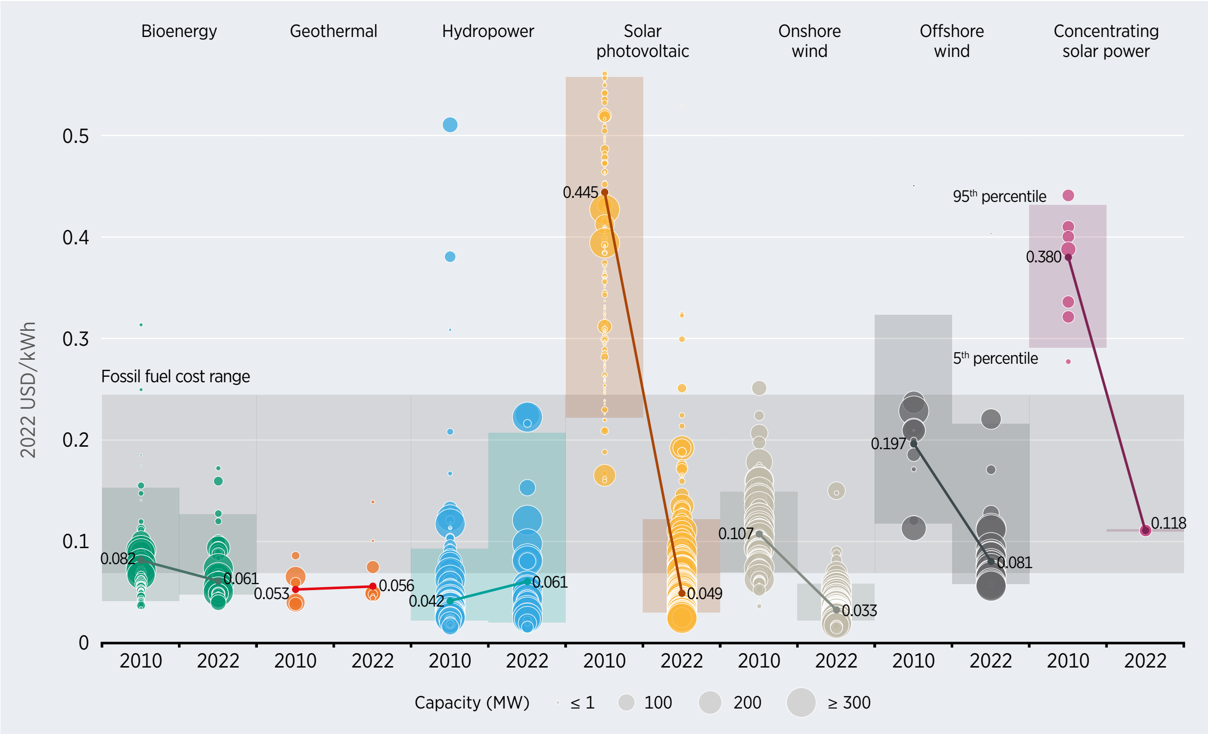


Figure 12: Global weighted average levelized cost of energy (LCOE) from utility scale renewable power generation technologies compared to fossil fuel, from 2010 to 2022 (IRENA, 2023)

Technological innovations in low-carbon technologies, such as solar and wind power, will be needed to decarbonise other sectors. As a result, the need for coal mining is set to substantially decrease. As the costs of renewables fall and as renewable technology continues to expand on a large scale due to technological advancements, coal will become less competitive. According to the consultancy firm McKinsey, coal used in steel manufacturing would need to decline by 80% between now and 2050 in order to fulfil the 1.5°C pathway. This transition will particularly affect the production of thermal and metallurgical coal, which currently constitute about 50% of the global mining market (McKinsey, 2020a). The shift away from coal in favour of new technologies could have severe financial impacts on firms in the sector. In October 2019, Murray Energy became the eighth US coal producer to file for bankruptcy in 12 months. This was just the most recent development in a long-term trend of coal mine closures in the United States and globally. The number of coal mines in the United States has fell from 1,435 in 2008, for example, to 671 in 2017. Since 2016, the country's top three coal producers have filed for bankruptcy (NS Energy, 2020). Falling demand for coal due to low gas prices, coupled with the growth of wind and solar power was a key factor for these closures (NS Energy, 2020).

With the growth of new innovations in low-carbon technologies, minerals used for these technologies will see increased demand. The rise of new technologies, such as EVs and wind turbines, means that companies with vast portfolios of metals and minerals will become more competitive than traditional mining companies focused primarily on coal. For example, forecasts by the Australian government showed that the lithium industry will triple by 2027–28, compared to 2021–22 levels. Along the same timeframe, Australia's coal exports are estimated to decrease by 70%. By 2027–28, export revenue from coal and lithium are estimated to reach the same levels (Figure 13) (The Guardian, 2023; Government of Australia, 2023). As a result, firms with portfolios focused on coal mining will see a shrinking role in the clean energy transition.

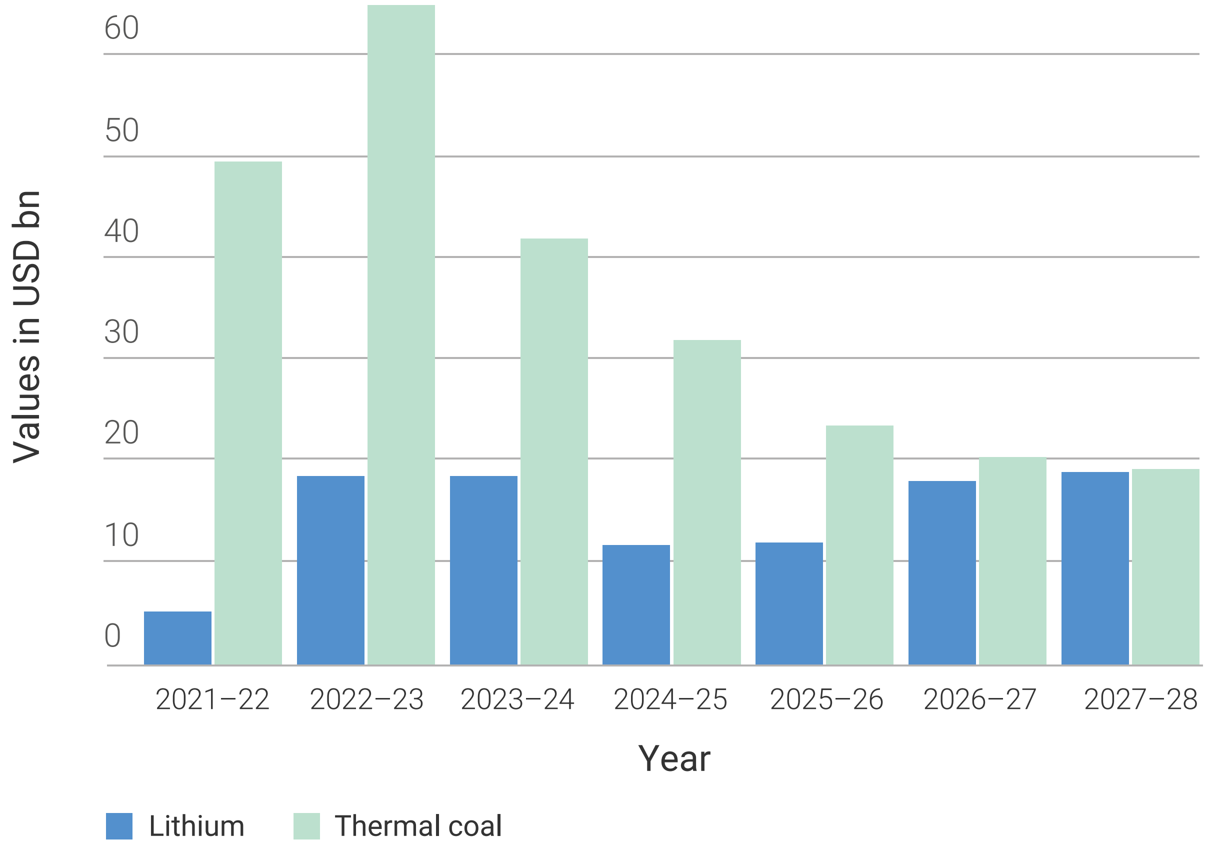


Figure 13: Estimates of Australian lithium and thermal coal exports from 2021 to 2028 (The Guardian, 2023)

Case study 4: Technology and low-carbon alternatives

Hecla Mining Company Annual Report 2022

American mining company for primary silver production

Transition risk identification
Transitioning to a lower-carbon economy may entail extensive market changes and will require significant investment to address mitigation and adaptation requirements related to climate change. The development and deployment of technological improvements or innovations will be required to support the transition to a low-carbon economy, which could result in write-offs and early retirement of existing assets, increased costs to adopt and deploy new practices and processing, including planning and design for mines, development of alternative power sources, site level efficiencies and other capital investments. A failure to meet our climate strategy commitments and/or societal or investor expectations could also result in decreased investor confidence and challenges in maintaining positive community relations, which can pose additional obstacles to our ability to conduct our operations and develop our projects, which may result in a material adverse impact on our business, financial position, results of operations and growth prospects.

Mitigation measures
Hecla 2022 Sustainability Report

Stakeholder Engagement: In 2022, we continued to evolve our ESG process by further incorporating the perspectives of external stakeholders regarding the economic, environmental, and social impacts of activities at our mines and local communities. We accounted for these perspectives during the execution of projects at the site-level and used them to inform our 2022 Sustainability Report during the Subject Matter Expert (SME) interview portion of our annual reporting process. We engage regularly with stakeholders in our communities to learn about and address local concerns and to develop partnerships that help maintain long term relationships.

ESG Reporting: Hecla operations vary greatly from site to site, depending on the location. The environmental conditions, community and cultural heritage factors, and economic setting all inform our activities. Therefore, we take a site-specific approach to reporting on our ESG impacts. Hecla is committed to transparency and consistent communication of the company's ESG programmes and performance. We communicate comprehensively each year in the form of our sustainability report, which is prepared with reference to the GRI Standards. Hecla also benchmarks its performance against the SASB [Sustainability Accounting Standards Board] Metals and Mining Standard, and reports against relevant aspects of the Task Force on Climate-Related Financial Disclosures (TCFD). The Mining Association of Canada's Towards Sustainable Mining (TSM) Protocols also guide reporting and communications for our Canadian operations.

5. Rising reputational risk

With growing concern for climate change and the sector's contribution to GHG emissions, the reputation of businesses in the metals and mining sector is at a growing risk of damage. Figure 14 illustrates the societal expectations regarding the environmental responsibility of companies within the sector. The assessment of environmental responsibility involves evaluating whether these firms have implemented measures to reduce their impact on natural resources and ecosystems. According to the Responsible Mining Foundation, firms are falling short on meeting societal expectations, a gap that could be reduced through the adoption of good practices (Responsible Mining Foundation, 2022).

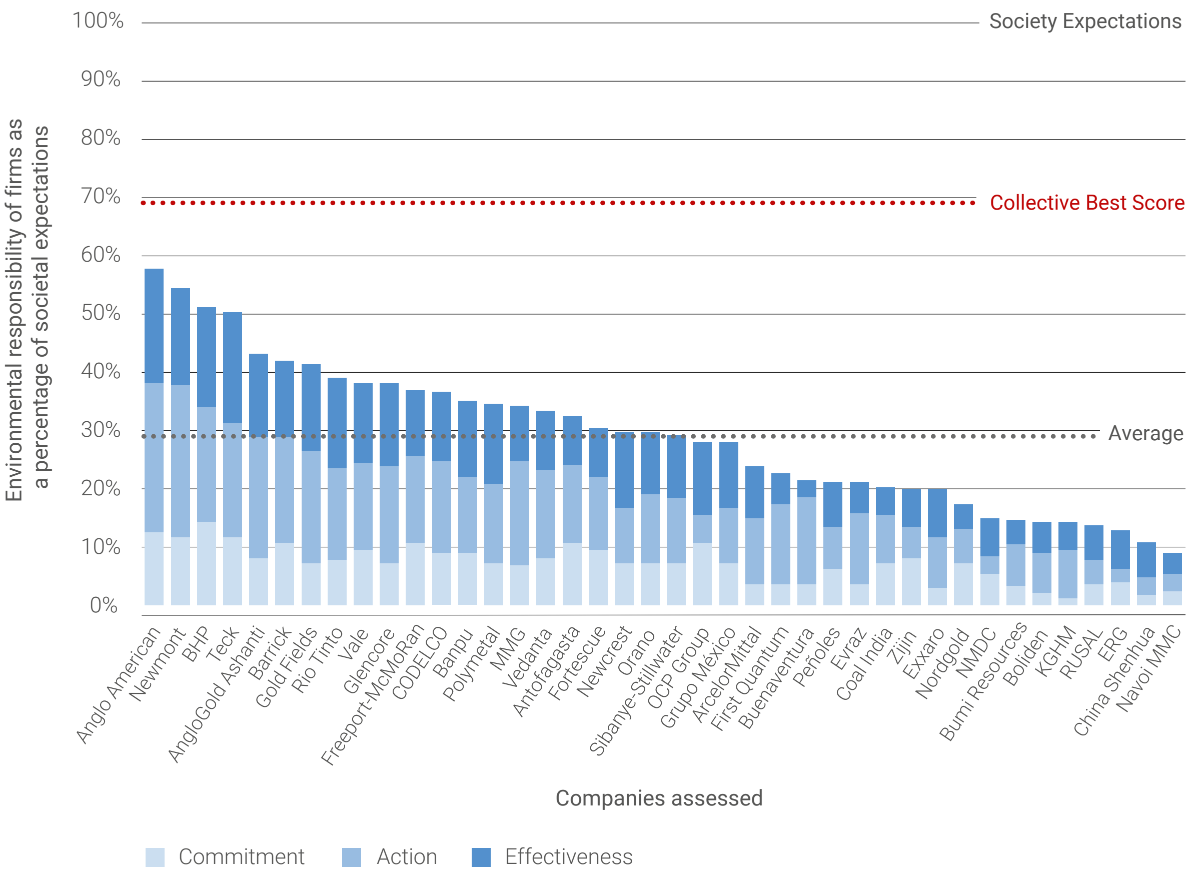


Figure 14: Societal expectations of firms in the sector compared to current contribution[5] (Responsible Mining Foundation, 2022)

Firms taking part in mining activities that contribute to climate change, as well as, environmental damage and social impacts face reputational risks. Non-profit organisations,

5 The vertical axis shows the environmental responsibility of firms as a percentage of societal expectations (100%). The horizontal axis shows the companies assessed.

activists, and other public-interest entities have been running campaigns against companies in the sector. For example, in Germany, as many as 35,000 individuals gathered to block entry to the Garzweiler coal mine. The site is owned by the German multinational energy company RWE, which annually extracts 25 million tonnes of lignite[6] from the facility. Police had to remove protestors blocking the entry way. The incident attracted considerable media coverage due to the arrest of climate activist Greta Thunberg by the German police (BBC, 2023; Reuters, 2023b). Meanwhile in Mexico, US gold mining company Newmont-Goldcorp suspended its operations at a silver mine in 2018 as local residents urged that the mine used excessive levels of water, which had negative impacts on the surrounding environment and on nearby communities. As Mexico's second-largest silver mine, this closure led to a potential loss of 20 million ounces of this precious metal, equivalent to USD 477 million at the current market price (DBJ, 2023).

In Australia, the world's second-largest coal exporter, climate activists are raising awareness of the contribution of coal mining to climate change. In 2021, two members of the activist group Blockade Australia climbed a large piece of coal-handling equipment to prevent operations in the Port of Newcastle, the world's largest coal port. They shared their stunt on social media to draw attention to the emissions contribution of the Australian coal mining sector (Washington Post, 2021). Another protester in Australia chained herself to the entrance to the port to prevent coal supplies from entering (Washington Post, 2021). Meanwhile, environmentalists in Tukey clashed with the police in 2023 during a protest against plans by the Turkish company YK Energy to expand its coal mine across 780 acres of woodland (Euro News, 2023). Protests are also increasingly common in Europe. In 2023, for example, activists from the campaign group Greenpeace took control of equipment at a Czech coal mine to protest against plans to extend operations at the site until 2035 (Greenpeace, 2023). In Serbia, meanwhile, British-Australian mining firm Rio Tinto faced prolonged demonstrations over plans for a lithium mine in the country. Protestors said that the project would damage the surrounding ecosystem and contaminate water supplies. The demonstrations led to the Serbian government eventually revoking Rio Tinto's permit, leading to a subsequent drop of 4% in the company's share price (BBC, 2022). Without appropriate mitigation measures and sufficient procedures in place for community engagement, firms in the sector will continue face such instances of reputational risk.

Financial institutions investing in the metals and mining sector are also at risk of reputational damage. Between 2000 and 2017, 58% of the complaints received by the International Finance Corporation on investments in the mining sector were related to water issues (University of British Columbia, 2020). Risks related to water use and scarcity will be further covered in the Physical Risks Section (Section B).

6 Lignite is a form of coal that is considered very low-grade due to its low heat content.

6. Emerging legal risks

The metals and mining sector faces increased climate and social-related legal action due to the severe environmental impacts of mining processes, as well as shifting policies and growing interest by society in climate and environmental health.

The decision made in 2022 in the case of Waratah Coal Pty Ltd v Youth Verdict Ltd & Ors is just one of a number of examples that highlight the legal risks associated with large-scale mining projects (Library of Congress, 2022). In this case, a group of young people associated with the Youth Verdict campaign in Australia challenged a proposed coal mining project on the grounds that it would negatively impact the human rights of the population due to its contribution to climate change (Library of Congress, 2022). The land court recommended to the relevant state authorities that the coal mine project should not be approved on climate change and human rights grounds, although it did not have the authority to make an enforcing decision on this matter.

In December 2022, the British Government approved the building of a new coal mine in Cumbria despite lobbying other countries to 'consign coal to history' when it hosted COP26 in Glasgow in 2021 (Friends of the Earth, 2023). Two environmental groups, Friends of the Earth and South Lakes Action on Climate Change (SLACC), are suing the UK government for their approval of the mine. Their argument centres on the government's failure to consider the mine's significant impacts on climate. They also argue that opening a new mine would set an international precedent that would have repercussion for the global coal market. In May 2023, the High Court judge assigned to the case gave the go-ahead to proceed.

In the United States, meanwhile, the township of Ann Arbor filed a lawsuit against the mining company Mid Michigan Materials. The complainants say the company's Vella Pit has caused a number of wells used by local residents to dry up as well as negatively impacting the surrounding environment. In October 2023, a motion was also filed to grant temporary restraining order so as to halt operations at the mine (NPR, 2023). A judge in Montana went further, ruling that the state was violating the rights of young people with policies that prevent climate change impacts being considered when reviewing coal mining projects. The decision came after 16 plaintiffs (ranging from the ages of 2 to 18 years old) sued the State of Montana for permitting coal mining for violation of its own constitution which requires the government to protect and improve of the natural environment (Reuters, 2023c).

Similarly, in Poland, a grassroots foundation called Development YES filed a case in 2018 against PZU, a leading insurer responsible for underwriting 85% of the country's hard coal mines. The complainants maintained that the firm's activities were exacerbating climate change by offering insurance to companies in the coal mining sector. They also accused it of a lack of transparency in respect of its financed CO_2 emissions. As a result, the Polish National Contact Point for the OECD Guidelines for Multinational Enterprises recommended that PZU discloses details of its climate footprint and develop clearer policies concerning human rights and the environment (Climate Case Chart, n.d.).

The above cases showcase that courts are embedding climate change considerations into their decisions, thereby presenting mining firms with increased legal risk.

7. Growing investor action

Investors are increasingly aligning their portfolios to the Paris Agreement by committing to net zero and joining initiatives such as the Net-Zero Asset Owner Alliance and Climate Action 100+. As a result, a growing number of investors are now considering climate change in their investment decisions. For example, more than 200 global financial institutions have disinvestment policies in place to restrict investments in thermal coal mining or coal-fired power plants (IEEFA, 2022). European investment companies, including France's AXA, Britain's Aviva, Germany's Allianz, and Switzerland's Zurich Insurance, are among the top firms committed to reducing their coal investments. AXA has committed to a total separation from coal by 2030 in developed nations and by 2040 globally (AXA, 2019). In 2022, HSBC Asset Management followed suit by announcing its commitment to phase out all investments in thermal coal globally by 2040 (HSBC, 2022). As investors announce plans to stop financing coal mining, this poses a significant risk for companies with portfolios primarily focused on coal mining.

Results from Accenture's Global Institutional Investor Study of ESG in Mining showed that 59% of investors want their mining clients to take strong mitigation actions (Accenture, 2022). In addition, 63% of investors expressed their willingness to divest from mining companies that do not actively work towards decarbonisation or that do not fulfil their decarbonisation targets. Figure 15 illustrates the growing importance that investors are placing on Scope 3 emissions (i.e. those produced up or down a company's value chain) (Accenture, 2022). As a result, metals and mining businesses face losing financial support from financial institutions if they do not demonstrate plans to decarbonise. For example, in 2022, Rio Tinto's investor Sarasin & Partners voted against the company's financial statements due to a lack of clarity surrounding its climate risks (The Guardian, 2022).

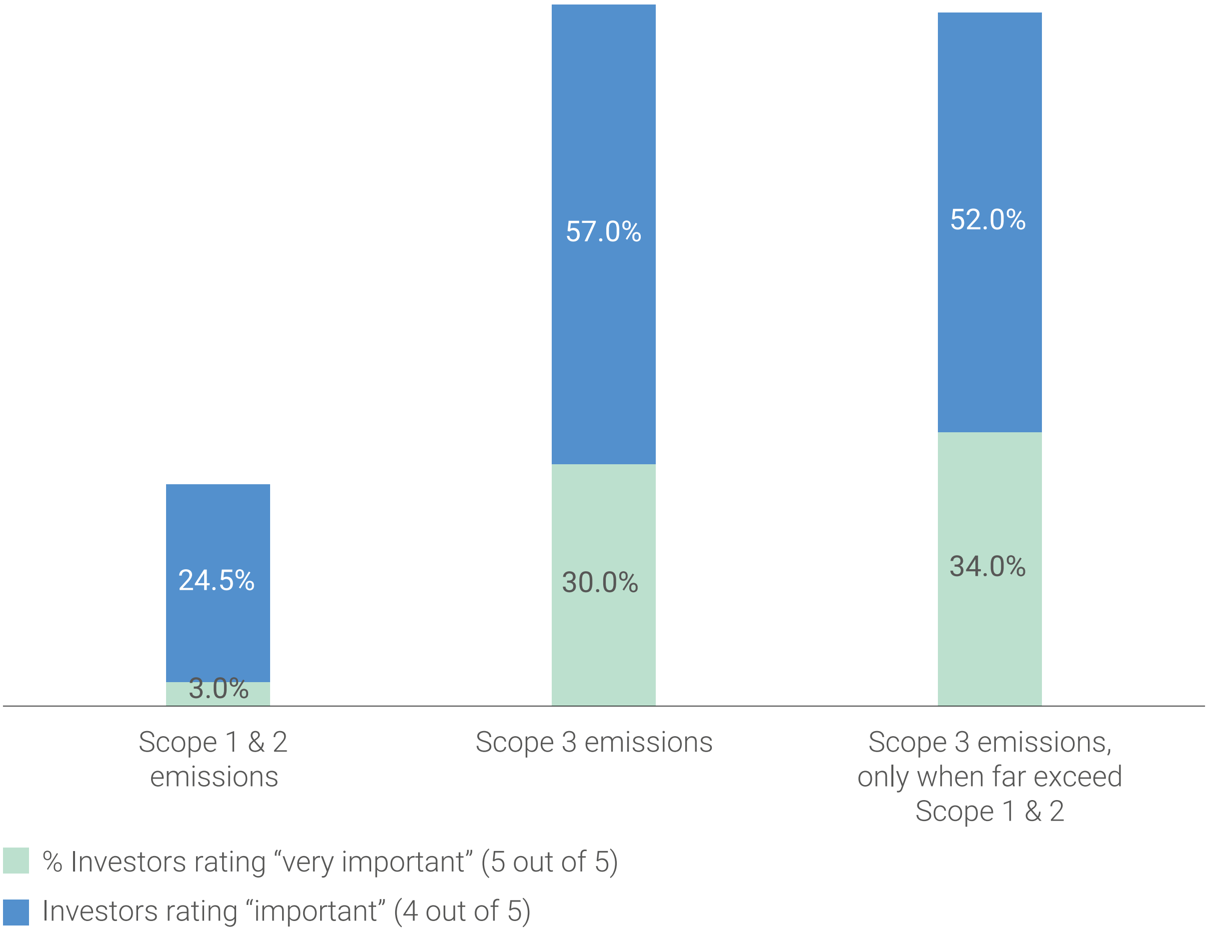


Figure 15: Importance of Scope 1, 2 and 3 emissions for investors (Accenture, 2022)

Investment pressure has led some mining companies to change their business models to phase out coal. In 2020, BHP, an Australian multinational mining and metals company, announced it would sell its thermal coal mines within two years to satisfy the criteria established by Norway’s Government Pension Fund Global. The state-backed fund company owns 3.8% of BHP’s London-listed arm as well as around 0.6% of its Australian-listed entity (The Guardian, 2020). BHP later announced it would close its Australian mine in New South Wales completely by the end of 2030 (BHP, 2022). In a similar move, Switzerland-headquartered commodity trading and mining company Glencore has announced that it will stop mining thermal coal by 2050 and that it will close 12 mines by 2035. The announcement followed questions from investors on how the company’s thermal coal business aligned with efforts to limit warming to 1.5°C (Bloomberg, 2023). Other mining firms have already paved the way for such divestments. Rio Tinto, the world’s second-largest metals and mining corporation, for example, sold its last coal mining operations back in 2018 (Mining Technology, 2020). Industry experts at the time stated that the move would make Rio Tinto more attractive to investors (The Guardian, 2018). Mining companies that face investor pressure but fail to shift away from coal mining could themselves face disinvestment.

8. Transition risk guidance

This section offers guidance on how financial institutions can address transition risks within the sector and support their clients in the process.

Key transition risk questions for financial institutions to consider

1. Gathering information
   - Are there any new governmental restrictions on coal mining activities or new low-carbon initiatives in our portfolio's footprint?
   - How rapidly is the low-carbon transition progressing across our portfolio footprint? What do energy costs, demand, and efficiency look like across our portfolio footprint?
   - What are the critical mineral requirements, and are there available projections for the countries where the client operates?
   - What have our clients disclosed in their financial, sustainability, and climate reports regarding their transition risks?
   - Are any of our clients facing legal action related to industrial activities, pollution, or other environmental issues?
   - How many of our clients do not have transition plans? Do they incorporate just transition considerations into these plans?
   - In the case of coal mining, does a client have a transition plan that considers plans for phasing down or restructuring?
   - Do we have emissions data for our clients?

2. Assessing the risks
   - Have we looked at transition scenarios to see how those risks will evolve over time across the portfolio? Have we considered short-term, medium-term, and long-term risks?
   - What does our exposure to higher-risk clients look like? What are the terms of our financial relationship (e.g. debt/equity, tenor)?
   - How does the emissions intensity of our clients compare to industry and regional averages?
   - What is the cost of production for our clients? How does that compare to industry and regional averages?
   - How much are clients investing in low-carbon operations and research and development?
   - Which metals and minerals will be the most and least impacted in the in the low-carbon transition?
   - What are the margins for our clients? How do they compare to regional averages?

- Have we considered the potential environmental and social risks that might emerge from shifts in the value chain or changes in demand resulting from transition risks?

3. **Engaging with clients and updating strategy**
   - Do our senior leaders understand the transition risks of our clients?
   - How are we helping our clients to transition to a low-carbon future? How are we supporting their efforts to advance a just transition?
   - How will the transition risks identified and assessed influence our strategy in the metals and mining sector?
   - What specific updates to risk management practices or business activities will be needed to appropriately consider these transition risks in our operations?

Recommendations for risk management

1. **Understand the energy use of the sector**

The energy use and emissions footprint of a mining operation provides valuable information about the transition risk faced by a firm belonging to the sector. Mining is a highly energy-intensive process, with energy comprising one of the main expenses of a mining operation. As countries transition to a low-carbon economy, firms that are heavily reliant on carbon-intensive energy use will face a severe disadvantage. The implementation of government policies and restrictions (such as carbon prices and energy performance standards) can increase energy costs and bring about operational challenges for firms. Furthermore, the 2022 energy crisis exhibited volatility in energy markets that can impact firms in the sector. To limit exposure to such risks, financial institutions should get a baseline estimate of a mining asset's energy use and emission footprint. Such data can be used to determine the vulnerability of metals and mining firms to increased energy costs and exposure to transition risks.

2. **Determine how the transition will change the outlook for the sector**

With the climate transition underway, demand will rise for the raw materials used in clean technologies, such as lithium, cobalt, copper, and nickel. Concomitantly, as will rise while demand for coal mining will substantially fall. The metals and mining sector will need to supply large quantities of these metals to drive the transition. However, the supply of raw materials by the sector is highly capital-intensive and is vulnerable to long lead times and bottlenecks, especially as demand for these metals exceeds supply. Financial institutions should explore how, under different transition scenarios, the demand for metals in the sector will fall and rise due to the need for raw materials for various clean technologies, such as electric vehicles, wind energy, solar energy and hydrogen production. Such assessments can help financial institutions identify which clients will be particularly vulnerable as a result of changes within the sector.

Adaptive and mitigating actions of clients

1. **Investing in low-carbon operating models**

The metals and mining sector is highly carbon-intensive and a hard-to-abate sector. Some firms belonging to the sector are beginning to adopt practices to shift towards lower-carbon operating models. Such a shift is becoming increasingly important for firms as demand for raw materials in clean technologies creates pressure to grow the supply of critical metals. To change their operating models, mining companies need to switch to renewable energy and improve energy efficiency. Clients will need to develop strategies for producing lower carbon emissions. This will involve investing significantly in research and development. A firm should develop a transition plan to outline its shift to low-carbon operations and specify how different aspects of the business will be involved in the transition.

2. **Environmental and social stewardship**

Strong environmental and social practices are essential across all economic sectors. However, stewardship needs to be a particularly acute priority for firms in the metals and mining sector given the historic (and ongoing) environmental and social issues associated with their activities (e.g. excess use of water, chemical contamination of nearby soil and waterbodies, and so forth). Environmental and social responsibility in the sector begins with close examination of the impacts of the entire lifecycle of a mining operation. This then needs to be followed up with relevant controls and processes across for reducing or eliminating such impacts. For example, as demand for EVs grow, there will be an increased need for scarce minerals, leading to a necessity for expanded mining operations. Setting up a mining operation requires the clearing of large amounts of land, which will inevitably cause damage to local communities and biodiversity. Mining activities can also release hazardous materials and chemicals into nearby waterbodies as well as release pollutants into the atmosphere. In terms of social impacts, the creation of mining operations can result in nearby communities having to be relocated. Metals and mining firms should closely consider the legal and ethical implications of their operations and ensure that they conduct their business activities exclusively in areas where there is no risk to the well-being of nearby communities or fragile natural ecosystems. Responsibility is not only about mitigating risks. As well as promoting safe working condition, for example, mining companies should consider how the creation and operation of new mining facilities can positively impact local livelihoods. The following box offers examples of social factors that financial institutions and their clients should take into account during the transition to a low-carbon economy.

Examples of sector-specific social considerations (UNEP FI, 2023b)

Impacts on employment and livelihoods induced by lower production of coal leading to job losses and negative impacts on supply chain and communities heavily reliant on coal mining.

Skills development, particularly in the context of coal-dependent regions, to the extent that the skills required for the energy transition do not match existing skills in the sector.

Working conditions, particularly in the context of rapidly growing critical minerals mining. Many mining sector jobs are precarious, informal, and are far from conforming with labour standards. Accident rates in small-scale mines are routinely six or seven times higher than in larger operations.

Labour and human rights: a special issue within the sector is child labour and is mostly commonly found in artisanal and small-scale mines, with known cases in some of the critical minerals, such as cobalt.

Social dialogue and stakeholder engagement, including in the context of a decrease in coal production, where attention will need to be given to finding sustainable solutions for affected mines and their workers. Local communities are likely to be directly affected by both the coal mining decline and increase of critical minerals mining. The phasing down of coal will affect the surrounding communities, whose livelihoods depend on the existing mining sites. It is important to ensure proper community engagement including potential environmental remediation plans to mitigate pollution and degradation of the ecosystem.

Land rights and Indigenous peoples' rights due to the rush to supply critical minerals, which adds tension between the stakeholders in minerals-producing countries and the needs of global society leading to pressures on land use and rights as well as water use. Indigenous peoples are also concerned, as 47% of 300 undeveloped ore bodies are situated on, or close to, Indigenous peoples' land, and 65% are in high water risk areas.

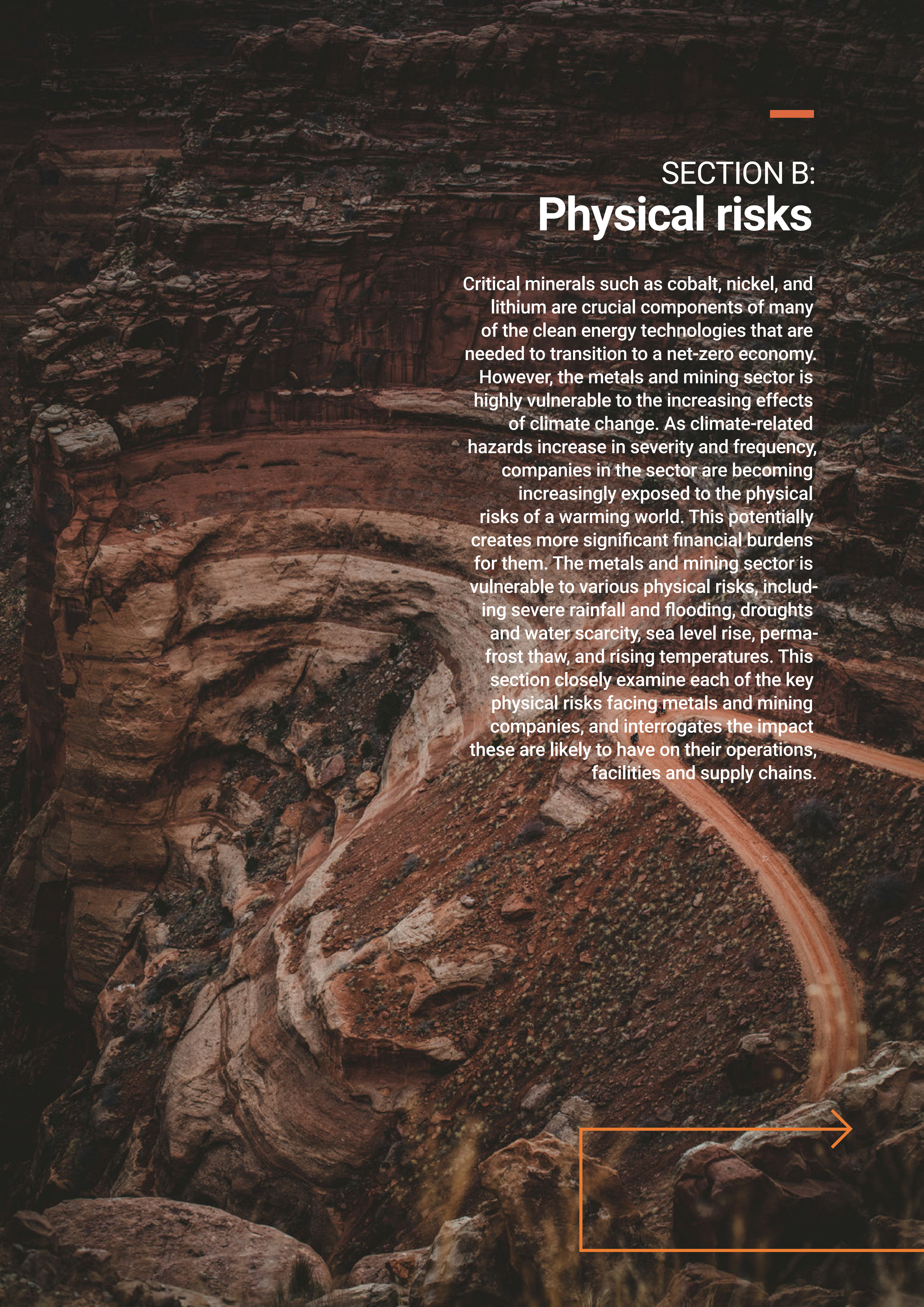
Gendered impacts: the mining sector is traditionally male dominated. While women form a minority of the workforce, they are disproportionately affected by negative externalities, such as discrimination and gender-based violence. The growing automation of the sector can transform the opportunities available to women.

Aligning to net zero

Financial institutions looking to manage their transition risks in the metals and mining sector should engage directly with clients and support client transitions. While necessary, however, this client-level approach must complement a more strategic plan for reducing the firm's financed emissions. Over the past few years, hundreds of major financial institutions have committed to net zero by 2050 across their portfolios. Most of these institutions have joined one of the industry-specific decarbonisation alliances (e.g., Net-Zero Banking Alliance, Net-Zero Asset Owner Alliance) to support them in fulfilling their climate goals. Beyond the financial sector, net-zero alignment has also gone mainstream in government policies worldwide, with nearly 90% of global emissions now covered by a net-zero commitment. Given the growing pressures on high-carbon sectors, plus the decarbonisation ambitions of financial and government actors, financial institutions can consider a credible and actionable net-zero commitment as a way to mitigate both the systemic and idiosyncratic risks of the transition. The process of operationalising a net-zero commitment begins by assessing baseline financed emissions. Then, using science-based scenarios, institutions need to set targets for their portfolios and specific sectors, such as metals and mining. After the targets are set, financial institutions develop holistic strategies to reduce their financed emissions. These processes can be explained to stakeholders in a transparent transition plan that demonstrates not only the net-zero commitment, but also how the firm in question is mitigating its transition risks.

Additional guidance

- The Equator Principle's guidance note on Climate Change Risk Assessment provides detailed information on transition risk assessment.
- The European Central Bank has published good practices for climate-related and environmental risk management for financial institutions.
- The Transition Plan Taskforce's draft Metals and Mining Sector guidance includes detailed guidance on transition planning for the sector.
- UNEP FI and the International Labour Organization's report on Just transition Finance includes guidance for banks and insurers on adopting a just transition lens in their banking and underwriting activities.
- The Transition Pathway Initiative has proposed a methodology for assessing emissions intensity of mining activities.
- UNEP FI and the Cambridge Institute for Sustainability Leadership's report on Leadership Strategies for Client Engagement: Advancing climate-related assessments provides guidance on advancing climate-related assessments and assessing client transitions for effective use in client engagement.



SECTION B:

Physical risks

Critical minerals such as cobalt, nickel, and lithium are crucial components of many of the clean energy technologies that are needed to transition to a net-zero economy. However, the metals and mining sector is highly vulnerable to the increasing effects of climate change. As climate-related hazards increase in severity and frequency, companies in the sector are becoming increasingly exposed to the physical risks of a warming world. This potentially creates more significant financial burdens for them. The metals and mining sector is vulnerable to various physical risks, including severe rainfall and flooding, droughts and water scarcity, sea level rise, permafrost thaw, and rising temperatures. This section closely examine each of the key physical risks facing metals and mining companies, and interrogates the impact these are likely to have on their operations, facilities and supply chains.

1. Intensifying storms and flooding

As the global temperature increases, storms are rising in severity and frequency, bringing with them the increased risk of flooding. Flooding can cause disruptions in mining operations and damage mining infrastructure, leading to higher costs for firms and more significant strain on the global supply of metals and minerals. In 2019, intensified storms and flooding were identified as the top two drivers of negative financial impact on global mining operations, accounting for 20% and 13% of this impact, respectively (Figure 16) (CDP, 2019).

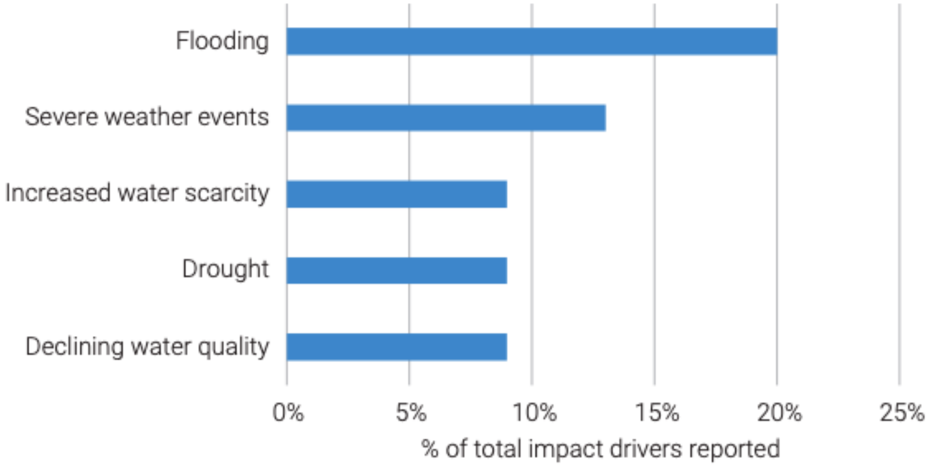


Figure 16: Percentage of financial impact on global mining operations driven by each water-related cause (CDP, 2019)

Recent studies have highlighted six 'wet spots' throughout the globe that are likely to experience an increase of 50–60% in extreme precipitation over the next century. Based on their location, certain mining operations will be more exposed to storm flooding than others. The at-risk areas include northern Australia, South America, and southern Africa during the southern hemisphere summer, and central and western Africa, India, southeast Asia, and Indonesia during the southern hemisphere winter (McKinsey, 2020b).

Extreme storms and flooding can prevent mines from operating, thereby decreasing profits and production. Such impacts have been witnessed in recent years with flooding events across various regions. For example, record levels of rainfall during the first week of March 2023 forced 29Metals, a copper-focused mining company, to cease operations at all five of its underground copper deposits at the Capricorn Copper mine in Queensland, Australia (29Metals, n.d.). The severe storm deposited 1.5 gigalitres of rainwater that destroyed the site's water treatment plant and caused damage to the mine's workshop, warehouse facilities, and reclamation infrastructure (29Metals, n.d.). As a result, two of the deposit sites, Greenstone and Mammoth, were announced to be out of operation until September 2023; a third site, Esperanza South, will remain out of operation until 2024 (29Metals, n.d.).

Similarly, in February 2023, Freeport-McMoran, an American mining company, was forced to shut down its Grasberg copper mine in Indonesia after severe rainfall caused flash flooding and mudslides. Grasberg is the second-largest copper mine and the fifth-largest gold mine in the world, producing 1,567 million pounds of copper and 1,798 thousands ounces of gold in 2022 (FCX, 2022). The February shutdown caused the production output and revenue of the Grasberg mine to decrease. Copper sales fell 8% from the first quarter, down from an estimated 900 million recoverable pounds to 832 million recoverable pounds (FCX, 2023). Gold sales fell 10% over the same period from an estimated 300,000 ounces to 270,000 recoverable ounces (FCX, 2023). At an average realised price of USD 4.11 per pound of copper and USD 1,949 per ounce of gold, the February shutdown cost Freeport-McMoRan an estimated USD 338.5 million (FCX, 2023).

In Germany, meanwhile, severe flooding in 2021 caused USD 32 billion (EUR 30 billion) in total damages and impacted production at mines and metal plants. A copper recycling plant with 400 employees was forced to stop production due to debris from the floods affecting the plant and its road access. Energy company RWE was also forced to stop coal mining for a few days (LiveEO, 2023). This forced the associated Wesiweler power plant to cut power output and remain below full capacity for seven months (LiveEO, 2023).

Figure 17: Satellite imagery of the 2021 German floods (LiveEO, 2023)

In the same year, Florida-based fertiliser producer Mosaic, the largest US potash producer, decided to immediately cut production at its biggest potash mine in Saskatchewan due to flood risk. The K1 and K2 shafts remained closed for nine months, reducing Mosaic's potash production by an estimated 1 million tons. This resulted in a fall in global supply of about 2–3% (Reuters, 2021b). Mosaic was forced to build a third shaft to counter the loss of production at the closed shafts. The construction of this additional shaft, coupled with the expense of bringing the flooded shafts back online, cost the company around USD 105–125 million for two consecutive quarters in 2021 (Reuters, 2021b).

In China, the impact of recent floods has been very considerable. After record-break in rainfall and subsequent flooding in the northeast province of Liaoning, 116 mines had to shut down operations in July 2023. In addition, 5,590 residents were compelled to evacuate (BNN, 2023). A month previously in Chile, meanwhile, similar major rainstorms caused flash flooding in central and southern Chile. This forced the state-owned copper mining company Codelco to halt some operations at its Andina and El Teniente mines (Mining.com, 2023).

Extreme storms and flooding also lead to dangerous working conditions for miners. In April 2022, flooding caused by heavy rainfall at Trevali Mining's Perkoa zinc mine in Burkina Faso led to the death of eight miners. The flooding event caused the mine to suspend operations temporarily. The mine is a major producer of zinc. Its total production of 316.2 million payable pounds in 2021 accounted for around 0.5% of global supply (Mining.com, 2022). The worst recently fatality incident occurred in Brazil. Back in 2019, heavy rains caused a dam run by Brazilian mining corporation Vale to flood. The accident, which occurred in the municipality of Brumadinho, in the state of Minas Gerais, led to the deaths of 270 people. Vale was ordered to pay over USD 7 billion in related liabilities. Its stock price also took a battering, falling by around 25% (Wall Street Journal, 2022).

Furthermore, flood events that force mining operations to temporarily shut down can cause an increase in unemployment for extended periods, for example, forcing workers to relocate frequently and find supplementary work. Workers impacted by flood events could also demand higher compensation in return for the additional risk these pose to their work (McKinsey, 2023). Data from a survey of 15 Canadian mining companies, representing more than 25,000 employees, suggests that mining is the least attractive sector for perspective work. More than two-fifths (42%)of those surveyed said that they "definitely would not" consider working in the metals and mining sector (McKinsey, 2023). Unemployment for extended periods can negatively impact the talent pool for mining engineers from which mining companies can hire (Figure 18). It is notable the number of in mining engineer graduates throughout the United States of America and Australia over the last decade or so (McKinsey, 2023).

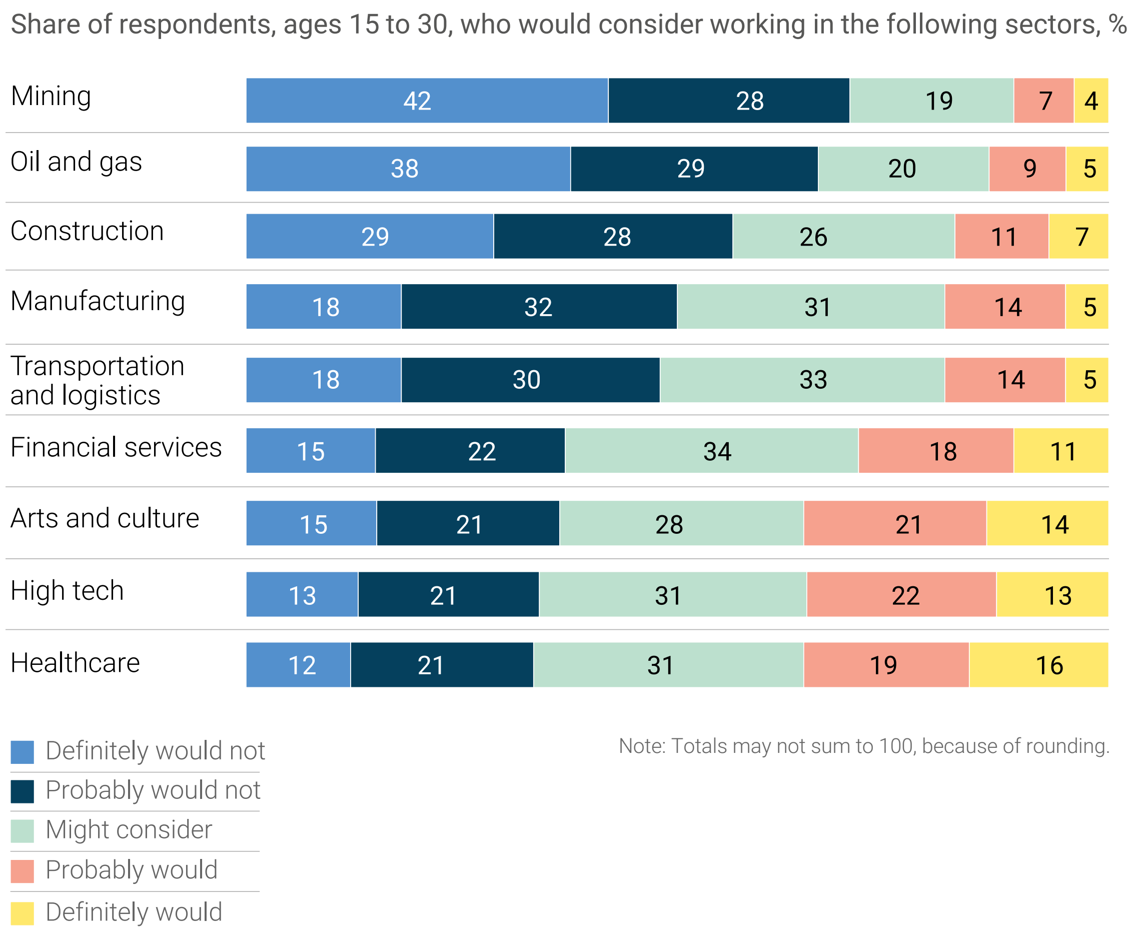


Figure 18: Percentage of respondents considering working in various sectors (Mckinsey, 2023)

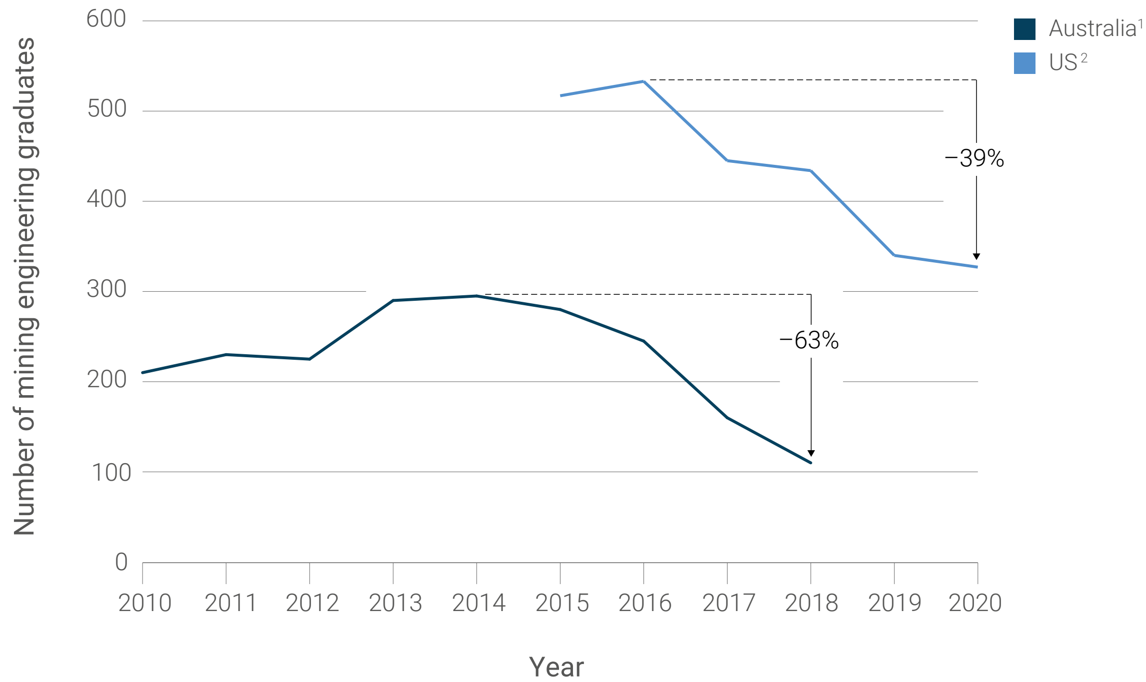


Figure 19: Percent decline in mining engineer graduates from the United States and Australia that joined the metals and mining sector workforce (McKinsey, 2023)

2. Sea-level rise

Rising sea levels due to global warming threaten the metals and mining sector by disrupting port and transportation route operations (UNCTAD, 2021). Sea-level rise can also halt drilling and site expeditions and cause infrastructural failure (WSP Global, 2022). Western Australia, whose economy relies heavily on mining, is experiencing sea-level rise at a rate three times higher than the global average (WSP Global, 2022). If no mitigation action is taken, financial losses to the Australian mining sector could reach an estimated total USD 350 billion by 2070 (Deloitte, 2020).

A number of cities located on the coast in China are facing rising vulnerability to rising sea-level. A study on the economic impact of sea level rise in China estimated that the mining sector could have a decrease in output of 2% in 2050. Under a scenario where the onset sea-level rise occurs with storm surges, output decreases by 10% (Figure 20). Overall, the research estimates that sea-level rise with extreme storm surges could result in a drop in GDP of 11% in the cities of Tianjin and Shanghai by 2050. The province of Jinagsu, meanwhile, could be looking at a decline of 20% (Cui et al., 2018).

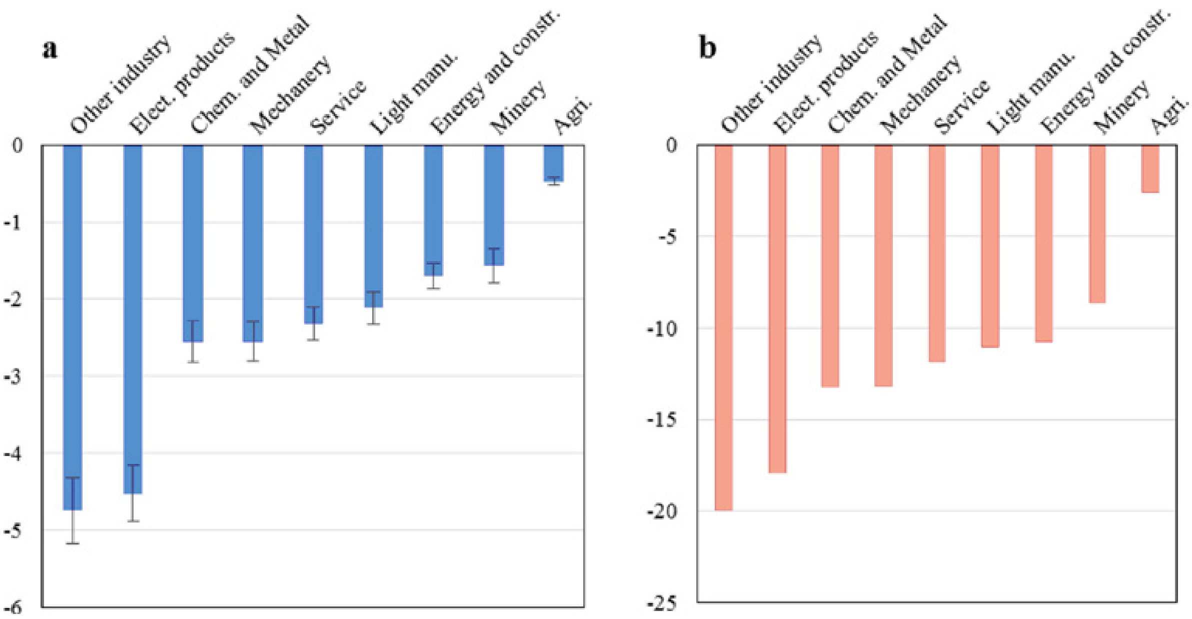


Figure 20: Industrial impacts of SLR in coastal regions of China by percentage of output in 2050 for Scenario S1 (Fig.a) and S2 (Fig.b)[7] (Cui et al., 2018)

7 Climate Scenario 1 (S1, left): Slow onset sea level rise caused by climate change. Climate Scenario 2 (S2, right): Sudden onset storm surges on top of slow onset sea level rise caused by climate change.

Along with threatening operations of firms in the metals and mining sector, supply chains and transportation of commodities will become increasingly exposed to worsening sea-levels. Rising sea-levels will negatively impact firms in the sector that rely on the global shipping industry to deliver mineral products, vital equipment, and supplies worldwide. Climate change-related damages to port infrastructure, coupled with economic losses due to storm-related port closures, could cost the global shipping industry up to USD 25 billion annually by 2100 (Environmental Defense Fund, 2022). As the shipping industry faces increased costs, it is possible that these costs are passed down to client companies, including metals and mining firms. Furthermore, climate change impacts, including sea-level rise, could reduce global trade growth by up to 10% by 2100, highly impacting countries reliant on mining exports (Government of Canada, 2023). In Canada, for example, the transportation of unprocessed ore and other mining material accounts for over half of the country's rail-freight tonnage per year (Government of Canada, 2023). Chile is also a large exporter of metals and miners. In 2021, it exported USD 29.7 billion of copper ore, more than any other country in the world (OEC, 2021). Its major importers included China (USD 20 billion), Japan (USD 4.45 billion), South Korea (USD 1.03 billion), India (USD 888 million), and Spain (USD 608 million) (OEC, 2021). Due to the uncertainty of climate change, it is hard to determine the exact financial implication of sea-level rise on individual metals and mining firms. It is likely that a major increase in the production of rare earth elements (REE) and critical metals will force the sector to depend more on shipping; this at a time when sea level rise threatens to disrupt global supply chains. This creates potential financial burdens for the metals and mining sector as companies may have to reroute their products or even, store large quantities of ore and other minerals for a period of time.

3. Water-related issues (droughts and water scarcity)

The metals and mining sector is heavily reliant on water for various essential procedures, such as mineral processing, dust control, the transportation and storage of slurry, extraction processes, and general site usage. Mining operators typically obtain water from groundwater sources, streams, rivers, lakes, or commercial water service providers in order to meet their vast water needs. In Brazil, 1.6% of the total water withdrawn in the country goes towards mining, equivalent to supplying water to 30 million people (Moura et al., 2022). In 2015, the metals and mining sector in the United States withdrew about 5.3 billion gallons of water per day, accounting for 1% of total water withdrawals across all sectors (US Geological Survey, 2019). Water use in the metals and mining sector has long been a source of conflict in countries. A study on water conflicts in Brazil by the Pastoral Land Commission, for example, found that 124 out of the 197 conflicts studied originated in areas with substantial mining activity (The Extractive Industries and Society, 2022).

As a water-intensive sector, extreme water stress due to rising temperatures poses a significant threat to mining companies in water-scarce regions. Water shortages can halt business operations (Figure 21) and increase financial losses. The impacts of water stress are already being felt today. For example, 30–50% of copper, gold, iron ore, and zinc production is concentrated in areas with high water stress (McKinsey, 2020a). The sector suffered over USD 20 billion in water-related financial impacts in 2018 alone (WWF, 2020). In a survey by CDP, 44% of respondents, 54 of the world's largest listed mining companies (with a total market capitalisation of USD 1.04 trillion) reported suffering water-related financial losses between 2014 and 2019, amounting to USD 11.8 billion. The risk of losses is also an additional constant. For the year 2018, 91% reported some form of risk from water-related stress. The total value of these risks amounted to USD 24.9 billion equivalent to around 6% of the surveyed companies' market capitalisation (CDP, 2019). By 2030, it is estimated that more than a quarter of mining production globally, worth USD 50 billion in revenue, will become exposed to significant water stress (CDP, 2017).

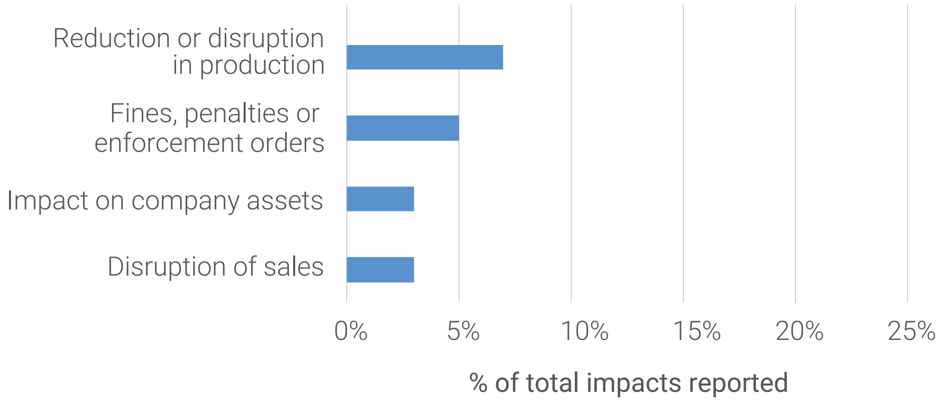


Figure 21: Top reported financial impacts of water security (CDP, 2019)

Table 4 highlights the overall water-related risks for various metals and minerals. All commodities included in the analysis face water-related risk to a certain extent. The extent of these risks depends in large part on the volume of water needed during the respective mining processes. In regard to water scarcity, the most vulnerable mineral or metal is chromite, which is commonly used in steel manufacturing. This is followed by palladium, platinum and potash. The analysis combined data from 3,174 active mines (WWF, 2020).

Table 4: Overview of water-related risks for metals and minerals, including water scarcity (WWF, 2020)

Commodities ▼	Number of Mine Sites	Overall Water Risk	Physical Water Risk	Regu-latory Water Risk	Repu-tational Water Risk	RC1 Water Scarcity	RC2 Flooding	RC3 Water Quality Status	RC4 Ecosystem Service Degrada-tion
Chromite	43	3.3	3.4	2.2	2.8	3.1	3.2	3.4	3.0
Coal	1270	3.3	3.0	2.3	3.7	2.2	3.5	3.5	3.2
Palladium	39	3.2	3.3	2.2	3.0	2.8	3.2	3.5	3.1
Platinum	44	3.2	3.2	2.1	3.1	2.7	3.2	3.5	3.0
Bauxite	55	3.2	3.0	2.5	3.5	2.3	3.4	3.1	3.0
Lead	303	3.2	3.0	2.4	3.5	2.4	3.4	3.2	2.8
Averages	**3174**	**3.1**	**3.0**	**2.4**	**3.5**	**2.3**	**3.2**	**3.2**	**2.9**
Zinc	350	3.1	3.0	2.4	3.4	2.3	3.3	3.2	2.8
Antimony	22	3.1	2.9	2.4	3.3	2.0	3.8	3.1	3.1
Copper	405	3.1	2.9	2.5	3.1	2.5	3.1	2.9	2.7
Iron Ore	229	3.1	2.8	2.3	3.5	2.3	3.1	2.9	2.7
Silver	494	3.0	2.9	2.5	3.2	2.5	3.1	2.9	2.7
Potash	28	3.0	3.0	2.0	3.2	2.6	2.8	2.9	3.0
Gold	708	3.0	2.9	2.4	3.2	2.5	2.9	2.8	2.7
Lithium	16	3.0	2.8	2.2	3.6	2.5	2.8	2.4	2.5
Vanadium	15	3.0	2.8	2.3	3.4	2.1	3.0	3.3	2.8
Nickel	94	2.9	2.7	2.3	3.2	2.3	3.0	2.7	2.5
Cobalt	72	2.9	2.6	2.5	3.2	2.2	2.9	2.6	2.7
Diamonds	49	2.8	2.5	2.7	2.9	2.4	2.3	2.4	2.2
Titanium	15	2.7	2.5	1.9	3.3	2.1	2.7	2.6	2.6

1 low risk ▬ 5 high risk

In 2017, mining sites for copper, gold, iron ore, and zinc in water-stressed areas accounted for roughly USD 150 billion in total annual revenues. These mining sites concentrated in Central Asia, the Chilean coast, eastern Australia, the Middle East, southern Africa, western Australia and western North America (Figure 22) (McKinsey, 2020b). As the impacts of climate change worsen, these regions are expected to face greater water scarcity (Figure 22). For example, 7% of zinc production could shift its exposure from medium-high water stress to high water stress. Similarly, 6% of copper production could shift from high to extremely high water stress. Even a small change in water availability could significantly impact a mine's operations and profits (McKinsey, 2020b). More than half of current lithium and copper production, for example, is concentrated in areas with high water stress levels (IEA, 2021b). In Chile, 80% of copper production is already located in extremely water-scarce areas; by 2040, this is expected to be 100%. Two-fifths (40%) of Russia's iron ore production is expected to shift from high water-stress to extreme water stress by 2040 (McKinsey, 2020b). A global study of 1,400 mines found that approximately one-fifth of the sites were located in areas where water consumption already exceeds 80% of the available total water available (S&P Global, 2020). Assuming no additional climate action occurs, 27% of these mines will see their exposure to water risk increase by 2030, with water risk expected to double for a third of gold and copper mines (S&P Global, 2020).

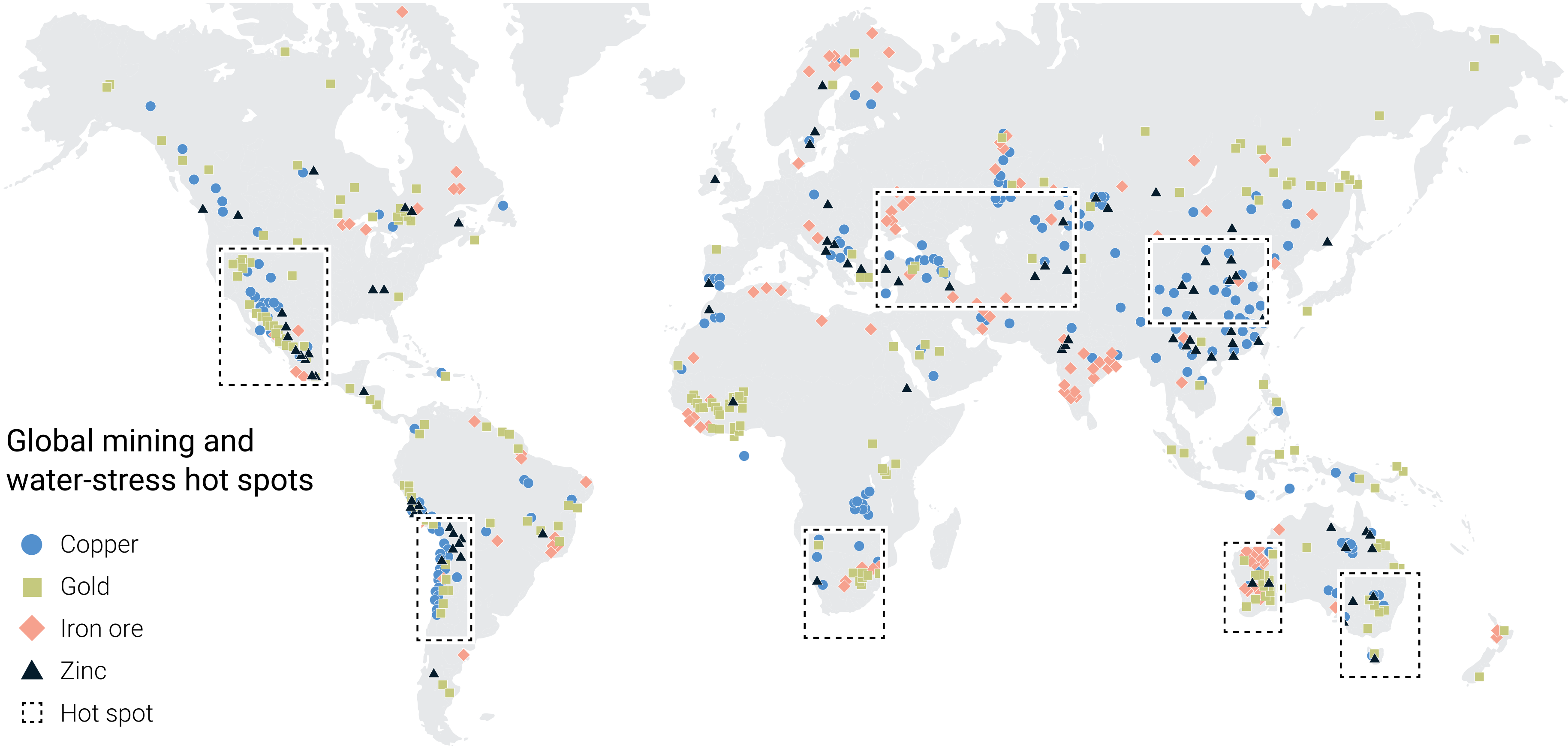


Figure 22: Global mining sites in water-stressed regions (McKinsey, 2020b; WRI, 2021)

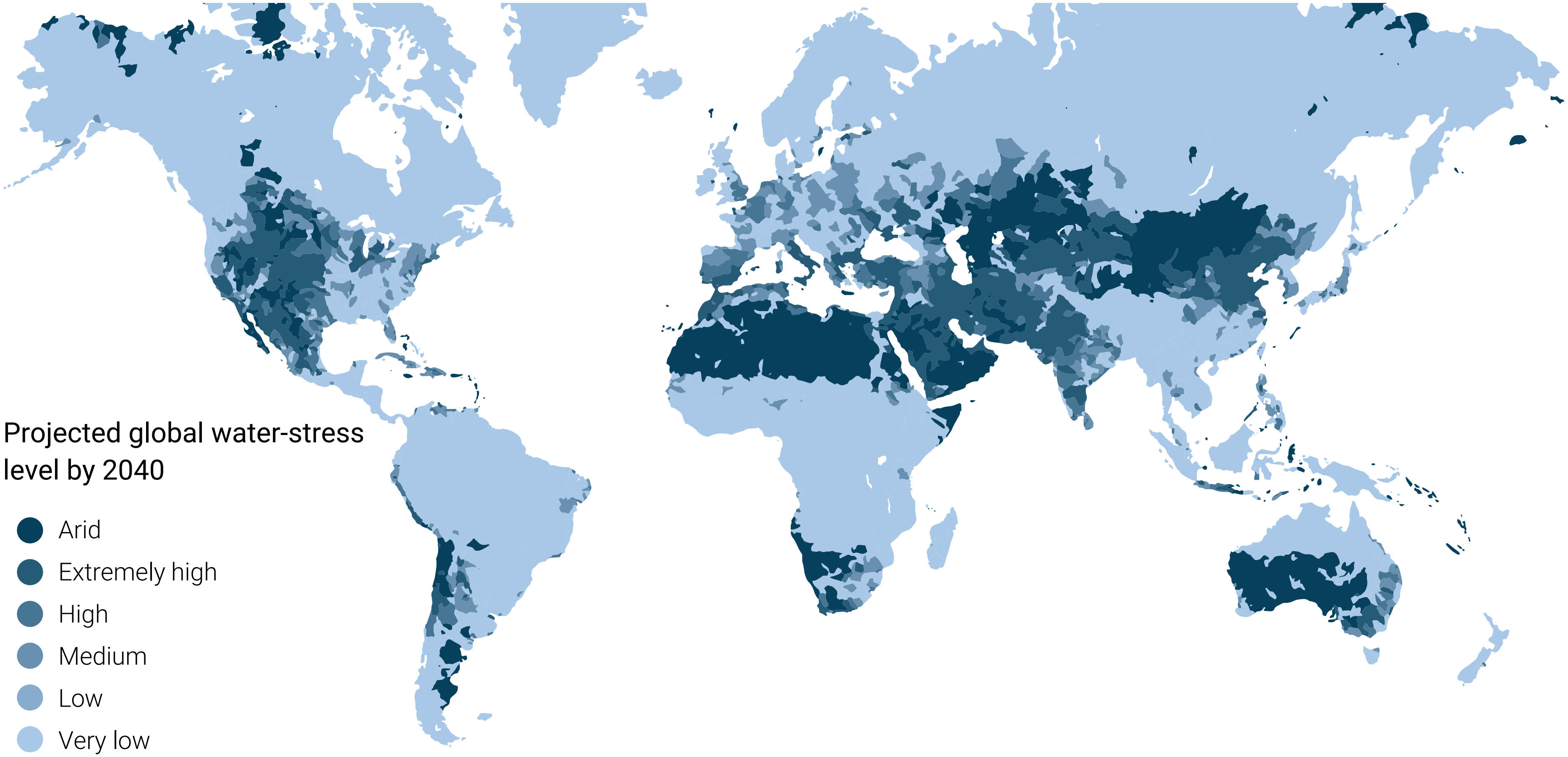


Figure 23: Projected global water stress levels in key mining regions by 2040 (McKinsey, 2020a)

As droughts and water stress increase in severity and frequency, reduced production for mining companies can lead to substantial financial losses. For example, Barrick Gold Corporation, the world's largest gold producer, experiences a 5% risk annually that a major drought event could reduce the value of the company by 35%. If each drought event reduces gold production by 10%, Barrick could face a 5% risk of a USD 1 billion loss in production value (Bonnafous and Siegel, 2017). Similarly, gold company Newmont Mining Corporation faces a 5% risk annually of losing USD 63 million due to drought events (EOS, 2017). In 2018, a German potash miner was forced to close mines in two locations due to severe water shortages, resulting in a loss of about USD 2 million per day at each site (Forbes, 2022). Drought conditions in Brazil prompted Leagold Mining to shut down its RDM gold mine for two months at the end of 2018 accumulating losses estimated at USD 5 million per month (S&P Global, 2018).

Droughts are not always the result of short-term water shortages. Some regions in central and northern Chile have experienced a decade-long drop in rainfall. As a result, Anglo American's Los Bronces mine in the centre of the country experienced a 17% reduction in production during the first quarter of 2022 (Reuters, 2022b). Antofagasta Minerals also reported a 24% first-quarter reduction in its first-quarter production at its Los Pelambres mine in Chile (Reuters, 2022b). The country's severe drought conditions has caused a 10.4% reduction in copper output during 2022, leading to a predicted increase in net cash costs of 4 cents per pound of copper from USD 1.61/lb in 2022 to USD 1.65/lb in 2023 (Reuters, 2023d). With copper demand expected to rise from 25 million metric tonnes (MMt) today to 50 MMt by 2035, the kind of drought events that caused Antofagasta's decline in supply threaten to cause a global shortage of copper. This will put increasing upward pressure on commodities prices (World Bank, 2020; S&P Global, 2022b).

A recent study by environmental group WWF clearly demonstrates the potential impact of water scarcity on various mining companies (Table 5). According to the study, major mining companies like Grupo Mexico, Freeport-McMoRan and Barrick Gold are among those at risk of very high overall water risks. Indeed, WWF calculates that six of the ten largest publicly listed mining companies could face higher than average physical water risks at their current projects. Grupo Mexico ranks as the most exposed public mining company in terms of water scarcity, with a 3.7 (out of a maximum of 5). This puts it a full higher than the group average of 2.3. Freeport-McMoRan and Barrick Gold could also face increased risk from water scarcity.[8] In comparison, BHP Billiton and Rio Tinto, the two top mining firms, rank lower for water scarcity risk. That said, both companies are judged to have higher-than-average reputational water risks due to their assets being located in countries with stronger regulations and greater water scrutiny (WWF, 2020).

8 Data may be partially skewed due to smaller sample sizes for certain companies; for example, the ranking of Barrick Gold and Grupo Mexico is based on an analysis of only six and eight mines, respectively, compared to 151 for Coal India and 50 for Glencore International (WWF, 2020)

Table 5: World's largest publicly listed mining companies categorised and scored by water risks (WWF, 2020)

Commodities	Number of Mine Sites	Overall Water Risk	Physical Water Risk	Regulatory Water Risk	Reputational Water Risk	RC1 Water Scarcity	RC2 Flooding	RC3 Water Quality Status	RC4 Ecosystem Service Degradation
Coal India	151	3.8	3.4	2.9	4.5	2.5	4.1	3.9	3.2
Grupo Mexico (Southern Copper)	8	3.6	3.7	2.6	3.0	3.7	2.7	3.8	2.9
China Shenhua Energy	7	3.5	3.4	2.4	3.8	2.7	3.3	4.1	3.0
Freeport-McMoRan	8	3.3	3.0	2.7	3.5	3.1	2.1	2.5	3.0
Anglo American	19	3.2	3.2	1.9	3.6	2.8	3.4	2.9	3.1
Glencore International	50	3.2	3.2	2.1	3.3	2.7	3.4	3.2	2.9
BHP Group	21	3.0	2.9	1.7	3.7	2.9	3.3	1.8	2.2
Barrick Gold	6	3.0	2.8	2.3	3.4	3.1	2.0	1.8	2.7
Rio Tinto	18	2.7	2.3	1.9	3.8	2.3	2.9	1.4	1.6
Norilsk Nickel	4	2.0	1.7	1.9	2.7	1.4	1.8	1.8	2.3
Averages	**3174**	**3.1**	**3.0**	**2.4**	**3.5**	**2.3**	**3.2**	**3.2**	**2.9**

1 low risk — 5 high risk

Falling ore grades, coupled with a rapid rise in demand for critical metals and minerals, are pushing mining projects to expand into remote areas (ADL, 2023). This makes it harder for them to obtain a consistent water supply without creating a disruption for local industry and communities. In response, some companies are investing in water desalination to secure water supplies for their operations. This is the case in Chile, where companies have been investing in such infrastructure for a decade or more. Research shows that forward investment in desalination infrastructure by mining giants Rio Tinto and BHP Billiton helped to prevent interruptions in their Chilean projects that would have otherwise occurred due to drought and water scarcity (AGU, 2017). This is highlighted by the experience of Anglo American Sur in central Chile, where the company chose not to invest in desalination. As a result, Los Bronces copper mine faced more frequent interruptions (AGU, 2017). The Tia Maria mine in Peru also faced operation interruptions due to water shortages after the operator elected to rely on local surface and groundwater instead of expensive upfront capital investment in desalination and pumping infrastructure (AGU, 2017). Companies in the sector that are quick to invest and adapt their practices to growing water stress are likely to face lower disruptions than companies that do not adapt.

Case Study 5: Severe droughts in Chile impact the world's leading copper producer

Chile is the world's leading copper producer. In 2017, the mining sector was responsible for 11.2% of the country's GDP and 51.6% of its total exports. In the same year, Chile accounted for about 27.5% of the global copper production. Estimates suggest that 20.5% of global copper reserves are found in Chile (Fine Print, 2019). However, the country has been devastated by a decade-long drought, which has been exacerbated by climate change (Mining.com, 2021).

Copper mines in Chile are located mainly in the Andean mountain range, a habitually dry region where water is scarce (Fine Print, 2019). The Coquimbo region, which hosts several copper mines, has observed rainfall decrease of about 30% over the last 20 years (Mining.com, 2021). Severe droughts have led to additional water stress and caused miners to rethink their copper production targets and operations.

The problem is long-standing. As far back as 2015, for example, droughts were severely hampering copper production in the country. Extremely dry conditions caused production levels to fall due to water restrictions. Copper production decreased by 10% due to water shortages at the Los Bronces mine of Anglo American, the world's sixth largest copper producer (Anglo American, 2015). Similar, impacts were reported in the second half of 2014. Copper output dropped by 2% at BHP Billiton's Escondida mine, for example, the largest such facility of its kind in the world (Reuters, 2015).

Such incidences have only grown worse as drought conditions have continued. In 2021, for example, miners were forced to cut their copper production target. The Chilean miner Antofagasta announced that its annual production of copper for that year would be between 710,000–740,000 tonnes, a drop of 20,000 tonnes on the initial amount forecast (Mining.com, 2021).

Along with droughts, rising demand for agriculture exports also increases the strain on Chilean water reserves (Bloomberg, 2022). The resulting water shortages have caused long-running tension between mining companies and farmers as they compete for water supplies (Reuters, 2015). In recent years, there have even been calls to amend the national constitution to include legal guarantees that water supplies will be safeguarded human consumption (Bloomberg, 2022).

An increasing number of Chilean miners are switching to seawater desalination and other expensive alternatives in order to meet water needs. Cochilco, Chile's government-run copper commission, estimates that the use of direct or desalinated seawater by mining companies will rise by about 167% by 2032. In comparison, freshwater use for mining will decrease by 45% (Bloomberg, 2022). Along with costs, seawater desalination brings with it other obstacles. For example, Antofagasta stated that the redesigning of a desalination plant at its Los Pelambres mine could be delayed, which would put at risk 50000 tonnes of copper production (Mining.com, 2021).

Case study 6: Water stress-related risk

Hecla Mining Company Annual Report 2022

American mining company for primary silver production

Physical risks related to water stress
Climate change is expected to create more extreme weather patterns that can increase the frequency of droughts and increase the amount of rainfall, circumstances that require careful water management. Potential key material physical risks to Hecla from climate change related to water management include, but are not limited to:

- Increased volumes of mine contact water requiring storage and treatment;
- Increased design requirements for stormwater diversion and associated water management systems;
- Reduced freshwater availability due to potential drought conditions;
- Damage to roads and other infrastructure at our sites due to extreme weather events, including intense rainfalls and related events such as landslides; and
- Unpermitted or otherwise non-compliant discharge of wastewater due to an increased frequency of extreme weather events exceeding the design capacity of existing tailings storage facilities and other stormwater management infrastructure

Such events can temporarily slow or halt operations due to physical damage to assets, reduced worker productivity for safety protocols on-site related to extreme weather events, worker aviation and bus transport to or from the site, and local or global supply route disruptions that may limit transport of essential materials and supplies. Additional financial impacts could include increased capital or operating costs to increase water storage and treatment capacity, obtain or develop maintenance and monitoring technologies, increase resiliency of facilities and establish supplier climate resiliency and contingency plans. The occurrence of weather and climate events have in the past and could in the future cause us to incur unplanned costs, which may be material, to address or prevent resulting damage.

Water Management Plan (Hecla, n.d.)

During all phases of the mine life cycle, our operations have controls in place to protect water resources, and we conduct extensive and ongoing assessments that inform decision making. Our water stewardship practices include reducing freshwater use where possible, using water efficiently including recycling and reuse, maintaining water quality, managing water discharge, and engaging with our communities to collaboratively manage shared water resources. Each site has a comprehensive water management plan tailored to that site, considering variations for water sources, levels of precipitation, and operational changes.

4. Shifting permafrost

As global temperatures rise, metals and mining operations at higher altitudes grow increasingly vulnerable to thawing permafrost. Thawing permafrost can expose human and wildlife populations to toxic waste from mining operations. In addition, it can cause water management problems for the mines operating in the area (Booshehrian et al., 2020).

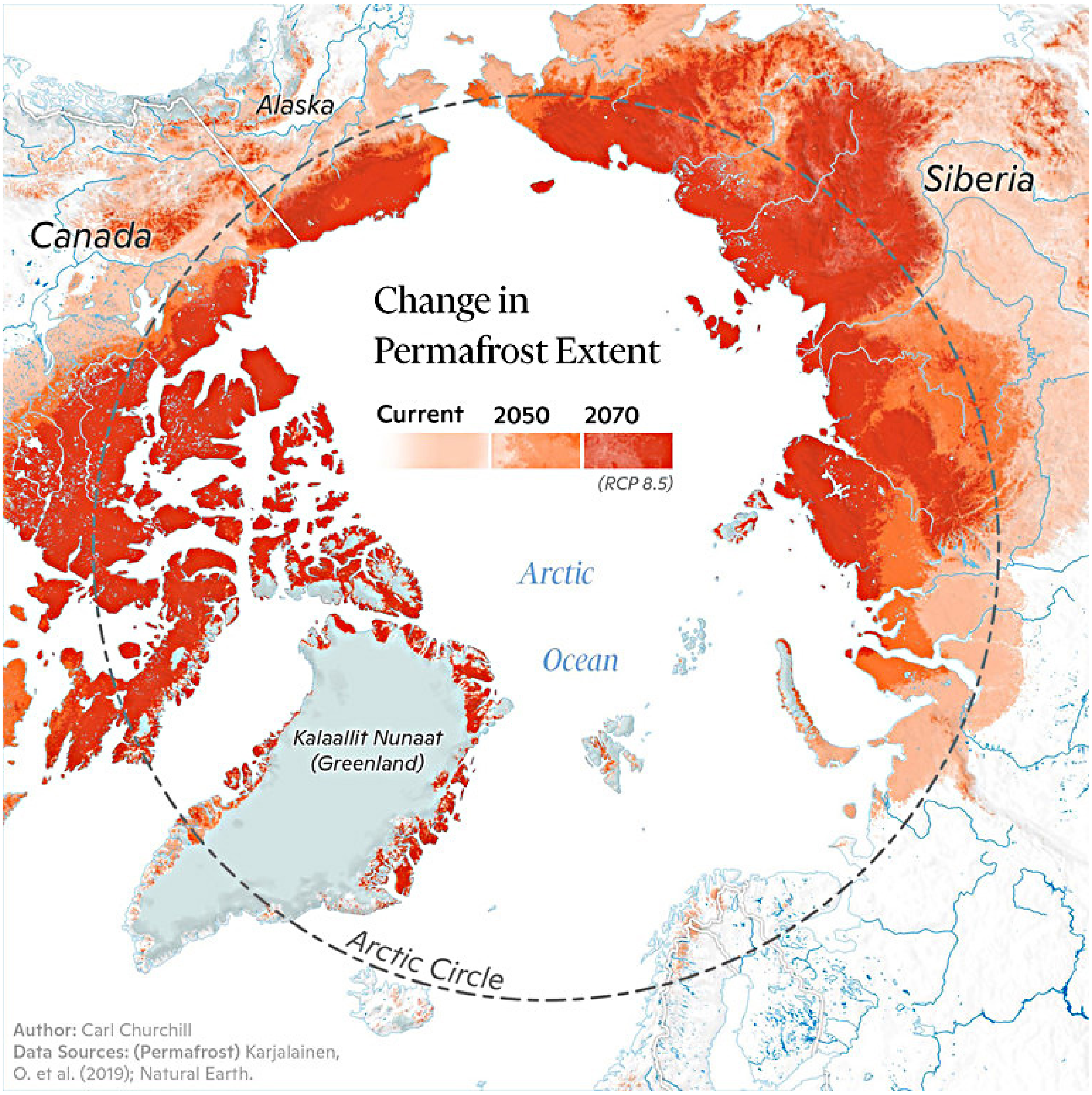


Figure 24: Projected permafrost coverage loss up until 2070 (UN, 2022)

Shifting permafrost reduces land stability and increases the likelihood of avalanches. Between 2015 and 2017, two avalanches in the mining town of Longyearbyen, Norway, decimated homes and caused many casualties. The town is susceptible to thawing permafrost, causing grounds to shift and building foundations to tilt. The town used to be dependent on coal mining, but mining was largely discontinued after 2022. The experience of Longyearbyen serves as a warning for other mining towns in the Arctic region. Towns in northern Russia are especially vulnerable. Two thirds of the country, which ranks as the third largest mining producer in the world, sits on permafrost (NPR, 2022). According to The Global Observatory, thawing permafrost threatens around USD 250 billion worth of physical infrastructure in Russia (The Global Observatory, 2021).

Permafrost thawing is already causing costly damages to Arctic mining companies. In 2019, Teck Resources, which operates the Red Dog zinc mine in northwestern Alaska, stated that thawing permafrost obliged the company to spend nearly USD 20 million to manage its water storage and discharge. This is because the melting permafrost within the mine's watershed released higher than natural levels of dissolved minerals and other particles into local streams (Figure 25). As a result, Teck Resource as restricted in how much treated water could be discharged from the mine into a nearby creek (CBC, 2020).

Figure 25: Flooding due to permafrost thaw at the Red Dog mine in Alaska (Alaska Public, 2020)

In 2021, Russian mining company Norilsk Nickel, the world's leading producer of palladium, was forced to suspend operations at its Oktyabrsky and Taimyrsky mines in Siberia mines due to flooding caused by thawing permafrost (Reuters, 2021c). The two mines in question account for 36% of the total ore mined by the company in Russia. At the time, projections suggested that nickel, copper, palladium, and platinum output would drop by 15–20%, resulting in a loss of earnings of around USD 1 billion. The company's shares decreased by 6.5% (Bloomberg, 2021; Mining.com, 2021). Current data shows that production of the above metals (three of which are key to the energy transition) reduced by 7% due to the temporary shutdown, falling to 81 tones at the two mines (Norislk Nickel, 2021). As permafrost thaws, mining waste is released into the environment, causing further capital costs to the companies responsible for this waste (Mining.com, 2021).

It is estimated that 300 to 600 MMt of net carbon will be released into the atmosphere annually as Arctic warming causes the thawing of permafrost (University of Colorado Boulder, 2022). As greater permafrost thaw occurs, more carbon will be released into the atmosphere, speeding up climate change and causing a more significant negative impact on the metals and mining sector. This negative feedback loop comprises an ongoing financial risk for the mining industry.

5. Rising temperatures and heat stress

High temperatures pose numerous risks for the metals and mining sector. Notable among these are an increase in hazardous working conditions, a greater incidence of wildfires, and an elevated risk of damage to mining infrastructure and transportation networks.

Rising global temperatures carries with it a major risk to the health and safety of those employed in mining, making it an even more dangerous occupation than it already is. Research on heat-related illnesses in Australia, for example, found that 79 of the 91 surface mine workers surveyed had experienced heat stress-related symptom over the previous year. Their symptoms included fatigue, headache and high body temperatures (Meshi et al., 2018). Heat stress occurs when the body cannot maintain thermoregulation between 36.2–37.7°C (Maurya et al., 2015). This is a particular problem for countries in climate-hit regions where mining is a major source of employment. Tanzania is a case in point. The fourth-largest gold miner in Africa, mining is responsible for 0.5% of the country's total employment. A 2018 research study found that the mean core body temperature of the majority of Tanzania's open-cut miners was above the threshold of 38°C for safety. This problem is expected to rise as global warming worsens, the study concluded (Meshi et al., 2018).

In addition to the negative effects on human health, heat stress and a dangerous working environment also reduce the efficiency of underground mine workers (Maurya et al., 2015). Studies show that excessive heat during work creates significant occupational health hazards as it restricts a worker's physical capabilities and functions, thereby reducing their work capacity, and productivity. Temperatures of 33–34°C can impact a worker operating at moderate physical intensity by reducing their work capacity by 50% (ILO, 2019). By 2030, heat stress is projected to reduce total working hours globally by 2.2% and decrease global GDP by USD 2.4 trillion (ILO, 2019). The metals and mining sector is already facing a shortage of skilled labour, but the growing problem of level of heat stress could cause it to become severely understaffed as mining employees become less willing to work in the sector.

Higher temperatures also heighten the conditions that cause wildfires. Warmer and drier weather is likely to result in longer and more active fire seasons (NOAA, 2022). Projections show for the western United States that an average annual increase of 1°C in temperature could increase the median burned area by up to 600% in some forests (NOAA, 2022). As wildfires spread, they can affect transport networks on which mines depend. In addition to causing significant infrastructure damage, such fires can potentially create fatal scenarios for workers. In 2023, for example, wildfires scorched 11 million hectares across Canada alone (Figure 26) (GZERO, 2023; CBS, 2023). This unprecedented fire season (which exceeded yearly averages by almost ten times) disrupted mining projects throughout the country with the most significant impact being felt by Quebec, Canada's major mining hub. In June 2023, 15 mining companies throughout the province were forced to suspend operations due to the fast-spreading wildfires (CWFIS_2023). This is not a one-off, either. Back in 2017, two prominent mines in British Columbia had to close after a sweltering, dry summer brought about high rates of forest fires (Mining.com, 2017). During July of that year, the temperature average reached 23°C, which is 3°C higher than the ten-year average for the province (CurrentResults, 2017). Imperial Metals, one of the mines impacted by the 2017 dry season, was also forced to close down several roads used to access its Mount Polley copper-gold mine as a precautionary measure. Imperial Metals reported that the proximity of forest fires also obliged it to evacuate some employees, though the mine continued operations at a reduced capacity for a while, before it was forced to cease operations altogether as the wildfires encroached closer and became an imminent danger (Mining.com, 2017).

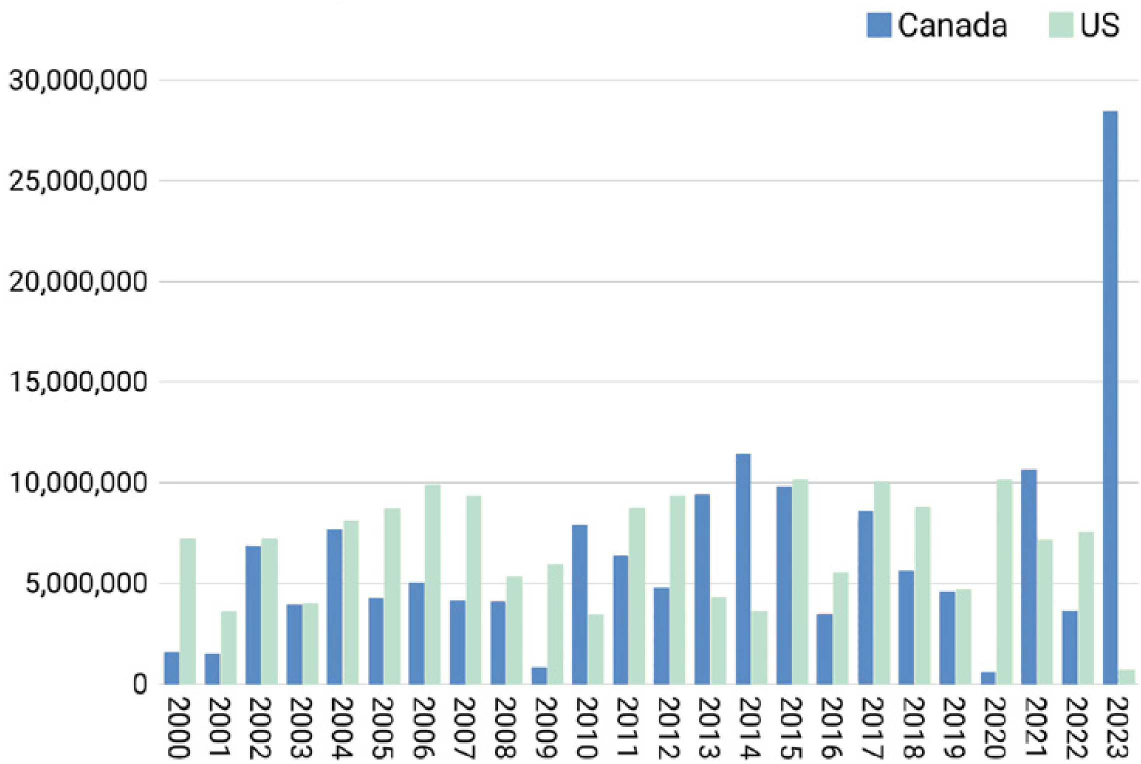


Figure 26: Area of land burned by forest fires in Canada and the United States from 2000 to 2023 (GZERO, 2023)

In the Arctic, the network of ice roads is crucial for stockpiling materials for mining (BSR, n.d). Warmer temperatures, combined with permafrost thaw (as discussed above), make the availability and safety of these roads insecure. They also threaten the integrity of roads, bridges, pipelines, and airstrips used in mining (BSR, n.d). Rising temperatures and the heightened occurrence of wildfires can disrupt critical transportation routes for mines, causing delays in the delivery of raw materials for operations and finished products. This disruption can also contribute to increased costs for firms.

Case study 7: Temperature rise risk

Harmony Gold Mining TCFD Report 2022

South African gold mining company

Climate-related material themes
Climate change is the most serious environmental risk confronting our business. We are susceptible to extreme weather events such as increasing temperatures that could affect underground ambient temperatures, often resulting in land degradation and other environmental risks. Climate-related risks will affect our future operating costs, infrastructure requirements, operations and operating conditions, host communities and supply chain.

Environmental management and stewardship
Our environmental management and stewardship policy, outlined in Harmony's sustainable development framework, guides us in fulfilling our commitments to:

- Prevent pollution wherever we operate or minimise, mitigate and remediate our harmful impacts on the environment
- Comply with host country environmental laws and regulations
- Promote active partnerships with governments, communities, labour and NGOs for environmental protection and conservation
- Continually improve environmental management systems with:
- Targets that promote efficient use of resources and reduce environmental exposure
- Progress reporting to internal and external stakeholders
- Responsible management of hazardous substances
- Contribute to biodiversity protection and consider ecological values and land use aspects in investment, operational and closure activities
- Engage in transparent dialogue about environmental matters with our communities
- Disclose our environmental KPIs through GRI assurance processes.

6. Physical risk guidance

This section offers guidance on how financial institutions can address physical risks within the sector and support their clients in the process.

Key physical risk questions for financial institutions to consider

1. Gathering information
   - What are the most prevalent physical risks across our portfolio footprint?
   - What have our clients disclosed in their financial, sustainability, and climate reports regarding their physical risks?
   - How many of our clients have business resiliency plans or a climate change risk assessment in place?
   - Do we have locational data on the major assets of our clients? Where are we lacking location data for the major assets of our clients?
2. Assessing the risks
   - How much of our portfolio operates in areas of high physical risk?
   - What does our exposure to higher-risk clients look like? What are the terms of our financial relationship (e.g. debt/equity, tenor)?
   - Have we looked at physical risk scenarios to see how these risks will evolve over time across the portfolio? Have we considered short-term, medium-term, and long-term risks?
   - How would physical hazards disrupt our clients' production and distribution activities?
   - How long might disruption last for the client? What might be the potential loss in revenue?
   - What indirect damages[9] might result from physical hazards (e.g. business disruption, changes in value of assets) for individual clients?
   - How might insurance markets (and insurability) change in the face of worsening physical risks? What proportion of our clients are covered? Which hazards are covered? Is uninsurability a risk in areas of more frequent physical hazards?
   - Have we explored if local adaptation measures are being taken by individual clients and, if so, how they will increase the resilience of assets to climate change?
   - Are water availability issues a concern for the client's operations? If they are, do

9 Indirect damages can result from tangible damages caused by a physical risk. An example of this is business disruption caused by the physical damage to a business's property or facilities.

the client's plans consider the water needs of the local populations?
- Has the client evaluated the probability of potential conflicts with local communities and security forces in the areas of operation due to an increase in the frequency and severity of extreme weather conditions?
- How much are clients investing in adaptation and resiliency measures?
- Have we considered the potential environmental and social risks that might emerge from changes in the value chain as a result of physical hazards?

3. Engaging with clients and updating strategy

- Do our senior leaders understand the physical risks of our clients?
- How are we helping our clients to transition to more resilient infrastructure, equipment, and other assets?
- How will the physical risks identified and assessed influence our strategy in the metals and mining sector?
- What specific updates to risk management practices or business activities will be needed to appropriately consider these physical risks in our operations?
- What health and safety measures does the client have in place, and do these measures account for extreme weather conditions?

Recommendations for risk management

1. Conduct geolocated asset-level analysis

Metals and mineral operations are extremely vulnerable to physical hazards, such as flooding and water scarcity. Many of these assets are worth billions of dollars. Disruptions in operations as a result of physical hazards can generate significant costs for firms, even if these disruptions are only temporary. In turn, this can add pressure on global supplies of metals and minerals, and as a consequence, cause commodity prices to rise. Rising costs is especially a concern for the sector as it seeks to shift to a low-carbon economy and decarbonize its operations. Therefore, financial institutions need to have an in-depth understanding of the major capital assets of their metals and mining clients as well as clarity on where they are located. Financial institutions should also be cognisant of the hazards to which these assets are exposed. These hazards could derive from either the type or location of the particular metal being mined, the nature of the company in question's insurance coverage and any mitigating or exacerbating risk factors. Financial institutions or their clients should conduct periodic analysis of the assets so as to be aware of the magnitude of the risks that these assets face and how the level of these risks change over time.

2. Review clients' resiliency plans

Many firms in the metals and mining sector have acknowledged the negative financial impact of physical risks, as shown in the disclosure examples above. Some firms have also begun disclosing business continuity planning and actions to improve resiliency. For financial institutions, information about the resiliency and adaptive capacity of its clients is crucial. As a first step, financial institutions should review its clients' annual reports and climate-related financial disclosures to gain information on physical risks and resilience. Financial institutions should also request further information on the adaptation measures being undertaken by the client for the major assets. These plans can be compared with national adaptation plans (NAPs) issued by governments as well as with other suggested resiliency measures (such as those within the IPCC AR 6 WG 2 report). Adaptation should be implemented having in mind both the concepts of "leaving no one behind (LNOB)" and "do no significant harm (DNSH).", therefore it is crucial to see if these plans consider the possibility of maladaptation, meaning that the adaption measures for the mining would lead to an increase in aggregate climate risks of neighboring communities (UNEP FI, 2023a).

Adaptive and mitigation actions clients can take

1. **Resiliency planning**
As global temperatures rise and the impacts of climate change worsen, the infrastructure of mining facilities face increasing risk from physical hazards. Firms can develop resiliency and adaptation plans for their most important mining sites. These plans can begin with an assessment of current climate risks and asset vulnerabilities. They should also explore different climate scenarios that focus on how these climate risks may evolve over time as physical hazards potentially increase in severity and frequency. As part of their resiliency planning, clients should create procedures for business units to respond to potential disruptions in downstream consumption. Clients of the metals and mining sector can focus on strengthening adaptation measures through synergies with other environmental issues, such as flooding, water stress, air quality and biodiversity conservation, at the same time they should make sure that such measures do not increase in aggregate climate risks of neighboring communities

2. **Climate-ready infrastructure**
Given the high costs of operating a mine, firms in the sector should invest in climate-ready infrastructure to ensure that their mining facilities are resilient to worsening climate hazards. For new mines this will need to take place during the planning process. It can be achieved by enacting standards that are appropriate for today's conditions as well as for potential future tail-risk events. For existing mining infrastructure, clients need to consider climate defences such as sea walls. The most effective of these investments may be those that also offer environmental and social co-benefits. Examples of projects that build resiliency while also supporting nature include the restoration of mangrove forests and wetlands and that also consider affected communities.

Additional guidance

- The Equator Principle's guidance note on Climate Change Risk Assessment provides detailed information on physical risk assessment.
- The note by the Network for Greening the Financial System, titled 'Physical Climate Risk Assessment: Practical Lessons for the Development of Climate Scenarios with Extreme Weather Events from Emerging Markets and Developing Economies', offers a framework to complement existing climate risk assessment practices.
- The European Central Bank has published good practices for climate-related and environmental risk management for financial institutions
- UNEP FI and the Cambridge Institute for Sustainability Leadership's report on Leadership Strategies for Client Engagement: Advancing climate-related assessments includes guidance on advancing climate-related assessments for effective use in client engagement.

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UN environment programme

finance initiative

UNEP Finance Initiative brings together a large network of banks, insurers and investors that collectively catalyses action across the financial system to deliver more sustainable global economies. For more than 30 years the initiative has been connecting the UN with financial institutions from around the world to shape the sustainable finance agenda. It has established the world's foremost sustainability frameworks that help the finance industry address global environmental, social and governance (ESG) challenges. Convened by a Geneva, Switzerland-based secretariat, more than 500 banks and insurers with assets exceeding US$100 trillion work together to facilitate the implementation of UNEP FI's Principles for Responsible Banking and Principles for Sustainable Insurance. Financial institutions work with UNEP FI on a voluntary basis and the initiative helps them to apply the industry frameworks and develop practical guidance and tools to position their businesses for the transition to a sustainable and inclusive economy.

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