INTERGOVERNMENTAL FORUM
on Mining, Minerals, Metals and
Sustainable Development

IGF CASE STUDY

Decarbonization of the Mining Sector:

Case studies on the role of mining in nationally determined contributions in Chile, Indonesia, and South Africa

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Introduction, Context, and Initial Observations

In the journey toward limiting greenhouse gas (GHG) emissions, decarbonizing the mining sector is critical to aligning global industries with international climate commitments and achieving the objectives set out in the Paris Agreement. As the demand for minerals and metals essential for energy transition technologies surges, it becomes increasingly important to manage the environmental impacts of their extraction and processing.

This report, featuring case studies from Chile, Indonesia, and South Africa, delves into the role of the mining sector in national efforts to reduce GHG emissions and highlights the challenges and opportunities inherent in this transition. It serves as a background document to the main scoping study, *Decarbonization of the Mining Sector: Scoping Study on the Role of Mining in Nationally Determined Contributions* (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development [IGF], 2024).

Chile, Indonesia, and South Africa have been selected for their significant contributions to the global mining industry and their unique approaches to integrating decarbonization strategies within their national frameworks. These case studies provide a comprehensive understanding of how different countries are navigating the complexities of maintaining a robust mining sector, supplying the world with critical minerals for the dual energy and digital revolutions, and reducing emissions from coal mining and use while committing to substantial GHG emissions reductions.

For each case study, the role of the country in global mining production, as well as the weight of the mining sector in each domestic economy, is assessed. Then, GHG emissions at the country level and from mining-related activities are studied before focusing on international commitments and targets. Finally, national policies and approaches by countries to support the decarbonization of their mining sector are presented. These case studies show how countries can supply raw materials for the energy transition globally while ensuring that their mining sectors contribute to their national sustainable development.

Background and Context

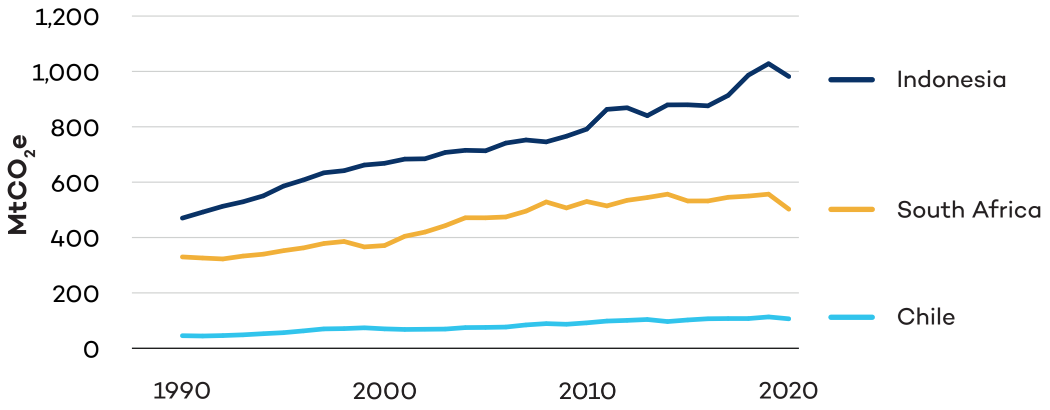
A major challenge for the mining and mineral extracting and processing sector is meeting the growing demand for mineral production while achieving ambitious GHG emissions reductions. In addition, for developing countries with a large mining sector, dealing with climate change adaptation and mitigation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

As the mining and refining sector is one of the larger industry emitters, governments need to consider sectoral emissions to set national- and international-level goals, devise policies, and implement GHG emissions reduction plans.

This study takes a deep dive into the country-level performance of GHG emissions, the role of the mining sector, and goals set in the nationally determined contributions (NDCs) that are relevant to mining sector decarbonization efforts. The focus countries—Chile, Indonesia, and South Africa—have all witnessed a steady increase in their energy emissions, as displayed in Figure 1. These three countries were chosen as case studies because (i) they are major mining countries; (ii) they cover three different geographies; (iii) they have a significant but differentiated exposure to coal mining and coal consumption; and (iv) they all hold major reserves of different critical minerals.

This report asks the central questions: What is the GHG emissions profile of the mining sector in each of these countries?

FIGURE 1. Summary of GHG emissions in Chile, Indonesia, and South Africa from 1990 to 2020



Source: Climate Watch, 2024.

How is the mining sector currently targeted through climate change mitigation goals as part of each government's international commitments (through NDCs) and national policy frameworks?

Approach and Benchmarking Indicators

The primary focus of the research was to obtain country-level data on GHG emissions of the domestic mining sector. Broader research and analysis on the national-level domestic policy context have been conducted to enrich the picture and give a general perspective. This allows a comparison between countries, their actual emissions, government ambitions as reflected in their NDCs, and opportunities and challenges in achieving progress toward GHG emissions reductions.

To compare country-level performance on decarbonization and climate change, desk-based research identified relevant indicators and information sources, focusing on the following:

1. **Country-level emissions of the mining sector**, extraction, and processing activities. Key indicators:
    - emissions from mining and smelting operations in absolute terms and as a percentage of total national emissions (Scope 1 and 2 emissions).
    - gross emissions intensity of mining activity: tonnes of carbon dioxide equivalent (CO_2e) emitted per dollar of output at a sectoral level.
2. **International climate change commitments** made by governments through their NDCs. Key indicators:
    - mention of the mining sector as a contributor to climate change risks and/or partner in climate change mitigation and adaptation efforts.
    - NDC commitments directly relevant to the mining sector.
3. **National government policies and approaches**. Key indicators:
    - approaches and actions selected to translate NDC commitments

into national actions targeting the mining sector.

- national or sub-national policies seeking to lower mining-related GHG emissions or support mining companies adapting to the impacts of climate change.

The NDC documents provided by the respective countries to the United Nations Framework Convention on Climate Change (UNFCCC)[1] have served as a basis to explore the countries' plans for the mining sector's contribution to emissions reduction. In addition to primary documents, the team used secondary resources, including studies and tools such as the Climate Action Tracker[2] and the International Monetary Fund (IMF) Climate Change Dashboard,[3] comparing NDC commitments and progress on an ongoing basis.

Case studies presented in this report will show a variety of disclosure practices, specific commitments and targets, and policy actions aimed at decarbonizing the mining sectors in Chile, Indonesia, and South Africa.

Initial Observations

The case studies confirm that the mining sector is a crucial economic driver for resource-rich countries, not to mention its vital role in supplying the minerals needed for the energy transition. They also highlight the challenges faced by resource-rich developing countries in creating and implementing policies and securing funding for a "just transition" while meeting decarbonization commitments under the Paris Agreement.

The three country case studies show a correlation between climate change mitigation policies, mining-derived GHG emissions, and decarbonization, as supported by country-level data. Ambitious domestic climate change mitigation policies, as seen in Chile, are beginning to yield results, leading to significant decarbonization and high percentages of renewable energy use in the mining industry.

The main difficulty of comparing country-level performance on decarbonization and climate change, and a main finding of this research, lies in the fact that mining is often not identified per se in most countries' NDCs. Therefore, most of the reporting and targets related to the mining sector are not directly comparable between countries. Some proxies must then be used for analysis, but because they are different for each country, any direct comparison remains difficult. On the one hand, Chile reports on its GHG emissions related to mining and has sector-specific reduction targets. On the other hand, both Indonesia and South Africa have their emissions from mining aggregated within the energy category under the manufacturing industries and construction and under the Industrial Products and Product Use category.

These case studies are the basis of a main scoping study (IGF, 2024), which presents recommendations to improve mining sector contributions to achieving countries' NDCs. Disaggregated data should be the first step in assessing actual GHG emissions from mining and identifying priority actions for the mining sector's contribution to national decarbonization objectives.

[1] The UNFCCC entered into force on March 21, 1994. It currently has 198 member countries, and its ultimate aim is to prevent "dangerous" human interference with the climate system. For more information, see: https://unfccc.int/

[2] See the Climate Action Tracker here: https://climateactiontracker.org/

[3] See the International Monetary Fund's Climate Change Indicators Dashboard here: https://climatedata.imf.org/

Mining and NDCs: The cases of Chile, Indonesia, and South Africa

Case Study 1: Chile

Context and Role of the Mining Sector

Chile is the world's biggest producer of mined copper, with 24% of global production in 2022 (U.S. Geological Survey [USGS], 2023a). Over the last 2 years, copper, lithium, iron, and molybdenum were Chile's main export products, with a total value of USD 111.89 billion (S&P Capital IQ, 2023).

Considering the rising global demand for lithium, Chile is an important player, as the world's second-largest lithium producer after Australia, and the host of the largest known quantity of commercially viable lithium reserves in the world (USGS, 2023b). The country accounts for 24%—equal to 235,000 tonnes (lithium carbonate equivalent)—of global lithium production (S&P Capital IQ, 2024a). In Chile, lithium is produced from brine in the Atacama Desert in the salt plains bordering Bolivia.

In terms of employment, Chile's mining industry provided 263,000 direct jobs in large-scale mining between March and May 2022, an increase of 21.4% compared to the same period in 2021 (BNamericas, 2022).

In 2020, the mining sector contributed 17.73% to the national GDP, according to the International Council on Mining and Metals (2022). These numbers show the importance of the mining sector for the Chilean economy. In April 2023, Chile's newly elected president announced government plans to have greater control of the lithium industry in Chile (Villegas & Scheyder, 2023). This would mean that future lithium contracts would only be issued as public–private partnerships with state control.

TABLE 1. Historical Chile GHG emissions in 2006 and 2020

GHG emissions (excluding LULUCF)	2006	2020
Total GHG (in Mt)	76.54	106.72
CO_2e from energy (in Mt)	57.15	86.26

Source: Climate Watch, 2023a.

Country-Level Emissions of the Mining Sector

Looking at economy-wide GHG emissions, according to the IMF, Chile's total GHG emissions in 2021 were 124.41 Mt (excluding land use, land-use change, and forestry [LULUCF]), up from 90.61 Mt in 2005 (IMF, 2023). The data slightly differs according to Climate Watch, as presented in Table 1.

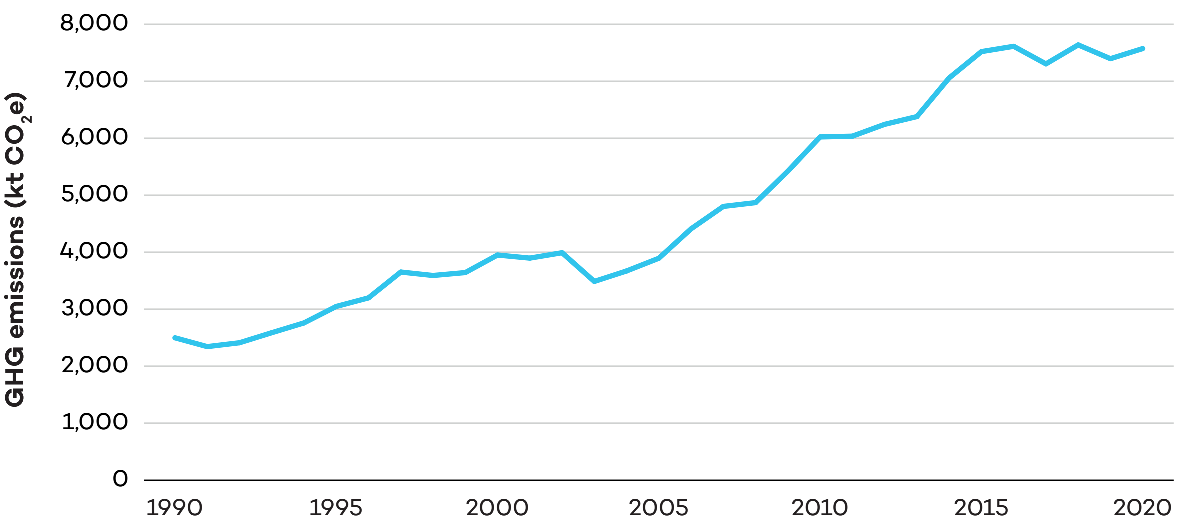
Climate Watch data also puts Chile's GHG emissions at 106.72 Mt in 2020, representing 0.10% of global emissions (Climate Watch, 2024). Historical data on GHG emissions, derived from Climate Watch data, show that Chile's total emissions have grown rather moderately over the past decade. Only 4.5% of GHG emissions are generated as a result of industrial processes. Energy accounts for 80% of emissions in Chile. It is unclear whether that includes mining. Overall, GHG emissions in Chile have increased by 114.7% since 1990 and 20.0% since 2007.

Data on emissions in Chile's mining sector are included as part of a sectoral focus in the *Biennial Update Report* (BUR) (Department of Mitigation and Transparency, 2023). As Figure 2 shows, GHG emissions from mining, especially copper mining and other mining activities (this also includes lithium), have tripled between 1990 and 2020. Reasons for that are the increase in mining activities, largely due to rising copper prices as well as rising demand over that period, on the one hand, and the increased consumption of diesel for mining of other minerals on the other hand.

Another set of emissions caused by the Chilean mining sector is coal mining and coal handling. This includes active open-pit and underground mines, as well as GHG emissions caused in the post-mining process, referring to processes related to mine closure. Figure 3 shows that they only make up less than 5% of the GHG emissions from copper mining. As coal mining has been decreasing in Chile for a few years, these numbers are expected to continue to decline.

Finally, as communicated in the 5th BUR report by the Government of Chile (2022), the Chilean mining industry is making significant progress in the use of

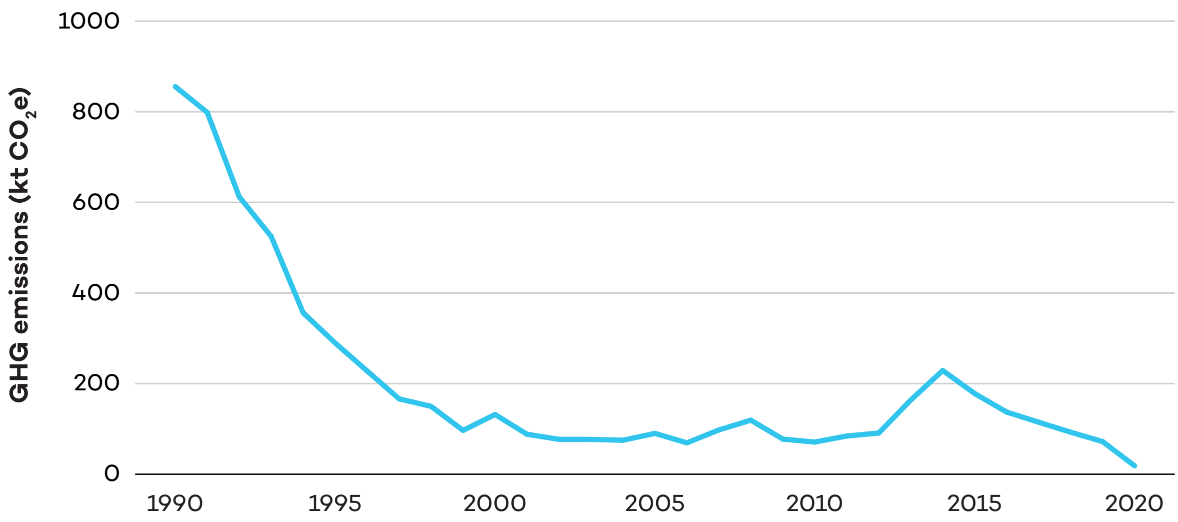
FIGURE 2. GHG emissions from the mining sector (1.A.2.i)* in Chile between 1990 and 2020



**Note: 1.A.2.i is a subsection of the energy category as defined in the Intergovernmental Panel on Climate Change (IPCC) nomenclature. For more information on IPCC classification, see IGF, 2024, Appendix A.*

Source: Department of Mitigation and Transparency, n.d., 2023.

FIGURE 3. GHG emissions from the coal mining and handling sector (1.B.1.a)* in Chile between 1990 and 2020



**Note: 1.B.1.a is a subsection of the energy category as defined in the IPCC nomenclature. For more information on IPCC classification, see IGF, 2024, Appendix A.*

Source: Department of Mitigation and Transparency, n.d., 2023.

renewable energy. Already in 2021, 44% of mining electricity consumption is from low GHG emissions sources, and in 2025, it is expected that 62% of the industry's electricity demand will come from solar and wind energy sources.

NDC International Climate Change Commitments

Chile's NDC versions and updates: The Chilean government published its first NDC (at the time called Intended Nationally Determined Contributions) in 2016. The document was updated and submitted to the UNFCCC in 2020 (Government of Chile, 2020). The 5th BUR was communicated in December 2022 (Ministry of the Environment, 2022) and offers extensive information on Chile's way forward in reducing GHG emissions.

References to the mining sector: Despite Chile being a large mining country, its updated NDC treats emissions reductions in the mining sector mainly as part of its ambitions in the energy sector.

Emissions reductions: In its NDC document, and as summarized in Table 2, Chile sets an absolute annual emissions target of 95 $MtCO_2e$ unconditionally by 2030 (excluding LULUCF) and committed to peaking emissions in 2025. This is a much higher target than the one set in Chile's 2015 NDC, where the country committed to an annual emissions target of 123 $MtCO_2e$. According to its last NDC report, Chile aims to be carbon neutral by 2050 and intends to use a GHG emissions budget of no more than 1,100 $MtCO_2e$ from 2020 to 2030.

Mining-sector emissions reduction targets: Chile's latest NDC includes mining-specific GHG emissions reduction targets by 2050:

- reduction by 57% in open-pit copper mines
- reduction by 74% in underground copper mining
- reduction by 52% in other mining activities

Reductions in GHG emissions should be achieved using electric vehicles in mining

TABLE 2. Summary of Chile's climate targets as part of the latest NDC, compared to mining sector-specific targets under domestic policies

Climate targets in the NDC (economy wide) vs. national mining sector targets	Economy-wide targets	Mining-sector specific targets
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 (excluding 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: Government of Chile, 2020.

operations to reach carbon neutrality. Other potential measures in mining include thermal electrification and hydropower. However, it needs to be pointed out that it is clearly stated in the NDCs that these measures might or might not be reflected in sectoral mitigation plans (Government of Chile, 2020). The 3rd BUR (Government of Chile, 2018) sets as its objective a reduction of GHGs in the sector of industry and mining of 2.38 $MtCO_2e$ by 2030. Furthermore, the Chilean government aims to incorporate energy efficiency in assessments and designs of future mining operations to reduce GHG emissions caused by fuel consumption in mining.

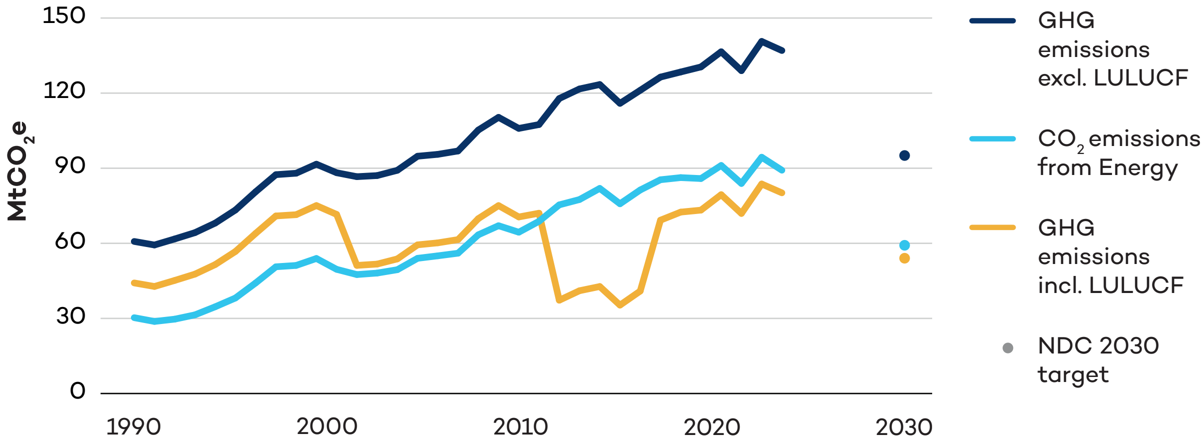
According to the Climate Action Tracker (2023a), Chile's updated 2030 NDC target is rated as "almost sufficient" when compared to modelled domestic pathways and "insufficient" when compared to its fair share contribution to climate action.

A comparison of actual GHG emissions compared to targets set by Chile in its last NDC is proposed in Figure 4.

Another important factor to mention is that Chile pledged to exit coal mining by 2040. This is also mentioned in their NDCs as one of their strategies to reduce GHG emissions. There is no mention of whether this also includes a pledge to end the use of coal as part of the energy mix. Figure 5 illustrates the evolution of Chile's energy mix. It shows that oil is the largest energy source, almost stable for the last 15 years, and that coal and biofuel use is dropping while renewable energy is experiencing steady growth.

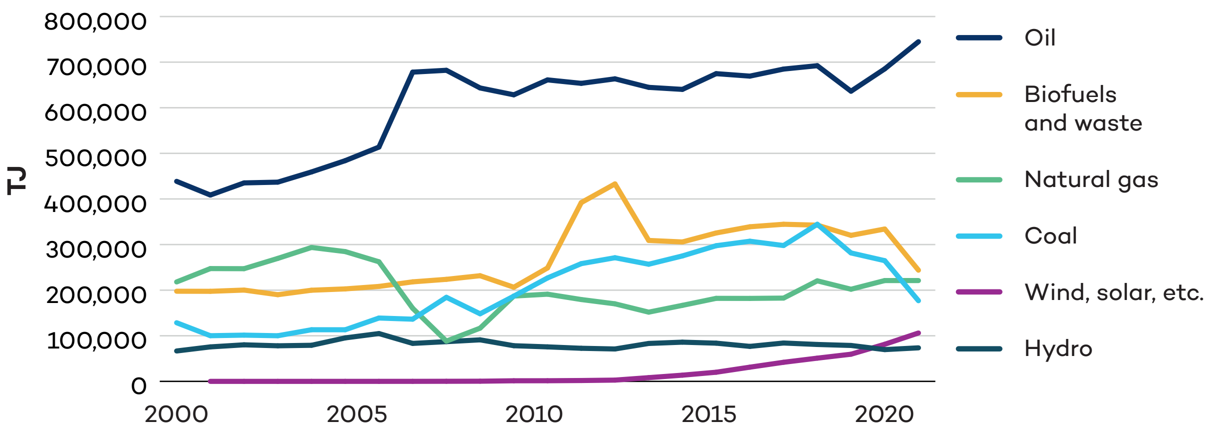
The updated NDC also enhances its adaptation component by updating its national adaptation plan and prioritizing the water sector. Given that lithium in Chile is primarily found in the Atacama Desert, one of the driest places on earth, water potentially plays a role in Chile's lithium production. Yet it needs to be noted that direct conflicts over water use associated with lithium mining in Chile are limited, as the brine from which lithium is extracted cannot be used for either human consumption or agricultural purposes. Much more water is used in copper mining, especially processing. Prioritizing the water

FIGURE 4. Reported GHG emissions vs. NDC targets from 1990 to 2022 – Chile



Source: IMF, 2023.

FIGURE 5. Total energy supply by source, Chile 2000–2022



Source: International Energy Agency (IEA), 2024a (CC BY 4.0).

sector in the NDC is thus related to the mining sector. The documents do not spell out how and to what extent this would impact mining activities.

National Government Policies and Approaches

Chile's rather robust national institutions, which provide stability to mining activities, make it comparatively advantaged and position it as a reference or benchmark for other countries in the region to emulate or learn from when it comes to mining.

As presented in Chile's 5th BUR, the recently launched National Mining Policy 2050 sets short- (2025), medium- (2030), and long-term (2050) goals for the mining sector and the government. The objective is to achieve a responsible mining sector that provides the minerals needed for the global energy transformation (Ministry of the Environment, 2022).

The Action Plan for Energy Efficiency policy imposes efficiency actions in different sectors, including the mining sector. It was disclosed in 2013 and is currently in the implementation phase. Further laws supporting the implementation of the Chilean contribution to the Paris Agreement include the Unconventional Renewable Energy Law (Law 20.257/2008), the Carbon Tax Law (Law 20.780/2014), the Energy Efficiency Law (Law 21.305/2021), and the Climate Change Framework Law (21455). None of these focuses on the mining sector, yet they touch upon the mining sector as a contributing sector on the path to climate neutrality. This is in line with the NDC mentioning mining as one factor for GHG emissions reduction, yet the assigned measures are related to energy and electrification.

Case Study 2: Indonesia

Context and Role of the Mining Sector

Indonesia is the world's largest nickel producer, accounting for more than half of global production (53%) (S&P Capital IQ, 2024b), witnessing a sharp increase from less than 40% in 2021 (USGS, 2023c). As cobalt is associated with nickel deposits, Indonesia is also a major cobalt producer—the second-largest in the world—accounting for more than 10% of global production.

In 2023, Indonesia accounted for 4% of global copper production, 3% of gold, and produced significant quantities of silver (S&P Capital IQ, 2024b). Indonesia is also the third-largest coal producer worldwide, with production of 641 Mt in 2022, representing an increase of 12% from the previous year (IEA, 2023).

The rapidly increasing global need for nickel is playing into Indonesia's hands. The export value of processed nickel contributed significantly to government revenues in 2022, reaching USD 30 billion, a significant increase from just USD 6 billion in 2013 (Prakash, 2024). Yet, the mining sector makes up only 2.62% of Indonesia's national GDP (International Council on Mining and Metals, 2022).

In terms of **employment**, the mining and quarrying sector in Indonesia employs over 1.4 million workers, equaling 1.1% of the country's total workforce (IMF, 2021).

Country-Level Emissions of the Mining Sector

Indonesia is one of the world's top 10 largest GHG emitters. In 2021, the country was the sixth-largest GHG emitter, with a total of 1,475 GtCO_2e, representing 3.11% of global emissions (Climate Watch, 2023b).

Historical data on GHG emissions derived from Climate Watch data (Climate Watch, 2023b) show substantial growth between 2006 and 2020.

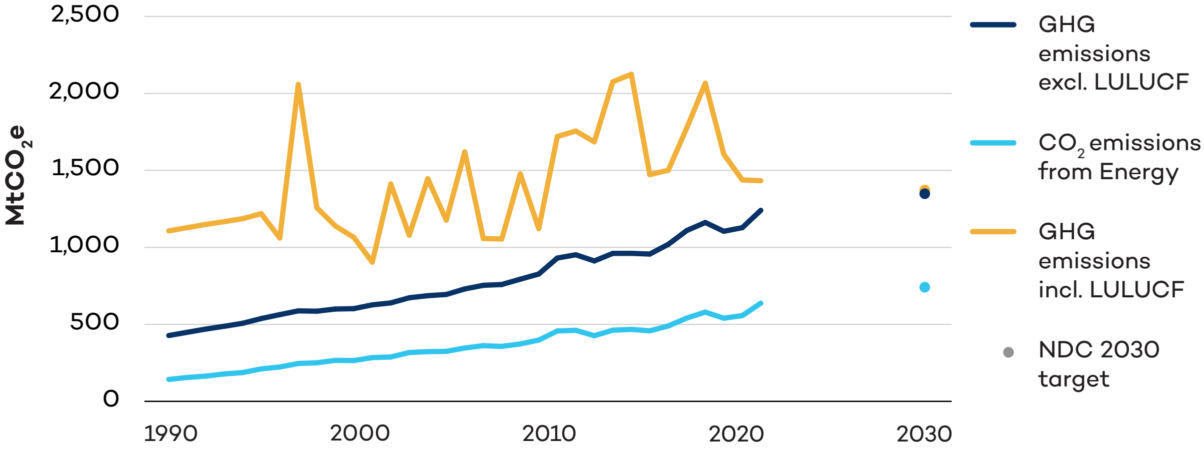
In 2021, Indonesia's GHG emissions (without LULUCF) were at a historical high of 957 MtCO_2e (Climate Action Tracker, 2023b). As Figure 6 shows (IMF, 2023), GHG emissions in Indonesia could have been even higher and, moreover, have been on the rise for the past 30 years. Even if numbers differ slightly, the overall picture and trends are similar. Furthermore, according to a report from Ember (2024), emissions related to coal mining disclosed by Indonesian authorities,

TABLE 3. Historical Indonesia GHG emissions in 2006 and 2020

GHG emissions (excluding LULUCF)	2006	2020
Total GHG (in Mt)	745	982
CO_2e from energy (in Mt)	434	656

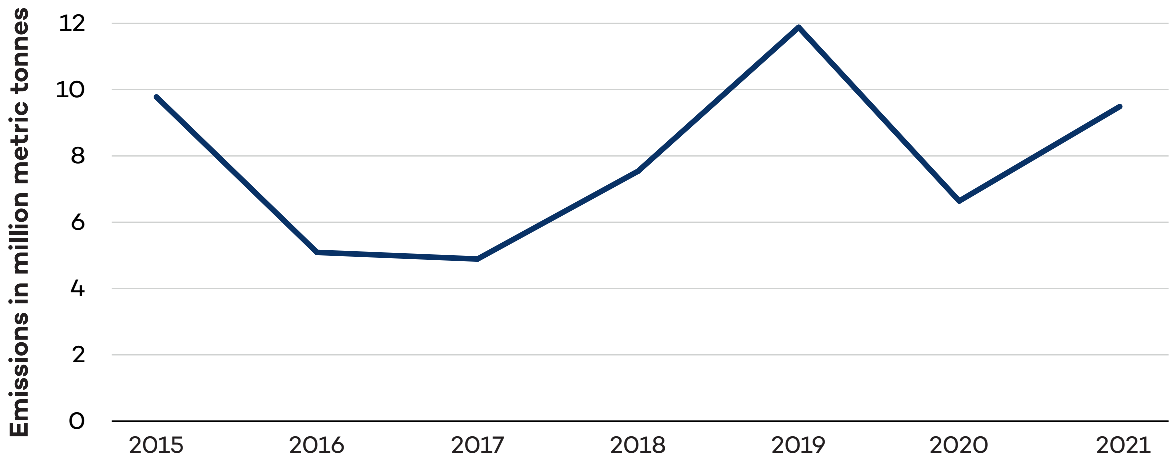
Source: Climate Watch, 2023a.

FIGURE 6. Reported GHG emissions vs. NDC targets from 1990 to 2022 – Indonesia



Source: IMF, 2023.

FIGURE 7. CO_2e emissions from the Indonesian mining sector between 2015 and 2021



Source: Statista, 2023.

especially fugitive emissions, need to be considered with caution, as they could be six to seven times higher, according to independent estimates.

Figure 7 shows the GHG emissions from mining and quarrying industries in Indonesia from 2015 to 2021 (in $MtCO_2e$). This includes all mining production except coal. As part of its third BUR (Republic of Indonesia, 2021a), Indonesia reported economy-wide and sector-specific GHG emissions. However, data from metallic mining are not identified in the energy category and are grouped with agriculture and construction under the “1A5 Non Specified Category” due to limitations in resources allocated for such survey activity. Emissions from coal mining are reported under the energy category, and, moving downstream the mineral value-chain, the mining sector is also part of the “Industrial Products and Product Use” category for the processing stage.

NDC International Climate Change Commitments

Indonesia's NDC versions and updates:

- **Latest NDC (and updates)**: The Indonesian government published its updated NDC in 2022 (Republic of Indonesia, 2022). It constitutes an adapted version of their first NDC from 2016.
- **Latest BUR**: In 2021, Indonesia published its third BUR, which consists of updates on national the GHG inventory, including a national inventory report and information on mitigation actions, needs, and supports received (Republic of Indonesia, 2021a).
- **Latest GHG Emissions National Inventory Report**: December 2021, as part of the third BUR.

Reference to the mining sector: The updated NDC (2022) hardly mentions the mining sector. It does, however, set sector-specific CO_2e emissions reduction targets for certain mining-related industrial processes and product uses, such as iron and steel smelters and aluminum processing plants (i.e., downstream activities, such as smelting and refining). It further attributes direct measures to reduce CO_2e emissions to post-mine closure activities, such as the reforestation of former mine sites. It should be emphasized that emissions from the upstream mining sector are not identified, justifying the use of mid- and downstream activities as a proxy, recognizing evident

TABLE 4. Summary of Indonesia's climate targets as part of the latest NDC, compared to mining sector-specific targets under domestic policies

Climate targets in the NDC (economy wide) vs. national mining sector targets	**Economy-wide targets**	**Mining-sector specific targets** (proxy used is Industrial Processes and Product Use, the metal industry: aluminum, iron, and steel)
Formulation of target	• Reduce emissions by 32% against 2030 BAU (unconditional) • Reduce emissions by up to 43% against the 2030 BAU (conditional)	• 0.7 $MtCO_2e$ emission reduction (unconditional) • 0.9 $MtCO_2e$ emission reduction (conditional) *(see Table 5 for details)*
Absolute emissions level in 2030 (excluding LULUCF)	• (Unconditional) 1,805 $MtCO_2e$ (150% above 2010) • (Conditional) 1,710 $MtCO_2e$ (136% above 2010)	not given
Net-zero commitment	Not included in NDC, but long-term scenarios given that might lead to net-zero by 2060	

Source: Republic of Indonesia, 2021a, 2022.

TABLE 5. Mining-related mitigation actions in Indonesia's NDC

Sector	BAU scenario	Counter Measure 1 (unconditional mitigation scenario)	Counter Measure 2 (conditional mitigation scenario)
Aluminum industry	CWPB (centre work pre-bake cell tech.)	Maintain improved plant operation (automation of feeding system/hardware improvement from CWPB to bar-brake technology)	n/a
		GHG emissions reduction target is 0.1 Mt CO_2e	
Iron and steel industry	No mitigation	Improvement of smelter processes and scrap utilization	Further mitigation activities in process for improvement of smelter and scrap utilization
		GHG emissions reduction target is 0.6 Mt CO_2e	GHG emissions reduction target is 0.9 Mt CO_2e
Post-mine reclamation	No additional post-mine reclamation since 2010	81,069 ha of additional post-mine reclamation	Further expansion of post-mine reclamation
		No GHG emission reduction target given	No GHG emission reduction target given

Source: Republic of Indonesia, 2022.

limitations in conclusions that can be drawn from such data.

Emissions reductions: Indonesia's updated NDC targets were submitted in September 2022. As summarized in Table 4, the updated targets include increased unconditional (from 29% to 32% below the business-as-usual [BAU] scenario) and conditional (from 41% to 43%) targets, including emissions from LULUCF.

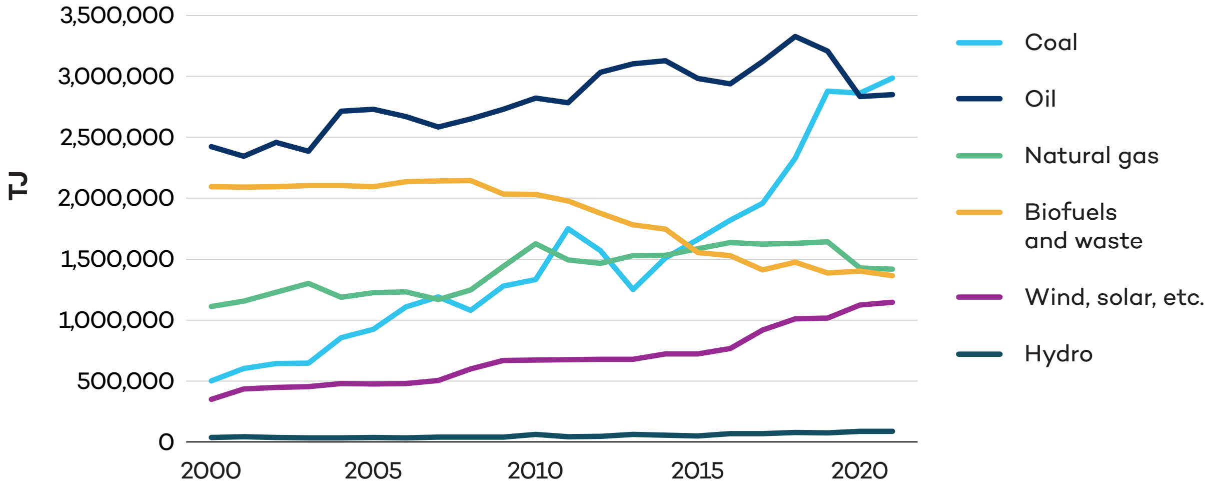
Climate mitigation policy implementation: The Indonesian government created measures according to the different scenarios: (i) BAU, (ii) following their unconditional mitigation plan, and (iii) implementing the conditional mitigation plan. Table 5 illustrates how specific measures foreseen in the NDC related to some parts of the mining sector would contribute to either of the three scenarios. Unfortunately, only downstream activities, such as smelting and refining, are identified in the NDC; extraction and processing are not.

According to its unconditional mitigation plan, Indonesia can reduce its emissions to 1,953 MtCO_2e by 2030. If it manages to implement its envisioned conditional mitigation plan, Indonesia's emissions can be reduced to 1,632 MtCO_2e. This compares to a projection of approximately 2,869 Mt CO_2e under a BAU scenario. Depending on the successful implementation of its mitigation plan, Indonesia has the potential to reduce its emissions by 30%–45% by 2030 (Cahyono et al., 2022).

National Government Policies and Approaches

The 2022 NDC (Republic of Indonesia, 2022) is aligned with the Long-Term Strategy for

FIGURE 8. Indonesia's energy mix from 1990 to 2022



Source: IEA, 2024c (CC BY 4.0).

Low Carbon and Climate Resilience 2050 (Indonesia, 2021b). This strategy develops a vision to achieve net-zero emissions by 2060 or sooner. Moreover, the NDC also emphasizes the need to balance between emissions reductions and economic development in its long-term strategy.

Like most countries, Indonesia puts more emphasis on energy than on the mining sector itself in its pursuit of reducing GHG emissions. This is also reflected in Presidential Regulation No. 22/2017 on the National Energy Grand Plan (Republic of Indonesia, 2017), which aims for 23% new renewable energy in Indonesia's national energy mix by 2025 and to reduce energy intensity by 1% per year.

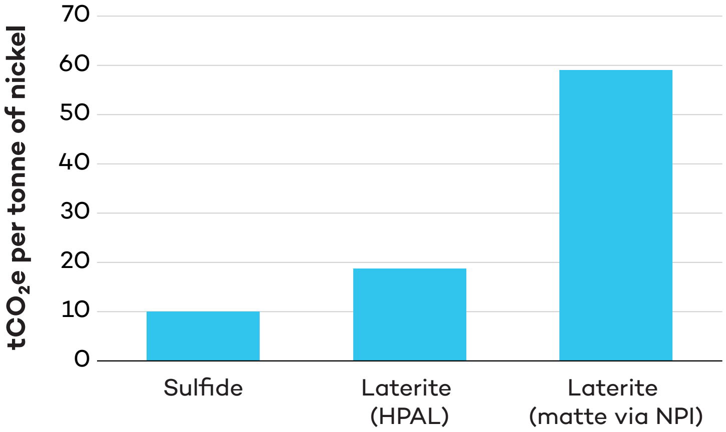
Figure 8 shows Indonesia's energy mix over the past 30 years, up to 2022. Today, coal is not only the major source of energy for Indonesia but has also been massively increasing over the past 10 years.

Indonesia further adopted **nationalization policies**, especially regarding bauxite and nickel. On January 11, 2014, then-Indonesian President Yudhoyono signed a regulation banning the export of unprocessed nickel and bauxite ores, which was reinforced in 2023 regarding bauxite ores. While some ore with nickel grade below 1.7% could legally be exported from 2017 to 2019, any export of raw ore has been forbidden since January 2020. With this ban, the country wanted to push miners and processors to build smelters in the country, thereby increasing domestic value addition related to its mineral resources while contributing significantly to an increase in GHG emissions.

While mining activities remain the most prominent, the government succeeded in attracting more processing (smelting) facilities to derive added-value benefits from nickel production. In 2023, Indonesia was operating 43 nickel smelters in Sulawesi and the Maluku Islands. A further 28 plants are under construction, and 24 are in the planning stages (Grace & Ayu Cindy, 2023). Many of these smelters are financed by Chinese companies. Foreign direct investment (FDI) in Indonesia in 2022 was dominated by the base metal and mining sectors, which saw more than USD 16 billion in FDI combined (Sulaiman & Suroyo, 2023).

The Indonesian government considers mining a key sector for economic development. Currently, President Joko Widodo's government has continued and extended the export ban on nickel ore with the objective of turning Indonesia into an electric vehicle

FIGURE 9. GHG emissions intensity for Class 1 nickel by resource type and processing route



Source: IEA, 2021 (CC BY 4.0).

(EV) powerhouse by benefiting from its nickel reserves. Indonesia is aiming to be a global EV manufacturing hub and one of the top three global producers of EVs and EV batteries by 2027. The government has courted major EV makers, such as Tesla and China's BYD, to establish their operations in the country (Falak Medina, 2023). Yet, this ambition to contribute to decarbonized mobility has its flipside.

The nickel industry is very energy intensive, and the Indonesian power grid is dominated by coal. According to the major mining company Glencore (2022), the average coal from Indonesia has a 20% to 25% lower energy content than coal from other countries, such as Australia, Colombia or South Africa, meaning 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 extracted from sulfide deposits. As Figure 9 shows, producing Class 1 nickel from Indonesia's laterite ore resources produces two to six times the amount of CO_2 emissions compared to producing Class 1 nickel from sulphide deposits (IEA, 2021).

It is thus not surprising that looking at the development of GHG emissions in Indonesia from fossil energy over the past decade, Indonesia's reduction ambitions, as mentioned in its enhanced NDC, seem very optimistic—probably even unrealistic. The Climate Action Tracker also rates climate change efforts and NDC implementation in Indonesia as critically insufficient (Climate Action Tracker, 2023b).

Part of Indonesia's transformation ambition, as laid down in Government Regulation No. 79/2014 on National Energy Policy (Indonesia, 2014), is the reduction of coal use for their energy mix. The government aims to reduce the use of coal to a minimum of 30% in 2025 and a minimum of 25% in 2050. If this is successful, emissions from coal mining and use will fall over the coming 25 years. As a large part of the mining sector in Indonesia is smelting, the energy mix will have a large impact on GHG emissions from the mining sector in Indonesia.

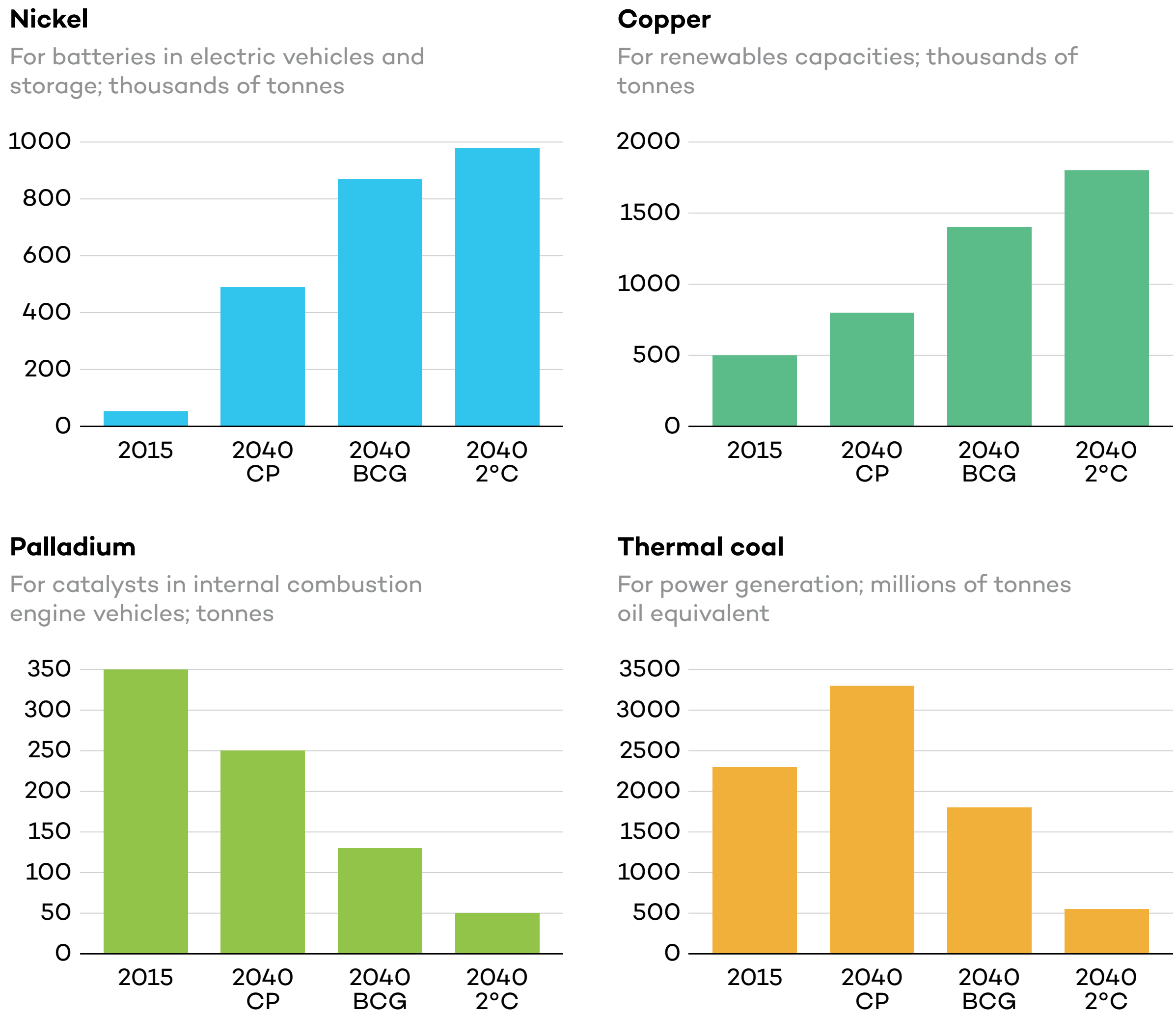
Case Study 3: South Africa

Context and Role of the Mining Sector

South Africa's mining sector is critical to the country's growth and transformation objectives, accounting for 7.5% of its national GDP in 2022 (Minerals Council South Africa, 2023), with mining being the largest economic sector in four of the nine provinces.

South Africa is a major producer of multiple commodities. In 2019, South Africa's share of global production was 37% for chromium; 30% for manganese; 9% for vanadium; 5% for diamonds; 4% for coal; 3% for gold, fluorspar, and iron ore; and 2% for nickel. South Africa's domination is indisputable when considering platinum group metals (PGMs): in 2019, South Africa was responsible for 92% of ruthenium, 84% of rhodium, 83% of iridium, 72% of platinum, and 36% of palladium in global production (Yager, 2024). South Africa also holds 91% of PGMs, 40% of chromite and 35% of vanadium global reserves (Yager, 2024).

FIGURE 10. Projected 2040 commodity demand based on three different abatement scenarios



Source: Bour et al., 2020.

In the context of the mining sector (and society at large), the impacts of climate change in South Africa are experienced through multiple challenges. The transition toward a low-GHG emission and climate-resilient economy is already part of the country's National Development Plan 2030.

Projected **demand growth** for some minerals (including nickel and manganese) is such that new mining facilities will need to be developed, and existing mining facilities will need to step up production levels, which may compromise social and environmental concerns.

On the other hand, the implications of climate change mitigation on South Africa's mining industry depend on different emissions scenarios. Governments and industry actors need to plan for their own decarbonization efforts and, equally, strategize their mining portfolios based on emissions scenarios.

The demand for energy transition minerals is likely to benefit from various emissions reduction scenarios. On the other hand, the story is far more mixed for thermal coal and palladium, as illustrated in Figure 10 (Bour et al., 2020).

In terms of **employment**, the South African mining industry employed 514,859 individuals in 2019 and 458,954 individuals in 2021, with around 40% employed in the PGM sector, 20% in the coal sector, and 20% in the gold sector. During the period 2015 to 2019, the mining sector in South Africa showed a strong decline in direct employment by mines (with 22,622 positions lost), whereas contractors and flexible arrangements increased, with around 3,700 positions (South Africa Department of Statistics, 2019).

Country-Level GHG Emissions of the Mining Sector

South Africa is one of the world's top 10 largest GHG emitters. In 2020, South Africa emitted 508.38 MtCO_2e, representing 1.07% of global emissions (Climate Watch, 2023c). As presented in Table 6, historical data on GHG emissions show that South Africa's total GHG emissions are peaking as a top emitter.

As several of South Africa's coal-fired power stations are slated for retirement between 2030 and 2050, substantial investments in new generation capacity will be essential to meet projected electricity demand and support economic growth. Although coal will remain part of the electricity mix in 2050, the expected additions of significant low-carbon generation capacity will considerably reduce the country's GHG emissions.

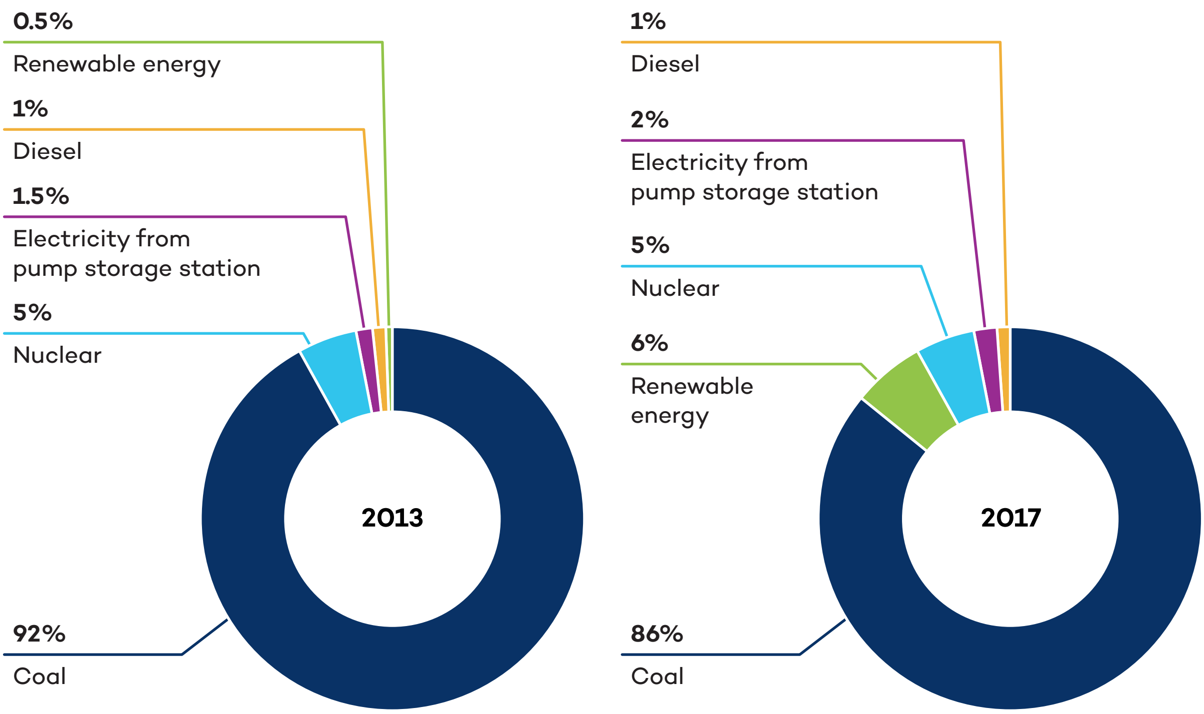
According to South Africa's fifth BUR in 2023 (Republic of South Africa, 2023a), although South Africa has the 30th largest GDP in the world, it ranks 17th in terms of GHG emissions. The report acknowledges that the mining sector, being deeply energy intensive and coal dependent, is the main factor for such high emissions levels. However, no disaggregated data are available on GHG emissions from mining. Emissions from mining are part of industry, which is a subsection of energy.

TABLE 6. South Africa's historical GHG emissions in 2006 and 2020

GHG emissions (excluding LULUCF)	2006	2020
Total GHG (in Mt)	493.82	501.52
CO_2e from energy (in Mt)	379.74	393.24

Source: Climate Watch, 2023c.

FIGURE 11. Percentage of electricity generated in South Africa by source (in gigawatt hours) in 2021 in South Africa

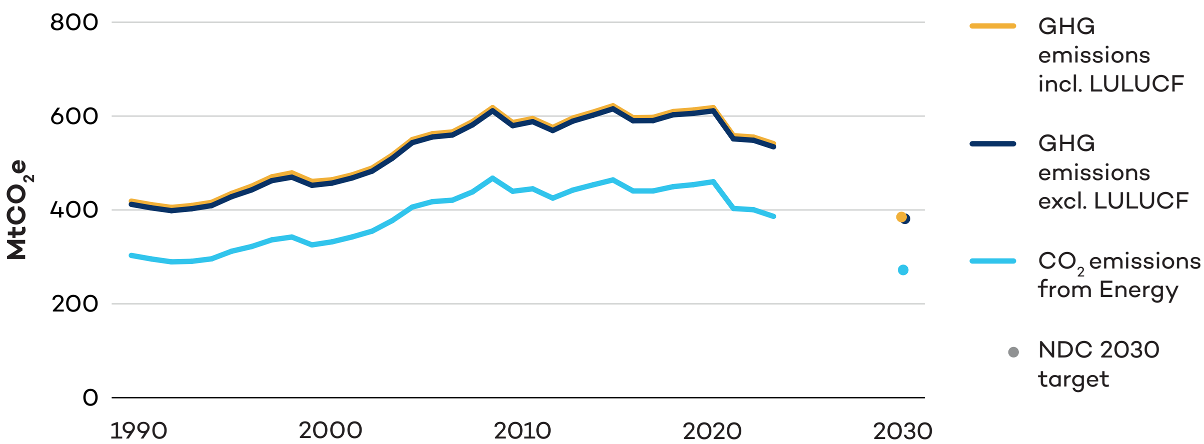


Source: South Africa Department of Statistics, 2021.

In terms of climate mitigation opportunities and challenges for the mining sector, it is noticeable that in 2021, South Africa only derived 6% from **renewable electricity**, whereas almost 86% of electricity generation is represented by coal. As illustrated in Figure 11, it represents only a slight reduction in coal from 92% in 2013 (South Africa Department of Statistics, 2021).

Figure 12 shows the historical growth, with a relatively high percentage of GHG emissions accounted for by CO_2 emissions from energy.

FIGURE 12. Reported GHG emissions vs. NDC targets from 1990 to 2022 – South Africa



Source: IMF, 2023.

From 2006 to 2019, there has not yet been a noticeable decrease in GHG and/or CO_2 emissions from energy. However, in 2020, GHG emissions witnessed a significant reduction with no rebound in the following 2 years (IMF, 2023).

South Africa's updated NDC document reports that

> lower than expected GHG emissions have been estimated over the last decade, which are partly a result of lower economic growth, but also a result of a drop in GHG intensity in the economy. The latter suggests the start of the process of relative decoupling of economic growth from GHG emissions, which is because of increased energy efficiency, investment in renewable energy and a shift in economic growth to less energy intensive sectors. (Republic of South Africa, 2021)

In the second NDC, expected in 2025, the effects of strong mining sector production levels, new exploration permits, and mining investments will likely be visible.

NDC International Climate Change Commitments

South Africa's NDC versions and updates:

Latest NDC (and updates): South Africa's first NDC was communicated to UNFCCC in September 2015, and an updated version was made available in September 2021 (Republic of South Africa, 2021). The second NDC will be communicated in 2025, as confirmed in the updated first NDC. The fifth BUR was released in November 2023 (South Africa, 2023a).

Mining sector references in the latest NDC: Currently, South Africa's NDC does not entail a sector-specific approach. Instead, the coverage of the NDC is economy wide, based on the national GHG inventory report (based on Intergovernmental Panel on Climate Change methodologies and "reflecting some uncertainties"). The mining sector is mentioned as one of the priority sectors as part of South Africa's First Adaptation Communication Elements Undertaking for the period 2021–2030 in the updated NDC (Republic of South

TABLE 7. A summary of South Africa's climate targets as part of the latest NDC, compared to mining sector-specific targets under domestic policies

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

Source: South Africa, 2021, 2023a.

Africa, 2021). Here, it is mentioned that in the National Climate Change Adaptation Strategy, mining is one of the priority sectors.[4] With a view to the Climate Change Bill (Republic of South Africa, 2022a), South Africa's second NDC, expected for 2025, will likely entail sector-specific references linked to reduction targets for the mineral resources sectoral GHG emissions.

Emissions reductions: South Africa's mitigation targets are based on the most recent *National Inventory Report*. The NDC targets, submitted in September 2020, do not distinguish between "conditional" and "unconditional," but reference is made to the expectation that financial and technological support will be provided to allow South Africa to reach its targets (Republic of South Africa, 2021).

In its updated NDC, South Africa commits to absolute GHG emissions target levels from 398 to 510 $MtCO_2e$ in 2025 and 350 to 420 $MtCO_2e$ by 2030. These may be equivalent to a 3%–23% increase above 1990 levels (excluding LULUCF).

According to the Climate Action Tracker (2023c), South Africa's updated 2030 NDC target is rated as "almost sufficient" when compared to modelled domestic pathways and "insufficient" when compared to its fair share contribution to climate action.

"Just transition" and "common but differentiated responsibilities": In South Africa's updated NDC (South Africa, 2021), there has been a strong focus on its specific situation as a developing country, by recognizing that national circumstances and capabilities should be considered when identifying responsibilities and mitigation actions. Common but differentiated responsibilities are also mentioned in reference to the mitigation targets for 2025 and 2030. As mentioned in South Africa's NDC, "the context of development is critical to implementing and achieving climate goals in South Africa and elsewhere. As highlighted in our National Development Plan, South Africa faces a triple development challenge of poverty, inequality and unemployment" (p. 3).

Multilateral support for finance and technology: South Africa emphasizes the importance of the provision of multilateral support in the implementation of this updated NDC, as provided for in the Paris Agreement, to meet both their adaptation and mitigation goals. As a developing country, the updated NDC highlights that "we continue to assume 'that implementation and ambition will be enabled by finance and technology and capacity building support'" (South Africa, 2021, p. 4) as stated in the first NDC and stipulated in the Paris Agreement.

National Government Policies and Approaches

The South African government introduced its Climate Change Bill to the Parliament in February 2022 (Republic of South Africa, 2022a). It provides the overarching framework for the goal setting, action planning, and institutional coordination of climate change efforts. According to the government, the **Climate Change Bill** aligns with South Africa's NDC.

It proposes, among other things, the following (Republic of South Africa, 2022a):

- First, climate adaptation objectives and scenarios are developed, as well as sector adaptation strategies and plans.
- Second, a national GHG emissions trajectory is to be developed, including specified reduction objectives (with quantitative

[4] Others are biodiversity and ecosystems, water, health, energy, settlements (coastal, urban, rural), disaster risk reduction, transport infrastructure, mining, fisheries, forestry, and agriculture.

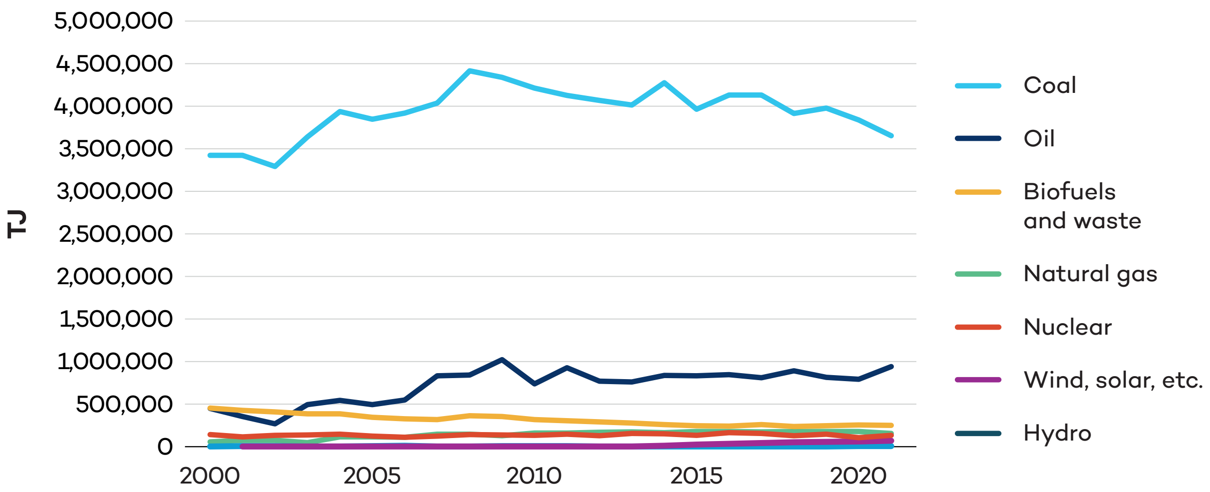
descriptions of total amounts of GHG emissions to be emitted and reduced).

- Third, sectoral emissions targets are equally to be determined, including for the "mineral resources" sector. Sectoral emissions should consider the socio-economic impacts of sectoral emissions targets and "the best available science, evidence and information." A specific calculation methodology for GHG emissions has not been included in the Climate Change Bill. The sectoral emissions targets should include quantitative and qualitative reductions for the next 5-, 10-, and 15-year periods thereafter.
- Finally, carbon budgets are made available under the Climate Change Bill for individuals to support GHG mitigation plans.

When it comes to the implementation and enforcement of the Climate Change Bill, the government has put forward its **Just Energy Transition (JET) Implementation Plan 2023-2027**, which is a roadmap "that enables South Africa to take targeted and aligned strides towards meeting its decarbonisation commitments in a manner that will deliver just outcomes for the people affected by the energy transition and that contributes to inclusive economic growth, energy security, and employment" (Republic of South Africa, 2023b, p. 19). The plan details how South Africa will decrease its reliance on coal, develop renewable energy sources, and create new industries and jobs for affected communities and workers.

With regard to the progress in implementation, the JET recognizes that South Africa is in an "early and evolving stage … with complex challenges to overcome" and that "project preparation is not where it should be" (Republic of South Africa, 2023b, p. 29). One of the key challenges mentioned is energy security—the country's electricity supply still faces significant limitations, managed through ongoing rolling blackouts that negatively affect all aspects of society and the economy. The need for *energy security* is delaying the retirement of old coal plants, impacting the planned pace of decarbonizing electricity generation.

FIGURE 13. The evolution of total energy supply in South Africa since 2000



Source: IEA, 2024d (CC BY 4.0.).

The Energy Mix in South Africa

South Africa's economy is one of the most dependent on coal compared to other countries—it represents about 70% of total electricity production, as presented in Figure 13.

South Africa has a sizable coal industry and is one of the top five coal-exporting countries in the world (IEA, 2024b). The importance of the coal industry in South Africa is reflected in strong lobbying campaigns, which, according to some non-governmental organizations, makes it more difficult to achieve an energy mix that is less reliant on coal (Molekwa, 2023). This includes the phasing-out of a large number of coal plants under the JET.

In 2023, with the worsening of the national electricity supply crisis, businesses, households, and public services were faced with longer and more frequent periods of load shedding imposed to curtail demand. As a result, the government assessed its options to deal with the crisis and, in the interest of energy security, decided to reassess coal plant decommissioning to extend the lives of retiring coal generation units.

The example of South Africa's coal dependency, which is responsible for a sizeable portion of GHG emissions, shows the complexities around realizing a (just) energy transition, with short- and longer-term interests to be weighed and balanced in the context of the economic and social development of the country.

Other relevant policies that help mining companies lower GHG emissions and adapt to climate change include South Africa being the first African country with a carbon tax. In 2019, South Africa published its Carbon Tax Act (Act No. 15 of 2019), which aims to provide for the imposition of a tax on the CO_2e of GHG emissions. The act defines the calculation of the tax and its application to different activities (Republic of South Africa, 2019). When it comes to implementation, the current projected trajectory of South Africa's carbon tax rate is likely insufficient to meet the country's NDC commitments. The NDC aims to reduce GHG emissions to 350–420 $MtCO_2e$ between 2026 and 2030, equating to a 15% to 30% reduction from current levels. However, the Carbon Pricing Assessment Tool model indicates that the existing carbon tax proposal, while significantly contributing to emission reduction efforts, would result in GHG emissions ranging from 475 to 492 $MtCO_2e$ during 2026–2030.

In March 2022, South Africa's Treasury issued the first edition of the **Sustainable Finance Taxonomy (South Africa, 2022b), which is a policy that guides investments toward low GHG emissions, including in the mining industry**. The taxonomy outlines a baseline of assets, projects, activities, and sectors that can be classified as "green," aligning with international best practices and national priorities. It is designed for use by lawmakers, government officials, regulators, and the financial services sector. Adoption of the taxonomy is voluntary.

Financing: Furthermore, South Africa is one of the driving forces, since the UNFCCC 26th Conference of the Parties in 2021, to the Just Energy Transition Partnership (JETP), an innovative financing agreement to support the transition to a low-carbon economy and society. The development of the JETP Investment Plan, led by the country, is in progress and will focus on critical sectors.

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