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Decarbonization of the Mining Sector

Scoping study on the role of mining in nationally determined contributions

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Decarbonization of the Mining Sector: Scoping study on the role of mining in nationally determined contributions

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Executive Summary

This report critically examines the mining sector's role in the global energy transition and its alignment with international climate commitments. Recognizing the urgent need to decarbonize to address climate change, this scoping study provides an in-depth analysis of the mining industry's current status, challenges, and opportunities in participating in the global effort to curb greenhouse gas (GHG) emissions.

The urgency to decarbonize our societies to limit global GHG emissions is driven by global climate goals and commitments under the Paris Agreement. This report focuses on the essential role of the mining sector in supplying critical minerals and metals necessary for energy transition technologies. However, the sector's energy-intensive nature makes it a significant source of GHG emissions, necessitating strategic management to reduce its own GHG emissions and to prevent exacerbating other major planetary crises, such as pollution and biodiversity loss.

The report covers the extraction and processing of minerals and metals, including coal, but excluding non-metallic materials. It explores the mining sector's contribution to nationally determined contributions (NDCs) and the efforts of mineral-rich developing countries to meet the surging demand for minerals and metals. It specifically examines the sector's GHG emissions, informed by case studies from Chile, Indonesia, and South Africa and provides practical recommendations to support decarbonization efforts.

The report begins by outlining the international framework for decarbonization, focusing on the Paris Climate Agreement and NDCs. It highlights national policies and strategies that drive these efforts, emphasizing the importance of coordinated global actions to meet climate goals.

The report then dives into the mining sector's critical role and responsibility in the energy transition, identifying sources of GHG emissions and factors impacting these emissions. It addresses the specific challenges faced by coal mining, understanding that close to 80% of all GHG emissions related to mining are fugitive methane emissions from coal mines. It also examines the implications of global demand shifts linked to the energy transition for producing countries. Here, the concept of a “just transition” is central, emphasizing fair and inclusive distribution of benefits. Challenges and policy choices in selected nations are then discussed.

The next section highlights the mining industry's commitments to reducing its carbon footprint. The industry's response to the decarbonization challenge is explored, including voluntary disclosures, legal reporting requirements, international transparency initiatives, and how decarbonization could be used as a corporate communication tool.

Finally, the report offers several key policy recommendations to support the mining sector’s transition to a low-GHG emission future. They include the following:

- High-quality data is key for informed decision making on climate action and to monitor and assess policy performance.
- Incentivizing (local) businesses to decarbonize requires a mining sector-specific approach as part of government climate mitigation policy.
- Adaptation and mitigation need interlinked strategies shaped by the energy transition.

- Leveraging international Paris Climate Agreement plans and ambitions.
- Domestic government policy mitigation efforts involve balancing the benefits and challenges of decarbonization.
- Energy transition benefits and challenges demand new models of shared responsibility between producing and destination countries.
- Businesses have a role in climate mitigation.

The report concludes by underscoring the need for coordinated efforts between governments, the mining industry, and international stakeholders to ensure that the surge in mining activity for the energy transition does not aggravate other planetary crises. The proposed policy recommendations aim to create a balanced and sustainable path forward, ensuring the mining sector contributes effectively to global decarbonization efforts.

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Acronyms

GHG	greenhouse gas
CO_2e	Carbon dioxide equivalent. See Appendix B.
UNFCCC	United Nations Framework Convention on Climate Change
NDCs	nationally determined contributions
LULUCF	land use, land-use change, and forestry
IPCC	Intergovernmental Panel on Climate Change
BUR	Biennial Update Reports

1.0 Background and Objectives

1.1 Introduction

Recognizing the urgent need to align with global climate goals, governments worldwide have committed to decarbonizing their economies through nationally determined contributions (NDCs) under the Paris Agreement. In the same vein, the global imperative to combat climate change has spurred unprecedented efforts toward decarbonization across industries.

The mining sector has a critical role to play in helping achieve climate goals. It is the key supplier of minerals and metals that are indispensable in the manufacturing of energy transition technologies. However, mineral extraction and processing activities are highly energy intensive, and, therefore, the sector is also an important contributor to greenhouse gas (GHG) emissions, which needs to be addressed as governments undertake their decarbonization efforts. Central to the energy transition is the concept of a "just transition," which underscores the need to ensure that the benefits of the transition are shared and distributed fairly and inclusively.

Given the implications of mining-derived GHG emissions, this scoping study seeks to explore the role and contribution of the mining sector to NDCs. The report looks at efforts and initiatives that have been put in place by resource-rich developing countries as the demand for minerals and metals is expected to surge in the decades to come.

The report also examines the current decarbonization status of the mining sector. Its scope is limited to metallic and coal mining,[1] representing most mining activities in the world. Non-metallic mining is excluded due to the major differences in the actors involved, the technologies used, and the value added. The impact of coal is considered from the extraction process and, potentially, as the source of energy for mining-related activities, but not for other activities.

The report seeks to understand the sector's contribution to GHG emissions. It provides valuable insights into the challenges and opportunities associated with the decarbonization

[1] This represents activities under section B: Mining and Quarrying, subsections 05: Mining of coal and lignite and 07: Mining of metal ores of the International Standard Industrial Classification of All Economic Activities (2008).

of the mining industry. The report's analysis is informed by three country case studies from Chile, Indonesia, and South Africa (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development [IGF], forthcoming). Finally, looking at industry practices, regulatory frameworks, and technological innovations, this report offers some practical recommendations to support governments and industry in their decarbonization efforts.

1.2 Objective, Structure, and Methodology of the Scoping Study

This report aims to assess the role and contribution of the mining sector in helping national governments achieve their international climate commitments under the Paris Climate Agreement through the NDCs.

Mining and related processing activities are highly energy intensive, and the mining sector is a significant contributor of global GHG emissions, which are one of the main causes of global warming. The sector is estimated to generate between 1.9 and 5.1 gigatons of CO_2 equivalent (CO_2e) of GHG emissions annually (Delevingne et al., 2020), representing 2% to 7% of global GHG emissions and up to 10% of annual global energy-related GHG emissions (Azadi et al., 2020; Bellois, 2022; GlobalData, n.d.).

The most significant volume of mining-derived emissions is generated from coal mining. However, other minerals, including those needed for the energy transition—the so-called "critical minerals"—are also responsible for a significant share of global GHG emissions.

According to the latest estimates, copper production contributes to around 4.6 tonnes of CO_2e per tonne produced (International Copper Association & Power of Zero, 2023), while nickel production generates between 12 and 78 tonnes of CO_2e per tonne (Carbon Trust, n.d.). Together, copper and nickel production account for close to 0.5% of global GHG emissions (International Copper Association & Power of Zero, 2023; Nickel Institute, 2022).

Given the significant GHG emissions from the mining sector and the need to respond to the surging demand for minerals and metals needed for the energy transition, this report highlights the importance of decarbonizing the mining sector as a material part of national (and, ultimately, international) climate mitigation efforts.

Through a sector-specific lens on mining, the report outlines the challenges and opportunities involved in decarbonizing the sector. Key to assessing these challenges and opportunities is a thorough understanding of mining-derived GHG emissions, particularly in countries where mining activities for the critical minerals needed for the energy transition will continue to surge. Three countries—Chile, Indonesia, and South Africa—have been selected to illustrate and assess the extent to which mining GHG emissions are considered in national NDC policies.

The report acknowledges several gaps in the availability of data, reporting systems, and supporting literature. One area for further research is the different development trajectories that could factor into the policy design and options available (e.g., developing, emerging, least developed). More research is also needed to further assess the opportunities and challenges the mining sector faces with respect to climate change actions, both to mitigate and adapt to, respectively, the impacts of climate change. This is also relevant with respect to actions to decarbonize mining-related and energy transition supply chains of the future.

Based on the findings, recommendations are proposed for discussion and for further in-depth work around GHG emissions in the mining sector and its role in the global energy transition.

This scoping study is structured as follows:

- Section 2 unpacks the road to decarbonization, looking at international commitments and national actions.
- Section 3 presents the state of play of the mining sector and the energy transition.
- Section 4 examines the nexus between climate change and the energy transition and zooms in on the role that mining companies can play in helping national governments achieve their Paris Agreement commitments.
- Section 5 provides policy recommendations.

2.0 The Road to Decarbonization: International commitments and national actions

To meet international climate change commitments under the Paris Agreement, governments around the globe are expected to develop and implement a comprehensive package of **climate mitigation and adaptation policies** to reduce their GHG emissions and decarbonize their economies. The NDCs are part of such policies, whereby governments establish specific targets for mitigating GHG emissions and adapting to the impacts of climate change.

BOX 1. CLIMATE CHANGE ADAPTATION OR MITIGATION?

Distinguishing between climate adaptation and climate change mitigation actions:

Climate change adaptation refers to enhancing the capacity to adapt to negative impacts of climate change, promoting climate resilience and advancing low-GHG development.

Climate change mitigation means holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5°C, recognizing that this would significantly reduce the impacts of climate change. The United Nations Intergovernmental Panel on Climate Change (IPCC) defines climate change mitigation as "a human intervention to reduce the sources or enhance the sinks of greenhouse gases" (IPCC, 2014, p. 4).

This report seeks to understand how governments of mineral-rich countries use their NDCs to set their national targets to decarbonize their economies, to meet their international commitments under the Paris Climate Agreement, given the significant role the mining sector plays in their economies.

2.1 Background: The Paris Climate Agreement and NDCs

2.1.1 The Paris Agreement

The Paris Agreement (the Agreement) is a legally binding international treaty on climate change that was adopted in December 2015 at the UN Climate Change Conference (COP 21) by 196 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, n.d.-b, 2016). As of February 2023, 195 Parties, representing 194 states and the European Union, have ratified the Agreement, pledging to limit global warming to below 2.0°C, and ideally not more than 1.5°C above pre-industrial levels. However, in recent years, the expectation has been raised toward not more than 1.5°C global warming to limit severe climate change consequences.

To achieve this goal, the IPCC (2018) asserts that

- global GHG emissions must be cut by 45% from 2010 levels by 2030;
- net-zero CO_2e emissions must be reached around 2050;
- from 2050 onwards, negative emissions are the way forward.

Acknowledging that countries have differing commitments, as well as varying development paths and trajectories, the UNFCCC organizes countries into three main groups:

- **Annex I parties**, representing the industrialized (Organisation for Economic Co-operation and Development countries) and some economies in transition countries, including Russia, the Baltic States, and Central and Eastern European Countries.
- **Annex II parties**, consisting of the Organisation for Economic Co-operation and Development members of Annex I, but not the economies in transition parties. Annex II Parties are required to provide financial resources for emissions reduction activities for developing countries.
- **non-Annex I parties**, representing most developing countries, amongst which some countries are more vulnerable to climate change effects (adaptation) and/or more vulnerable to economic impacts of climate change response measures due to the high carbon intensity of their industries.

This report focuses on Annex I and non-Annex I parties.

2.1.2 Just Transition and Common but Differentiated Responsibilities

There are two key features of the Paris Agreement relevant to the efforts of national governments to decarbonize their mining sectors.

First, the concept of **just transition** reflects the idea that "transitions must be both fast and fair if they are to obtain the social approval required to reach the targets enshrined in the Paris Agreement" (Climate Strategies, n.d.). It was first introduced in the preamble of the 2015 Paris Climate Agreement and reinforced during COP 24 (2018) in Katowice, Poland, where the Silesia Declaration (Just Transition & COP24, 2018, p. 2) stressed that

just transition of the workforce and the creation of decent work and quality jobs are crucial to ensure an effective and inclusive transition to low greenhouse gas emission and climate resilient development, and to enhance the public support for achieving the long-term goals of the Paris Agreement.

Second, the concept of "**common but differentiated responsibilities**" is to be considered when reflecting upon countries' national action plans (i.e., NDCs) under the Paris Climate Agreement.

Embedded in the preamble of the Agreement, "common but differentiated responsibilities" refers to the fact that while all countries have the duty and responsibility to take climate action, the types of action they take will depend on their differing national circumstances.

In practice, this means that there are differing pledges and goals. The Agreement recognizes that some more vulnerable countries have specific needs and concerns that need to be addressed. This includes investment, insurance, and technology transfers. Still, it remains up to each government to devise and adjust the right mix of adaptation and mitigation policies and incentives (market based and compliance based). Governments' climate mitigation policy packages need to consider their individual GHG emissions profiles based on sector-specific insights. Countries can select the sectors that are expected to contribute the most to achieving their NDCs. Unfortunately (and as identified in the case studies), very few countries, even major producing ones, disaggregate their data to specifically identify the current contribution of the mining sector to national GHG emissions. Therefore, the mining sector cannot be specifically targeted to support countries reaching NDCs.

2.1.3 The NDCs

Article 4, Paragraph 2 of the Paris Agreement requires each party to prepare, communicate, and maintain successive NDCs. NDCs are essentially climate action plans and commitments that countries submit to the UNFCCC. They contain the country's targets, strategies, and reduction plans to mitigate GHG emissions and adapt to climate change, and, in some cases, the NDCs also contain the climate financing strategy the country intends to pursue.

BOX 2. NDC TARGETS AND CONDITIONALITY

NDCs' objectives contain two types of targets:

1. "unconditional" targets that a country can implement alone and with domestic resources; and
2. "conditional" targets that have higher emission reductions but need international support to be achieved. Targets for Chile, Indonesia, and South Africa are summarized in Appendix E.

Since 2015, all 195 Parties that have signed and ratified the Paris Agreement must regularly report on their national GHG emissions and track progress toward the implementation and achievement of their NDCs. For non-Annex I parties, national GHG inventories are presented in Biennial Update Reports (BURs) (UNFCCC, n.d.-a) and submitted to the UNFCCC

Secretariat.[2] New or updated NDCs are expected to be submitted every 5 years to show how much countries intend to reduce emissions (each submission is expected to be more ambitious than the previous one). This is called the "ratchet mechanism" (Yeo, 2015).

Closing the gap between *needed* emissions reductions, on the one hand, and *committed* (and *realized*) emissions reductions, on the other, requires a joint effort from countries and industries. More ambitious commitments by governments are crucial; at the same time, stronger action by the mining sector, as part of the private sector at large, is necessary.

2.2 National Policies and Strategies

At the **national** level, governments need to translate their international commitments into domestic policies and action plans: this is where the NDCs come into play. While there is no obligation to align the two, the expectation is that NDCs are informed by national legislation or vice versa. Domestic climate mitigation plans come in all forms and shapes, targeting the economy as a whole but also including specific primary sectors, such as the mining sector, that are key to the national economy.

Decarbonization requires a string of concrete actions and clear policies and institutions to guide, execute, and monitor implementation. Therefore, the role of public policies in climate governance is key. Governments must put in place enabling conditions that encourage decarbonization, including investments in renewable and energy efficiency technologies, and incentivize private actors in their climate adaptation plans. This includes measures such as strong institutional mechanisms, targeted policies and incentives, and funding instruments.

BOX 3. THE CLIMATE GOVERNANCE FRAMEWORK

The Climate Governance Framework developed by Climate Action Tracker (2021) proposes four key elements for effective climate action at the national level:

1. **political commitment and government leadership** to transition to a zero-emissions society.
2. an **institutional framework** to help reach emissions reduction targets and support the transition. This includes a framework for coordination and adequate financial resources.
3. **policy processes** aimed at implementing and reviewing mitigation policies. This includes an emissions pathway compatible with the Paris Agreement, a transparency framework, and a "ratchet" mechanism to improve on ambitions.
4. **strengthened stakeholder engagement** to support climate actions.

From a regulatory perspective, government-mandated reporting on GHG emissions is the most frequently deployed—and to some extent effective—instrument to identify private sector GHG emissions and to incentivize businesses to reduce their GHG emissions.

[2] BURs should include updates of national GHG inventories according to standardized data tables (quantitative information) based on common reporting formats, as well as a national inventory report with estimations on GHG emissions.

Examples of these reporting requirements include the U.S. Environmental Protection Agency's Mandatory Greenhouse Gas Reporting Program and South Africa's National Greenhouse Gas Emission Reporting. There are also market-based programs, such as carbon taxes and emissions trading, that governments can use alongside regulatory requirements.

In the case of **South Africa**, carbon taxes may serve to discourage the use of fossil fuels and encourage a shift to energy systems generating lower GHG emissions. Globally, according to the International Monetary Fund (IMF), more than 60 carbon tax and emissions trading systems now operate at the regional, national, and subnational levels (Parry, 2021). However, setting the correct price is key to the efficient use of any carbon tax. The IMF has estimated that

> a $35 a ton carbon tax would be particularly effective in reducing emissions in heavy coal users such as China, India, and South Africa. The tax would roughly double coal prices but would increase pump prices for road fuels only moderately. .... These findings may make the case for some degree of international price coordination. A group of large-emitting countries could agree to impose a minimum price on carbon. (Parry, 2019)

Furthermore, the IMF emphasizes that coherent policy packages are needed "to provide broader and stronger mitigation incentives, accounting for national efficiency, distributional, and political economy considerations" (Parry, 2019). Such mitigation policy package is also promoted by the IFC, "Implemented well, the mitigation policy package would promote low-carbon investments, raise government revenues, and support economic growth" (IMF, 2023).

Increasingly, governments also see the benefits of a coherent approach to incentivize businesses to decarbonize using a "climate mitigation policy package."

However, it is too early to define what a "best practice" approach and/or policy for climate mitigation at the national level looks like and how effective they are for climate adaptation. Furthermore, although there are merits in designing sector-specific goals and action plans, not all countries currently include a sectoral approach in their national policies.

3.0 State of Play of the Mining Sector and the Energy Transition

3.1 The Mining Sector Is Key to the Energy Transition

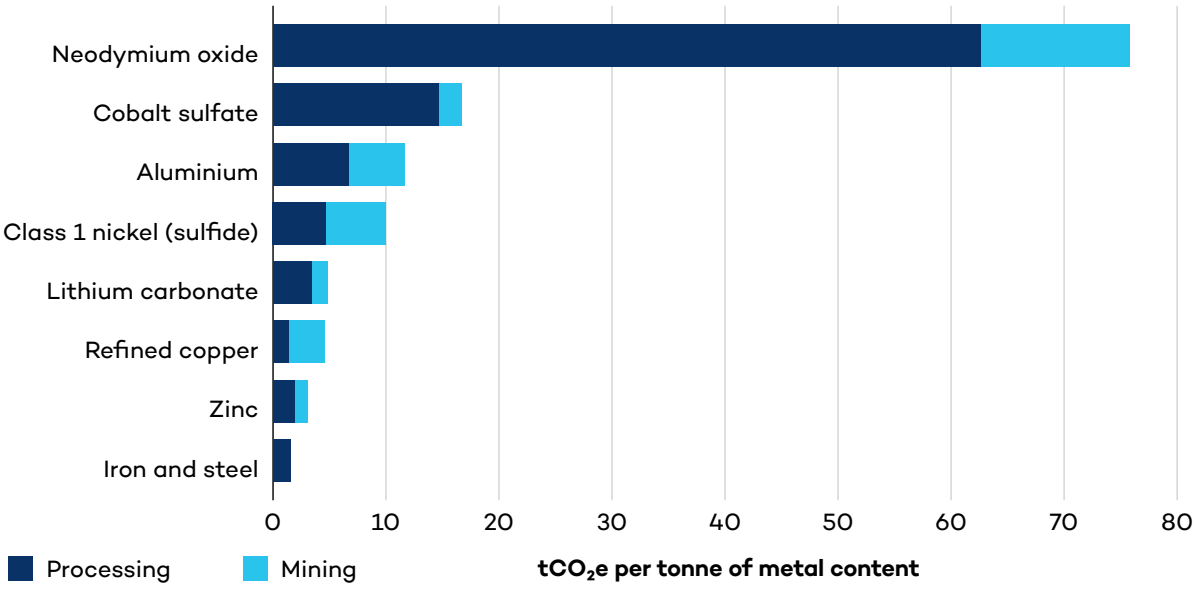
The mining sector plays a crucial role in the global economy, providing the resources to manufacture almost everything needed for the functioning of modern society. The sector is a key contributor to the national economies of resource-rich countries, where it provides substantive economic benefits through fiscal and export revenues and employment of local populations (International Council on Mining and Metals [ICMM], 2022). If harnessed and managed well, the sector has the potential to be transformative for current and future generations, as it can be leveraged to develop home-grown solutions, finance the energy transition, and fund climate change mitigation and adaptation.

With the energy transition, demand from minerals and metals is set to grow exponentially. The World Bank observed in 2022 (Hund et al., 2020) that the production of minerals, such as graphite, lithium, and cobalt, could increase by nearly 500% until 2050 to meet the growing demand for cleaner energy technologies.

One of the key reasons for this exponential growth is that the technologies needed to accelerate the energy transition—notably, e-mobility and renewable energy technologies—are significantly more minerals intensive than current fossil fuel-based technologies. Apart from steel and aluminum, as shown in Figure 1, a typical electric car needs six times more mineral inputs than a combustion car (International Energy Agency [IEA], 2022).

Similarly, moving away from fossil-fuel based power generation technologies toward renewable energy technologies requires significant volumes of minerals such as cobalt, lithium, graphite, copper, manganese, nickel, and zinc (IEA, 2022).

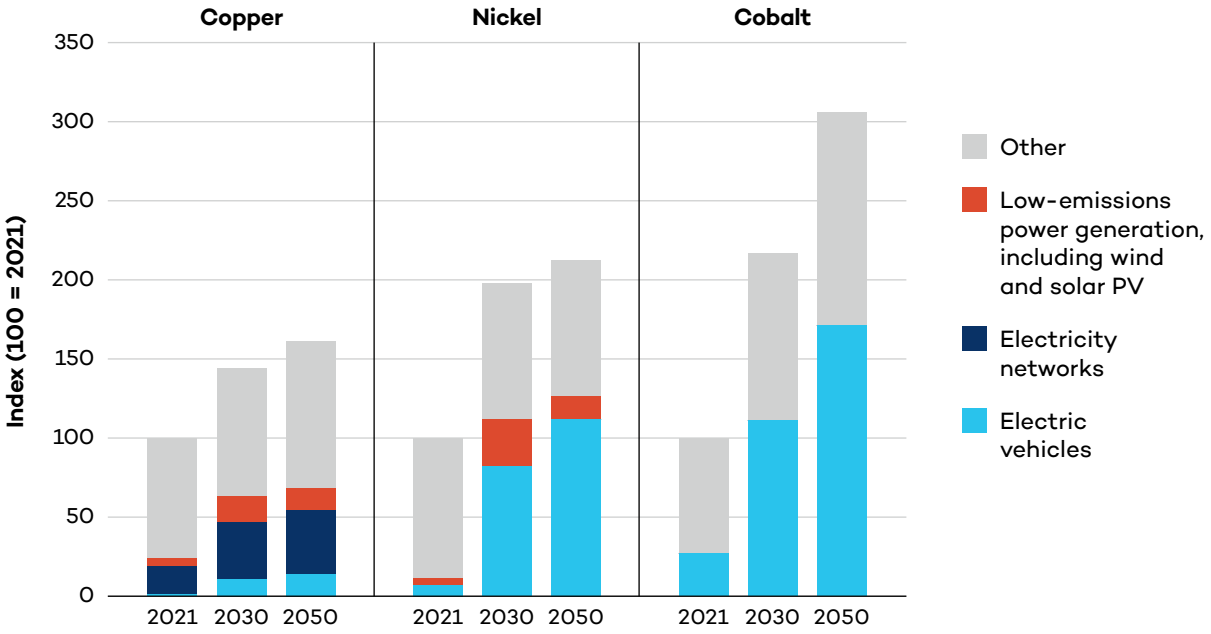
FIGURE 1. Minerals used in selected clean energy technologies



Source: IEA, 2022, p. 6. CC BY 4.0

As Figure 2 shows, the total demand for copper, cobalt, and nickel by end-use in a net-zero scenario (i.e., if countries meet and go beyond their NDC commitments) is expected to grow significantly by 2050. Overall, the demand for critical minerals is expected to grow by three-and-a-half times by 2030. Electric vehicles, battery storage, and low-emissions power generation and electricity networks are expected to drive demand (IEA, 2023b).

FIGURE 2. Total demand for copper, cobalt, and nickel by end-use in a net-zero scenario



Source: IEA, 2023b. CC BY 4.0

3.2 Where Do GHG Emissions From the Mining Sector Come From?

Paradoxically, although the mining sector is indispensable to manufacture technologies to achieve GHG emissions reduction objectives, mining extraction and processing activities can exacerbate climate risks through their own GHG emissions. Increased activities can also lead to other and additional negative environmental impacts, such as land degradation, biodiversity loss, air and water pollution, and resource (e.g., water) depletion (IEA, 2022c).

A 2020 study by McKinsey estimates that the mining sector, specifically extraction and processing—in particular, coal mining—is responsible for 4% to 7% of direct GHG emissions globally. The study highlights that between 75% and 85% of these GHG emissions come from fugitive methane emissions from coal mines, which account for about 3% to 6% of total global emissions. The rest (roughly 1% of global GHG emissions from the mining sector) is attributed to mining extraction and processing, both of which are Scope 1 and Scope 2 emissions (Delevingne et al., 2020).

75% to 85 % of all GHG emissions related to mining are fugitive methane emissions from coal mines.

3.3 Factors Impacting GHG Emissions in the Mining Sector

GHG emissions in the minerals and metals sector depend on a variety of factors, including amongst others the types of minerals extracted and processed, the total output of the production process, the energy efficiency of the metallurgical technologies used.

First, it is important to acknowledge and understand the linkages between mineral resources and energy intensity. There is a strong correlation between mineral extraction and production processes, on the one hand, and energy requirements, on the other, across the life cycle of mining projects, which is one of the key GHG-emitting factors (for non-coal minerals).

At the extraction stage, ore grades and depth of mines are inversely correlated to energy consumption. This means that more energy is required to obtain the same amount of valuable minerals as ore grades decrease or the deeper the ores to be extracted from, due to increased extraction activities (Aramendia et al., 2023).

Second, to produce metals—the semi-finished products that are required to manufacture energy transition technologies—ores must be transformed through different stages of beneficiation. Processing stages differ from one mineral to the other and each has different energy requirements (Aramendia et al., 2023; Welgryn & Scache, 2023) depending on the extraction techniques employed, volumes of production, and energy mix used at various stages of the production process. For example, Rio Tinto's climate change report (2022) highlights that 80% of GHG emissions come from processing and producing minerals and metals, with the remaining 20% coming from extraction itself.

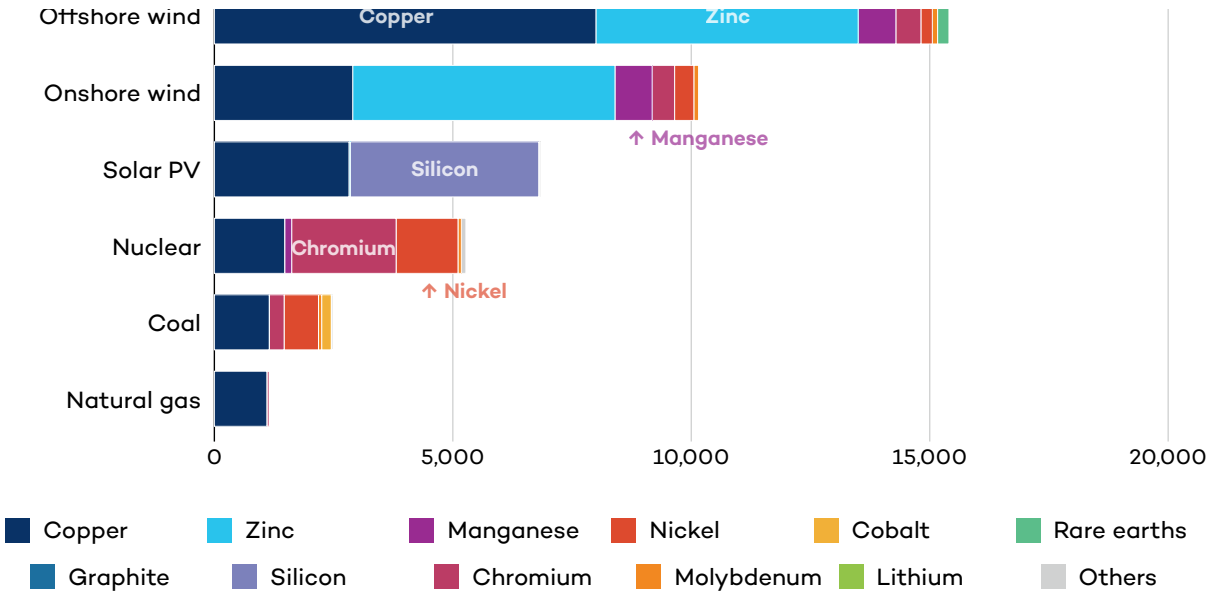
In terms of GHG emissions, data on combined emissions from mining and processing operations reveals that substantial differences in emission intensity relate to the type of processed commodity (IEA, 2022c). Average GHG emissions from the production of selected minerals required for the energy transition, such as neodymium oxide, cobalt sulfate, aluminum, nickel, and lithium carbonate are illustrated in Figure 3.

Taken together, the emissions intensity of the smelting and refining processes (dark blue in Figure 3) is sometimes higher (such as with cobalt sulfate, and neodymium oxide), sometimes more or less equal (aluminum, zinc and Class 1 nickel sulfide), and at times less intense than emissions generated by the mining operations before processing. In the case of neodymium and cobalt, this is also linked to the fact that they are almost exclusively mined as by-products (Bellois & Ramdoo, 2023); thus, emissions from mining are largely attributed to the major host metal.

Third, the transportation of mineral products requires physical transport infrastructure, such as roads and railways, from production sites to manufacturing hubs, nationally and globally. These roads and railways are also highly intensive in minerals and metals, such as cement, iron ore, or copper, demand for which will also surge.

Fourth, the willingness and **the need to mitigate climate change affect the demand for outputs of the mining sector differently.** It can sometimes lead to reduced demand (such as in the case of coal mining in some developed countries, but still not worldwide as coal production reached its all-time global high in 2023) (Enerdata, n.d.) as well as increased demand and expansion opportunities for (certain) minerals (such as nickel, cobalt, or lithium). This, in turn, will equally impact GHG emissions.

FIGURE 3. Average GHG emissions intensity for production of selected commodities



Source: Source: IEA, 2022c. CC BY 4.0

Fifth, taking a circular economy approach, notably by minimizing wastes and through end-of-life product recycling, can help reduce the demand for primary metals. In the case of copper, recycling of post-consumer and pre-consumer copper scrap could lead to fulfilling 41% of current demand in Latin America (International Copper Association, 2023). Recycling could reduce the pressure on primary copper demand and help limit the rise in GHG emissions expected from increasing copper demand and higher GHG emissions per tonne of copper produced due to declining grades in deposits.

BOX 4. DATA LIMITATIONS: A NOTE OF CAUTION WHEN READING GHG EMISSIONS DATA

When available, global estimates of GHG emissions from the mining sector are often underestimated due to poor reporting systems and imperfect accounting methods. The most complete data sets available are published by the IEA. Their data include mainly direct energy use (i.e., energy used in situ by mining companies) but excludes indirect energy use across supply chains (Aramendia et al., 2023).

Other sources are unclear about whether energy consumption in mining includes downstream and metallurgical processes in addition to extraction activities.

Acknowledging data limits, absolute emissions from the production of critical minerals are still relatively small, as they represent a low percentage of global mining production. However, these emissions will increase as supply expands to meet the projected growth in demand. This growth will be further exacerbated by future production potentially shifting to more energy-intensive pathways, which will put additional upward pressure on emissions (IEA, 2022c). For example, and as detailed in the forthcoming case studies, Indonesia, the world's largest global nickel producer, has an energy mix largely dominated by coal. Furthermore, the average

coal from Indonesia has a 20% to 25% lower energy content than coal from other countries (Glencore, 2022), such as Australia, Colombia, or South Africa. This means that Indonesian coal contributes to higher CO_2 emissions per unit of energy produced. Additionally, Indonesia's nickel reserves are mainly laterite ore, requiring more processing and thus using more energy to become battery-grade nickel. As a result, producing battery-grade nickel (also known as Class 1 nickel) in Indonesia is much more energy and carbon intensive than in Australia, Canada, or Russia where nickel is mostly found in sulfide deposits.

For governments of mineral-rich countries, a "policy coherence" puzzle arises, whereby the mining sector needs to serve climate and sustainability ambitions, as well as economic development and job generation ambitions and policies of the government.

3.4 Coal Mining: A sector at the "losing end" of the energy transition?

According to the IEA, coal supplies just over a third of global electricity generation. After reaching a record all-time high in 2022, growing by 3.3% from the previous year, global coal consumption for 2023 was expected to grow only slightly (IED, n.d.).

The dilemma around coal is two-fold: first, coal is the largest source of electricity generation and a significant fuel for industrial use. Second, it is also the largest emitter of energy-related GHG emissions from fugitive emissions, accounting for over 40% of the overall growth in global CO_2e emissions in 2021, reaching an all-time high of 15.3 billion tonnes (IEA, n.d.-c). For the first time, a pledge to transition away from fossil fuels in energy systems has been agreed on during COP 28 in Dubai. To achieve this objective in a just and equitable way, some propositions included a clear mention in countries' NDCs (Jones & Parra, 2024).

> Coal is both the single biggest source of CO_2 emissions from energy and the single biggest source of electricity generation worldwide, which highlights the harm it is doing to our climate and the huge challenge of replacing it rapidly while ensuring energy security. (IEA, 2022a).

Coal consumption varies widely across geographic regions. In developed countries like the United States and Western European countries, where access to energy is universal and affordable, coal consumption is relatively low. Increased investment in and adoption of renewable energy technologies are expected to lead to a significant drop in coal consumption (IEA, 2023a), which also has an impact in changing the fossil-fuel-based energy mix.

In developing countries, the realities are different. Based on a 2022 estimate by the IEA, 760 million people have no access to electricity, 80% of whom live in sub-Saharan Africa. Meanwhile, around 2.3 billion people have no access to clean cooking facilities, relying instead on solid biomass, kerosene, or coal as their primary cooking fuel. In these countries, energy policies adopted are primarily driven by the need to provide universal access to affordable energy.

In the emerging economies of Asia, rising coal consumption is driven by robust growth in demand for power generation, industrial applications, and low hydropower output (IEA, 2023a). Coal demand in China (around 5%), India (over 8%), Indonesia, and other Asian countries together represent 70% of global coal demand.

As energy security remains an important matter on the political agenda, especially after the market disruptions during the COVID-19 pandemic and Russia's invasion of Ukraine, the coal industry continues to provide a reliable source of energy for many countries, including China, India, Indonesia, and South Africa.

For many countries, coal mining provides the energy needed to fuel major industries, and generate jobs and government income, hence contributing to economic growth and poverty reduction. In addition, coal serves as a process material or energy fuel for other industries, including for 70% of the world's steel, 90% of the world's cement, and 61% of the energy used to make aluminum (FutureCoal, 2024).

With many countries highly dependent on coal as a source of energy, it is not a surprise that coal is a key mineral in the energy transition pathway. Currently, the production of steel from iron ore—the metal that accounts for 20% and 90% of turbine mass for onshore and offshore wind turbines, respectively (Mukherjee & Sheridan, 2021)—is still largely dependent on coking coal. China continues to lead the way in wind turbine manufacturing with a strong dependency on coal: each turbine requires 260 tonnes of steel made from 170 tonnes of coking coal and 300 tonnes of iron ore.

Reversing this trend is expected to be slow. Throughout the coming years, it is expected that emerging and developing economies such as India, Indonesia, among other countries will continue to mostly rely on coal to drive strong economic growth, even though this doesn't necessarily align with their commitments to accelerate the adoption of renewables and other low-emissions technologies (IEA, 2023a).

Although there has been a marked increase in renewable energy technologies in developing countries, new low-GHG-emitting sources are expected to meet the new demand for industries and population growth but may not yet be sufficient to replace the existing fossil-fuel base load.

However, the fact that the net GHG emissions of the energy sector need to be taken to zero implies there will need to be significant overhaul of energy systems to diversify away from combustion and mining of coal. In the long term, coal-mining activities can thus be expected to be on the "losing end" of the energy transition in favour of a renewable energy mix.

In the metals sector, some efforts are visible, with a switch to hydrogen and biofuels as energy sources, which has caused a decline in demand for coal in some situations (Delevingne et al., 2020), although this is not yet sufficient to reverse the rise in global trends.

For coal-dependent countries, reducing dependency on coal raises the question of a just transition: because the industry equally generates jobs, it can be a significant source of fiscal revenues and livelihoods for local communities. The closing of coal mines consequently leads to the loss of livelihoods for many of these mining-affected communities. Women in particular are likely to be highly impacted given their often-limited access to opportunities compared to their male counterparts due to gender biases and discrimination.

In **South Africa**, the coal industry employed nearly 91,000 people in 2022, mostly in mining activities, but with nearly 30% in coal-fired power plants run by ESKOM, the state-owned electric utility.

As unemployment in South Africa remains around 30%, potential job losses resulting from reduced coal production could trigger social unrest and strong opposition from influential coal-linked unions. In 2017, when ESKOM announced the closing of coal-fired power plants, trade unions reacted strongly, including by blocking roads. This led to the launch of Social Partner Dialogues on Pathways for a Just Transition by the South African government to build toward delivering the just transition chapter in South Africa's National Development Plan (World Resources Institute, 2021).

Climate financing will also be key to decarbonizing the coal industry, as the IEA has noted that "Over the period to 2030, emerging market and developing economies outside China require about USD 500 billion in investment to put them on a path to transition securely away from unabated coal" (IEA, n.d.-a).

It is important to ensure that the increased demand for minerals and metals needed for the energy transition does not compromise the climate ambitions of resource-rich countries. With more ambitious energy transition scenarios come higher demand for minerals and hence higher energy needs, which may in turn translate into higher GHG emissions if decarbonization of the mining sector does not become a priority. In fact, understanding the emission footprint of any new low-GHG-emission technology should become a precondition to the decarbonization of other economic sectors if one wants to avoid the "whack-a-mole"[3] effect.

3.5 Implications for Producing Countries of Global Demand Shifts

As highlighted above, demand for raw materials, and especially critical minerals, is set to grow due to climate change mitigation efforts around the globe. Producing countries are, therefore, at the centre stage of supplying the minerals needed for the energy transition.

Governments and mining-related businesses have become more proactively engaged, through climate change mitigation and adaptation commitments and actions, on setting and meeting Paris Climate Agreement goals over the past years. However, the consequences of ambitious international climate commitments for the mining industry are still to be fully understood, with several research initiatives underway.

The growing demand for minerals and metals means that more and larger mines are expected to open globally. A key question for producing countries is the extent to which the economic benefits that result from more production and processing will be effectively leveraged and equitably shared.

As mentioned, the growing demand for minerals and metals offers producer countries a unique opportunity to catalyze economic diversification, notably through new growth avenues and the development of low-GHG-emitting technologies. However, this requires navigating

[3] Whack-a-mole as an arcade game where one is given a mallet and instructed to hit the moles that appear out of the many holes on the game board. When one mole is hit, another pops up that needs to be taken care of.

a delicate balance: harnessing economic potential while prioritizing social inclusion and environmental stewardship. It is particularly important to manage the environmental and social costs of increasing the extraction of minerals and metals to avoid any risks of inaction at a global level due to potential conflicts with local stakeholders.

Decarbonization of the mining sector requires complementary country- and mineral-specific approaches. Countries that produce and export coal and are highly reliant on fossil fuels in their energy mix face more challenges in decarbonizing their mining sector. In coal-consuming developing countries like South Africa and Indonesia, industry divestment from coal will lead to the closure of many coal plants in the medium to long term.

For South Africa in particular, a country already stifled by economic challenges and where coal is the largest mining sector employer, closures will have significant socio-economic consequences, with ripple effects on the livelihoods of thousands of people. A sector-specific approach is needed to embrace a just transition if the government wants to get the buy-in of local communities. Furthermore, the importance of coal goes beyond its negative effects on the climate. It is the main source of energy in South Africa's energy system, accounting for around 70% of installed power generation capacity, according to the IEA (n.d.-b). While the 2019 Integrated Resource Plan sets goals to reduce the share of coal in the country's energy mix, in practice, a number of challenges will have to be addressed. The country currently faces an acute energy deficit due to old and rundown existing systems and insufficient production to meet its growing industrial and household needs. The other key challenge is the cost of energy supply, already considered too high. Any alternative to coal will have to be cheaper and more reliable. Until these options come to fruition, the switch away from coal may take long to materialize.

3.6 Challenges and Policy Choices in Selected Countries

3.6.1 Country Choice and Justification

For the mining and minerals processing sector, a major challenge lies in meeting the growing demand for mineral production while achieving ambitious GHG emissions reductions. In addition, for developing countries with a large mining sector, dealing with climate change adaptation and mitigation challenges simultaneously adds additional complexities.

Because the mining and refining sector is one of the largest GHG-emitting industries, governments need to consider sectoral emissions when setting national and international-level goals, devising policies, and implementing GHG emissions reduction plans.

To understand the real implication of GHG emissions (see summary of GHG emissions for Chile, Indonesia and South Africa in Appendix D) and reduction commitments in mineral-rich countries producing different commodities, three country case studies, namely Chile, Indonesia, and South Africa, were conducted (see IGF forthcoming, 2024). Key criteria for choosing the countries include (i) they be developing countries; (ii) they be in different geographical locations; (iii) they be major mining countries; (iv) they have a significant but differentiated exposure to coal mining and coal consumption. Furthermore, all these countries hold major reserves of different critical minerals.

3.6.2 Main Findings

The three countries—Chile, Indonesia, and South Africa—show similarities in their approaches and challenges in decarbonizing their mining sectors. Despite being important mineral-producing countries, their NDCs tend to address emissions reductions primarily within the broader context of energy transition goals. Except for Chile to some extent, their NDCs also do not seem to have a specific focus on the decarbonization of the mining industry. Instead of direct targets for mining-specific activities such as extraction or processing, their NDCs only include targets for mining-related activities, such as energy from the coal or metal sector.

Chile, for instance, emphasizes measures such as the use of electric vehicles and electrification to achieve carbon neutrality in mining operations, while Indonesia's NDCs mention emissions reduction targets for certain industrial processes and downstream activities related to mining. Similarly, South Africa's NDCs lack a sector-specific approach, with only general references to the mining industry within broader climate change adaptation strategies.

See Appendix E for a summary of climate targets committed in each country's latest NDCs, compared to mining-sector specific targets under domestic policies.

A common theme across these countries is the emphasis on transitioning to low-carbon energy sources and reducing reliance on coal. Strategies to achieve this include promoting renewable energy alternatives and implementing policies to reduce coal use. Acknowledging the socio-economic importance of coal mining, South Africa has put forward a Just Energy Transition Implementation Plan that serves as a roadmap to facilitate strategic and coordinated steps toward fulfilling decarbonization goals, ensuring fair outcomes for individuals impacted by the energy transition while also fostering inclusive economic growth, safeguarding energy security, and promoting employment opportunities.

However, challenges such as limited data availability and complexities in assessing emissions hinder precise quantification of emissions reduction efforts. Additionally, issues related to ensuring energy access and security, infrastructure limitations, and slow project implementation impact the pace of decarbonization initiatives in these countries.

4.0 Decarbonization Commitments and Action From the Mining Industry

Since the Paris Climate Agreement was signed in 2015 (UNFCCC, 2016), the mining sector has initiated decarbonization agendas, while proactively reflecting on the future of mining in the context of the energy transition. At the business level, companies primarily invested in shifting power sources to reduce emissions (for example, through the increasing use of renewable energy or natural gas to transition away from higher-emitting energy sources such as coal, diesel and heavy fuel).

While performance varies across the industry, some companies, especially large-scale and publicly listed ones, have set short-term targets to be met by 2030 with a possible net-zero target (by 2050) by addressing Scope 1 (direct emissions by the site) and Scope 2 (emissions from the use of energy) GHG emissions. More details on GHG emissions scopes and different greenhouse gases are provided in Appendix B.

BOX 5. EXAMPLE: RIO TINTO'S AMBITIONS IN REDUCING SCOPE 1 AND 2 EMISSIONS IN THE MINING SECTOR

Like most major mining companies, Rio Tinto is a large GHG emitter, with a reported total of 30.3 Mt CO_2e of Scope 1 and 2 emissions in 2022, a reduction of 7% below the 2018 baseline. Rio Tinto's initial efforts to reduce its GHG footprint were supported by the decision to sell its coal assets and thus reduce coal mining GHG emissions by 2018.

Scope 1 and 2 emissions:[4] The majority of GHG emissions are accounted for by aluminum (21.1 Mt).

Scope 3 emissions: Rio Tinto's Scope 3 emissions were 584 Mt CO_2e in 2022. Over 94% of this is from the downstream processing of iron ore, bauxite, and other products (refining and smelting).

[4] Details on scope emissions are presented in Appendix B. Emissions generated **directly** by mining operations are referred to as **Scope 1 emissions. Scope 2 emissions** are the overall emissions of a mining company that are generally attributed to third-party facilities. **Scope 3 emissions** are generated by suppliers, third-party transportation services, and the processing and use of their products.

To reduce its GHG emissions, Rio Tinto has set a target to achieve a 50% reduction in Scope 1 and 2 emissions by the year 2030 and a 15% reduction by 2025. These goals are aligned with 1.5°C global warming limitation—the stretch goal of the Paris Agreement—and are characterized as "really challenging," according to the 2022 Climate Change Report of Rio Tinto Rio Tinto (2022). This will partially be achieved by shifting from diesel-powered vehicles to electric vehicles in the mines.

Achieving progress in GHG emissions reduction entails prioritization and sometimes positive market developments.

As part of the reductions in Scope 1 and Scope 2 emissions reported by Rio Tinto in 2022, it is mentioned these are "primarily the result of switching to renewable power in prior years, as well as lower than planned production from selected aluminum smelters in 2022." This shows that part of the reduction is due to external factors, which means emissions might rise again if production increases back to foreseen levels or if demand for aluminum rises in the future.

4.1 Voluntary Disclosure

Mining companies have recently come under increasing pressure from investors and legislators to set and commit to more ambitious climate action goals.

Because international standards and legal requirements increasingly require climate-related disclosures, companies in the mining sector are investing in tracking and quantifying GHG emissions from various sources within their operations. Also referred to as "carbon accounting" mining companies are noticeable taking a concerted effort to measure, manage, and report on their GHG emissions.

When it comes to target setting toward GHG emissions reduction, voluntary industry standards have become a strong driving force. For example, in the mining sector, the ICMM and its 28 members (representing some of the world's biggest mining companies) collectively pledged commitment to net-zero Scope 1 and 2 GHG emissions by 2050 in line with the Paris Agreement (ICMM, 2024).

Furthermore, ICMM members have agreed to voluntarily report annually on their progress to decarbonize (Reuters, 2021). Their strategies include leveraging low-GHG-emissions energy technologies, introducing zero-emission mining vehicles, and using renewable energy sources at the mine sites. Chile provides an example of the NDCs as a means to reduce GHG emissions from the mining sector.

Mining companies are increasingly expected to disclose the actual progress made against agreed indicators. Here again, industry reporting standards are valuable, including the Global Reporting Initiative (GRI), the Carbon Disclosure Project (CDP), and Science-Based Targets initiative (SBTI) (more details are provided in Appendix C) or sector-specific standards, such as Copper Mark, to provide additional guidance for disclosures on GHG emissions reporting.

4.2 Legal Reporting Requirements

At the same time, government legislation, such as the **European Union Corporate Sustainability Reporting Directive** (CSRD) (European Commission, n.d.), with the accompanying European Sustainability Reporting Standards (ESRS), offers a strong incentive toward standardized reporting, including on environmental impact (ESRS E1). Through improved consistency and reliability of sustainability data reported by companies, stakeholders can assess and benchmark business performance against their commitments, limiting "greenwashing" of company sustainability progress. Complementary and enforceable anti-greenwashing legislations, such as those found in the United Kingdom (Jones, 2023), have the potential to further promote more reliable information on decarbonization measures in the mining sector inter alia.

Those measurable indicators at minimum include the reduction of GHG emissions in own operations as well as those of suppliers (Scope 1 and Scope 2). They also often include a commitment toward a less intensive GHG emissions energy consumption mix and overall energy reduction targets.

4.3 International Transparency Initiatives

Providing benchmark data on carbon emissions disclosures, the **Transition Pathway Initiative** (n.d.) offers insights into the carbon emissions disclosure and performance of 103 companies within the metals and mining sector, among a total of 425 participants.

Participating companies are categorized into four different mining sub-sectors as follows: 21 from the aluminum sub-sector, 13 from diversified mining, 34 from steel sub-sectors, and 35 from coal mining.

The results on company GHG emissions disclosure and reporting provide insights into the decarbonization efforts in the mining sector:

- companies reporting on Scope 1 and Scope 2 emissions: 66% (69 out of 103 in total) of metals and mining companies report their Scope 1 and 2 emissions vs 82% (264 out of 322 in total) of other sectors;
- companies reporting on Scope 3 emissions: 47% (48 out of 103) report their Scope 3 emissions in metals and mining vs 63% (203) of other sectors;
- external verification of Scope 1 and Scope 2 emissions (audits): 56% (58) of companies in the sector vs 63% (204) of companies in other sectors;
- long-term carbon emissions reduction targets: 36% (37 companies) vs 65% (209) in other sectors.

As the points above show, GHG reporting practices in the mining sector are less developed than in other industries. Mounting pressure from stakeholders for decarbonization action has resulted in additional commitments and progress on disclosures of GHG emissions reduction in own and supply chain operations. At the same time, such disclosures remain difficult to assess and verify in terms of actual progress against the ambitions set by governments.

Established indicators on environmental impact reporting, such as under the CSRD/ESRS standards, are necessary to show more consistent and reliable environmental impacts, including GHG emissions reduction information reported by companies in the mining sector.

For now, the integrity of GHG emissions information should be viewed with some skepticism, as showcased in the Corporate Climate Responsibility Monitor (New Climate Institute, 2023). This report assesses the transparency and integrity of the climate pledges and strategies of 24 major companies. Arcelor Mittal, active in the steel sector, is the only mining company assessed.

4.4 Decarbonization as a Corporate Communication Tool

With so many long-term commitments for which implementation can sometimes be difficult to assess, there is an increased risk of biased communication and greenwashing. Greenwashing practices are actions that mislead the public to believe that a company or other entity is doing more to protect the environment than it is (United Nations Climate Action, n.d.). For example, a company may set a net-zero target by 2050, which in practice is limited to Scope 1 and Scope 2 emissions and not covering its own production facilities (see New Climate Institute, 2023). A company may also report good results because it sold or divested away from its coal assets. While on the books GHG emissions of that company are effectively lower, this is due to a commercial deal rather than investments to decarbonize operations. At the level of the country where this company operates, GHG emissions have not been reduced—they have been moved to another company's books.

Although global companies are investing large budgets in decarbonization efforts, including through renewable electrification of energy-intensive mining and/or smelting processes and electric transportation, proper assessments are difficult because information regarding the share of revenue that large mining companies spend on decarbonization is not always available or retrievable. This can be partly explained because budget allocations specifically dedicated to decarbonization sometimes cannot be decoupled from wider capital expenditures on mining equipment. Therefore, efforts may not be visible and hence communicated.

5.0 Conclusion and Policy Recommendations

As the world transitions toward a low-GHG emissions economy, governments and businesses in resource-rich countries are confronted with a complex dilemma: how to mitigate climate change and meet international commitments under the Paris Agreement while developing the domestic mining sector to support economic development at home and increase the supply of minerals and metals necessary for the energy transition.

Through the research and case study insights provided, this report confirms that the mining sector is a key economic driver for resource-rich countries and essential to the supply of minerals for the energy transition. The report equally confirms the particular difficulties that resource-rich developing countries face in designing and implementing the right policy solutions and financial means to achieve a just transition while supplying energy transition minerals and keeping decarbonization commitments under the Paris Agreement. Hence, there is a need for enhanced insights and best practices on the solutions and policy mixes available for governments and businesses to collectively decarbonize the mining sector and include mining-specific mitigation and adaptation measures into the NDCs to achieve economic growth, sustainable development, and just transition.

First, this report pointed out that while acknowledging that most emissions from mining are linked to coal mining, the starting point for climate mitigation is a recognition that the metallic mining sector is key to providing the minerals and metals needed for the energy transition. However, it must be acknowledged that the mining sector is not homogenous. Mineral extraction and processing technologies vary widely across minerals. Energy intensity—and, hence, GHG emissions—varies significantly.

The three country cases show that there is a correlation between climate mitigation policies, mining-derived GHG emissions, and decarbonization, with country-level data supporting this correlation.

Looking at country-level GHG emissions data, climate mitigation efforts are beginning to show results in some countries where ambitious domestic mitigation policies were introduced. For instance, in Chile, decarbonization appears more successful. For the mining industry, this translates into high percentages of electricity sourced from renewable energy.

The case studies further illustrate that reliable and accurate data sets on emissions at the sector and commodity levels play an important role unlocking progress toward mining sector decarbonization.

When looking at the role of the mining sector in the decarbonization of the economy, the report has found that climate change-related data sets at sectoral level—while differing per commodity—are not always available and often fragmented. Data gathering on GHG emissions is gaining pace but at present it is limited to multinational businesses. Local businesses, particularly in developing countries, appear to lack the incentive, technical know-how, and financial resources to track and monitor their GHG emissions.

It is not possible to forecast future emissions for different abatement scenarios without reliable and accurate insights on current GHG emissions, globally and at country level. This situation hinders the ability of governments to develop the appropriate policies and to strategize toward a decarbonized mining sector.

5.1 Quality Data Is Key for Informed Decision Making on Climate Action and to Monitor and Assess Policy Performance

TABLE 1. Policy recommendations: Data quality

Policy objectives	Recommendation
Improve national statistics systems to leverage data for climate actions and sharpen policy responses.	Governments need to develop their national statistics capacity, institutionally and technically, including putting in place reliable data collection systems at the sectoral level, which, in turn, can be used to inform national action plans on climate change and, in particular, GHG emissions reporting. Governments should assess which data needs to be collected and accessible. This could include • GHG emissions at the mine-site level disaggregated by activity (extraction, processing, transport, etc.) • GHG emissions per tonne of ore extracted, of metal processed and refined • level of GHG emissions from the mining sector in total country GHG emissions • source of energy for mining and processing operations • plans to change the energy source of mining and processing operations • assessment for fugitive methane emissions for coal mining or when relevant • mining plans and their associated GHG emissions Governments need to explore and set aside the required financing, which should be included in their NDCs as part of their climate financing strategy.

Policy objectives	Recommendation
The implementation of policies to reduce GHG emissions hinges on the availability of good-quality data and forecasts.	Governments and companies must collaborate to develop a harmonized system to track and collect GHG emissions data, then ensure comparability and analysis. Governments must require mining companies and midstream beneficiation companies (i.e., smelters and refiners) to submit data on GHG emissions. Governments must have information systems in place to • aggregate company-level data to produce industry-level data, by commodities and by levels of processing • aggregate data at the national level for the mining sector in general
Design and implement a national database to offer accessible and reliable data on GHG and CO2 emissions from energy disaggregated by sector (with a specific lens on the mining sector).	Governments and industry must work in concert to ensure that data is produced in a timely manner in forms that are easily accessible for analysis and relevant for policy-making.
Address data limitations (for coal): Fugitive methane emissions from coal mining account for a major part of GHG emissions from the mining sector and globally. However, there is not enough data due to the difficulty in measuring these types of emissions. Consequently, research on their impacts and on ways to reduce emissions are limited.	Conduct further research on challenges related to GHG emissions measurement from coal mining. Conduct further research on suitable proxies for GHG emissions from coal mining when issues with direct data limitation cannot be addressed. Undertake further research on how to reduce emissions from coal mining.

Source: Authors.

5.2 Incentivizing (Local) Businesses to Decarbonize Requires a Mining Sector-Specific Approach as Part of the Government Climate Mitigation Policy

This report has shown that the mining sector will increasingly face **changing demand patterns** because of the increasingly prominent domestic and global decarbonization agenda and other industrialization requirements. This requires rethinking policies and instruments and strategic planning at all levels of government, at corporate level, and through multistakeholder engagement with local communities.

Countries without a mining sector-specific policy and action plan, leveraging solid data analysis, can neither inspire nor incentivize beyond the multinational enterprises into local companies to implement decarbonization in mining operations.

TABLE 2. Policy recommendations: Sector-specific policies toward local businesses

Policy objectives	Recommendation
Develop mining **sector-specific domestic policies and action plans** to provide incentives and guidance, especially for local businesses.	Governments and businesses must work together to develop a coherent sectoral approach to decarbonization in the mining sector, based on an agreed understanding of the mining sector's current and future CO_2e emissions, and on pathways on various abatement scenarios (at commodity level). For coal mining, this would include targets for production reduction that could consider scenarios, modelling, and projections for phasing out fossil fuel production.
Ensure a comprehensive approach in decarbonization programs.	Decarbonization programs must consider • mineral-specific challenges and realities (i.e., coal is different from copper) • mining life cycle • a value chain approach (from mining, processing, fabrication, use, disposal and recycling)
Ensure coherence between company decarbonization plans and NDCs.	Decarbonization action plans must be submitted to governments to ensure they are duly accounted for in NDCs and national climate goals. Governments and industries must work together to align priorities for policy coherence between sectoral policies and national objectives.
Design a coherent approach to incentivize businesses to decarbonize through a "climate mitigation policy package."	As mentioned by the IMF: "Implemented well, the mitigation policy package would promote low-carbon investments, raise government revenues, and support economic growth" (IMF, 2023, p. 31). Governments must design incentive programs to support industries' decarbonization plans. This must be viewed in the broader context of attaining NDC objectives.

Source: Authors.

5.3 Adaptation and Mitigation: Interlinked strategies shaped by the Energy Transition

Decarbonization in the mining sector cannot be seen in isolation from wider climate change effects demanding adjustment and resilience efforts. This report shows that the varying mineral portfolios of countries lead to different distributional effects of decarbonization efforts, potentially complicating domestic policy ambitions and implementation of decarbonization.

The case studies provided insights into country-level specifics, challenges and various governance models and policy responses regarding the mining sector's role in the economy as well as paths toward decarbonization. While avoiding generalizations, the case studies on Chile, South Africa, and Indonesia confirmed that there is no straight path for the mining sector to play its role in decarbonization. The challenges and opportunities need to be well understood as a basis for crafting future plans. Here, mitigation and adaptation cannot be seen separately from each other, as the mining sector is often operating in vulnerable areas, and investments toward "resilience" are often prioritized to ensure operations remain viable.

TABLE 3. Policy recommendations: Adaptation and mitigation strategies

Policy objectives	Recommendation
In decarbonization strategies, dialogues and assessments, it is important to develop and implement adaptation and mitigation plans together.	Governments and businesses need to co-design decarbonization plans that consider an integrated approach to adaptation and mitigation. Investments and incentive packages need to accompany the plans to secure resources and ensure implementation.

Source: Authors.

5.4 Leveraging International Paris Climate Agreement Plans and Ambitions

The case studies discussed here reveal that the NDCs of the three countries selected do not mention the mining sector as a key piece of the puzzle to reduce GHG emissions.

This could be due to the fact that "the mining sector" comprises a large variety of minerals and metals, and the mining life cycle involves various phases, each with a different GHG emissions intensity. As seen from the NDCs of the three selected countries, there is no standard disaggregation of data by stage of mineral production. For example, smelting is sometimes categorized as mining and, at other times, as industry. The dichotomy of the mining sector can also explain the lack of mining-specific targets in the NDCs. The sector, being a source of emissions-intensive coal-powered electricity generation (such as in Indonesia and South Africa), offers clear opportunities to decarbonize itself and to participate in the decarbonization efforts of producing countries.

Based on the NDCs analyzed for this report, the depth of emissions reduction commitments related to the mining sector under NDCs clearly varies to a great extent. Most notably, looking at the assessment of NDC commitments toward GHG emissions reduction, the high level of flexibility offered by the Paris Agreement under the "Common but Differentiated Responsibilities" clause has allowed governments of Annex I country groups [see Appendix A] to refrain from more ambitious commitments and concrete climate mitigation planning.

For example, while Chile has set some unconditional emissions reduction targets of 95 mt CO_2e by 2030, Indonesia has given an unconditional and a conditional target, and South Africa does not clarify whether the target is conditional or unconditional. Consequently, a direct comparison between countries is difficult.

In some developing countries, such as South Africa and Indonesia, governments use their NDC commitments to pave the way for domestic decarbonization plans, leveraging the flexibility offered by the Paris Agreement. This way, they also express the motivation to implement more ambitious plans while anticipating that international support will be provided and the intention to work toward improved domestic legislative frameworks, institutional structures and coordination mechanisms. In emerging countries, such as Chile, the NDCs align better with actual domestic climate change mitigation policies and plans, reflecting more progress with regard to sector-specific approaches, including in the mining sector. The report acknowledges that these different approaches could be attributed to the different development and growth trajectories of the countries (e.g., developing vs. emerging).

TABLE 4. Policy recommendations: Leverage NDCs to informal national policies

Policy objectives	Recommendation
Improve reporting and sectoral target setting for the mining sector.	A clear gap in current reporting is the lack of detailed information about CO_2e reduction in relation to the mining sector in NDCs. Most countries mention the mining sector but include it in the energy sector. GHG emissions reporting should clearly identify emission scopes. With the 2025 deadline approaching for new NDCs to be submitted, updated climate plans and commitments provide an opportunity for resource-rich countries to fill in this gap in their NDCs. For coal mining sectors, production reduction targets should be part of the NDCs.
Leverage NDCs to inform national development plans.	Governments can leverage the new NDCs to "lock in" and/or incentivize domestic policies on climate mitigation targeting the mining sector, including by engaging the mining sector to improve synergies in approaches and targets, given the pressure that the mining industry also faces to decarbonize.

Source: Authors.

5.5 Domestic Government Policy Mitigation Efforts: Balancing the benefits and challenges of decarbonization

How the Paris Climate ambitions will impact the mining sector in selected countries depends largely on the extent to which governments, businesses, and investors translate the ambitions into action plans and follow-up with actual implementation.

That said, domestic decarbonization efforts in selected countries vary, inter alia, depending on opportunities offered by the energy transition, as well as the distributional effects of climate mitigation actions proposed. Such variations help explain how some countries show more coherent and integrated climate mitigation policies (Chile) while others are still in development and are struggling to obtain societal approval (South Africa and Indonesia). This

equally reflects the sensitivity of climate change mitigation reforms as well as the historical legacy of the energy mix in countries with an emissions-intensive mining sector.

At the national level, there is strong merit in realizing the mining sector climate change mitigation and adaptation policies, which acknowledges that there will be "winners" and "losers" as a result of decarbonization efforts. However, for developing countries, there remain limited insights into what constitutes the appropriate policy mix for climate mitigation, combining compliance and market-based instruments and taking account of the importance and sensitivities of the mining industry.

TABLE 5. Policy recommendations: Balancing benefits and challenges of decarbonization

Policy objectives	Recommendation
Support government capacities to achieve transformations required by necessary climate actions	Although this is a country-specific objective, governments in mineral-rich countries, especially developing countries, need adequate support—including financial support—to implement international decarbonization ambitions to address the multiple challenges of • mitigating the impact of increased mining activities on national GHG emissions due to rising demand related to the energy transition; • energy security and affordability, which will affect the pace at which countries may be able to change their energy mix with more renewable energy technologies; • addressing socio-economic impacts that will result from the gradual phasing out of coal mining in coal-producing countries.

Source: Authors.

5.6 Energy Transition Benefits and Challenges Require New Models of "Shared Responsibility" Between Producing and Destination Countries

The rising demand for minerals and metals needed for the energy transition—driven largely by advanced, developed countries—is putting increasing pressure on developing producer countries to boost production levels. While the surging demand and production will undoubtedly create economic opportunities, more operations will also increase GHG emissions, especially if the energy systems are dependent on fossil fuels.

As a result, given the lack of visibility of the anticipated GHG emissions of future mining projects, the increased demand for energy transition minerals may compromise the climate ambitions of the producer country or slow down the implementation of its commitments. This calls for global collaboration and shared responsibilities between producer and buyer countries.

A mining sector-specific perspective from the case studies shows that domestic policies of governments toward decarbonization are more complex to realize in countries where the mining sector has more to lose. Realizing a just transition remains complex, as shown in the case of South Africa, with no ideal recipe on how just transition looks for mining sector mitigation consequences in terms of job losses.

Climate change mitigation remains a long-term commitment, and the challenges of domestic politics and electoral realities can prove a complicating factor.

TABLE 6. Policy recommendations: Relationships between producing and destination countries

Policy objectives	Recommendation
Design national frameworks informed by global best practices.	To advance government ambitions translating international NDC commitments into national frameworks, best practice guidance could be provided toward improved national frameworks on climate change mitigation and adaptation plans, with specific attention to coherence in the use of various instruments and policy mixes available. For countries with a large mining sector, the focus could be on how to ensure a balanced approach between compliance-based (i.e., GHG target-setting and reporting requirements) and market-based (i.e., carbon border taxes) approaches.
New global partnerships to support producer countries in realizing their NDCs.	**The principle of climate justice calls for a redefining of relations** between producer and buyer countries and governments to ensure fair distribution of benefits reaped from the energy metals produced and the burdens caused. **Advocacy and awareness raising at the international level** about the importance of having pathways to decarbonization that reflect the realities of countries at various levels of development. This should lead to concrete actions and commitments for shared responsibilities and innovative support (including financial support) to ensure producing countries under pressure to mine more for technologies that they may not be able to afford are not left alone to deal with all the challenges that come with increased mining activities.

Policy objectives	Recommendation
Improved global support to ensure energy transition is fair, just, and equitable.	Improved global collaboration is needed for Governments challenged by just transition consequences of mining sector mitigation. Such support should be context specific and demand driven (based on more elaborate needs assessments) and could possibly entail the following elements: • **Fact-based research on the impacts** of increased demand for minerals and metals, coupled with the need for the decarbonization of the sector. This should be based on systematic stakeholder engagement with local communities so that policy design reflects their needs. • **Public–private dialogues** to build trust, share perspectives, and design collective policy responses and pathways toward a responsible future for the mining sector.

Source: Authors.

5.7 The Role of Businesses in Climate Mitigation

Globally, multinational mining companies and those involved in the mining sector are advancing in climate change plans and actions, partially driven by increased domestic policies with mandatory disclosure and compliance, as well as industry standards and ambitions (such as ICMM).

The report shows that, with the exception of coal mining, most GHG emissions of mining companies are generated at the processing stage during smelting and refining operations. In many countries, and depending on the strategy of the mining operator, the processing stages are not conducted by mining companies, but by other companies, who buy ores and concentrates from mining to process further. Their GHG emissions are therefore accounted for separately, although technically, their emissions are related to the mining sector.

Given the lack of clarity on GHG accounting methods, especially for Scope 3 emissions, it is challenging to assess the extent to which decarbonization, and net-zero ambitions and responsibilities of global mining companies are in line with their actual footprint. Furthermore, limited insights exist regarding domestic mining sector climate mitigation ambitions and progress.

TABLE 7. Policy recommendations: Role of the private sector

Policy objectives	Recommendation
Improved data disclosure to enable accurate analysis of industry-level GHG emissions.	Governments must work with all stakeholders involved in the mining activities to report GHG emissions based on a standardized accounting method to enable industry-wide analysis and forecasting. These documents should be made public.
Leverage GHG emissions reporting to engage mining and processing companies to take concrete actions to decarbonize their operations.	Governments should consider adding decarbonization plans as part of the permitting process requirement. This could be similar to requirements to submit procurement or labour plans in the context of the permitting process, leveraging these policies to engage companies for concerted efforts.
Provide incentives to stimulate compliance.	Governments should consider introducing market-based instruments to incentivize mining and processing companies to fast-track investments to decarbonize their sectors.

Source: Authors.

6.0 Conclusion

This report sheds light on the critical intersection of the mining sector and global decarbonization efforts. With the pressing need to align with the climate goals outlined in the Paris Agreement, governments worldwide are committed to decarbonizing their economies through NDCs. However, achieving these goals requires a nuanced understanding of the mining sector's role, as it both supplies essential minerals for the energy transition and contributes significantly to GHG emissions.

The report examines the current state of the mining sector's decarbonization efforts and identifies key challenges and opportunities. Through case studies from Chile, Indonesia, and South Africa, the report provides insights into industry practices, regulatory frameworks, and technological innovations driving decarbonization.

Drawing on these insights, the report offers practical recommendations to support governments and industry in their decarbonization endeavours. From enhancing data quality for informed decision making to incentivizing businesses to decarbonize, the recommendations underscore the multifaceted approach required to navigate the complexities of decarbonizing the mining sector.

Ultimately, this report serves as a valuable resource for stakeholders seeking to understand and address the nexus of mining, decarbonization, and sustainable development. By fostering dialogue and collaboration, it contributes to advancing global efforts toward a more sustainable and resilient future.

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Appendix A. Standardizing Greenhouse Gas Emissions Information Across Governments and Industries: Greenhouse gas emissions inventories in NDCs

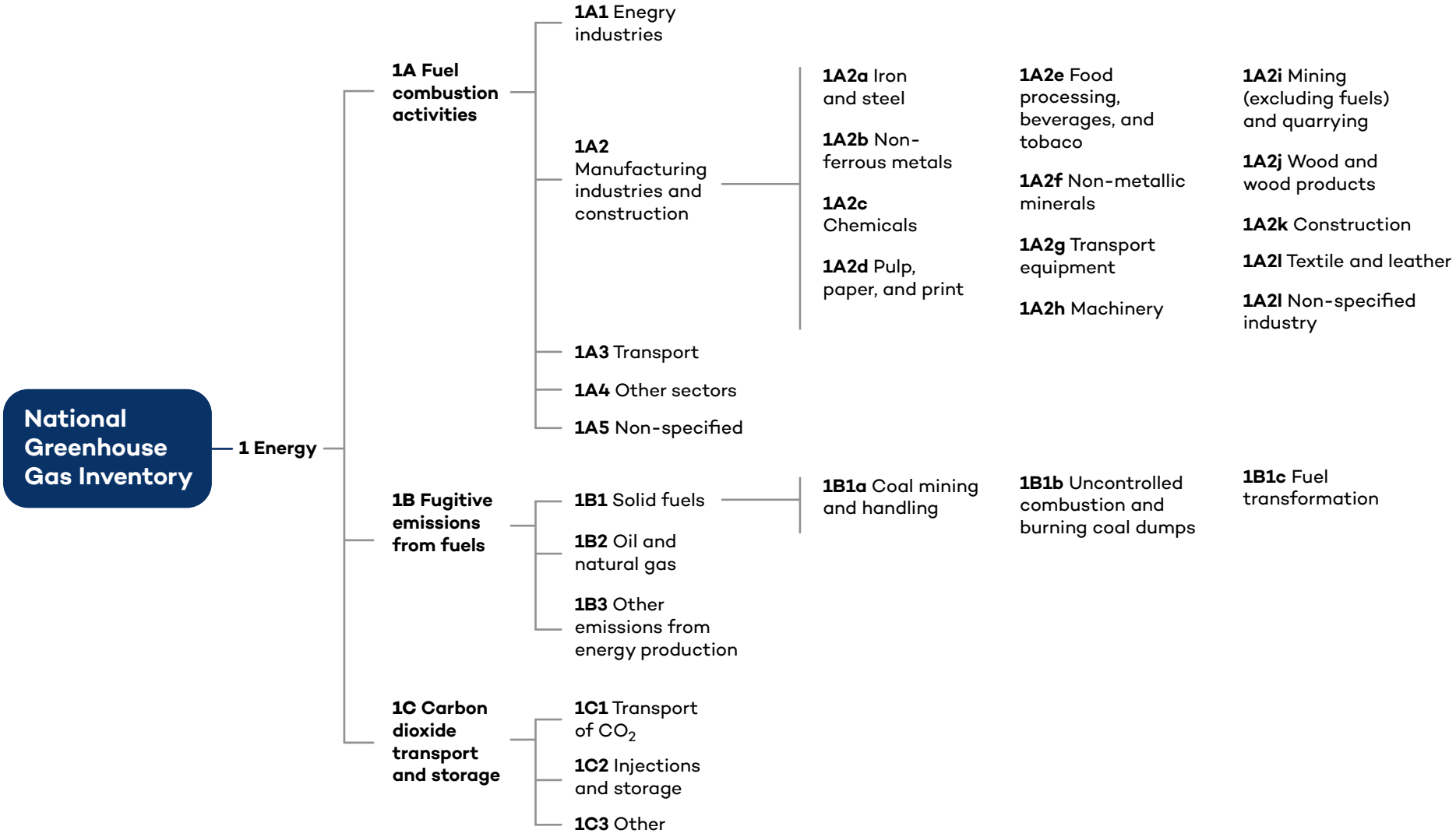
Decarbonization of industries and (national) economies requires accurate and reliable information with regards to greenhouse gas (GHG) emissions from a wide variety of industrial activities.

Whereas carbon accounting is fast becoming an integrated process in the mining sector, the methodologies and standards remain to be further refined. One of the most common tools for carbon accounting is the Greenhouse Gas Protocol (GHG Protocol, n.d.). Set up in the 1990s, it provides an international overarching accounting standard for companies to calculate their GHG emissions and measure the benefits of climate change mitigation projects.

The IPCC has produced guidelines for national GHG inventories (2006, updated in 2019), with specific guidance for industrial processes and product use (Taskforce on National Greenhouse Gas Inventories, n.d.). Based on the IPCC methodology, governments can make GHG inventories reflecting the GHG impact of a country's economic activities and its domestic carbon footprint.

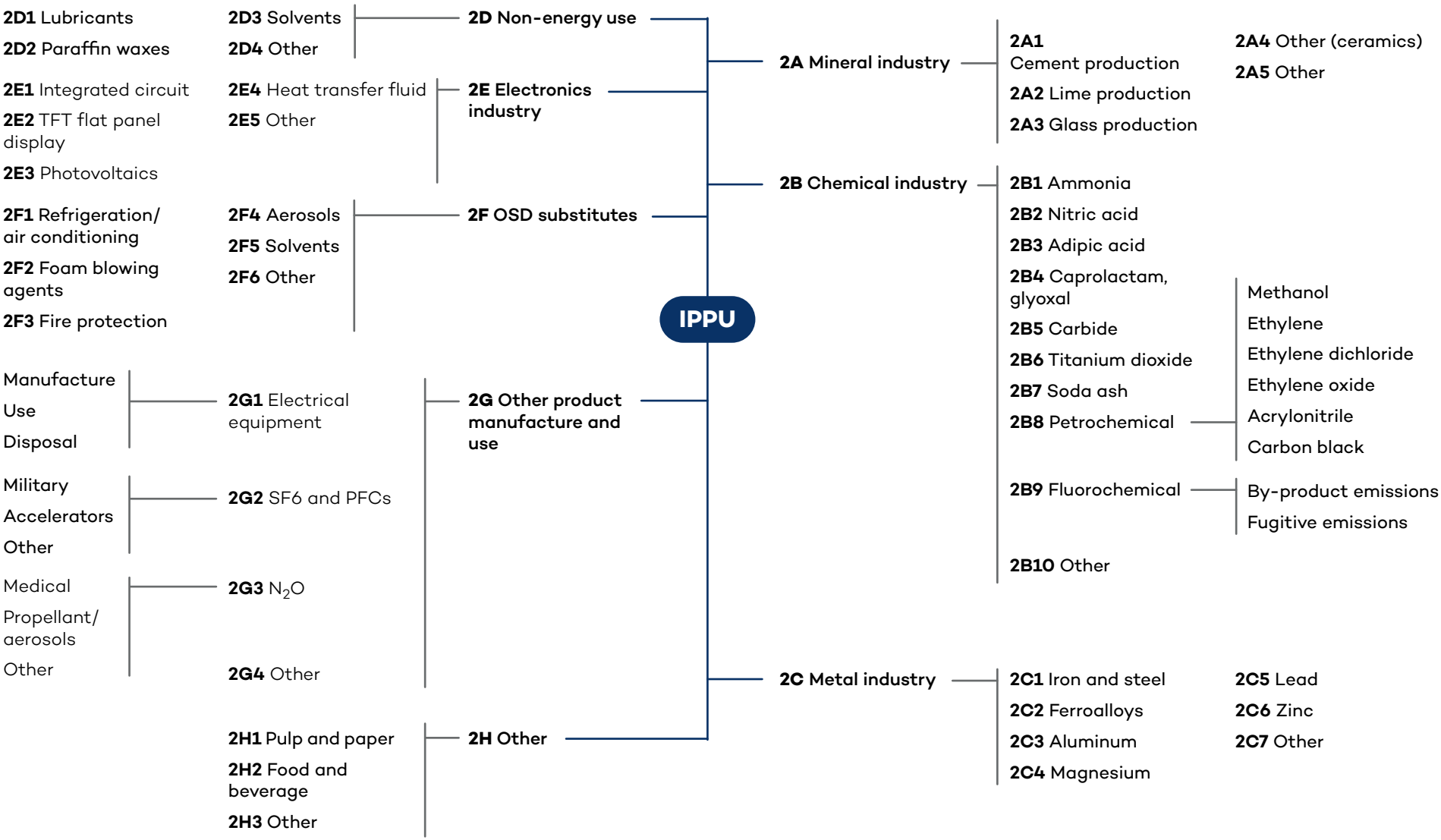
For non-Annex I Group countries, reporting is required only for CO_2, CH_4, and N_2O emissions. In contrast, Annex I parties must report on CO_2, CH_4, and N_2O, as well as perfluorocarbons, hydrofluorocarbons, sulfur hexafluoride, and nitrogen trifluoride (UNFCCC, 2013).

FIGURE A1. Intergovernmental Panel on Climate Change: Energy Category



Source: Garg, A., & Weitz, M. M. (2019).

FIGURE A2. Intergovernmental Panel on Climate Change: Industrial products and product use category



Source: Shermanau, 2019.

Reflecting on the value of the nationally determined contributions (NDCs) for the mineral sector, it is important to mention that the Intergovernmental Panel on Climate Change (IPCC) Guidelines for GHG Inventories distinguish between relatively broad categories:

- The "Energy" category reflects combustion activities emitting CO_2. It includes manufacturing industries such as iron and steel production, non-ferrous metal production, chemical manufacturing, pulp, paper and print, non-metallic minerals, and mining (excluding fuels) and quarrying. This broad category also includes fugitive emissions from fuels, such as coal mining and handling
- "Industrial Products and Product Use" (IPPU) category: it reflects GHG emissions occurring from industrial processes and from the use of GHG in products.

As shown in the Energy and IPPU charts presented in Figures A1 and A2, the mining sector, as defined in the mineral scope of this report, falls under the Energy category (1A2a Iron and Steel, 1A2b Non-Ferrous Metals, 1A2i Mining (excluding fuels) and Quarrying, and 1B1a Coal Mining and Handling) and the IPPU category (2C Metal industry).

Government reporting on national GHG inventories sometimes entails a broad reference to GHG emissions in the IPPU sector, including upstream (mining production and processing) as well as downstream (electronics, original equipment manufacturers processes and emissions as a result of product use) without proper allocation between Energy and IPPU.

Appendix B. Understanding Greenhouse Gas Emissions in Mineral Value Chains: Scope of emissions

Industrial processes produce and emit different types of greenhouse gases (GHGs), including CO_2, CH_4, N_2O, and hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. GHG emissions are produced at different stages of value chains.

To support businesses in their GHG emissions assessment and reporting requirements, the Greenhouse Gas Protocol (n.d.) distinguishes between three different scopes (1, 2, and 3). As part of the Corporate Accounting Reporting Standard, a global framework is offered for measuring and managing GHG emissions for all different sectors and industries. In addition, the framework prevents "double counting" in businesses' emissions reports.

Emissions generated directly by mining operations are referred to as **Scope 1 emissions**. This includes emissions from trucks and other machinery used at the mine site. The overall emissions of a mining company that are generally attributed to third-party facilities (this includes services such as electricity or steam) are referred to as **Scope 2 emissions. Scope 3 emissions** are generated by suppliers, third-party transportation services, and the processing and use of their products. Being largely out of control of the company, Scope 3 emissions are more complex to tackle.

When calculating GHG emissions, there is furthermore the need to distinguish between CO_2 and CO_2 equivalent (CO_2e), which measures CO_2 plus all other greenhouse gases, including methane, nitrous oxide, and more. The CO_2 equivalent emissions of other GHG gases vary strongly:

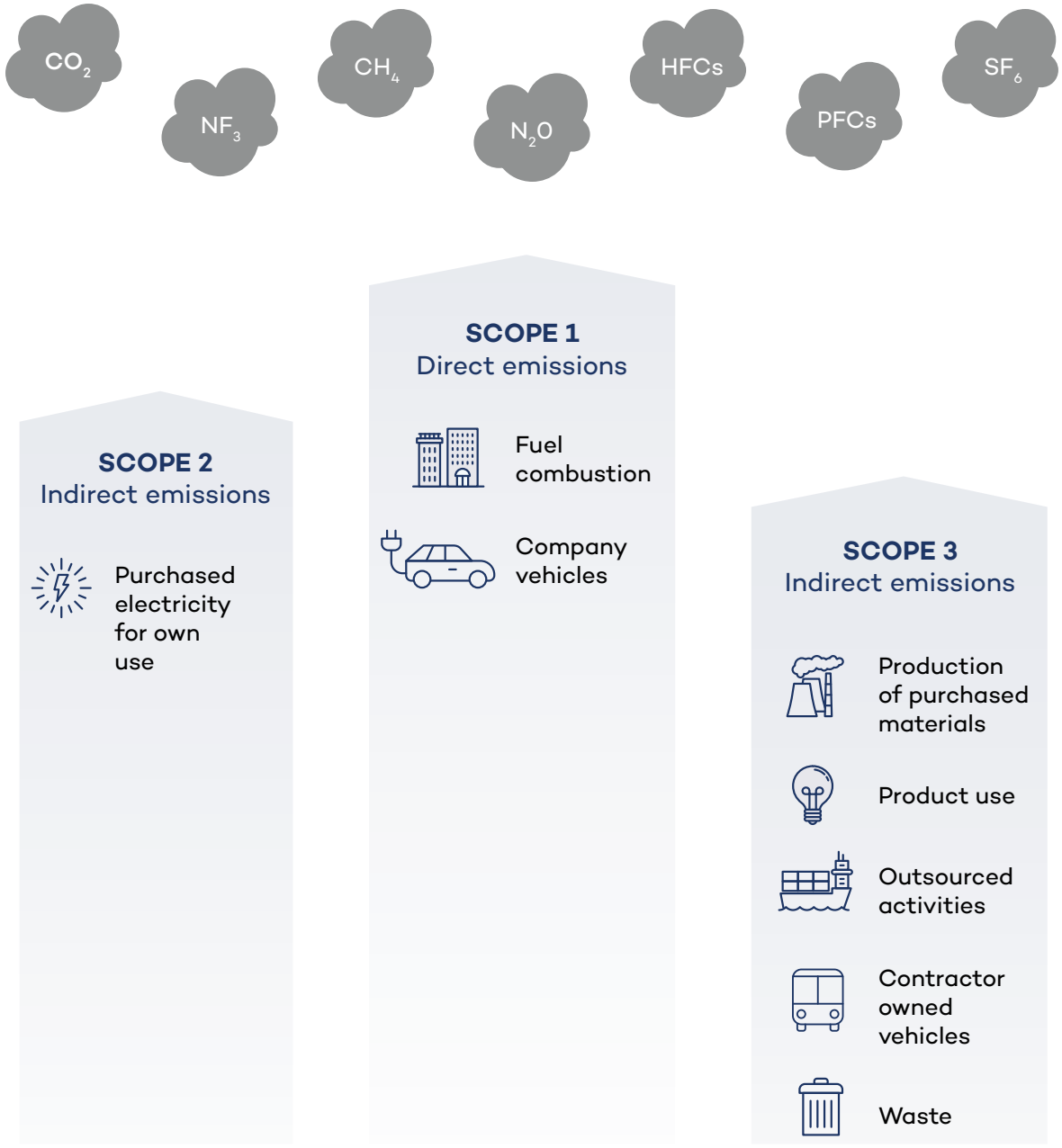
- 1 kg of nitrous oxide equals 298 kg of CO_2e.
- 1 kg of methane equals 25 kg of CO_2e.

Hence, CO_2e allows other GHG emissions to be expressed in terms of CO_2 emissions based on their relative global warming potential (GWP). GWP measures the warming that is contributed by each of the gases to the greenhouse effect.

Example: CO_2 has a GWP of 1, and CH_4 has a GWP of approximately 25 (on a 100-year time horizon). In other words, every tonne of CH_4 emitted has the equivalent warming potential of the emission of 25 tonnes of CO_2.

Emissions of GHG are generally expressed in megatons of CO_2e (Statistics Netherlands, n.d.).

FIGURE B1. Overview of scopes and emissions across a value chain



Source: Greenhouse Gas Protocol, n.d.

Appendix C. Greenhouse Gas Emissions Reduction Target Setting for Companies: Science-Based Targets initiative

Complementing government initiatives to drive more sustainable growth patterns and stay within temperature limits set by the Intergovernmental Panel on Climate Change (IPCC), the Science-Based Targets initiative (SBTi) (n.d.) aims at corporate efforts. It was launched in 2015 to support best practices in setting emissions reduction targets for greenhouse gas (GHG) emissions-intensive industries.

Through the SBTi, companies can set absolute GHG emissions reduction targets necessary to stay within a 1.5°C (or 2°C) temperature rise above pre-industrial levels. Sector-specific guidelines were developed including for aluminum and steel, currently resulting in pressure for the mining sector to assess and report on Scope 1 and Scope 2 emissions.

With the increased number of business actors across supply chains reporting according to SBTi methods, the initiative currently exercises pressure upstream including in the mining sector. Apart from sharing best practices, the SBTi Secretariat offers resources and guidance to reduce barriers to adoption, and independently assesses and approves companies' targets.

In the aluminum sector, the SBTi has created the Sectoral Decarbonization Approach, a method for developing science-based targets in the aluminum and other GHG-intensive industries.

Appendix D. Comparing Greenhouse Gas emissions and CO_2e emissions from energy in Chile, Indonesia, and South Africa (2006 and 2020)

TABLE D1. Comparative table of GHG emissions and CO_2e emissions from energy by Chile, Indonesia, and South Africa for 2006 and 2020

Greenhouse gas (GHG) and CO_2e emissions from energy*		2006	2020
Chile	Total GHG emissions (in Mt)	76.54	106.72
	Total CO_2e emissions from energy (in Mt)	57.15	86.26
Indonesia	Total GHG emissions (in Mt)	749.38	976.49
	Total CO_2e emissions from energy (in Mt)	364.47	563.20
South Africa	Total GHG emissions (in Mt)	493.82	501.52
	Total CO_2e emissions from energy (in Mt)	379.74	393.24

*Excl. land use, land-use change, and forestry [LULUCF].
Source: Climate Watch, 2024.

Appendix E. Summary of Climate Targets as per Latest Nationally Determined Contributions, Compared to Mining Sector-Specific Targets Under Domestic Policies for Chile, South Africa, and Indonesia

TABLE E1. Chile: GHG emissions reduction targets according to last nationally determined contribution (NDC)

Climate targets in NDCs (economy wide) vs national mining sector targets	Economy-wide targets	Mining sector-specific targets
Chile		
Formulation of target	• Reduce GHG emissions by 30% by 2030 compared to 2016 • Reduce GHG emissions potentially by up to 45% by 2030 compared to 2016	GHG emissions reduction by: • 57% in open pit copper mines • 74% in underground copper mining • 52% in other mining activities
Absolute emissions level in 2030 (excl. land use, land-use change, and forestry [LULUCF])	• (unconditional) 95 $MtCO_2e$ (111 $MtCO_2e$ in 2016)	• 2.38 $MtCO_2e$ reduction by 2030
Net-zero target	Carbon neutrality by 2050	

Source: Climate Action Tracker, n.d-a.

TABLE E2. Indonesia: GHG emissions reduction targets according to last NDC

Climate targets in NDCs (economy wide) vs national mining sector targets	Economy-wide targets	Mining sector-specific targets
Indonesia		
Formulation of target	• Reduce emissions by 32% against 2030 BAU (unconditional) • Reduce emissions by up to 43% against 2030 BAU (conditional)	• 0.7 $MtCO_2e$ emissions reduction (unconditional) • 0.9 $MtCO_2e$ emissions reduction (conditional) (see table below for details)
Absolute emissions level in 2030 (excl. LULUCF)	• (unconditional) 1,805 $MtCO_2e$ (150% above 2010) • (conditional) 1,710 $MtCO_2e$ (136% above 2010)	not given
Net-zero target	Not included in NDCs, but long-term scenarios given that might lead to net-zero by 2060	

Source: Climate Action Tracker, n.d-b; Republic of Indonesia, 2021, 2022.

TABLE E3. South Africa: GHG emissions reduction targets according to last NDC

Climate targets in NDCs (economy wide) vs national mining sector targets	Economy-wide targets	Mining sector-specific targets
Indonesia		
Formulation of target	• In 2030 South Africa's annual GHG emissions will be in a range from 350 to 420 $MtCO_2e$ (interpreted by Climate Action Tracker as an "unconditional' target")	• Sector-level targets not included in NDCs • Sector-level targets under development under new Climate Change Bill
Absolute emissions level in 2030 (excl. LULUCF)	• 366-436 $MtCO_2e$ (excl. LULUCF)	TBC
Net-zero commitment	• 2050 target (probably not achievable)	

Source: Climate Action Tracker, n.d.-c; Republic of South Africa, 2021, 2023.

Appendix F. Company Case Study on PT Vale Indonesia: Decarbonization and innovative collaborations in nickel supply chains

To provide company-specific insights on decarbonization efforts in selected case study countries, ambitions and implementation realities from one of the biggest operating mining companies provides relevant insights. This case study shares insights on (investments in) nickel smelting in Indonesia by the Brazilian company Vale.

How Does PT Vale Integrate Climate Ambitions in Nickel Supply Chain Investments in Indonesia?

Vale has invested in nickel smelting in Indonesia since 1978.

Vale has expressed the target to be carbon neutral, and PT Vale in Indonesia is part of this initiative, looking at ways to reduce carbon emissions. In 2021, Vale had revenue of USD 52,694 million. During the same year, Vale's total GHG emissions reached 505.2 $MtCO_2e$, with Scope 3 emissions making up 98% of the company's total GHG emissions. In response to the challenge of reducing emissions, Vale has established ambitious goals, aiming for a 33% reduction in Scope 1 and 2 emissions by 2030 and a 15% reduction in Scope 3 net emissions by 2035.

In its Conventional and Greenhouse Gas Emissions Reduction Policy Vale commits to reduce GHG CO_2e emissions by 33% by 2030 through a combination of efforts. These include reducing CO_2e emissions of the steam-producing boilers by switching to electrified boilers that run on hydropower, replacing lamps with LED, optimization of electrical energy use from various hydropower plants, and river-flow utilization programs for hydroelectric power generation.

PT Vale has been utilizing renewable energy to power its furnaces at the refining facility for more than 40 years. The Sorowako nickel smelter operates three hydropower plants with a combined capacity of 365 MW, reducing reliance on fossil fuels. By utilizing hydropower, PT Vale has avoided around 1Mt of CO_2e emissions per year compared to coal-based energy. Additionally, the electricity generated by these hydropower plants is shared with the East Luwu community through Perusahaan Listrik Negara (the state-owned electricity provider).

The company reporting on climate change ambitions and actions provides relevant information in relation to one dimension of the impact of the mining sector. However, external stakeholders have expressed concerns with regards to other dimensions, such as environmental practices around the nickel processing of Chinese companies for Tesla's car-manufacturing facilities in Indonesia. In November 2022, concerns were raised on "Tesla's nickel transactions with Chinese companies leav[ing] trails of pollution and environmental suffering" through the Business and Human Rights Resource Centre. Company responses were received from Vale and Huayou, but none received from Tesla (Business & Human Rights Resource Centre, 2022a). In December 2022, Vale responded with a set of clarification answers (Business & Human Rights Resource Centre, 2022b).

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