Federal Ministry
for Economic Cooperation
and Development

Economic implications of the energy transition on government revenue in resource-rich countries

Published by

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

In Copperation with

econias

Preamble

Decarbonising the global economy and energy sector requires an unprecedented deployment of clean energy technologies within the next three decades. The transition to a net-zero economy and the subsequent appetite for electric vehicles, wind turbines, solar panels and new electricity connections will require huge quantities of minerals – so-called 'energy transition minerals'. These energy transition minerals include some materials that are already produced in large volumes today, such as aluminium, copper, nickel, and steel. But they also include commodities that have had relatively few applications and limited demand in the past, such as lithium, cobalt, and rare earth elements.

This demand for minerals is mostly driven by higher material intensity of renewable energy technologies compared with fossil fuel-based power generation and transport solutions. The production of an electric car requires approximately six times more minerals than an internal combustion engine car. The material requirements for clean energy generation are even greater – for every megawatt (MW) of electricity produced, offshore wind requires nine times more minerals than natural gas.

Some of the increased demand for energy transition minerals could be met by increasing the collection and recycling rates of metals at the end of life of products. However, only a small fraction of the rapidly rising demand can be met by increased recycling. A large increase in production from primary sources will therefore be necessary for the foreseeable future, including bringing many new mines into production beyond those already operating or under construction. This offers an opportunity for many resource-rich countries to generate additional government revenues from the extraction of their energy transition mineral reserves.

Key findings

- Increased demand for 7 energy transition minerals (bauxite, cobalt, copper, graphite, lithium, nickel, and rare earth elements) could be worth between $100 billion and $260 billion per year on average in gross revenues from mineral sales over the next 20 years.
- Resource-rich countries stand to benefit by $5 billion to $25 billion per year in additional government revenues from this increased demand for energy transition minerals.
- This could mean an additional $100 billion to $500 billion by 2040 to fund investment in public infrastructure and fuel economic development.
- The benefits will go to those regions with largest production and reserves of energy transition minerals. The Latin America and Caribbean region is expected to collect 39% of additional government revenues in absolute terms, followed by the East Asia and Pacific region with 34%.
- Relative to the size of their economies, countries in Sub-Saharan Africa could also be major beneficiaries, with additional gross revenues from sales of transition minerals worth 0.76% of regional GDP, second only to Latin America and Caribbean at 1.2%.
- While most of the benefits will flow to high-income and upper middle-income countries, transition minerals could have outsized significance for low-income resource-rich countries given the smaller size of their economies.
- Copper will be the most important driver of government revenues, accounting for 44% of additional government revenues, followed by lithium (22%) and nickel (20%). Lithium's share increases under scenarios with a faster transition to net zero and higher mineral prices.
- Other energy transition minerals could be important drivers of revenues at a regional level, such as cobalt in Sub-Saharan Africa and rare earth elements in East Asia and Pacific.
- Governments of resource-rich countries can maximize the benefits by implementing a modern fiscal regime, increasing investment attractiveness, improving the understanding of the geological potential, and developing an enabling environment for sustainable mineral extraction with a focus on environment, social, and governance (ESG)


27
Co
Cobalt
58,933
29
Cu
Copper
63,546
6
C
Carbon
12,011
66
Dy
Dysprosium
162,500
28
Ni
Nickel
58,693
13
Al
Aluminum
26,982
3
Li
Lithium
6,941

Executive summary

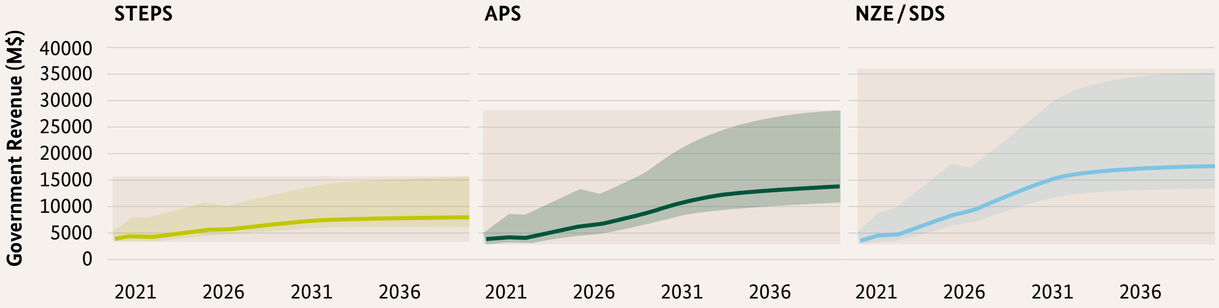
Decarbonising the global economy and energy sector requires an unprecedented deployment of clean energy technologies within the next three decades. This will spur demand for huge quantities of 'energy transition' minerals needed for electric vehicles, wind turbines, solar panels and new electricity connections, driven by the higher material intensity of renewable energy technologies compared to fossil fuel-based power generation and transport solutions. Only a small fraction of the rapidly increasing demand can be met by increased recycling, and a large increase in production of energy transition minerals from primary sources will be necessary for the foreseeable future, including bringing many new mines into production beyond those already operating or under construction. This offers an opportunity for many resource-rich countries to generate additional revenues from the extraction of their energy transition mineral reserves. **We estimate that additional government revenues from energy transition minerals could average between $5 billion and $25 billion per year in the period to 2040.**

These estimates depend on various factors, including the pathway to net zero and corresponding future mining production. We estimate future production based on demand forecasts for each mineral less secondary supply, using scenarios developed by the IEA (2021; Kim 2022):

1. **Stated Policies Scenario (STEPS)** is the estimated demand for minerals for energy transition under current policy settings based on a sector-by-sector assessment of specific policies that are in place or have been announced by governments. It provides an indication of where today's policies and plans lead the energy sector, and the corresponding demand for minerals.
2. **Announced Pledges Scenario (APS)** assumes that all climate commitments made by governments around the world, including Nationally Determined Contributions (NDCs), longer-term net zero targets, and targets for access to electricity and clean cooking will be met in full and on time.
3. **The Net Zero Emissions by 2050 Scenario (NZE)** is the most ambitious scenario setting out a pathway for the global energy sector to achieve net zero emissions by 2050. It does not rely on emissions reductions from outside the energy sector to achieve its goals. Universal access to electricity and clean cooking are achieved by 2030.

Estimates of the revenue potential from cobalt, copper, lithium, and nickel follow these three scenarios. The IEA has not published estimates of demand for bauxite, graphite, or REOs under the APS or NZE scenarios. For these minerals, we use the **Sustainable Development Scenario (SDS)**, for which demand estimates have been published by Gregoir and van Acker (2022). Like the NZE scenario, SDS assumes that current net-zero pledges are achieved in full and there are extensive efforts to realise short-term emissions reductions.

Figure E.S.1: Additional annual government revenues by scenario



Note: line shows central scenario, upper and lower ends of the shaded area show high and low scenarios respectively.

Our analysis also finds that some regions will benefit significantly more than others. We estimate that most government revenues will be raised by countries in the Latin America and Caribbean region, followed by East Asia and Pacific. The regions expected to collect the least revenue from energy transition minerals are Middle East and North Africa, and South Asia.

When looking at country income groups, we estimate that most government revenues will be collected in upper-middle income countries (38 % of the total government revenue), followed by the high-income group countries.

Figure E.S.2: Total government revenue shares by region (in %)

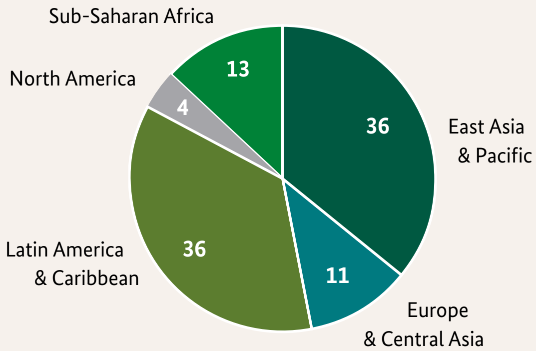
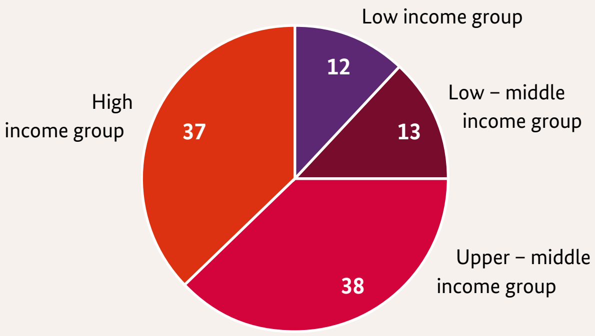


Figure E.S.3: Total government revenue shares by income group (in %)



Note: Estimated under APS central scenario.

However, the relative economic importance of additional mining sector activity and government revenues depends on the size of economies in each region. Latin America and Caribbean and Sub-Saharan Africa will benefit more proportionally than their overall gross revenue potential suggests. If total gross revenues are expressed as a share of each region's GDP, Latin America and Caribbean and Sub-Saharan Africa will generate the largest additional gross revenue from energy transition minerals compared to the current sizes of their economies. Similarly, low-income countries stand to benefit more than implied by their 12% share of government revenues due to the outsize impact of additional mining sector activity as a share of GDP.

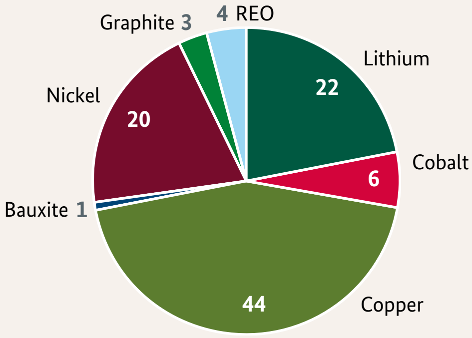
Table E.S.1: Average annual gross revenue as a share of GDP by region

Region	Average annual gross revenue (US$ million, real terms)	GDP in 2021 (US$ million, real terms)	Gross revenue as share of 2021 GDP (%)
East Asia & Pacific	52,950	30,056,574	0.18
Europe & Central Asia	15,700	24,952,561	0.06
Latin America & Caribbean	59,562	4,964,237	1.20
Middle East & North Africa	52	2,743,880	0.00
North America	10,892	24,993,943	0.04
South Asia	293	4,061,703	0.01
Sub-Saharan Africa	14,543	1,910,122	0.76

Source: GDP figures come from World Bank (2022b). Note: Estimated under APS central scenario.

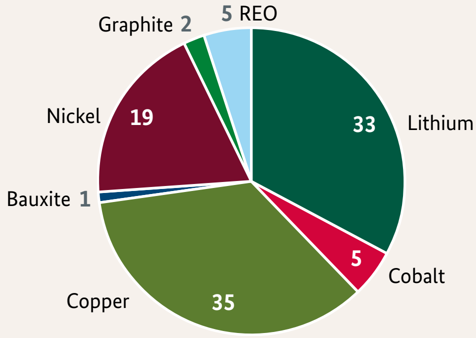
Under our central scenario the largest share of government revenues will come from copper, followed by lithium and nickel. Lithium becomes an increasingly important contributor to government revenues under scenarios with faster energy transition and higher mineral prices.

Figure E.S.4: Total government revenue shares by mineral (in %)



Note: Estimated under APS central scenario.

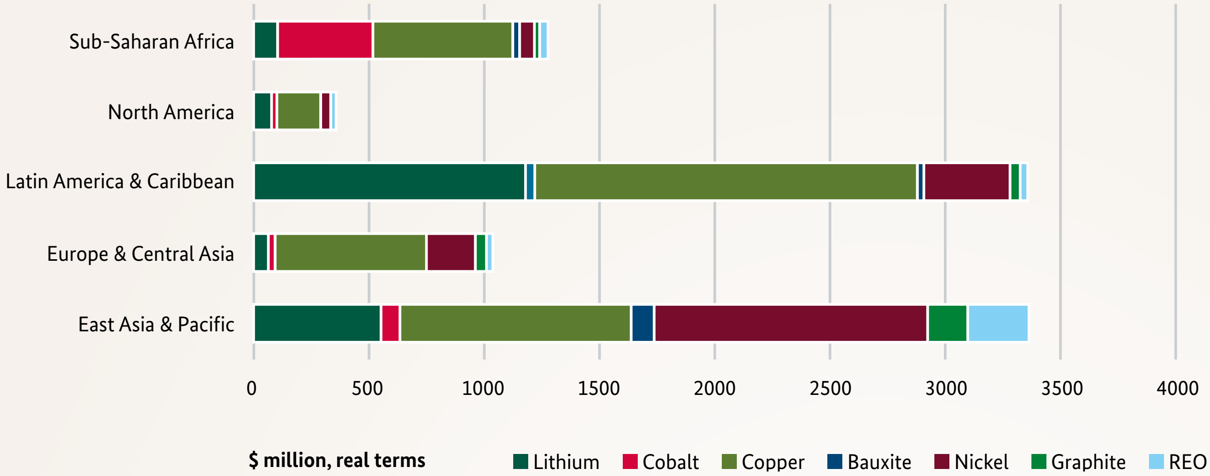
Figure E.S.5: Government revenue shares by mineral under fast transition and high prices (in %)



Note: estimated under NZE high scenario.

Copper is also generally the most important driver of revenues in most regions under most scenarios. In Latin America and Caribbean, copper and lithium are the most important minerals, with lithium's importance increasing under more ambitious net zero pathways. East Asia and Pacific will benefit most from nickel, followed by copper and lithium. Revenues from rare earth oxides will mostly be generated in East Asia and Pacific, with only small amounts projects in other regions based on current production and known reserves. In Sub-Saharan Africa, cobalt will also be a large driver of government revenues.

Figure E.S.6: Annual government revenues by mineral in selected regions



Note: Estimated under APS central scenario.

Policy Implications for resource-rich developing countries

Governments in resource-rich countries should act now to maximise the potential revenues from energy transition minerals. The opportunity presented by the extraction of energy transition minerals is significant for some countries and regions, albeit highly contingent on various external factors. There is strong empirical evidence that favourable geological potential by itself is not enough to develop a well-functioning mining sector that delivers benefits for governments and citizens. It is therefore important that governments of resource-rich developing countries proactively set the course to create a conducive policy environment that allows them to derive maximum benefit from their endowment of energy transition minerals.

We identify 4 key areas of policy development that governments of countries endowed with energy transition minerals should pay particular attention to:

1. **Implement a modern fiscal regime and sound public financial management policies.**
   Fiscal regimes for mining will need to encourage investment while ensuring the state receives a fair share from its natural resources. Governments should take the opportunity to review and improve their fiscal regimes to meet their specific objectives for the mining sector and public finances, while recognising that there is no single 'ideal' fiscal regime.

2. **Increase investment attractiveness.**
   Geological potential is often the most important factor for mining investments. Evidence suggests taxation is not as important as other factors such as macroeconomic and political stability, infrastructure, and labour. While meaningful reforms in these areas can take years to achieve, governance reforms that improve transparency and accountability could be enacted relatively quickly to lay the foundations.

3. **Improve the understanding of the geological potential.**
   Mineral exploration is the most economically risky part of the mining cycle. The effective collection, storage, and public availability of geodata from mineral exploration has high returns and governments should develop these areas. Governments should also pay particular attention to the tax treatment of exploration costs when designing the fiscal regime.

4. **Develop an enabling environment for sustainable mineral extraction with a focus on ESG.**
   Environment, social and governance (ESG) is the number one risk and opportunity for mining companies. Governments will increasingly need to compete for mining sector investments based on non-traditional enabling factors that meet consumer and producer demands for enhanced ESG, such as the provision of clean energy to reduce the carbon intensity of mining.

Content

List of figures, tables and boxes

List of figures

List of tables

List of boxes

List of abbreviations

AETR	Average effective tax rate
APS	Announced Pledges Scenario
ASM	Artisanal and small-scale mining
BEPS	Base erosion and profit shifting
CIT	Corporate income tax
CSP	Concentrated solar power
DLE	Direct lithium extraction
DRC	Democratic Republic of the Congo
DTAs	Double taxation agreements
EC	European Commission
ESG	Environment, social and governance
EVs	Electric vehicles
FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gases
HPAL	High pressure acid leaching
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
JV	Joint venture
LDCs	Least developed countries
LSM	Large-scale mining
MHP	Mixed hydroxide precipitate
MNEs	Multinational enterprises
MW	Megawatt
NZE	Net Zero Emissions by 2050 Scenario
PBIT	Profits before tax, impairments and royalties
PV	Photovoltaics
REEs	Rare earth elements
REOs	Rare earth oxides
SDS	Sustainable Development Scenario
STEPS	Stated Policies Scenario
VAT	Value added tax

1. Introduction

Decarbonising the global economy and energy sector requires an unprecedented deployment of clean energy technologies within the next three decades. This will require large amounts of critical minerals – so called 'energy transition minerals' – as renewable energy technologies, electric vehicles, and batteries all require significantly more minerals than their fossil-fuel based alternatives. The future public revenue that resource-rich countries might derive from the extraction of energy transition minerals is highly uncertain, as various external factors will have an influence on the demand for minerals and their prices.

There is currently a lack of reliable and comprehensive data to support policymakers in resource-rich countries to maximise the opportunities and minimise the risks from the energy transition. Revenue forecasting and financial modelling can be used as a practical tool to help policy makers and other key stakeholders to understand the revenue potential from energy transition minerals, as well as the impacts of underlying uncertainties in mineral prices, production costs, and production volumes. It can also help policy makers to understand how different fiscal regime designs and non-fiscal enabling policies, such as power provision, environmental regulations, and the promotion of value-addition activities impact on revenue potential.

This report aims to provide an overview of the public revenue potential of a selection of energy transition minerals: bauxite (used in aluminium), cobalt, copper, graphite, lithium, nickel, and rare earth oxides (REOs) such as dysprosium, neodymium, and praseodymium. For each mineral we give an overview of its role in the energy transition, demand forecasts based on anticipated pathways to net zero emissions, and price forecasts from market commentators and mining companies. We then produce initial estimates of the revenue potential at a global level, based on different assumptions and scenarios for the profitability of mining operators and the amount of revenues governments could collect through taxes and royalties. These are presented on a global and regional level and for each mineral in fact sheet format in section 6 of the report.

To place those revenue estimates in context, we also provide high-level background research into the role of critical minerals in the energy transition (*section 2*), an overview of the mining sector, its structure, and its investment cycle (*section 3*), a briefing on fiscal regimes used in the mining sector (*section 4*, with more detail in *Annex A*), and the methodology used for producing the revenue potential estimates (*section 5*, with more detail in *Annex B*). Finally, we set out policy implications for resource-rich developing countries (*section 7*) and provide 12 country case studies that demonstrate some of the common challenges faced by governments in the development of their energy transition minerals (*section 8*), before giving some concluding remarks (*section 9*).


CAT
CAT
112

CH-06
San
Martin

2. The role of critical minerals in the energy transition

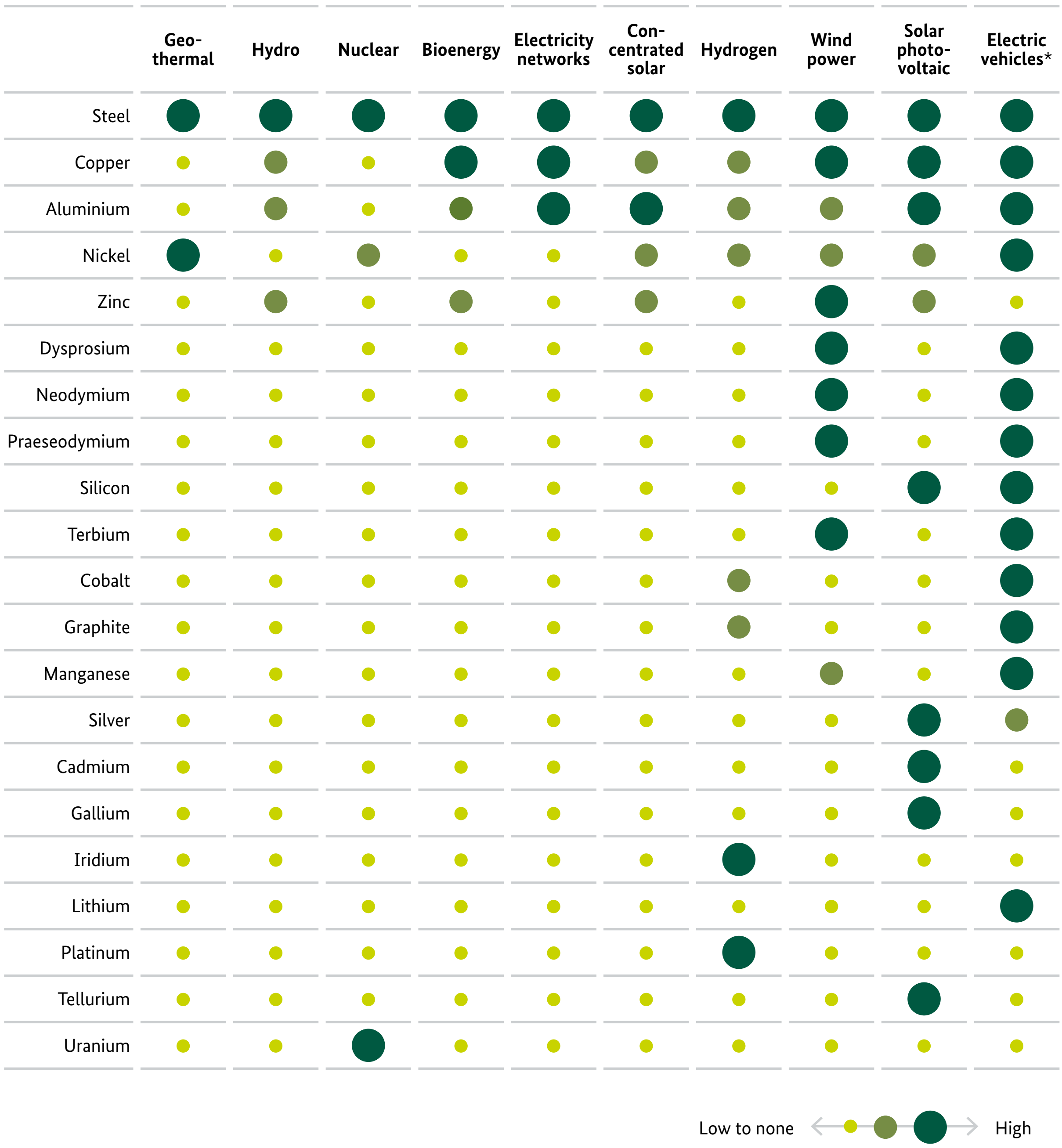
This chapter explains why production of critical minerals will need to increase to meet the material needs of clean energy technologies. In this chapter we:

- Explain how the higher material intensity of low-carbon technologies leads to increased demand for minerals.
- Present the key low-carbon technologies that require significant mineral inputs.
- Identify the different minerals that are critical for the energy transition.
- Set out why mining activities will need to increase to meet new demand for minerals.

We conclude that a large increase in mining production will be necessary to meet the material demands of clean energy technologies over the coming decades, and that this will mean bringing many new mines into production beyond those already operating or under construction.

Since the signing of the Paris Accord in 2015, many countries and companies have made wide-reaching commitments to reduce drastically their greenhouse gas (GHG) emissions. The transition to a net-zero economy and the subsequent appetite for electric vehicles (EVs), wind turbines, solar panels and new electricity connections will require huge quantities of minerals (IEA, 2021; World Bank, 2017). These so-called 'energy transition minerals' include some materials that are already produced in large volumes today, such as aluminium, copper, nickel, and steel. But they also include commodities that have had relatively few applications and limited demand in the past, such as lithium and cobalt for batteries, and rare earth elements such as dysprosium, neodymium, and praseodymium for permanent magnets used both in wind power generation and EVs. Other commodities, notably steel and aluminium, will play an enabling role in the construction of additional infrastructure for clean energy technologies and EVs (*Figure 2.1*).

Figure 2.1: Materials critical for a transition to a low-carbon economy by technology type



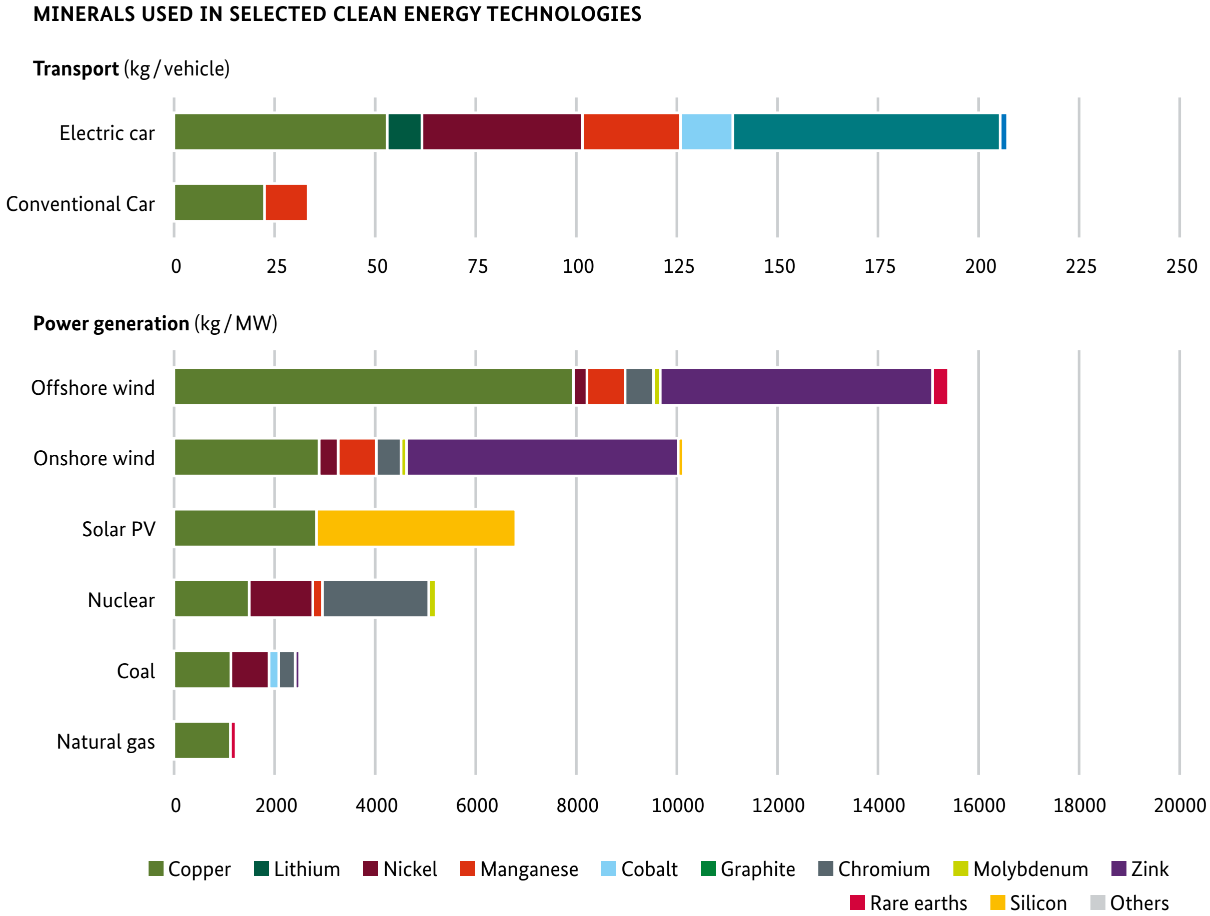
Source: McKinsey & Company (2022).

** includes energy storage*

This demand for minerals is mostly driven by higher material intensity of renewable energy technologies compared with fossil fuel-based power generation and transport (Born, 2022; Hund et al., 2020).

The International Energy Agency (IEA) finds that the production of an electric car requires approximately six times more minerals than an internal combustion engine car (IEA, 2021). The material requirements for clean energy generation are even greater – for every megawatt (MW) of electricity produced, offshore wind requires nine times more minerals than natural gas, and eight times more than coal (*Figure 2.2*).

Figure 2.2: Material intensity of transport and power generation technologies



Notes: kg = kilogramme, MW = megawatt. Steel and aluminium not included.
Source: IEA (2021).

The production of energy transition minerals will need to increase rapidly and significantly to meet the material demand from clean energy technologies. A World Bank Group report from 2017 finds that the production of minerals such as graphite, lithium, and cobalt would need to increase by nearly five times existing levels by 2050 to meet the growing demand for clean energy technologies. It estimates that over three billion tons of minerals and metals will be needed to deploy wind, solar, and geothermal power as well as energy storage required to achieve a 'below 2°C' future (World Bank, 2017). Similarly, the IEA estimates that mineral requirements for clean energy technologies would need to quadruple by 2040 to reach the goals of the Paris Agreement based on the stated policies of governments (the 'Stated Policies Scenario', or 'STEPS'). A faster transition toward net zero by 2050 (the 'Net Zero Emissions', or 'NZE') would require six times more minerals in 2040 than today.

The European Commission (EC) reaches a similar conclusion to the World Bank and the IEA. Every three years, the EC publishes a list of raw materials that are critical to its economy (European Commission, 2020). The list does not only include materials required for the transition to a decarbonised economy, but most materials on the list will be impacted by the energy transition. The report indicates that compared to current consumption by the whole EU economy, for renewable energy solutions and e-mobility alone, up to 18 times more lithium and five times more cobalt would be required in 2030, and almost 60 times more lithium and 15 times more cobalt by 2050. Demand for rare earth elements used in permanent magnets for EVs or wind generators could increase tenfold.

Some of the increased demand for energy transition minerals could be met from increasing the collection and recycling rates of metals at the end of life of products. However, recent studies by the European Commission and KU Leuven University in Belgium have found that only a small fraction of the rapidly rising demand can be met by increasing recycling efforts (Blagoeva et al., 2018; Gregoir and van Acker, 2022). Mature recycling industries for materials such as copper, steel and aluminium currently reach end-of-life recycling rates of between 30 % and 60 %. But for several important energy transition minerals, such as lithium and rare earth elements, the rate is currently less than 1 % (Born, 2022; Gregoir and van Acker, 2022).

Increased innovation activities are taking place to develop new low-carbon technologies that are less material intensive than current applications. There have been some successes in rationalising mineral inputs for EV batteries, and it is likely that EV batteries and other low carbon technologies will need less raw materials in the future than they require today. But this would only lead to incremental changes to mineral demand, as many of the potential breakthrough technologies that would significantly reduce mineral requirements currently display low levels of technological readiness. It is therefore not currently conceivable that even simultaneous advances in recycling and increased technological innovation will significantly reduce the requirement for primary mineral extraction over the coming two decades. A large increase in production from primary sources will be necessary for the foreseeable future, including bringing many new mines into production beyond those already operating or under construction.

3. Overview of the mining sector

This chapter provides an overview of how the mining sector operates and its role in the global economy. In this chapter we:

- Give an overview of economic dynamics in the mining sector.
- Explain why mining is an important economic activity and how the sector is integrated into global value chains.
- Present the structure of mineral extraction activities, including the difference between large-scale and artisanal and small-scale mining.
- Set out the four phases of a large-scale mining projects' life cycle and the implications for government revenue generation.

We conclude that the special characteristics of the mining sector require a well-designed fiscal regime that balances the need for private-sector investors to make a return on their investment with the need for governments to share fairly in the financial value of their finite natural resources.

3.1. The economic importance of the mining sector

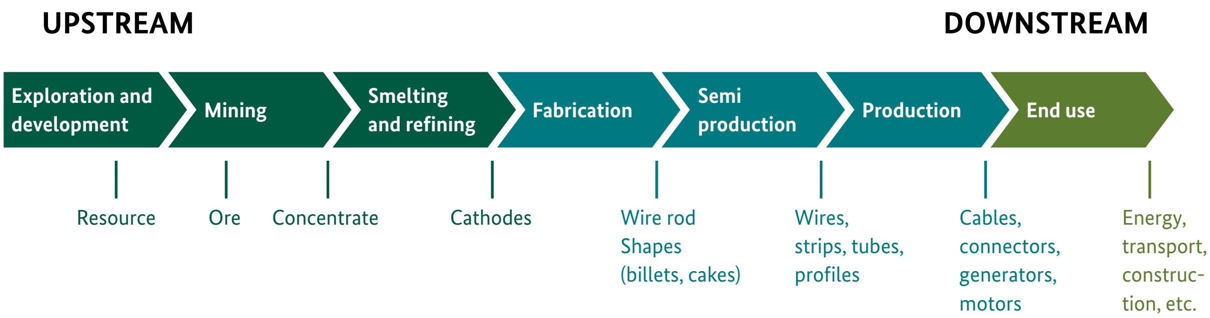
Throughout the 20th century a shift took place and, for the first time in human history, the resources obtained from the exploitation of a large but finite mineral stock became more important than renewable biomass (Krausmann et al., 2018). With accelerating technological innovation there has been a continuing evolution and expansion in the minerals we consume and the range of uses to which they are put (Highley, Chapman and Bonel, 2004). As a result, the extraction of finite mineral stocks from the ground has become one of the key enablers for the functioning of advanced global value chains.

Today, the mining sector plays a significant role in the economies of many resource-rich countries. It accounts for at least 20 percent of total exports, and 20 percent of government revenue in 29 low-income and lower-middle income countries. In eight such countries, mining sector outputs accounted for more than 90 percent of total exports and 60 percent of total government revenue (Halland, Lokanc and Nair, 2015; ICMM 2018). Mining activities are also a key driver of foreign direct investment (FDI) in many resource-rich countries, with least developed countries (LDCs) in particular reliant on FDI flows associated with mineral extraction (UNCTAD, 2021).

3.2. Mineral value chains

Mineral extraction is the first of many steps in the production of complex products that power the global economy. Mining is situated in the 'upstream' of global value chains. After a raw material has been extracted it is then processed and beneficiated before it is fabricated and manufactured into finished goods, which are then sold 'downstream' to end consumers (*Figure 3.1*).

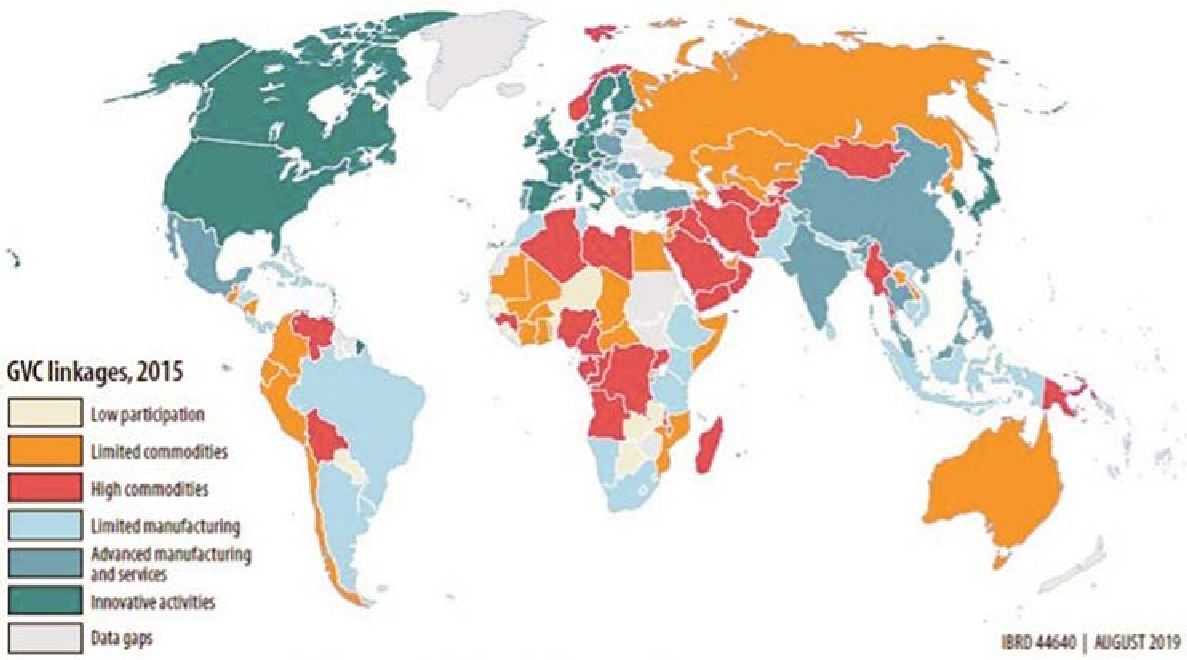
Figure 3.1: The copper value chain



Source: adapted from Langner (2015).

Due to the highly globalised nature of today's value chains, mining, production and sales activities do not necessarily take place in the same country, and the goods derived from mined raw materials have often changed ownership several times before they reach the end consumer. The 'upstream' mining sector is necessarily located in resource-rich regions where the geological conditions allow for the extraction of the raw materials. Midstream and downstream sectors do not have to locate in close geographic proximity to their raw material inputs, as the proximity to raw material sources is only one of many elements that determines the comparative advantage of processing and manufacturing sectors (Korinek, 2020). Therefore, despite producing a large amount of the 'upstream' mined raw materials, many less developed resource-rich countries participate relatively little in the midstream and downstream value chain stages and remain dependent on raw materials exports (*Figure 3.2*).

Figure 3.2: Global value chain linkages



Source: World Bank (2019) – WDR 2020 team, based on the GVC taxonomy for 2015.

3.3. The structure of the mining business

Mining activities can happen at different scales. Extraction activities are generally classified as either 'large-scale' or 'artisanal and small-scale'. This section discusses the characteristics of each extraction scale and how the scale of extraction impacts governments' abilities to raise revenues from mining activities.

3.3.1. Large-scale mining

Large-scale mining (LSM) accounts for the vast majority of mineral production and government revenue from mining globally. LSM is a formal economic activity that provides relatively few, but comparatively well-paid local employment opportunities.

The LSM sector is globally competitive, highly economically productive and characterised by high upfront capital requirements and the use of modern mining technology. As a result, the sector is dominated by large multinational enterprises (MNEs) with often vertically integrated value chains and specialized intellectual property (Halland, Lokanc and Nair, 2015). According to a recent survey conducted by UNCTAD, 70 per cent of large-scale mining companies are MNEs who rely on FDI to enable exploration and extraction activities worldwide (Formenti and Casella, 2019).

LSM represents the best opportunity for governments to raise revenues from mining activities and create skilled jobs in the mining sector. However, the globalised nature and vertical integration of many firms presents a unique set of challenges for resource-rich countries' abilities to raise tax revenues from mining activities.[7] Accordingly, despite the potential for governments to derive significant tax revenues from LSM activities, a country's fiscal regime design and its enforcement capacity have an impact on the revenue it derives from the LSM sector beyond the geological potential it possesses.

3.3.2. Artisanal and small-scale mining

Artisanal and small-scale mining (ASM) activities occupy a spectrum from small, informal subsistence mining activities with rudimentary equipment through to small, formal and organised mining activities carried out with machinery. There is no universally agreed definition for ASM, but it is broadly understood to refer to mining activities that are labour-intensive and relatively capital-, mechanization- and technology-poor in comparison to LSM (IFC and ICMM, 2010).

ASM is believed to account for 15 to 20 per cent of global non-fuel mineral production. Despite its significantly lower levels of productivity compared to LSM, ASM has experienced explosive growth in recent years, driven by the rising value of mineral prices and increasing pressures on rural populations in developing countries who earn a living from agriculture and other rural activities. An estimated 40.5 million people were directly engaged in ASM in 2017, up from 30 million in 2014, 13 million in 1999 and 6 million in 1993. That compares with only 7 million people working in industrial mining in 2013 (IGF, 2017).

In addition, at least 70 per cent of ASM activities are carried out informally (IGF, 2017). The widespread informality of ASM activities leads to low levels of regulatory oversight, which has negative socioeconomic and health impacts for people engaged in the ASM sector. The informal nature of the sector also has an outsized impact on the ability of governments to tax its production. This means that despite its growth, ASM will for the foreseeable future only make limited contributions to resource rich countries' public revenues from mining activities. The following section therefore focuses exclusively on the project dynamics of large-scale mining.

7 Specifically, MNEs have significantly more opportunities at their disposal to exploit gaps and mismatches between different countries' tax systems than firms that do not operate transnationally. This is known as tax base erosion and profit shifting (BEPS). Resource-rich developing countries, which are more reliant on corporate income tax while also often displaying lower levels of tax enforcement capacity, suffer from BEPS disproportionately (OECD, 2022). See section A.2.2 in Annex A for more information on this topic.

3.4. The life cycle of a large-scale mining project

LSM projects differ from many other economic activities. Mineral extraction is the activity of recovering and processing finite resources from a geologically pre-determined deposit. In almost all countries, sub-surface mineral deposits are owned by the state. Accordingly, governments derive revenue from mining through economic rents on a deposit that they own. Mining companies do not own the mineral deposit but extract and sell it on behalf of the government. To make this activity worthwhile for private companies, they demand a share of the economic rent that a project yields.

Another key difference between mining projects and other economic activities is the fact that the exploration of minerals involves high levels of geological uncertainty, large initial capital investments, and long exploration and project development periods. The high volatility of mineral prices and the unpredictability of costs over the long lifespan of projects generates significant additional risks (Halland, Lokanc and Nair, 2015).

The development and operation of a mining project can be divided into four distinct phases (*Figure 3.3*). It should be noted that many mining projects do not experience a linear, end-to-end succession of the four phases, as projects often change hands between different companies along their life cycle and resource price fluctuations can lead to temporary or permanent halting of operations. In addition, projects can expand into adjacent deposits or transition from one mining method to another, for example from open pit mining to underground mining.

Figure 3.3: The project phases of a large-scale mining project

Exploration	Development		Production	Closure	
Exploration	**Feasibility**	**Construction**	**Production**	**Closure**	**Post-closure**
1 – 10 years	**2 – 10 years**	**1 – 3 years**	**2 – 100 years**	**1 – 10 years**	**In perpetuity**
Exploration	Detailed site investigation, design, estimating, evaluation and permitting	Construction	Operation	Final closure and decomissioning	Post-closure

Source: NRGI (2015).

3.4.1. Exploration

The process with mineral extraction begins with exploration. Companies or governments often carry out airborne studies and mapping initially, as well as seismic analysis to understand the chemical composition and density of a potential mineral deposit. If this initial information is promising, further exploration activities are carried out – usually drilling and extraction of core samples to gain additional certainty of the size and quality of a deposit. This process usually takes several years – sometimes decades – and can be very costly. Most projects do not make it beyond the exploration phase.

3.4.2. Development

Once the existence of a mineral deposit of interest is proven, a company must consider a variety of factors to assess whether the deposit is economically viable to mine. This is often done through a series of feasibility studies, which assess the potential costs and revenues of mining the discovered deposit and transporting the product to its point of sale. Once the mineral deposit is deemed to be commercially viable to mine, a mining company will look to receive an appropriate licence from the government to mine and sell the minerals.

When all appropriate licences have been granted, the company will begin constructing the necessary infrastructure to begin production. This phase is the most capital intensive. It is also the most labour intensive, as it creates many construction jobs, albeit only for a few months or years. It takes on average 14 years from the discovery of a deposit to the completion of the development phase (IEA, 2021).

3.4.3. Production

After construction is completed, the production phase begins. During this phase, the company extracts the mineral-rich ore from the ground before separating and processing it. The material is then transported to the point of sale for further processing. The length of this phase is highly dependent on the size and characteristics of the mineral deposit, but it can last for up to 100 years, depending on the commodity (NRGI, 2015; Statista, 2022). Capital costs fall to a sustaining level and the costs of operating the extraction and processing activities become the largest costs. Only during the production phase does the company generate revenues which have to pay for all capital and operating costs incurred throughout the four project phases. This phase also creates well-paid jobs, albeit relatively few compared to industrial activities in other sectors.

3.4.4. Closure and rehabilitation

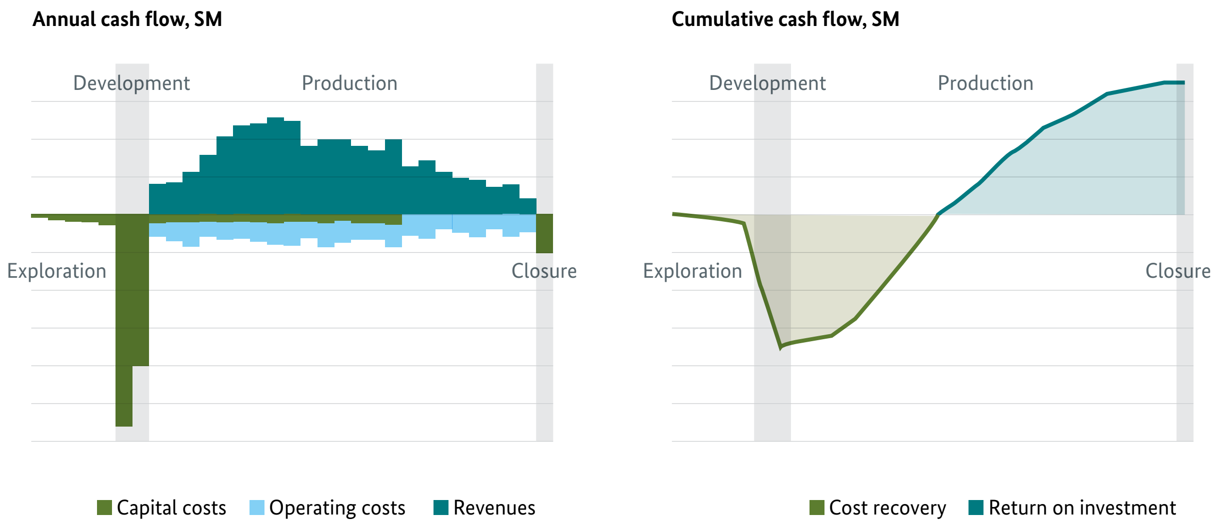
Once all parts of the deposit that can be extracted profitably have been exhausted, the operator has a legislated responsibility in most countries to safely close the mine and rehabilitate the land affected by its operations. In the initial part of this phase, the company should decommission and make safe all areas of its operation, including the securing of the large amounts of waste and tailings that are usually generated by mining operations. The company should then either return the land affected by its operations back to its original state prior to the commencement of mining operations or repurpose the affected land for other economically productive activities.

The costs to carry out the final phase of operations can be very high, as it neither generates any profits for the company nor does capital spent during this phase generate opportunities for future profits. As a result, there have been many instances where companies failed to appropriately close and rehabilitate a mine. Government legislation that enforces appropriate handling of the liabilities created by mining companies, such as requiring financial contributions into a ring-fenced decommissioning fund during production, is therefore paramount to ensuring the successful completion of this phase.

3.5. The mining project life cycle's public revenue implications

The special characteristics of the life cycle of mining projects has significant implications for public revenue generation from mineral extraction. The capital intensity and lack of revenue during the exploration and development phase means that the initial cost outlay is only fully recovered years or even decades after the start of the production phase (*Figure 3.4*). Most tax regimes allow for cost recovery on capital spending before taxes with the highest public revenue potential, such as corporate income tax, start to fully apply. This leads to a significant time lag between the start of production and the full fiscal benefit from mineral extraction for governments.

Figure 3.4: Costs and revenues of mining projects during different production phases



Source: illustrative representation based on authors' own research.

In addition, the exhaustible, non-renewable character of mineral resources presents further challenges for governments. It raises complex questions for governments on how best to manage extraction rates in different price environments, as each unit of a mineral that is being extracted and sold today could potentially bring in higher or lower public revenue in the future. It also makes decisions on how to allocate resource revenues to different uses, such as investment, consumption, and foreign savings, more difficult compared to other economic activities that do not rely on non-renewable natural resources (Halland, Lokanc and Nair, 2015).

To overcome the challenges presented by the special characteristics of mining projects and the non-renewable character of mineral resources, well-designed fiscal regimes that capture the maximum amount of economic rent for governments, while keeping a country attractive for sophisticated mining firms with the right expertise and technology, are crucial if governments are to derive significant public revenue from mining activities. The following section will therefore discuss fiscal regimes in the mining sector in more detail.

4. Fiscal regimes in the mining sector

This chapter is intended to give an overview of fiscal regimes in the mining sector and how to assess them from a qualitative and quantitative perspective. In this chapter we:

- Set out the main types of mining fiscal regimes and common fiscal instruments used by governments.
- Suggest a framework for assessing fiscal regimes based on principles of tax policy.
- Highlight the different tax regimes that usually apply to Artisanal and Small-scale Mining (ASM).
- Present key metrics for mining fiscal regime appraisal, such as the 'government take' and the combined effective royalty and tax rate.

We conclude that there is no 'ideal' fiscal regime for the mining sector and that fiscal regime design involves making informed trade-offs between different priorities. Governments should design a fiscal regime based on their specific objectives for the mining sector and public finances. More detailed information on current international practices is set out in Annex A.

Fiscal revenues are a key benefit to host countries from mining, especially as mining can often be an enclave sector that has limited upstream and downstream integration into the domestic economy. Converting the state's sub-soil mineral assets into public revenues that can fund growth-enhancing public infrastructure is key to economic development.[8] This is difficult to achieve in practice, as it requires sound macro-fiscal policies to manage revenue volatility and ensure natural resource revenues are allocated to public investments that are likely to increase productivity and economic growth.

8 As mineral resources are a finite public asset, it is important to consider inter-generational fairness. This generally means that revenues should be invested in infrastructure and programs that benefit current and future citizens, and not used to meet current spending needs, such as the salaries of public sector workers.

4.1. Types of mining fiscal regime

As described in the previous section, mining is different from other sectors of the economy:

- It involves the extraction and exploitation of finite mineral resources that belong to the state.
- It requires large up-front investment that pays back over a long period of time.
- There is a high level of uncertainty, for example in the quality of the mineral deposit, costs to extract, and future mineral prices.
- It can lead to the generation of 'economic rents' – profits above normal returns due to the intrinsic value of the mineral assets.

For these reasons, host countries often use a special fiscal regime for mining. The most common approach is a tax and royalty regime[9], under which the government levies royalties on mineral production as compensation for the loss of its finite resources, taxes the mining company on its activities and profits (often including special provisions or additional taxes, such as a resource rent tax or state equity) and withholds taxes on outbound payments to service providers, lenders and shareholders. *Box 4.1* provides further details on some of the key fiscal instruments used in a mining sector tax and royalty fiscal regime.

The mining fiscal regime is often specified in the general law, either within the general fiscal corpus, or in sector-specific legislation. Many countries sign concession contracts with mining companies for specific mining projects. These contracts can modify the fiscal regime under the general law, for example, by granting tax incentives to investors for a specific project. In some cases, the contract can specify the fiscal regime in its entirety, either replacing the fiscal regime under the general law, or backfilling legislation in countries where mining is a relatively new activity, and the full legal and regulatory framework is not yet in place. International treaties, especially bilateral Double Taxation Agreements (DTAs), can override domestic tax law – often by reducing the rates of withholding taxes on outbound payments to the other country. To determine the fiscal regime for a specific mining project, it is therefore important to review the general law, sector-specific law, concession contracts, and international treaties.

9 *In the oil and gas sector, an alternative approach to tax and royalty regimes is production sharing, under which the state receives a share of petroleum production after the petroleum company has recovered costs. This approach often leads to a higher share of financial benefits for host countries than tax and royalty regimes, although this could reflect the higher economic rents that are usually generated by petroleum projects rather than the different approach to the fiscal regime per se. Production sharing in mining is increasingly being considered, and over the coming decades it is possible that this approach is tried by some countries.*

Box 4.1: Fiscal instruments used in mining

- **License fees** and **surface rents** are payments to the state for the rights to conduct mining operations in specific areas. These can be lump sum payments, fixed annual charges, or levied as a small percentage of sales or profits. For large-scale mining these fees are usually negligible relative to taxes and royalties.
- **Royalties** are payments to the state for the right to extract minerals and provide compensation to the state for the loss of finite natural resources. Royalties are usually charged on all units of production, most commonly as a percentage of the selling value (known as 'ad valorem'). In some instances, royalties can be fixed charges per unit of mineral extracted, or can be charged on the operating profits of the mining company. Host countries are increasingly making use of 'sliding-scale' royalties that increase the royalty rate when mineral prices or mining company profits are higher, and vice versa.
- **Import duties** are ordinarily levied on the importation of goods into a country. As mining projects often require imports of expensive equipment and machinery in the development stage (before the mine moves into production and generates revenues) and consumables during production, some states reduce duty rates or exempt the mining company from duties to reduce input costs.
- **Export duties** are charged on the exportation of goods from a country. As mining companies compete in a global market, host countries usually exempt mineral exports from export duties to ensure competitiveness of host mining operations. In some cases, host countries impose export duties on unprocessed mineral exports but exempt processed minerals and metals from export duties to encourage investment in downstream processing facilities.
- **Value added tax (VAT)** is a tax on sales that is applied incrementally through the value chain, with the full value ultimately borne by the end consumer. Producers pay VAT on their inputs (known as input VAT) and reclaim VAT on their sales (known as output VAT). In most countries, exports are 'zero-rated', meaning there is no VAT charged on the export sale and input VAT is reclaimed from the government and refunded to the exporter. Due to timing differences between input VAT during the development stage of a mine and refunds that would be due on exports during production, some countries exempt mining companies from VAT altogether.
- **Corporate income tax (CIT)** is a tax on the profits of companies. In the mining sector, the standard corporate income tax regime is often modified. For example, some countries provide capital allowances or accelerated depreciation to support cost recovery of large up-front investments. In some countries a higher rate of CIT is charged in the mining sector, reflecting the state's ownership of mineral assets, while other countries provide a lower rate of CIT for mining to attract investment.
- **Resource rent taxes** are sometimes used in the mining sector to tax economic rents, reflecting the state's ownership of mineral resources. Rent taxes are usually charged on the accumulated cash flows of a project after they exceed a hurdle rate of return. They are therefore unlikely to deter investment but usually only generate revenues later in the project life cycle, if at all.
- **Withholding taxes** are taxes on the recipients of payments from the mining company that are withheld by the mining company and remitted to the tax authorities on behalf of the payee. If the payee is a domestic entity, they are effectively pre-payments of income tax. If the payee is a foreign entity, they are final taxes on the profits the payee derives from its activities in the host country.
- **State equity** is when the state participates in the mining project as a shareholder, entitling it to a share of profits or dividend distributions. Depending on the form of state equity, the state might purchase equity or receive it for free, and it might contribute to project expenditures or not.

4.2. Framework for assessing mining fiscal regimes

There is no 'ideal' fiscal regime for mining and governments should decide what combination of fiscal instruments and terms will be appropriate for their specific circumstances. These circumstances include how much the government wants to raise and spend, how competitive the government wishes to be to attract investment and encourage resource exploration, development and production, and the capacity of the country to implement specific fiscal instruments (OECD, 2019).

Designing a mining fiscal regime therefore involves making informed trade-offs between different principles (see *Box 4.2*). For example, a government may want to ensure that the fiscal regime is progressive, meaning it increases the government's share of financial benefits when mining company profits are higher, and vice versa, but in doing so may need to accept a higher level of revenue volatility, more complexity, and a greater risk of tax avoidance that comes from profit-based taxes and royalties. Host countries often use a mix of fiscal instruments in the mining fiscal regime, each with its own characteristics, with the overall impact of the fiscal regime determined by the balance between different fiscal instruments.

Box 4.2. Framework for assessing mining fiscal instruments and regimes[10]

- **Economic efficiency.** In theory, a neutral fiscal regime is one that does not distort the behaviour of investors or mining companies. This would mean the fiscal regime, in and of itself, would not deter investment, would not alter the order in which projects (including exploration) are undertaken, and would not affect the pace or level of resource extraction, decisions about reinvestment, or decisions to close the mine. In practice, all taxes tend to distort decisions, although some taxes are more distortive than others. The economic efficiency of fiscal instruments measures the extent to which they distort decisions.
- **Progressivity.** A progressive fiscal regime increases the government share of financial benefits collected by the state when the project is more profitable and reduces the government share when a project is less profitable. A progressive fiscal regime responds automatically to changing profitability without requiring explicit policy changes. Progressivity means that the effective tax rate increases or decreases with profits, not just the absolute amount of revenues collected. A regressive fiscal regime is the opposite of progressive – it imposes a higher fiscal burden when profits are low, and vice versa. An overly regressive fiscal regime can deter investment, by increasing the risk that an investor will not make a minimum return on its investment.
- **Simplicity.** The simplicity of the fiscal regime refers to how easy it is for tax authorities and the taxpayer to administer and comply with the fiscal regime. This can reduce the time and effort needed by both parties to assess and pay taxes. An individual fiscal instrument can be more or less simple (for example, a royalty on sales is generally simpler than a profit-based royalty), and the fiscal regime as a whole can be more or less simple depending on the number of different fiscal instruments used and their individual complexity.
- **Timing.** The timing of revenues is important to both governments and investors. Generally, both would prefer earlier revenues – investors to recover their costs and make a return as soon as possible, and governments to fund public investments as soon as possible, especially in lower-income countries with low existing capital stocks. This means there is a trade-off between supporting investors to recover costs and generating early revenues to fund public investment.
- **Robustness.** Finally, as large-scale mining is often undertaken by multinational enterprises with the capabilities to shift profits, the robustness to tax avoidance is an important consideration for governments. A fiscal regime can be made more robust be relying on fiscal instruments that are harder to avoid, such as ad valorem royalties and withholding taxes, or by implementing measures to tackle tax base erosion and profit shifting (BEPS) that can support revenues from CIT and resource rent taxes.

10 *Framework developed by reference to Cottareli (2012), NRGI (2015) and UN (2018).*

4.3. Taxation of artisanal and small-scale mining

ASM is very different from LSM, and therefore requires a different approach to taxation. In the ASM sector, mines often rely on informal labour rather than large capital investments, and mining companies are not always registered with the tax authorities. The taxation of the ASM sector therefore often relies more on ad valorem royalties and license fees. Because of the greater risk of smuggling in the ASM sector, particularly for small, high-value minerals such as gold and diamonds, royalty rates are sometimes lower than in large-scale mining to reduce the incentives for smugglers to evade royalties. In Sierra Leone, for instance, an increase in the royalty rate for gold and diamonds from 3 % to 5 % and from 3 % to 6.5 % in 2010 respectively, led to an immediate decrease in the official gold and diamond exports and hence a possible increase in smuggling. As a result, authorities decided to lower royalty rates for both products back to 3 % in 2013 (Mano River Union, 2017). As such, the artisanal mining sector usually provides less government revenues than large-scale mining, as revenue collection is concentrated on the collection of royalties (with often lower royalty rates) and licence fees.

Many of the minerals critical to the energy transition are bulk minerals that are only produced in LSM operations. The only energy transition mineral that currently has a significant share of production from the ASM sector is cobalt, where the EU Raw Materials Information System (2019) estimates that around 25 % of supply is from ASM.

4.4. Appraisal and measurement of the fiscal regime

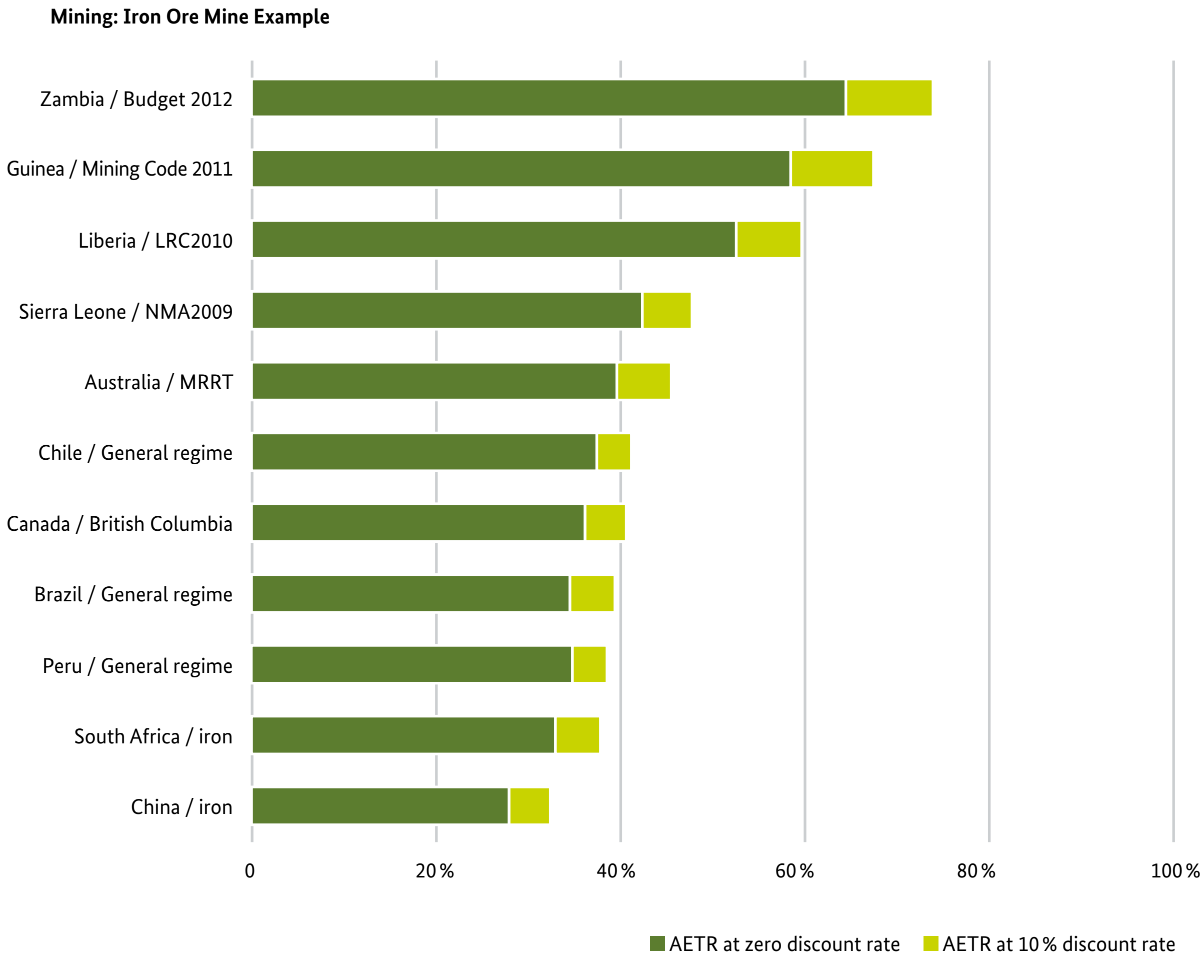
Measuring the burden of the fiscal regime is important for investors and governments alike. Investors are concerned with their return on investment after tax, and governments want to know if they are receiving a 'fair share' of the financial value from the exploitation of their finite mineral resources. The payment of taxes and royalties are also a key element of the 'social license' to operate for mining companies, making the transparency of payments made by mining companies an important aspect of the fiscal regime. The management of public expectations at the beginning of mining projects is also critical, given revenues from the mining sector are often low in the initial years due to higher depreciation and debt interest deductions as investors recover their costs, reducing payments of income tax.

Despite the importance of understanding the government's share of financial benefits, there is no single, standard approach to its measurement. Below, we set out two common approaches: the 'government take' and the combined effective royalty and tax rate.

4.4.1. The 'government take'

The 'government take', or formally the average effective tax rate (AETR), is a measure of the share of pre-tax project cash flows collected by the government in royalties and taxes over the life of the project. There is no standard definition of the government take and material differences can arise depending on how they are calculated. For example, the scope of taxes included in the government take is not fixed, with some counting only direct taxes and payments by the mining company (such as royalties and income taxes) and its shareholders (withholding taxes on dividends), and others considering indirect taxes on mining company inputs (such as import duties and VAT) and withholding taxes on outbound payments (such as withholding taxes on services and debt interest) part of the government take. The government take can also be measured in real terms, or using discounted cash flows, in which case the choice of discount rate can have a material impact on results. The valuation point is also important – the government take can be estimated from the point at which a final investment decision is made by the investor and large development costs begin to be incurred, or it could include previous years' exploration expenses. The IMF (Cottarelli, 2012) estimates that a government take of between 40 and 60 per cent is achievable in the mining sector (see *Figure 4.1*).

Figure 4.1: Estimates of the government take in mining

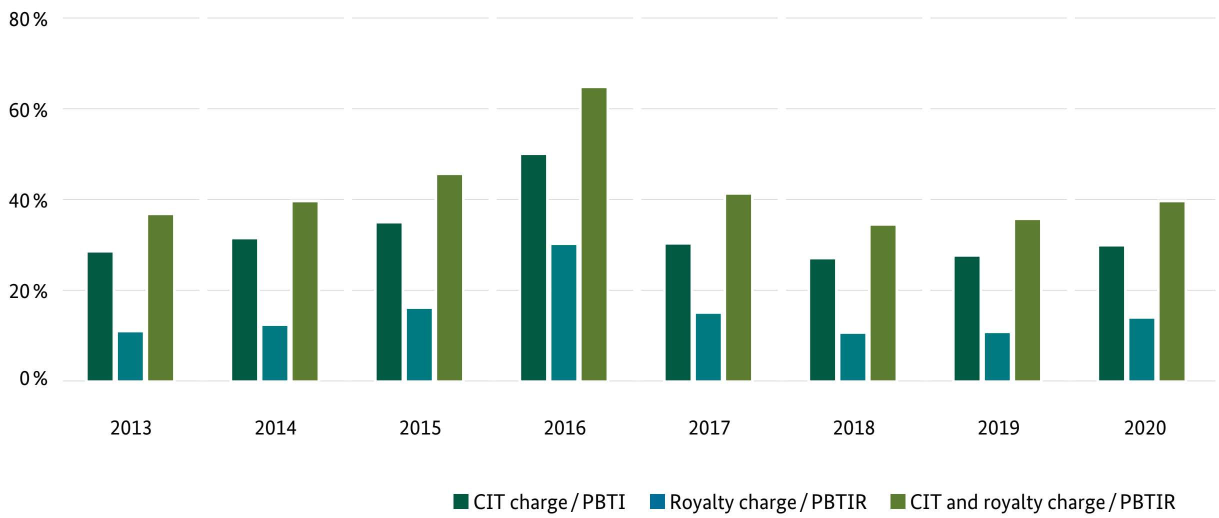


Source: Cottarelli (2012).

4.4.2. The combined effective royalty and tax rate

An alternative approach is to estimate the effective tax rate using accounting profits. This is used by the International Council on Minerals and Metals (ICMM), an industry body that brings together a third of the global metals and mining industry, in its periodic ICMM Members' Tax Contribution Report (ICMM, 2020). The approach begins with net profits as reported in audited accounts, adds back royalties that have already been accounted for in net profits, and adds back impairments and other extraordinary items that are not usually tax-deductible to arrive at profits before tax, impairments and royalties (PBTIR). The combined effective royalty and tax rate is then the amount collected in royalties and CIT as a share of PBTIR, which can either by an annual figure or estimated over a period of years to account for cyclical changes in mineral prices, profits, and taxes paid. Estimates are also given for the effective CIT rate (as a share of profits before tax and impairments, or PBTI) and effective royalty rate (as a percentage of PBTIR). Effective tax rates, as reported by ICMM members, are shown in *Figure 4.2*. While the ICMM approach includes only royalties and CIT, the methodology can be expanded to include other fiscal instruments such as resource rent taxes and withholding taxes.

Figure 4.2: Estimates of effective tax and royalty rates in mining



Notes: CIT = Corporate Income Tax, PBTI = Profits Before Tax and Impairments, PBTIR = Profits Before Tax, Impairments and Royalties. Source: ICMM (2020).

5. Methodology for estimating government revenue potential

This chapter provides an overview of the methodology and assumptions used to estimate the revenue potential from energy transition minerals. In this chapter we:

- Present the methodology that underpins the findings of this study.
- Set out the steps that were taken to forecast the gross revenue potential and government revenues.

More detail on the methodology and assumptions used is presented in *Annex B*.

Forecasting revenues from natural resources is challenging as it depends on many future events that are difficult to predict. These include the amount of minerals that will be produced, the market price of minerals (which historically have been volatile and difficult to forecast), the costs to produce, and profitability of mining companies, as well as the amount of financial value that governments can collect as public revenues through the fiscal regime. In this report, we present estimates of the revenue potential for each energy transition mineral at a global and regional level. These estimates are presented as a range, reflecting the uncertainties of key variables such as demand and mineral prices. The general methodology is in seven steps, as set out in *Box 5.1*.

Box 5.1. Steps to estimating revenue potential from energy transition minerals

→ **Step 1: Estimate mining production by mineral and country.** We begin with demand scenarios for each mineral and subtract from this secondary supply (recycling) to estimate the demand that would need to be met from primary supply (mining), henceforth net demand. We then disaggregate this net demand according to the share of current production and reserves of the respective countries.

- *Demand – secondary supply = net demand by mineral (estimated production by mineral)*
- *Primary supply * production and reserves shares by country = net demand by country (estimated production by country)*

→ **Step 2: Estimate large-scale versus artisanal and small-scale mining per country.** We then split these country estimates into LSM and ASM based on the historical proportion of supply from each sector for each mineral.

- *Estimated production from LSM by country = historical proportion from LSM * estimated production by country*
- *Estimated production from ASM by country = historical proportion from ASM * estimated production by country*

→ **Step 3: Estimate revenue from sales.** We combine mining production with forecasts of future mineral prices to estimate the potential revenue from sales. Our estimate for the potential revenue from sales can therefore be also referred to as "gross revenues".

- *Revenue from sales = estimated production by country * price*

→ **Step 4: Estimate mining company profits for LSM production.** For LSM, we use historical data on mining company profit margins to estimate aggregate pre-tax profits[11] and operating profits for each mineral.

- *Pre-tax profits = revenue from sales * pre-tax profit margin*
- *Operating profits = revenues from sales * operating profit margin*

→ **Step 5: Estimate the 'fiscal take' from LSM production.** For LSM, we assume that governments mainly collect taxes through royalties, corporate income taxes and state participation. For royalties, we differentiate a range of country-specific royalty regimes whereby royalties are either collected on the revenues from sales or operating profits. To estimate corporate income tax collection, we multiply estimated pre-tax profits with the applicable corporate income tax rate for each country. Returns from state participation are estimated on the basis of post-tax profits.

- *Royalties = revenues from sales or operating profits * applicable royalty rate*
- *Corporate income tax = pre-tax profits * applicable corporate income tax rate*
- *Post-tax profits = Pre-tax profits – corporate income tax*
- *State participation = post-tax profits * applicable equity share/state participation*
- *Fiscal take from LSM = Royalties + Corporate income tax + State participation*

→ **Step 6: Estimate the 'fiscal take' from ASM production.** For ASM, we assume governments collect only royalties on sales and are not able to levy profit-based taxes. We identify the country-specific royalty rate regimes to estimate the fiscal take from ASM production.

- *Fiscal take from ASM = revenue from sales * applicable royalty rate*

→ **Step 7: Estimate the revenue potential.** Finally, we add together the fiscal take from the LSM and ASM sectors to determine the revenue potential for each mineral.

- *Revenue potential = fiscal take from LSM + fiscal take from ASM*

We repeat the steps multiple times for each mineral and country using different scenarios for demand, prices, and profit margins to generate a range of revenue potential estimates. We produce these estimates of production for each of the main countries that are currently producing or have significant reserves and generate estimates of the revenue potential 'bottom up' using each country's specific royalty and tax rates.

Further details on the methodology and underlying assumptions used to produce the estimates and findings presented in this report are set out in Annex B.

11 *Pre-tax profits are equal to gross revenues less operating costs, financing costs (debt interest) and the depreciation of capital costs (Finbox, 2022).*

6. Findings on revenue potential

This chapter sets out the key findings from our analysis of the revenue potential from energy transition minerals for resource-rich countries. In this chapter we:

- Highlight the global gross revenue potential from the extraction of energy transition minerals and the potential government revenues from royalties and taxes.
- Show that different regions and country income groups have differing levels of revenue potential due to varying resource endowments and fiscal regime designs.
- Highlight which minerals will make the largest contribution to government revenues.
- Present detailed analysis of the geological potential, current production, and forecast prices and revenue potential from each mineral in a fact sheet format.

We conclude that the annual government revenue potential could be between US$5 billion and US$25 billion per year on average in the period to 2040, on top of existing public revenues from the mining sector. This could mean between $100 billion and $500 billion in additional government revenues from energy transition minerals by 2040. Countries in the Latin America and Caribbean region and East Asia and the Pacific are likely to benefit most. As a share of GDP, the potential revenue benefits in Sub-Saharan Africa are also significant. Given the low current production and limited reserve base in South Asia, and North Africa and the Middle East, governments in those regions will likely only receive negligible revenues.

There is a high level of uncertainty surrounding revenue estimates, depending on the policy and technological pathways to net zero, and the corresponding impact on demand, supply, and mineral prices. The estimates are intended to illustrate the revenue potential and show broad trends across different regions, country income levels, and minerals.

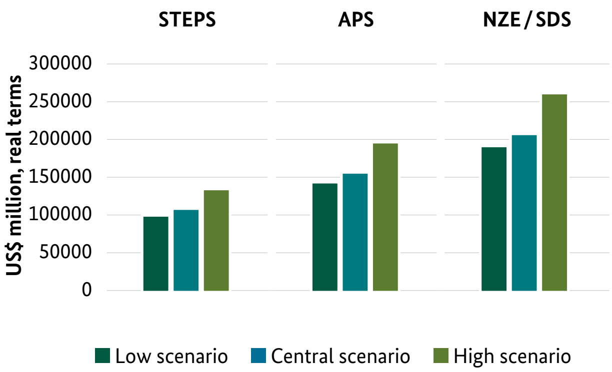
6.1. Global revenue potential

Our analysis finds that the gross revenue from sales (excluding production costs and taxes) of the 7 key energy transition minerals that were assessed is significant. The average annual gross revenue until 2040 ranges from US$98 billion under the low STEPS scenario to US$259 billion under high NZE/SDS scenario (*Figure 6.1* and *Table 6.1*). As outlined in the methodology section, these estimates take into account potential variations in mineral prices, demand and production.

Table 6.1: Average annual gross revenues by scenario

Scenario	**STEPS** (US$ million, real terms)	**APS** (US$ million, real terms)	**NZE/SDS** (US$ million, real terms)
Low scenario	98,013	142,000	189,294
Central scenario	106,055	153,992	205,368
High scenario	131,541	194,271	258,781

Figure 6.1: Average annual gross revenues by scenario

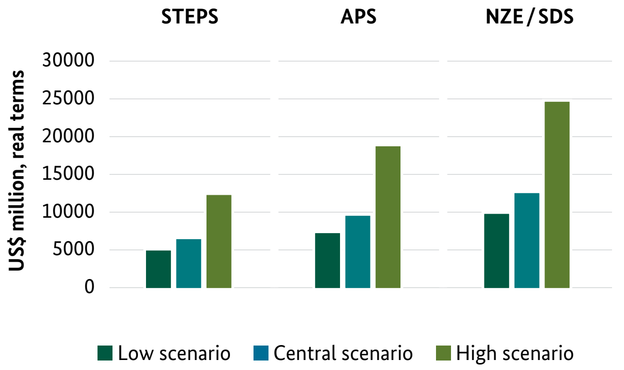


This gross revenue potential translates into significant government revenue potential. We estimate that the tax and royalty revenue potential from the key energy transition minerals we assessed will average between US$5 billion and US$25 billion annually in the period to 2040 (*Figure 6.2* and *Table 6.2*). This equates to additional government revenues of between $100 billion and $500 billion from selected energy transition minerals by 2040.

Table 6.2: Average annual government revenues by scenario

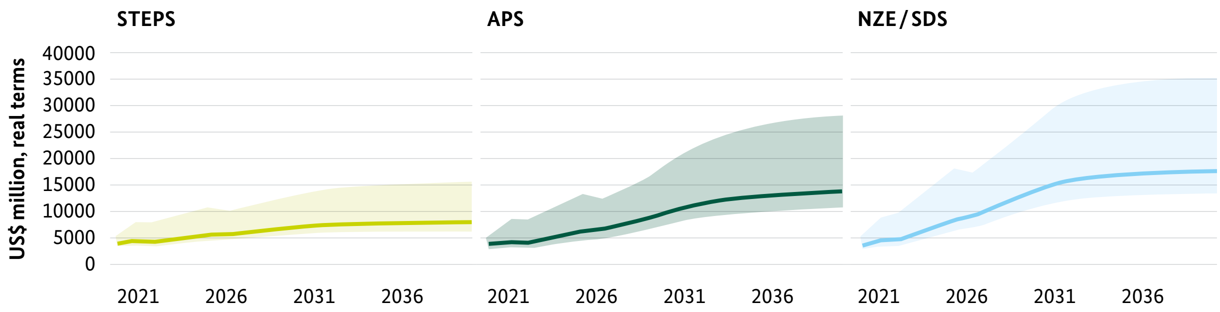
Scenario	**STEPS** (US$ million, real terms)	**APS** (US$ million, real terms)	**NZE/SDS** (US$ million, real terms)
Low scenario	4,961	7,260	9,656
Central scenario	6,422	9,398	12,487
High scenario	12,263	18,616	24,513

Figure 6.2: Average annual government revenues by scenario



Under all scenarios, there is a steady increase in government revenues until the early 2030s, where revenue growth starts to level off before stabilising (*Figure 6.3*).

Figure 6.3: Annual government revenues by scenario



Note: line shows central scenario, upper and lower ends of the shaded area show high and low scenarios respectively. STEPS = Stated Policies Scenario, APS = Announced Pledges Scenario, NZE = Net Zero Emissions by 2050 Scenario, and SDS = Sustainable Development Scenario.

Our analysis shows that government revenue from energy transition minerals is predominately driven by four factors. First, by the adoption speed of renewable energy technology and EVs – if the adoption speed is slower (STEPS scenario), governments will receive significantly lower revenues than under a faster adoption (APS or NZE). Second, mineral prices have significant impacts on government revenues. If prices are lower, mining companies' revenue will be lower, reducing their profit margins. If prices are higher, mining companies' profit margins increase, and this will lead to higher tax payments to governments. Third, potential revenues depend largely on mineral reserves that are only coming online slowly, while the production capacity of existing mining projects is declining. Hence, if a country with limited production fails to develop its reserves or a country with existing production fails to develop additional reserves to replace existing mining projects' falling output, revenue collection will be significantly lower. Fourth, the speed at which recycling capacity will develop has a significant impact on the primary demand of energy transition minerals and in turn government revenue from mining. For example, recycling capacity is predicted to increase fast for minerals like cobalt and nickel, crowding out some of the primary demand for those minerals.

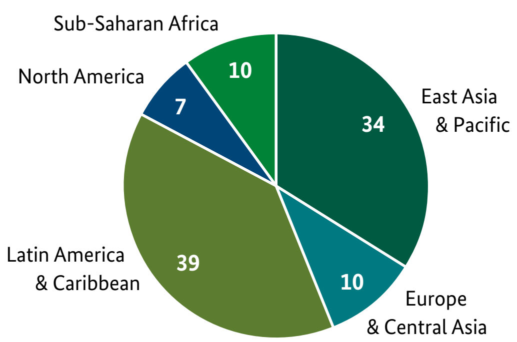
6.2. Regional and country income-level differences

6.2.1. Gross revenue potential

Our analysis finds that some regions will benefit significantly more than others (*Figure 6.4*).[12] The regions that we estimate to generate the largest gross revenues from energy transition minerals in absolute terms are Latin America and the Caribbean (37 %), followed by East Asia and the Pacific (34 %). Europe and Central Asia, and Sub-Saharan Africa, will each generate 10 % of gross revenues from the mining of energy transition minerals. South Asia and the Middle East and North Africa regions will generate the lowest gross revenues, in both cases accounting for less than 1% of the global total.

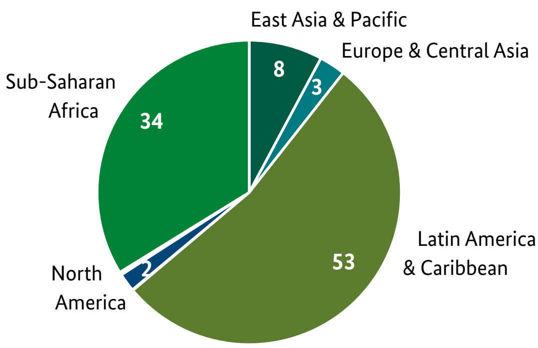
This distribution of gross revenues will have significantly different impacts on the overall economic output of different regions, with Sub-Saharan Africa especially benefiting more than their overall gross revenue potential suggests, and East Asia and Pacific benefiting significantly less. If total gross revenues are expressed as a share of each region's GDP, Latin America and the Caribbean and Sub-Saharan Africa will generate the largest additional gross revenue from energy transition minerals compared to the sizes of their economies (*Figure 6.5*). In Latin America and the Caribbean, the mining of energy transition minerals would generate economic output of 1.2 % of current GDP, while Sub-Saharan Africa's gross revenue as a share of GDP would be 0.76 % (*Table 6.3*).

Figure 6.4: Share of gross revenue by region (in %)



Note: Estimates under APS central scenario.
Source: GDP figures from World Bank (2022b).

Figure 6.5: Share of gross revenue by region adjusted for regional GDP (in %)



Note: Estimates under APS central scenario.
Source: GDP figures from World Bank (2022b).

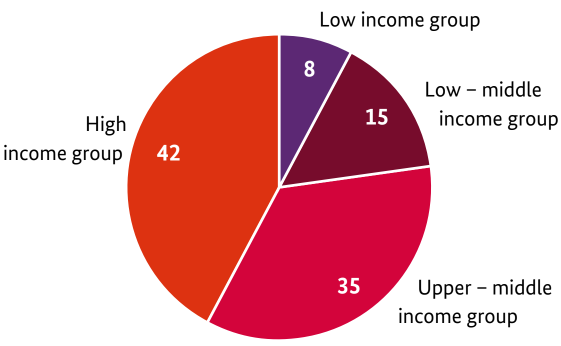
12 *This study uses the regional classification developed by the World Bank. For more information see: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html*

Table 6.3: Average annual gross revenues by region as a share of GDP
Source: GDP figures from World Bank (2022b). Note: Estimates under APS central scenario.

Region	Average annual gross revenue (US$ million, real terms)	GDP in 2021 (US$ million, real terms)	Gross revenue as a share of 2021 GDP (%)
East Asia & Pacific	52,950	30,056,574	0.18
Europe & Central Asia	15,700	24,952,561	0.06
Latin America & Caribbean	59,562	4,964,237	1.20
Middle East & North Africa	52	2,743,880	0.00
North America	10,892	24,993,943	0.04
South Asia	293	4,061,703	0.01
Sub-Saharan Africa	14,543	1,910,122	0.76

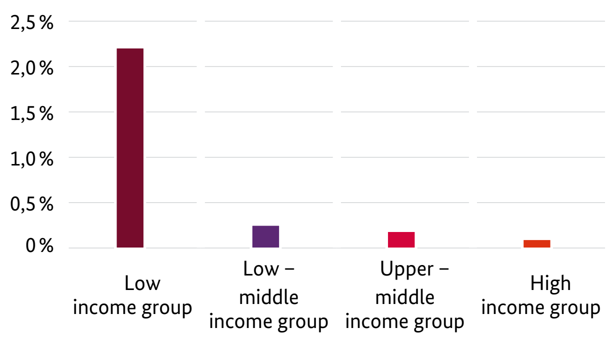
We estimate that most revenues will not be generated in low-income or lower-middle income countries, but in high-income and upper-middle income group countries (*Figure 6.6*). Only 8 % of total gross revenues will be generated in low-income countries. The main driver for this is the lower share of reserves compared to current production that can be observed in these countries. This reflects the fact that the geological potential for energy transition minerals in these regions are comparatively poorly understood and under-developed. Hence, unless there is investment in geological exploration in low-income countries, and regions like Sub-Saharan Africa, these countries will see fewer new mines developed and therefore less gross revenue over time. As low-income countries' economies are significantly smaller than high-income countries' economies, the impact of energy transition mineral extraction will nonetheless be of outsized significance for low-income countries (*Figure 6.7*).

Figure 6.6: Share of gross revenues by country income group (in %)



Note: Estimates under APS central scenario.

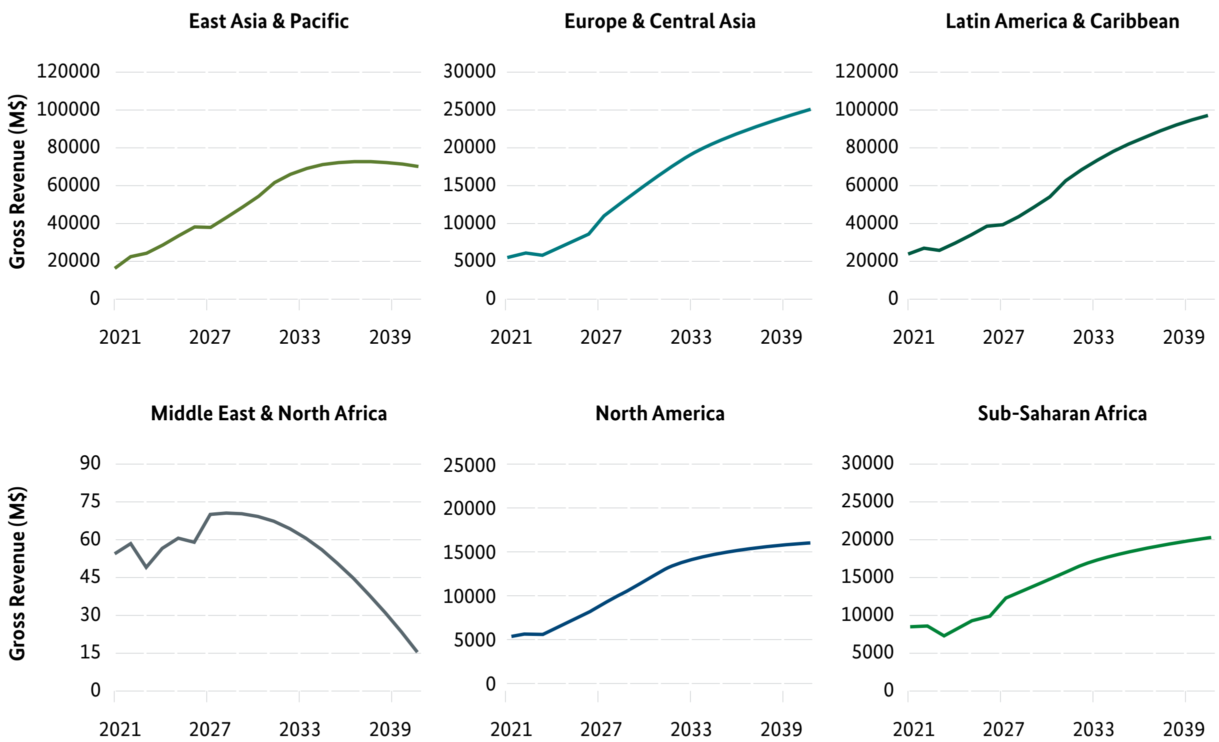
Figure 6.7: Average annual gross revenues as a share of 2021 GDP by country income group (in %)



Note: Estimates under APS central scenario

We also find that gross revenues in most regions increases significantly before 2030. Growth then decelerates in the 2030s (*Figure 6.8*). Only in one region, the Middle East and North Africa, does annual gross revenue decrease over time. This decrease is primarily driven by low levels of current energy transition mineral production and a very limited proven reserve base.

Figure 6.8: Annual gross revenues for selected regions



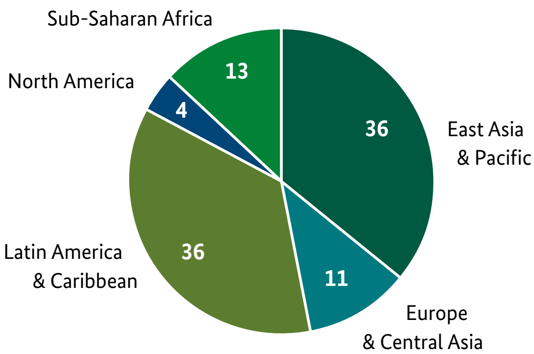
Note: Estimates under APS central scenario.

6.2.2. Government revenue potential

The potential government revenues collected in each region and respective income groups shows a similar trend to the one observed in gross revenue generation (*Figure 6.9*). We estimate that most government revenues will be raised by countries in the Latin America and the Caribbean region, followed by East Asia and the Pacific. North American countries' governments will collect the least revenue from energy transition minerals. Countries in Sub-Saharan Africa will benefit from 13 % of the total government revenues generated from the mining of energy minerals over the coming 20 years. Given the low current production and limited reserve base in South Asia, and North Africa and the Middle East, governments in those regions will only receive negligible revenues

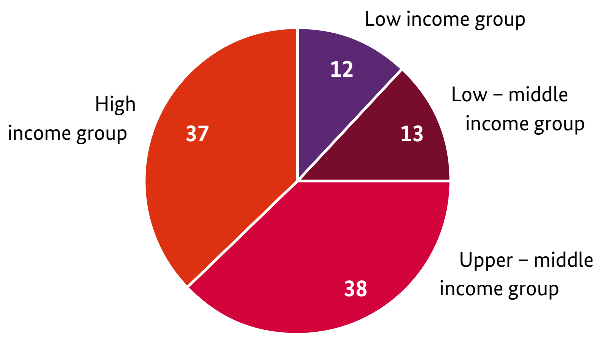
When looking at income groups, we estimate that most government revenues will be collected in upper-middle income countries (40 % of the total government revenue), followed by the high-income group countries (*Figure 6.10*). Low income and low-middle income countries will receive 12 % and 13 % of total government revenues respectively.

Figure 6.9: Total government revenue shares by region (in %)



Note: Estimates under APS central scenario.

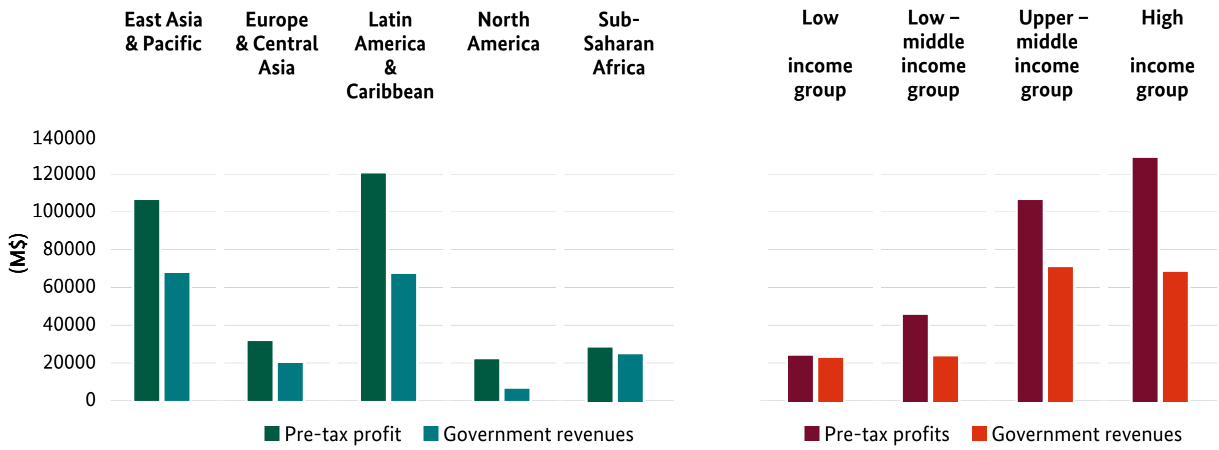
Figure 6.10: Total government revenue shares by income group (in %)



Note: Estimates under APS central scenario.

When comparing estimated government revenues to pre-tax profits, we find that the share of government revenues collected from pre-tax profits is the highest for Sub-Saharan Africa and comparatively low for North America and Latin America. This reflects higher average royalty and tax rates in Sub-Saharan Africa (see *Annex B*).

Figure 6.11: Total pre-tax profits and government revenues for selected regions and country income groups



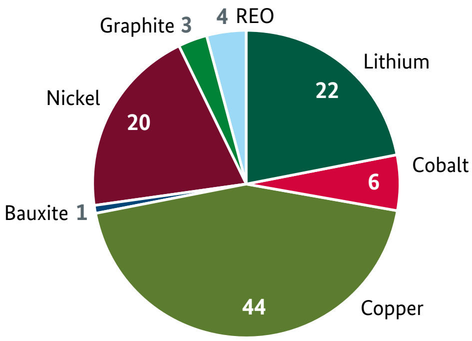
Low-income group countries tend to tax energy transition minerals proportionally more than high-income group countries (see *Figure 6.11*). The combined effective royalty and tax rate can be high, and therefore government revenue estimates close to total pre-tax profits, especially when a large share of revenues is collected by ad valorem royalties. This is the case for DRC, which displays the highest potential revenue collection from energy transition minerals in Sub-Saharan Africa. DRC currently charges a royalty of 10 % on gross revenues.

6.3. Revenue potential estimates for each energy transition mineral

In this section we set out revenue potential estimates for each energy transition mineral in fact sheet format, together with key information on the mineral's role in energy transition, current reserves and production around the world, and demand and price forecasts. The revenue potential estimates were generated using the methodology outlined in *section 4*.

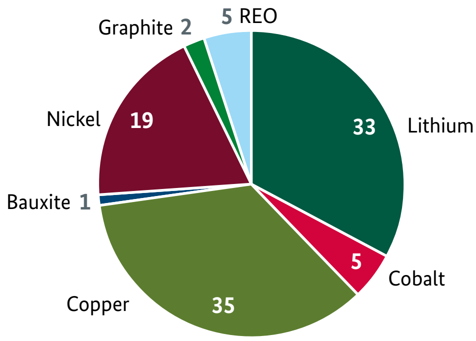
Under our central scenario the largest share of government revenues will come from copper, followed by lithium and nickel (*Figure 6.12*). Lithium becomes an increasingly important contributor to government revenues under scenarios with faster energy transition and higher mineral prices (*Figure 6.13*). Cobalt, REOs and graphite are likely to be significant drivers of revenues at a regional level. The least revenues will be generated from the production of Bauxite. This is because bauxite prices are expected to remain comparatively stable and low as energy transition demand will only lead to a relatively small increase in total aluminium demand, while aluminium is already one of the most recycled materials globally.

Figure 6.12: Total government revenue shares by mineral (in %)



Note: Estimated under APS central scenario

Figure 6.13: Government revenue shares by mineral under fast transition and high prices (in %)



Note: estimated under NZE high scenario

Copper is also generally the most important driver of revenues in most regions under most scenarios (see *Figures 6.14* and *6.15*). In Latin America and Caribbean, copper and lithium are the most important minerals, with lithium's importance increasing under more ambitious net zero pathways (*Figure 6.16*). East Asia and Pacific will benefit most from nickel, followed by copper and lithium. Revenues from rare earth oxides will mostly be generated in East Asia and Pacific, with only small amounts projects in other regions based on current production and known reserves. In Sub-Saharan Africa, cobalt will also be a large driver of government revenues.

The factsheets in the following sub-sections provide more insights for each energy transition mineral.

Government revenues by mineral in different regions ...

Figure 6.14: ... under STEPS central scenario (US$ million, real terms)

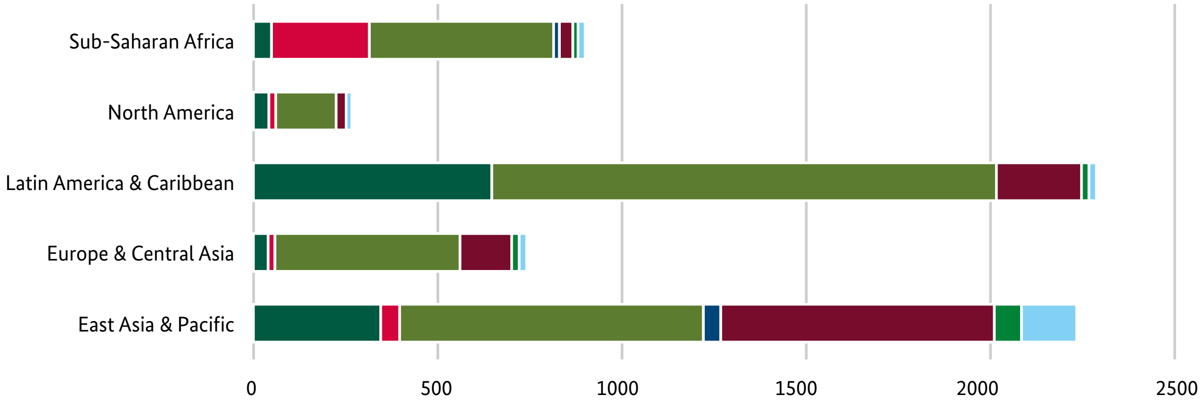


Figure 6.15: ... under APS central scenario (US$ million, real terms)

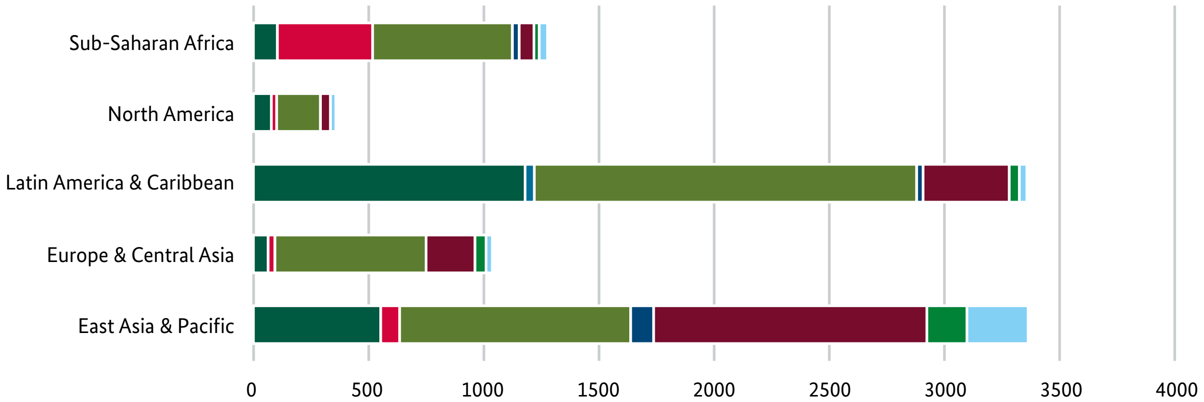
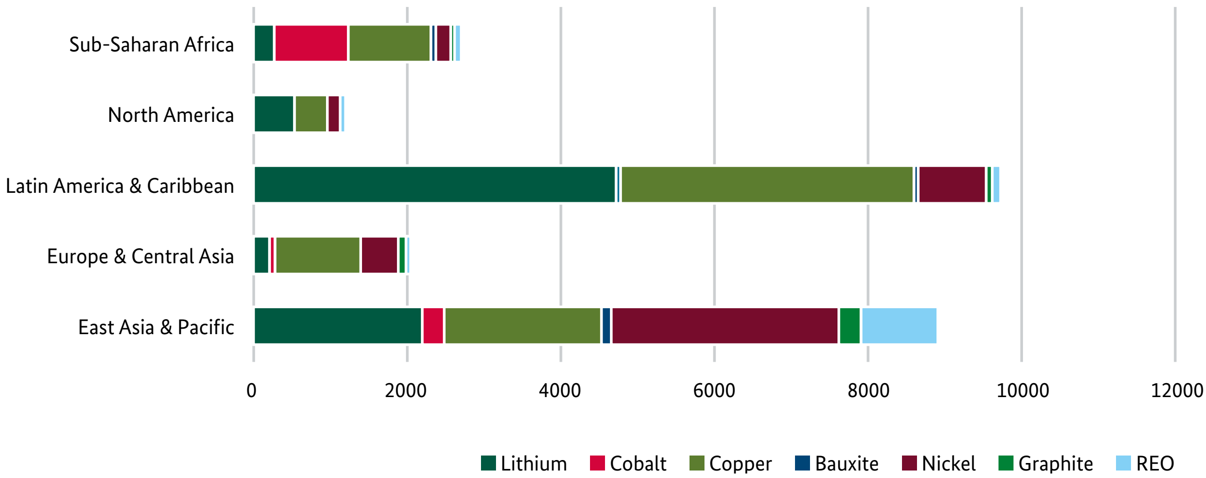


Figure 6.16: ... under NZE/SDS high scenario (US$ million, real terms)




P&H

6.4. Bauxite fact sheet

Why bauxite will be critical in the energy transition

The bulk of world bauxite production (approximately 85 %) is used as feed for the manufacture of alumina. Subsequently, most of the resulting alumina is used as feedstock to produce aluminium metal.
In the energy transition, aluminium will be needed for electric vehicles (to reduce weight and in batteries), electricity networks, and solar panels. All other clean energy technologies also require aluminium in varying quantities.

Main uses of bauxite in the energy transition

Solar PV	Wind	Hydro	CSP	Bioenergy	Geothermal	Nuclear	Grid	EVs	Hydrogen
high	moderate	moderate	high	moderate	low	low	high	high	moderate

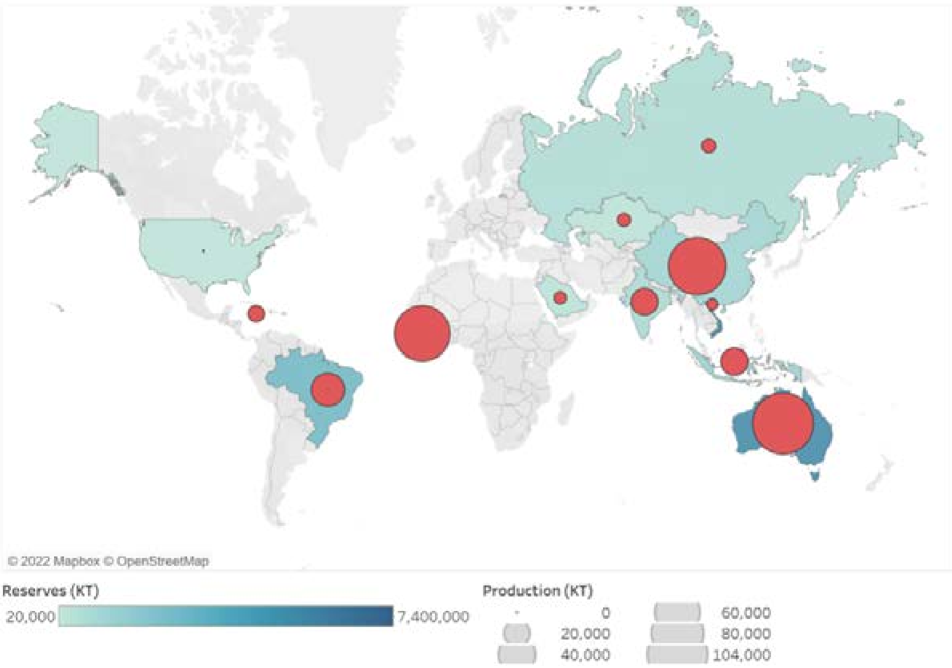
Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low
CSP = concentrated solar power Grid = electricity networks EVs = electric vehicles and includes batteries

Source: IEA (2021).

Known bauxite reserves and current production

There are sufficient reserves of bauxite (and alumina) to cover all demand due to energy transition. Australia, China, and Guinea are the world's largest producers and together account for over two-thirds of global production. All three countries have large reserves and significant excess output capacity.

Bauxite reserves and production (2020)

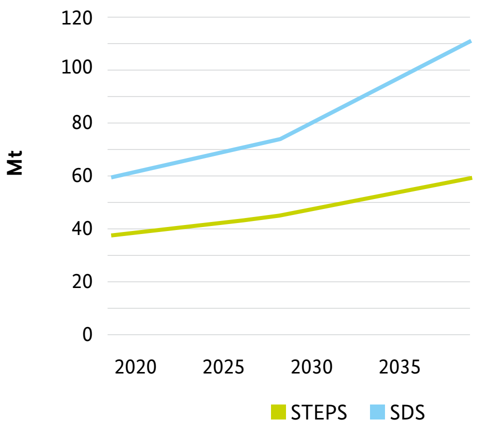


Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Bauxite demand and price forecasts

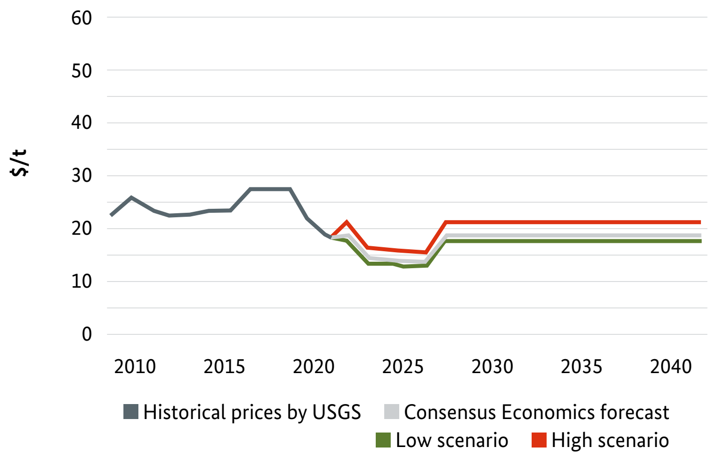
Given the large reserves and abundant excess output capacity, bauxite supply is forecasted to match demand even under the fastest renewable energy build-out scenarios. As a result, the bauxite price is forecast to be relatively stable over the coming decades. However, energy-intensive aluminium refining capacity might struggle to keep up with the required demand, which could lead to significant spikes in the price of aluminium.

Bauxite net primary demand forecasts



Source: Gregoir and van Acker (2022), authors' own calculations

Bauxite price forecasts

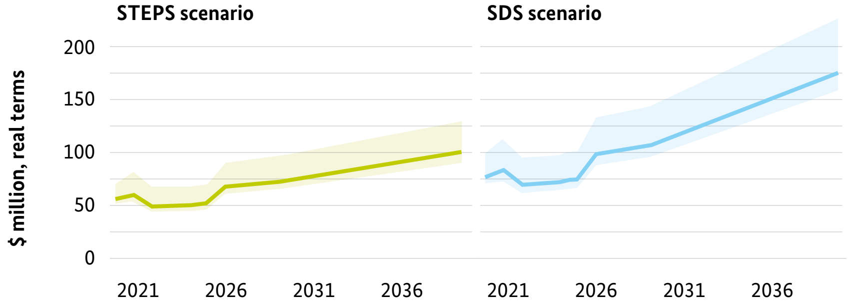


Source: USGS (2022), Consensus Economics (2022).

Revenue potential from bauxite

The annual revenue potential from energy-transition demand for bauxite is estimated at $72 million by 2030 and $99 million by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster SDS transition scenario to $110 million by 2030 and $175 million by 2040 (also using central price and profitability assumptions). Under the high price and profit scenario and faster SDS transition the revenue potential is as high as $227m per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $90m per year.

Estimated annual government revenue from energy transition demand for bauxite



Source: authors' own calculations.
Note: line shows central scenario, shaded area shows high and low scenarios.

6.5. Cobalt fact sheet

Why cobalt will be critical in the energy transition

Cobalt is a metal used in numerous diverse commercial, industrial, and military applications, many of which are strategic and critical. The main use of cobalt is in rechargeable battery electrodes, the production of which is forecast to grow exponentially over the coming years due to the transition to electric vehicles and the increasing use of batteries for grid storage.

Main uses of cobalt in the energy transition

Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low

CSP = concentrated solar power Grid = electricity networks EVs = electric vehicles and includes batteries

Source: IEA (2021).

Known cobalt reserves and current production

The Democratic Republic of the Congo (DRC) is home to half of the world's known cobalt reserves, and currently accounts for around 70 % of global production. A significant proportion of the DRC's cobalt exports are produced by artisanal and small-scale miners.

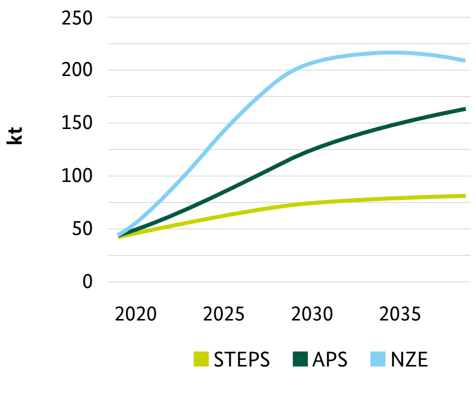
Cobalt reserves and production (2020)

Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Cobalt demand and price forecasts

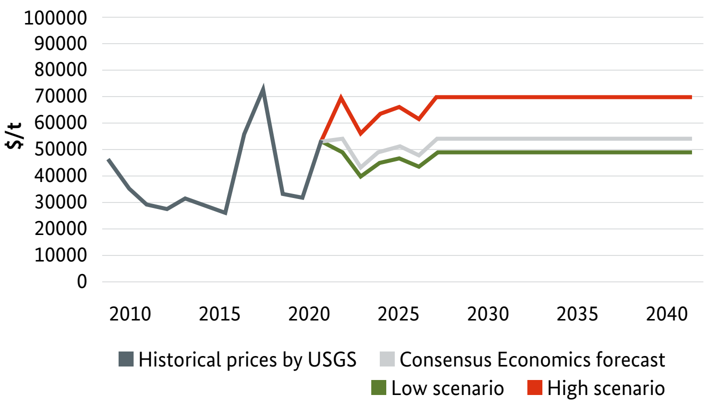
Although battery producers are reducing cobalt usage in batteries, demand for cobalt for energy transition is expected to grow between 7 % and 10 % per year until 2040. Most primary cobalt is produced as a by-product of copper and nickel production. Production growth of these minerals is projected to be 3 % to 4 % less than the required cobalt growth, potentially creating a supply deficit and a relatively high long-term price forecast. Cobalt recycling is forecast to ramp up slowly over time, so most demand will need to be met from mining.

Cobalt net primary demand forecasts



Source: Kim et al. (2022), author's own calculations.

Cobalt price forecasts

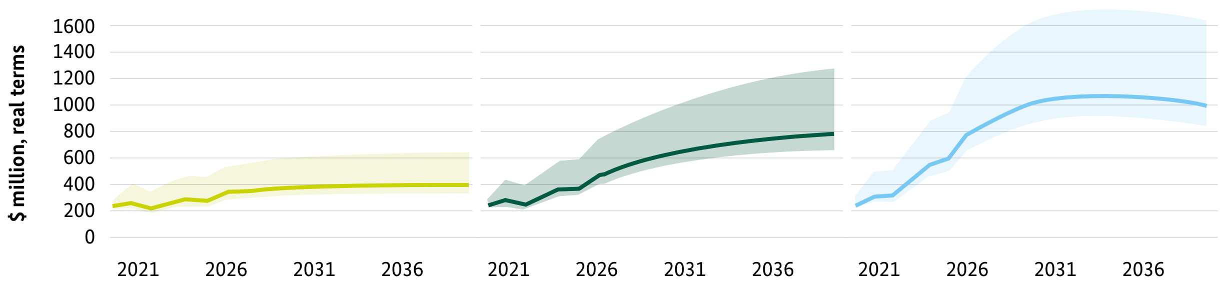


Source: LME(2022), Consensus Economics (2022).

Revenue potential from cobalt

The annual revenue potential from energy-transition demand for cobalt is estimated at $380 million by 2030 and $400 million by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster APS transition scenario to $600 million by 2030 and $780 million by 2040, and to about US$1 billion by 2040 under the NZE scenario (assuming a central price and profitability scenario). Under the high price and profit scenario and faster NZE transition the revenue potential is as high as $1.7 billion per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $340m per year.

Estimated annual government revenue from energy transition demand for cobalt



Source: author's own calculations. Note: line shows central scenario, shaded area shows high and low scenarios.

6.6. Copper fact sheet

Why copper will be critical in the energy transition

Copper is essential to all energy transition plans, as it is the key raw material for electricity transmission cables. With the rapidly increasing electrification of energy systems globally, copper demand is already increasing significantly.

Main uses of copper in the energy transition

Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low

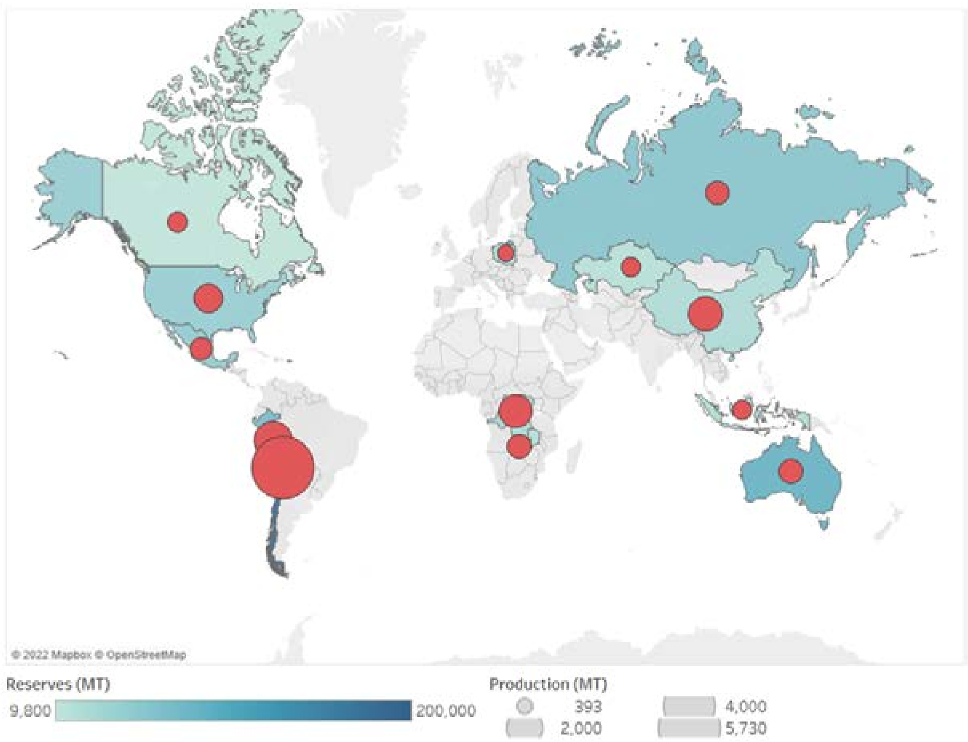
CSP = concentrated solar power Grid = electricity networks EVs = electric vehicles and includes batteries

Source: IEA (2021).

Known copper reserves and current production

Copper reserves are widespread globally and production is relatively dispersed. There are enough copper reserves available to fulfil the demand for energy transition. However, copper ore grades are declining globally (as the industry produces from the highest-grade deposits first), and copper mining's detrimental impacts on land use and freshwater are becoming increasingly divisive across many copper-producing countries.

Copper reserves and production (2020)

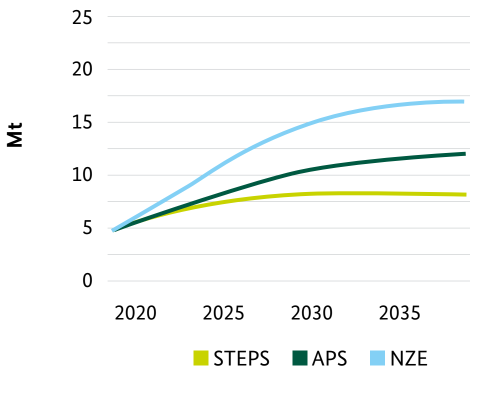


Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Copper demand and price forecasts

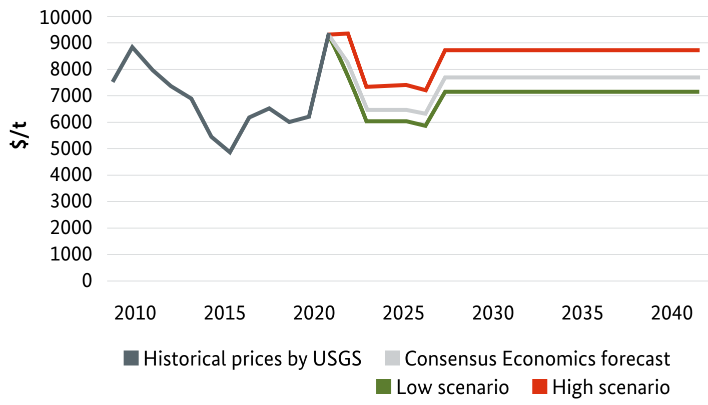
Copper demand is forecast to grow between 1.6 % and 2.8 % annually until 2040. Unlike many other energy transition minerals, increasing copper demand can be met by increasing levels of secondary supply through established copper collection and recycling systems and because there is a large installed base. Significant price spikes are therefore not anticipated in long-run copper price forecasts.

Copper net primary demand forecasts



Source: Kim at al. (2022), authors' own calculations.

Copper price forecasts

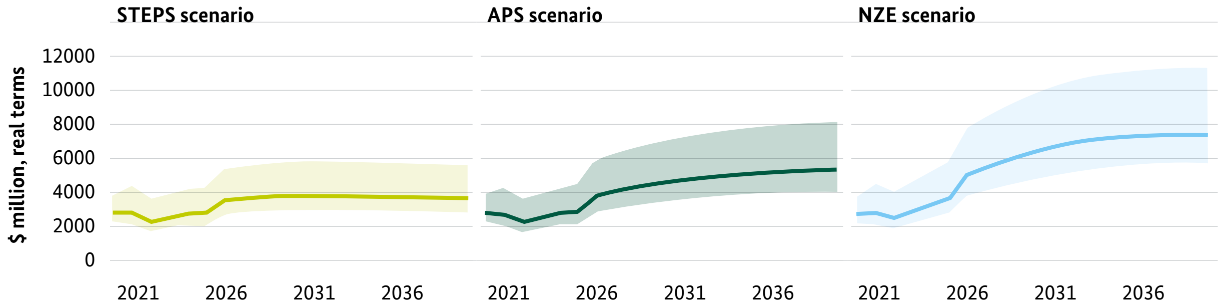


Source: USGS (2022), Consensus Economics (2022).

Revenue potential from copper

The annual revenue potential from energy-transition demand for copper is estimated at $3.7 billion by 2030 and $3.6 billion by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster APS transition scenario to $4.5 billion by 2030 and $5.3 billion by 2040 (also using a central price and profit scenario). Under the high price and profit scenario and faster NZE transition the revenue potential is as high as $11 billion per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $2.8 billion per year.

Estimated annual government revenue from energy transition demand for copper



Source: authors' own calculations. Note: line shows central scenario, shaded area shows high and low scenarios.

6.7. Graphite fact sheet

Why graphite will be critical in the energy transition

The mineral graphite, as an anode material, is a crucial part of lithium-ion (Li-on) batteries. While there has been a spotlight on increasing demand for battery cathode materials, such as lithium and cobalt, not as much attention has been paid to graphite, despite the anode material facing similar issues.

Main uses of graphite in the energy transition

Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low

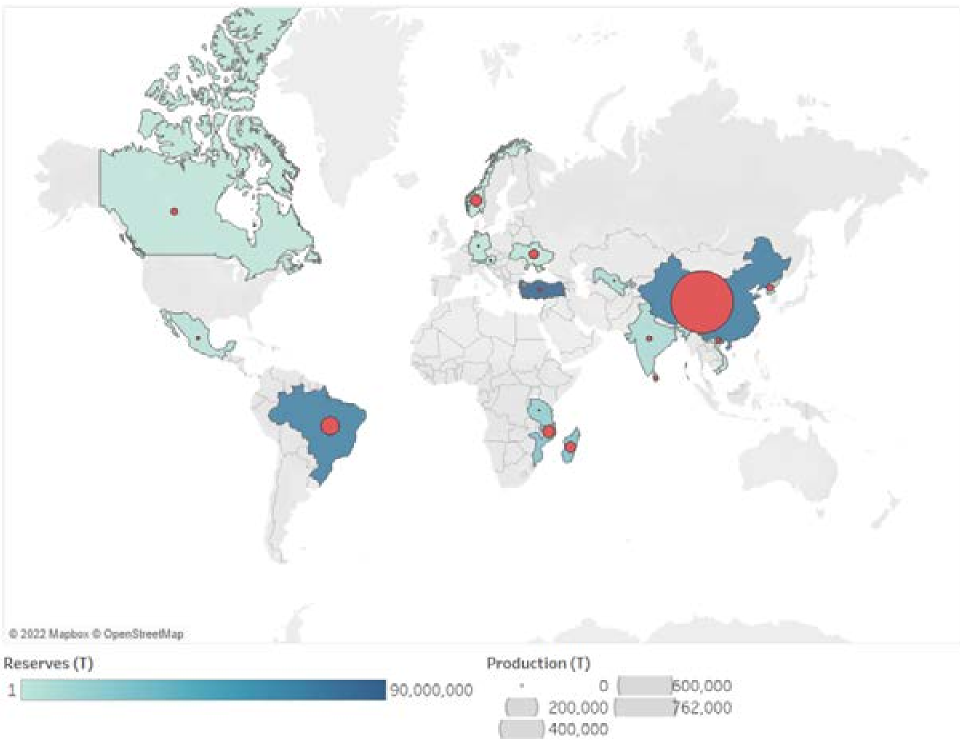
CSP = concentrated solar power *Grid = electricity networks* *EVs = electric vehicles and includes batteries*

Source: IEA (2021)

Known graphite reserves and current production

Battery-grade graphite reserves are geographically dispersed and relatively abundant. China, Brazil and Turkey have the largest known deposits of graphite. Most production is currently concentrated in China (80 % of global production in 2020), although several companies are exploring, developing and producing in East Africa, as well as Scandinavia and the Americas.

Graphite reserves and production (2020)

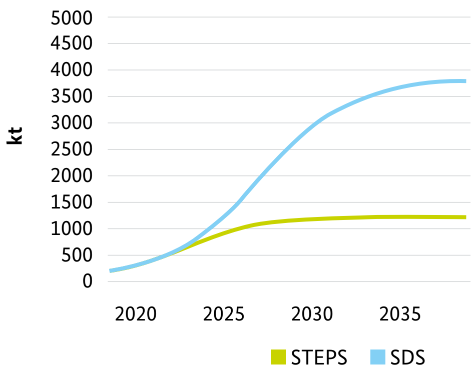


Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Graphite demand and price forecasts

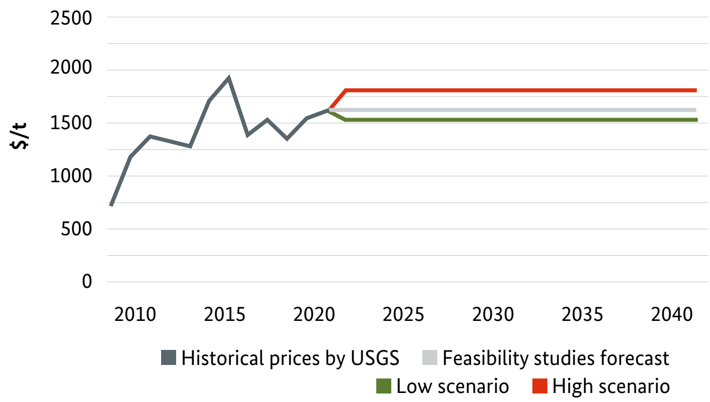
The IEA anticipates that demand for graphite will grow faster than any other energy transition mineral. By 2030, graphite demand is expected to at least triple relative to current global production. Large demand pressures are forecast to translate into a relatively high long-term price by historical standards. Large volatility in graphite markets until 2040 is also a possibility given potential periodic demand and supply mismatches.

Graphite net primary demand forecasts



Source: Gregoir and van Acker (2022), authors' own calculations

Graphite price forecasts

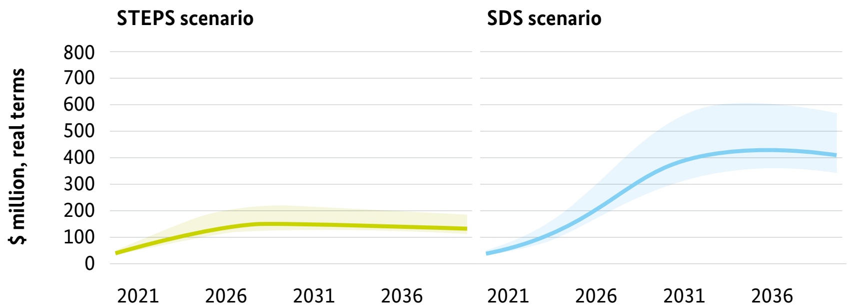


Source: USGS (2022), Central price scenario is average of predicted price in feasibility studies of 5 projects

Revenue potential from graphite

The annual revenue potential from energy-transition demand for graphite is estimated at $146 million by 2030 and $127 million by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster SDS transition scenario to $335 million by 2030 and $404 million by 2040 (also assuming a central price and profit scenario). Under the high price and profit scenario and faster SDS transition the revenue potential is as high as $568m per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $107m per year.

Estimated annual government revenue from energy transition demand for graphite



Source: authors' own calculations. Note: line shows central scenario, shaded area shows high and low scenarios.

6.8. Lithium fact sheet

Why lithium will be critical in the energy transition

Lithium's energy transition demand is driven by its use in lithium-ion batteries. Most lithium-ion batteries are destined for electric vehicles, with a smaller share going to grid storage.

Main uses of lithium in the energy transition

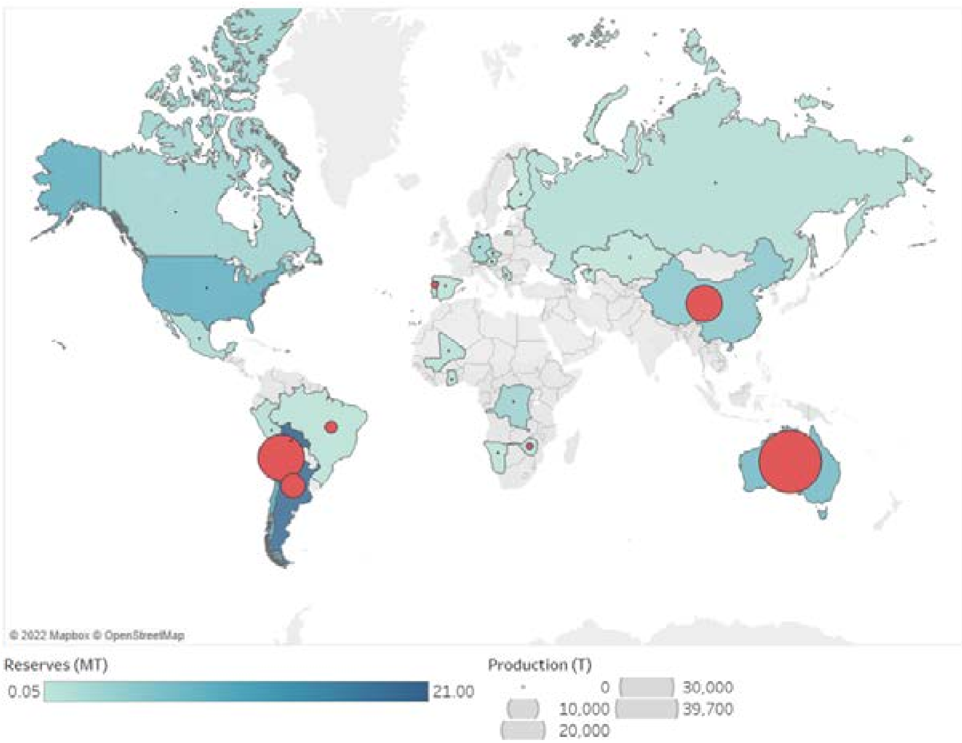
Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low
CSP = concentrated solar power Grid = electricity networks EVs = electric vehicles and includes batteries

Source: IEA (2021)

Known lithium reserves and current production

Lithium is one of the most abundant metals in the earth's crust, but current production levels are low compared to expected demand. Lithium production will therefore need to ramp up significantly to meet energy transition demand. Chile, Bolivia and Argentina have the largest known lithium brine reserves, while Australia has a large amount of hard rock spodumene lithium reserves.

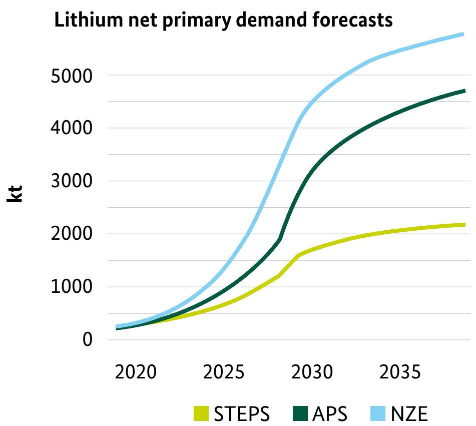
Lithium reserves and production (2020)

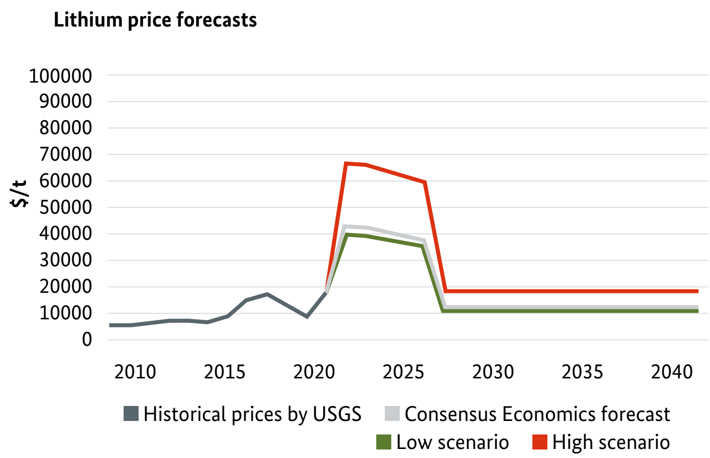


Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Lithium demand and price forecasts

Lithium demand is expected to increase dramatically under all energy transition scenarios, requiring a large supply-side response from the mining sector. Long-run lithium prices could therefore be relatively high compared to historical prices, and potentially volatile given the likelihood of demand and supply mismatches.



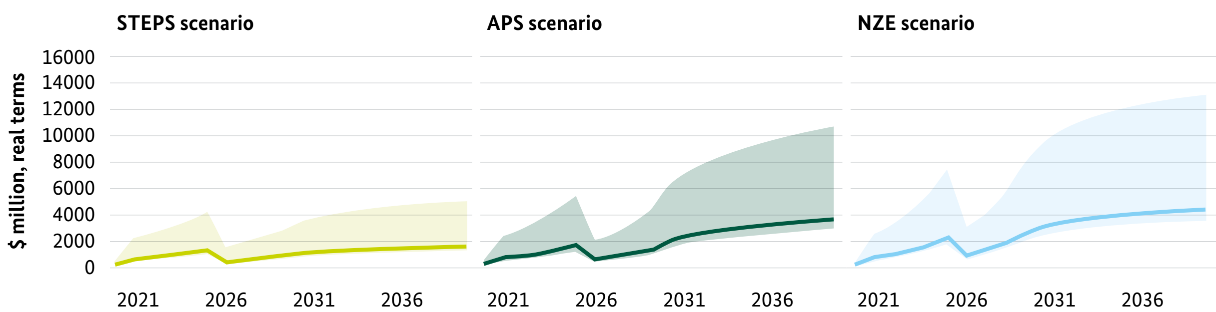


Source: Kim et. Al. (2022), authors' own calculations. *Source: USGS (2022), Consensus Economics (2022).*

Revenue potential from lithium

The annual revenue potential from energy-transition demand for lithium is estimated at $725 million by 2030 and $1.7 billion by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster APS transition scenario to $620 million by 2030 and $3.6 billion by 2040. Under the high price and profit scenario and faster NZE transition the revenue potential is as high as $13 billion per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $1.4 billion per year. The sharp drop in the revenue forecast in 2026 is due to a forecast decline in prices following a period of rapid price increases between 2021 and 2026.

Estimated annual government revenue from energy transition demand for lithium



Source: authors' own calculations. Note: line shows central scenario, shaded area shows high and low scenarios.

6.9. Nickel fact sheet

Why nickel will be critical in the energy transition

Nickel is primarily sold for first use as a refined metal (cathode, powder, briquet etc.) or ferronickel. About 65 % of the nickel consumed in advanced economies is used to make austenitic stainless steel. The properties of nickel facilitate deployment across the entire spectrum of clean energy technologies – geothermal, batteries for EVs and grid energy storage, hydrogen, wind, and concentrating solar power.

Main uses of nickel in the energy transition

Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low

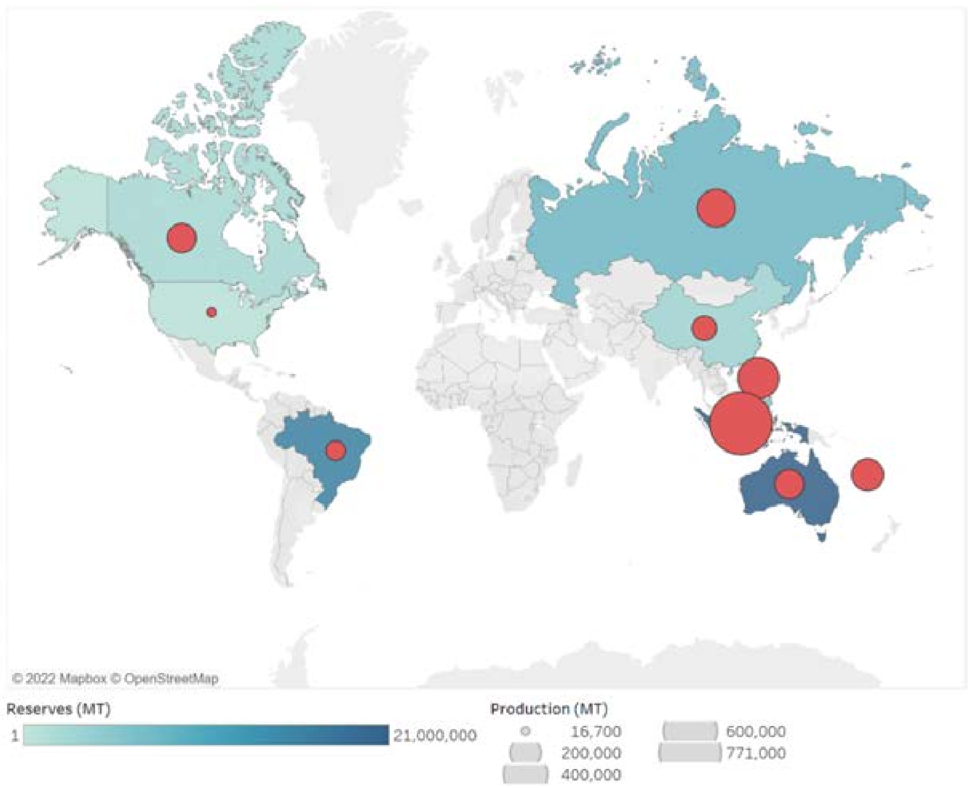
CSP = concentrated solar power   Grid = electricity networks   EVs = electric vehicles and includes batteries

Source: IEA (2021)

Known nickel reserves and current production

Known land resources of nickel are estimated at 300 million metric tons, distributed primarily in the Americas, Asia, and the Pacific, with little known reserves in Africa or Europe. In 2020, global mined nickel production reached around 2.5 million metric tons, down by almost 8 % compared to the previous year. Nevertheless, it represented more than twice the amount produced in 2000.

Nickel reserves and production (2020)

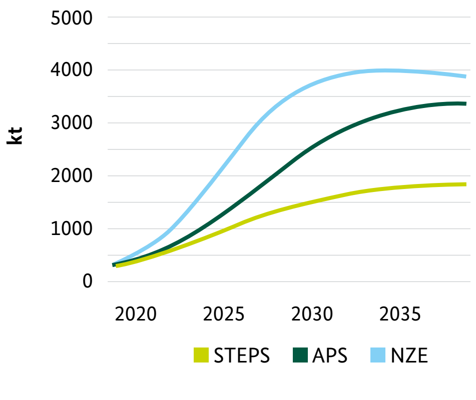


Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Nickel demand and price forecasts

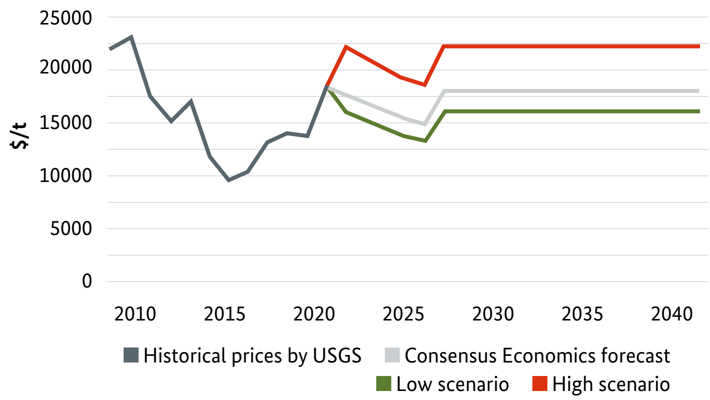
The widespread adoption of electric vehicles by 2050 is expected to lead to a four-fold increase in the demand for nickel. There are enough nickel reserves globally to meet this demand. However, constraints on the extraction and processing of high-quality nickel for batteries are a concern, as the existing structural volatility of nickel prices does not encourage investment in production and processing capacities while nickel demand is increasing rapidly. Continued high price volatility is therefore likely.

Nickel net primary demand forecasts



Source: Kim, et. Al (2022), authors' own calculations.

Nickel price forecasts

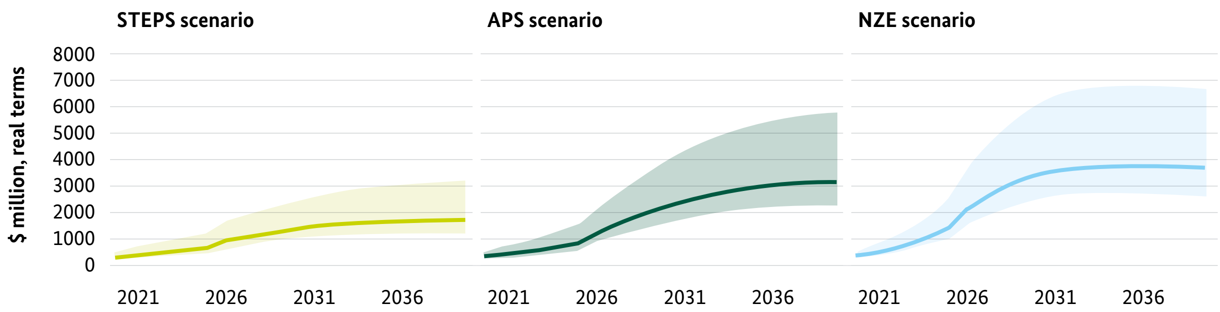


Source: LME (2022), Consensus Economics (2022).

Revenue potential from nickel

The annual revenue potential from energy-transition demand for nickel is estimated at $1.3 billion by 2030 and $1.7 billion by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster APS transition scenario to $2 billion by 2030 and $3.1 billion by 2040, also assuming a central price and profit scenario. Under the high price and profit scenario and faster NZE transition the revenue potential is as high as $6.7 billion per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $1.3 billion per year.

Estimated annual government revenue from energy transition demand for nickel



Source: authors' own calculations. Note: line shows central scenario, shaded area shows high and low scenarios.

6.10. Rare earth elements (REEs) fact sheet

Why rare earth elements will be critical in the energy transition

The rare earths are a group of 17 chemical elements, several of which are critical for the energy transition. Rare earth oxides are essential for the production of wind turbines and electric vehicles. Neodymium, praseodymium, dysprosium and terbium are key to the production of the permanent magnets used in electric vehicle and wind turbine motors. Neodymium is the most important in terms of volume.

Main uses of REOs in energy transition

Shading indicates importance of mineral for a particular clean energy transition: ● = high ● = moderate ● = low

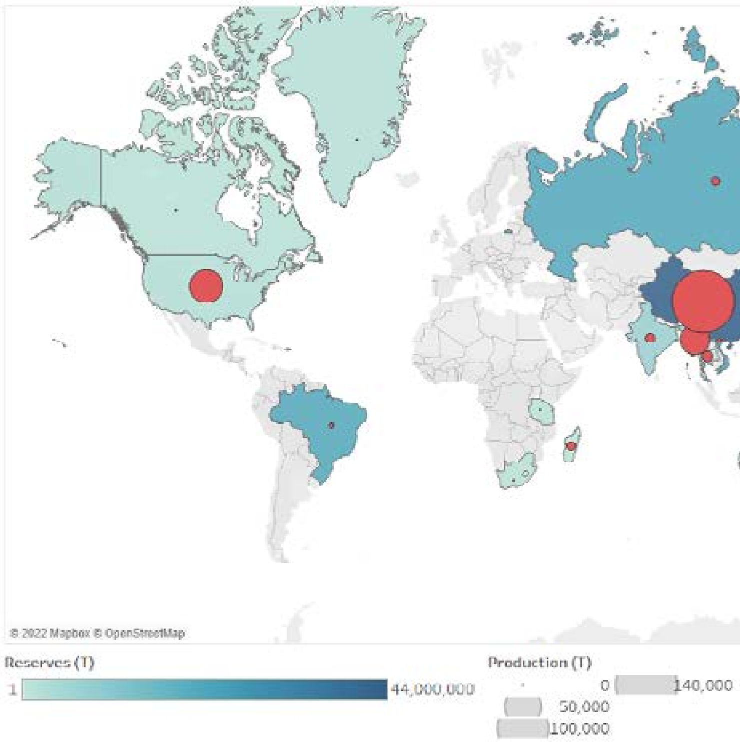
CSP = concentrated solar power Grid = electricity networks EVs = electric vehicles and includes batteries

Source: IEA (2021)

Known rare earth element reserves and current production

Although there are sufficient known REE resources to supply all the needs of the energy transition, the main challenge is to expand mining and processing activities across the entire value chain and in line with demand growth. Currently, China is by far the largest producer of REEs. However, there are significant deposits in other countries. Natural rare earth deposits usually contain a mixture of REEs. The supply of each REE needs to be assessed separately – data for the whole group are of limited value and do not reflect actual scarcity levels.

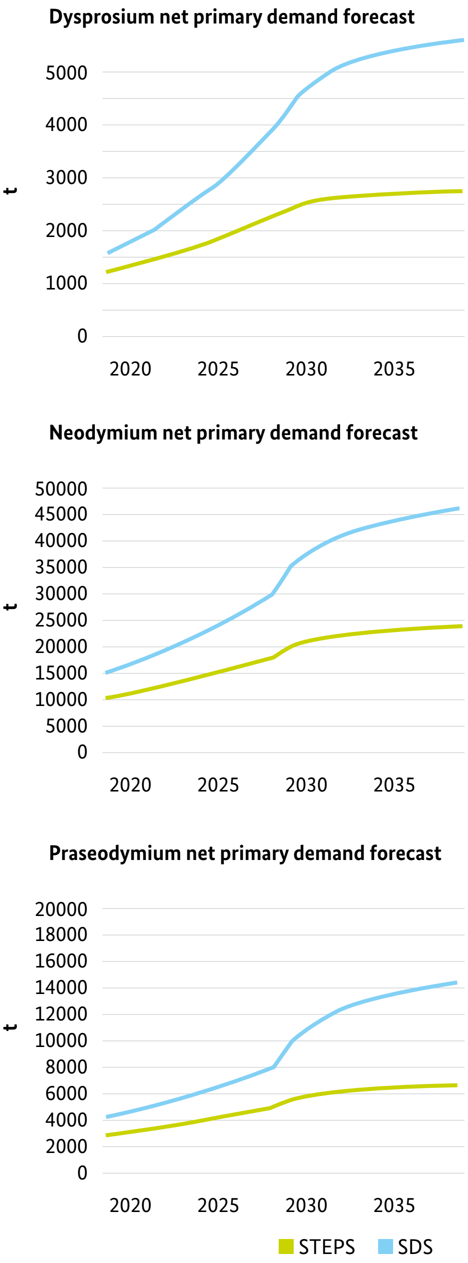
REO reserves and production (2020)



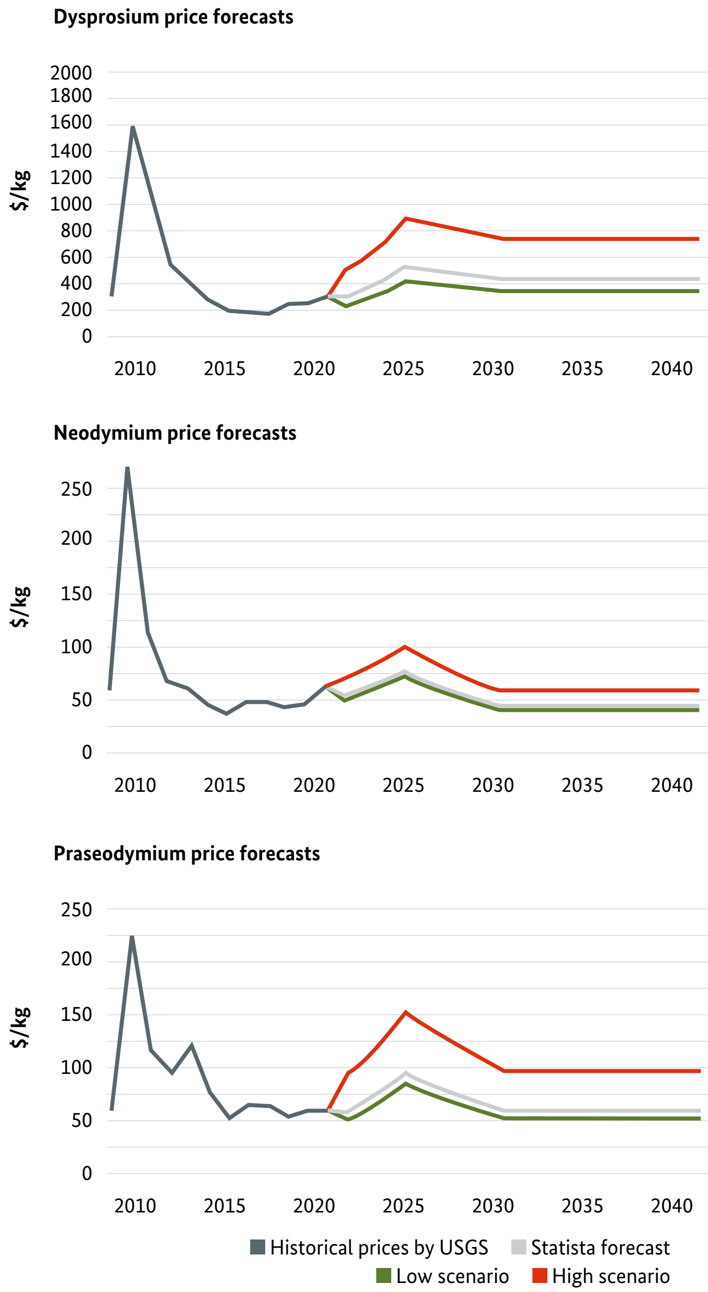
Source: USGS (2022). Mineral Commodity Summaries 2022. U.S. Department of the Interior, U.S. Geological Survey.

Rare earth elements demand and price forecasts

Rare earths are especially needed to produce permanent magnets, demand for which is expected to grow substantially in the coming years. REE deposits are widely distributed, and it is economically viable to expand mining in many places, but processing capacity is less readily expandable. Demand for dysprosium and neodymium is expected to increase at least four-fold, while praseodymium demand is expected to increase three-fold. This is forecast to lead to significant upward pressure on prices, like market dynamics in the early 2010s.



Source: Gregoir and van Acker (2022), authors' own calculations.

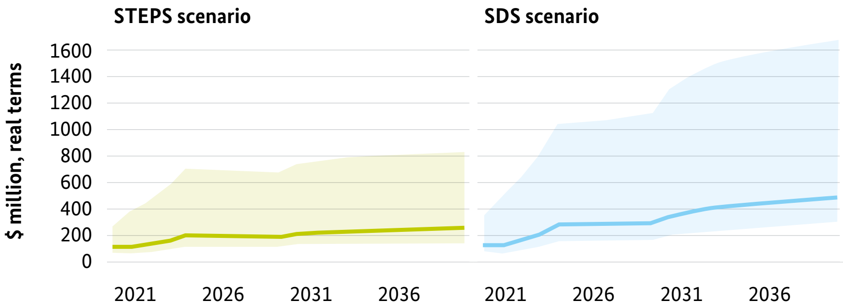


Source: USGS (2022), Statista (2022).

Revenue potential from rare earths

The annual revenue potential from energy-transition demand for REOs is estimated at $183 million by 2030 and $246 million by 2040 under the STEPS transition scenario and using central price and profitability assumptions. This increases under the faster SDS transition scenario to $310 million by 2030 and $500million by 2040, also assuming a central price and profit scenario. Under the high price and profit scenario and faster SDS transition the revenue potential is as high as $1.7 billion per year by 2040, while the slower STEPS scenario with lower prices and profits could generate as little as $155 million per year.

Estimated annual government revenue from energy transition demand for dysprosium, neodymium and praseodymium



Note: line shows central scenario, shaded area shows high and low scenarios.
Source: authors' own calculations.

7. Case studies illustrating real-world policy challenges

This chapter illustrates some of the common real-world challenges faced by governments in the development of appropriate policies and enabling environments to facilitate the development of their energy transition mineral potential. In this chapter we:

- Present 12 case studies across different minerals and countries.
- Each case study illustrates a different challenge faced by governments and the approaches policy makers have taken to address these challenges.

We conclude that the successful development of energy transition mineral mining activities is highly dependent on countries' individual contexts and circumstances.

7.1. Democratic Republic of Congo (cobalt)

The Democratic Republic of Congo (DRC) has around 3.5 million metric tonnes of cobalt reserves, almost 50 % of the known global reserves. It is also the world's largest cobalt producer with an annual production of more than 770,000 metric tonnes (USGS, 2022). Russia, the second largest, produces 10 times less cobalt than the DRC. Given its predominant position in the global cobalt trade, DRC has an opportunity to benefit from the rapidly growing demand for cobalt.

However, despite having several of the world's largest industrial cobalt mines, it is estimated that artisanal and small-scale (ASM) production accounts for 18 to 30 percent of the DRC's total cobalt production (OECD, 2019b). Not only does the informal nature of the ASM sector make it significantly more difficult for the DRC's government to administer and tax its production, but there is evidence of severe human rights issues in the ASM operations and their interface with large-scale mining. Fatal accidents, child labour, low wages and violent clashes between artisanal miners and security personnel of large mining firms have been widely documented (UNEP, 2022).

These incidents have increased global scrutiny and many consumer-facing brands have been trying to find alternative sources of cobalt outside DRC to not be associated with the ongoing human rights issue in cobalt mining in the DRC. In addition, 24 large cobalt consumers, including Glencore, Google and Tesla have joined the Fair Cobalt Alliance, which was set up in August 2020 to help bring about change in the DRC's artisanal mining sector (Holman, 2022).

The case of cobalt in the DRC highlights that even if the ASM sector does not account for most of a country's energy transition mineral exports, a lack of ASM formalisation does not only affect the country's public revenue creation from the ASM production – it can also have indirect impacts on the demand for its industrial production. This shows that it is paramount to address a lack of formalisation and adherence to human rights issues in the ASM sector if a country is to benefit fully from its reserves of energy transition minerals.

7.2. Zambia (copper)

Zambia has for many decades been one of the world's top copper producers. It produced 880,000 metric tonnes of copper in 2021 and relies on copper exports for 70 % of its export earnings (HSF, 2022). Zambia's copper output declined in recent years due to high levels of uncertainty in its tax regime triggered by frequent changes to income tax and royalty rates (Vandome, 2022). The new government that came to power in 2021 rolled back many of the changes and set an ambitious target of increasing copper production to more than 3 million metric tonnes (HSF, 2022).

However, like many other copper producing countries, the ore quality of new deposits in Zambia is declining. Globally, operating copper mines have an average grade of 0.53 % while projects under development only have an average grade of 0.39 % (McCrae, 2018). As a result, fuel and electricity consumption per unit of mined copper more than doubled since the early 2000s (Azadi et al., 2020; IEA, 2021). Zambia is no outlier in this regard and meeting its target copper production will require significant additional energy capacity in addition to a stable fiscal regime.

One key advantage Zambia has is large existing hydropower capacity, as well as significant potential for wind and solar (Creamer, 2022). Offering cheap and clean energy makes Zambia more globally competitive, as mining companies are rushing to decarbonise their operations (Mwirigi, 2022). This shows that in addition to the importance of stable fiscal policies to attract investments, access to clean energy sources is one of the increasingly relevant 'enabling' factors that will determine whether countries will be able to attract mining investment going forward.

7.3. Tanzania and Mozambique (graphite)

After many years of receiving limited attention, high grade graphite has become one of the most sought-after minerals used in the production of EV batteries, with the IEA predicting that graphite will face the largest supply shortfall of all energy transition minerals (IEA, 2021).

Mozambique has over 25 million tonnes of confirmed graphite reserves and has been able to increase its graphite production significantly in the last few years from less than 1,000 tonnes in 2017 to 114,000 tonnes in 2019 (Brown et al., 2021). In addition, there are currently eight ongoing graphite exploration projects in Mozambique (Mitchell and Deady, 2021). Tanzania, by contrast, has failed to bring any significant production of graphite online, despite also having large, confirmed reserves of more than 18 million tonnes and more than 10 active exploration projects (Mitchell and Deady, 2021).

In Mozambique, the government imposes a 32 % corporate tax and takes 3 % in royalties, while also offering prospective mining companies a five-year exemption from import duties and a capital allowance scheme for 10 years (Saigal, 2019). Tanzania on the other hand imposed a mandatory, non-dilutable free-caried state participation of 16 % equity in all new mining projects in 2020, has a 30 % corporate tax rate, and only allows prior-year losses to offset 70 % of current year taxable profits. In addition, the Government of Tanzania charges a 6 % royalty and a withholding tax of 10 % on all foreign dividend payments (Matiko and Sipemba, 2022; Shikana Law Group, 2022).

Although several junior mining and exploration companies continue to try and bring some of Tanzania's prospective graphite reserves into production, Tanzania's less attractive tax regime and a perception of high political risk due to high profile disputes between the Government of Tanzania and foreign mining companies in the past years has led to Tanzania losing out on investment compared to its Southern neighbour.

This shows that geological prospects are only one important aspect to attracting FDI into mining. Governments will therefore need to pay special attention to the design of their fiscal and licencing regimes for mining if they are to attract sufficient capital to develop reserves into production.

7.4. Chile & Argentina (lithium)

Over half the world's lithium resources are found in the salt flats of the Lithium Triangle, a region in South America covering parts of Chile, Argentina and Bolivia. Of these three countries, Chile used to be the most dominant force in the lithium market for years due to its mining-friendly policies, lower production costs and positive business climate (The Economist, 2017a).

Figure 7.1: The Lithium Triangle

Source: The Economist (2017a).

Chile used to be the world's largest lithium producer but has seen its market share shrink since the Chilean government imposed more regulatory hurdles (Sherwood, 2019). Despite only having less than a third of the proven lithium reserves compared to its western neighbour, Argentina has been able to attract significantly more FDI into lithium mining in recent years. While Chile has had restrictive regulations in place regarding lithium extraction, which has limited the number of lithium producers to two companies, Argentina has taken a more open approach to international investment and its legal system permits corporations and individuals to explore and produce lithium under the normal mining legislation (Lillo, 2022; The Economist, 2022).

Chile's government has for many years promised an overhaul of its legal framework to allow for a more efficient allocation of lithium concessions to developers. However, the volatile political situation in the country and more pressing political priorities, such as the re-writing of the constitution, has led to a long delay in the development of the new framework. This uncertainty has led to a drying up of new investment and limited additional production capacity (Luft et al., 2022). Argentina on the other hand has attracted some of the largest lithium deals of the past years, including the development of the large Cauchari-Olaroz brine project, as well as the acquisition of the Pastos Grandes project by Lithium Americas and the Salar de Rincon mine by Rio Tinto (Lillo, 2022).

This shows that even developed mining jurisdictions like Chile with a deep technical skills base, good geological prospects and a developed mining services industry can easily fall behind in the fast-changing market environment of energy transition minerals if they do not ensure that their regulatory and legislative enabling environment is regionally or globally competitive.

7.5. Philippines (nickel)

The Philippines has the sixth largest reserves of nickel in the world and is the second largest nickel producer globally (USGS, 2022). In 2017, the Philippines' environment secretary ordered 23 of the country's 41 mines to close permanently, and another five to suspend operations indefinitely, for alleged environmental violations (Cruz and Serapio Jr, 2017). Most of the mines that were closed produced nickel and were responsible for around half the country's annual nickel output (The Economist, 2017b). That decision was overturned by President Rodrigo Duterte in December 2021, and the new government led by President Ferdinand Marcos Jr. has announced that it wants to triple the size of the country's mining sector by 2027 (Mine, 2022).

Nickel will need to form one of the cornerstones of the targeted increase in output. The Philippines's Mines and Geosciences Bureau notes that the country could have as many as 190 new mining projects during the next four years with Nickel mines accounting for one-third of the new mines. This would give a significant boost to the local economy. Whereas currently, the large-scale mining sector contributes around 0.7 % to GDP, that could rise to as much as 5 % by 2027 if the government's plan is met (Mitchell 2022). Yet the environmental concerns that led to the closure of many nickel mines in 2017 remain, including deforestation and water pollution in one of the most biodiverse geographies on the globe (NBC, 2021).

The case of the Philippines highlights the trade-offs that will have to be made by resource-rich developing countries. On the one hand, there is a strong incentive to expand mining of energy transition minerals, as it will generate economic growth, additional government revenue and employment opportunities in rural areas. On the other hand, opening many new mines with a large land footprint will necessarily cause significant environmental damage. Accordingly, governments will need to ensure that the accelerated development of mineral deposits goes hand in hand with bolstered environmental regulations and monitoring, while also assessing critically whether less efficient high-cost and low-grade deposits with a comparatively large negative environmental footprint should go ahead.

7.6. Vietnam (REEs)

Rare earth elements (REEs) are a group of 17 elements with unique optical and magnetic properties that are required in growing quantities for various high-tech applications, such as motors, catalysts, light-emitting diodes and batteries (Fuyuno, 2012).

Vietnam holds the world's second largest reserves of REEs after China, but currently produces only 700 tonnes of REEs per year (USGS, 2022). China has been the largest producer and exporter of REEs for the past 3 decades and currently produces 168,000 tonnes of REEs per year, which represents 80 % of global production (USGS, 2022). With its large reserves, growing industrial strength and human capital base, Vietnam has a prime opportunity to establish an integrated mining and downstream processing industry for REEs that can rival China's dominance.

Vietnam has chosen an interesting route to develop its REE potential. Rather than trying to attract international mining companies to independently develop its REE deposits, it has embarked on a strategy of seeking bilateral support from industrialised countries who want to reduce their dependence on Chinese REE production (Kubota, 2010). In 2012, the Government of Vietnam signed a Copperation agreement with Japan, which led to the establishment of a REE research and technology transfer centre in Hanoi (Fuyuno, 2012). Since then, it has also received funding from the Government of Germany to develop sustainable processing techniques for one of Vietnam's rare earths deposits (Helmholtz Zentrum, 2021).

Although Vietnam has yet to bring a large-scale REE mining and processing operation into production, its approach shows that the growing demand for energy transition minerals represents an opportunity for resource-rich countries to seek support from industrialised countries who want to secure their future supply of energy transition minerals to develop their local mining and processing industries.

7.7. Bolivia (lithium)

Bolivia is home to the world's largest lithium resources. Together with Chile and Argentina, the so-called "lithium triangle" holds almost 60 percent of the planet's known lithium (USGS 2022a).

In Bolivia, lithium reserves are regarded as a great asset for the country that will allow it to become more globally competitive and bolster the economy. Unfortunately, a lack of technical capacity and funding, as well as political instability, have impeded any significant development of Bolivia's lithium resource.

For two decades, successive governments have tried to jump-start Bolivia's lithium industry, attempting both pro-market and statist strategies. Efforts to privatise the industry in the 1990s failed. So did attempts by long-time President Evo Morales to expand the government's role in the industry through a state-owned lithium company and to promote local production of batteries and electric vehicles (Vásquez, 2022).

As of now, a restrictive law (Law 928) establishes that all extraction and processing of lithium must be carried out by state-owned entities, leaving the industrialization of lithium closed to the private sector and foreign participation (Vásquez, 2022). In addition to this, lithium extraction has faced political opposition from local communities (Vander Molen, 2022).

It seems unlikely that the Bolivian state will be able to develop its lithium unless it is willing to enter partnerships with foreign partners, as it lacks the necessary critical infrastructure and access to technology to extract lithium in a way that is both economically viable and keeps excessive water waste at bay (Vander Molen, 2022). However, recent collaborations with a German company and Chinese state-owned companies to develop lithium reserves have failed. Recently, the companies EnergyX and MOBI Latam have expressed interest in partnering with Bolivia to pursue sustainable and Copperative lithium projects by using the lithium development through direct lithium extraction (DLE) process (Vander Molen, 2022).

The example of Bolivia highlights that geological potential is only one factor that determines whether a mining sector develops and is not sufficient on its own. For a nascent mining sector like lithium in Bolivia, an enabling political environment is key to gain access to financing, skills and technology.

7.8. Chile and Peru (copper)

Chile and Peru are the world´s leading copper producers but have different strategies when it comes to collecting tax revenues from copper production. While Peru focuses exclusively on the extraction and export of copper concentrates, an intermediate product that requires smelting and refining to produce copper, Chile chose a different route by strongly investing in downstream refining capacities.

Chile's state-owned company Codelco not only produces 10 percent of global copper output (Castaneda et al., 2015), but also runs 5 copper smelters. In total about 25 % of copper concentrates produced within Chile are refined in Chile. Of this share 75 % is refined via Chile's state-owned refineries and the remaining 25 % by privately operated refiners (Perez Vallejos, 2017) (Mining News Wire, 2020).

Weighing up the costs of downstream refining via Codelco against government revenues, it is not clear that Chile's value-addition strategy leads to higher government revenue collection compared to Peru, especially as most of the revenues across the copper value chain are obtained by the mine (Langner, 2015). A lack of investment over the past years means that the majority of Codelco's smelters date back to the 1970s and lack the efficiency of new technological developments (Perez Vallejos 2017). Chile's domestic smelters face high operating costs in terms of labour remuneration, materials, services and energy, while on the revenue side, treatment charges for smelting concentrate have fallen. The combination of these factors has caused Codelco's processing business to lose its competitiveness, which in turn has led to mounting losses at the state-owned refineries. It is estimated that state-owned smelters would have to invest around USD 2.5 billion to adapt their operations to new environmental regulations alone (Perez Vallejos 2017). Coupled with potential future decreases in ore quality (Reuters, 2022), this will likely mean that Codelco and therefore the Chilean state will be able to capture less revenue from its copper wealth in the future.

This case shows that seeking downstream value addition opportunities does not by itself lead to increased government revenues. This is not to say that value addition activities should not be considered, but it is important that the increased costs and ongoing investment needs of state-owned mineral processing capacity is carefully weighed up against other alternatives.

7.9. Guinea (bauxite)

As the leading bauxite producer in the world with the largest bauxite reserves globally, Guinea's mining sector has the potential to drive the country's development (USGS, 2022b). Despite the comparative high quality of bauxite found in Guinea, which allows for efficient refining to the intermediary product of alumina, the country completely lacks refining capacity (Wood, 2022). The Government of Guinea recently tried to address this issue by forcing current private investors to invest in and build refineries, setting a deadline of end May 2022 for foreign companies to submit a timeline for the construction of alumina refineries. In June 2022, the government noted that none of the companies had complied and extended the deadline by a further 10 days (Samb, 2022).

Refining operations in Guinea face multiple obstacles. Alumina refining is one of the most energy intensive operations – using about 2.5 MWh per tonne, equivalent to the electricity used by about 800 homes during one hour in the United States (EIA, 2022). As a low-income country Guinea lacks the infrastructure and capacity to produce and provide the necessary electric power to refine bauxite into alumina. Only about half of the Guinean population currently has access to electricity (World Bank, 2020). Stricter environmental regulations and adherence to meeting the goals of the Paris Agreement further require this electricity to be mainly produced from renewable sources (Wood, 2022). While it would be possible to meet the required energy demand through the development of further hydro-power plants and solar PV installations, large investment would be required to produce enough electricity to run even one alumina refinery. According to the African Development Bank given the current political instability and a long-standing lack of transparency in the country, it is unlikely that such large-scale investments will be forthcoming in the near future (Kambanda et al., 2021).

Finally, it is also questionable whether alumina refining would bring many economic and fiscal benefits to Guinea. Refining is a capital-intensive industry and is therefore not likely to increase employment opportunities or payroll taxes significantly. Making a profit from alumina refining is difficult given multiple cost pressures. Next to the material input costs, energy makes up about 20% of production costs and will have a decisive impact on whether the government will collect more revenues or not (Mawhinney, 2020). Nonetheless, the export of refined goods would provide more transparency on the pricing and therefore the value of the exported goods. As of now, the aluminium industry is heavily vertically integrated, and the pricing of bauxite is notoriously opaque. Alumina is publicly traded and therefore it would be comparatively easy for the government to access benchmark prices for the evaluation of the royalty and income tax base.

This case study shows that the value of creating mid-stream processing activities is highly dependent on the local context of a country and that governments need to carefully investigate the benefits and costs of value addition policies.

7.10. Madagascar (graphite)

Graphite is one of the most important minerals used in the production of EV batteries. With the fourth largest graphite reserves world-wide, Madagascar has increasingly attracted mining investors over the past years (USGS, 2022c). Africa could become the world's largest producer of natural graphite by 2026. By that date, the combined production of African countries could represent 40 % of supply (against 15 % in 2021), while China would represent a 35 % market share compared to 68 % in 2021 (Benchmark Source, 2022). Currently the second biggest producer in Africa after Mozambique is Madagascar, followed by Tanzania and Namibia (USGS, 2022c).

One of the factors that has attracted investors to Madagascar compared to other countries in Sub-Saharan Africa is the "significant high-quality data from historic French exploration and production" (Sandell-Hay, 2022). In addition, graphite reserves are high quality, and deposits located close to the surface leading to low mining and processing costs (Sandell-Hay, 2022). One of the leading producers is Tirupati Graphite that announced in September 2022 the purchase of three mining permits covering 31.25 km^2 in addition to two graphite mines that it already operates in Madagascar (Tirupati Graphite, 2022).

These investments have been going forward despite missing policies to improve the investment environment in Madagascar (US Department of State, 2021). For instance, Madagascar currently ranks 161 out of 190 on the World Bank's Doing Business Report, after Mozambique and Tanzania (World Bank, 2021). As such, Madagascar is an example of how high-quality geological data and mineral reserves can attract mining investment, despite the lack of an investment-friendly environment.

7.11. Indonesia (bauxite)

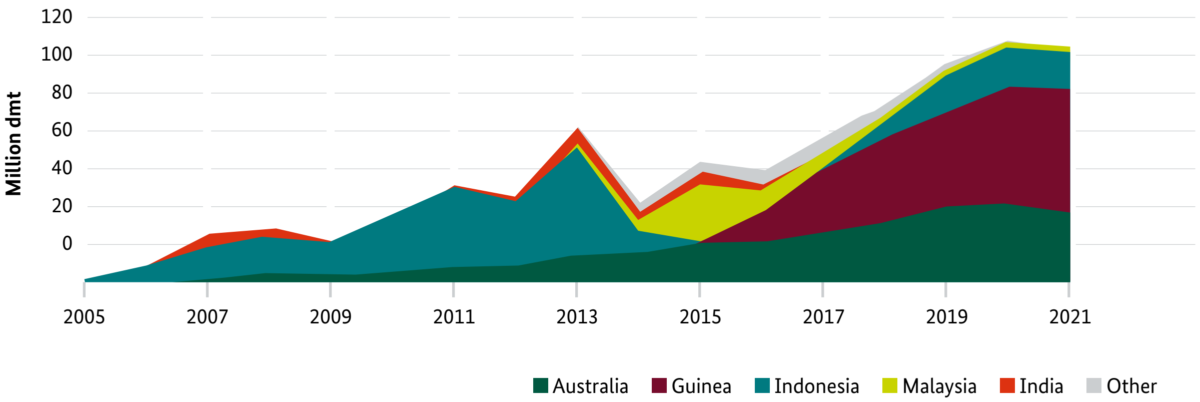
Prescriptive policies that forcefully implement downstream value addition can back-fire and in the worst-case lead to a significant loss in revenue collection, as the example of a bauxite ban in Indonesia shows. In 2014, Indonesia banned exports of unprocessed bauxite and nickel ores, implementing a law passed in 2009 to force mining firms to export only processed minerals and attract investment in smelters and refineries. Copper concentrate was not included in the ban at the last moment, reflecting threats from the largest miner to cut production by 60 per cent (Kapoor and Asmarini, 2014). Instead, high export taxes of 25 per cent in 2014 rising to 60 per cent in 2016 were imposed on copper concentrates. In 2016, this contributed to the government missing its revenue target by USD$17.6 billion (Asmarini and Munthe, 2017).

The export ban of unprocessed minerals significantly reduced mining activities in Indonesia. Bauxite output fell from 57 million metric tonnes in 2013 to 200,000 metric tonnes in 2015. The law's "most noticeable effects were the closure of hundreds of mines, the loss of thousands of jobs and a collapse in government revenue from mining" (The Economist, 2017). But, more importantly, the ban seemed to have missed its goal in the case of bauxite and by 2015 no plans for the building of new alumina smelters were realised (Home, 2015). In 2022, the country again announced a halt of all bauxite exports by 2023 (Ajmera, 2022).

The ban and subsequent rule changes have undermined the investment climate in Indonesia and led to a diversification of supply base for large refineries, especially in China (Afifa, 2022; Ajmera, 2022). About half of bauxite imports to China now come from Guinea, while Indonesia used to make up almost three-quarter of bauxite imports up until the ban in 2014 (Wood, 2022).

Figure 7.2: Share of Chinese bauxite imports by source

Chinese auxite Imports by Source – overwhelmingly from Guinea, Australia and Indonesia



› Chinese bauxite imports have grown strongly and totalled 107 million tonnes in 2021
› Guinea accounted for 51 % of total Chinese imports in 2021
› The proportion of low-temp bauxite imports reached around 80 % of total imports in 2021

Source: Wood (2022).

The export ban on bauxite did not lead to the envisioned increase in revenue collection. Instead, bauxite exports reduced and as of now no significant alumina refining capacity has been added. This is because compared to nickel, bauxite production in Indonesia can be replaced by other countries (Home, 2015). The example of the bauxite ban in Indonesia demonstrates that aggressive policies aimed at increasing downstream value addition are unlikely to be successful unless the mineral concerned has an exceptional position in that country and cannot easily be substituted by third countries. Indonesia`s prescriptive policy was only successful in the case of nickel as Indonesia holds a large share of the world`s nickel reserves and has therefore outsized importance to the nickel industry.

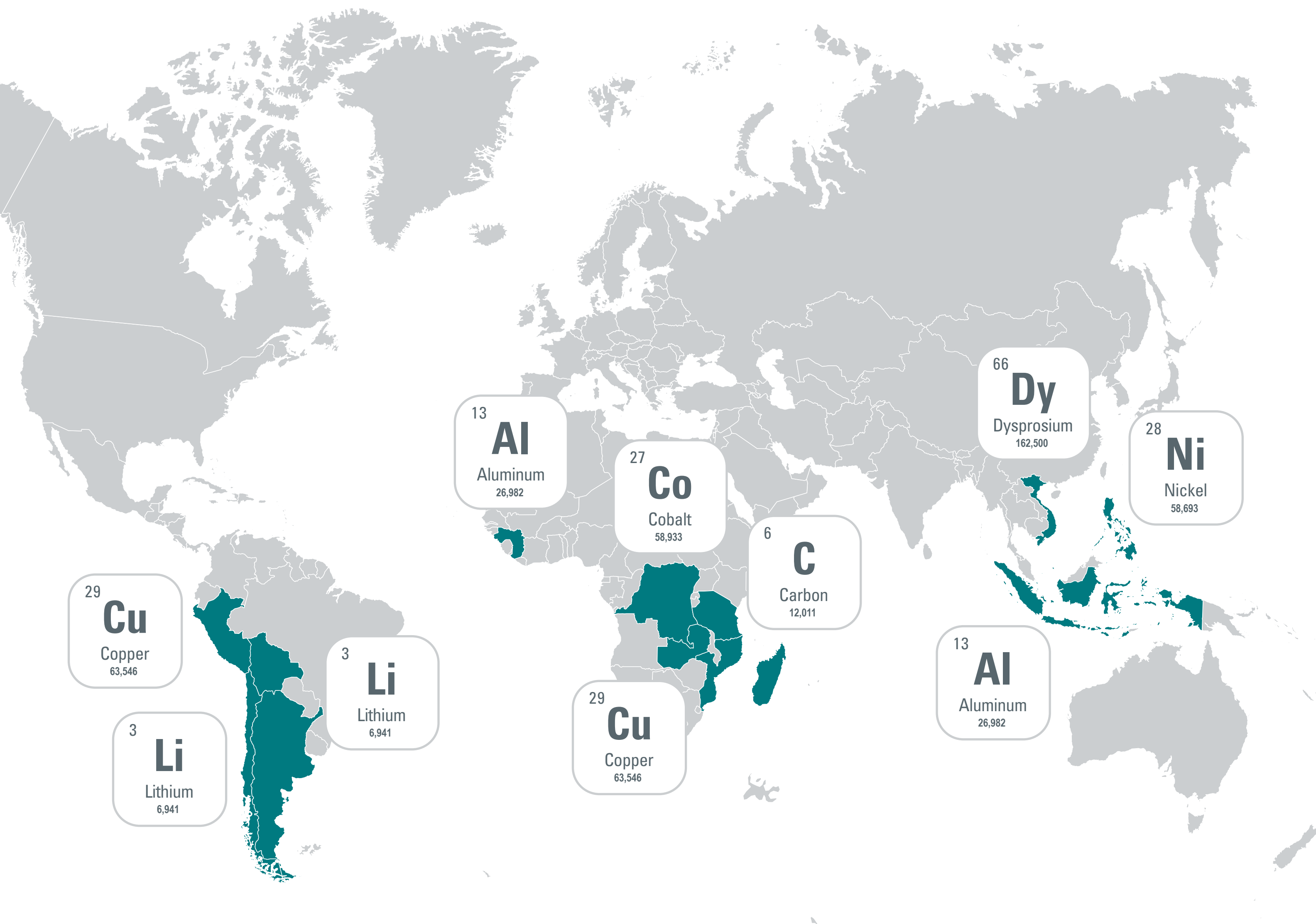
7.12. Indonesia (nickel)

Indonesia is home to 22 % of the world's nickel reserves, and its ban on nickel ore exports has caused major shifts in the supply chains of strategic products such as electric vehicles and rocket engines (USGS, 2022d) (Jiyeong Go 2022). Although nickel output initially decreased 8-fold between 2013 and 2015, following the nickel ore export ban in 2014, Indonesia's strategy was interpreted by some experts as a success, as it created a well-developed intermediate nickel product and stainless-steel industry in the country (Merwin, 2022). Nickel is a key intermediary product in the production of stainless steel and the nickel ban in 2014 helped Indonesia to become the second-largest producer of stainless steel in the world as of 2021 (Statista, 2022).

Some experts believe the renewed export ban of nickel ores in 2020 is intended to replicate for electric vehicles (EVs) battery production the previous success in downstream upgrading in the stainless-steel market (Merwin, 2022). However, there are several obstacles for Indonesia to replicate this success. While nickel is plentiful, the quality or class of reserves determines its suitability for stainless steel or battery cathodes. Class 1 nickel is critical for EV batteries. While Indonesia's nickel reserves are the largest in the world, these reserves are predominantly Class 2. The Class 1 nickel supply constraint has recently focused efforts on developing new technologies to process Class 2 nickel into Class 1 (Merwin, 2022). The most promising process involves high pressure acid leaching (HPAL) of Class 2 nickel to produce mixed hydroxide precipitate (MHP). MHP is then further refined in the process of producing EV battery cathodes. However, there are environmental concerns with the HPAL process: it consumes water, produces caustic tailings, and consumes considerable energy (Mining Technology, 2022).

Despite these obstacles, the strategy has demonstrated some success as several MHP investment projects have been announced. These include Halmahera Persada Lygend, a joint venture (JV) between Indonesia's Harita Group and China's Ningbo Lygend and Huayue; and a JV of Huayou, Chinese stainless-steel giant Tsingshan Holding Group, and China Molybdenum Co (Daly et al., 2021). Approximately five other projects are under consideration or beginning construction (Huber, 2021). The Halmahera Persada Lygend project achieved initial commercial success in June 2021 to produce MHP. Progress toward step two began in late 2021 when a South Korean consortium broke ground on an EV battery plant scheduled to reach mass production in 2024. For Indonesia, success will be measured over many years as it builds out MHP capacity and attracts other EV car companies to locate battery production within the country (Merwin, 2022).

Compared to the negative impact of the bauxite export ban on revenue collection, the nickel export ban was comparatively successful due to the strategic size and importance of Indonesia's nickel reserves for the world market. Key nickel consumers like China were not able to diversify their imports from other sources. Instead, Indonesia's strategy was able to force Chinese EV companies, and by extension the Chinese government, to switch from importing nickel ore to assisting in the development of HPAL/MHP production facilities in Indonesia. This case shows that banning raw material exports to promote in-country value addition can be successful. However, for it to work, a country needs to have a relatively strong market position and clear and stable policies in place that gives companies enough certainty to make large-scale investment decisions in processing capacity.



29 Cu Copper 63,546
3 Li Lithium 6,941
3 Li Lithium 6,941
13 Al Aluminum 26,982
27 Co Cobalt 58,933
29 Cu Copper 63,546
6 C Carbon 12,011
66 Dy Dysprosium 162,500
28 Ni Nickel 58,693
13 Al Aluminum 26,982


FC-21
777D
21
777D
FC-21

8. Policy Implications for resource-rich developing countries

The increased demand for energy transition minerals presents an opportunity for resource-rich countries to raise public revenues to develop their economies. In this chapter we highlight four key areas of public policy development for governments of resource-rich countries seeking to maximise benefits and minimise risks from energy transition.

1. **Implement a modern fiscal regime and sound public financial management policies.** Fiscal regimes for mining will need to encourage investment while ensuring the state receives a fair share of the financial value from its natural resources. While there is no 'ideal' fiscal regime in mining, governments should take the opportunity to review their fiscal regimes to ensure they are consistent with their overall objectives for the mining sector and public finances. Increased volatility in the prices of transition minerals, potentially amplified by more progressive fiscal regimes that collect more public revenues at higher prices, need to be actively managed, for example through the use of stabilisation funds. As international standards in mining taxation evolve over time, governments should seek to retain flexibility to develop fiscal policies to respond to changing norms over time.
2. **Increase investment attractiveness.** The geological potential of a country is often the most important factor for attracting investment in mining exploration and extraction. Even so, capital is scarce, and investors may prioritise countries with favourable investment climates. Evidence suggests that low taxation is not as important for attracting investment as other factors, such as macroeconomic and political stability, public infrastructure, and the availability of skilled labour. Meaningful improvements in these areas can take time to achieve. However, governance reforms that improve transparency and accountability, and limit opportunities for corruption, can be implemented relatively quickly and lay the foundations for improvements elsewhere.
3. **Improve the understanding of geological potential.** Mineral exploration is the most economically risky part of the mining cycle requiring large up-front costs with no guarantee of success. While exploration knowledge worldwide lies principally with the private sector, and most of the exploration costs are borne by private companies, governments can and should take steps to enable mining exploration. The effective collection, storage, and public availability of geodata from mineral exploration has high returns and governments should develop policies and internal capacity to effectively acquire, manage, and disseminate geodata. The tax treatment of exploration costs can also have material impacts on the allocation of risk between private-sector companies and states, and between incumbent mining companies and new entrants. Governments should therefore pay particular attention to this when designing the fiscal regime.
4. **Develop an enabling environment for sustainable mineral extraction with a focus on ESG.** Environment, social, and governance (ESG) is the number one risk and opportunity for mining companies, and investors are increasingly demanding more transparency in this area. Consumers of products branded as sustainable, such as electric vehicles, are increasingly demanding that producers of these products prove the sustainability of their production. This development has led to producers of these products demanding that upstream suppliers improve their mining practices to emit less carbon, use less water, have lower impacts on biodiversity, and improve benefits for local communities. This trend has implications for governments, who increasingly could compete for mining sector investments based on non-traditional enabling factors, such as the provision of clean power to reduce the carbon intensity of mining projects.

The increased demand for primary production of energy transition minerals presents an opportunity for resource-rich countries to raise public revenues to fund investment in infrastructure and develop their economies. The scale of the opportunity will vary for each energy transition mineral with some minerals offering significantly higher revenue potential than others. Although some resource-rich countries can expect significant additional public revenues, it is important to note that the extraction of energy transition minerals will not reach the level of government revenues generated by hydrocarbons over the past half century. While the most optimistic scenarios estimate gross revenue from energy transition minerals to be USD 250 billion per annum on average, a recent study has estimated rents from oil alone to have averaged USD 1 trillion per year over the past 50 years (The Guardian, 2022). In addition, the future public revenue that might be derived from the extraction of energy transition minerals is highly uncertain, as a number of external factors will have an influence on the demand for minerals, such as the adoption speed of renewable energy and EVs, the availability of alternative sources for the primary minerals (substitutes or recycling), and the political commitment to phasing out fossil fuels (Blagoeva et al., 2021; IEA, 2021).

Even though the potential opportunity for countries rich in energy transition minerals is highly contingent on various external factors and smaller than the one that countries with a large endowment of hydrocarbons have been experiencing, the opportunity for some countries and regions is still significant. At the same time, there is strong empirical evidence that favourable geological potential by itself is not enough to develop a well-functioning mining sector that delivers benefits for governments and its people (Otto, 1997; Bainton and Jackson, 2020). It is important that governments of resource-rich developing countries proactively set the course to create a conducive policy environment that allows them to derive maximum benefit from their endowment of energy transition minerals, and to manage risks to the public finances and public policy priorities in general. Resource-rich developing countries will need to develop carefully designed public policies fit for purpose in the fast-developing new market environment.

The following sub-sections highlight 4 key areas of policy development that governments of countries endowed with energy transition minerals should pay particular attention to.

8.1. Implement a modern fiscal regime and sound public financial management policies

Fiscal regimes for mining will need to encourage investment while ensuring that the state shares fully in the financial value of its natural resources. Governments in resource-rich countries should take the opportunity to review their fiscal regimes ahead of the large-scale investments likely to be needed in their countries, recognising that norms in international mining taxation evolve over time. For example, the importance of measures to tackle international tax avoidance strategies used by multinationals has gained prominence internationally only in the last few years. As there is no 'ideal' fiscal regime for mining, governments should set priorities and design a fiscal regime that best meets their specific objectives, recognising the trade-offs inherent to fiscal regime design, and retain flexibility to respond to changing international norms.

Due to the expected speed of the energy transition and associated potential supply shortages, prices of energy transition minerals are likely to be volatile over the next two decades. This will create challenges for public budgeting that will need to be managed through appropriate fiscal regime design and public financial management. The expected higher price volatility for energy transition minerals increases the importance of progressive fiscal regime designs that can capture outsized rents or windfall profits during phases of high prices. As most countries' income tax regimes use a fixed rate that is not progressive, sliding-scale royalties, resource rent taxes, and other progressive profit-sharing instruments should be considered more closely by policymakers as a means to improve progressivity and capture a larger share of rents.

Increased price volatility also demands prudent public financial management if countries are to generate long-term benefits from increased government revenues. More progressive fiscal regimes imply more volatility in government revenue. The benefits of progressivity need to be weighed against this, and ensuing revenue volatility actively managed. Fiscal rules and stabilization funds, if well thought out and implemented, can be particularly useful tools to ensure that windfall revenues are used as economically efficiently as possible.

Many countries, especially low-income countries, lack the necessary capacity within their revenue authorities to implement existing fiscal regimes and ensure that mining companies do not shift profits into jurisdictions with a lower tax burden. Proactive investment in the capacity of tax authorities to administer mining tax regimes prior to the expected large increase of demand in the latter half of the 2020s will be key if governments are to collect revenues effectively from mining activities.

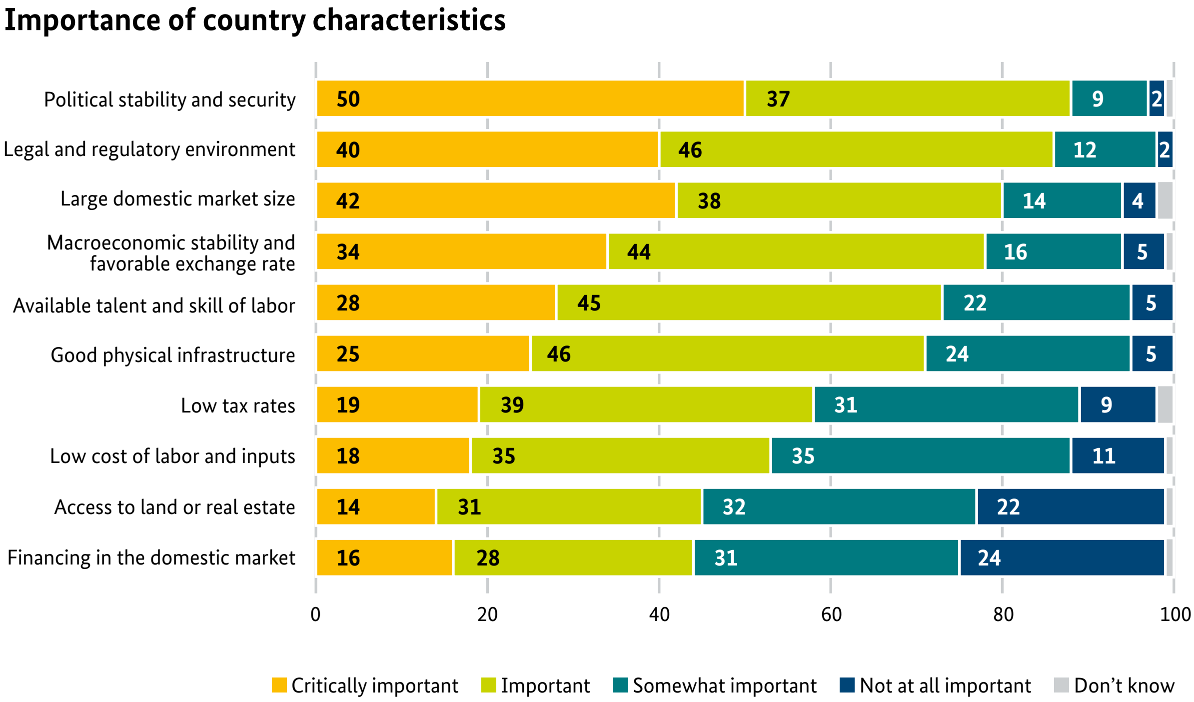
Lastly, mining often produces environmental and social externalities that need to be identified, mitigated and managed along the mining value chain, with the costs of externalities allocated to budgets accordingly. Project failures tend to rise in volatile price environments. Requiring companies to progressively rehabilitate and clean up polluted and disturbed land during production, as well as make financial contributions into a ring-fenced fund for future closure and reclamation costs, are important legislative tools that policymakers should consider to mitigate the negative externalities caused by mining operations.

8.2. Increase investment attractiveness

Mining activities are mostly carried out by multinational private companies. It is therefore paramount for resource-rich countries to create an attractive investment environment to have a better chance to find a private-sector partner to develop their energy transition mineral deposits.

Although it is often presumed that a country's fiscal regime is the key determinant to attract mining investment or other forms of FDI, there is evidence that low tax rates are far from being the most important factor for private sector companies looking to invest in a new jurisdiction (World Bank, 2018). Political stability, a well-functioning legal and regulatory environment, macroeconomic stability, the availability of skilled workers and good physical infrastructure all rank higher than low tax rates for global investors.

Figure 8.1: Characteristics that make countries attractive for FDI



Source: World Bank (2018).

Unlike other types of investment, a country's geological potential is often the most important consideration when multinational mining companies are making decisions on whether to start exploration or mining activities in a new jurisdiction. An outstanding geological potential might therefore be able to sway companies to invest despite a comparatively low score on other country characteristics. However, global capital is scarce, and investors will likely still prioritise countries that have a generally favourable investment climate. Low-income countries tend to score lower on investment attractiveness characteristics compared to more developed countries (Fraser Institute, 2022), and should therefore try to improve their overall investment attractiveness to have better chances of attracting private sector investment to explore and develop their energy transition mineral potential. Meaningful improvements in some areas are difficult to achieve in practice and require long-term commitment – a government cannot establish a reputation for macroeconomic and political stability overnight, as investors need to see proof of that stability over time. However, governance reforms that improve transparency and accountability, and limit opportunities for corruption, can be implemented relatively quickly and lay the foundations for improvements elsewhere.

8.3. Improve the understanding of the geological potential

A profitable mining operation necessarily requires a geological ore deposit that can be mined in an economically viable manner. Accordingly, the perceived geological potential of a country or region is one of the crucial factors which leads to mineral exploration and investment in mine development. To gain confidence in the geological prospects of a country, it is essential to gather geodata and carry out exploration activities. Exploration is the economically riskiest part of the mining investment cycle as investments in determining the geological potential of a country, region or prospective mining area is complex and requires high upfront costs without any certainty of success.

Exploration knowledge worldwide lies principally with the private sector and most of the exploration costs are borne by private companies. Nonetheless, there are ways in which governments can increase the understanding of the country's geological potential and thus make their country more attractive for exploration and mining investors. Governments should attempt to develop policies and internal capacity to effectively acquire, manage, and disseminate geodata (Halland, Lokanc and Nair, 2015). There is strong evidence that the effective collection, storage and public availability of geodata from mineral exploration have high returns for governments, as they attract investors who will be able to use reliable geoscientific datasets to reduce risks and costs (BGS International, 2012). A government with a good understanding of the country's geological potential can also improve its capacity and position in contract negotiations and licence awarding (Halland, Lokanc and Nair, 2015).

Although setting up well-functioning geodata management systems and collecting the requisite data i s a difficult undertaking, especially for low-income countries with limited existing capacity and a relatively small skilled labour force, it is essential for governments to prioritise these activities if they are looking to develop their energy transition minerals reserves. The tax treatment of exploration costs can also have material impacts on the allocation of risks between private-sector companies and states, and between incumbent mining companies and new entrants. Governments seeking to improve the understanding of geological potential should pay particular attention to the impact of the fiscal regime on exploration activities.

8.4. Develop an enabling environment for sustainable mineral extraction with a focus on ESG

Investors are increasingly demanding more transparency with regards to carbon emissions and other environment, social and governance (ESG) criteria (Accenture, 2022; Taylor et al., 2022). ESG is now integral to mining companies' strategies and is considered the top risk and opportunity for mining companies (Mitchell, 2022). The last few years has seen a new development in which users of energy transition minerals are starting to demand additional sustainability requirements from mining companies that go beyond what is required in markets for non-energy transition minerals.

This is not surprising, as the majority of demand growth for energy transition minerals come from products branded as 'sustainable', such as wind turbines and electric vehicles. Coupled with a rising awareness of the harmful impacts of the practices found in the supply chains of some industrial inputs, there is growing pressure on the consumer and public-facing end-producers of these products (such as car manufacturers) to prove that the inputs for their products are also produced sustainably and meet ESG requirements. This development leads to rising demands from the end-producers of these products on their upstream suppliers to improve their mining practices to emit less carbon, use less water, have lower impacts on biodiversity and improve the benefits for local communities. Hence, there are expectations of higher levels of sustainability in the production of energy transition minerals than in other mined materials, such as coal.

There is growing evidence that mining companies who are investing in the exploration and development of energy transition minerals' deposits are starting to show additional investment preferences, which go beyond the general push towards greater ESG alignment in the mining industry. This changing market environment and increased focus on ESG has implications for governments of countries with energy transition mineral reserves. To be globally competitive and attract investments from ESG conscious mining and exploration companies, governments will need to develop 'non-traditional enabling policies' in addition to the usual investment competitiveness concerns. The novelty of this trend and the rapidly developing new market environment means that there is only a limited evidence base and few examples that governments can look towards when developing policy.

However, the new enabling environment will likely need to include:

- Aspects of clean power provision to reduce the carbon intensity of mining projects.
- A greater emphasis on environmental regulations and innovative post-closure planning.
- The development of uncomplicated regulatory frameworks to allow mining companies to more easily trial emerging technologies.
- Developing policies that enable the emergence of a circular economy within mining industrial systems, such as the characterisation and re-use of mine waste and tailings.
- Stronger community conflict resolution frameworks and associated regulations.

Bibliography

- Accenture (2022). "How investors view mining's new role as a champion of decarbonization", Accenture.
  › *Available at: https://www.accenture.com/content/dam/accenture/final/a-com-migration/r3-3/pdf/pdf-173/accenture-mining-role-champion-of-decarbonization.pdf#zoom=40*
- Afifa, L. (2022), "Indonesia Announces Bauxite Export Ban", *Tempo.co*.
  › *Available at: https://en.tempo.co/read/1586514/indonesia-announces-bauxite-export-ban*
- Ajmera, A. (2022), "Indonesia's bauxite export ban to have limited impact on China supply", *Global Times*.
  › *Available at: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/112521-indonesias-bauxite-export-ban-to-have-limited-impact-on-china-supply*
- Albertin, G. et al. (2021), "Countering Tax Avoidance in Sub-Saharan Africa's Mining Sector", *International Monetary Fund*.
  › *Available at: https://www.imf.org/en/Blogs/Articles/2021/11/05/blog-countering-tax-avoidance-sub-saharan-africa-mining-sector*
- Asmarini, W. and Munthe, C., (2017). "Indonesia eases export ban on nickel ore, bauxite", *Reuters*.
  › *Available at: https://www.reuters.com/article/us-indonesia-mining-exports-idUSKBN14W1TZ*
- Azadi, M., Northey, S.A., Ali, S.H. and Edraki, M. (2020). "Transparency on greenhouse gas emissions from mining to enable climate change mitigation", *Nature Geoscience*, 13(2), pp.100-104
- Bainton, N., & Jackson, R. T. (2020). "Adding and sustaining benefits: Large-scale mining and landowner business development in Papua New Guinea", *The Extractive Industries and Society*, 7(2), 366-375
- Benchmark Source (2022). "Flake graphite production in Africa set to overtake China this decade".
  › *Available at: https://source.benchmarkminerals.com/article/flake-graphite-production-in-africa-set-to-overtake-china-this-decade*
- BGS International (2012). "Geodata for Development, A Practical Approach."
  In EI Source Book, ed. Peter Cameron and Michael Stanley.
  › *Available at: http://www.eisourcebook.org/*
- Blagoeva, D.T., Alves Dias, P., Marmier, A. ; Pavel, C.C. (2018). "Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU: Wind power, photovoltaic and electric vehicles technologies, time frame: 2015-2030".
  EUR28192 EN. doi:10.2790/08169
- Bnamericas (2021). "Initiativa legislativa elevaría derechos mineros que pagan mineras in México por concesiones", *Noticias*.
  › *Available at: https://www.bnamericas.com/es/noticias/iniciativa-legislativa-elevaria-derechos-que-pagan-mineras-en-mexico-por-concesiones*
- Born, K. (2022). "Energy transition minerals: What are they and where will they come from?", *Economics Observatory*.
  › *Available at: https://www.economicsobservatory.com/energy-transition-minerals-what-are-they-and-where-will-they-come-from*
- Brown, T J, Idoine, N E., Wrighton, C E, Raycraft, E R, Hobbs, S F, Shaw, R A, Everett, P, Deady, E A, Kresse, C. (2021). "World Mineral Production 2015–19", *British Geological Survey*, Keyworth, Nottingham.
  › *Available at: https://www2.bgs.ac.uk/mineralsuk/download/world_statistics/2010s/WMP_2015_2019.pdf*
- Castaneda, F., Barria, D., Astorga, G. (2015). "Is the OECD model suitable for strategic public enterprises in terms of national development? Reflections from CODELCO case, Chile*", CIRIEC Working Paper: 2015/18*.
  › *Available at: http://www.ciriec.ulg.ac.be/wp-content/uploads/2016/02/WP15-18.pdf*

- IFC and ICMM (2010). "Working together: How large-scale mining can engage with artisanal and small-scale miners", *International Finance Corporation and International Council on Mining and Metals*.
  › *Available at: https://www.commdev.org/wp-content/uploads/pdf/publications/Working-together-How-large-scale-mining-can-engage-with-artisanal-and-small-scale-miners.pdf*

- Consensus Economics (2022), "Energy and Metals Consensus Forecast from October 2022".
  › *Available at: https://www.consensuseconomics.com*.
  The forecasts used in the inception report are sourced from a subscription to the database.

- Cottarelli, C. (2012), "Fiscal Regimes for Extractive Industries: Design and Implementation. Prepared by the Fiscal Affairs Department", *International Monetary Fund*.
  › *Available at: https://www.imf.org/external/np/pp/eng/2012/081512.pdf*

- Crawford, A., Davis, N., Bliss, M. (2020), "Assessment: Jamaica and the mining policy framework, IGF Mining Policy Framework Assessment", *Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF)*.
  › *Available at: https://www.iisd.org/system/files/publications/jamaica-mining-policy-framework-assessment-en.pdf*

- Creamer, M. (2021). "Zambia going all out to up green energy, copper with private-sector at Helm", *Mining Weekly*.
  › *Available at: https://www.miningweekly.com/article/zambia-helping-private-sector-to-flourish-as-it-ups-green-energy-copper-2021-11-16/rep_id:3650*

- Cruz, E.D. and Serapio Jr, M. (2017).
  "Philippines to shut half of mines, mostly nickel, in environmental clampdown", *Thomson Reuters*.
  › *Available at: https://www.reuters.com/article/us-philippines-mining-idUSKBN15H0BQ*

- Daly, D., Zhang, M., Nguyen, M. (2021). "China's Lygend starts milestone nickel project in Indonesia", *Reuters*.
  › *Available at: https://www.reuters.com/article/indonesia-nickel-lygend-idUSL2N2N60XR*

- Deloitte (2018), Indonesia Tax Guide.
  › *Available at: https://www2.deloitte.com/id/en/pages/tax/articles/indonesian-tax-guide.html*

- DLA Piper (2018). "A new mining code for the DRC".
  › *Available at: https://www.lexology.com/library/detail.aspx?g=7e116ac8-47b7-41e3-ad84-9ce381daab66*

- EIA (2022). "Frequently asked questions", *U.S. Energy Information Administration (EIA)*.
  › *Available at: https://www.eia.gov/tools/faqs/faq.php?id=97&t=3*

- Ericsson, M. and Loef, A. (2020). "Analysis of tax regimes: Comparative analysis of tax regimes of land-based mining in 15 countries", *RMG Consulting*.

- European Commission (2020). "Critical Raw Materials for Strategic Technologies and Sectors in the EU".
  › *Available at: doi:10.2873/865242*

- EU Raw Materials Information System (2019). "Artisanal and small scale mining statistics".
  › *Available at: https://rmis.jrc.ec.europa.eu/?page=artisanal-and-small-scale-mining-a6f8a3*

- EY (2017). "Mining and metals tax guide – Colombia".
  › *Available at: http://cdn.ceo.ca.s3-us-west-2.amazonaws.com/1e62qu9-ey-colombia-mining-and-metals-tax-guide-2017-may.pdf*

- EY (2018). "Mining and metals tax guide: Mongolia".
  › *Available at: https://assets.ey.com/content/dam/ey-sites/ey-com/en_mn/news/2018/08/ey-mongolia-tax-guide-sep-2018.pdf*

- FERDI (2020). "Taxation of mining industries database".
  › *Available at: https://fiscalite-miniere.ferdi.fr/en*

- Finbox (2022). Historical operating profit and pre-tax profit margin data for mining companies between 2012 and 2021", *Finbox database* subscription.
  › *Available at: https://finbox.com/*

- Fleming, A. and Manley, D. (2022). "Variable Royalties: An answer to volatile mineral prices", *Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), Consultative Draft under the Future of Resource Taxation Series*.
  › *Available at: https://www.igfmining.org/wp-content/uploads/2022/11/variable-royalties-an-answer-to-volatile-mineral-prices.pdf*

- Forstater, M. (2017). "The Good, the Bad, and the Ugly: How Do Tax Incentives Impact Investment?", Blog post, *Center for Global Development (CGD)*.
  › *Available at: https://www.cgdev.org/blog/good-bad-and-ugly-how-do-tax-incentives-impact-investment*

- Formenti, L. and Casella, B. (2019). "Mining for tech advances? The impact of mineral-resource FDI in the era of global value chains", *LSE blog*.
  › *Available at: https://blogs.lse.ac.uk/gild/2019/09/18/mining-for-tech-advances-the-impact-of-mineral-resource-fdi-in-the-era-of-global-value-chains/*

- Fraser Institute (2022). "Annual Survey of Mining Companies, 2021", *Fraser Institute*.
  › *Available at: https://www.fraserinstitute.org/sites/default/files/annual-survey-of-mining-companies-2021.pdf*

- Fuyuno, I. (2012). "Japan and Vietnam join forces to exploit rare earth elements", *Scientific American*.
  › *Available at: https://www.scientificamerican.com/article/japan-vietnam-join-forces-exploit-rare-earth-minerals/*

- Garside, M. (2021). "Global price forecast of rare earth oxides 2020-2030", *Statista*.
  › *Available at: https://www.statista.com/statistics/449838/forecast-average-rare-earth-oxide-prices-globally/#:~:text=Global%20price%20forecast%20of%20rare%20earth%20oxides%202020%2D2030&text=By%202030%2C%20the%20price%20of,are%20are%20less%20economically%20exploitable*

- Gomez, F., Guzman, J. I., & Tilton, J. E. (2007). "Copper recycling and scrap availability", *Resources Policy*, 32(4), 183-190.

- Government of Canada (2022). "Aluminium facts, Natural Resources Canada".
  › *Available at: https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/aluminum-facts/20510*

- Gregoir, L. and Van Acker, K. (2022). "Metals for Clean Energy: Pathways to solving Europe's raw materials challenge", *KU Leuven*.
  › *Available at: https://www.eurometaux.eu/media/20ad5yza/2022-policymaker-summary-report-final.pdf*

- Halland, H., Lokanc, M. and Nair, A., (2015). "The extractive industries sector: essentials for economists, public finance professionals, and policy makers", *World Bank Publications*.

- Helmholtz Zentrum (2021). "Sustainable Processing Of Rare Earths (REE Nam Xe)", *Helmholtz-Zentrum Dresden-Rossendorf, HZDR*.
  › *Available at: https://www.hzdr.de/db/Cms?pOid=46743&pNid=22*

- Herbert Smith Freehills (HSF) (2022). "Green Energy Transition Presents 'unparalleled' opportunity for Zambia", *Africa notes*.
  › *Available at: https://hsfnotes.com/africa/2022/03/31/green-energy-transition-presents-unparalleled-opportunity-for-zambia/*

- Highley, D. E., Chapman, G. R., & Bonel, K. A. (2004). "The economic importance of minerals to the UK", *British Geological Survey*.

- Home, A. (2015). "Bauxite and the limits of resource nationalism", *Reuters*.
  › *Available at: https://www.reuters.com/article/indonesia-bauxite-ahome-idUKL6N0WT1TS20150330*

- Huber, I. (2021). “Indonesia’s Nickel Industrial Strategy”, *Center for Strategic and International Studies (CSIS)*. *› Available at: https://www.csis.org/analysis/indonesias-nickel-industrial-strategy*
- Hund, K. et al. (2020). “Minerals for climate action: the mineral intensity of the clean energy transition”, *World Bank*. *› Available at: https://www.commdev.org/wp-content/uploads/pdf/publications/MineralsforClimateActionTheMineralIntensityoftheCleanEnergyTransition.pdf*
- ICMM (2020). “ICMM Members’ Tax Contribution Report: 2020 Update”. *› Available at: https://www.icmm.com/en-gb/research/social-performance/2021/tax-contribution*
- IDB (2020). “Design and Performance of Mining and Petroleum Fiscal Regimes in Latin America and the Caribbean: Survey of Current Practices, Lessons Learned and Best Practices”. *› Available at: https://publications.iadb.org/en/design-and-performance-mining-and-petroleum-fiscal-regimes-latin-america-and-caribbean-survey*
- Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) BEPS (2022). “Overview of work by IGF BEPS”. *› Available at: https://www.igfmining.org/beps/*
- Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) BEPS (2021). “Taxing the Digital Economy: Implications for Mining”. *› Available at: https://www.igfmining.org/beps/current-topics/taxing-the-digital-economy-implications-for-mining/*
- Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) (2021). “Tax incentives”. *› Available at: https://www.igfmining.org/beps/current-topics/tax-incentives/*
- Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) (2017). “Global Trends in Artisanal and Small-Scale Mining (ASM): A review of key numbers and issues”, Winnipeg: *IISD*. *› Available at: https://www.iisd.org/system/files/publications/igf-asm-global-trends.pdf*
- International Council on Mining and Metals (ICMM) (2018). “The role of mining in national economies (4th edition)”. *International Council on Mining & Metals (ICMM)*, 16pp. *› Available at: https://www.icmm.com/website/publications/pdfs/social-and-economic-development /181002_mci_4th-edition.pdf*
- International Energy Agency (IEA) (2021). “The Role of Critical Minerals in Clean Energy Transitions“, part of World Energy Outlook, *International Energy Agency (IEA)*. *› Available at: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions*
- Jiyeong Go, (2022). “Indonesia attracts $15bn of investment in the EV supply chain”, *FDI Intelligence*. *› Available at: https://www.fdiintelligence.com/content/news/indonesia-attracts-15bn-of-investment-in-the-ev-supply-chain-80942*
- Kambanda, C. et al. (2021). “Country priority plan and diagnostic of the electricity sector: Guinea”, *African Development Bank (AfDB)*. *› Available at: https://www.afdb.org/sites/default/files/2021/11/22/guinea.pdf*
- Kapoor, K. and Asmarini, W. (2014). “Indonesia bans mineral ore exports, all eyes on nickel impact”, *Reuters*. *› Available at: https://www.reuters.com/article/indonesia-minerals-idUSL3N0KM01W20140112*
- Kim, T. Y. (2022). Updated data shared with authors under the study “The Role of Critical Minerals in Clean Energy Transitions”, part of World Energy Outlook, *International Energy Agency (IEA)*. *› Available at: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions*
- Korinek, J. (2020). “The mining global value chain”, *OECD Trade Policy Papers*, No. 235, OECD Publishing, Paris. *› Available at: https://doi.org/10.1787/2827283e-en*

- KPMG (2022). "BEPS 2.0 What you need to know".
  › *Available at: https://assets.kpmg/content/dam/kpmg/xx/pdf/2022/03/beps-what-to-know-flyer-web-final.pdf*
- Krausmann, F., Lauk, C., Haas, W. and Wiedenhofer, D. (2018). „From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015", *Global Environmental Change*, 52, pp.131-140.
- Kubota, Y. (2010). "Vietnam and Japan to mine rare earths together", *Thomson Reuters*.
  › *Available at: https://www.reuters.com/article/us-japan-vietnam-idUSTRE69U05F20101031*
- Langner, E. (2015). "Examining the copper value chain", *Copper Worldwide*, Vol 5 No 1, 2015.
- Lillo, M. (2022). "Chile at risk of missing lithium boom amid political, policy instability", *S&P Global*.
  › *Available at: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/chile-at-risk-of-missing-lithium-boom-amid-political-policy-instability-70712711*
- LME (2022). "Historical Data", *London Metal Exchange (LME)*.
  › *Available at: https://www.lme.com/Market-data/Accessing-market-data/Historical-data*
- Luft, G., Bass, C., Blair, J.J.A., Jiminez, D., Agosin, M., Tahil, M., Michienzi, M., Wehner, N. (2022). "Is Chile losing ground to other lithium producers?", *The Dialogue*.
  › *Available at: https://www.thedialogue.org/analysis/is-chile-losing-ground-to-other-lithium-producers/*
- Matiko, J. and Sipemba, T. M. (2022). "Spotlight: Mining law in Tanzania", *East African Law Chambers*.
  › *Available at: https://www.lexology.com/library/detail.aspx?g=b14bbf0b-16e4-491d-9172-0ed5750a343f*
- Mano River Union (2017). "Fiscal Harmonization across the Manu River Union, presentation by Sierra Leone", Meeting in August 2017.
- Massmann, O. (2015). "Mining in Vietnam – And the Message is: Better Transparency on Fee and Tax Management by Authorities", *Duane Morris Hanoi Overview*.
  › *Available at: https://blogs.duanemorris.com/vietnam/2015/07/24/mining-in-vietnam-and-the-message-isbetter-transparency-on-fee-and-tax-management-by-authorities/?utm_source=Mondaq&utm_medium=syndication&utm_campaign=LinkedIn-integration*
- Mawhinney, S. (2020). "Dull with a shiny side – the case for Alumina", *Live Wire*.
  › *Available at: https://www.livewiremarkets.com/wires/dull-with-a-shiny-side-the-case-for-alumina*
- McCrae, M.A. (2018). "Early stage copper projects have grades one-third below operating mines", *Mining.com*.
  › *Available at: https://www.mining.com/copper-supply-deficit-worse-think/*
- McKinsey & Company (2022). "The raw-materials challenge: How the metals and mining sector will be at the core of enabling the energy transition".
  › *Available at: https://www.mckinsey.com/industries/metals-and-mining/our-insights/the-raw-materials-challenge-how-the-metals-and-mining-sector-will-be-at-the-core-of-enabling-the-energy-transition*
- Merwin, M. (2022). "Indonesia's Nickel Export Ban Impacts on Supply Chains and the Energy Transition", *The National Bureau of Asian Research*.
  › *Available at: https://www.nbr.org/publication/indonesias-nickel-export-ban-impacts-on-supply-chains-and-the-energy-transition/*
- Mining News Wire (2020). "Chile Considers Growing Copper Smelting Capacity".
  › *Available at: https://www.miningnewswire.com/chile-considers-growing-copper-smelting-capacity/*
- Mining Technology (2022). "PT Vale and Huayou sign agreement for new HPAL plant in Indonesia".
  › *Available at: https://www.mining-technology.com/news/vale-huayou-hpal-indonesia/*

- Miranda, N. (2022). "Chile's Codelco to push forward maiden lithium exploration in Maricunga", *Reuters*.
  › *Available at: https://www.reuters.com/markets/commodities/chiles-codelco-push-forward-maiden-lithium-exploration-maricunga-2022-01-10/*
- Mitchell, C. and Deady, E. (2021). "Graphite resources, and their potential to support battery supply chains, in Africa", *British Geological Survey Open Report*, OR/21/039, 30pp.
  › *Available at: https://nora.nerc.ac.uk/id/eprint/531119/1/Graphite%20supply%20chains%20in%20Africa_Report.pdf*
- Mitchell, J. (2022). "No sacrifices: Inside nickel mining in the Philippines", *Mine*, Issue 118: July 2022.
  › *Available at: https://mine.nridigital.com/mine_jul22/philippines_nickel_mining*
- Mitchell, P.D. (2022). "Top 10 business risks and opportunities for mining and metals in 2023", *EY*.
  › *Available at: https://www.ey.com/en_gl/mining-metals/risks-opportunities*
- Mkokweza, C., Zulu, M.A., Shandavu, N. (2019). "Mining taxes, royalties and duties in Zambia", *Lexology*.
  › *Available at: https://www.lexology.com/library/detail.aspx?g=d5f6c22c-35fe-4bf9-8ad2-8b2ee7e12a3f*
- Mwirigi, C. (2022). "Copper miner plans solar and wind capacity in Zambia", *PV Magazine International*.
  › *Available at: https://www.pv-magazine.com/2022/03/23/copper-miner-plans-solar-and-wind-capacity-in-zambia/*
- NBC News (2021). "How the rise of electric cars endangers the 'last frontier' of the Philippines", *NBCNews.com, NBCUniversal News Group*.
  › *Available at: https://www.nbcnews.com/specials/rise-of-electric-cars-endangers-last-frontier-philippines/index.html*
- NRGI (2015). "The Mining Industry: Overview and Trends", *Natural Resource Governance Institute,* NRGI Reader.
  › *Available at: https://resourcegovernance.org/sites/default/files/nrgi_Mineral-Industry.pdf*
- NRGI (2022). "Economic models of mining, oil and gas projects", *Natural Resource Governance Institute*.
  › *Available at: https://resourcegovernance.org/economic-models*
- Odendaal, M. and Dolo, S., (2020). "Case Study Chile: National Capacity", *Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF)*.
  › *Available at: https://www.iisd.org/sites/default/files/publications/case-study-chile-national-capacity.pdf*
- Open Oil (2016). "Oyu Tolgoi Model and Narrative Report".
  › *Available at: https://openoil.net/portfolio/oyu-tolgoi-model-and-narrative-report/*
- Organisation for Economic Co-Operation and Development (OECD) (2015). "OECD/G20 Base Erosion and Profit Shifting Project 2015 Final Reports".
  › *Available at: https://www.oecd.org/ctp/beps-frequently-asked-questions.pdf*
- Organisation for Economic Co-Operation and Development (OECD) (2017). "OECD releases latest updates to the Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrations".
  › *Available at: https://www.oecd.org/tax/transfer-pricing/oecd-releases-latest-updates-to-the-transfer-pricing-guidelines-for-multinational-enterprises-and-tax-administrations.htm*
- Organisation for Economic Co-Operation and Development (OECD) (2019). "Guiding Principles for Durable Extractive Contracts".
  › *Available at: https://www.oecd.org/dev/guiding-principles-for-durable-extractive-contracts-55c19888-en.htm*
- Organisation for Economic Co-Operation and Development (OECD) (2022). "Base erosion and profit shifting – OECD BEPS".
  › *Available at: https://www.oecd.org/tax/beps/*
- Otto, J.M. (1997). "A national mineral policy as a regulatory tool", Resources Policy, 23(1-2), pp. 1–7.
  › *Available at: https://doi.org/10.1016/s0301-4207(97)00007-x*

- Perez Vallejos, P. (2017). "Problemática de las fundiciones de cobre en Chile y lean management como metología de gestion", *University of Chile*.
  › *Available at: https://repositorio.uchile.cl/bitstream/handle/2250/145188/Problemática-de-las-fundiciones-de-cobre-en-Chile-y-Lean-Management-como-metodolog%C3%ADa-de-gestión.pdf?sequence=1*
- PWC (2012). "Corporate income taxes, mining royalties and other mining taxes: A summary of rates and rules in selected countries".
  › *Available at: https://www.pwc.com/gx/en/energy-utilities-mining/publications/pdf/pwc-gx-miining-taxes-and-royalties.pdf*
- PWC (2022a). "Mining Taxes Summary Tool".
  › *Available at: https://www.pwc.com/gx/en/industries/energy-utilities-resources/mining-metals/mining-taxes-summary-tool.html*
- PWC (2022b). "Worldwide Tax Summaries Online: Corporate and individual taxes in 150 territories worldwide".
  › *Available at: https://taxsummaries.pwc.com*
- Readhead, A. (2017). "IGF Addresses Corporate Tax Avoidance in the Mining Industry", *Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF)*.
  › *Available at: https://www.igfmining.org/stage_new/igf-addresses-corporate-tax-avoidance-mining-industry/*
- Reuters (2022). "Chile's Codelco profits slump 50 % to September, cuts production target".
  › *Available at: https://www.reuters.com/article/codelco-results-idUSL1N31T1GW*
- Samb, S (2022). "Guinea extends deadline for bauxite miners to present refinery plans", *Reuters*.
  › *Available at: https://www.reuters.com/world/africa/guinea-extends-deadline-bauxite-miners-present-refinery-plans-2022-06-10/*
- Saigal, K. (2019). "Mozambique's glittering graphite mining boom", *the Africa report.com*.
  › *Available at: https://www.theafricareport.com/412/mining-mozambique-glittering-graphite/*
- Sandell-Hay, C. (2022). "Madagascar Helping to Meet Global Graphite Demand", *The Assay*.
  › *Available at: https://www.theassay.com/articles/analysis/madagascar-helping-to-meet-global-graphite-demand/*
- Shamsiev, B. (2022). "Dentons Global Mining Guide: Uzbekistan", *Dentons*.
  › *Available at: https://www.dentons.com/en/insights/newsletters/2022/january/17/dentons-global-mining-guide/dentons-global-mining-guide-2022/uzbekistan*
- Sherwood, D. (2019). "How lithium-rich Chile botched a plan to attract battery makers". *Thomson Reuters*.
  › *Available at: https://www.reuters.com/article/us-chile-lithium-focus-idUSKCN1UC0C8*
- Shikana Law Group (2022). "Tanzania: State Participation in Mining Operations in Tanzania Mining Law", *Mondaq*.
  › *Available at: https://www.mondaq.com/mining/1179732/state-participation-in-mining-operations-in-tanzania-tanzania-mining-law-*
- Somay, S. et al. (2021). "Mining in Turkey: overview", *Practical Law*, *Thomson Reuters*.
  › *Available at: https://uk.practicallaw.thomsonreuters.com/4-616-5262?transitionType=Default&contextData=(sc.Default)&firstPage=true*
- S&P Global (2019). *"Zambian mineral royalties increase"*.
  › *Available at: https://ihsmarkit.com/research-analysis/zambian-mineral-royalties-increase.html*
- Statista (2022a). "Mine lifespan by selected commodities", *Statista*.
  › *Available at: https://www.statista.com/statistics/255479/mine-life-per-commodity/*

- Statista (2022b). “Production of stainless steel slabs in the Asia-Pacific region in 2020, by country or territory”.
  › *Available at:* *https://www.statista.com/statistics/1129906/apac-stainless-steel-slab-production-by-country-or-region/*
- Taylor, A., Nana, P., Moutia-Bloom, J. (2022). “How mining & metals companies can make ESG work in a downturn”, *White & Case LLP*.
  › *Available at:* *https://www.whitecase.com/insight-our-thinking/mining-metals-2022-how-mining-metals-companies-make-ESG-work-downturn*
- The Economist (2014). “Mining in Indonesia – Smeltdown”, January 18, 2014.
  › *Available at:* *https://www.economist.com/business/2014/01/18/smeltdown*
- The Economist (2017a). “A battle for supremacy in the Lithium Triangle”.
  › *Available at:* *https://www.economist.com/the-americas/2017/06/15/a-battle-for-supremacy-in-the-lithium-triangle*
- The Economist (2017b). “Indonesia and the Philippines hobble the mining industry”.
  › *Available at:* *https://www.economist.com/asia/2017/02/23/indonesia-and-the-philippines-hobble-the-mining-industry*
- The Economist (2022). “Argentina could help the world by becoming a big lithium exporter”.
  › *Available at:* *https://www.economist.com/the-americas/2022/11/15/argentina-could-help-the-world-by-becoming-a-big-lithium-exporter*
- The Guardian (2022). “Revealed: Oil sector’s ‘staggering’ $3bn-a-day profits for last 50 years”. *Guardian News and Media*.
  › *Available at:* *https://www.theguardian.com/environment/2022/jul/21/revealed-oil-sectors-staggering-profits-last-50-years*
- Tirupati Graphite (2022). “Projects overview”.
  › *Available at:* *https://www.tirupatigraphite.co.uk/projects/*
- United Nations (UN) (2018). “United Nations handbook on selected issues for taxation of the extractive industries by developing countries”, *UN Department of Economic and Social Affairs*.
  › *Available at:* *https://digitallibrary.un.org/record/3801187?ln=en*
- UNCTAD (2021). “World Investment Report 2021”, *United Nations Conference on Trade and Development*.
  › *Available at:* *https://unctad.org/system/files/official-document/wir2021_en.pdf*
- US Department of State (2021). “2021 Investment Climate Statements: Madagascar”.
  › *Available at:* *https://www.state.gov/reports/2021-investment-climate-statements/madagascar/*
- U.S. Geological Survey (USGS) (2022). “Mineral commodity summaries 2022”, *U.S. Geological Survey*.
  › *Available at:* *https://doi.org/10.3133/mcs2022*
- Vander Molen, I. (2022). “Bolivia: Pursuing Sustainable Lithium Mining”, *Center for Strategic and International Development (CSIS)*.
  › *Available at:* *https://www.csis.org/blogs/development-dispatches/bolivia-pursuing-sustainable-lithium-mining*
- Vandome, C. (2022). “Reforming zambia’s mines needs more change and support”, *Chatham House – International Affairs Think Tank*.
  › *Available at:* *https://www.chathamhouse.org/2022/05/reforming-zambias-mines-needs-more-change-and-support*
- Vásquez, P. (2022). “Can Bolivia Jump-Start its Lithium Industry? A Q&A with Analyst Juan Carlos Zuleta”, *Wilson Center*.
  › *Available at:* *https://www.wilsoncenter.org/blog-post/can-bolivia-jump-start-its-lithium-industry-qa-analyst-juan-carlos-zuleta*

- Wood, A. (2022). "Raw Materials: Bauxite & Alumina Issues – Guinea, China and alumina supply/demand outlook", *CRU conference* presentation.
  › *Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjxo8flnNH7AhXBTKQEHdJxCH0QFnoECBEQAQ&url=https%3A%2F%2Fwww.aluminalimited.com%2Fdatabase-files%2Fview-file%2F%3Fid%3D20150&usg=AOvVaw1lDfHM903nGWAzBBIDELDl*
- World Bank Group (2017). "The Growing Role of Minerals and Metals for a Low Carbon Future".
  › *Available at: https://documents1.worldbank.org/curated/en/207371500386458722/pdf/117581-WP-P159838-PUBLIC-ClimateSmartMiningJuly.pdf*
- World Bank Group (2018). "Global Investment Competitiveness Report 2017/2018: Foreign Investor Perspectives and Policy Implications". *Washington, DC: World Bank*.
  › *Available at: https://openknowledge.worldbank.org/entities/publication/58e3709a-29e0-5c3e-931d-6afad17d20f1*
- World Bank Group (2019). "World development report 2020: Trading for development in the age of global value chains". *Washington, DC: World Bank*.
  › *Available at: https://www.worldbank.org/en/publication/wdr2020*
- World Bank Group (2020). "Electricity Access (% of population) Data".
  › *Available at: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=GN*
- World Bank Group (2021). "Ease of doing business ranking".
  › *Available at: https://data.worldbank.org/indicator/IC.BUS.EASE.XQ*
- World Bank Group (2021b). "The Role of the State in Mongolia's Mining Sector", *Washington, DC: World Bank*.
  › *Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/37298/P173631074c7de069090eb01f85e276b405.pdf?sequence=1&isAllowed=y*
- World Bank Group (2022). "Data from the Pink Sheet", *Commodity Markets*.
  › *Available at: https://www.worldbank.org/en/research/commodity-markets*
- World Bank Group (2022b). "World Bank IBRD – IDA Database, current GDP by countries and regions".
  › *Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD*


CAT

Annex A. Fiscal regimes in the mining sector

There are a range of different approaches to mining taxation around the world, even within the general approach of tax and royalty regimes. This annex sets out current practices for the main taxes and some of the key cross-cutting issues.

A.1. Current practices in mining taxation

A.1.1. Royalties

Royalties are payments to the government for the right to extract finite mineral resources that belong to the state, and not technically a tax.[13] For many governments, it is important that royalties are collected on all units of production as compensation for the loss of those finite resources. For this reason, 'ad valorem' royalties charged as a percentage of sales value are common. These royalties are simple to administer and generate fiscal revenues as soon as the mine starts production. However, as these are charged on all sales regardless of profitability, they are regressive and can deter investment and production. For this reason, some countries charge royalties on operating profits. Countries are increasingly making use of 'sliding-scale' royalties, where the royalty rate increases depending on mineral prices or mining company profits, to increase the progressivity of royalties. An overview of current approaches to royalties is set out in *Figure A.1*, and a simple assessment of the different types of royalties against the principles of mining taxation in *Figure A.2*.

Figure A.1: Current practices in mining royalties

Type	Base	Rate	Examples of where it is used
Unit based (or 'specific')	Volume	Value per unit of volume	Australia (Queensland, for some minerals), India (some minerals), Russia (coal)
Ad valorem with fixed rate	Sales revenue	Fixed percentage	Australia (most minerals in most states), Colombia, Ghana, Indonesia, Kazakhstan, Mexico, Nigeria, Philippines, DRC, Russia (most minerals), Tanzania, Zimbabwe
Ad valorem with variable rate by price	Sales revenue	Variable percentage depending on mineral price	Burkina Faso, Côte d'Ivoire, Mauritania, Mongolia, Zambia
Ad valorem with variable rate by profits	Sales revenue	Variable percentage depending on operating margin	Niger, South Africa
Profit based	Operating profits	Variable percentage depending on the operating margin	Chile, Peru (with minimum ad valorem royalty)

Sources: FERDI (2020), PWC (2012), IDB (2020), S&P Global (2019), Fleming and Manley (2022).

13 *Taxes are mandatory and unrequited payments to the state. While royalties are mandatory, they are not unrequited, as the mining company receives the right to extract, sell, and profit from the minerals in return for paying the royalty.*

Figure A.2: Assessment of different royalty types

Type	Economic efficiency	Progressivity	Simplicity	Timing	Robustness to BEPS
Unit based (or 'specific')	Low	Low	High	Beginning of production	High
Ad valorem with fixed rate	Low	Low	High	Beginning of production	Medium
Ad valorem with variable rate by price	Medium	Medium	Medium	Beginning of production	Medium
Ad valorem with variable rate by profits	Medium / High	High	Medium / Low	Beginning of production	Medium
Profit based	High	High	Low	Potentially later in production and not in all years (unless combined with ad valorem)	Low

Source: authors' own analysis.

A.1.2. Corporate income tax (CIT)

Corporate income tax (CIT) is used commonly around the world to collect fiscal revenues on the profits of private companies. CIT is usually charged at a fixed percentage rate on taxable income. While precise definitions of taxable income vary around the world, it is generally calculated as revenues less allowable deductions, including cost of goods sold, general and administrative costs, depreciation of assets, debt interest, and carried forward losses. Over the past decade, global CIT rates have been falling, from between 35% to 40% around 10 to 15 years ago, to an average of 24% today (World Bank Group, 2021b) as countries compete for foreign direct investment. However, comparisons of headline CIT rates can be misleading, as differences in allowable deductions can have a large impact on the effective tax rate.

In some countries, mining companies are taxed on their profits the same as any other company in the CIT regime. But in many countries that have large mining sectors, a different CIT regime is used for mining. This can include a higher CIT rate, reflecting the state's ownership of natural resources, or a lower CIT rate reflecting the desire to attract investment into the mining sector. Governments also often make changes to allowable deductions for mining companies to support cost recovery, recognising the large up-front costs and inherent risks involved in mining projects. Cost recovery measures in CIT can include capital allowances (an upfront deduction for investment costs), accelerated depreciation (allowing larger depreciation deductions in earlier years), and extended limits on losses carried forward (so that any large losses incurred in the early years of a mining project can be used to offset future profits).

Mining projects are often undertaken by large multinationals that are adept at making use of international tax avoidance[14] strategies to minimise their global tax liabilities. In response to international tax avoidance, over 130 countries have joined the OECD BEPS Inclusive Framework and are implementing a set of measures to tackle tax base erosion and profit shifting (BEPS).[15]

14 *Note that tax avoidance is the legal practice of exploiting allowable deductions and differences between tax regimes around the world to minimise tax liabilities. It is not the same as tax evasion, which is the illegal non-payment or underpayment of tax.*

15 *See section 10.2.2. (International Tax Avoidance) for a short overview*

Figure A.3: Assessment of different royalty types

Type	Colombia	DRC	Ghana	Indonesia	Laos	Mongolia	PNG	Tanzania	Zambia
CIT rate	33%	30%	25%	22%	20%	25%	30%	30%	30%
Depreciation	2-20% DB	2-25% DB	5 years SL	5-12.5% SL	2-50 years SL	2-40 years SL	7.5%-100% DB	5 years SL	4 years SL
Limit on loss carry-forward	12 years	60% of taxable income	5 years	5 years	5 years	4 years, 50% of taxable income	None	70% of taxable income	5 years, 50% of taxable income

Sources: Deloitte (2018), DLA Piper (2018), PWC (2022b).

Notes: DB = declining balance, SL = straight line

Figure A.4: Assessment of income tax

Type	Economic efficiency	Progressivity	Simplicity	Timing	Robustness to BEPS
Income tax	High	High	Low	Later in production, not paid in all years (e.g. if loss-making)	Low

Source: Authors' own analysis

A.1.3. Withholding taxes

Withholding taxes are taxes on the recipients of payments from the mining company that are withheld by the mining company and remitted to the tax authorities on behalf of the payee. The main types of withholding taxes in mining are:

- Withholding tax on services, a tax on entities that provide services to the mining company, such as technical and engineering services or management services.
- Withholding tax on interest, a tax on entities that lend to the mining company, for example to fund capital expenditures in the development phase.
- Withholding tax on dividends, a tax on the shareholders of a mining company on the profits they receive through dividend distributions.

If the payee is a domestic entity, withholding taxes are effectively pre-payments of income tax. If the payee is a foreign entity (non-resident in the host country), they are final taxes on the profits the payee derives from its activities in the host country. In this case, the withholding tax on outbound payments to foreign entities can be relieved from double taxation by the tax authorities in the payee's country, either under bilateral Double Taxation Agreements (DTAs) or unilaterally via credits or deductions.

Withholding taxes on non-residents are an important part of the fiscal regime, as they are the only way to tax non-residents on profits derived from the mining project. They are also often one of the most direct defences against international tax avoidance, as they impose taxes on high-risk payments to related parties, such as debt interest on related-party loans or management fees paid to head offices. The effectiveness of withholding taxes on non-residents as a defence against tax avoidance can be undermined by DTAs, as these often reduce the rates of withholding taxes.

Figure A.5: Assessment of withholding tax

Type	Economic efficiency	Progressivity	Simplicity	Timing	Robustness to BEPS
Dividends	High	High	High	Late in production	Low
Interest	Low	Low	High	Beginning of production	High
Services	Low	Low	High	During development and production	High

Source: Authors' own analysis

A.1.4. Resource rent taxes

Resource rent taxes featured prominently in discussions of resource tax policy in the 1970s and gained popularity again during the 2000s. They are intended to tax windfall profits (or 'economic rents') from mining projects after investors have achieved a hurdle rate of return. This is usually measured by accumulated project cash flows, which are uplifted each year by the hurdle rate. The required return is achieved once accumulated project cash flows after uplifts turn positive, at which point the resource rent tax is usually charged as a fixed percentage of cash flows above the hurdle rate. Resource rent taxes can be applied before income tax, in which case the rent tax is usually deductible from taxable income, or applied after CIT, in which case CIT payments are included in the accumulated cash flows.

Resource rent taxes are currently legislated for in several countries, including Angola, Australia, Ghana, Liberia, Madagascar, Malawi, Namibia, Papua New Guinea, Sierra Leone, and Timor Leste. In practice, resource rent taxes often fail to deliver the anticipated benefits for governments. This could be because some developing country tax authorities lack the administrative capacity to apply a complicated fiscal instrument that requires annual assessments of cumulative cash flows over many years, or it could be because the project never meets the hurdle rate, or if it does, only late in the project life cycle.

Figure A.6: Assessment of withholding tax

Type	Economic efficiency	Progressivity	Simplicity	Timing	Robustness to BEPS
Resource rent tax	Very high	Very high	Low	Late in production	Medium

Source: Authors' own analysis

A.1.5. State participation

State participation is commonly used in mining, perhaps because host governments equate state participation to retaining ownership over its finite natural resources. There are three main types of state participation:

- **Free equity**, where the state receives an ownership interest at no cost to itself and is not obliged to contribute to the costs of the project but receives dividends or a share of profits.
- **Full participation**, where the state purchases equity and contributes to exploration and development costs (and any future cash calls) in proportion to its shareholding, in return for a share of profits or dividends.
- **Carried interest**, where the initial purchase of shares by the state is "carried" by the private investor and repaid by the state from its share of future profits or dividends. The amount due to the investor from the state accrues interest, unless the state receives a "free carried interest", in which case the carry is effectively an interest-free loan to the state.

Free equity shares are relatively common, particularly in sub-Saharan Africa, and usually entail a relatively small share of equity, making it effectively a form of withholding tax on dividends combined with (non-controlling) board representation. Full participation is more common where State Owned Enterprises (SOEs) actively participate in mining projects, such as Codelco in Chile and Kumul Mineral Holdings, the state-owned mining company in Papua New Guinea.

State participation has come into focus recently, with many commentators arguing that it does not achieve value for host countries (World Bank, 2021b). In the case of full participation, the state must find resources to contribute to mining project expenses, either from within (potentially already stretched) national budgets or by borrowing. While carried interest means the state does not need to contribute direct resources, interest on the carry often means the state does not receive dividends until the mine has been producing for many years, if it receives dividends at all.[16] Even free equity can generate lower revenues than anticipated, and later in the project life cycle than other fiscal instruments, as international mining companies can use profit-shifting techniques such as excessive interest deductions on related-party loans to withdraw profits from host countries without paying dividends.

Figure A.7: Assessment of state participation

Type	Economic efficiency	Progressivity	Simplicity	Timing	Robustness to BEPS
State participation – free equity share	Low	High	Medium	Late in production	Low
State participation – carried equity share	Medium	High	Low	Late in production, if at all	Low
State participation – full equity share	High	High	Low	Cost during development, revenue late in production, if at all	Low

Source: Authors' own analysis

16 See, for example, commentary on the Oyu Tolgoi copper mine in Mongolia by Open Oil (2016).

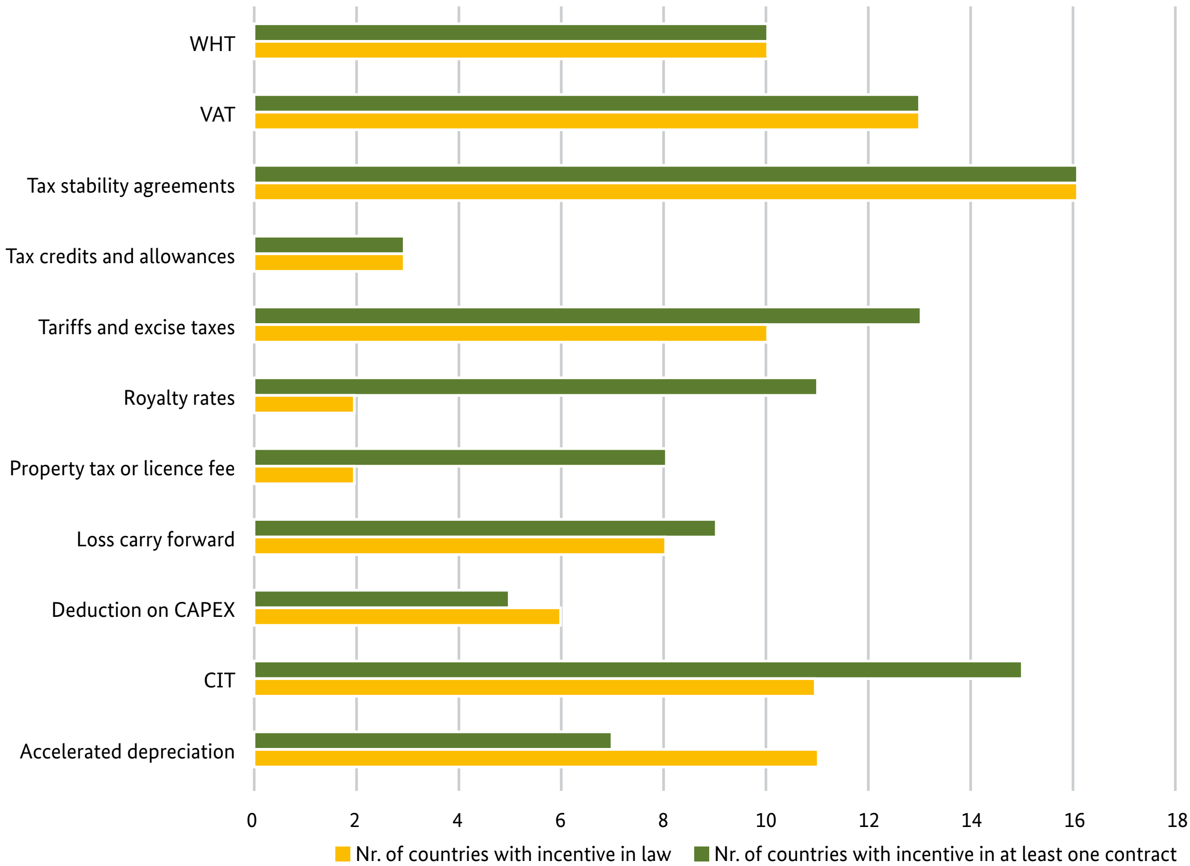
A.2. Cross-cutting issues in mining taxation

A.2.1. Tax incentives

Tax incentives are commonly used to attract foreign direct investment around the world, including in the mining sector. Even so, the evidence is mixed and their use controversial. Some economists believe that tax incentives are an ineffective way to attract investment (Forstater, 2017), and investor surveys tend to show that other factors matter more for investment decisions than taxes, such as macroeconomic and political stability, infrastructure, and the availability of skilled labour (World Bank, 2018). Others argue that tax incentives can be an effective way to attract investment, although where tax incentives are effective, it tends to be for efficiency-seeking investments that are mobile and can relocate to countries that are most competitive on costs, including those offering low taxes or incentives.[17] Many therefore argue that tax incentives are less effective for natural-resource investments, as the mineral resources are fixed and cannot be moved to another country in response to lower taxes.

Even so, tax incentives remain common, including for mining investments. A recent study of 22 countries found tax incentives are used across a broad range of taxes and are provided both in law and in concession contracts (IGF Mining, 2022) (*Figure A.8*). Cost-based incentives, such as capital allowances and accelerated depreciation, tend to be more effective than profit-based incentives, such as tax holidays. This is because cost-based incentives have limited and predictable costs for governments and reduce the capital costs for investors, whereas profit-based incentives provide the largest costs for governments and the greatest benefit for more profitable mines – those that least need tax incentives to support investment in the first place.

Figure A.8: Prevalence of tax incentives in mining



Notes: WHT = withholding tax, VAT = value-added tax, CAPEX = capital expenditure, CIT = corporate income tax.
Source: IGF Mining (2022).

17 This includes manufacturing of exported goods, which will tend to locate in countries where production costs are lowest and have good access to large markets, financial services with a relatively small economic footprint in terms of capital assets or employees, or intangibles such as intellectual property.

A.2.2. International tax avoidance

Large-scale mining is dominated by multinational corporations with numerous subsidiaries located in different tax jurisdictions. Their ability to spread their activities across different subsidiaries allows them to shift profits to low-tax jurisdictions. They can do so by taking advantage of withholding tax reductions or exemptions in double taxation treaties (so-called treaty shopping) and by artificially inflating the costs of services or goods provided by subsidiaries to the mining company in the host country (so-called transfer mispricing).

Developing economies lose an estimated US$100 to US$240 billion in potential tax revenues annually across all sectors due to these activities (OECD, 2022). To counter this loss, the OECD Base Erosion and Profit Shifting (BEPS) Action Plan was launched in 2015. Within this framework over 135 countries and jurisdictions are collaborating on the implementation of 15 actions to tackle tax avoidance, improve the coherence of international tax rules and ensure a more transparent tax environment. For resource rich economies the following measures are especially relevant (IGF BEPS, 2022):

- Limitation on excessive interest deductions (Action 4)
- Prevention of tax treaty abuse (Action 6)
- Transfer pricing (Action 8 to 10)

For instance, the BEPS initiative currently recommends the limitation of excessive interest deductions, via the implementation of a limit to the level of interest deductible for tax purposes relative to earnings, usually being a percentage of earnings before interest, tax, depreciation and amortization (EBITDA). It also has developed detailed guidelines to determine comparable prices between un-related parties (according to the so-called arm´s length principle) to limit transfer mispricing. To contain tax treaty abuses, BEPS provides guidance on specific and general anti-abuse rules or judicial doctrines (OECD, 2015). Moreover, the OECD developed detailed guidelines on the application of the “arm’s length principle”, which represents the international consensus on the valuation of cross-border transactions between associated enterprises, for income tax purposes (OECD, 2017).

While the BEPS initiatives led to many changes to the international tax rules to limit profit shifting, some authorities believed that it had not adequately addressed the challenges of the digitalization of the economy. Many countries started to impose unilateral tax measures, including new legislation to tax companies that are active in a jurisdiction via online platforms, online sales, or via other means with the introduction of a digital services tax (KPMG, 2022). This led to the launch of BEPS 2.0 which applies to multinational groups with revenues of at least 750 million Euros. The second BEPS pillar, also called Global Anti-Base Erosion Proposal (GloBE), seeks to use a global minimum tax of 15% to discourage MNEs from transferring profit away from countries of operation. Additionally, specified payments made to related parties and taxed below 9 percent may be subject to new withholding taxes. While GloBE is often labelled a digital tax reform it can have a significant impact on mining countries and in worst case allocate taxing rights away from resource-rich countries. Governments should therefore pay a close attention to the ongoing reform process and implement measures where necessary to protect taxation rights over their natural resources (see more under IGF BEPS, 2022).

Annex B. Methodology for estimating government revenue potential

This Annex provides a more detailed description of the methodology and assumptions used to produce estimates of revenue potential presented in this report.

B.1. Estimating mining production

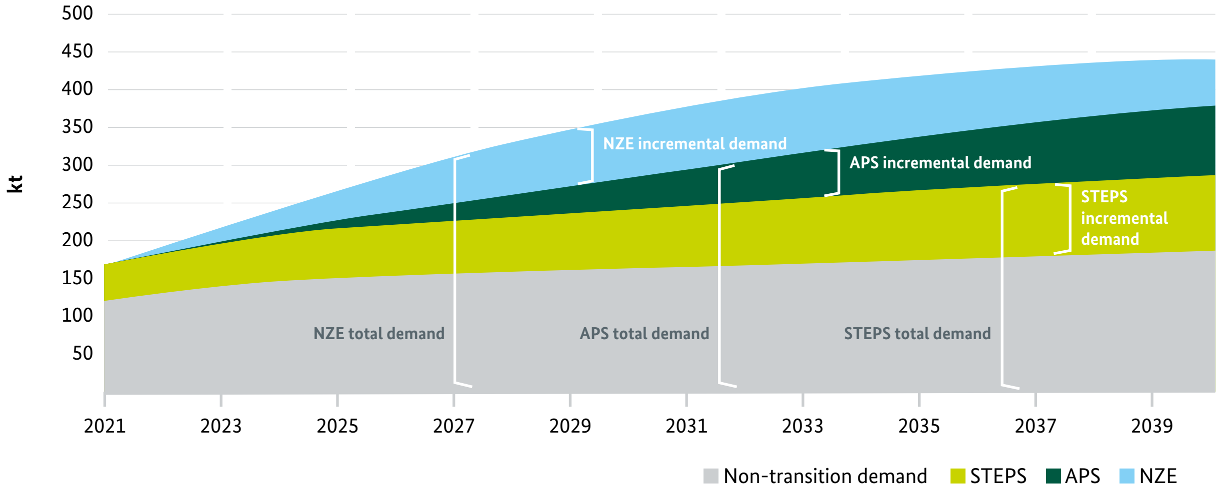
The estimates of future mining production are derived from demand forecasts for each mineral less secondary supply. For the demand forecast, we use three main scenarios that have been developed by the IEA (2021; Kim, 2022):

5. **Stated Policies Scenario (STEPS)** is the estimated demand for minerals for energy transition under current policy settings based on a sector-by-sector assessment of specific policies that are in place or have been announced by governments. It provides an indication of where today's policies and plans lead the energy sector, and the corresponding demand for minerals.
6. **Announced Pledges Scenario (APS)** was introduced in 2021 and assumes that all climate commitments made by governments around the world, including Nationally Determined Contributions (NDCs) and longer-term net zero targets, as well as targets for access to electricity and clean cooking, will be met in full and on time. The IEA has not published estimates for the demand of bauxite, graphite, or REOs under this scenario.
7. **The Net Zero Emissions by 2050 Scenario (NZE)** is the most ambitious scenario by setting out a pathway for the global energy sector to achieve net zero CO2 emissions by 2050. It does not rely on emissions reductions from outside the energy sector to achieve its goals. Universal access to electricity and clean cooking are achieved by 2030. The IEA has not published estimates for the demand of bauxite, graphite and REOs under this scenario. For these products we assume a production under the **Sustainable Development Scenario (SDS)**, for which demand estimates have been published by Gregoir and van Acker (2022). Similar to the NZE scenario, SDS assumes that current net-zero pledges are achieved in full and there are extensive efforts to realise short-term emissions reductions – advanced economies reach net zero by 2050, China around 2060, and all other countries by 2070 at the latest.

The mineral demand estimates for lithium, cobalt, copper and nickel due to the energy transition are taken directly from estimates shared by the IEA with the authors of this study (Kim, 2022). For bauxite, graphite and REOs demand estimates for the energy transition are taken from a report by the University of Leuven (Gregoir and van Acker, 2022), which combined the IEA's clean energy technology forecasts with the average intensity across each application for the respective minerals. For example, the global demand for copper for energy transition was estimated by quantifying the amount of copper needed across the IEA's forecasts for electric cars, solar panels, wind turbines, hydrogen batteries, and grid infrastructure.

As many energy transition minerals have existing uses that are not related to energy transition, the IEA and the KU Leuven report includes estimates of total demand under all scenarios, as well as the incremental demand related to energy transition (IEA, 2021; Gregoir and van Acker, 2022). The different presentations are illustrated in *Figure B.1* below using cobalt as an example.

Figure B.1: Presentation of demand scenarios for cobalt



Source: IEA (2021) and Kim (2022).
Note: STEPS = State policies scenario; APS = Announced pledges scenario; NZE = Net zero scenario.

For some minerals that have wide industrial uses unrelated to the energy transition, such as copper and bauxite (used in aluminium), energy transition demand is expected to be a relatively small share of total demand. For other minerals that have limited uses outside of renewables and electric vehicles, such as lithium, demand from the energy transition represents a larger share of total demand.

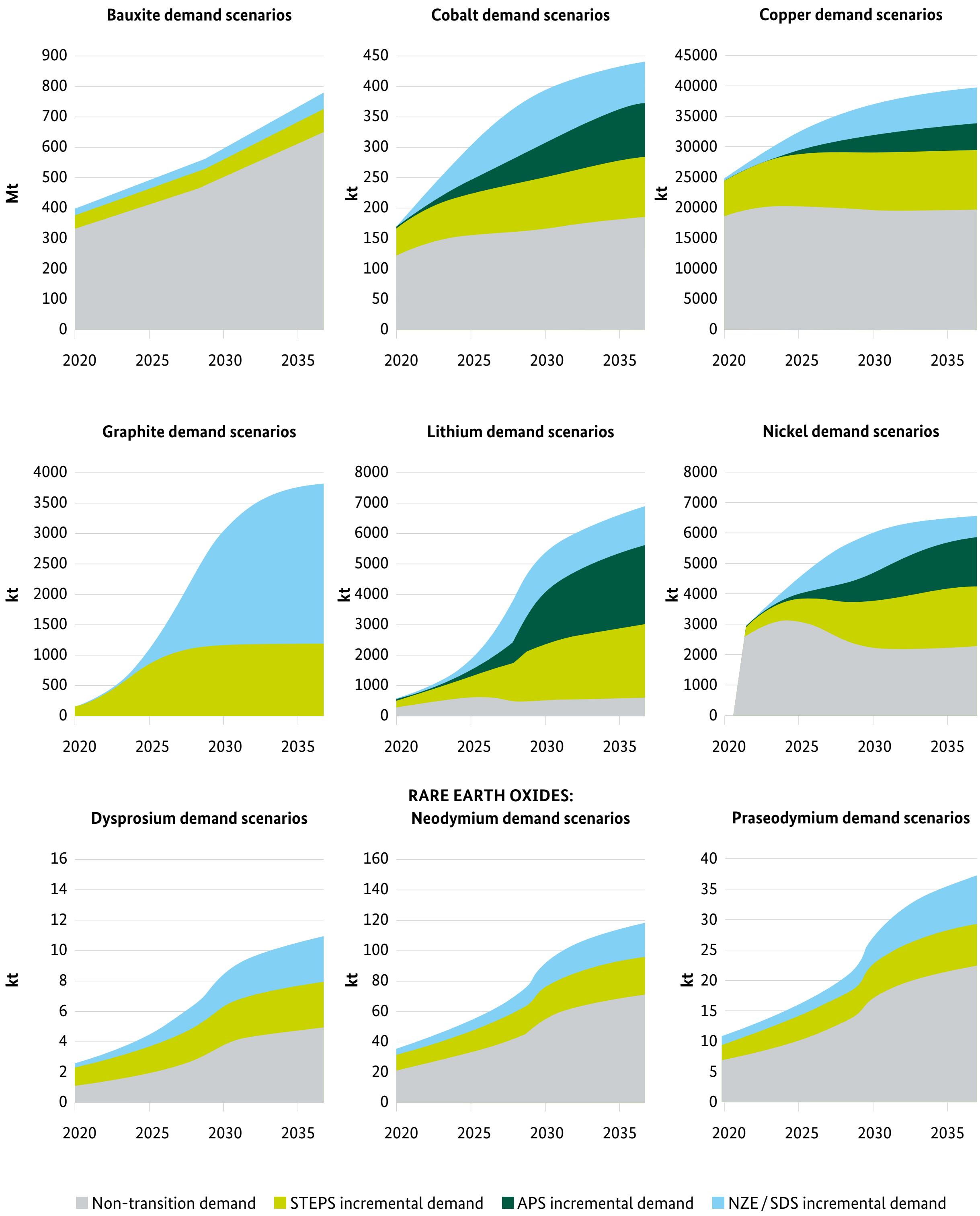
There were three key limitations in the available demand data. First, there are no demand forecasts for bauxite. In this case, we used the demand forecast data for aluminium published by KU Leuven (Gregoir and van Acker, 2022) to derive the demand for bauxite. We calculated the amount of bauxite required to produce one tonne of alumina (an intermediate product in the manufacture of aluminium) and then the amount of alumina required to produce one tonne of finished aluminium. The final ratio of bauxite to aluminium is around 4:1 (Government of Canada, 2022).

Second, there were no estimates of total demand for graphite. We therefore present only the incremental demand for graphite for the energy transition under STEPS and SDS scenarios as reported in the study by KU Leuven (Gregoir and van Acker, 2022).

Third, demand data for bauxite, graphite and REOs is taken from the KU Leuven study, which only provides demand estimates for the STEPS and SDS scenarios, but nor for the APS scenario. Hence, for global and regional estimates we used the SDS demand forecasts for both the NZE/SDS and the APS scenarios.

The demand scenarios used for our estimates of revenue potential are set out in *Figure B.2*.

Figure B.2: Presentation of demand scenarios for cobalt

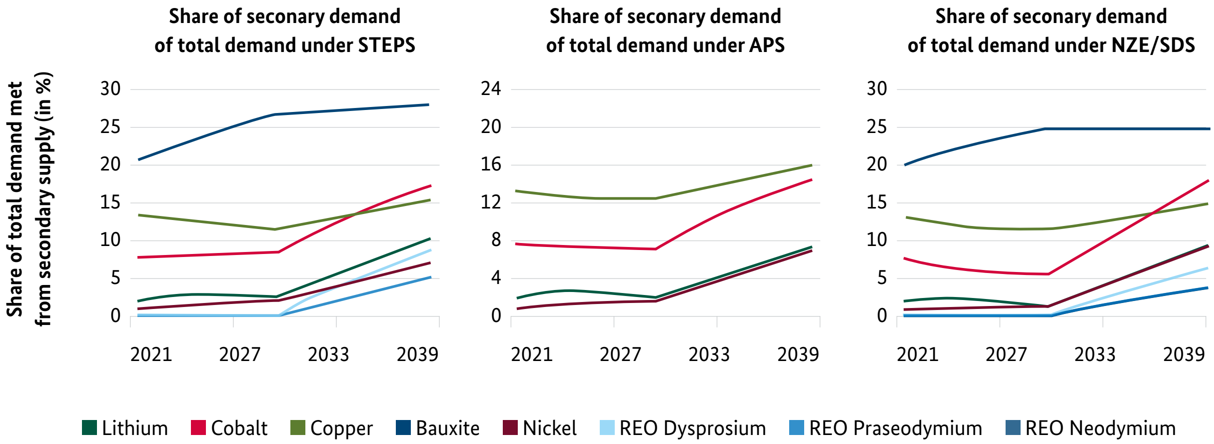


Notes: Estimates of non-transition demand for graphite were unavailable.
Bauxite demand is derived from the demand for aluminium.
Source: IEA (2021), Kim (2022), Gregoir and van Acker (2022).

To estimate primary supply from mining, we subtract estimates of secondary supply (recycling) from the demand scenarios. Estimates of secondary supply are also available for lithium, cobalt, copper and nickel in the data shared by the IEA with the authors of the report (Kim, 2022). Secondary supply data for the remaining minerals is presented in the KU Leuven report (Gregoir and van Acker, 2022). The KU Leuven report includes data for new and old scrap but does not differentiate between total secondary supply and incremental secondary supply for energy transition. New scrap tends not to replace primary production, as it is mostly immediately re-processed and re-used in manufacturing and fabrication processes, which means that new scrap is not usually considered a net addition to supply (Gomez, Guzman and Tilton, 2007). We therefore exclude new scrap and deduct the estimated recycling of old scrap from the demand estimates to derive primary supply. In addition, we estimate incremental secondary supply due to the energy transition based on the annual share of transition-driven demand compared to total demand.

Contribution of secondary supply to mineral demand under …

Figure B.3: … STEPS **Figure B.4: … APS** **Figure B.5: … NZE/SDS**

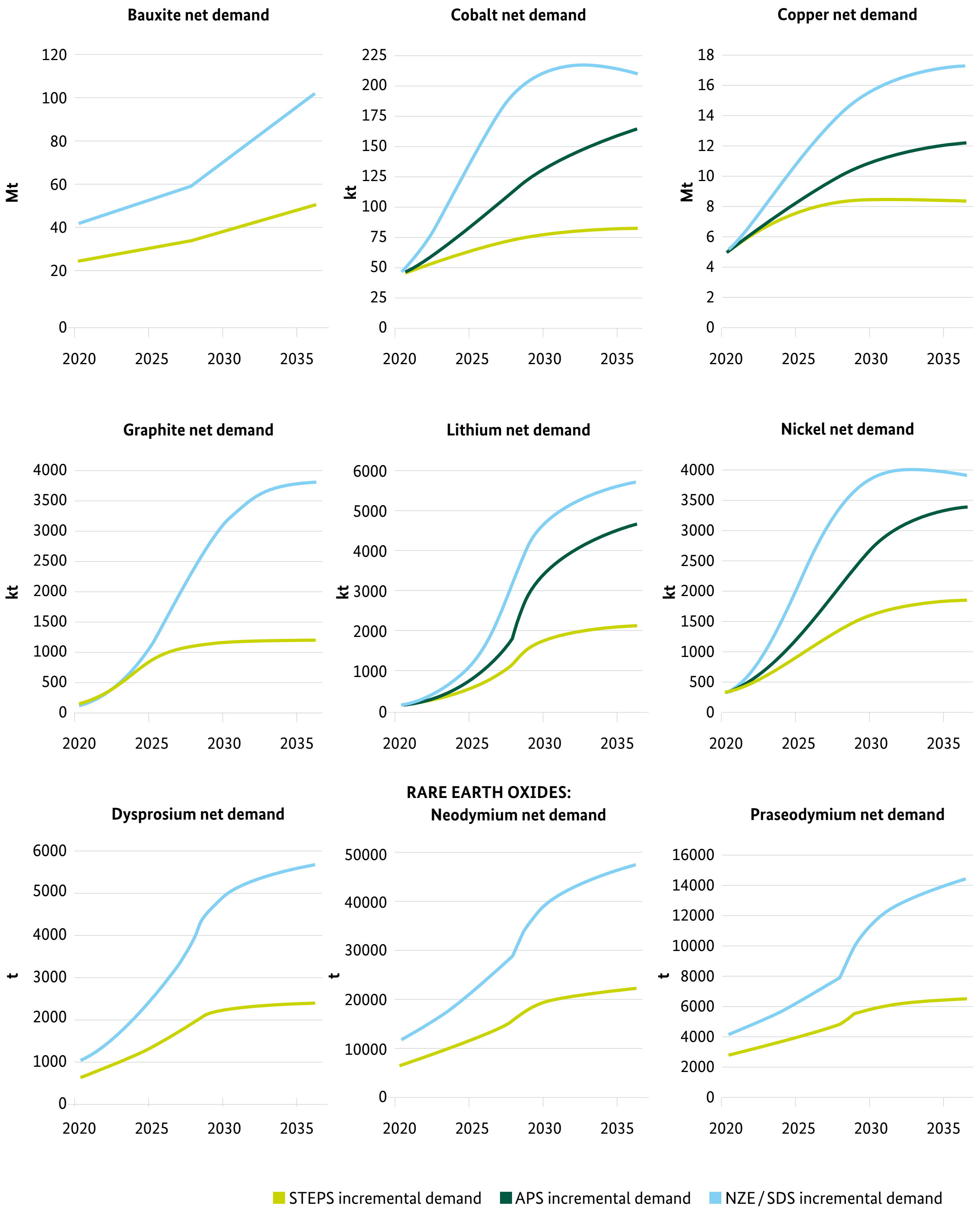


Source: Authors' own calculations based on IEA (2021), Kim (2022) and Gregoir and van Acker (2022).

Net demand from mining for each mineral is then estimated under STEPS, APS and NZE[18] by subtracting secondary supply from total demand (*Figure B.6*).

18 In the case of bauxite, graphite and REOs, NZE is replaced by SDS.

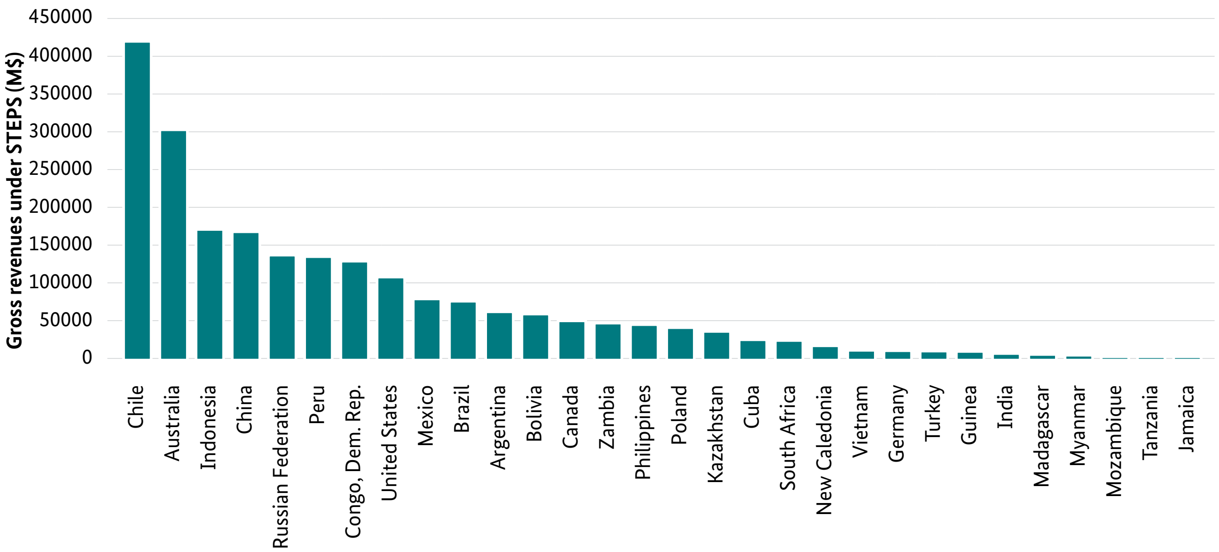
Figure B.6: Net demand from mining for each selected energy transition mineral under STEPS, APS and NZE/SDS



Source: Authors' own calculations based on IEA (2021).

We further disaggregate the primary supply/production estimates by country, for countries that are currently producing or have significant reserves according to USGS, of which there were 52 countries in total (see *Figure B.7*).[19] This calculation allows us to account for both the revenues from current levels of production and the potential future revenues from reserves. In practice, reserves will not come online immediately, as it will take time to for new deposits to get explored and developed to reach production. Conversely, currently producing mines become depleted. To account for this, we made a simplified assumption that reserves would come online incrementally over the forecasting period while production would phase out by the same rate.

Figure B.7: Countries with significant reserves and production of energy transition minerals and gross revenues over US$ 1bn under STEPS



Source: Authors' own analysis

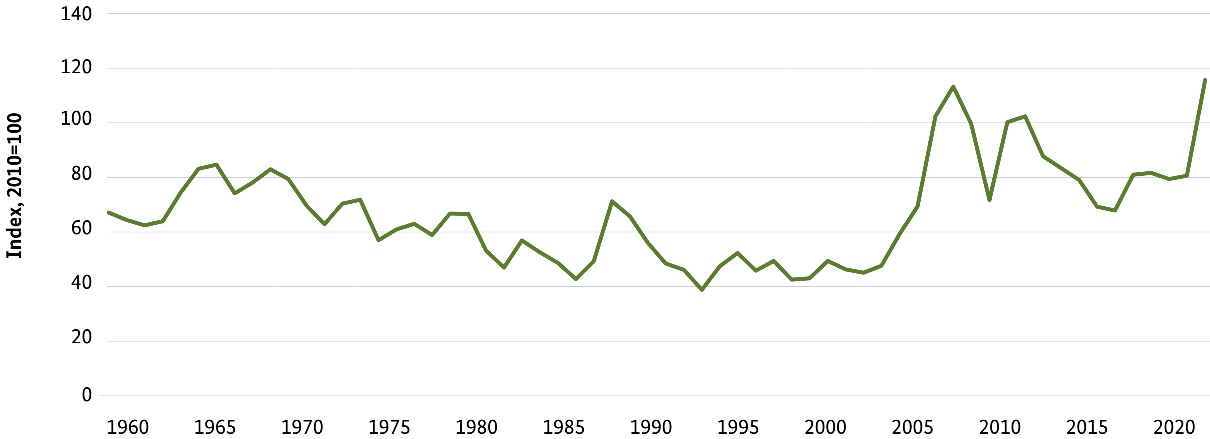
For countries that are currently producing and have significant reserves, this would mean that their current production share would get incrementally replaced by their reserve share. For countries that currently produce but do not have any significant reserves this means that their supply of energy transition minerals phases out over the forecasting period. On the other hand, for countries that have significant reserves but do not currently produce, their supply of that energy transition minerals will phase in incrementally over the forecasting period.

19 *If a country is currently producing "w" tonnes of an energy transition mineral and the total production of energy transition minerals is "x", we estimated that the country has a production share of "w/x %". If the same country has reserves of "y" tonnes and the total amount of estimated reserves for that critical mineral are "z", then we would assign a reserve share of "y/z" to that country.*

B.2. Mineral price forecasts

Mineral prices are volatile and difficult to forecast. Mining is a cyclical industry, with demand dependent on growth in key markets and sectors. There is usually a long lead-in time to increase supply, as it takes several years to develop a deposit through exploration and development into production. This can lead to periods of supply crunches with high mineral prices, which in turn induces new investments into supply that can later lead to an oversupply and periods of lower prices (see *Figure B.8*).

Figure B.8: Historical price index of metals and minerals



Source: World Bank (2022). Note: Annual index of metals and minerals prices in US Dollars, real terms (2010=100).

Past performance is not necessarily a good indicator of future mineral prices. For example, a backward-looking price assumption at the end of the last century would have proven wildly inaccurate as it would have failed to anticipate the commodity super-cycle in the first decade of the 20th century, largely driven by industrialisation in China. A backward-looking price assumption for this study may fail to anticipate an energy-transition led super-cycle for some energy transition minerals. We therefore use forward-looking price forecasts for each mineral as the starting point for estimating revenue potential from energy transition minerals. The main source for forward-looking price forecasts is Consensus Economics (2022), which polls investment banks and other economic commentators for their forecasts of mineral prices and then produces an average 'consensus' forecast. Consensus forecasts were not available for graphite and rare earth oxides. We instead use long-run price assumptions reported by mining companies in feasibility studies for the development of new graphite mines[20], and a forecast from Statista for rare earth oxides (Garside, 2021).

To reflect uncertainty in future mineral prices, we construct low- and high-price scenarios around the central price forecasts. These scenarios are a simple percentage deviation around the central price scenario, with the ranges for each mineral determined by the inter-quartile range of historical prices. For example, if the upper quartile was historically 10% higher than the median price historically, the high-price scenario is 10% above the central-price scenario. The price scenarios for each mineral are set out in *Figure B.1*.

20 One project in Madagascar (NextSource's Molo project) and four in North American (Northern Graphite, NOU, Focus and Mason).

Table B.1: Long-run price assumptions for each mineral

	Bauxite $/t	Cobalt $/t	Copper $/t	Graphite $/t	Lithium $/t	Nickel $/t	REOs: Dy / Nd / Pr $/kg
Low	22	48,673	7,112	1,525	10,713	16,026	340 / 44 / 52
Central	23	53,286	7,629	1,609	11,600	17,864	440 / 46 / 60
High	26	69,110	8,686	1,795	18,210	22,112	737 / 61 / 96

Note: Lithium price is for lithium carbonate; REOs = Rare Earth Oxides; Dy = Dysprosium; Nd = Neodymium; Pr = Praseodymium. Long-run Consensus Economics prices are in real terms and apply for the period 2027-31.

Source: Consensus Economics (2022), Gardside (2021), feasibility studies of 4 graphite mines, and authors' own calculations.

B.3. Mining company pre-tax profits

Most fiscal regimes in mining are profit-based, in that corporate income taxes, resource rent taxes, and withholding taxes on dividends are all levied on some measure of profits. Royalties can be either levied on sales value ('ad valorem') or on operating profits. To estimate revenue potential, we therefore first need to estimate the aggregate pre-tax profits of mining companies.

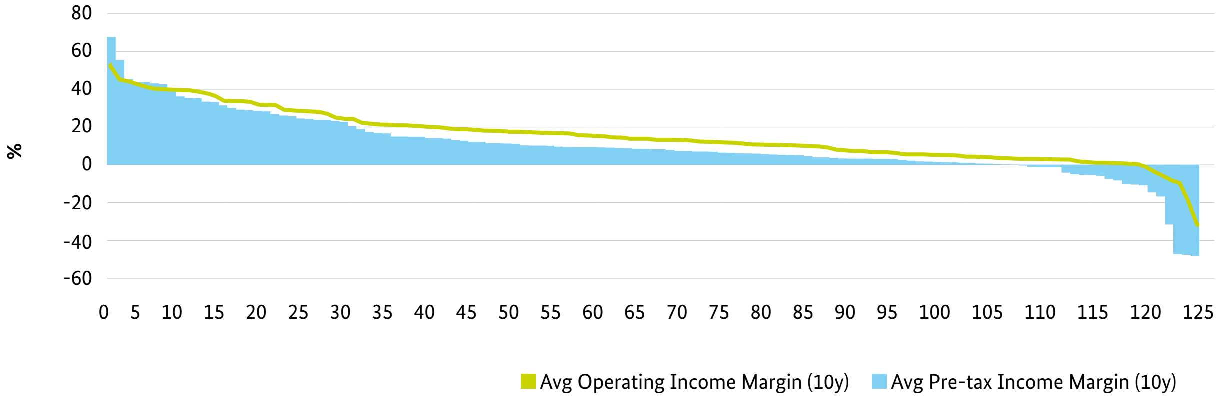
The profitability of individual mines can vary significantly, depending on the grade of the mineral resources, the size of capital investment, the methods of and challenges in mining and processing operations, and the costs of inland transportation and freight to export minerals. To estimate the aggregate profitability of mining companies, we used data on historical pre-tax profit margins as reported in financial statements and collated by Finbox (2022).

To focus on the most relevant firms in the Finbox dataset, we filtered by industry to 'Metals and Mining' and by revenues to show only companies with annual revenues above $750 million. This revenue threshold was selected to remove exploration companies (which do not generate revenues) and to broadly align to the threshold for large multinationals covered by the OECD proposals for a global minimum tax. This resulted in 392 companies in the initial dataset.

The 'Metals and Mining' industry includes companies that are not upstream mining companies, such as smelters and refineries, manufacturers of intermediate metal products (such as sheets, rods and pipes) and firms that provide services to the metals and minerals industry. As economic rents are usually captured at the upstream mining stage, these non-mining firms tend to have lower profit margins than mining companies. A series of keyword filters were therefore applied to remove companies likely to be non-mining companies, resulting in the exclusion of 139 companies. Finally, a manual filter was applied to exclude a further 122 companies that could be identified as being non-mining companies from internet searches. Companies that could be identified as having both upstream mining activities and some downstream processing into metals (but not into intermediate products) were included in the dataset, as we would expect some production of energy transition minerals to be undertaken by integrated mining and processing companies. This resulted in a dataset of 130 companies, from which 3 firms were excluded as the figures presented were likely to be statistical errors, leaving a final sample of 127 companies.

The distribution of average 10-year pre-tax income margins and operating margins for the 127 companies included in the analysis are set out in *Figure B.9*. Pre-tax income margins are typically lower than operating margins, reflecting the broader set of costs that are deducted in pre-tax income but below the line for operating incomes (such as debt interest costs). In a few instances, pre-tax income margins are higher than operating margins, most likely due to the inclusion of non-operating income in pre-tax income (such as interest received on loans). Over the 10-year period between 2012 and 2021, the median pre-tax income margin was 8% and the mean 10%, while the median operating income margin was 14% and mean 16%.

Figure B.9: Distribution of 10-year average pre-tax and operating income margins for mining companies



Source: Finbox (2022), and authors' analysis.

The profitability of mining also varies over the economic cycle, with periods of high mineral prices correlated with higher revenues and vice versa. Usually, an increase in mineral prices is also correlated with price increases for other commodities, such as oil and gas, and therefore associated with an increase in mining and processing costs, which can be energy intensive. However, as other costs are not correlated to higher commodity prices, such as labour and some consumables used, revenues are usually more sensitive than operating costs to mineral price changes. This means overall, profit margins tend to increase with mineral prices, and vice versa (*Figure B.10*).

Figure B.10: Mining company profit margins and mineral prices

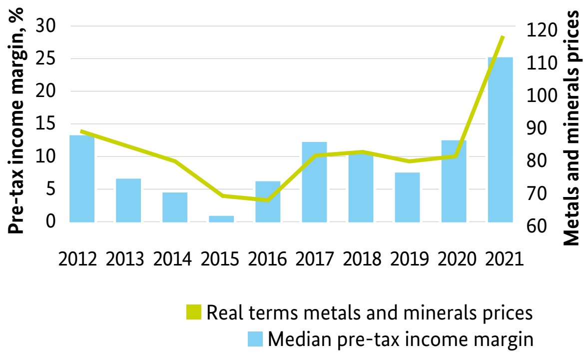
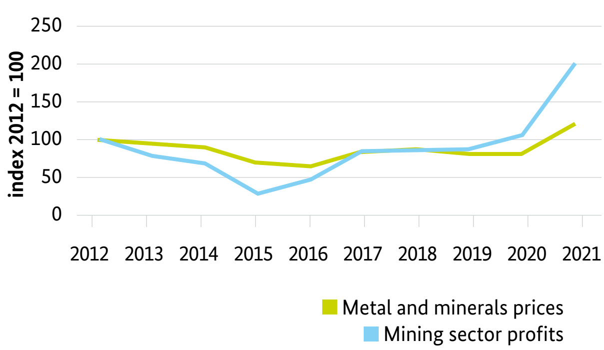


Figure B.11: Metals and minerals prices and mining sector profits, 2012 to 2021 (2012=100)



Source: World Bank (2022), Finbox (2022).

To account for the correlation between mineral prices and mining company profits, we increase (decrease) the profit assumption when we use the high (low) price scenario. Over the past ten years, mining company profits have been more volatile in percentage terms than mineral prices (see *Figure B.11*), with an 1ppt change in mineral prices corresponding to a 3.3ppt change in operating profits. We therefore apply a factor of 3.3 to the underlying price differential in the low and high scenarios to arrive at the corresponding profit assumptions. For example, if the high price scenario is 10% above the central price scenario, we assume profits are 33.3% above the central scenario.

B.4. Fiscal take assumptions

Globally, the majority of fiscal revenues from the mining sector are collected via royalties, corporate income tax and state participation (Albertin et al., 2021). For the fiscal revenue forecasts, we therefore estimate revenues coming primarily from these three fiscal instruments.

There are 52 countries that currently produce or have significant reserves of energy transition minerals. 28 out of these 52 are 'focus producers', as they are forecast to have more than 1 billion USD in gross revenues under the STEPS scenario or are case study countries. For these focus producers, we conducted detailed research on each country's fiscal regime. For the remaining 24 countries, we assumed a simplified tax regime representing the average royalty and corporate income tax rate of the 28 focus producers.

For royalties we differentiate between ad valorem royalties with a fixed rate or varying rate and royalties that are charged on operating profits. Out of the 28 focus producers we identified:

- 20 countries that have an ad valorem royalty with a fixed rate (see *Table B.2*).
- 1 country (Zambia) that has an ad valorem royalty with a rate varying by the price of a critical mineral produced (in this case copper) (see *Figure B.12*).
- 1 country that has an ad valorem royalty with a rate varying by the operating margin (see *Figure B.13*).
- 1 country (Mexico) that charges a fixed rate royalty of 7.5% on earnings before interest and tax.
- 3 countries that have a royalty charged on operating profits where the rate varies according to the operating margin (see *Table B.3* and *Figure B.14*).
- 1 country (Jamaica) that charges a unit-based royalty of $0.5 per tonne of bauxite mined (Crawford et al., 2020).

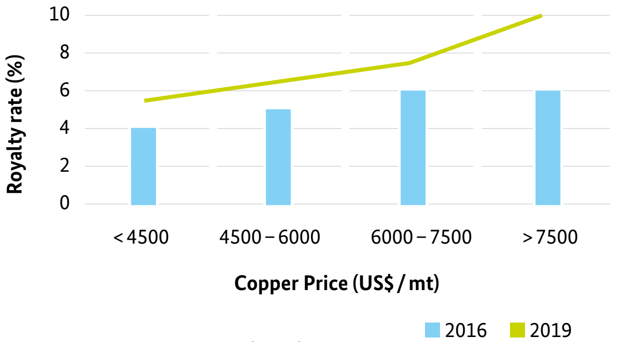
For six focus producers we had to make simplifying assumptions due to a lack of data (China, Cuba, New Caledonia, Indonesia) or complexity of the royalty regime (Poland, Canada). For China we assume an average ad valorem fixed royalty rate of 2.25% although according to a publication by PWC the rate should vary between 0.5% and 4% according to the "sales revenue of mineral exploitation-recycle ratio" (PWC, 2012). For Cuba and New Caledonia, we could not access information on the current mining royalty regime and therefore also assumed a simplified ad valorem fixed royalty based on the countries for which we could access data. In the case of Poland "the complexity of the system is such that translating it to a simple percentage is difficult and the country uses a mix between volume based, value based and profit-based royalty systems" (Ericsson et al., 2020). For this reason, we also applied a simplified regime in the case of Poland. Canada applies a royalty on operating profits whereby the rate varies between 5% and 16% depending on the operating profit margin and the province (PWC, 2012). Because of this complexity we assume that an average rate of 10% applies on the operating profits of energy transition minerals extracted in Canada. Finally, the USA is one of the only countries in the world in which sub-soil mineral wealth is not the property of the state and therefore no royalties are charged.

Table B.2: Ad Valorem royalties with fixed rates for selected countries with confirmed energy transition mineral reserves

Rate	Bauxite	Cobalt	Copper	Graphite	Lithium	Nickel	REOs
< 1.0 %	Guinea						
1.00 %							
2.00 %	Indonesia (alumina)	Indonesia, Madagascar, Philippines	Brazil	Madagascar		Indonesia (battery grade nickel), Philippines	Burundi, Madagascar, Myanmar
3.00 %	Australia, India	Australia, India	Australia, India	India, Mozambique	Australia, Bolivia, India	Australia, India	Australia, India
3.50 %	Turkey		DRC	Turkey			
4.00 %	Russia (assumed average rate)	Russia (assumed average rate)	Indonesia (copper con-centrate), India, Russia (assumed average rate)			Russia (assumed average rate)	Russia (assumed average rate)
5.00 %						Indonesia (pig iron)	
5.70 %	Kazakhstan (assumed to be the same rate as for copper)		Kazakhstan				
6.00 %				Tanzania			Tanzania
7.00 %	Indonesia (bauxite)						
7.50 %					Argentina (com-bined rate at the federal and regional level)		
8.00 %		Zambia					
9.00 %							
10.00 %	Vietnam	DRC		Vietnam	DRC, Germany		Vietnam

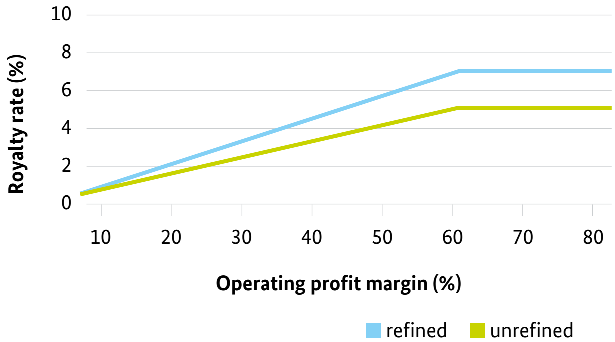
Note: This table includes all countries that are forecast to have more than 1 billion USD in gross revenues under the STEPS scenario, as well as case study countries.
Sources: PWC (2012 and 2022a), NRGI (2022), FERDI (2020), FERDI (2020), Shamsiev (2022), Massmann (2015); Fleming and Manley (2022), Bnamericas (2021), Somay (2021).

Figure B.12: Ad Valorem with tax varying by price – the case of the copper royalty in Zambia



Source: Mkokweza (2019).

Figure B.13: Ad valorem royalty with tax rate varying by operating profits – the case of South Africa



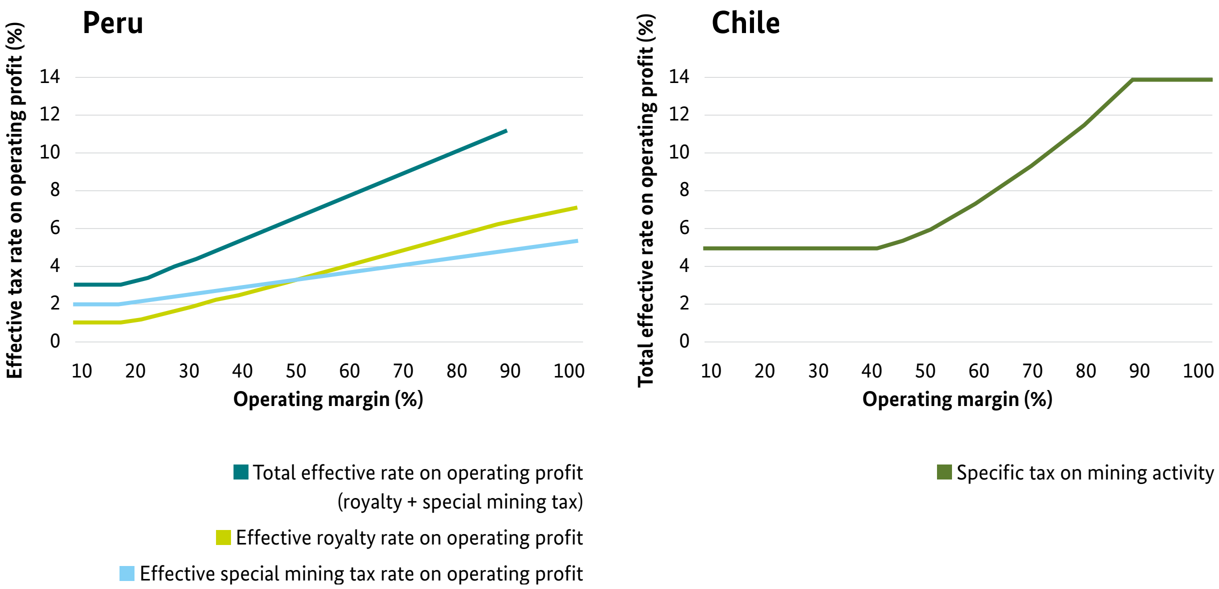
Source: Fleming and Manley (2022).

Table B.3: Royalties based on operating profits

Rate range	Country
5 % – 16 %	Canada
5 % – 14 %	Chile
1 % – 13.12 %	Peru

Note: Canada, Chile and Peru are the three focus producers that have sliding scale royalties based on operating profits.
Source: Fleming and Manley (2022), PWC (2012).

Figure B.14: Effective royalty rates in Peru and Chile



Source: Fleming and Manley (2022).

With respect to the corporate income tax rate forecast, we applied the individual headline corporate income tax rates to the estimated pre-tax profits. As for the royalty regime, we applied the country-specific corporate income tax rates for the 28 leading producers and case study countries. For the remaining 24 countries, we assumed that the corporate income tax rate would be 28% based on the average of the 28 countries. (See a detailed list of countries with corporate income tax rates below.) Due to a lack of data, we also assume the average corporate income tax rates for New Caledonia and Cuba.

Table B.4: Corporate income tax rates for focus producers and case study countries

Statutory rate	Countries
13.00 %	Canada
19.00 %	Poland
20.00 %	Kazakhstan, Russia, Turkey
20.50 %	Germany, Madagascar
23.50 %	Indonesia
25.00 %	Bolivia, Chile, China, Jamaica
28.00 %	Australia
29.50 %	Peru (without stabilisation agreement)
30.00 %	Argentina, Australia, Burundi, Guinea, Mexico, Myanmar, Philippines, DRC, Tanzania, Zambia
31.50 %	Peru (with stabilisation agreement)
32.00 %	Mozambique
34.40 %	Brazil
35.00 %	USA
40.00 %	India (CIT rate on foreign companies with income above 1.2 million USD)
50.00 %	Vietnam

Source: PWC (2012 and 2022b).

Finally, we estimated revenues from a state participation in the form of an equity share or a state-owned mining company operating a mine or entering in a joint-venture with a private operator. We estimated after-tax profits by deducting estimated corporate income tax from pre-tax profits. For countries with a state-equity share or state-owned mining company, a respective share of the post-tax revenue was added to government revenues from royalties and corporate income tax. We identified that 3 out of the 28 countries had a state equity share, 2 of which had a free equity share and the third a negotiable equity share. Further, we identified two countries with state-owned mining companies involved in the production of energy transition minerals. Codelco produces currently 31.30 % of copper in Chile and is ramping up the entry into the lithium sector (Odendaal and Dolo, 2020; Miranda, 2022). For this reason, we assume that

31.30% of post-tax revenues of all energy transition minerals produced in Chile will be collected via the state-owned company. In China, critical mineral production is assumed to be entirely run via state-owned mining companies.

Table B.5: State participation in the production of energy transition minerals

State participation assumption	Country
31.3 % of copper currently produced by state-owned enterprise Codelco. Due to reports that Codelco will enter the lithium market, we assume the same 31.3 % will be produced by the state for all energy transition minerals in Chile.	Chile
100% mine production from state-owned enterprises	China
10% free equity share	DRC
15% free equity share	Guinea
Free or negotiable equity share. We assume an average 10 % free equity share.	Tanzania

Source: FERDI (2020), Odendaal and Dolo (2020).

B.5. Methodological limitations

The future is uncertain and so are all the projections of the variables that go into the estimation of the revenue potential from energy transition minerals. For each of the variables we had to make simplifying assumptions, both due to uncertainty of future developments and due to a lack of data.

1. **Uncertainty around demand and secondary supply forecasts**
   We had to make simplifying assumptions to estimate primary production for each mineral in each country. Our methodology estimates primary production based on net demand (demand for energy transition minerals less secondary supply), and the current production and reserve share for each mineral by country. We rely on demand estimates from the IEA (2021) and Gregoir and van Acker (2022). While both studies are internationally recognised, the estimates are understandably subject to a high level of uncertainty. We do not have access to the underlying data and therefore cannot assure the quality of these estimates ourselves.
2. **Difficulty accounting for supply constraints**
   We make a generalising assumption that net demand can be met from mining, without factoring in the lead time for new projects to come on stream. We assume that reserves come online gradually and current production phases out gradually. In reality, known reserves and potential mining projects are at different stages of development in each country. Current production levels will decrease differently over time depending on the age of different projects and remaining reserves. Ideally, one would want to take into account these supply constraints in more detail, for instance, by using granular data on the primary production potential for each country. In fact, the study by Gregoir and van Acker (2022) used such granular data from the McKinsey MineSights service, a subscription service to which the authors of this paper did not have access. Even with our simplified approach, we gain valuable insights – for instance, that the revenue potential for Sub-Saharan Africa is constrained by a lack of new known reserves that could replace the depletion of existing ones.

3. **Uncertainty around price forecasts and costs**
   Except for REOs, central price forecasts are only available to us up to 2027. Beyond that date, we assume that long-term prices are static. While it is difficult to forecast future mineral prices, we would expect to see significant volatility in prices consistent with past experiences. We would also expect mineral prices to respond to supply constraints, rising at certain points where global demand cannot be met, and falling in years where there is an oversupply. Similarly for operating costs in mining, we would expect to see some correlation with prices and for this to have an impact on pre-tax profit margins.
   We account for the uncertainty of future prices by considering different price scenarios for each production scenario. The true profitability of a mining project, however, depends on the costs of producing and extracting the mineral. We account for this by using historical data on profit margins across the mining sector and creating different profit margin scenarios based on historical variations. In reality, profit margins vary for each project, mineral and country. However, there is no publicly available database of such granularity and we therefore had to simplify this measure.

4. **Difficulty to model all potential government revenue streams**
   We had to simplify the estimation of the revenue potential for each country by focusing on royalties, corporate income taxes and state participation only. As outlined in the section on fiscal regimes, there are a variety of other tax instruments at the disposal of governments, such as withholding taxes on interests and services, and resource rent taxes. The calculation of these taxes depends on specific cost figures for individual mines which we did not have access to.

5. **Difficulty accounting for differences in tax bases**
   The detailed royalty and tax base for each of the fiscal instruments that we consider varies from one country to another. For instance, ad valorem royalties are charged on the sales value of the mineral which we assume to be equal to the gross value of the minerals exported (production forecast times the price forecast). However, we had to disregard deductions for transport, treatment, refining and the quality of the exported product that are allowable under some fiscal regimes. To estimate the corporate income tax base in each country we derived pre-tax profits using industry profit margins. We were unable to account for differences in allowable deductions according to the individual fiscal regimes for each country. Instead, we made the simplified assumption that differences in the allowable deductions are broadly accounted for in the defined pre-tax margins derived from data of companies in different jurisdictions at various stages of production and development. Finally, with respect to state participation, we were unable to account for the cost contributions by countries that receive money from the extraction of energy transition minerals either via a state-owned mining company or full equity share.

6. **Difficulty accounting for countries' capacities to administer tax regimes**
   The revenue potential for each country strongly depends on its capacity to implement its chosen tax regime to collect the prescribed taxes and minimise BEPS risks. Due to a lack of capacity in many low-income countries, governments are often unable to collect more complex profit-based taxes, such as corporate income tax (Readhead, 2017). Due to a lack of data in this area, we were unable to account for this fact and our estimates do not take into account differences in the revenue collection capacity between different countries and regions. We therefore assume that each prescribed fiscal regime is implemented in line with the law.

PUBLISHED BY
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices:
Bonn and Eschborn, Germany

PROJECT:
Sector Programme Extractives and Development
Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany

T +49 228 44 60-0
F +49 228 44 60-17 66
E rohstoffe@giz.de
I www.rue.bmz.de

AUTHOR
This report was written by Konstantin Born, Stefanie Heerwig and Iain Steel (Econias).

The study team would like to thank Tae-Yoon Kim, Energy Analyst at the International Energy Agency (IEA) for meeting with the team to discuss the IEA's work on critical minerals and for sharing updated critical mineral demand projections.

On behalf of
German Federal Ministry for Economic Copperation and Development (BMZ)

DESIGN / LAYOUT
Atelier Löwentor, Darmstadt, Germany

PRINTED BY
Braun & Sohn, Maintal, Germany
Printed on 100% recycled paper, certified to FSC standards.

AS AT
April 2023