Heavy industry, Lighter footprint

Latin America's path to a decarbonised metals industry

Julian Kettle
Chairman of Metals and Mining

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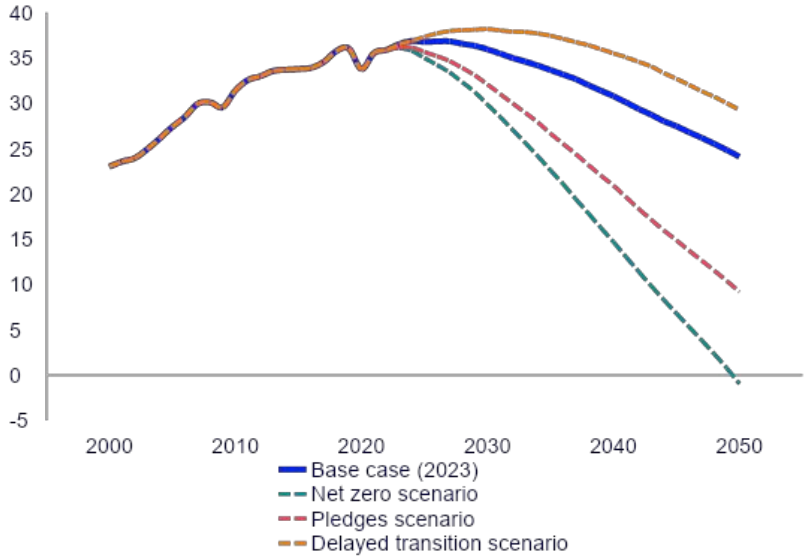
Less focus on the transition as energy security and slow economic growth trump low carbon solutions, so a slower transition looks likely

Net zero policies are being scaled back as fiscal and geopolitical pressures push governments to prioritize domestic issues. Tariffs and slow growth worsen challenges—unless China accelerates its transition

Key points from COP 28 and 29 | Non-Exhaustive

Fossil Fuels	▪ Transitioning away from fossil fuels ▪ Natural gas as the bridging fuel
Low Carbon	▪ Triple Renewables capacity by 2030; nuclear by 2050 ▪ Double the rate of energy efficiency improvements by 2030 ▪ Nuclear energy solidified as a cornerstone of decarbonization ▪ Conclusion of the first ever Global Stock Take (GST) emphasizing the need for determined action on renewable energy and a just transition
Finance	▪ Climate finance gap may balloon to US$4-5 trillion a year by 2030 ▪ Secure a new goal on climate finance, stronger climate action, emissions reduction, and building resilient communities ▪ Further discussions on equitable climate finance, fossil fuel subsidy reform, national climate commitments and climate justice

WM Scenarios: Global Energy-Related CO_2 Emissions (Bt)

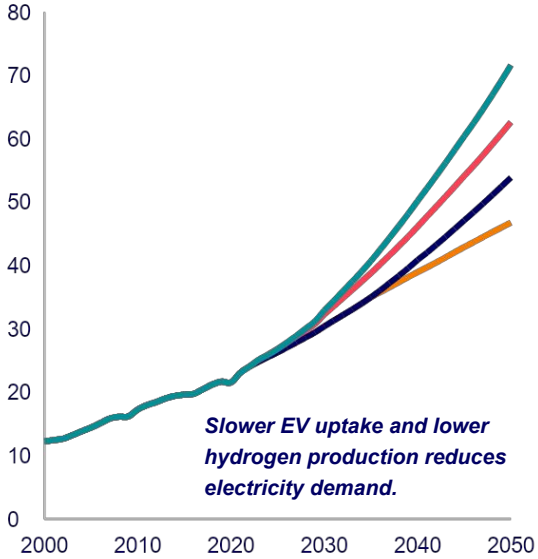


Source: Wood Mackenzie

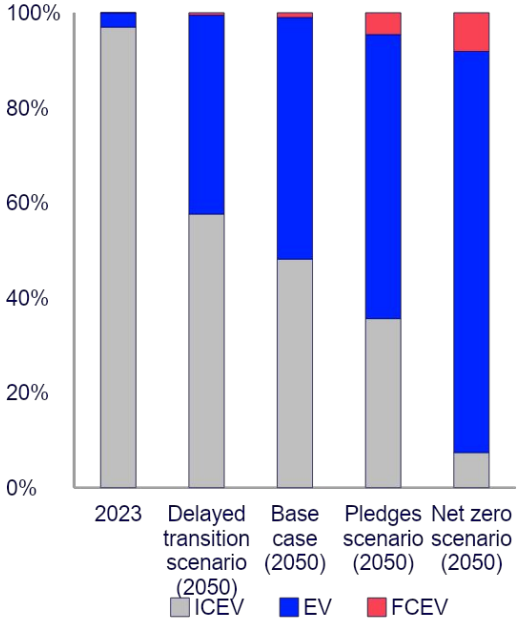
Irrespective of the pace of the transition electrification is the future; are renewables, storage and EVs the solution ?

"Critical minerals" supply, storage, grid expansion, economic backdrop and geopolitics among the challenges

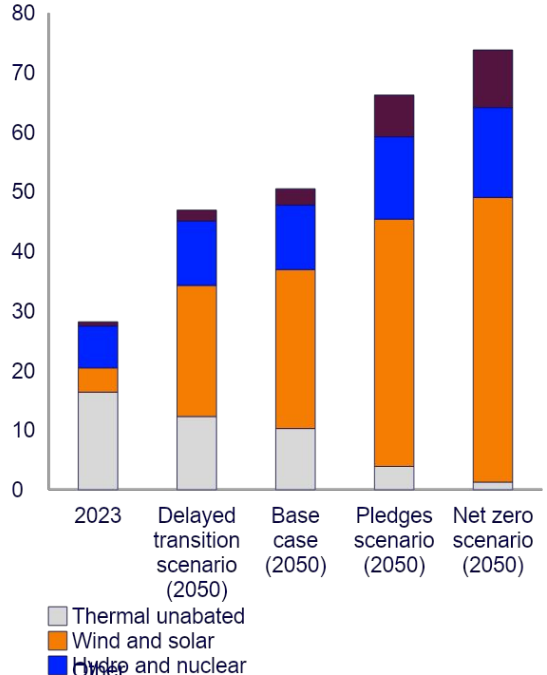
Electricity Demand (PWh)



Road Transport Share by Type (%)



Electricity Generation (PWh)

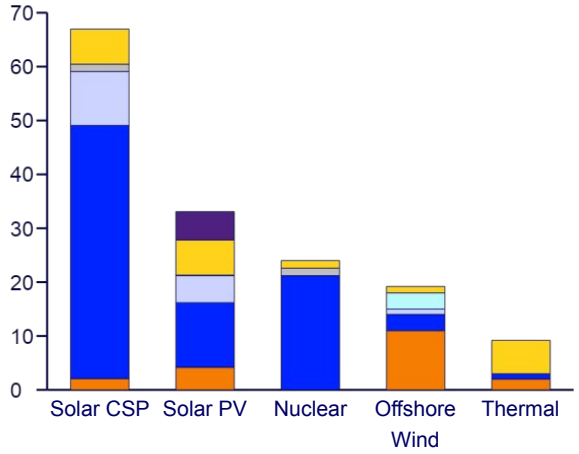


Source: Wood Mackenzie

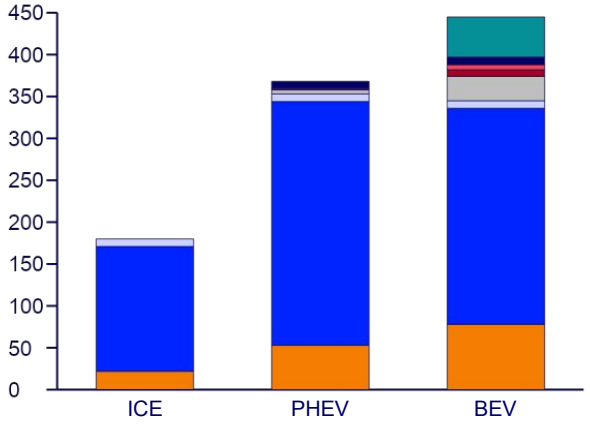
The generation, transmission, storage and use of electrons is becoming more metals intensive and with an ever-growing list of “critical” metals

Offshore wind needs up to 15x more copper than a coal-fired plant and there is a need for storage!

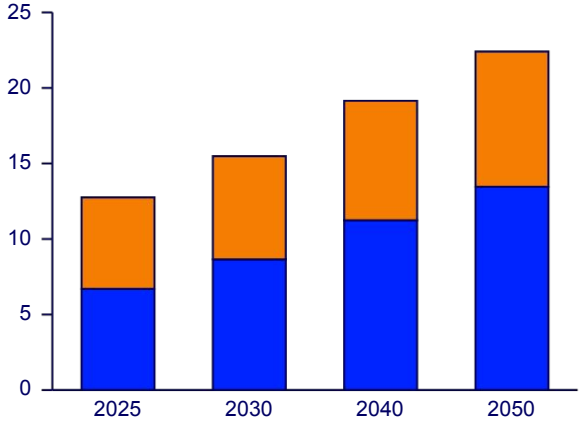
Base Metals Used in Clean Energy Technologies (kt/GW)



Metals Used in Passenger ICEs, PHEV, and BEVs (kg/unit)



Consumption in Transmission and distribution networks (Mt)

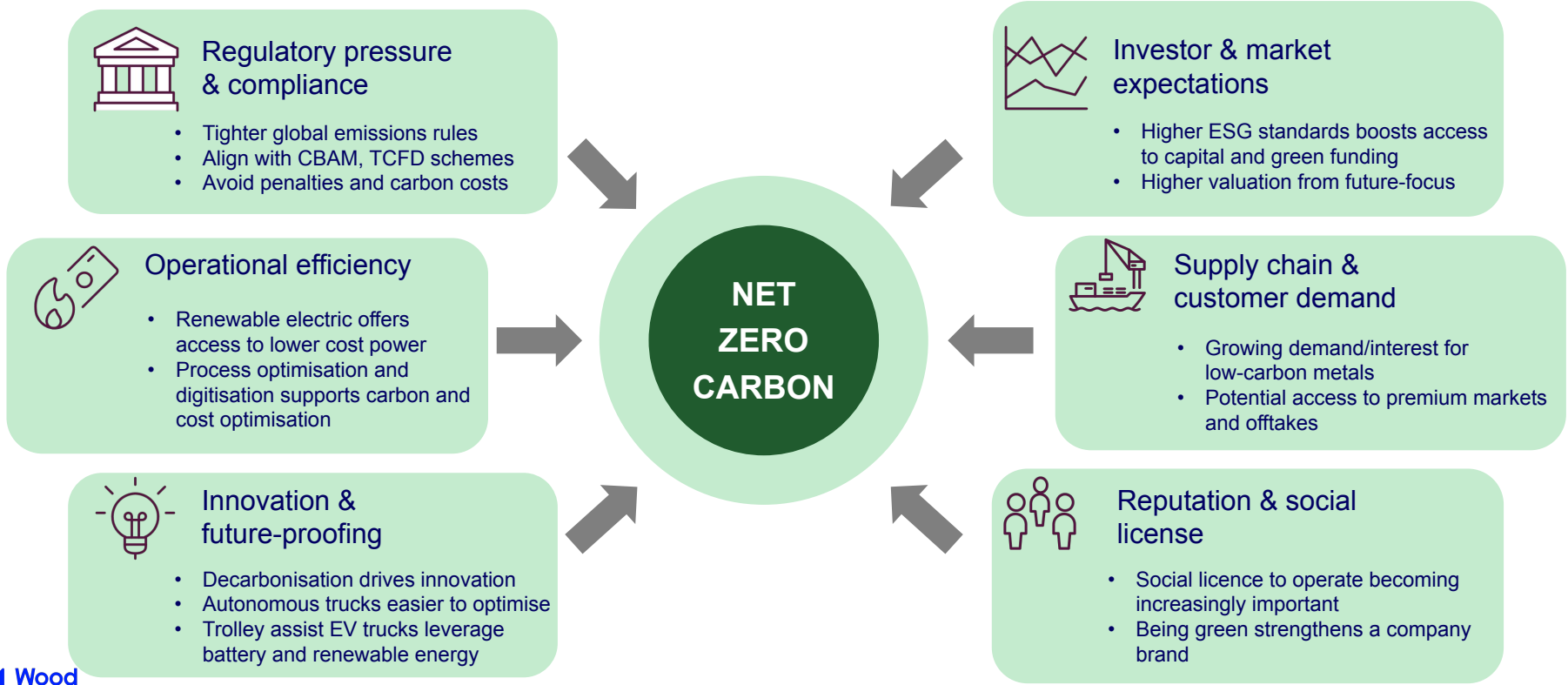


Wood Mackenzie

Source: Wood Mackenzie

Strategic drivers for metals decarbonisation

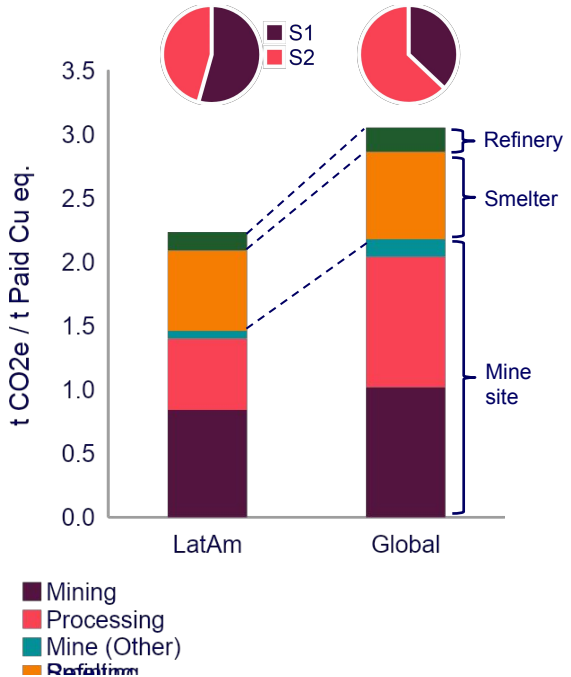
Compliance, competitiveness, future proofing, access to capital, customer demand and social license



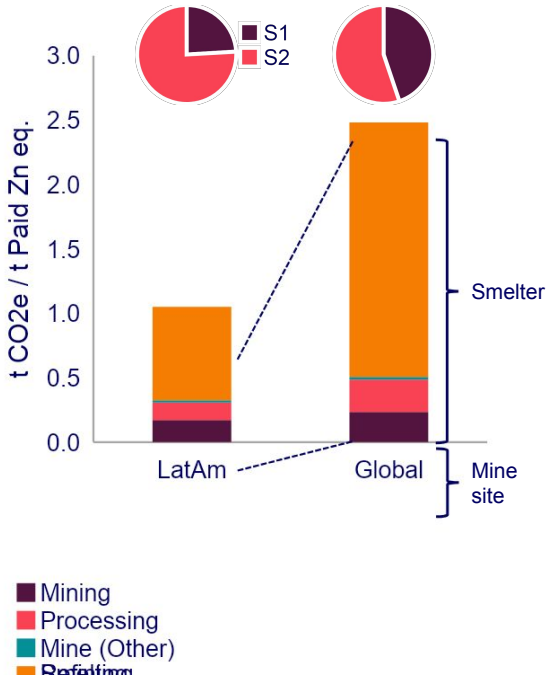
Carbon emissions: Current performance snapshot

LatAm's scope 1 & 2 emission profile compares favourably, underpinned by good renewable power availability

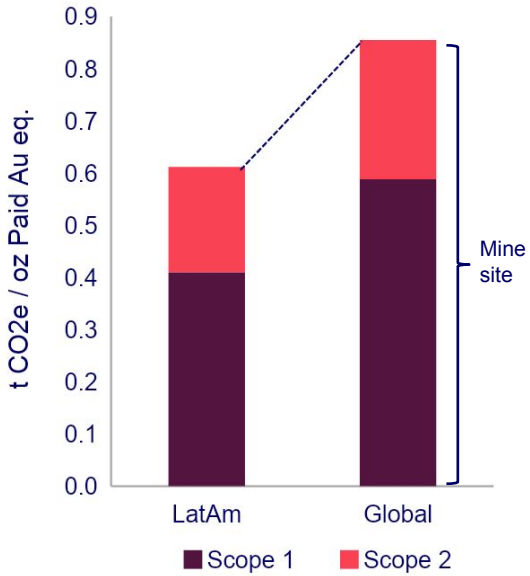
Copper mining, smelting & refining*



Zinc mining & smelting



Gold mining



* Copper from concentrate, excluding production via Sx-Ew processes.

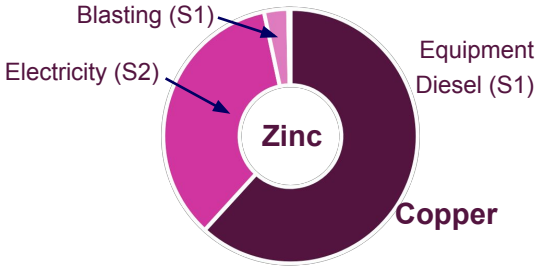
Source: Wood Mackenzie Emissions Benchmarking Tool

Carbon emissions: Targeting key sources for Latin American abatement

Each industry segment has its own unique set of decarbonising opportunities and challenges

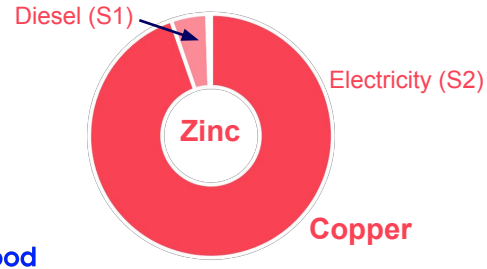
Mining emissions by source

*Mining activities account for **38%** of LatAm's total copper value chain emissions & **16%** of zinc's*



Mine site processing emissions by source

*Mine processing activities account for **25%** of LatAm's total copper value chain emissions & **13%** of zinc's*



Scope 1 Direct Emissions

Emissions from operations, including equipment and processes, that a company directly controls.

Scope 2 Indirect Emissions

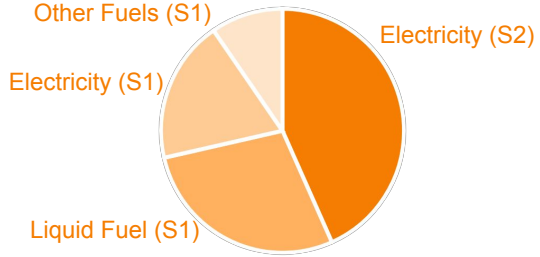
Emissions from electricity used by operations, generated indirectly and typically from the grid.

Scope 3 Indirect Emissions

Emissions from sources not owned or controlled and include supply chain, transportation, product usage

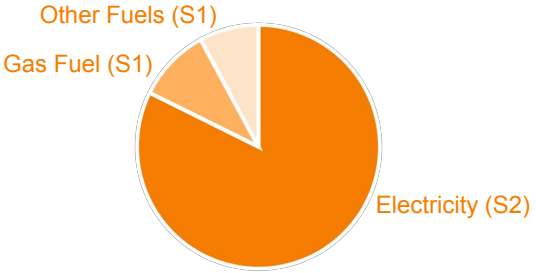
Copper smelting emissions by source

*Smelter operations account for **22%** of LatAm's total copper value chain emissions*



Zinc smelting emissions by source

*Smelter operations account for **69%** of LatAm's total zinc value chain emissions*



Source: Wood Mackenzie Emissions Benchmarking Tool

Scope 1 abatement: Requires a proactive multifaceted strategy

Hybrid/BEV/FCEV mining equipment

Haul trucks represent bulk of emitters from mine fleets, but there is a growing list of OEM/, mining company and initiatives to provide electrified options, including:

- Electric trolley
- Recharging stations
- Hydrogen refuelling and storage
- Electrolysers

More efficient mines = less emissions

Autonomous mine fleets with big data optimisation management of mining fleets will lead to more efficient digging, improved truck queuing, optimal drilling for improved productivity and less fuel. But requires a fundamental re-evalution of mine designs and potential fleet and truck sizes.

Biofuels to replace diesel

Seen as a stop gap for mobile mine equipment decarbonisation An option to replace diesel in ANFO explosives

Removing carbon from processes

Hydrogen and electricity replacements in roasting, calcining, drying, reduction processes reliant on coal and other fossil fuels

Recycling to play a pivotal role

The secondary metal market is fundamental to the global net zero pathway including smelting with goals of 100% scrap use

Heat recovery improvements

Recovery of heat generated during smelting/ refining processes to improve overall facility efficiencies and drive lower emissions

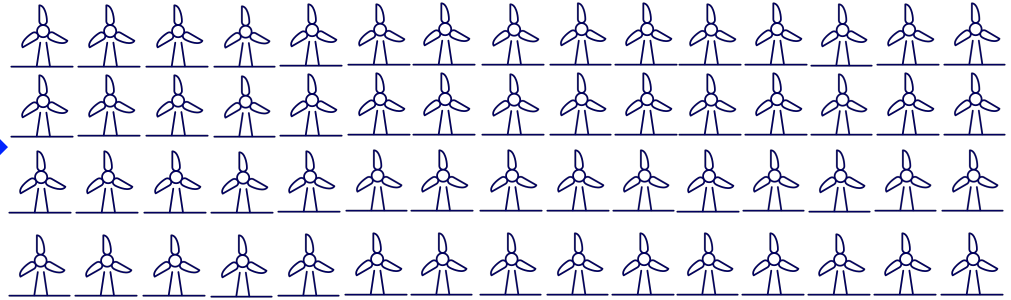
Scope 1 abatement: Scale of the challenge is huge e.g. electrification of mine haul fleet requires Denmark scale supply of renewable power

First miners must secure the power to run them, install grid infrastructure and then finance the trucks !

SCENARIO: Converting global copper mine haul trucks from diesel to electricity by 2030

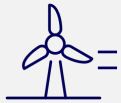
- 9.1 billion litres of diesel in 2030, surface and U/G mines
- Assume 65% used for haul trucks
- 6 billion litres for haul trucks
- 5.6 kWh of electrical energy equivalent/litre of diesel (90% efficiency for BEV versus 35% for diesel)

12 to 16 GW - Incremental renewable power equivalent for haul trucks alone



- ~35 TWh of electricity for haul trucks alone or the electricity used by Denmark in a year

- Critical for the mining industry to understand their power needs earlier to plan with electricity providers and governments



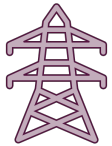
200 MW wind
35% capacity factor
No storage

Source: Wood Mackenzie

Scope 2 abatement: Options for reducing emissions from power ?

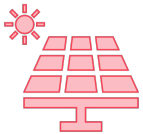
The dominant trend has been towards corporate renewable power purchase agreements

1 Rely on the grid energy mix



Advantage	Disadvantage
Typically, the grid is more accessible and convenient for end-users.	Chances of grid not being able to meet peak demand or adjust to extreme weathers
No capital investment required versus self-generation.	Potentially more exposed to price volatility and energy shocks.
	Little control over decarbonisation targets

2 Invest in self-generation



Advantage	Disadvantage
Can reduce grid interruptions by tapping into self-generated source for electricity needs	Huge upfront cost and maintenance cost
Some flexibility in capital management. Can control zero-carbon pathway	Non-core business or skill set
Control over net-zero pathway	

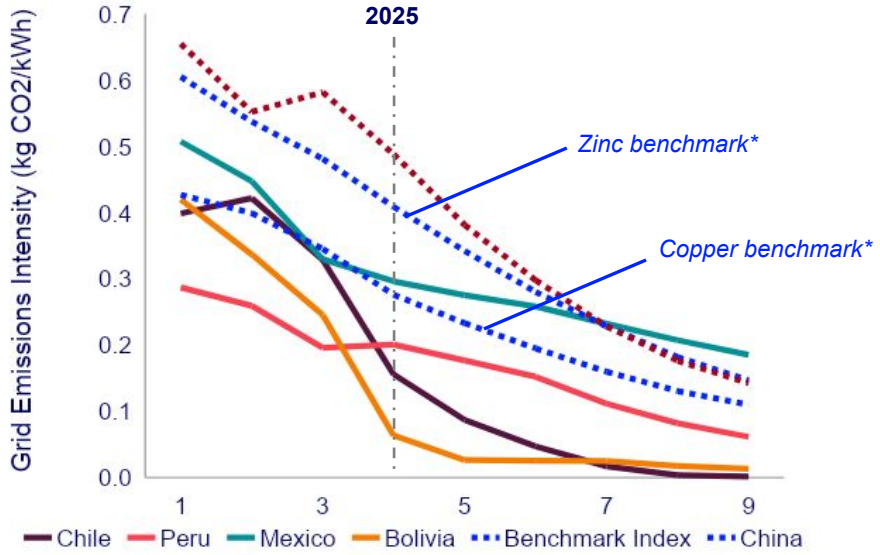
3 Power purchase agreements (PPAs)

Advantage	Disadvantage
The agreed upon price reduces corporate off-takers' exposure to market risk and allows them to hedge against any anticipated upward price pressure	May include annual cost escalations which may net off cost benefits reaped from reducing exposure to price volatility
Allows corporate off-taker to fulfil its climate target by having an option of only procuring renewable sources	May include penalties for early contract terminations

Scope 2 abatement: The outlook for electricity grid decarbonisation?

Renewables' rising competitiveness over fossil fuel options is accelerating LatAm's energy transition

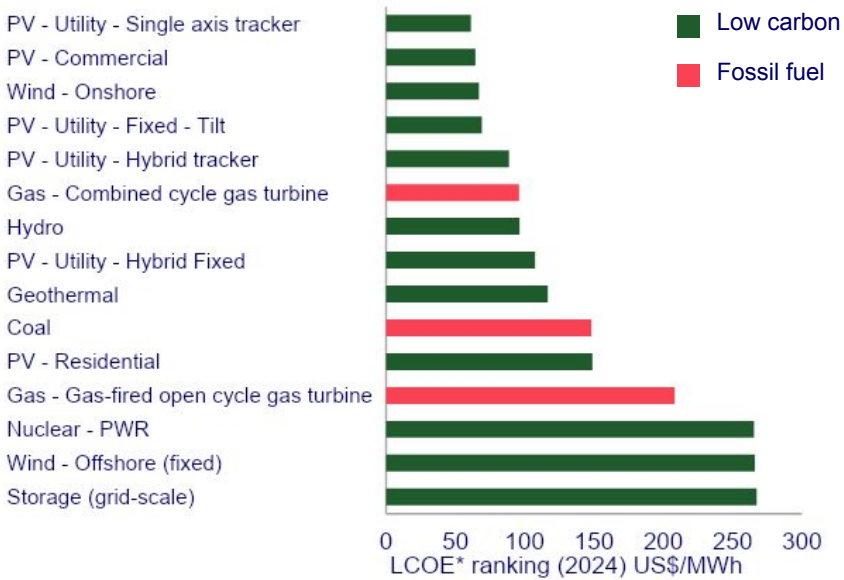
Grid decarbonisation of key producing countries



* Average grid emissions of top 10 producing countries weighted by mine production

Source: Wood Mackenzie – Energy Transition Service

LatAm's levelised cost of electricity (LCOE) installation



*LCOE is a power industry metric used to measure the total cost of power generation over a project's lifetime

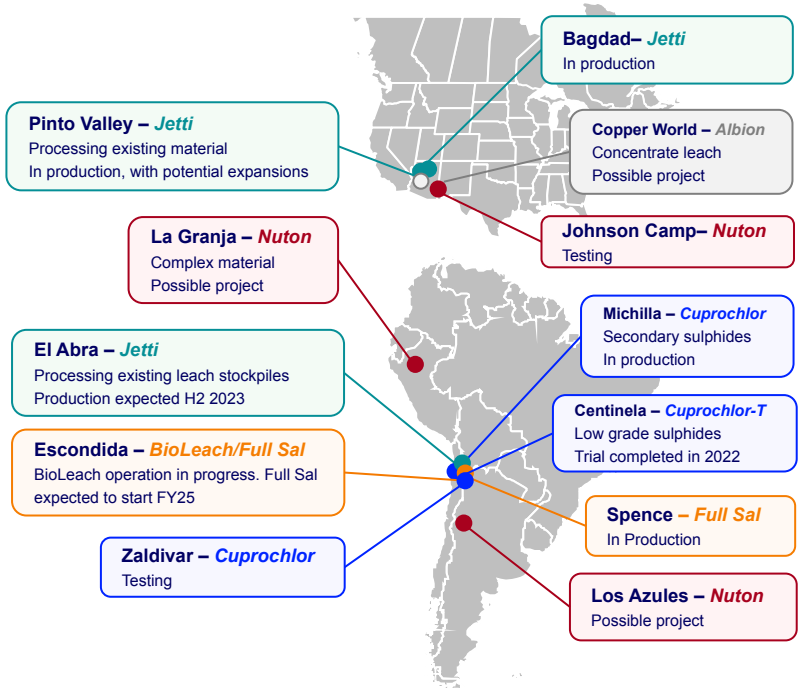
Source: Wood Mackenzie – Latin America levelised cost of electricity (LCOE) report

Wood Mackenzie

Technology: Leach processing to reduce smelting dependency

New technology could offset declining leached Cu while reducing concentrate transport and smelting emissions

New leach technologies being implemented



Key advantages:

Jetti *(Catalytic Leaching)*

- Uses a proprietary catalyst (thiocarbonyl compounds) that **enables copper extraction from chalcopyrite**, which is typically refractory to conventional leaching.
- The catalyst prevents and removes the passivation layer, enabling **reprocessing of previously leached material**.

Nuton *(Bioleaching)*

- Leverages engineered microorganisms specifically adapted to target ore mineralogy to **accelerate copper extraction from primary sulphide ores**, particularly chalcopyrite.
- Under favourable conditions, Rio Tinto affirms that **the technology can enable up to 85% copper recovery rates**, surpassing industry benchmarks.

Cuprochlor & Cuprochlor-T *(Chloride Leaching)*

- They use a mix of leach solution, chloride salts, and sulphuric acid to treat sulphide ores, with **Cuprochlor-T applying elevated temperatures ~30 °C to process primary sulphides**.
- Antofagasta reports **~90% recovery from secondary sulphides with Cuprochlor**, and **>70% from primary sulphides using Cuprochlor-T**.

Albion *(Atmospheric oxidative leaching)*

- This technology **combines ultrafine grinding (via IsaMill™) with oxidative leaching at atmospheric pressure to extract Cu**, Zn, and Au from variable and low-grade feed.
- Glencore states that the process operates at atmospheric pressure, making it safer and more cost-effective than POx systems, **with up to 99% copper recovery from chalcopyrite**.

***Smelting will remain dominant:** But its carbon intensity makes it a target for innovation and substitution, especially for new projects. A notable example is Aurubis's pilot-scale implementation of Metso Outotec's hydrogen-ready anode furnace technology at its Hamburg East copper smelter, which is set to become the first to use hydrogen instead of natural gas—potentially cutting 5,000 tonnes of CO_2 annually.

Source: Wood Mackenzie Jetti Resources, Nuton LLC, Antofagasta PLC, Glencore, Aurubis

Scope 3 abatement: Four Strategies have emerged in metals and mining

Each scope 3 strategy varies in its speed of emissions reduction and effectiveness

	Technology development	Transition-focused pivot	Supply chain optimisation	Carbon offsets
2050 Vision	Develop low-carbon technologies and shape demand for the commodities companies produce. Includes using VC to broaden technology development.	Focus diversification on commodities with lower and easier-to-abate downstream emissions. Includes exiting or retiring thermal and met. coal.	Selectively move to lower-emissions-intensity partners, e.g. through near-shoring.	Expansion of mineral and nature-based offset projects to offset continued Scope 3 emissions (potential to develop carbon-as-a-business).
Benefits	Diverse pipeline of low carbon technology reduces risk. Optimise solutions for products. Leverages technical and financial strength.	Exposure to buoyant commodities with strong growth outlook. Leverage existing expertise.	Localisation brings alignment in objectives in similar policy environment. Lower costs associated with shorter transport routes.	Leverage large land holdings and ultramafic mineralogy to scale up rapidly. Allows for focus on lower abatement cost decarbonisation solutions.
Challenges	Technology commercialization is too slow to hit climate goals. Risk of lower returns and profitability in downstream operations.	Lower-margin businesses and a lack of organic growth options requires M&A. Legacy scope 3-intensive products still required for the transition.	Limited impact on a standalone basis. Localisation comes with concentration risk.	Achieving the scale of offsets required for downstream industries. Risk of stakeholder backlash due to lower actual emissions reduction.

Source: Wood Mackenzie Metals and Mining Corporate Strategy and Analytics Service

Battles on multiple fronts to decarbonise Latin America’s metals industry

Near-term investment and technology advancements critical to support future net zero success

1. Growing a renewable power and transmission backbone

M&M decarbonisation lives and dies on adequate incremental renewable power **AND** strong transmission infrastructure **FULL STOP**. Industry needs confidence the power will be there when needed but it is a two-way street. Storage?

2. Proving and scaling diesel replacement solutions

Late 2020s will see the first true BEV ultra class mine haul trucks arriving in force though the “devil is in the details” for a successful and more widespread rollout. Trolley assist? Hybrids? Alternative fuels? Other equipment?

3. Rethinking mine planning and operations

Traditional approaches to mine design and operations will be challenged. Low carbon equipment and infrastructure, autonomous fleets, new labour requirements and expectations plus AI requires a total rethink of what mining is, how we do it and how much it costs.

4. Alternative carbon-free smelting solutions

Copper and zinc smelting technologies mainly rely on electricity and will be supported by the transition to renewables. Developments in the direct leaching of ore will reduce smelting dependency, and support efficiencies through reduced milling of ore.

Q&A

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Carbon emissions: Targeting key sources for abatement

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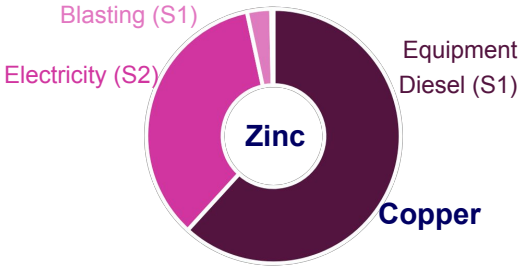
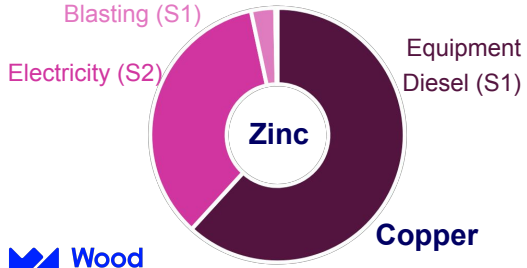


Copper processing (mine site)

Mine processing activities account for 25% of LatAm's total copper value chain emissions & 13% of zinc's



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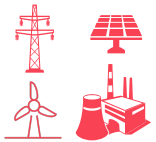

Scope 3 Indirect Emissions

Emissions from electricity used by operations, generated indirectly and typically from the grid.

Copper smelting emissions by source

Zinc smelting emissions by source

Source: Wood Mackenzie Emissions Benchmarking Tool

Most copper and diversified companies are targeting scope 1&2 net zero by 2050

The path to get there is varied – some companies have interim 2030 targets that look very ambitious

Carbon reduction targets of diversified mining companies

		AngloAmerican	BHP	Fortescue	GLENCORE	RioTinto	SOUTH32	VALE	ZiJin	ANTOFAGASTA PLC	CODELCO	FIRST QUANTUM MINERALS	FREEPORT-McMoRan	SOUTHERN COPPER	Teck
Net zero 2050 (or before)	*Scope 1 & 2*	✔ 2040	✔	✔ 2030	✔	✔	✔	✔	✔	✔	✔	✘	✔	✔	✔
	Scope 3	✘	✔	✔ 2040	✔	✘	✔	✔	✔	✔	✔	✘	✘	✘	✔
Interim target (between 2030 and 2050)	*Scope 1 & 2*	30% by 2030	30% by 2030	NA	25% by 2030; 50% by 2035	50% by 2030	50% by 2035	33% by 2030	Intensity - 38% by 2029	50% by 2035	70% by 2030	50% by 2035	Various by 2030	40% by 2035	Intensity - 33% by 2030
	Scope 3	50% by 2040	Shipping, iron ore - 2030	Shipping, iron ore - 2030	25% by 2030; 50% by 2035*	Shipping – 40% by 2030	✘	15% by 2035	✘	10% by 2030	25% by 2030	✘	✘	✘	Shipping - 40% by 2030
Short-term target (2025 to 2030)	*Scope 1 & 2*	✘	✘	✘	15% by 2026	15% by 2025	✘	✘	✘ Carbon peak by 2029*	30% by 2025	✘	30% by 2025	✘	8% by 2027	Net zero scope 2 by 2025
	Scope 3	✘	✘	✘	25% by 2030	✘	✘	✘	✘	✘	✘	✘	✘	✘	✘

Source: Wood Mackenzie Corporate Strategy and Analytics Service, Company Sustainability Reports; Note: Glencore's scope 3 net zero target only refers to its Industrial emissions; *Zijin targets a peak in absolute emissions