NET ZERO ROADMAP TO 2050

For Copper & Nickel Mining Value Chains

International Finance Corporation
WORLD BANK GROUP
Creating Markets, Creating Opportunities

Climate-Smart Mining

CEO's guide to mining transition for an inclusive low-carbon future

FOREWORD

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.

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ACKNOWLEDGEMENTS

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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).

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COLORADO SCHOOL OF MINES EARTH • ENERGY • ENVIRONMENT

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

ACRONYMS & ABBREVIATIONS

BAU	Business-as-usual
BVCM	Beyond Value Chain Mitigation
CO_2e	Carbon dioxide equivalent
CSM	Climate Smart Mining Initiative
CSP	Concentrated Solar Power
ETMs	Energy transition metals
ICE	Internal Combustion Engine
ICMM	International Council on Mining and Metals
IFC	International Finance Corporation
IPPs	Independent Power Producers
$MtCO_2e$	Metric tons of carbon dioxide equivalent
MVR	Mechanical Vapor Compression
NDCs	Nationally Determined Contributions
NZCB	Net Zero carbon budget
RD&D	Research Design and Development
RE	Renewable Energy
PPAs	Power Purchasing Agreements
WACC	Weighted Average Cost of Capital

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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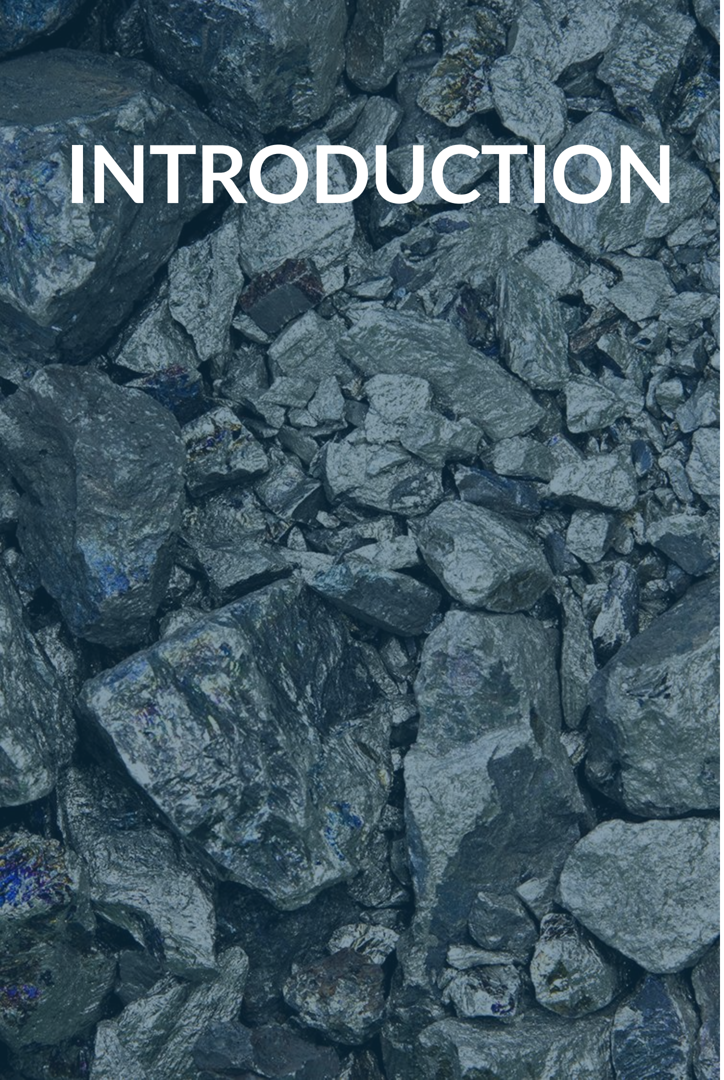
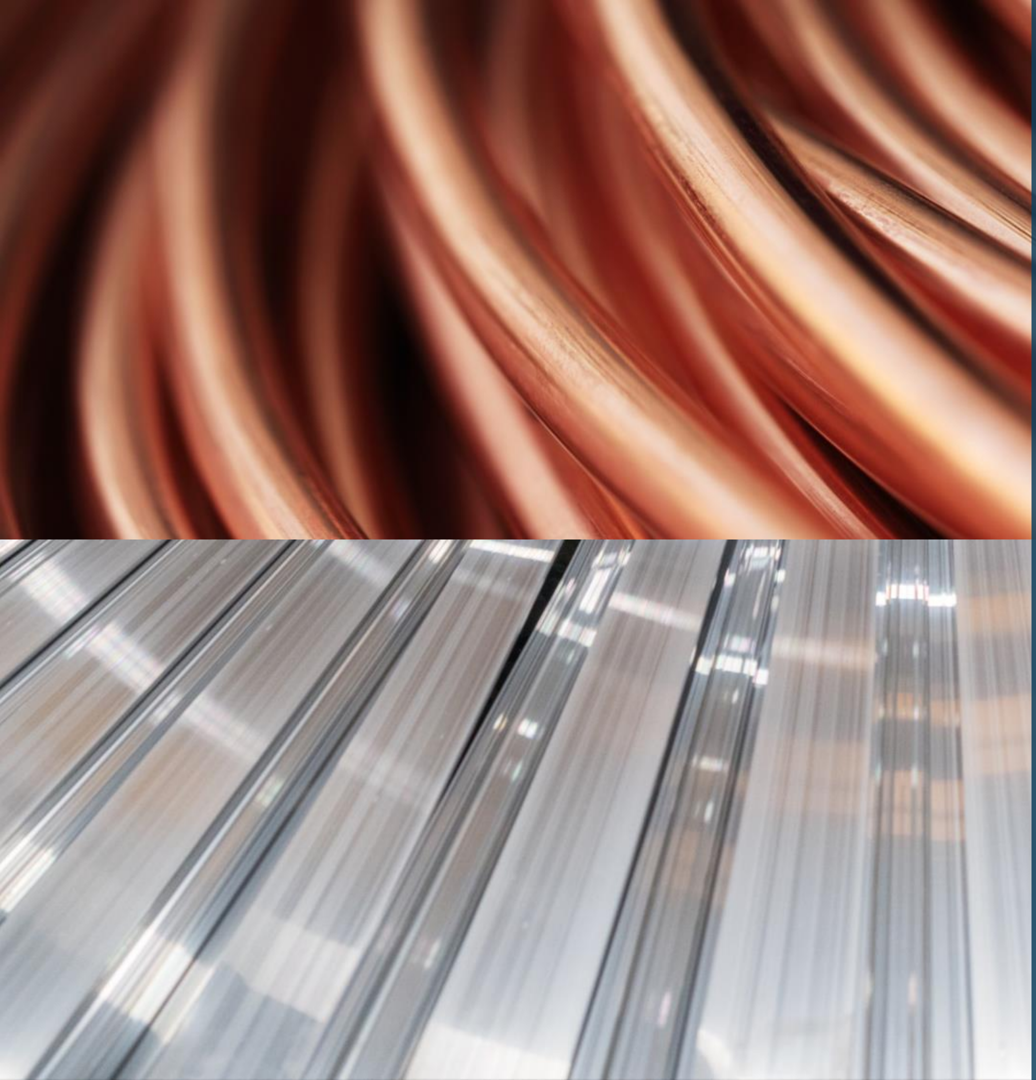


INTRODUCTION

- 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.



1

ENERGY-TRANSITION METALS

Keys to Low-Carbon Future

ENERGY-TRANSITION TECHNOLOGIES ARE MINERAL-INTENSIVE

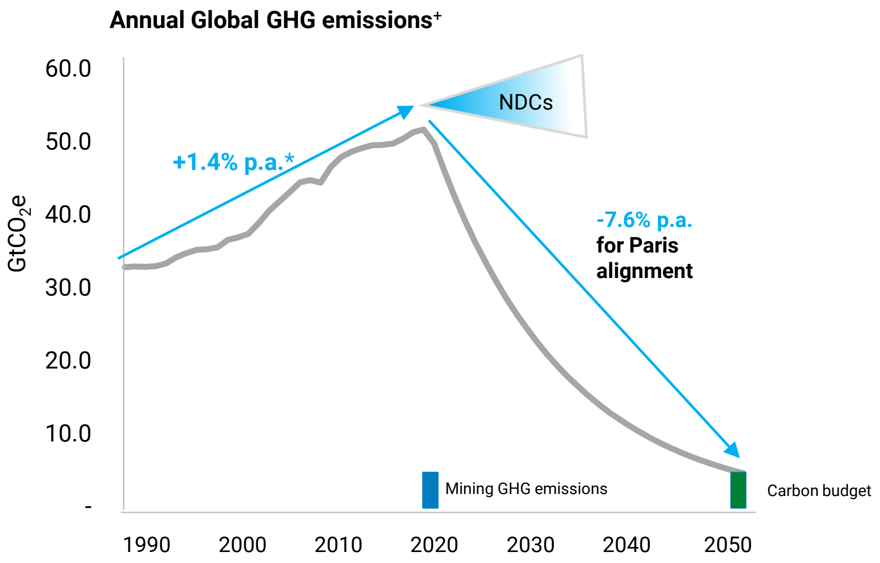
- *17 minerals and metals will require significantly expanded production to meet global net zero emissions goals by 2050.*
- **But without massive, transformative change, GHG emissions from scaled-up production will increase exponentially.**
- **Mining value chains will need to reduce absolute emissions by ~90% from 2020 levels, and remove remaining emissions, to achieve *net zero* by 2050.**

	Wind	Solar PV	CSP	Hydro	Geothermal	Energy Storage	Nuclear
Aluminum	■	■				■	■
Chromium	■				■	■	■
Cobalt						■	
Copper	■	■	■	■	■	■	■
Graphite						■	
Indium		■					■
Iron	■					■	
Lead	■	■		■		■	■
Lithium						■	
Manganese	■			■	■	■	
Molybdenum	■	■		■	■		■
Neodymium	■						
Nickel	■	■		■	■	■	■
Silver		■	■				■
Titanium				■	■		■
Vanadium						■	■
Zinc	■	■		■		■	■

Sources: Azadi, M., Northey, A., Ali, S.H. and M. Edraki, Transparency on greenhouse gas emissions from mining to enable climate change mitigation, 2020, Nature Geoscience, Vol 13, 100-104; IEA (2021), The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions, License: CC BY 4.0

Mineral and metal production across all market segments is responsible for

~10% OF GLOBAL GHG EMISSIONS



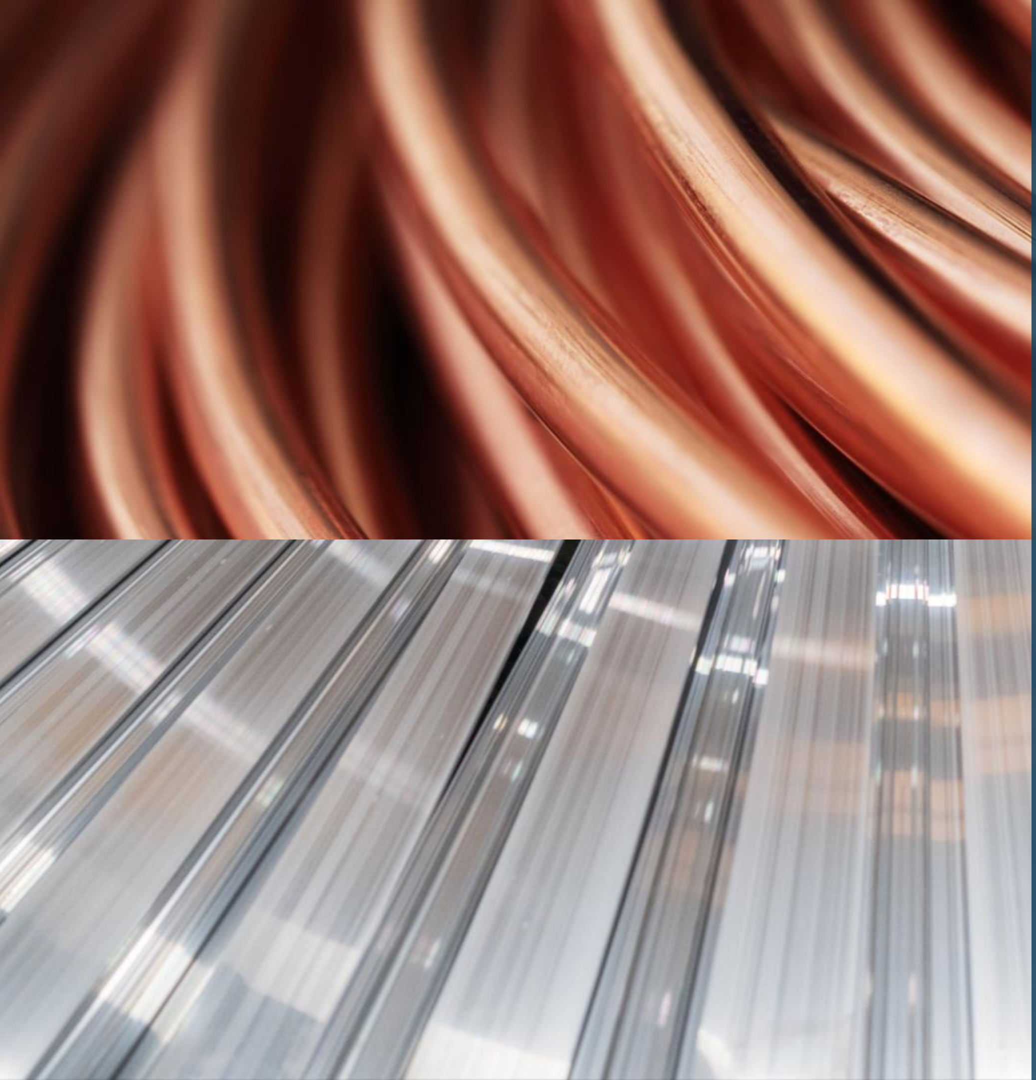
All mining emissions today are equivalent to the global 2050 net zero carbon budget (NZCB)

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

Sources: Azadi, M., Northey, A., Ali, S.H. and M. Edraki, Transparency on greenhouse gas emissions from mining to enable climate change mitigation, 2020, Nature Geoscience, Vol 13, 100-104; Carbon Trust analysis, *+Trends in global CO_2 and total greenhouse gas emissions: 2021 report.* Netherlands Environmental Assessment Agency . * Average annual emissions growth excluding LULUCF. NDCs – Nationally Determined Contributions.



2

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 $MtCO_2e/y$

Ni 88 to 8.8 $MtCO_2e/y$

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

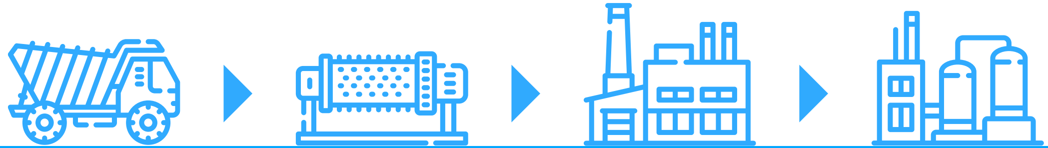
Industry-Led

NET ZERO ROADMAP EMISSIONS SCOPE

includes majority of key emissions sources for metal production

Fuel
Electricity
Purchased Goods

Mining → Milling → Smelter → Refinery



Copper
Copper Cathode

Nickel
Class 1 Nickel
Class 2 Nickel

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

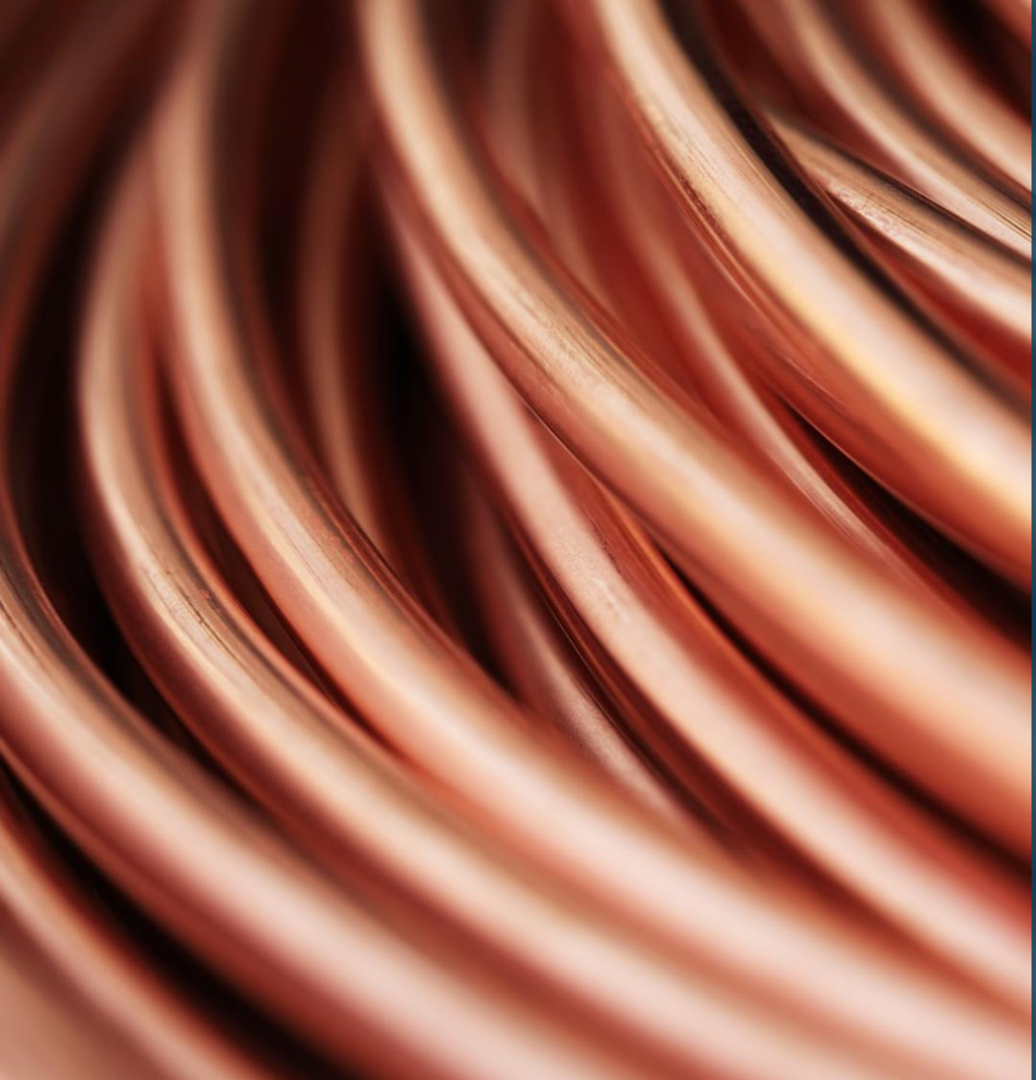
Included — SCOPE 1

Included — SCOPE 2

Partial Inclusion* — SCOPE 3

- **Category 1:** Purchased goods and services
- **Category 3:** Fuel and energy related activities
- **Category 4:** Upstream transportation
- **Category 9:** Downstream transportation and distribution
- **Category 10**: Processing of sold products if the company sells intermediate products e.g., concentrate

**Only material categories were included for Scope 3 emissions*



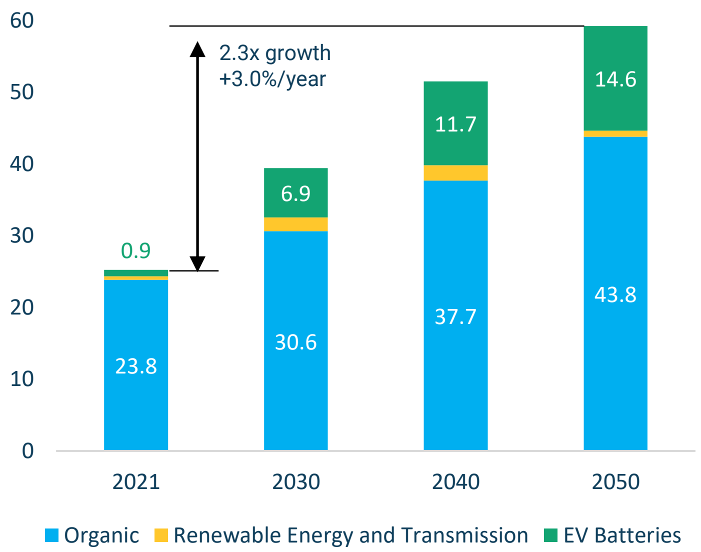
3

THE COPPER VALUE CHAIN

Net Zero Challenges

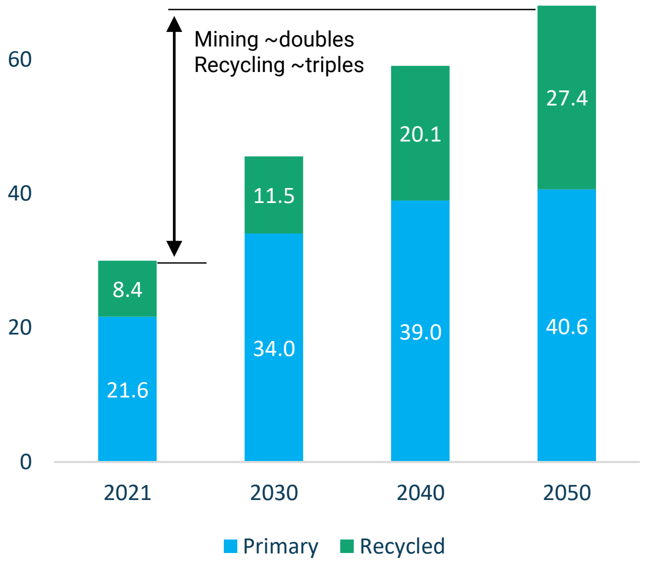
By 2050 copper supply needs to match
230%+ INCREASE IN DEMAND

Global Copper Demand (Mt/y)



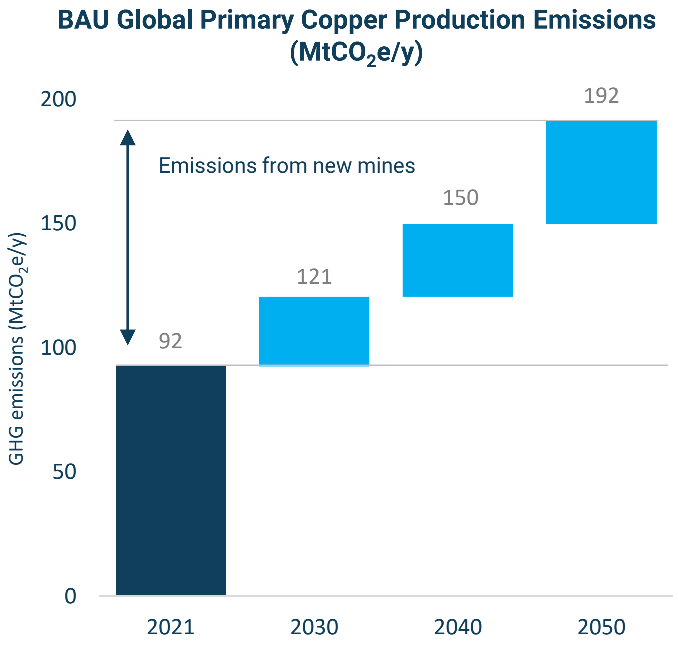
Global Copper Supply (Mt/y)

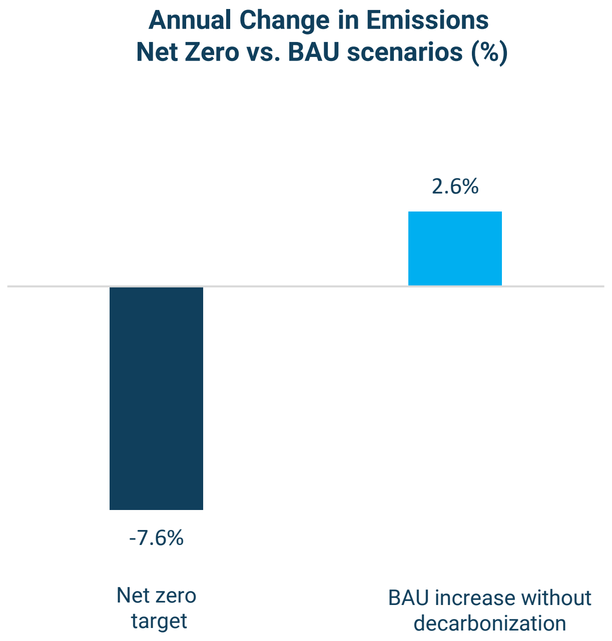
Before fabrication loss



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

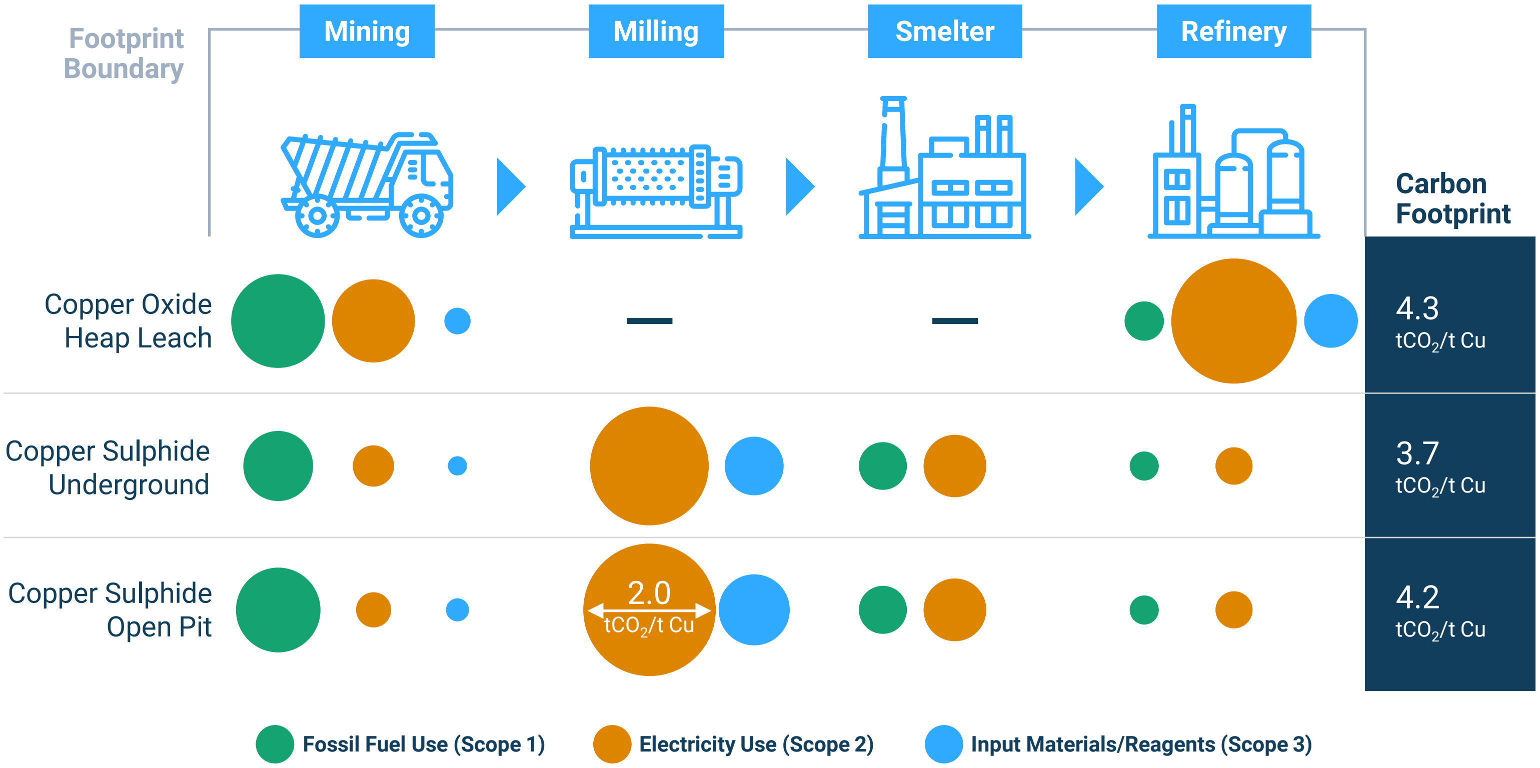




1 year delay in decarbonizing ≡ ~10% year-on-year deviation away from Net Zero, requiring larger capital allocation later

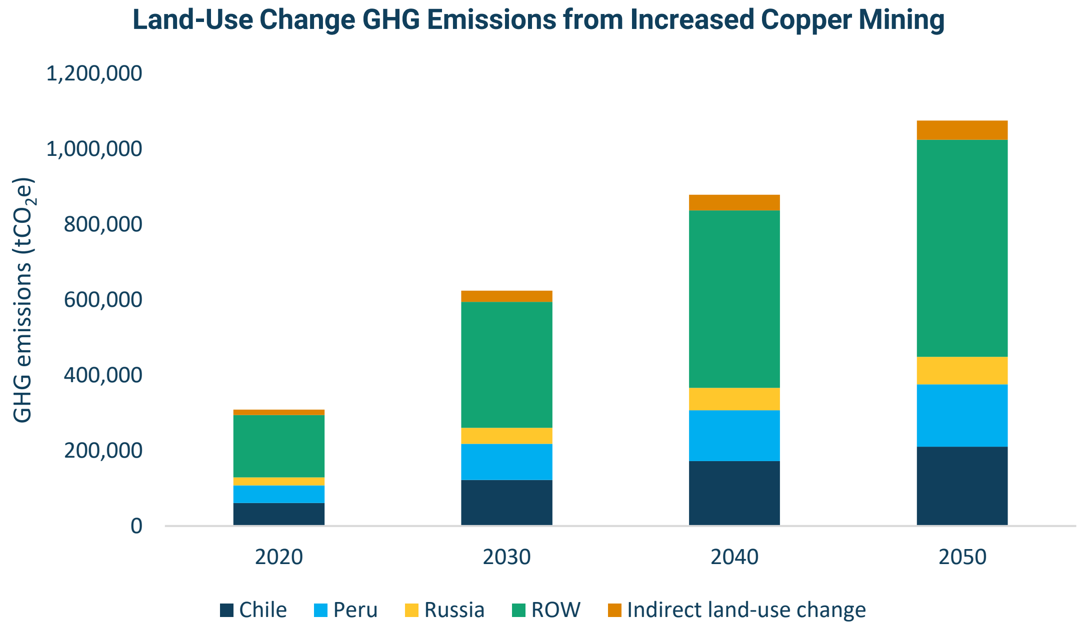
Copper production emissions are

PRIMARILY CAUSED BY ENERGY USE



Note: excludes transportation emissions

As copper mining expands, emissions from land-use change WILL RISE THREEFOLD



ANNUAL EMISSIONS

2020 0.3 $MtCO_2e$

2030 0.6 $MtCO_2e$

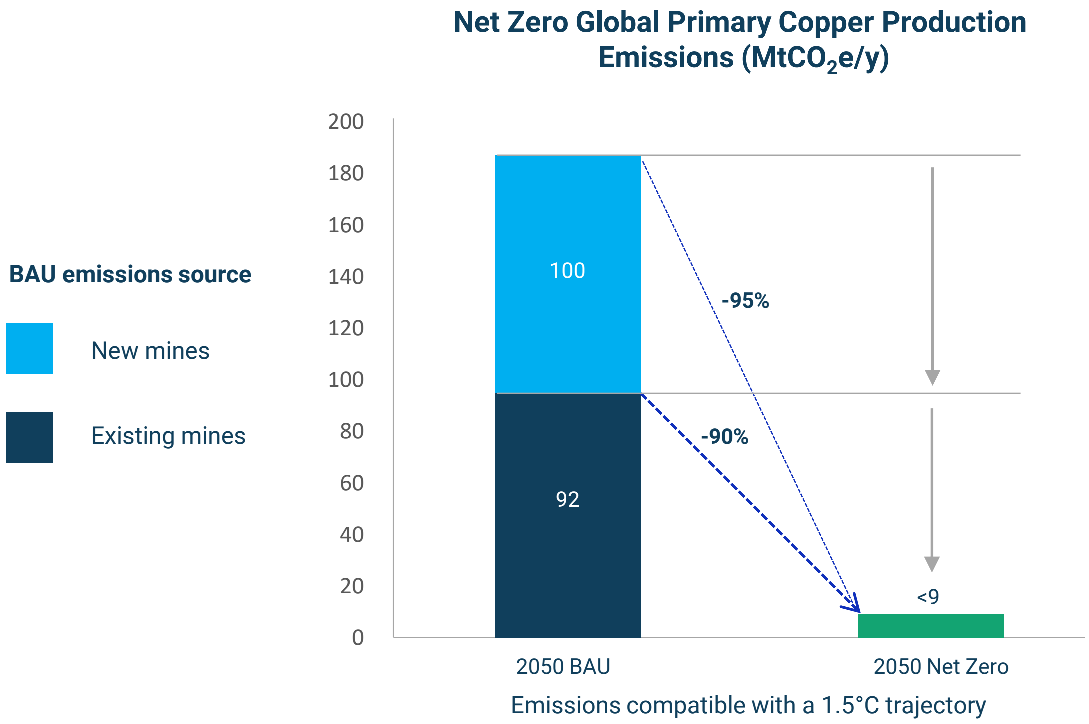
2050 1.1 $MtCO_2e$

Cumulative emissions 2020–2050
~22.7 $MtCO_2e$

Source: Carbon Trust analysis based on Murguia, D. 2015. Global Area Disturbed and Pressures on Biodiversity by Large-Scale Metal Mining. Kassel University Press. http://www.uni-kassel.de/upress/online/OpenAccess/978-3-7376-0040-8.OpenAccess.pdf. Iwatsuki, Y., Nakajima, K., Yamano, H., Otsuki, A. and Murakami, S. 2018. Variation and changes in land-use intensities behind nickel mining: Coupling operational and satellite data. Resources, Conservation and Recycling, 134: 361-366. Nakajima K., Nansai K., Matsubae K., Tomita M., Takayanagi W. and Nagasaka T. 2017. Global land-use change hidden behind nickel consumption. Science of the Total Environment, 586: 730-737. IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, vol. 4, Agriculture, Forestry and Other Land Use. https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html.

TO ACHIEVE NET ZERO

we must reduce GHG emissions from copper production by >90% from today's levels



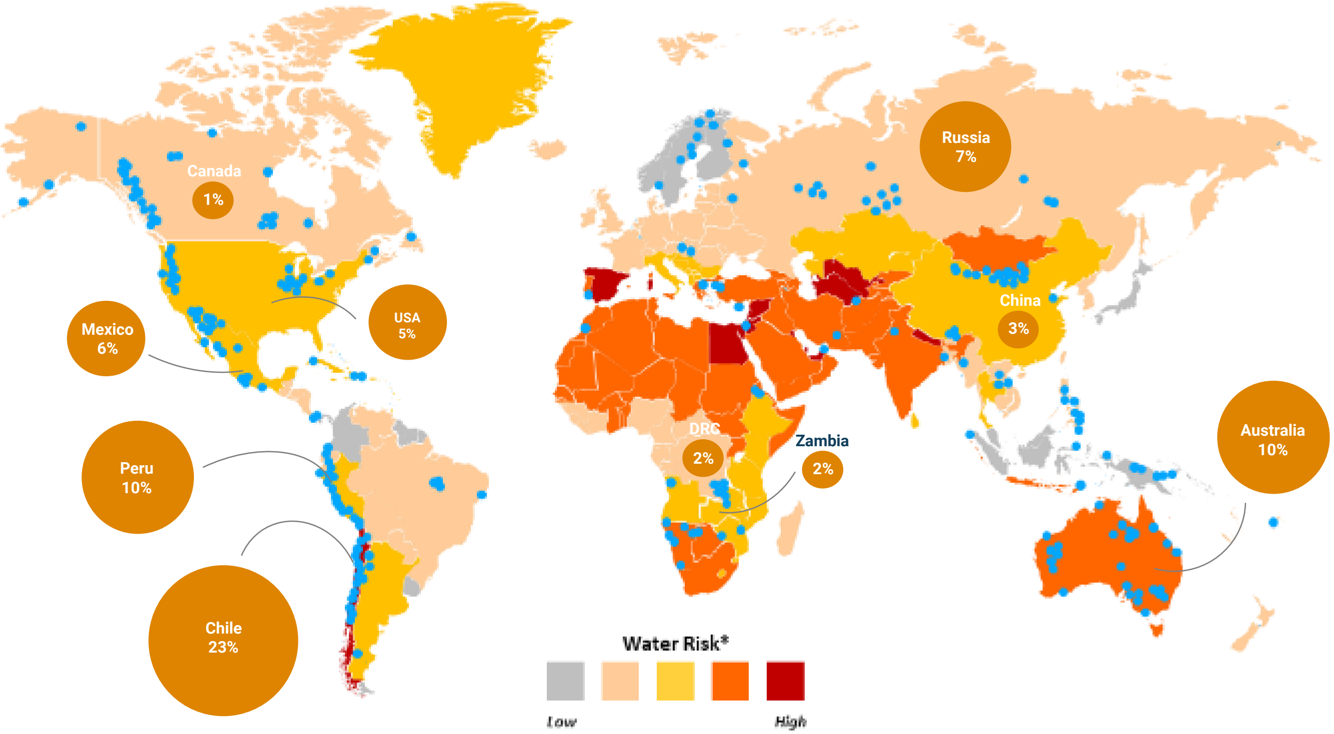
Doubling copper supply will significantly INCREASE COMPETITION FOR WATER

33%

of copper reserves are in **high water-risk** countries

SOLUTION**

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



Copper reserves

Relative share of global copper reserves

*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

Source: Carbon Trust analysis based on WWF Water Risk Filter 2021: https://waterriskfilter.org/explore/map.; USGS. 2021. U.S. Geological Survey, Mineral Commodity Summaries: Copper. https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-copper.pdf.

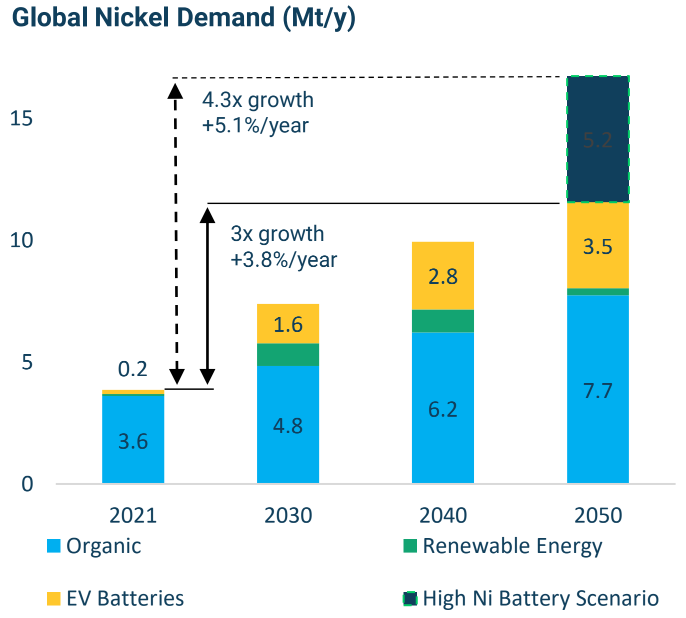
4

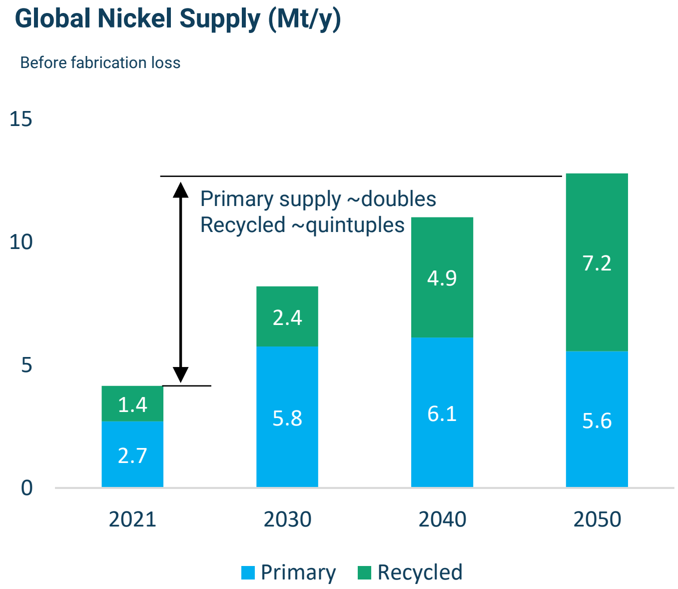
THE NICKEL VALUE CHAIN

Net Zero Challenges

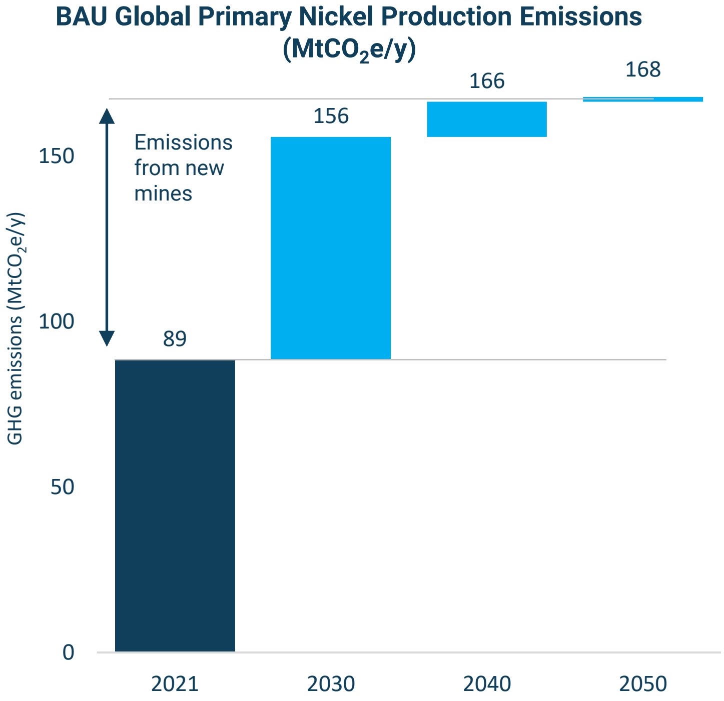
NICKEL DEMAND WILL TRIPLE BY 2050

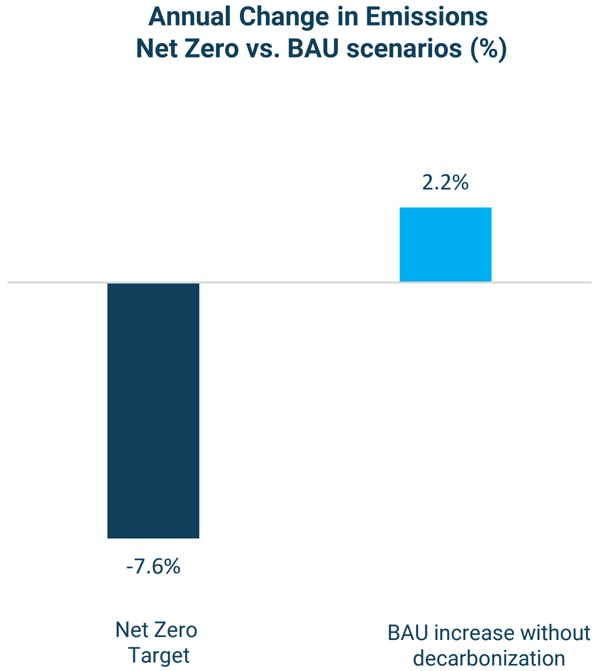
recycled sources become the dominant supply route





Without decarbonization, GHG emissions from nickel production WILL NEARLY DOUBLE BY 2050

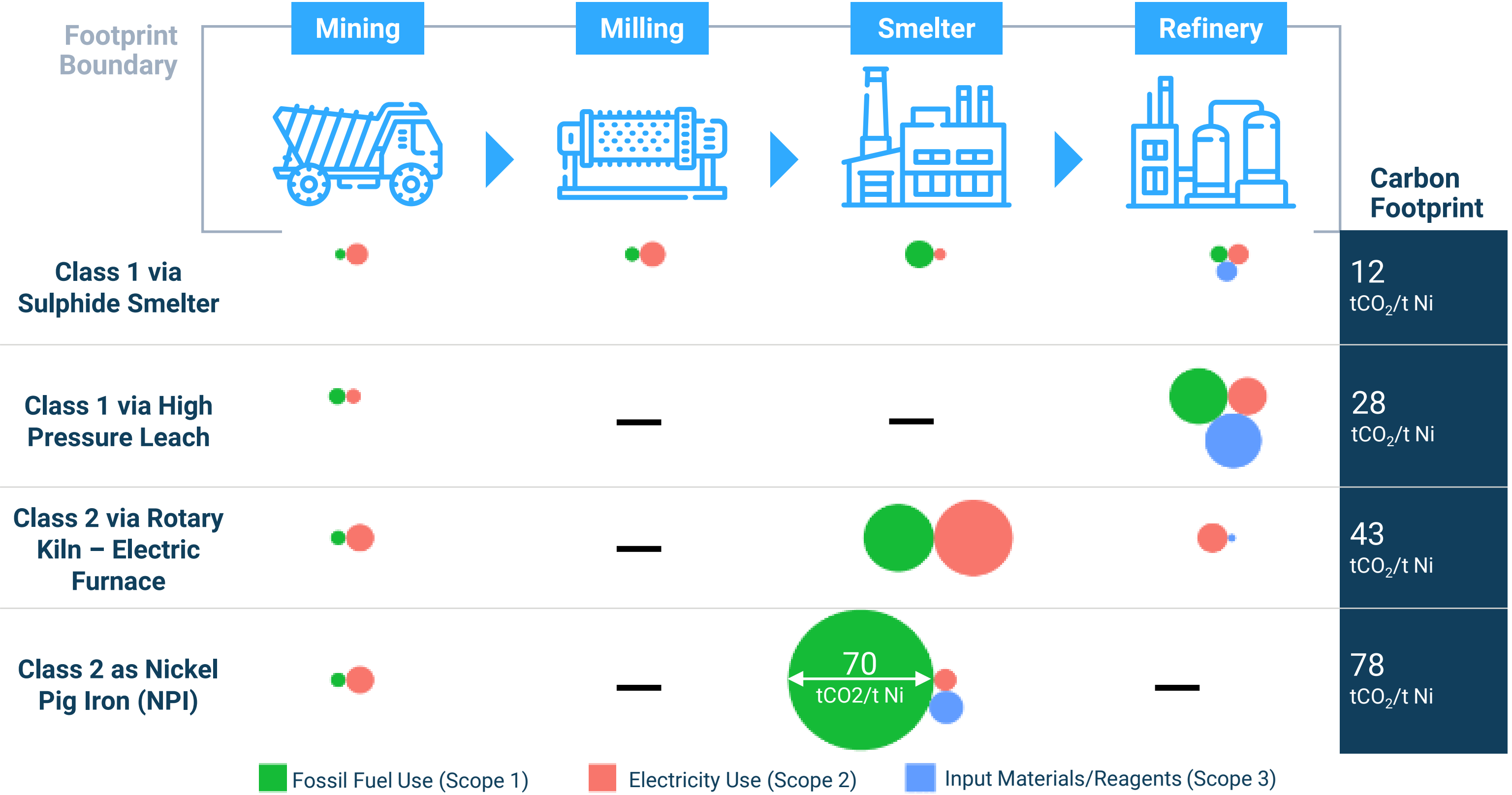




1 year delay ≡ ~10% year-on-year deviation away from Net Zero outcome requiring larger capital allocation later

Most nickel production emissions

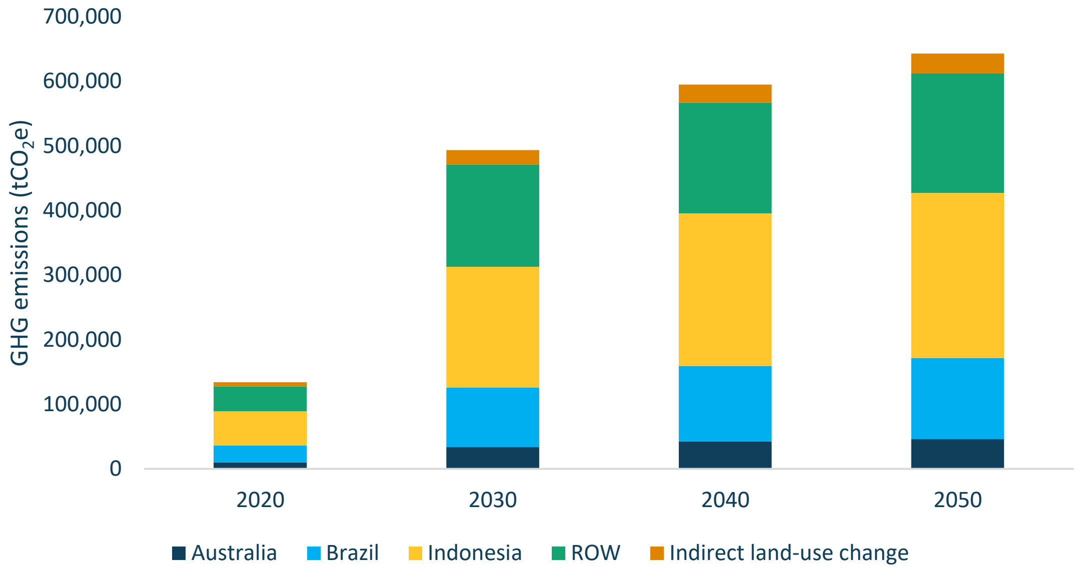
ARE CAUSED BY ENERGY USE INCLUDING HEAT



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



ANNUAL EMISSIONS

2020 0.15 $MtCO_2e$

2030 0.45 $MtCO_2e$

2050 0.65 $MtCO_2e$

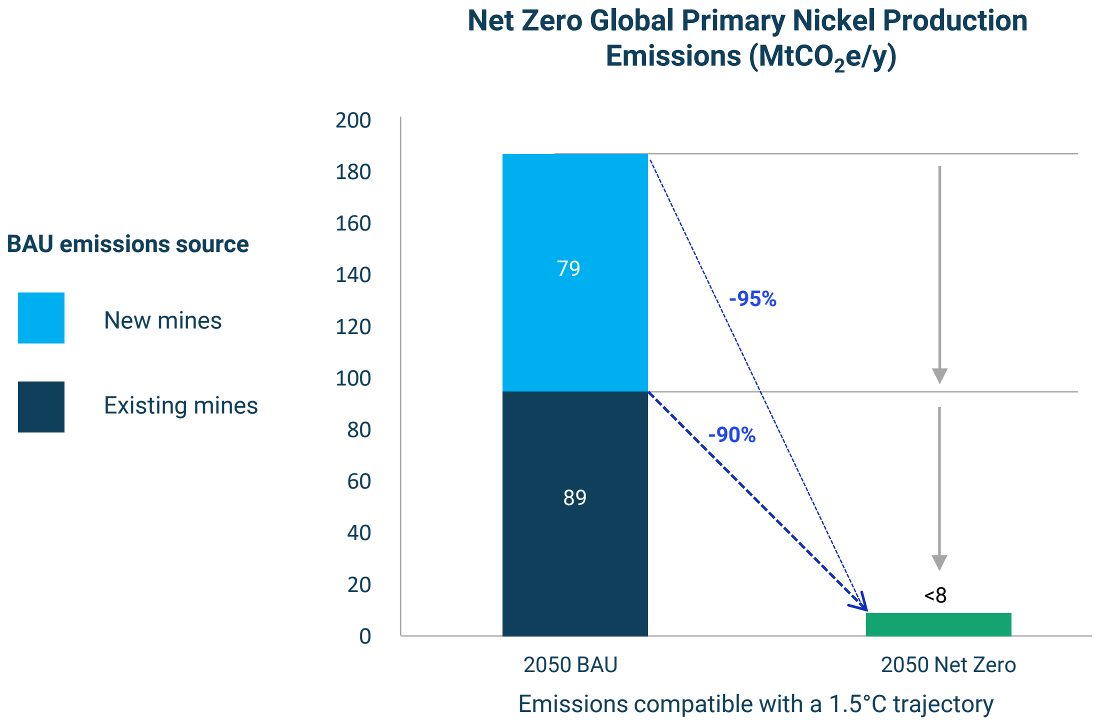
Cumulative emissions 2020–2050

~15 $MtCO_2e$

Source: Carbon Trust analysis based on Murguia, D. 2015. Global Area Disturbed and Pressures on Biodiversity by Large-Scale Metal Mining. Kassel University Press. http://www.uni-kassel.de/upress/online/OpenAccess/978-3-7376-0040-8.OpenAccess.pdf. Iwatsuki, Y., Nakajima, K., Yamano, H., Otsuki, A. and Murakami, S. 2018. Variation and changes in land-use intensities behind nickel mining: Coupling operational and satellite data. Resources, Conservation and Recycling, 134: 361-366. Nakajima K., Nansai K., Matsubae K., Tomita M., Takayanagi W. and Nagasaka T. 2017. Global land-use change hidden behind nickel consumption. Science of the Total Environment, 586: 730-737. IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, vol. 4, Agriculture, Forestry and Other Land Use. https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html.

TO ACHIEVE NET ZERO,

we must reduce GHG emissions from nickel production by >90% from today's levels



Tripling nickel supply will require

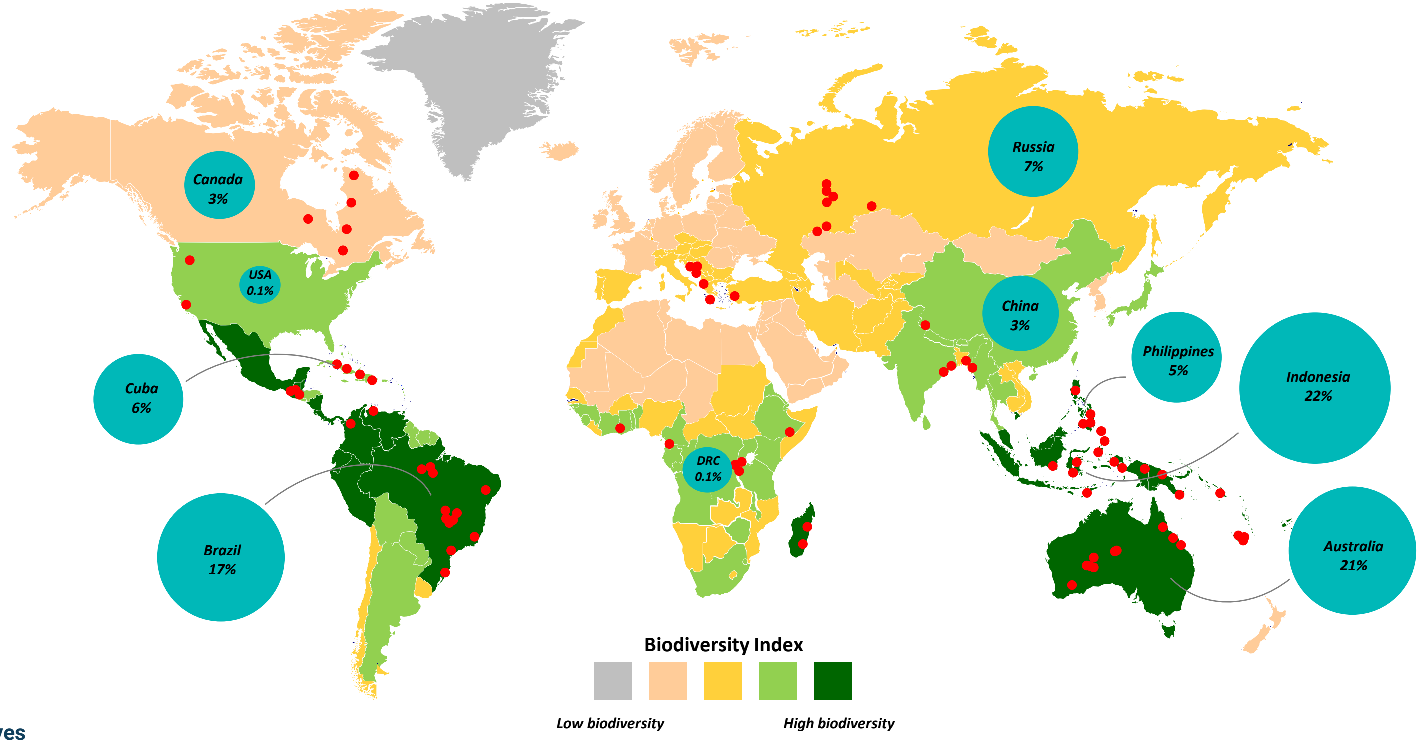
PROACTIVE MITIGATION OF BIODIVERSITY RISK

75%

of nickel reserves are in **high biodiversity** countries

SOLUTION*

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



Nickel reserves

Relative share of global nickel reserves

Biodiversity Index is based on species richness adjusted to country area (Source: Convention on Biological Diversity)
**For practical guidance: IFC Performance Standard 6 and ICMM Mitigation Hierarchy*

Source: Carbon Trust analysis based on: Convention on Biological Diversity, Annex 1: Biodiversity information by country. https://www.cbd.int/gbo1/annex.shtml#note1.; USGS. 2021. U.S. Geological Survey, Mineral Commodity Summaries: Nickel. https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-nickel.pdf.

5

ADDRESSING THE CHALLENGES

Transition to Net Zero Mines for a Low-Carbon Future

Mine of the Future

Green Hydrogen

Availability: Now — 10+ years
Cost
Emissions

Green hydrogen based fuelcell vehicles are currently being piloted for large haul truck applications. May also find applications in chemical reduction or high temperature processes which are difficult to electrify.

Conveyers and Trolley Assist

Availability: Now — 10+ years
Cost
Emissions

Mature technologies available today although cannot eliminate haulage emissions. Sites should consider maximising use of these technologies in the short-term and support future electrification (e.g., use of trolley-assist for in-haul charging).

Battery-Electric Vehicles

Availability: Now — 10+ years
Cost
Emissions

BEVs are already available for underground applications where the elimination of tailpipe emissions also reduces ventilation costs. Larger sizes for open pit applications are under development.

Energy Storage

Availability: Now — 10+ years
Cost
Emissions

Energy storage when combined with renewable energy (RE) enables elimination of electricity based emissions. Battery price declines continue to improve cost competitiveness, mines should also consider unique options such as compressed air storage.

Process Optimization

Availability: Now — 10+ years
Cost
Emissions

Includes both mature (e.g., mine-to-mill) and emerging (e.g., ore sorting) technologies which can reduce energy use and help alleviate the declining ore grade challenge. As with efficiency upgrades these investments also lower future RE costs.

Efficient Equipment

Availability: Now — 10+ years
Cost
Emissions

Including both mature hardware upgrades (e.g., best-in-class electric motors) and newer digital technologies (e.g., haul truck automation to reduce fuel use). Efficiency measures both reduce emissions today and lower costs for future RE deployments.

Inclusivity and Just Transition

Net zero mines are socially responsible and inclusive. They contribute to local economic development, community resilience and a healthy environment that enables additional, net-positive outcomes for local livelihoods, human well-being, health, autonomy and resilience.

Renewable Energy

Availability: Now — 10+ years
Cost
Emissions

RE such as solar PV and wind is cost competitive in many regions today. It can have an immediate deep impact on emissions (70% reduction) even when hybridised with diesel in an onsite mini-grid.

Carbon Removal Offsets

Availability: 2040 — 2050
Cost
Emissions

To reach net zero emissions by 2050, mines will have to use carbon removal offsets to mitigate any residual, hard-to-abate emissions (10% of 2020 levels). Carbon removal offsets should be deployed in-line with the mitigation hierarchy.

A NET ZERO MINE

uses low-carbon technology, collaborates across value chains, and leads in delivering additional, net-positive environmental and social outcomes

Key attributes of a sustainable Net Zero mine

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

Technology interventions are already available or will be WITHIN THE NEXT 10 YEARS

 Technology ready | cost competitive

 Technology close to market | costs nearing competitiveness

 Technology requires innovation | no current cost competitive

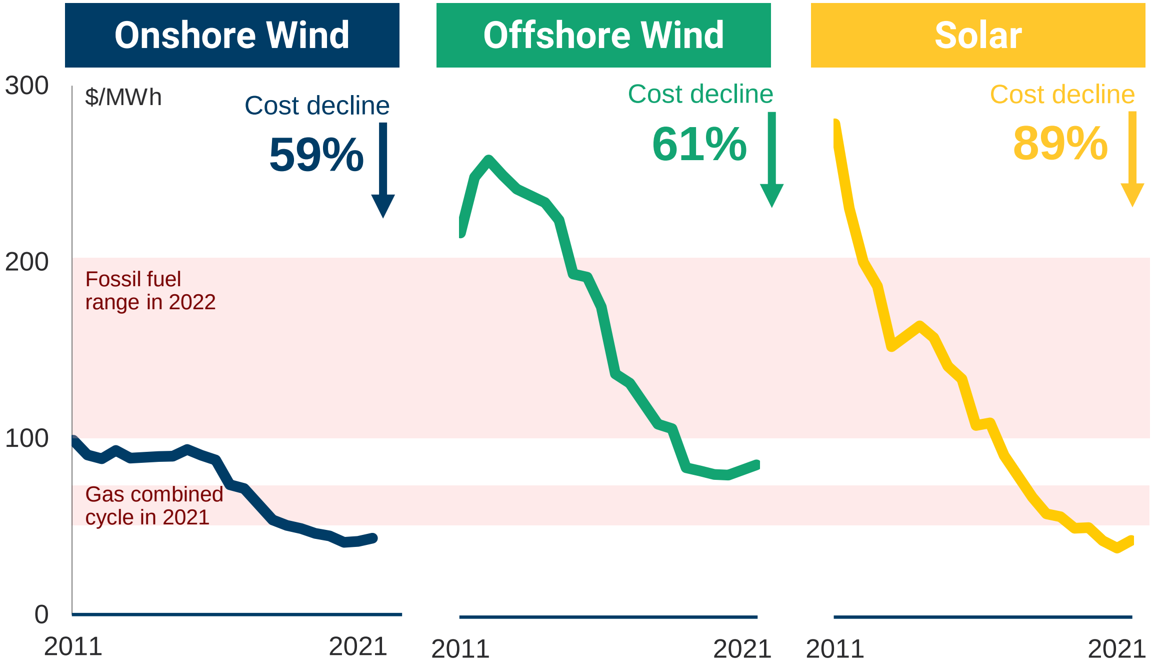
 Some technologies ready, others close to market | some cost competitive or nearing competitive

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

*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



Source: BNEF; Lazard

EXAMPLES

Power Purchase Agreement

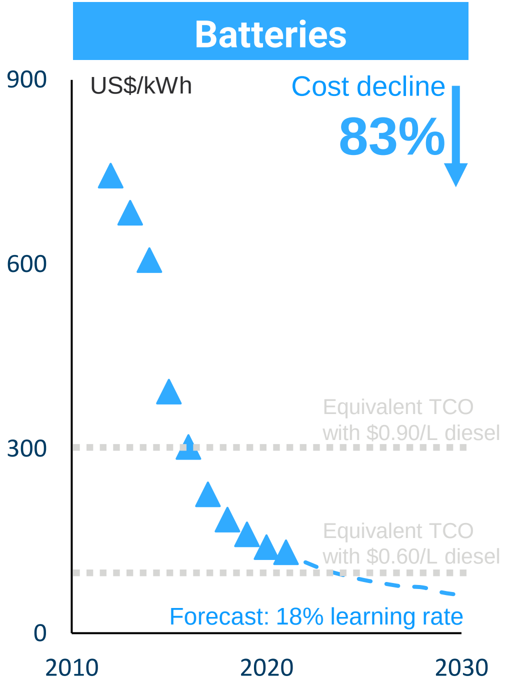
BHP signed RE PPAs for 6 TWh/y of electricity in 2021 for its Chilean copper operations, cancelling its previous coal-based PPAs.

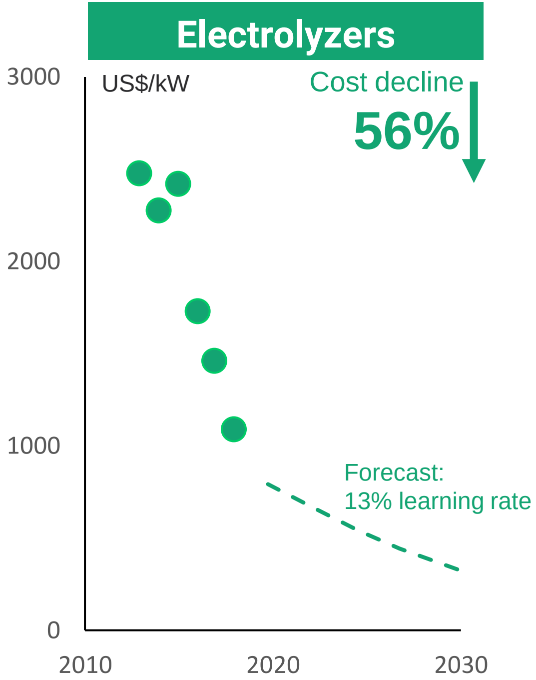
Onsite Generation

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.

BATTERY & ELECTROLYZER COST DECLINES

Cost competitive haulage electrification before 2030





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

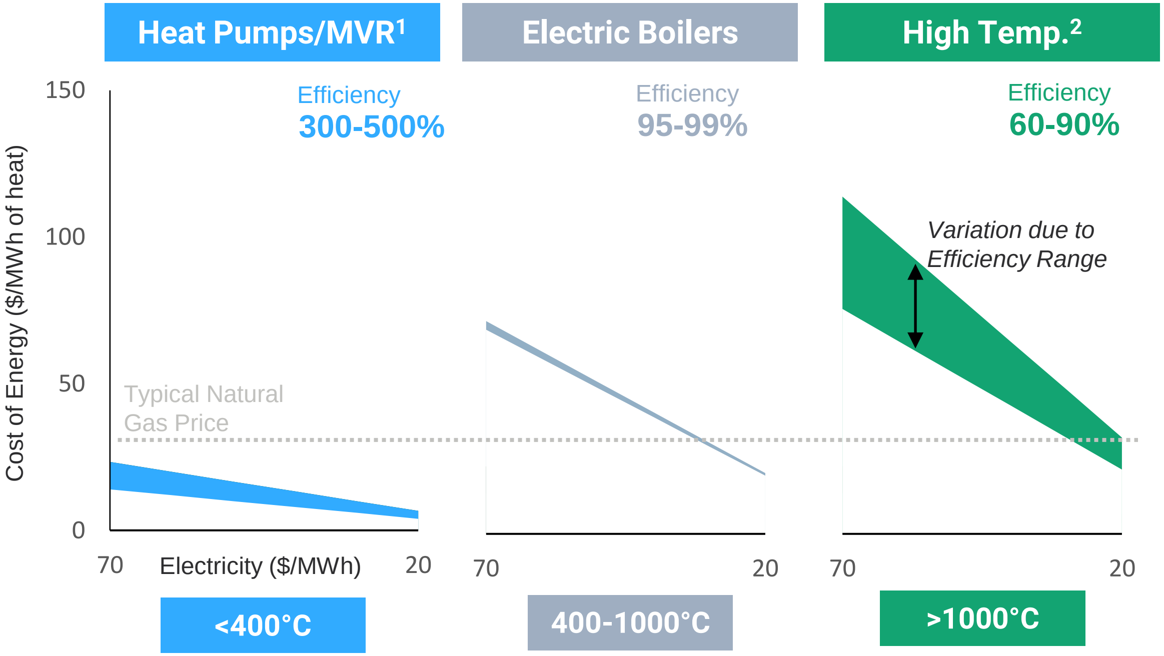
Glencore's Onaping Depth mine is planning to use an all-electric underground fleet providing savings of 44% and 30% on mine ventilation and cooling.

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



Source: Silvia Madeddu *et al* 2020 *Environ. Res. Lett.* 15 124004.
1 – Mechanical Vapor Recompression. 2 – High temperature options cover multiple technologies including induction furnace, electric arc furnace, resistance furnace, plasma technology and green H_2 burners.

EXAMPLES

MVR

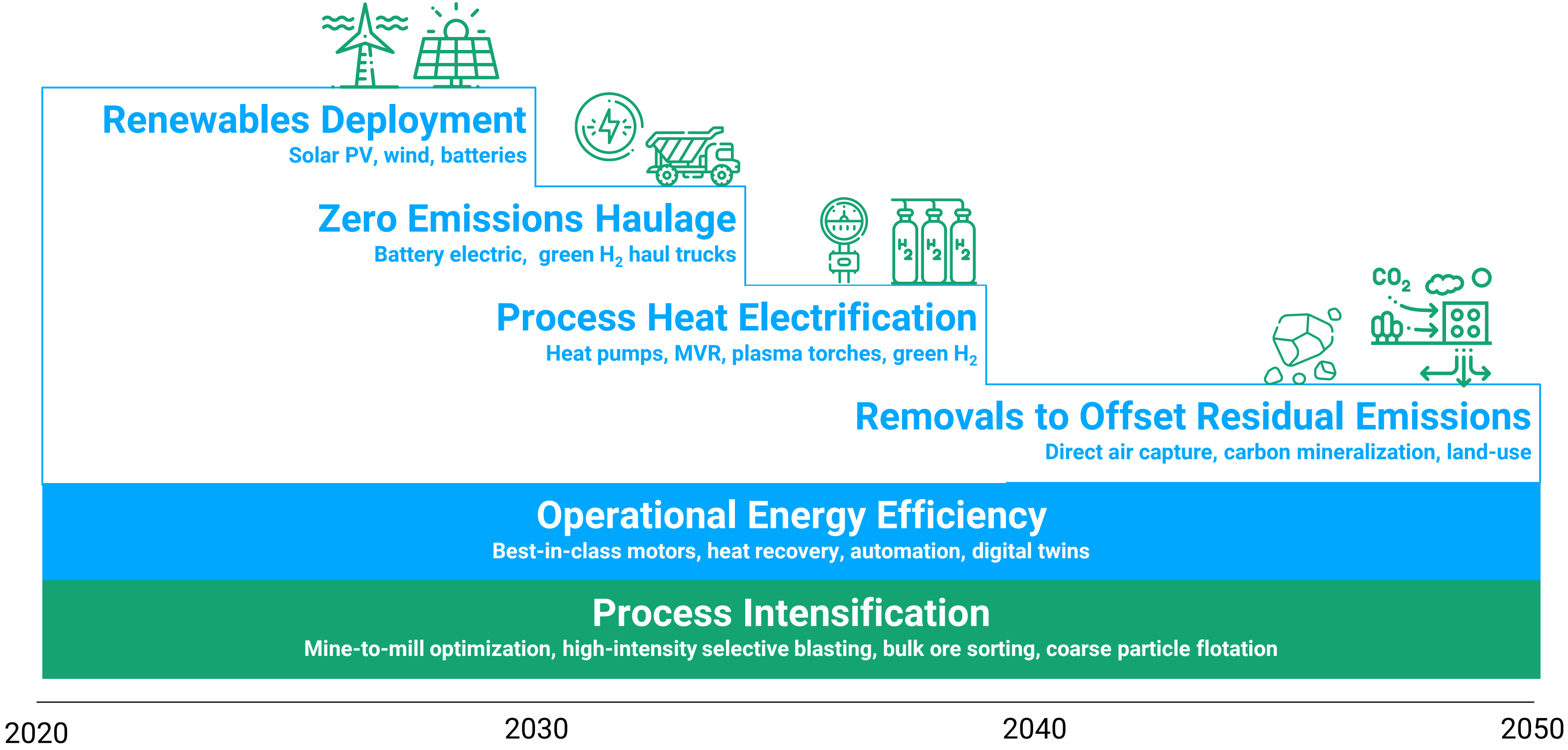
Alcoa is testing MVR at its Wagerup plant in Western Australia, which could reduce alumina refinery emissions by 70%.

Green Hydrogen

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

STAGED IMPLEMENTATION OF TECHNOLOGY

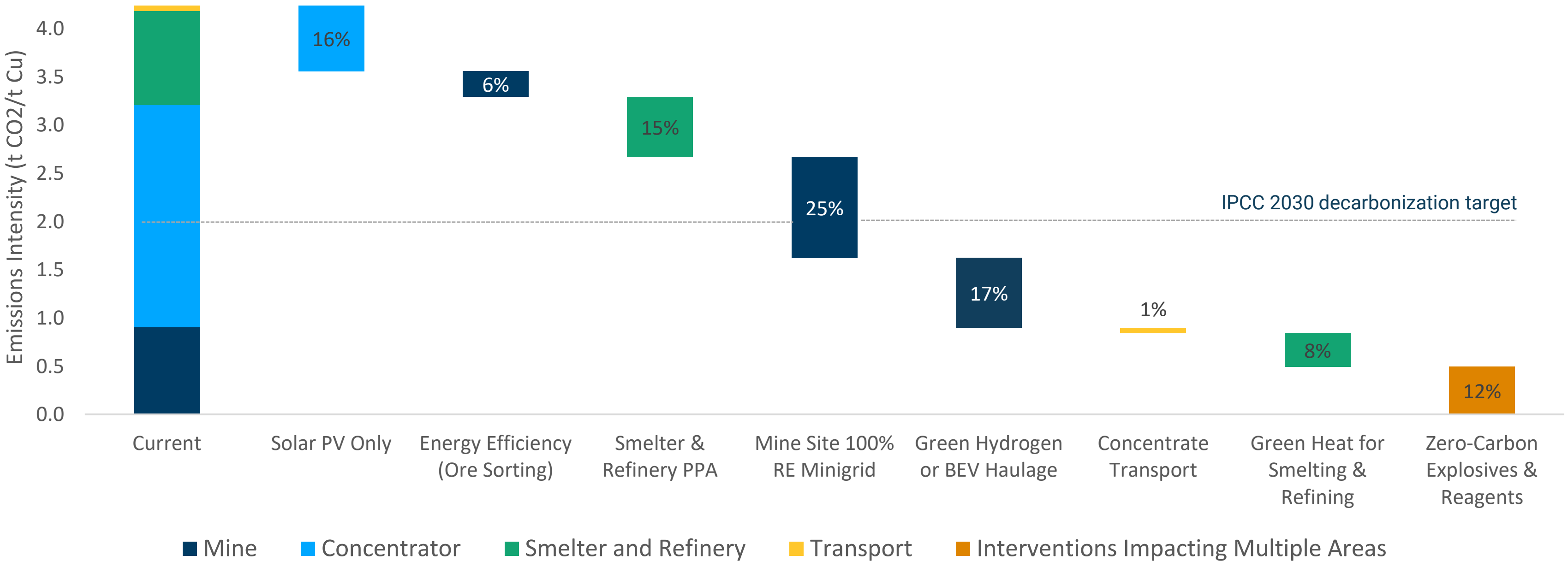
Will be needed to achieve net zero



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

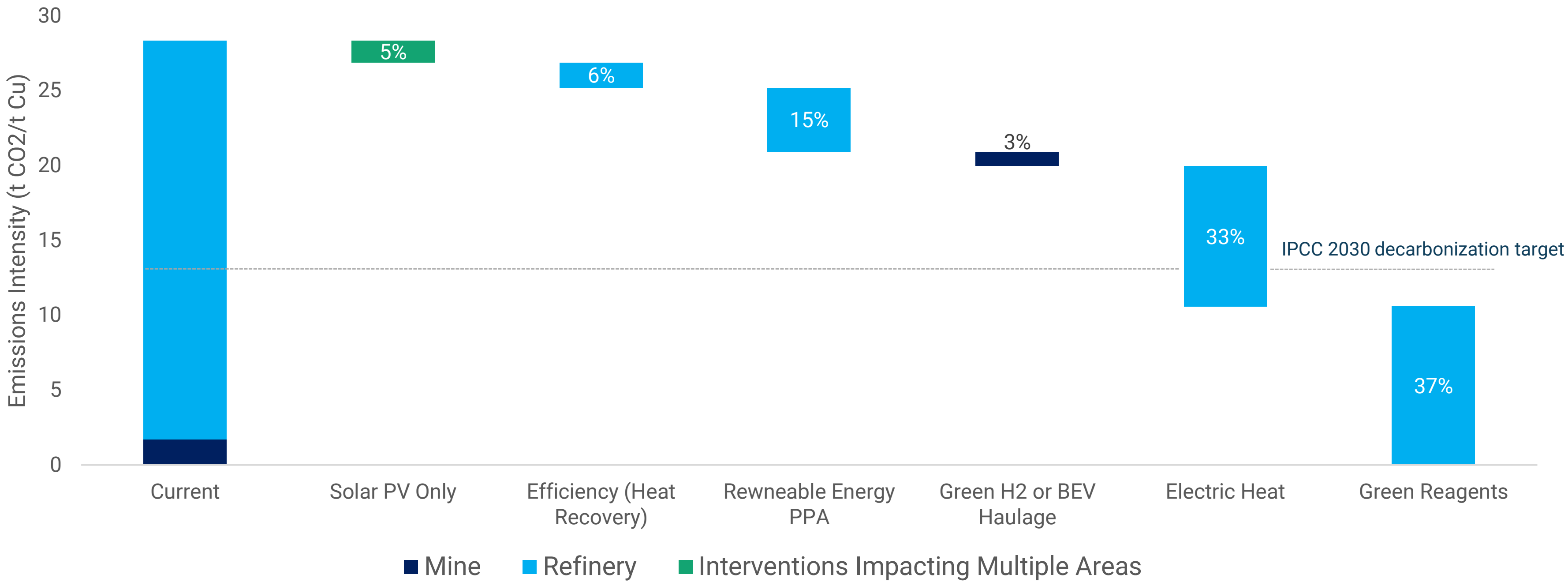


Note: 'Solar PV Only' refers to onsite solar hybridized with diesel generators, percentage reductions refer to the total emissions footprint.

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.

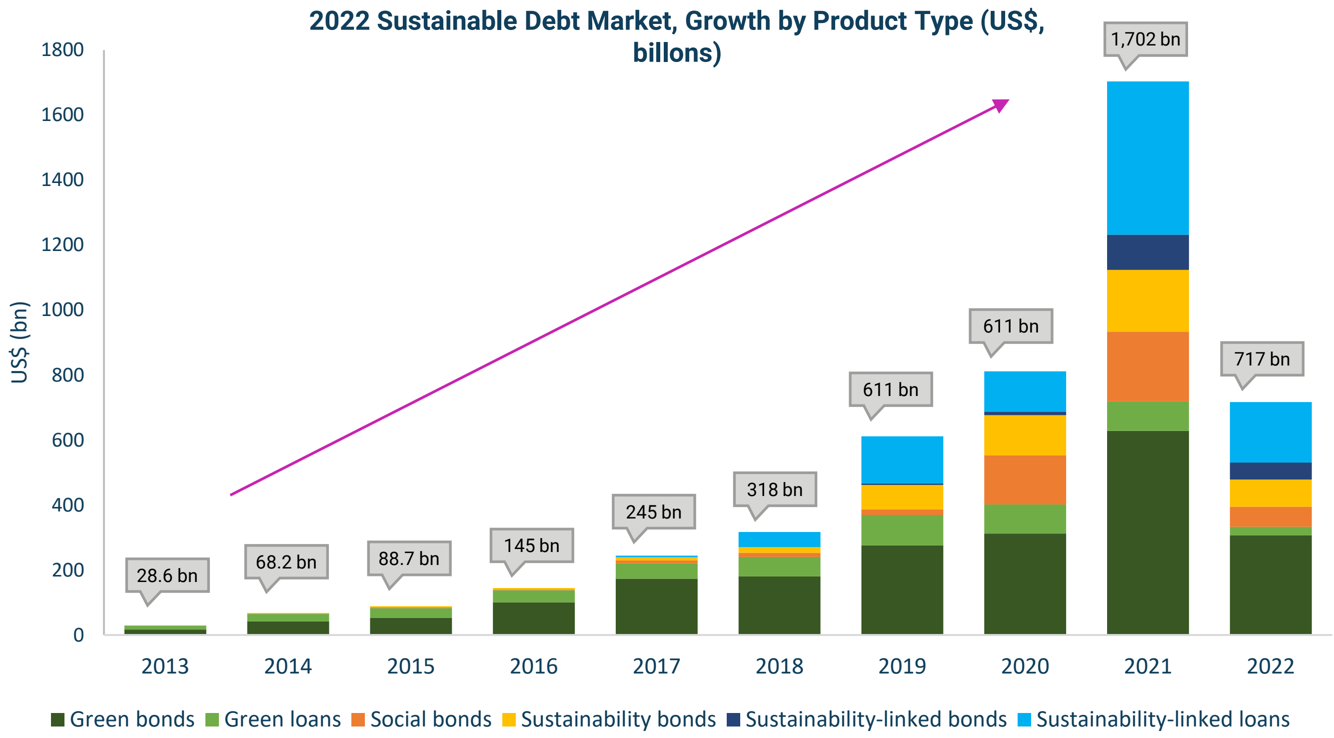
6

INVESTING IN DECARBONIZATION

through Sustainable Finance

SUSTAINABLE FINANCE

instruments can enable the technology deployment



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**

Sources: SQM. 2021. Green Bond Framework. https://s25.q4cdn.com/757756353/files/doc_downloads/2021/09/SQM-Green-Bond-Framework_Sept2021.vFINAL.pdf. Anglo American. 2022. Anglo American agrees sustainability-linked loan with International Finance Corporation. https://www.angloamerican.com/media/press-releases/2022/09-06-2022#:~:text=Anglo%20American%20has%20signed%20a,Anglo%20American's%20Sustainable%20Mining%20Plan. Climate Fund Managers. Climate Investor1. https://climatefundmanagers.com/funds/#CIO.

7

OPPORTUNITIES

for Environmental and Social Co-Benefits

Low-carbon technology interventions can deliver

ENVIRONMENTAL AND SOCIAL CO-BENEFITS

	ENVIRONMENTAL CONSIDERATIONS					SOCIAL CONSIDERATIONS			
	Water management	Energy demand	Pollution	Biodiversity	Climate risk & adaptation	Health & Safety	Employment, livelihoods, & decent work	Human rights, security, and inclusion	Community relationships
Energy efficiency: Operational efficiency	✓	✓	✓	✓	✓	✓	?	○	○
Energy efficiency: Process optimization	✓	✓	✓	✓	✓	✓	?	○	○
Automation & digitization	✓	✓	✓	○	○	✓	⚠	○	○
Renewable energy (solar & wind)	✓	○	✓	⚠	✓	✓	?	✓	✓
Energy storage (batteries)	?	?	?	?	?	?	?	✓	✓
Sustainable biofuels	?	✓	⚠	⚠	?	✓	?	?	✓
Green hydrogen	?	✓	✓	?	⚠	✓	?	✓	✓
Trollies, BEVs, & conveyors	○	✓	?	?	○	?	?	○	○

KEY
- ✓ **Potential co-benefits** from deployment
- ? **Uncertain** due to competing risks and co-benefits
- ⚠ **Potential risks** from deployment
- ○ **No or uncertain** risk/co-benefit

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

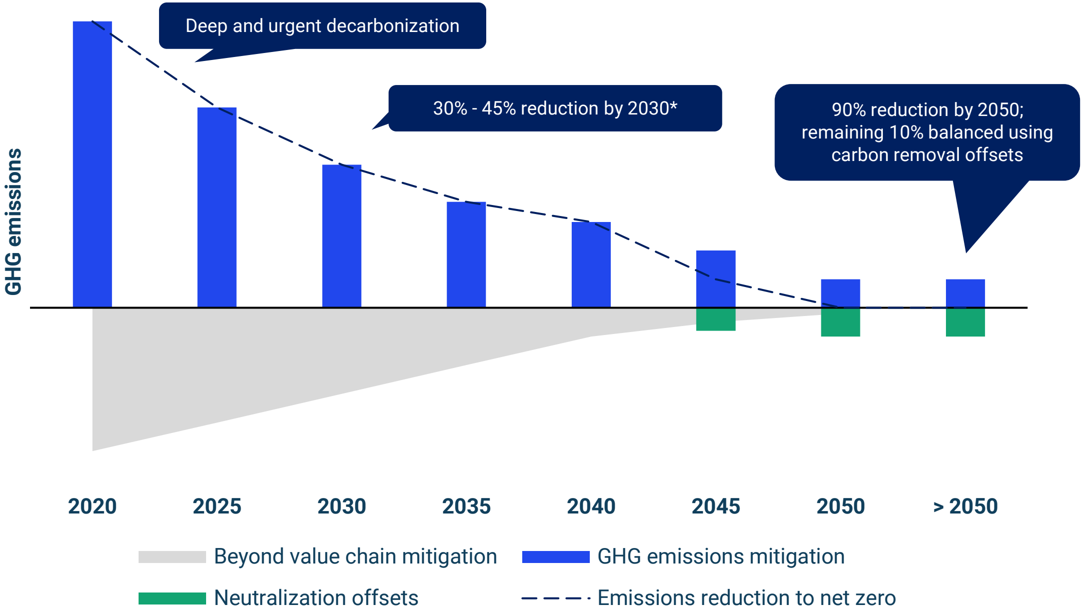
i Prioritize absolute GHG emissions reductions in line with a 1.5°C trajectory

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 1.5C. 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/

The net zero mining transition can be a PLATFORM FOR DELIVERING A JUST TRANSITION

CASE STUDIES

De Beers' Accelerating Women Owned Micro-Enterprises (AWOME)[1]

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[2]

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[3]

The "Thriving Communities" pillar aims to build thriving communities with better health, education and levels of 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

8

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

LOW-CARBON TECHNOLOGY INITIATIVES

RE100 · ERGI. · Green Hydrogen Catapult · icct (The International Council on Clean Transportation) · Global Battery Alliance · World Economic Forum – Digital Transformation Initiative · ReThink Mining · WIPO GREEN (The Marketplace for Sustainable Technology) · CTCN (Climate Technology Centre & Network) · EV100 by The Climate Group · Electric Mine Consortium · Ellen MacArthur Foundation · Think & Act Differently · OZ Minerals – Energy and Mining Collaboration · Smart Freight Centre · amira · Third Derivative · Charge On Innovation Challenge · Green Hydrogen Coalition

RESPONSIBLE & SUSTAINABLE MINING INITIATIVES

EITI (Extractive Industries Transparency Initiative) · GMG (Global Mining Guidelines Group) · ICMM · IGF · IRMA (Initiative for Responsible Mining Assurance) · Responsible Mining Foundation · Responsible Minerals Initiative · The Copper Mark (Responsibly Produced Copper) · World Economic Forum – Mining & Metals Industry Community · World Bank Group Climate-Smart Mining

CROSS-CUTTING COLLABORATIVE INITIATIVES

Transition Pathway Initiative · The B Team · Just Transition Initiative · Mission Possible Partnership · Council for Inclusive Capitalism · Just Transition Centre · tpi · LeadIT (Leadership Group for Industry Transition)

VOLUNTARY CARBON OFFSET STANDARDS

American Carbon Registry · Gold Standard · VERRA · Climate Action Reserve · ICROA (International Carbon Reduction & Offset Alliance)

COPPER INDUSTRY ASSOCIATIONS

International Copper Association (Copper Alliance) · International Copper Study Group

NICKEL INDUSTRY ASSOCIATIONS

Nickel Institute · INSG · NiPERA (Nickel Health and Environmental Sciences)

KEY

Mapping initiatives against the mining value chain

Extraction · Processing · Transport

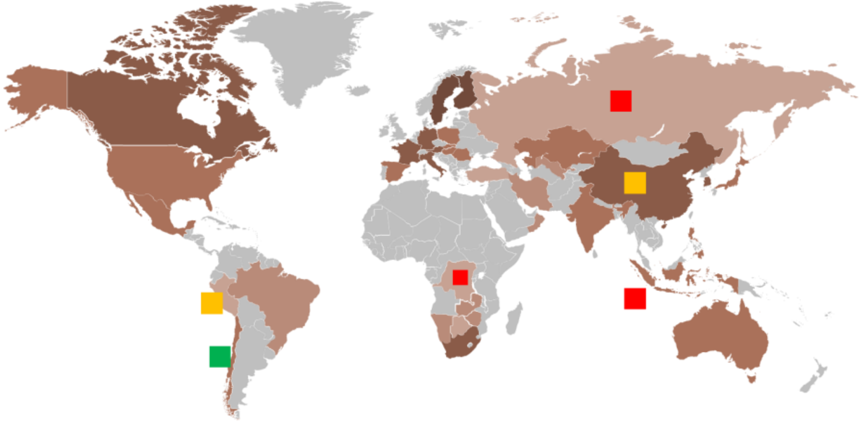
PARTNERSHIP APPROACHES:

- Supports low-carbon **technology deployment** and **RD&D**
- Supports **sustainable mining** practices and **good ESG performance**
- Supports **ambitious climate action** and a **just transition**
- Supports **credible carbon offsetting**
- Supports **copper and nickel value chain actors**

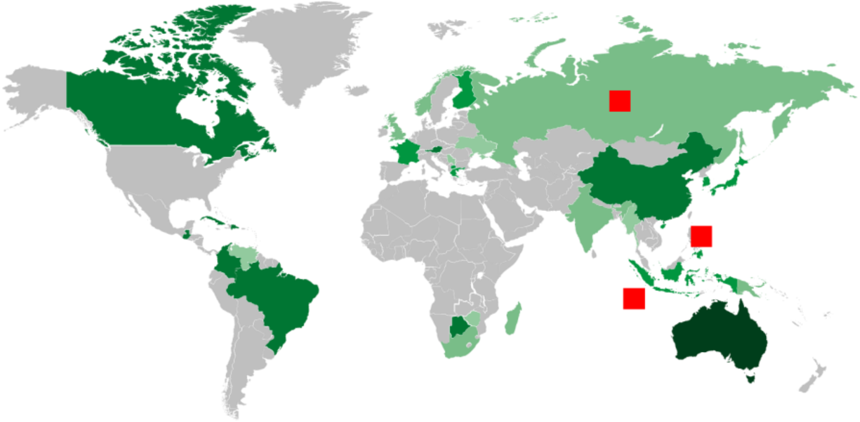
ENGAGE POLICYMAKERS

to address legal and regulatory barriers to mining decarbonization

Policy & Regulatory Barriers in Copper Mining & Smelting Countries



Policy & Regulatory Barriers in Nickel Mining & Smelting Countries



Policy & Regulatory Environments

Copper and nickel mining

- Weak
- Moderately enabling
- Enabling

Smelting

Copper

Nickel

Unsupportive — Enabling

Key Takeaways	
Energy Policy	Weak access to power purchasing agreements and independent power producers
Mining Legal Framework	Limited or no incentives to encourage energy efficiency or renewable energy use; and counterincentives
Climate Change Policy	Weak nationally determined contributions and Net Zero commitments

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

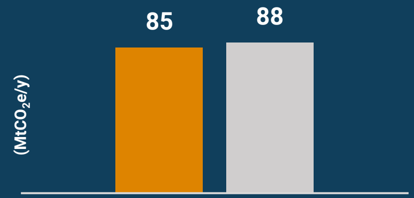
STEP 4 **Identify solutions** to reduce emissions and enhance resilience

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

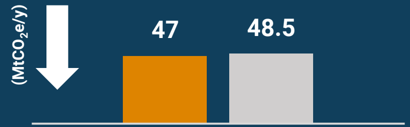
STEP 6 **Engage your people** and **collaborate** with other value chain actors

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

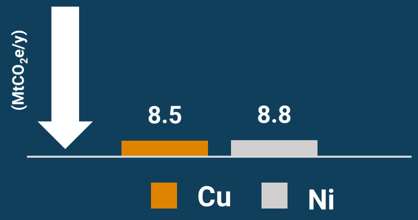
2021 EMISSIONS



30%–45% EMISSIONS REDUCTION BY 2030



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



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IFC CommDev

NET ZERO ROADMAP TO 2050

For Copper & Nickel Mining Value Chains

IFC International Finance Corporation WORLD BANK GROUP

Creating Markets, Creating Opportunities

Climate-Smart Mining

Thank You