NET ZERO ROADMAP TO 2050
For Copper & Nickel Mining Value Chains
As a development finance institution, IFC is committed to climate action and the sustainable development of critical minerals in emerging markets. We support our clients in their decarbonization journeys by catalyzing investment in low-carbon technologies, using green and sustainability-linked financing, mobilizing private capital, and co-sponsoring research, as well as by working in partnership with the public and private sector.

To meet the Paris Agreement’s goal of limiting global warming to 1.5°C, the world needs to rapidly transition towards a low-carbon economy. This transition is reliant on mining minerals and metals such as copper and nickel, which are critical inputs to clean energy technologies, from electric vehicles to renewable energy sources like wind and solar and for energy transmission and storage.

Nickel and copper are among at least 17 minerals and metals requiring significantly expanded production to meet net zero emissions goals by 2050. And herein lies the challenge: There are significant greenhouse gas (GHG) emissions associated with mining these critical minerals today. To achieve net zero on a global basis by 2050 or sooner, the mining sector must find ways to meet the exponentially growing demand for these critical minerals while operating on a net zero basis itself.

To this end, the industry’s net zero commitments must: include credible, science-based plans, with interim targets on scope 1, 2, and material scope 3 GHG emissions; lay out technological deployment pathways and associated resourcing; support positive social and environmental outcomes; build community and supply chain resilience; ensure a just transition; and be intentional about collaboration. Scaling the existing and emerging technology solutions at the necessary rate will require extensive collaboration across the mineral value chain. Positive examples of such collaboration with upstream and downstream suppliers and customers are described in this roadmap.

On behalf of the World Bank Group’s Climate Smart Mining (CSM) initiative, I am pleased to bring you IFC’s net zero roadmap for copper and nickel value chains. This document was developed in partnership with the Carbon Trust, Rocky Mountain Institute (RMI), the Colorado School of Mines, and the Columbia Center on Sustainable Investment at Columbia University. We hope that this resource will support mining companies in building their decarbonization action plans and encourage continued collaboration among industry players, policymakers, communities and sustainable finance investors to ensure the metals and minerals for green technologies are supplied in a resilient, equitable, and sustainable manner.
ACKNOWLEDGEMENTS

The *Net Zero Roadmap for Copper and Nickel Mining* was prepared by International Finance Corporation (IFC) as part of the World Bank Group’s Climate Smart Mining Initiative.

We thank the project’s steering committee and technical working group members for their input, diligent reviews, and support spanning the 12 months of development, and the many subject experts that were interviewed and assisted with peer reviews. These contributors are listed at the back of this report.

The roadmap was coordinated by IFC (Arjun Bhalla, Krishna Matturi, Ross Hamilton). The analysis and development of the roadmap were undertaken by the Carbon Trust (Paul Huggins, Christelle van Vuuren, Renata Lawton-Misra, Reinhardt Arp, Juliana Meng, Tim Mew, Zaira Renteria), RMI (Paolo Natali, Lachlan Wright, Alastaire Dick, Sravan Chalasani, Valentina Guido), The Payne Institute for Public Policy at the Colorado School of Mines (Jordy Lee), and Columbia Center on Sustainable Investment (Perrine Toledano, Martin Dietrich Brauch, Jack Arnold, Bryan Sherill, and Sarah Ahmad).

Further information and references supporting this Roadmap can be found in the *Net Zero Roadmap for Copper and Nickel Technical Report*. 

Sponsored by
- Government of the Netherlands
- AngloAmerican
- RioTinto

Prepared by
- Climate-Smart Mining
- IFC

Delivered by
- Carbon Trust
- ARMII
- RMI
- The Payne Institute for Public Policy
- Columbia Center on Sustainable Investment
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAU</td>
<td>Business-as-usual</td>
</tr>
<tr>
<td>BVCM</td>
<td>Beyond Value Chain Mitigation</td>
</tr>
<tr>
<td>CO$_2$e</td>
<td>Carbon dioxide equivalent</td>
</tr>
<tr>
<td>CSM</td>
<td>Climate Smart Mining Initiative</td>
</tr>
<tr>
<td>CSP</td>
<td>Concentrated Solar Power</td>
</tr>
<tr>
<td>ETMs</td>
<td>Energy transition metals</td>
</tr>
<tr>
<td>ICE</td>
<td>Internal Combustion Engine</td>
</tr>
<tr>
<td>ICMM</td>
<td>International Council on Mining and Metals</td>
</tr>
<tr>
<td>IFC</td>
<td>International Finance Corporation</td>
</tr>
<tr>
<td>IPPs</td>
<td>Independent Power Producers</td>
</tr>
<tr>
<td>MtCO$_2$e</td>
<td>Metric tons of carbon dioxide equivalent</td>
</tr>
<tr>
<td>MVR</td>
<td>Mechanical Vapor Compression</td>
</tr>
<tr>
<td>NDCs</td>
<td>Nationally Determined Contributions</td>
</tr>
<tr>
<td>NZCB</td>
<td>Net Zero carbon budget</td>
</tr>
<tr>
<td>RD&amp;D</td>
<td>Research Design and Development</td>
</tr>
<tr>
<td>RE</td>
<td>Renewable Energy</td>
</tr>
<tr>
<td>PPAs</td>
<td>Power Purchasing Agreements</td>
</tr>
<tr>
<td>WACC</td>
<td>Weighted Average Cost of Capital</td>
</tr>
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</table>
EXECUTIVE SUMMARY

The net zero roadmap for copper and nickel mining value chains is a solutions guide aimed at decarbonizing the mining of critical minerals. The roadmap addresses the greenhouse gas emissions (GHG) from mining and processing operations, outlining tangible decarbonization actions the industry can take to cut emissions by 90 percent and reach net-zero emissions goals by 2050. It offers a range of solutions, including renewable and low-carbon technologies, energy efficiency, and digitization. Designed to encourage cross-industry collaboration among mining value-chain companies, policymakers, and sustainable finance investors, the roadmap identifies ways to capture potential environmental and social benefits and highlights opportunities to invest in technology innovation. Copper and nickel mining value chains were used as test cases to explore the challenges and opportunities that will occur between now and 2050 as the global energy transition accelerates. The roadmap learnings are adaptable to other metals needed ensure a successful global energy transition.

Key Takeaways for CEOs

- **Demand for Energy Transition Metals (ETMs) doubles GHG emissions: to reach net zero, ETM emissions will need to reduce by 90%**.

- **Technological solutions are already or soon will be available: Three waves of technology deployment**: (i) Renewable energy, site operational energy efficiency improvements, and process optimization; (ii) zero-emissions haulage trucks; (iii) process heat electrification and green hydrogen.

- **Material ESG risks associated with rising ETM demand**: For example, many copper and nickel reserves are located in high water risk and high biodiversity areas respectively, necessitating proactive and responsible management.

- **Just Transition: mining companies, governments and other actors have an important role** in enabling communities to reimagine their future at the center of a new climate economy and in the process build community resilience.

- **Collaboration is key to achieving net zero**: Mining companies and value chain actors must work together to accelerate the development, deployment and co-investment in the technological innovations required for the mine of the future, and to develop net zero industry standards, regulations, and frameworks.
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INTRODUCTION

- Achieving net zero by 2050 requires **deep decarbonization** of the global energy sector.
- Transition towards renewable energy sources and low-carbon technologies (e.g., solar) is underway and will become the norm.
- Energy transition technologies are mineral intensive.
- Rapid energy technology change to decarbonize is inevitable, cost effective, and beneficial.
- Technology interventions are already or will be available within the next 10 years.
- Decarbonization of the mining sector should be **inclusive and just** to support regional resilience.
- Sustainable finance mechanisms support responsible climate action and risk mitigation while providing favorable rates.
- Policy, legal, and regulatory barriers can be addressed through engagement with governments.
- The roadmaps for copper and nickel aim to give mining companies a framework to decarbonize their value chains and plan for climate action.
ENERGY-TRANSITION METALS
Keys to Low-Carbon Future
ENERGY-TRANSITION TECHNOLOGIES ARE MINERAL-INTENSIVE

17 minerals and metals will require significantly expanded production to meet global net zero emissions goals by 2050.

But without massive, transformative change, GHG emissions from scaled-up production will increase exponentially.

Mining value chains will need to reduce absolute emissions by ~90% from 2020 levels, and remove remaining emissions, to achieve net zero by 2050.

Mineral and metal production across all market segments is responsible for

~10% OF GLOBAL GHG EMISSIONS

All mining emissions today are equivalent to the global 2050 net zero carbon budget (NZCB)

Without ambitious action by 2030 the 1.5°C carbon budget will be exhausted

Some countries and customers are acting quickly to secure long-term supply of ETMs (e.g., ICE phase out, RE scale up)

Achieving mining’s NZCB of 0.5 GtCO2e will require dramatic transformation of energy use, equipment, processes, transport, and materials

WHY COPPER & NICKEL
Pathway to Net Zero Future
The Copper and Nickel Roadmap

**PAVES THE WAY**
for other ETMs and sector transitions for a low-carbon future

- Many low-carbon technologies use copper and nickel
- To meet demand, copper production will need to increase 230% and nickel production will need to triple by 2050
- Without decarbonization, GHG emissions from copper and metal production will double by 2050
- Nickel and copper production must be sustainable; 90% reduction in today’s GHG emissions level is needed
- Potential for long-lasting societal benefits and a priority for limiting negative environmental effects

**Cu** 85 to 8.5 MtCO2e/y  
**Ni** 88 to 8.8 MtCO2e/y
THE NET ZERO ROADMAP

guides a just transition to rapid, responsible, & scaled-up nickel and copper production

1.5°C-Aligned  Technology-Focused  Assessed for ESG Risks and Opportunities  Industry-Led
**NET ZERO ROADMAP EMISSIONS SCOPE**

includes majority of key emissions sources for metal production

- **SCOPE 1:** Purchased goods and services
- **SCOPE 2:** Fuel and energy related activities
- **SCOPE 3:** Upstream transportation
- **SCOPE 4:** Downstream transportation and distribution
- **SCOPE 10:** Processing of sold products if the company sells intermediate products e.g., concentrate

Cradle-to-gate boundary—corresponding to typical mining company's emissions scopes—includes all emissions from fuel, electricity, and purchased goods

*Only material categories were included for Scope 3 emissions*
By 2050 copper supply needs to match **230%+ INCREASE IN DEMAND**

Global Copper Demand (Mt/y)

<table>
<thead>
<tr>
<th>Year</th>
<th>Organic</th>
<th>Renewable Energy and Transmission</th>
<th>EV Batteries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021</td>
<td>0.9</td>
<td>23.8</td>
<td>6.9</td>
<td>30.6</td>
</tr>
<tr>
<td>2030</td>
<td>11.7</td>
<td>37.7</td>
<td>6.9</td>
<td>56.3</td>
</tr>
<tr>
<td>2040</td>
<td>14.6</td>
<td>43.8</td>
<td>11.7</td>
<td>69.1</td>
</tr>
</tbody>
</table>
| 2050 | 2.3x growth +3.0%/year

Global Copper Supply (Mt/y)

<table>
<thead>
<tr>
<th>Year</th>
<th>Primary</th>
<th>Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021</td>
<td>8.4</td>
<td>21.6</td>
</tr>
<tr>
<td>2030</td>
<td>11.5</td>
<td>34.0</td>
</tr>
<tr>
<td>2040</td>
<td>20.1</td>
<td>39.0</td>
</tr>
<tr>
<td>2050</td>
<td>27.4</td>
<td>40.6</td>
</tr>
</tbody>
</table>

Source: RMI stock and flow analysis based on Glöser, et. al (2013) and using growth rates for 11 key clean energy technologies from the IEA Net Zero Emissions scenario
Without decarbonization, GHG emissions from copper production WILL MORE THAN DOUBLE BY 2050.

**BAU Global Primary Copper Production Emissions (MtCO₂e/y)**

- 2021: 92
- 2030: 121
- 2040: 150
- 2050: 192

**Annual Change in Emissions**

- **Net Zero vs. BAU scenarios (%):**
  - Net zero target: NA
  - BAU increase without decarbonization: 2.6%
  - Emissions from new mines:
    - 2021: 92
    - 2030: 121
    - 2040: 150
    - 2050: 192

1 year delay in decarbonizing ≈ ~10% year-on-year deviation away from Net Zero, requiring larger capital allocation later.
Copper production emissions are **PRIMARILY CAUSED BY ENERGY USE**

- **Carbon Footprint**
  - Copper Oxide Heap Leach: 4.3 tCO$_2$/t Cu
  - Copper Sulphide Underground: 3.7 tCO$_2$/t Cu
  - Copper Sulphide Open Pit: 4.2 tCO$_2$/t Cu

**Footprint Boundary**
- Mining
- Milling
- Smelter
- Refinery

**Input Materials/Reagents (Scope 3)**
- Fossil Fuel Use (Scope 1)
- Electricity Use (Scope 2)

*Note: excludes transportation emissions*
As copper mining expands, emissions from land-use change WILL RISE THREEFOLD

ANNUAL EMISSIONS

- 2020: 0.3 MtCO$_2$e
- 2030: 0.6 MtCO$_2$e
- 2050: 1.1 MtCO$_2$e

Cumulative emissions 2020–2050 ~22.7 MtCO$_2$e

TO ACHIEVE NET ZERO we must reduce GHG emissions from copper production by >90% from today’s levels.

![Net Zero Global Primary Copper Production Emissions (MtCO₂e/y)](chart.png)

- **New mines** (100 MtCO₂e/y in 2050 BAU, 95% reduction to <9 MtCO₂e/y in 2050 Net Zero)
- **Existing mines** (92 MtCO₂e/y in 2050 BAU, 90% reduction to <9 MtCO₂e/y in 2050 Net Zero)

Emissions compatible with a 1.5°C trajectory.
Doubling copper supply will significantly
INCREASE COMPETITION FOR WATER

33% of copper reserves are in high water-risk countries

SOLUTION**
Adopt a water stewardship approach to address water challenges and build trust**


*Water Risk is based on “water scarcity,” which refers to the physical abundance or lack of freshwater resources, which significantly impact business.
**For practical guidance: IFC Performance Standards and ICMM Environmental Resilience.
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THE NICKEL VALUE CHAIN

Net Zero Challenges
NICKEL DEMAND WILL TRIPLE BY 2050
recycled sources become the dominant supply route

**Global Nickel Demand (Mt/y)**

- 2021: 3.6
- 2030: 4.8
- 2040: 6.2
- 2050: 7.7

**Global Nickel Supply (Mt/y)**

- 2021: 0.2
- 2030: 1.6
- 2040: 2.8
- 2050: 3.5

- **Organic**: Before fabrication loss
- **Renewable Energy**: 4.3x growth +5.1%/year
- **EV Batteries**: 3x growth +3.8%/year
- **High Ni Battery Scenario**: 4.3x growth +5.1%/year

**Notes**

- Primary supply ~doubles
- Recycled ~quintuples
Without decarbonization, GHG emissions from nickel production WILL NEARLY DOUBLE BY 2050

**Annual Change in Emissions**

**Net Zero vs. BAU scenarios (%)**

- **Net Zero Target**: -7.6%
- **BAU increase without decarbonization**: 2.2%

1 year delay ≡ ~10% year-on-year deviation away from Net Zero outcome requiring larger capital allocation later
Most nickel production emissions are caused by energy use including heat. The nickel value chain includes:

- Class 1 via Sulphide Smelter: 12 tCO₂/t Ni
- Class 1 via High Pressure Leach: 28 tCO₂/t Ni
- Class 2 via Rotary Kiln – Electric Furnace: 43 tCO₂/t Ni
- Class 2 as Nickel Pig Iron (NPI): 78 tCO₂/t Ni

Note: excludes transportation emissions.
As nickel mining increases, emissions from land-use change WILL RISE FIVEFOLD

Land-Use Change GHG Emissions From Increased Nickel Mining


TO ACHIEVE NET ZERO, we must reduce GHG emissions from nickel production by >90% from today’s levels.
Tripling nickel supply will require

**PROACTIVE MITIGATION OF BIODIVERSITY RISK**

75% of nickel reserves are in high biodiversity countries

**SOLUTION***
The mitigation hierarchy presents a best practice approach for addressing biodiversity impacts.

*Biodiversity Index is based on species richness adjusted to country area (Source: [Convention on Biological Diversity](https://www.cbd.int/gbo1/annex.shtml#note1).)*

*For practical guidance: IFC Performance Standard 6 and ICMM Mitigation Hierarchy.*

ADDRESSING THE CHALLENGES

Transition to Net Zero Mines for a Low-Carbon Future
A NET ZERO MINE uses low-carbon technology, collaborates across value chains, and leads in delivering additional, net-positive environmental and social outcomes.

<table>
<thead>
<tr>
<th>Key attributes of a sustainable Net Zero mine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monitors, measures and reports its Scope 1, 2 and 3 emissions</td>
</tr>
<tr>
<td>2. Has developed a Net Zero strategy that has interim targets and is appropriately resourced</td>
</tr>
<tr>
<td>3. Implements technologies to reduce ~90% of current emissions</td>
</tr>
<tr>
<td>4. Has an effective residual emissions management plan</td>
</tr>
<tr>
<td>5. Avoids and minimizes adverse land-use change, biodiversity impacts, social impacts, and other ESG risks</td>
</tr>
<tr>
<td>6. Ensures good governance that enables a just transition</td>
</tr>
<tr>
<td>7. Collaborates with local and global stakeholders to realize a 1.5°C world</td>
</tr>
<tr>
<td>8. Ensures a planned closure of the mine when exhausted, creating shared value with the community in the future</td>
</tr>
</tbody>
</table>
## Technology Readiness

<table>
<thead>
<tr>
<th>Technology</th>
<th>Technology Readiness</th>
<th>Cost</th>
<th>Available at Scale</th>
<th>Emissions Abatement Potential</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient Equipment</td>
<td></td>
<td></td>
<td>Now</td>
<td>5-10%</td>
<td>Best-in-class motors, variable speed drives</td>
</tr>
<tr>
<td>Process Optimization</td>
<td></td>
<td></td>
<td>&lt;5 years</td>
<td>10-20%</td>
<td>Mine-to-mill, high-intensity selective blasting, coarse ore flotation &amp; ore sorting</td>
</tr>
<tr>
<td>Digitization &amp; Automation</td>
<td></td>
<td></td>
<td>&lt;5 years</td>
<td>5-10%</td>
<td>Haul truck automation to reduce fuel use</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td></td>
<td></td>
<td>Now</td>
<td>70-100%</td>
<td>On-site RE hybridized with diesel can provide 70% emissions reduction</td>
</tr>
<tr>
<td>Energy Storage</td>
<td></td>
<td></td>
<td>&lt;5 years</td>
<td>100%</td>
<td>Enables complete RE penetration. Mines have unique storage options (compressed/liquid air)</td>
</tr>
<tr>
<td>Sustainable Biofuels</td>
<td></td>
<td></td>
<td>Now</td>
<td>30-70%</td>
<td>Even without blending ~30% of emissions remain, typical 20%–30% premium</td>
</tr>
<tr>
<td>Green Hydrogen</td>
<td></td>
<td></td>
<td>5–10 years</td>
<td>100%</td>
<td>Used in large haul truck or for high temperature heat. <em>May have indirect global warming impacts</em></td>
</tr>
<tr>
<td>Battery-Electric Vehicles</td>
<td></td>
<td></td>
<td>Underground: Now Open Pit: 5–10 years</td>
<td>100%</td>
<td>BEVs already used at underground mines. Larger BEVs for open pit mines in development.</td>
</tr>
<tr>
<td>Conveyors &amp; Trolley Assist</td>
<td></td>
<td></td>
<td>Now</td>
<td>30%</td>
<td>Mature, cost-competitive haulage electrification.</td>
</tr>
</tbody>
</table>

*Refers to scope 1 and 2 reductions with respect to the typical business-as-usual alternative*
RENEWABLE ENERGY COST DECLINES
Cost competitive with fossil alternatives

Onshore Wind
Offshore Wind
Solar

$/MWh


Gas combined cycle in 2021
Fossil fuel range in 2022

Cost decline 59%
Cost decline 61%
Cost decline 89%

EXAMPLES

Power Purchase Agreement
BHP signed RE PPAs for 6 TWh/y of electricity in 2021 for its Chilean copper operations, cancelling its previous coal-based PPAs.

Onsite Generation
Rio Tinto is installing a 34 MW solar facility at its new Gudai-Darri facility which will provide 65% of the mine’s average electricity demand.

Source: BNEF; Lazard
BATTERY & ELECTROLYZER COST DECLINES
Cost competitive haulage electrification before 2030

Batteries
- US$/kWh
- Cost decline 83%
- Equivalent TCO with $0.90/L diesel
- Forecast: 18% learning rate

Electrolyzers
- US$/kW
- Cost decline 56%
- Forecast: 13% learning rate

Source: BNEF; INET Oxford – TCO (total cost of ownership) analysis based on 290t haul truck with 2MWh battery, 3MW charging rate, 10,000-hour battery life and $60/MWh electricity.

EXAMPLES & INITIATIVES

Hydrogen Truck
Anglo American is testing a 2MW hydrogen-battery hybrid truck at its Mogalakwena mine in South Africa.

Battery Electric Truck
Glencore’s Onaping Depth mine is planning to use an all-electric underground fleet providing savings of 44% and 30% on mine ventilation and cooling.

Innovation Challenge
The Charge On Innovation Challenge brings together mining companies and equipment providers to develop solutions for in-haul fast charging to further drive down costs.
HEAT COST DECLINES WITH ELECTRICITY PRICE

High efficiency will be key to enable cost competitive electric heat

- **Heat Pumps/MVR**: Efficiency 300-500%
- **Electric Boilers**: Efficiency 95-99%
- **High Temp.**: Efficiency 60-90%

### Typical Natural Gas Price

- 

#### Heat Pumps/MVR

- Efficiency 300-500%
- 

#### Electric Boilers

- Efficiency 95-99%
- 

#### High Temp.

- Efficiency 60-90%
- 

### Variation due to Efficiency Range

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**MVR**

Alcoa is testing MVR at its Wagerup plant in Western Australia, which could reduce alumina refinery emissions by 70%.

**Green Hydrogen**

Aurubis is testing the use of green hydrogen to replace natural gas in anode furnaces at its copper smelter in Hamburg.


1 – Mechanical Vapor Recompression. 2 – High temperature options cover multiple technologies including induction furnace, electric arc furnace, resistance furnace, plasma technology and green H2 burners.
STAGED IMPLEMENTATION OF TECHNOLOGY
Will be needed to achieve net zero

Renewables Deployment
Solar PV, wind, batteries

Zero Emissions Haulage
Battery electric, green H₂ haul trucks

Process Heat Electrification
Heat pumps, MVR, plasma torches, green H₂

Removals to Offset Residual Emissions
Direct air capture, carbon mineralization, land-use

Operational Energy Efficiency
Best-in-class motors, heat recovery, automation, digital twins

Process Intensification
Mine-to-mill optimization, high-intensity selective blasting, bulk ore sorting, coarse particle flotation
Example:

NET ZERO COPPER PRODUCTION

Technology interventions to achieve net zero for a large (>20 Mtpa ore processed) sulphide open pit, remote (off-grid) copper mine supplying concentrate a short distance (via road) to a grid connected smelter and refinery.
Example:

NET ZERO CLASS 1 NICKEL PRODUCTION

Technology interventions to achieve net zero for a nickel laterite operation (~2 Mtpa feed) using high pressure acid leach to produce Class 1 nickel at a grid-connected mine site.

Note: ‘Solar PV Only’ refers to onsite solar with remaining power needs provided from the grid, percentage reductions refer to the total emissions footprint.
INVESTING IN DECARBONIZATION through Sustainable Finance
INVESTING IN DECARBONIZATION

SUSTAINABLE FINANCE
instruments can enable the technology deployment

2022 Sustainable Debt Market, Growth by Product Type (US$, billions)

Bonds
- 2022 YTD Issuance: $503 billion
- Green bonds: $306 billion
- Sustainability bonds: $84 billion
- Social bonds: $61 billion
- Sustainability-linked bonds: $52 billion

Loans
- 2022 YTD: $214 billion
- Green loans: $27 billion
- Sustainability-linked loans: $186 billion

Source: BNEF Sustainable finance database
SUSTAINABLE FINANCE PROVIDES INDEPENDENT VALIDATION of a company’s funded decarbonization activities; reduces perception of greenwashing

**Instrument**
- Sustainable bonds and loans (use of proceeds)
- Sustainability-linked bonds and loans (target-driven)
- Sustainable concessional/ blended finance
- Listed green equity

**Funding objective**
- Funding mature low-carbon technologies (e.g., RE, EE) where use of proceeds can be monitored
- Funding general corporate sustainability action meeting sustainability performance targets tied to debt pricing
- Suitable for smaller companies in developing countries or innovative technologies on the cusp of being commercial
- Funding general corporate sustainability interventions by large listed mining companies with mature sustainability strategies

**Examples**
- **SQM and Livent Corporation** each raised green bonds ($700M and $225M) to finance energy efficiency and transport electrification projects.
- **Anglo American** secured a $100M sustainability-linked loan from IFC; the first in the global mining sector to exclusively focus on social indicators.
- **Climate Investor One** provides early-stage project development, construction financing, and refinancing to renewable energy projects in developing countries ($850M budget in 2019).
- **Armadale Capital, Harvest Minerals Ltd, Tirupati Graphite Plc, Goldplat** are listed on the London Stock Exchange Green Economy Mark.

OPPORTUNITIES
for Environmental and Social Co-Benefits
Low-carbon technology interventions can deliver **ENVIRONMENTAL AND SOCIAL CO-BENEFITS**

### ENVIRONMENTAL CONSIDERATIONS

<table>
<thead>
<tr>
<th>Water management</th>
<th>Energy demand</th>
<th>Pollution</th>
<th>Biodiversity</th>
<th>Climate risk &amp; adaptation</th>
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</thead>
<tbody>
<tr>
<td>✅</td>
<td>✅</td>
<td>✅</td>
<td>✅</td>
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</tr>
</tbody>
</table>

- Energy efficiency: Operational efficiency
- Energy efficiency: Process optimization
- Automation & digitization
- Renewable energy (solar & wind)
- Energy storage (batteries)
- Sustainable biofuels
- Green hydrogen
- Trollies, BEVs, & conveyors

### SOCIAL CONSIDERATIONS

<table>
<thead>
<tr>
<th>Health &amp; Safety</th>
<th>Employment, livelihoods, &amp; decent work</th>
<th>Human rights, security, and inclusion</th>
<th>Community relationships</th>
</tr>
</thead>
<tbody>
<tr>
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- Potential co-benefits from deployment
- Uncertain due to competing risks and co-benefits
- Potential risks from deployment
- No or uncertain risk/co-benefit

**KEY**

*Sources: Carbon Trust analysis based on an extensive literature review and stakeholder engagements on each low-carbon technology intervention and their potential environmental and social risks and co-benefits.*
TO ACHIEVE NET ZERO
Hard to abate emissions need to be balanced using carbon removal offsets

2020 to ~2045

i. Prioritize absolute GHG emissions reductions in line with a 1.5°C trajectory

ii. Support "beyond value chain mitigation" while minimizing own emissions to help societal decarbonization occur more quickly

Beyond ~2045

iii. Neutralize residual, hard-to-abate emissions using high-quality carbon removal offsets

iv. Balance the Net Zero equation ~10% residual emissions = carbon removal offsets

*Note: IFC’s good practice recommendation is to pursue a 45% emission reduction by 2030 to limit global warming to 1.5°C. Delaying emission reductions means more aggressive annual emission reductions will be required post 2030 to achieve net zero by 2050*
A JUST MINING TRANSITION ENABLES communities to reimagine their future at the center of a new climate economy

The Just Energy Transition Framework for Company Action*

- **UNIVERSAL NET-ZERO ENERGY**
  Supporting universal access to energy and a net-zero emissions world.

- **WORKFORCE EVOLUTION**
  Evolving the energy workforce to support a low and zero carbon energy future.

- **COMMUNITY RESILIENCE**
  Building community resilience.

- **COLLABORATION & TRANSPARENCY**
  Fostering collaboration and transparency throughout the process.

Principles for a just mining transition

- Sustainable future for all
- Fair and decent work
- Workers’ rights and social dialogue
- Community led approach
- Social consensus and due participation
- Diversity and inclusion
- Collaboration and transparency

*Source: [https://www.inclusivecapitalism.com/](https://www.inclusivecapitalism.com/)
The net zero mining transition can be a **PLATFORM FOR DELIVERING A JUST TRANSITION**

**CASE STUDIES**

- **De Beers’ Accelerating Women Owned Micro-Enterprises (AWOME)**
  Provides mentoring, network, business, and life skills training, which in turn, creates new jobs, regular wages, and a wider range of businesses to help local communities to thrive.

- **Enel’s Global Framework Agreement**
  Enel agreed to a Global framework agreement with international unions and a just transition agreement with its Italian sector unions that includes apprenticeships to ensure knowledge transfer of competences from elderly to young workers; commitment to retention, retraining and redeployment, as opposed to retrenchment, particularly for workers at thermal plants; Early pension for older workers; and dedicated training for qualification and employability of workers.

- **Anglo Americans’ Sustainable Mining Plan, pillar two: Thriving Communities**
  The “Thriving Communities” pillar aims to build thriving communities with better health, education, and employment.

  They work with local governments, community leaders, and NGOs to contribute to community needs, from housing and infrastructure to healthcare, education and recreation.

---

1. De Beers’ AWOME program
2. Enel Global Framework Agreement
3. AA Sustainable Mining Plan
CALL TO ACTION
For Mining Companies to Achieve Net Zero & Deliver Shared Benefits
Rapid decarbonization requires a collaborative multi-stakeholder approach for ecosystem change aligned with best practice.
ENGAGE POLICYMAKERS
to address legal and regulatory barriers to mining decarbonization

Key Takeaways

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<tr>
<th>Policy &amp; Regulatory Environments</th>
<th>Energy Policy</th>
<th>Mining Legal Framework</th>
<th>Climate Change Policy</th>
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<tr>
<td>Smelting</td>
<td>Weak access to power purchasing agreements and independent power producers</td>
<td>Limited or no incentives to encourage energy efficiency or renewable energy use; and counterincentives</td>
<td>Weak nationally determined contributions and Net Zero commitments</td>
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</table>

Policy & Regulatory Environments
Copper and nickel mining
- Weak
- Moderately enabling
- Enabling

Smelting
- Copper
- Nickel

Unsupportive  Enabling

Sources: CCSI analysis based on an extensive literature review. For more information, please refer to the Net Zero Roadmap for Copper and Nickel Technical Report
7 STEPS TO GUIDE COMPANY’S ON THEIR NET ZERO PATHWAY

STEP 1: Understand your Scope 1, 2 & 3 emissions

STEP 2: Benchmark to harvest lessons from peers on their decarbonization approach

STEP 3: Apply an internal carbon price and other ESG criteria to inform investment decisions

STEP 4: Identify solutions to reduce emissions and enhance resilience

STEP 5: Set an ambitious net-zero goal with interim targets and a detailed plan

STEP 6: Engage your people and collaborate with other value chain actors

STEP 7: Transparently disclose progress, lessons learned and collaboration opportunities

CALL-TO-ACTION

2021 EMISSIONS

Cu | Ni
---|---
85 | 88

30%–45% EMISSIONS REDUCTION BY 2030

Cu | Ni
---|---
47 | 48.5

90% EMISSIONS REDUCTION TO ACHIEVE NET ZERO BY 2050 & BEYOND

Cu | Ni
---|---
8.5 | 8.8
We would like to thank the Roadmap’s steering committee and technical working group members for their continuous review, input, and support, and the subject experts that were interviewed and assisted with conducting peer reviews. They include:

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<tr>
<th>Steering Committee:</th>
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NET ZERO ROADMAP TO 2050
For Copper & Nickel Mining Value Chains

Thank You