DECARBONIZATION OF THE MINING SECTOR

MODULE 1

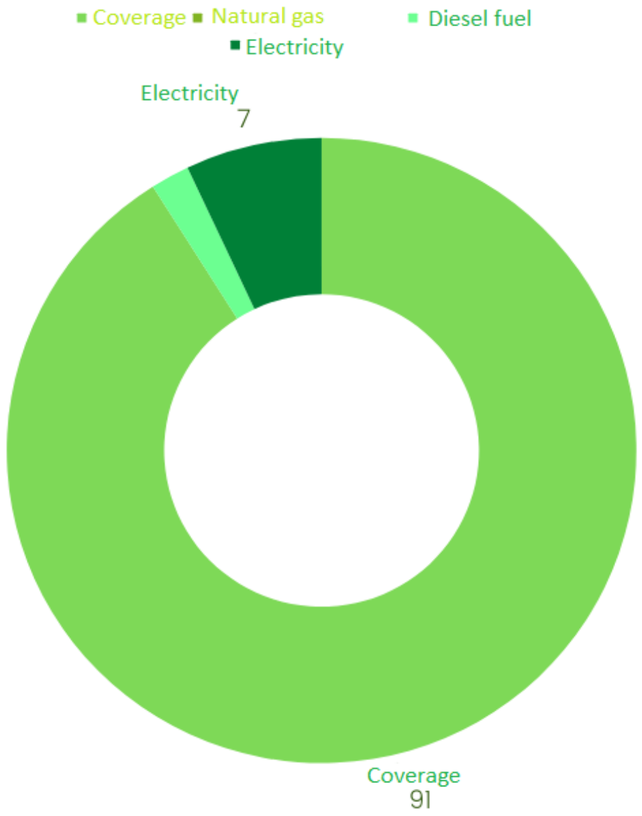
Material for group work

GOALS OF SECTORAL GROUP WORK

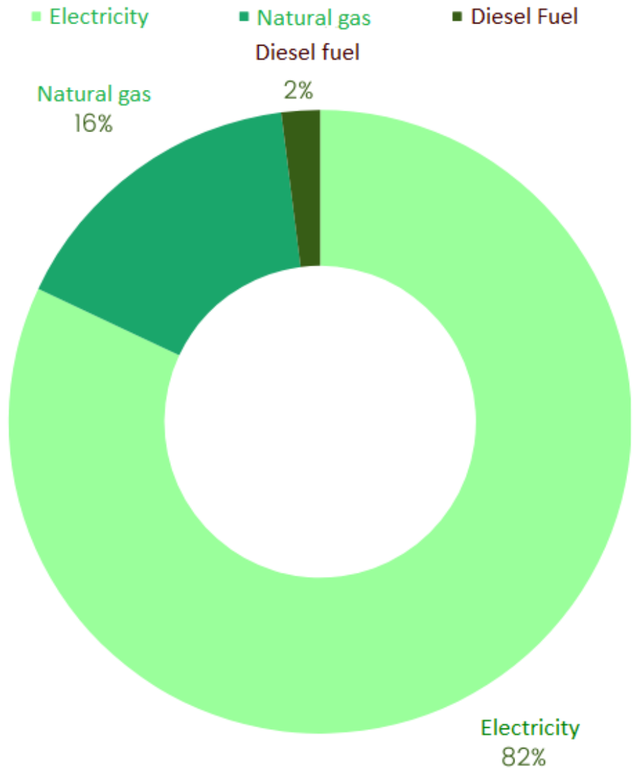
- Identify major sources of greenhouse gas emissions in your sector
- Familiarize yourself with target indicators and quantitative metrics for decarbonization in the industry
- Learn about the climate risks that companies in this sector consider the most significant
- Assess the activities and technological solutions that are most common and acceptable in the short and long term to decarbonize the sector

SOURCES OF EMISSIONS IN MINING

Distribution of emissions in million tons CO2-eq./year

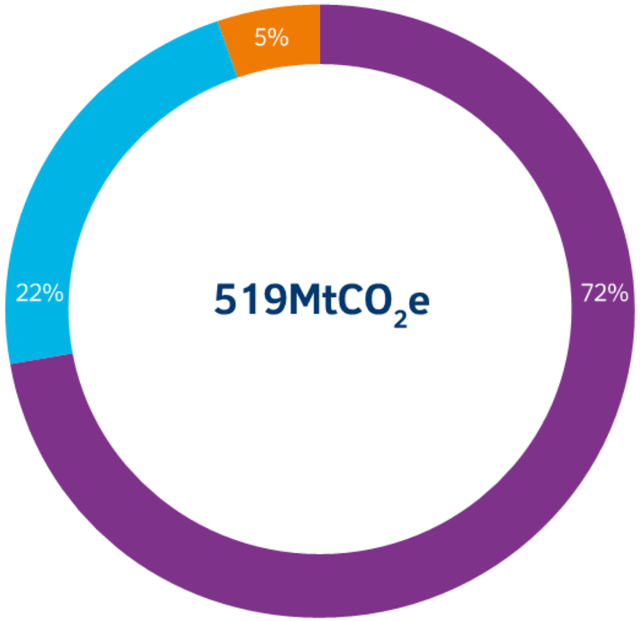


Breakdown of Scope 1 and 2 emissions in million tons CO2-eq./year



SOURCES OF EMISSIONS IN SCOPE 3: RIO TINTO

Distribution of emissions in million tons CO2-eq./year



	$MtCO_2e$
Processing of iron ore	376.4
Processing of bauxite and alumina	116.4
Processing of titanium dioxide feedstocks	5.8
Processing of copper concentrate	0.5
Processing of other sold products	2.5
Purchased goods	6.6
Capital goods	0.1
Fuel related activities	2.8
Business travel	0.1
Upstream and inter-company transportation	5.1
Downstream transportation	3.0

WHICH PROCESSES LEAD TO SCOPE 1 AND 2 GHG EMISSIONS AT YOUR ENTERPRISE?

Use of electricity:_____

Use of diesel fuel: _____

Use of natural gas:_____

Other sources:

CORPORATE EMISSION REDUCTION TARGETS

Company	Target year: 2030	
	Scope 1 & 2	Scope 3
Vale S.A. (Brazil)	33% (vs 2017) or 2.54% per year	15% by 2035 (vs 2018) or 1.25% per year
BHP Group (Australia)	30% (vs 2020) or 3.0% per year	30-40% (vs 2020) or 3-4% per year
Polymetal (Russia)	35% (vs 2019) or 3.2% per year	No target
KazMinerals (Kazakhstan)	5% by 2024 (vs 2018) or 1% per year	No target

DOES YOUR ENTERPRISE HAVE DECARBONIZATION RELATED TARGETS?

Scope 1 and 2:_____

Scope 3 : _____

Other targets:

- Energy efficiency improvement _____
- Other targets:_____

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FORTESCUE METAL: DECARBONIZATION STRATEGY

82 MILLION LITERS OF DIESEL FUEL IN 2021 2214 MILLION TONS CO2 EQ.

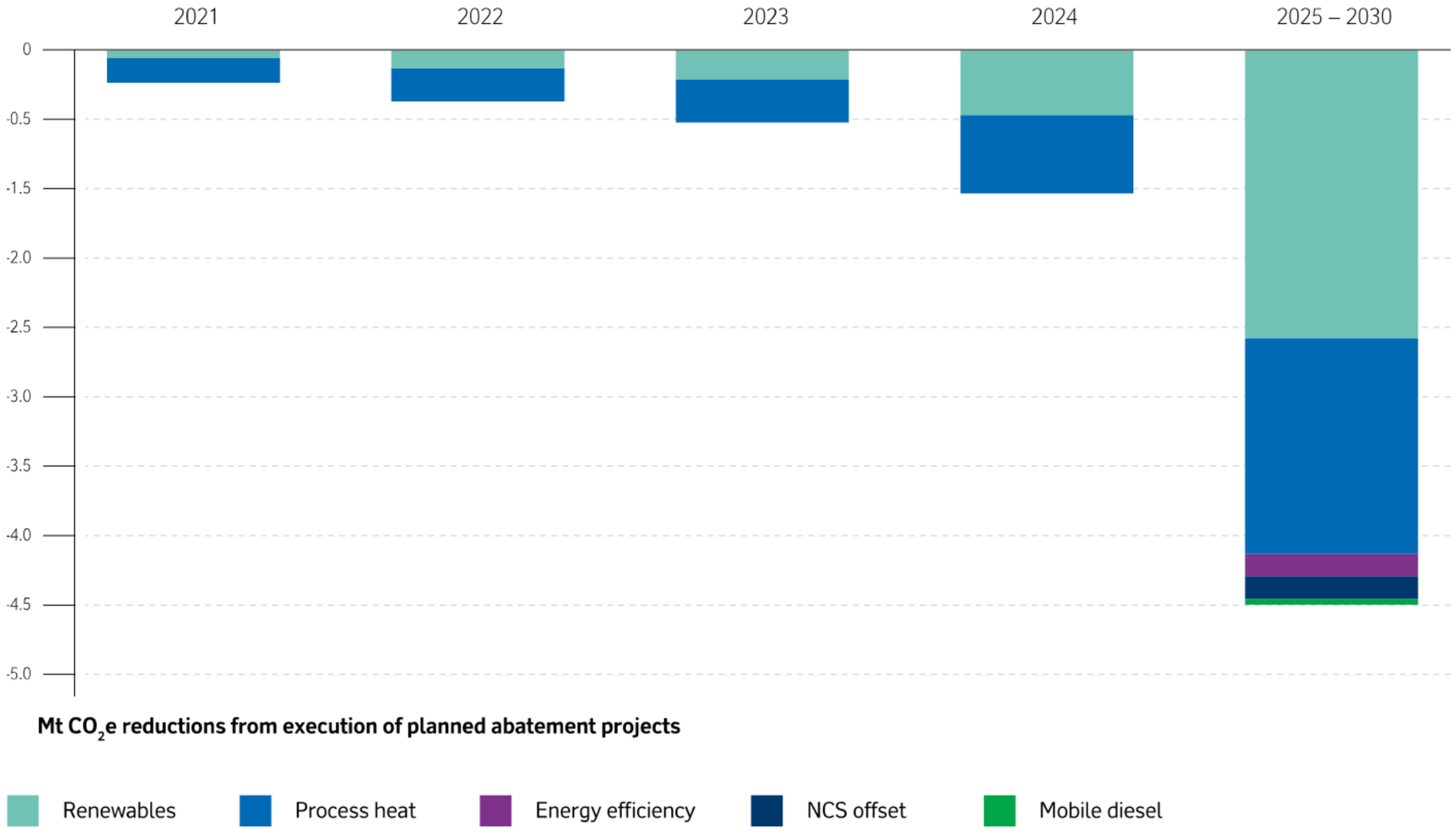
Fortescue is developing the world’s first Infinity Train with zero emissions. The regenerative battery electric train will use gravitational energy to fully recharge its battery electric systems without any additional charging requirements on the return trip.

The Infinity Train will not only accelerate Fortescue's quest to become carbon neutral by 2030, but also reduce operating costs, improve maintenance efficiency, and increase productivity potential.

This technology will help reduce emissions in the hard-to-abate heavy industry sector, with significant potential for global commercialization

Research and development costs for the Infinity Train are expected to be $50 million over the next two years

RIO TINTO: DECARBONIZATION STRATEGY



By 2030, the company plans to reduce Scope 1 and 2 emissions by 15% (45 million tons CO2) through

- Use of renewable energy resources
- Electrification of heat production processes
- Improving energy efficiency

KAZ MINERALS: DECARBONIZATION STRATEGY

- The company continuously strives to implement advanced technologies in its mining and processing operations to optimize operational performance and minimize resource usage.

- In 2021, the company expanded the use of artificial intelligence in mining and processing operations to improve production efficiency and reduce energy consumption per ton of produced copper.

- KAZ Minerals implemented the TRIT-AI system at the Aktogay sulphide ore processing plant, which is now being deployed at Bozshakol and the second sulphide ore processing plant in Aktogay. The tool uses advanced analytics to optimize ore beneficiation processes.

•The result of using the tool is the optimization of throughput and recovery rates at processing plants. Pilot implementation at Aktogay demonstrated an increase in copper recovery and ore processed.

•This allows the company to operate more efficiently and reduces energy consumption per ton of produced copper. The effect of the implementation amounted to 37 thousand tons of CO2 or 2% of the company's total emissions.

COMPARISON OF ACTIONS

Summary of the action	Efficiency improvement	Sustainable fuel	Alternative modes of transport	Electricity generation from RES
Emission sources	Electricity, gas, diesel	Diesel	Diesel	Electricity and gas
Emission reduction potential in %	from -5 to -20%	from -40 to -70%	-100% at full realisation	-100% at full realisation
Technological readiness (from 1 to 3)	3	3	2	2
Investments	Low	Average	High	Average

EVALUATE THE TECHNICAL AND ECONOMIC FEASIBILITY OF IMPLEMENTING DECARBONIZATION ACTIONS AT YOUR ORGANIZATION

Actions	Technologically possible	Economically justified
Improvement of energy efficiency and production modernisation		
Utilisation of renewable energy sources (RES)		
Full electrification of thermal needs: Transition from gas to RES electricity		
Transition to sustainable fuels (biofuels or synthetic fuels)		
Transition to alternative modes of transport		

WHAT ACTIONS HAVE ALREADY BEEN IMPLEMENTED AT YOUR COMPANY?

Utilization of renewable energy sources:_____

Energy efficiency improvement:_____

Utilization of alternative fuels and/or modes of transportation:_____

Other actions:_____

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ASSESSMENT OF CLIMATE RISKS

- Credit Risk Associated with ESG (Environmental, Social, and Governance): Risk of facing higher interest rates and difficulties in accessing financing due to strict ESG compliance requirements.

- Regulatory Risk: Risk of potential changes in national climate-related legislation, including greenhouse gas taxation, carbon footprint reduction targets, and potential litigation for non-compliance with regulatory requirements.

- Market risk: Risk exposure to carbon taxation in importing countries of production.

- Customer Risk: Risk of losing customers due to failure to meet their decarbonization targets as a supplier.

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ASSESSMENT OF CLIMATE RISKS

Risks related to the negative impact of climate change on operations:

- Operational risk for the mining industry and tailings storage facilities due to changes in precipitation
- Operational risk due to extreme temperatures
- Operational risk due to extreme weather conditions in the mining industry and at tailings storage facilities
- Operational risk due to water scarcity

ASSESS THE IMPACT THAT THE RISK MAY HAVE ON YOUR ENTERPRISE AND THE PROBABILITY THAT THE RISK WILL MATERIALISE

RATE FROM 1 LOW)TO 5 HIGH)

Risk	Impact	Probability
Credit risk: Access to capital		
Regulatory risk: Stricter legislation		
Market risk: Taxation of imports		
Customer risk: Loss of markets		
Operational Risk: Changes in precipitation levels		
Operational Risk: Extreme temperatures		
Operational Risk: Extreme weather conditions		
Operational risk: Water scarcity		

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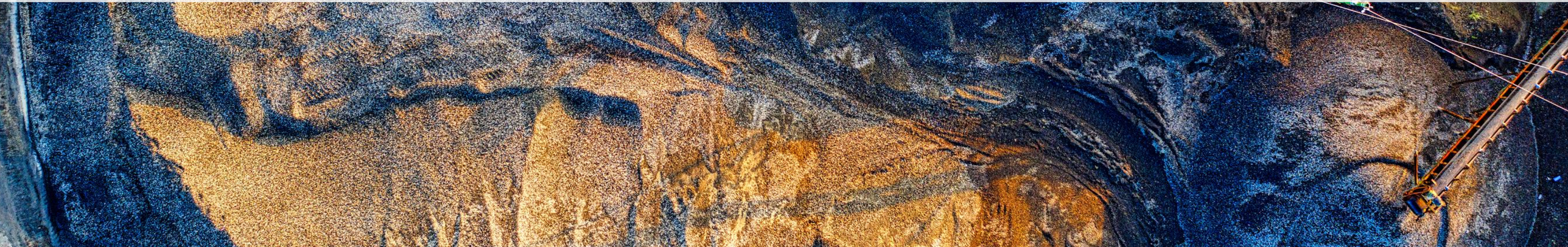
RESULTS OF GROUP WORK

- What are the main sources of GHG emissions in your industry?
- What goals do your companies set for themselves?
- Which decarbonization measures do you consider most realistic?
- Which measures have already been implemented?
- What are the main climate risks for your company?

DECARBONIZATION OF THE MINING SECTOR ?

Module 1 – Additional information



SECTORAL DECARBONIZATION: MINING INDUSTRY

More ambitious goals for reducing Scope 1 and 2 emissions.

Focus: renewable electricity and energy production (reducing emissions by 30-35%), replacing diesel-powered mining equipment (by 40 to 50%).

Targeting mines with the highest emissions and eliminating emissions from multiple sources.

SECTORAL DECARBONIZATION: MINING INDUSTRY

•The path highly depends on the type of operation.

Several decarbonization options:
- Scope 1 and 2: Improving operational efficiency, sustainable fuels, alternative transmissions.
- Scope 2: Green electricity, renewable energy sources.
- Scope 3: Sustainable sourcing of raw materials and engagement with customers.

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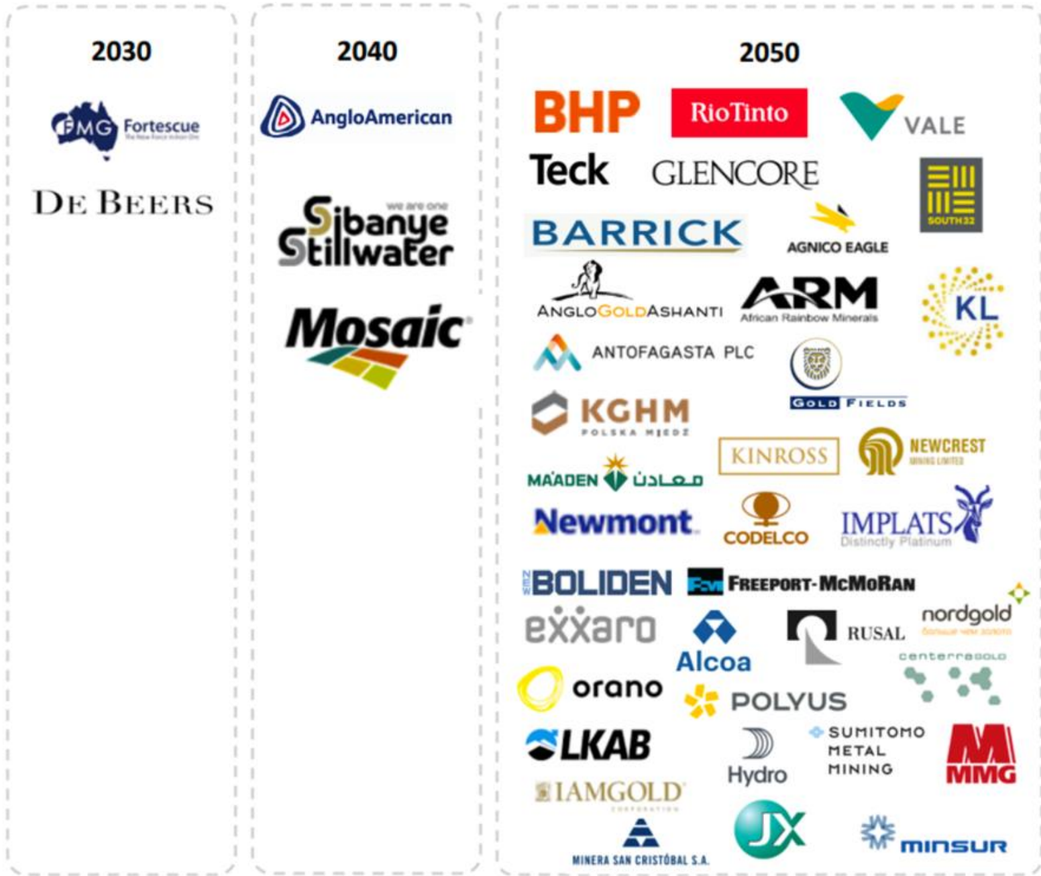
SECTORAL DECARBONIZATION: MINING INDUSTRY

- The mining industry accounts for approximately 2 to 3% of global greenhouse gas emissions.
- There is an increasing number of companies setting decarbonization targets for Scope 1 and 2 emissions.

COMPANIES WITH ZERO DECARBONISATION TARGETS AND TARGET YEAR. SOURCE: GLOBAL DATA.



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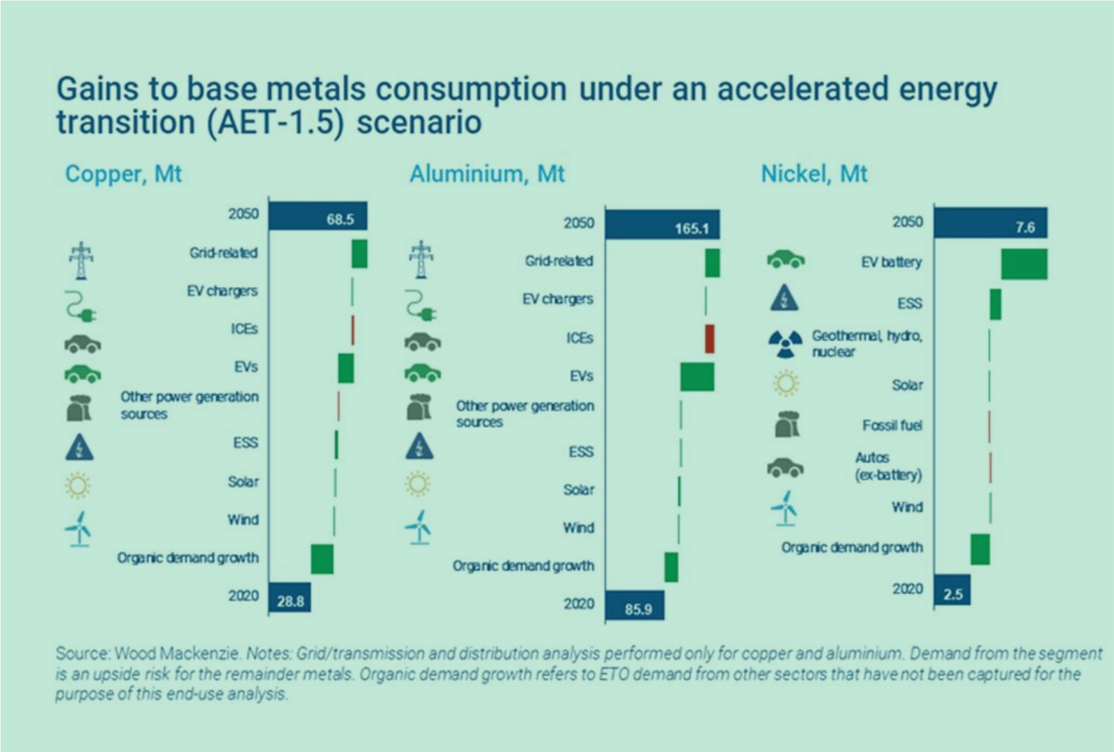
THE MAIN CHALLENGE FOR THE SECTOR



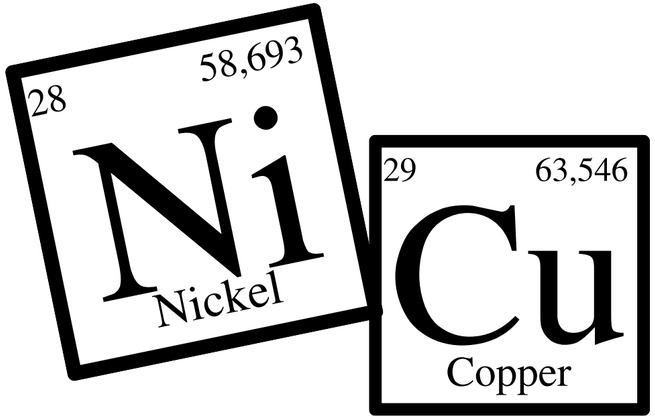
Copper and nickel mining value chains will need to reduce absolute emissions by around 90%:

-Copper: from 85 million tonnes CO2eq/year to 8.5 million tonnes CO2eq/year

-Nickel: from 88 million tonnes CO2eq/year to 8.8 million tonnes CO2eq/year

To meet future demand for key minerals, the supply will need to increase:

- Copper: from 25.8 million tonnes to 68.5 million tonnes.
- Nickel: from 2.5 million tonnes to 7.5 million tonnes.



DECARBONIZATION OF THE MINING SECTOR ?

Module 1 – Additional information

RIO TINTO: PROGRESS AND BEST PRACTICES

PROGRESS

Emissions	Total Scope 1 and 2 emissions were 7% higher in the 2021 fiscal year at 2.22 million tonnes of CO2-equivalent due to operational expansion.
Electrification	In partnership with Williams Advanced Engineering: a battery system to power a 240-ton electric quarry truck + rapid charging unit, utilizing renewable energy. Testings include replacing diesel engines in heavy mining equipment with electric motors powered by hydrogen fuel cells. Also, testing an environmentally friendly drilling rig powered by hydrogen.
Renewable recourses	Over $700 million USD has been invested in renewable energy initiatives, including 150 MW of photovoltaic solar panels and large-scale battery storage

MINING THE FUTURE

SUMITOMO METAL MINING: SUSTAINABLE DEVELOPMENT STRATEGY PROGRESS

GOALS

Emission reduction targets	Reduce greenhouse gas emissions by at least 26% compared to the 2013 fiscal year. Expand contributions to greenhouse gas emissions reduction through products contributing to a low-carbon society.
Net zero target year	Carbon neutral by 2050.

SOLUTIONS

Renewable energy	Reduction in emissions with solar energy
Reduction in diesel fuel usage	Not mentioned. Commitment to increase avoided greenhouse gas emissions through the creation of battery materials.
Alternative	Developing technologies to create value from unused resources of non-ferrous metals, commercializing recycling technologies.
Consumption	1 billion yen ($7 million) spent on research and development. 0.02% of revenues is reinvested in R&D.

SUMITOMO METAL MINING: PROGRESS AND BEST PRACTICES

PROGRESS

Emissions	Efforts to maintain greenhouse gas emissions below the 2013 fiscal year level (as of 2021) + reducing emission intensity by 5%. Implementation of an internal carbon pricing system.
Renewable sources	Reduction of greenhouse gas emissions through solar energy and other sources generated at the SMM solar power station in Kasama, Ibaraki Prefecture (approximately 1.6 thousand tons of CO2-equivalent in the 2021 fiscal year).

Best Practices:
- Research and development for sustainable and efficient smelting technologies, mineral extraction, and efficiency enhancement.
- Low-carbon footprint in mining operations through efficient technology utilization.
- Implementation of an internal carbon pricing system.

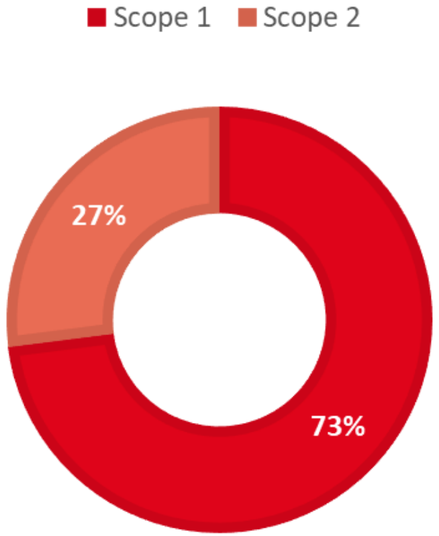
FORTESCUE METAL: PROGRESS AND BEST PRACTICES

PROGRESS

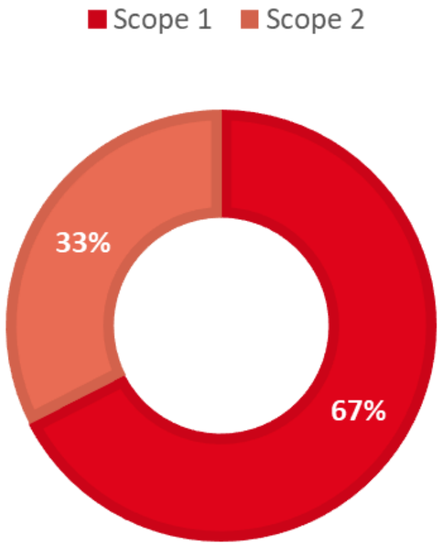
Emissions	Total Scope 1 and 2 emissions were 7% higher in the 2021 fiscal year at 2.22 million tonnes of CO2-equivalent due to operational expansion.
Electrification	In partnership with Williams Advanced Engineering: a battery system to power a 240-ton electric quarry truck + rapid charging unit, utilizing renewable energy. Testings include replacing diesel engines in heavy mining equipment with electric motors powered by hydrogen fuel cells. Also, testing an environmentally friendly drilling rig powered by hydrogen.
Renewable recourses	Over $700 million USD has been invested in renewable energy initiatives, including 150 MW of photovoltaic solar panels and large-scale battery storage

"COMPARISON OF COMPANIES

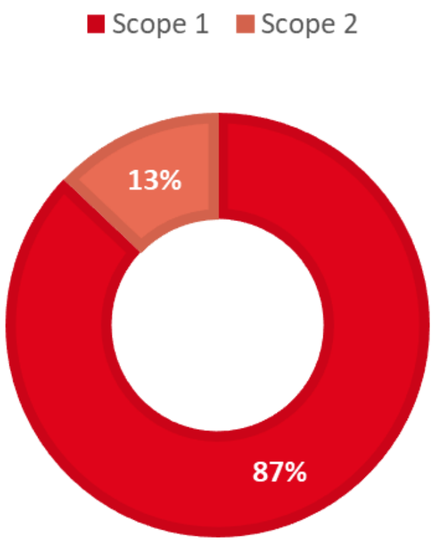
Breakdown of emissions for categories 1 and 2 (in million tons of CO2-equivalent)



Rio Tinto (2021):
Scope 1: 22.7 mil. tons CO2-eq
Scope 2: 8.4 mil. tons CO2-eq
Total: 31.1 million tons CO2-eq

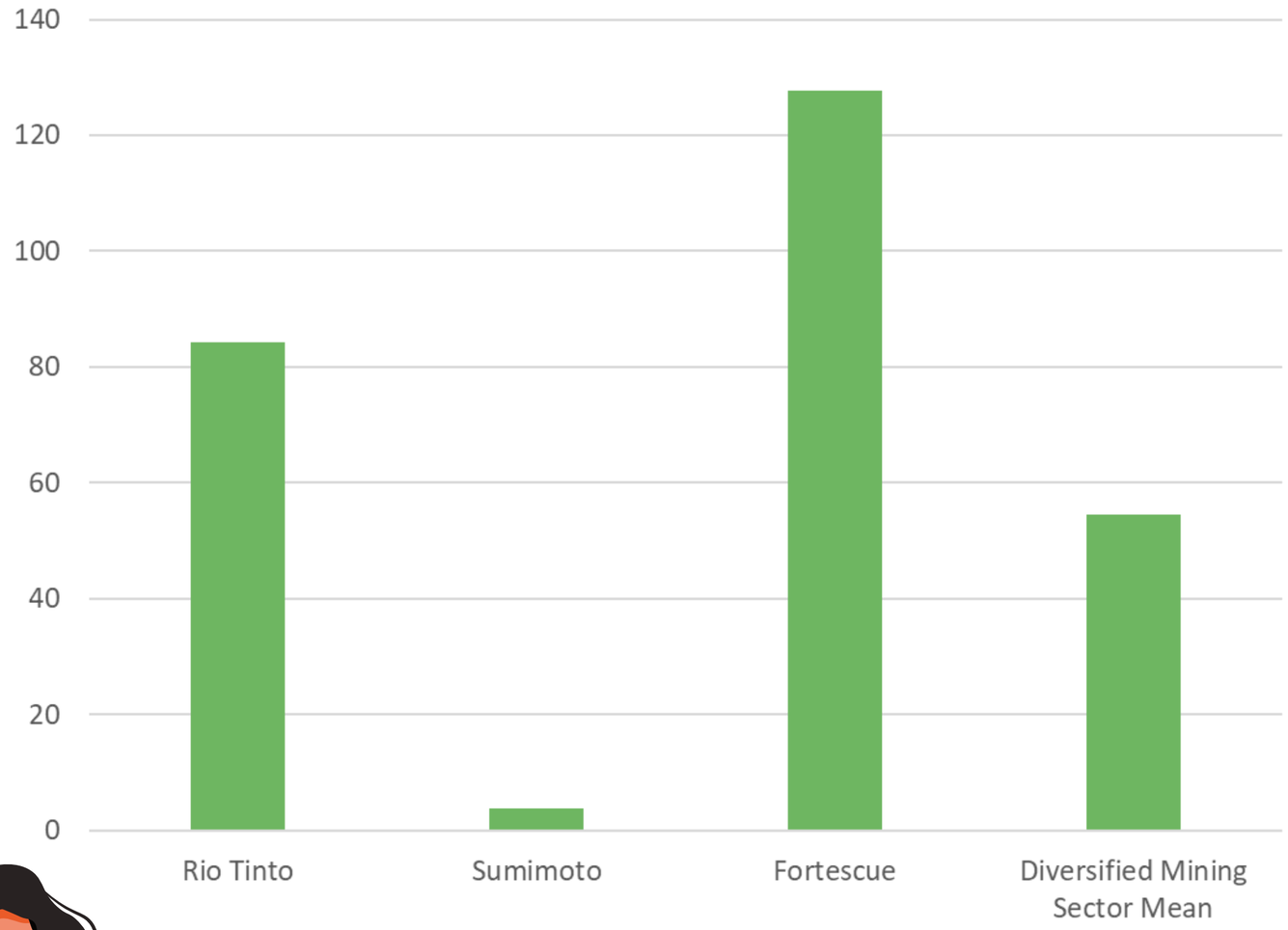


Sumitomo (2021):
Scope 1: 1.786 mil. tons CO2-eq
Scope 2: 0.861 mil. tons CO2-eq
Total: 2.647 mil. tons CO2-eq



Fortescue (2022)
Scope 1: 2,22 min. tonsCO2-eq
Scope 2: 0,33 min. tons CO2-eq
Total: 2,55 min. tons CO2-eq.

"COMPARISON OF COMPANIES



Source: Pathways Initiative. For information on methodology and indicator selection.
*Since Sumitomo mainly focuses on smelting and refining, the carbon intensity of Sumitomo's minor operations is below average.

Carbon intensity (tonnes of CO2 equivalent per tonne of copper equivalent), fiscal year 2020:
- Rio Tinto: 84.20
- Sumitomo: 3.85
- Fortescue: 127.73

Average for diversified mining sector: 54.47

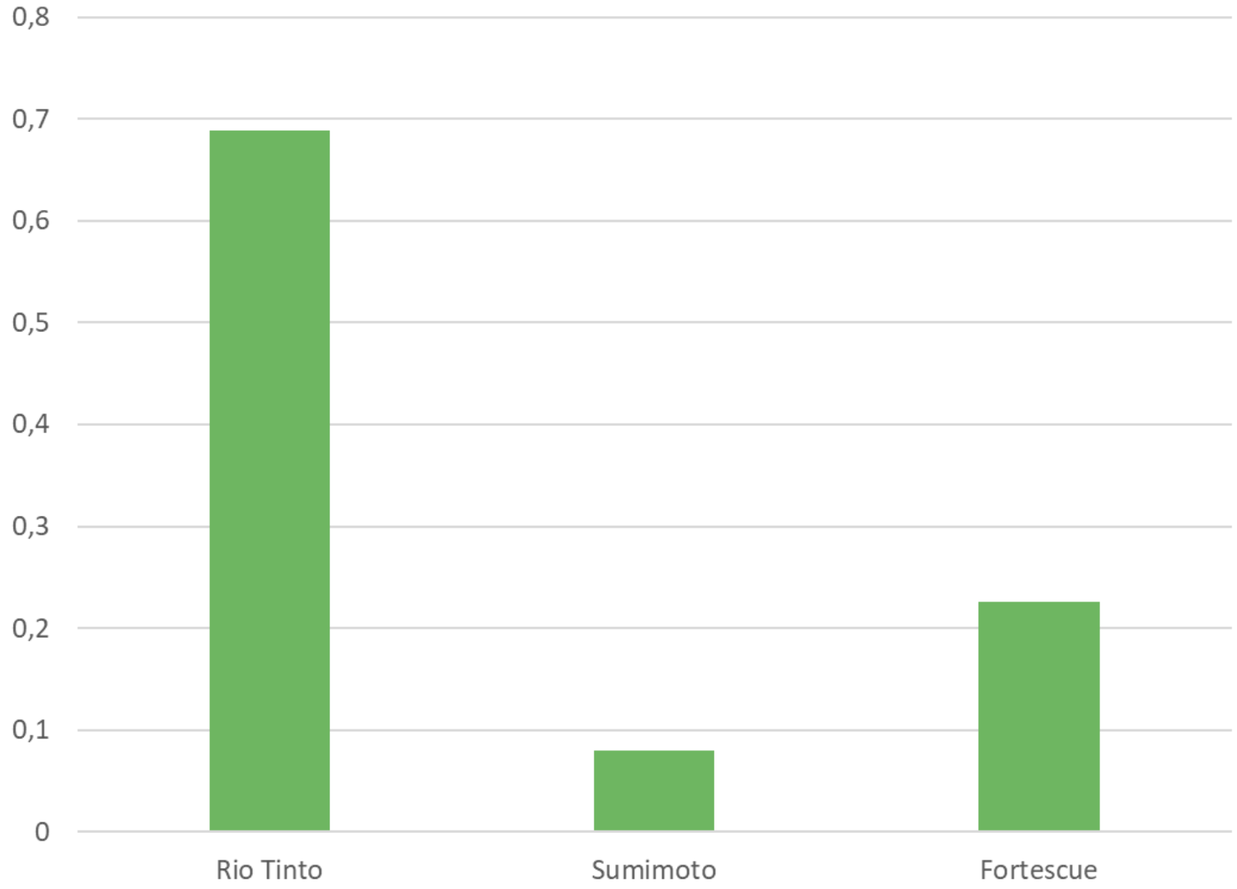
Compare also by revenue (Scope 1 and 2 area/million dollars).

Carbon intensity depends on various factors, including the country of production and its energy balance, the operations in which the company engages, and the utilization of local energy/electricity..

COMPARISON OF COMPANIES BASED ON REVENUE

Carbon intensity based on revenue (tonnes of CO2 equivalent per billion US dollars), fiscal year 2022:

- Rio Tinto: 0.69 (revenue $45.2 billion)
- Sumitomo: 0.08 (revenue $33 billion)
- Fortescue: 0.23 (revenue $11.3 billion)



Source: Rio Tinto, Sumitomo, Fortescue sustainability strategies.

DECARBONIZATION ROADMAP

"DECARBONIZATION GUIDE"

Institute of Mineral Resources Research, Western Australia: Report on Decarbonization Pathways for the Australian Mining Sector.

Determine: Identify the emission profile of the mine and critical sectors.
Target: Establish short-term and long-term objectives.
Plan: Determine the best approach and prioritize actions.
Implementation: Engage with stakeholders and ensure strictness and transparency.

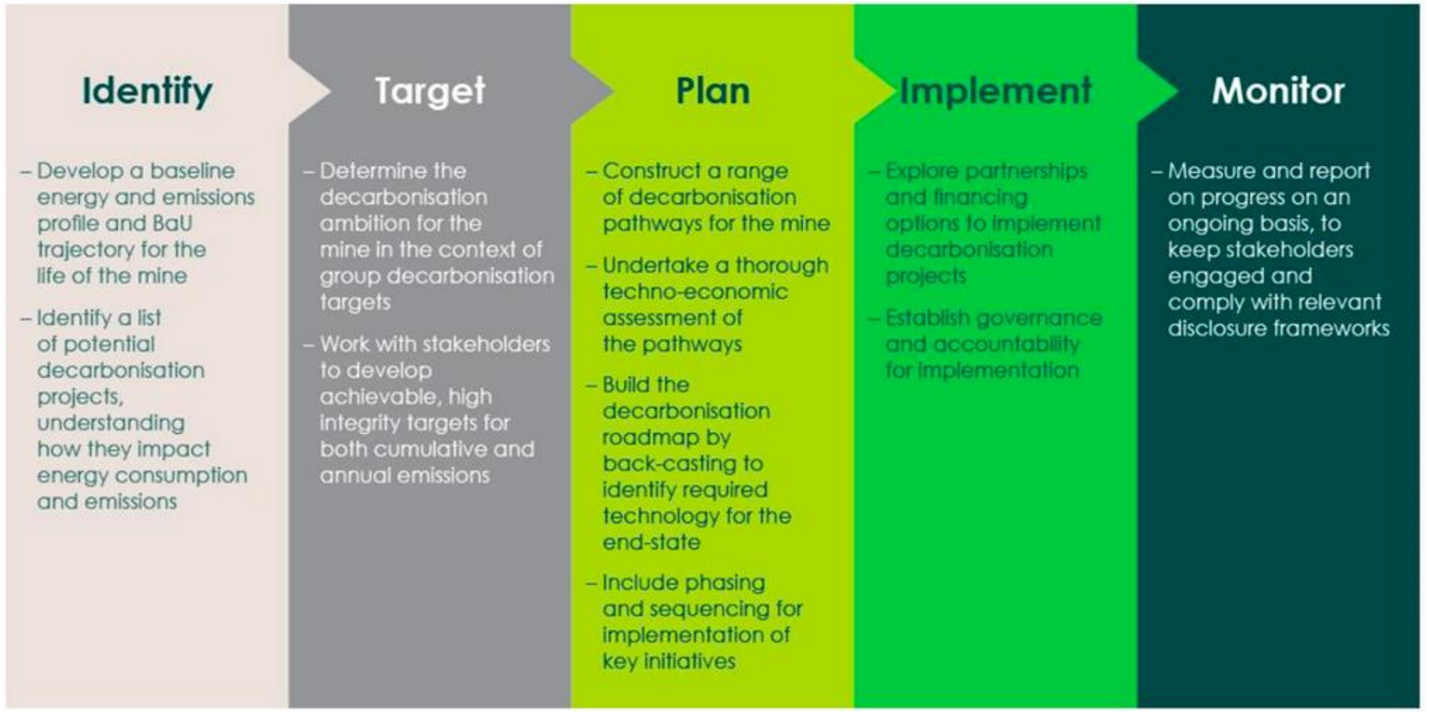


Figure 1: Moving from intent to action – steps to decarbonisation

Monitoring: use of generally accepted disclosure schemes (TCFD)

EXAMPLE: ZERO MINE

- An ideal case: copper production from mine to metal, located in remote Western Australia with a remaining mine life of 25 years.

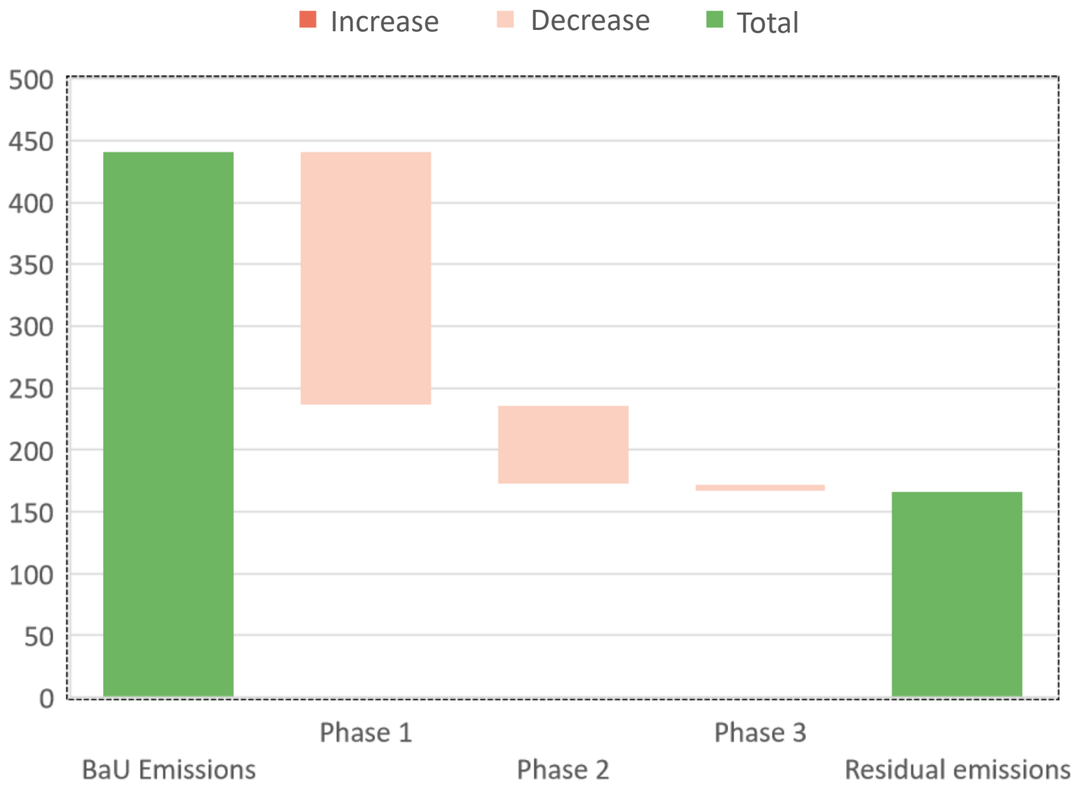
• Fossil fuels (natural gas and diesel fuel) dominate the energy value chain.

• Total annual emissions in Year 1: 441 thousand tonnes of CO_2 equivalent.
• 70% Electricity generation from natural gas.
• 14% Diesel fuel combustion.
• 10% Natural gas consumption for thermal processes.

• 4 decarbonization pathways with 3 stages: short-term, medium-term, and long-term.

MINE ZERO PATHWAY 1: ESTABLISHED TECHNOLOGY

Reduction in emissions on an annual basis for each phase of Pathway 1 (thousand tons of CO2-equivalent).



An ideal case: copper production from mine to metal, located in remote Western Australia with a remaining mine life of 25 years.

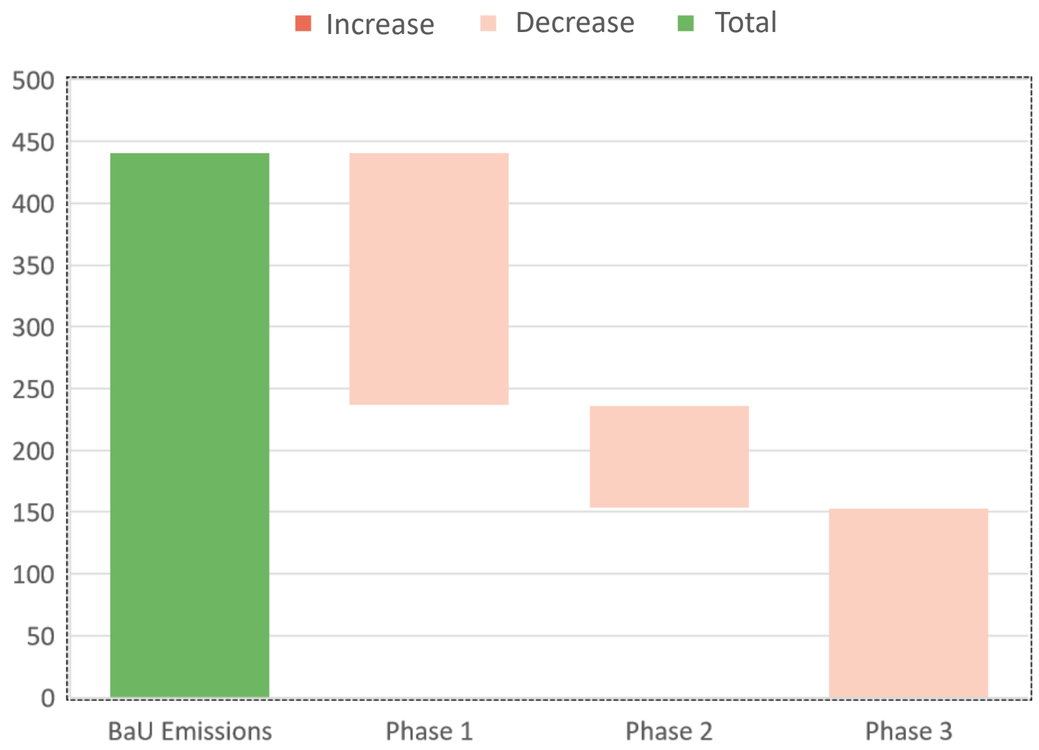
- Prioritization of electricity production from renewable sources onsite.
- Electrification of thermal processes and use of natural gas.
- Diesel remains in the mix, offsetting remaining emissions.
- Approximate percentage of emissions they can reduce using currently available technologies.

Total capital expenditure (CAPEX): $744 million

Source: cefc and mriwa

MINE ZERO PATHWAY 2: ELECTRIFICATION

Reduction in emissions on an annual basis for each phase of Pathway 1 (thousand tons of CO2-equivalent).



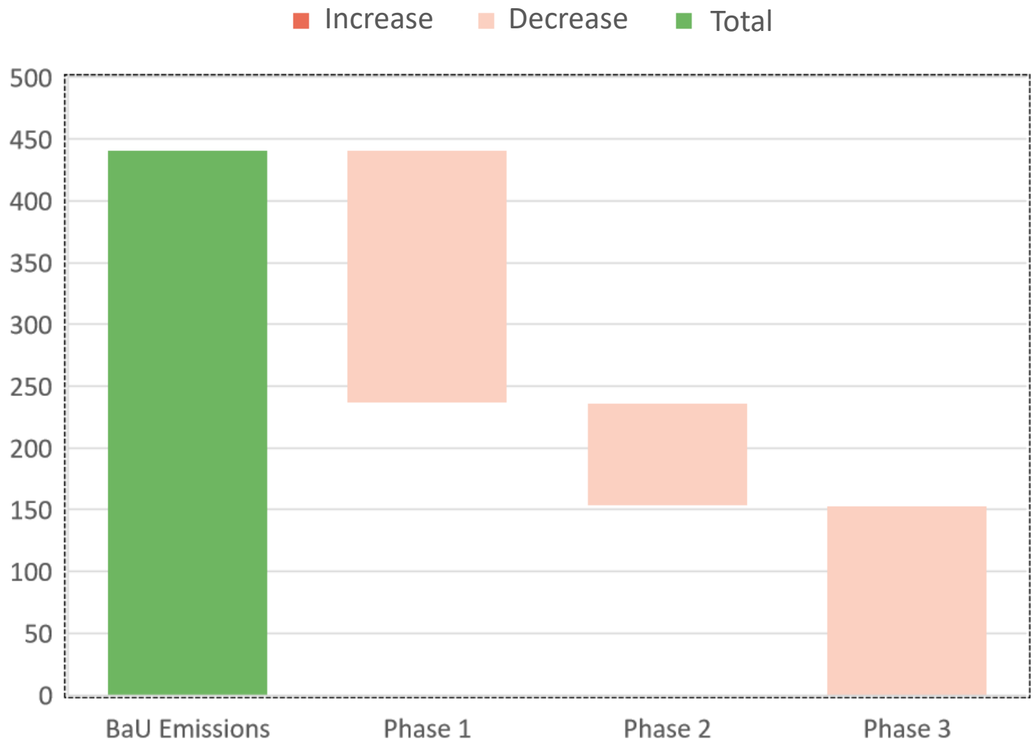
- Phase 1: Common for all pathways (focused on RE generation)
- Phase 2: Complete electrification of heat needs + battery power
- Phase 3: Phased elimination of diesel fuel with the import of e-fuel to also replace the remaining natural gas in electrification. Additional renewable energy capacity to meet electricity needs.

Total capital investment: $1.072 billion.

Source: cefc and mriwa

MINE ZERO PATHWAY 4: HYDROGEN PRODUCER

Reduction in emissions on an annual basis for each phase of Pathway 1 (thousand tons of CO2-equivalent).



- Phase 1 Common for all pathways.
- Phase 2: Increase in renewable energy capacity + implementation of batteries (diesel fuel still used for transport and natural gas for the remaining electricity generation)
- Phase 3: Phased elimination of diesel fuel, replacement with on-site hydrogen production + additional batteries

Total capital investment: $3,011 billion.

Source: cefc and mriwa

CONCLUSION

- There are various decarbonization pathways for the mining industry with different costs and effects.
- Costs and actions depend on the current situation, mine characteristics, type of ore extracted, and location.
- Focus on electrification, decarbonizing energy production, and phasing out diesel fuel.
- Many options are already available to start the decarbonization journey: energy efficiency and renewable energy.
- Focus on research and development.
- Split Scope 1 and 2 emissions by operations and sources.
- Disclose Scope 3 emissions, partner with processing companies to reduce them.
- Adoption of an internal carbon pricing system.