Inter-American Development Bank

Latin America and the Caribbean 2050

Becoming a Global Low-Carbon Metals and Solutions Hub

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Infrastructure and Energy (INE)
Mining, Geothermal Energy and Hydrocarbons (MGH)

TECHNICAL NOTE Nº IDB-TN-02172

July 2021

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Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Latin America and the Caribbean 2050: becoming a global low-carbon metals and solutions hub / Christian Spano, Paolo Natali, Charles Cannon, Suzanne Greene, Osvaldo Urzúa, Carlos Sucre, Adriana Unzueta.
p. cm. — (IDB Technical Note ; 2172)
Includes bibliographic references.
1. Carbon dioxide mitigation-Latin America. 2. Iron industry and trade-Environmental aspects-Latin America. 3. Steel industry and trade-Environmental aspects-Latin America. 4. Copper industry and trade-Environmental aspects-Latin America. 5. Recycling (Waste, etc.)-Latin America. I. Spano, Christian. II. Natali, Paolo. III. Cannon, Charles. IV. Greene, Suzanne. V. Urzúa, Osvaldo. VI. Sucre, Carlos. VII. Unzueta, Adriana. VIII. Inter-American Development Bank. Infrastructure and Energy Sector. IX. Series.
IDB-TN-2172
JEL Codes: Q01, Q30, Q38, Q55
Keywords: Scope 3 emissions, copper, iron ore, sustainable mining, climate change, energy transition, circular economy, recycling.

http://www.iadb.org

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Expert Network

> We are grateful for the guidance and input of the network of experts supporting this project. Through several in-depth interviews, content reviews and collective debate they have been key to generate this report.

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Executive Summary

Mining represents 4% of global emissions, but the emissions from mining supply chains can be more than 20 times higher. For example, supply chain emissions made up 96% and 97% of Vale and BHP's 2019 carbon footprint, respectively.[1,2] Focusing on low-carbon mining operations is an imperative first step to reducing the sector's environmental impact, but it is not enough from a full lifecycle perspective. As this report will show, the solution for decarbonization lies in the value chain.

This report provides leaders in Latin America and the Caribbean (LAC) with a broad set of strategies. It analyses a range of scenarios to position the region as a low-carbon mining and solutions hub. This vision is based on the potential for emissions reductions relating to the region's iron/steel and copper industries. Using intensity and volume reduction along the copper and iron/steel lifecycle as a guide, we propose that a Paris-aligned minerals value chain could position LAC to play a pivotal role in the global low-carbon economy.

In this report, we present four carbon emission scenarios that represent four different sets of decisions for the various players across the global copper and iron ore value chains.

Two scenarios fall short of aligning with the Paris targets: the business as usual (BaU) scenario with no further abatement action; and a BaU scenario with the current level of emission reduction potential from players in the value chain (BaU Possible).

The other two scenarios deliver the required carbon reductions to be compliant with the Paris Agreement by 2060, but through different strategies – in the third scenario (BaU Paris), alignment with Paris targets is achieved by keeping BaU volumes and reducing carbon intensity per tonne of metal. In the fourth (Decoupled) scenario – carbon intensity reductions are relaxed and compensated by a reduction in primary supply to align the value chain emissions to a Paris trajectory.

LAC has an advantage over other copper- and iron-ore-producing regions in all four scenarios. Even in the extreme scenario, where the world achieves full alignment with the Paris targets using the circular economy as a main driver for emissions reduction and decoupling primary production from metal demand, LAC has the right conditions to succeed.

First, LAC mining copper and iron ore operations are mostly positioned at the beginning of the global supply curve. This means that reductions in the global primary supply due to circular economy strategies in consuming markets would impact on supply from other regions first.

Second, LAC has the conditions to establish a competitive decarbonization pathway for its mining industry, including access to renewable electricity, nature- based solutions, and green hydrogen.

LAC should build optionality today to enhance resilience to a number of scenarios. This can be achieved by establishing the core fundamentals to become a global low-carbon hub – which supplies low-carbon metals and, more broadly, low-carbon solutions for other industries.

To keep this optionality open, governments, the private sector and civil society in LAC should work together to achieve the following goals:

- **Consumers –** engage with large mineral and metal consumer markets to better understand their perspective in terms of the emerging circular economy and their demand for low-carbon solutions.
- **Policy –** better understand the development and timing of policies and practices around climate change but also resource management (eg, extended producer responsibility (EPR)), both regionally and globally.
- **Finance –** engage with local and international financial institutions to understand the conditions that would position LAC as key destination of low-carbon and sustainable finance.
- **Technology –** stimulate innovation in local supply chains to support a transition to a low-carbon mineral value chain, and to develop international competitiveness in industries beyond mining and metals.

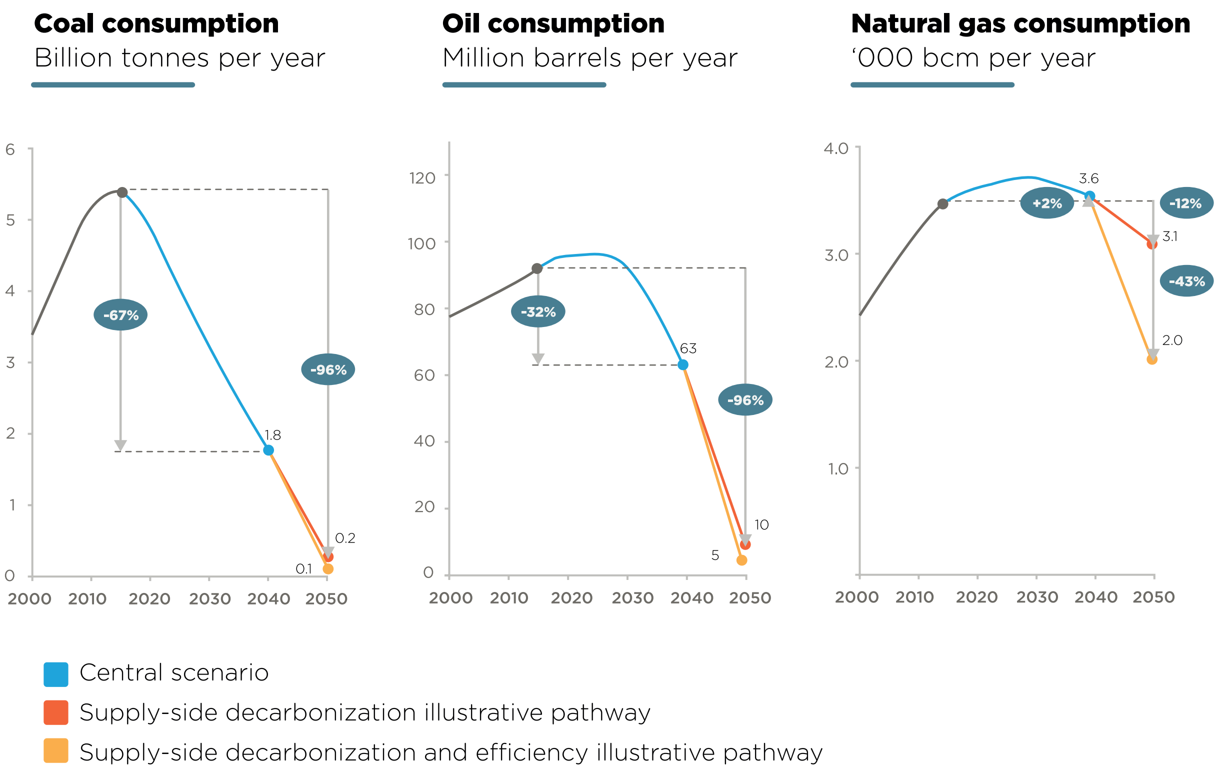
If planned properly, the investments required for LAC to become a global low-carbon mining and solutions hub by 2050 can deliver value across all scenarios presented in this report. The report sets an agenda for a broad set of stakeholders to support a successful transition to a low-carbon economy and create opportunities over time to increase the region's resilience to a broad set of scenarios, while also developing capabilities and infrastructure to increase the region's competitiveness in the short, medium and long term.

* The OECD defines EPR as "a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products."

Introduction

The response to global climate change and the transition to a circular economy will shape our society and economy in the coming decades. The COVID-19 crisis has emerged as a forcing event: a tragic and profound moment in history that has made it clear that we can no longer proceed with business as usual. LAC is in a strategic position to become a low-carbon mining and solutions hub, leveraging COVID-19 recovery funds made available in key markets for copper and iron ore alongside the progress that is already being made to expand green mining practices in the region.

Limiting warming to 1.75°C by 2100 – known as the Beyond 2-Degree Scenario (B2DS) – will require fossil fuel consumption to fall by 43% to 96% by 2050, as Figure 1 shows.[3,4,5] Climate change mitigation depends on the development of a low-carbon economy, traditionally linked to growth in mineral markets.[6,7,8] For example, beyond the materials required for infrastructure and manufactured goods, by 2050 the global economy will require more than 100 million tonnes of copper for solar panels and wind turbines.[9]



In the Energy Transition Commission decarbonization pathways, all emissions from remaining fossil fuel use are abated with CCS/U

Figure 1 - The decline of fossil fuel consumption required to meet climate goals. Source: Energy Transitions Commission 2018.

To meet the demand for minerals more sustainably, policymakers and key consumers may consider decoupling resource consumption from resource extraction, reducing the environmental impacts related to material lifecycles, as illustrated in Figure 2.[10] Globally, decoupling could lead to a 90% reduction in carbon emissions by 2060 and an additional 8% growth in global GDP compared with 2015.[11]

End consumers are not necessarily dependent on mining companies to achieve these goals, as in the oil and gas sector, the climate impacts of metals and minerals are primarily tied to processing and use, creating emissions far greater than the mining activities themselves. Consumers can achieve many of their goals through substitution of recycled content, new materials or alternative energy sources. LAC has the opportunity to pivot, in order to realize the benefits of transitioning from a resource-driven region to the global decoupled scenario that prioritizes low-carbon, circular materials.

As a signatory to the Paris Agreement, LAC must drive towards delivering its climate targets in a way that creates growth and prosperity, and promotes a vibrant, resilient economy. The efforts that many mining companies are making towards the adoption of alternative energy sources and more efficient practices are laying the foundation for green metals and minerals, which in turn will create capacity in the region to embrace the other new business models, technologies and fuels required for alignment with the Paris targets and the Sustainable Development Goals (SDGs).

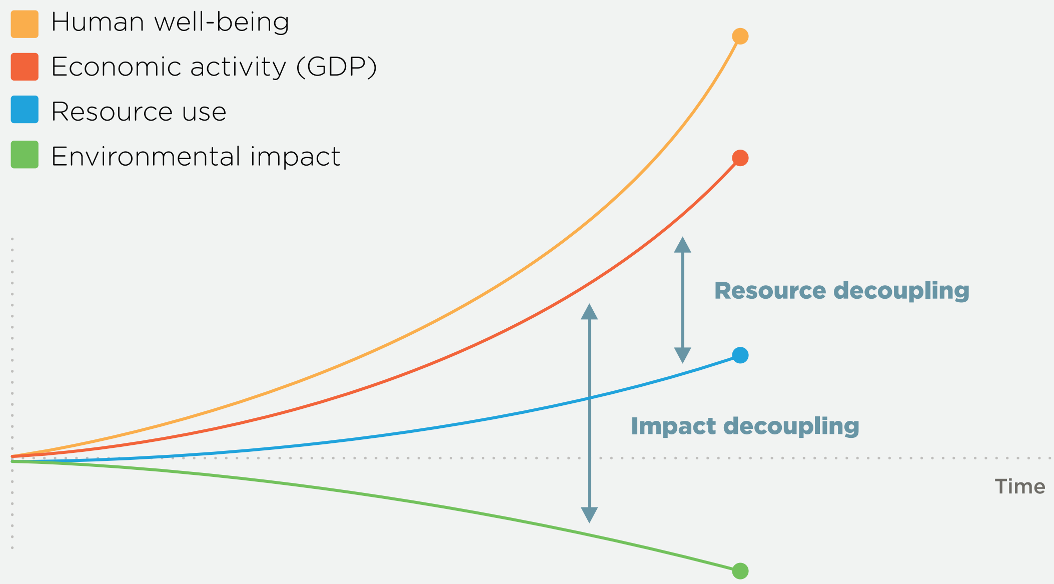


Figure 2 - The decoupling of resources from economic activity and environmental impacts. Source: International Resource Panel.[9]

The United Nations Environment Programme (UNEP) has previously challenged countries to "take the leap" towards sustainability, and the COVID-19 pandemic might be providing the push we need to ramp up progress towards the 2050 goals.

This report aims to provide a different set of strategies for leaders in LAC to consider: a scenario that would position the region as a low-carbon mining and solutions hub. This vision is based on the potential for emissions reductions relating to the region's iron/steel and copper industries. Using emissions intensity reduction, or a decrease in GHG emissions per tonne produced, along the copper and iron/steel lifecycle as a guide, we propose a progressive vision for a Paris-aligned LAC minerals sector that could position the region to play a pivotal role in the global low-carbon economy.

In chapter 1, we set the context about the importance of circular economy in the mining sector as a way to reduce scope 3 emissions and how current commitments of large corps will not suffice to bring us to a 1.5°C path. We also articulate why Covid-19 can actually accelerate change in such complex global value chains. In chapter 2, we explore the emissions profiles of the copper and iron ore supply chains, and determine the intensity of carbon emissions along the lifecycle from now to 2060. We created 3 potential "business-as-usual" scenarios, ranging from no progress towards climate goals to fully aligned with Paris emissions intensity. In chapter 3 we offer an alternative decoupled scenario, that reinvents BaU to create a new normal, in which demand for primary materials declines and efficient use, reuse and recycling of materials become key strategies for meeting global demand and emissions targets. In chapter 4, we make the case why we believe LAC has a comparative advantage to become a low carbon hub for metals & mining given its low cost position and access to renewable energy. Last but not least, in chapter 5 we summarize the main findings of the study, urging LAC to start building optionality for a global circular economy that is fully aligned with the Paris targets and creating new financial vehicles to support the investment requirements across the mining sector.

Chapter 1 – Climate Change, the Circular Economy, COVID-19 and the Latin American and Caribbean Mining Sector

> The Paris Agreement commits 195 governments to reduce emissions and limit temperature rises to well below 2°C. Climate science backs this commitment and encourages greater ambition towards a 1.5°C goal. Responsible businesses are responding to this challenge and are generally supportive of the Paris Agreement.

As yet, however, no industry is moving fast enough to meet the 2°C or 1.5°C scenarios – the mining value chain included. Not only does this risk the mining industry becoming seen as reactive and a climate policy-taker; but moving fast and at scale will also be crucial to avoid some of the irreversible feedback effects that an above 2°C scenario could unlock. It also places the sector at risk of being targeted as "hard to abate" by regulators, financiers, investors and end consumers. For mining, there is also upside potential and a strong business case for shaping and growing a low-carbon economy – for example, with models that are linked to the circular economy.[12]

Extraction and consumption of materials such as metals, minerals and cement contributed 23% of global emissions, or 11.5 gigatonnes of carbon dioxide (CO2), in 2015.[13] These emissions are largely driven by construction and manufactured goods – most notably cars and homes. The transition to a low-carbon economy presents a new opportunity and a new challenge: The transition to a low-carbon economy presents a new opportunity and a new challenge: the demand for materials is projected to grow by 110% by 2060 from 2015 levels, requiring resource extraction to more than double to 190 million tonnes per year.[14] Extracting, processing, using and recycling these minerals in a more sustainable manner is key to ensuring that progress towards the Paris targets does not simply shift emissions to other industries or regions.

In the specific case of LAC, all countries are signatories to the Paris agreement. However, the region is remarkably heterogeneous in terms of climate, ecosystems, human population distribution, and cultural traditions. Water resources, ecosystems, agriculture and plantation forestry, sea-level rises and human health are among the most important areas that may be impacted by climate change and directly or indirectly linked to mining activity. Most importantly, because most countries' economies and low-income populations depend on agricultural productivity, the issue of regional variation in crop yields linked to climate change is highly relevant[15] and could exacerbate the current tensions between the mining and agriculture communities.

A central requirement is to achieve carbon neutrality across the economy in the coming decades. However, this will be possible only if businesses, governments and civil society work together to produce the energy and products, and deliver the services, that society needs through transformed business models and regulation that decouple growth from emissions. Evolving customer and consumer expectations, new regulations, investor pressures and disclosure demands are challenging traditional business models and threatening to disrupt industry. Increased focus has been placed on high-emitting sectors of the economy and those that manufacture products which emit large quantities of CO2 when used.

While the mining sector has increased its engagement in emissions reduction, current efforts fall short of what is needed for the supply chain as a whole. Figure 3 shows the commitments made by some major extractive companies, some tied to improvements in their operations and/or their supply chains, and others bringing in carbon offsets to reach net zero carbon emissions. For global mining to be aligned with Paris targets it must reduce emissions to net-zero by 2050, which will require a massive investment in new technologies and processes, as well as carbon offsets to achieve.

Present None / limited

Company	Short term target	Long term target	Use of offsets	Remuneration link	Scope 3 target
BHP	2022 - keep absolute emissions bellow 2017 - adjusted for M&A	Net zero scope 1&2 second half of century	No for ST targets Yes for LT contribution	Yes - part of broader HSEC target	Yes $400m commitment
AngloAmerican	2022 - 21% reduction vs BAU 2030 - 30% reduction vs 2016	Aiming to be carbon neutral by 2040	Not currently, but not ruled out	Yes - linked to LTIP	X
GLENCORE	2020 - 5% intensity red. vs 2016 2030 - alignment with Paris goals, (not yet public)	Stop investing in new thermal coal projects	No - internal study in progress	X	X
SOUTH32	2021 target for scope 1 of 3% reduction from 2015 Review and reset every 5 years	Net zero by 2050 scope 1 emissions	Yes	Yes - for ExCo remuneration report	X
Hydro	2020 - carbon neutrality on a lifecycle basis	X	Yes	Yes - one of number of KPIs that contribute to bonuses	X
	Reduce Net Carbon Footprint by 2-3% by 2022 vs 2016	Reduce NCF 50% by 2050, 20% by 2035	Yes - natural climate solutions explicitly identified	Yes - senior leadership group LTIP	Yes - industry benchmark
bp	2025 - 3.5 Mtpa emissions reduction from 2016	2050 net zero target	Yes	Yes - applicable to 35,000 employees	Recent commitment includes scope 3
RioTinto	Reduce emissions intensity by 24% by 2020 vs. 2008. New targets being prepared.	A $1bn commited to achieve Net-Zero by 2050	X	X	Yes - NDA w Baowe steel but no costumer targets
VALE	2020 5% emissions reduction target Strong focus on renewable energy use, particularly biofuels	A $2bn commited to achieve Net-Zero by 2050	Yes - programme in place for replanting on old mine sites	X	Yes - considering costumer targets

Figure 3 - Climate goals pledged by a set of extractive companies. Source: Authors' work.

- Scope 1 emissions are direct emissions from owned or controlled sources.
- Scope 2 emissions are indirect emissions from the generation of purchased energy.
- Scope 3 emissions are all other indirect emissions that occur in the value chain of the reporting company, including both upstream, downstream, and end-of-life emissions.

Currently, mining companies hold a range of common views:

• Climate change represents both risk and opportunity, and difficult trade-offs need to be considered. For example, supplying the large amounts of minerals and metals required for solar panels, electric vehicles and wind farms will also generate significant carbon emissions across the value chain;

• Action to reduce the sector's direct footprint (ie, scope 1 and 2 emissions) must be accelerated to be aligned with Paris targets;

• The issue of emissions from the use of products – the scope 3 challenge – is not fully understood and is challenging to address; and

• Customers are innovating to create increasingly circular business models which have the potential to significantly reduce emissions in the value chain but also impact on "virgin" extraction.

The metals and mining sector's response has predominantly focused on its operations. Reducing emissions from its own productive processes and energy consumption – scope 1 and 2 emissions – has improved environmental performance, reduced energy use and costs, and lowered financial risk. These efforts are important and well received, but they do not address the 'elephant in the room': emissions from the use of commodities in the value chain, or scope 3 emissions.

Focusing on low-carbon mining operations is a necessary first step; but it is not enough from a full lifecycle perspective. Mining represents 4% of global emissions, but the emissions from mining supply chains can be orders of magnitude higher. For example, in 2019, supply chain emissions made up 96% and 97% of Vale and BHP's carbon footprint, respectively.[16]

The 12 largest publicly listed diversified mining companies by market capitalization reported scope 1 and 2 emissions to CDP of 214 million tonnes CO_2 e in 2016.[17] The scope 3 emissions for these companies are estimated by CDP to be at least 10 times higher. Many of these global mining companies have operations in LAC.

Tackling scope 3 emissions is crucial to reduce the industry's environmental footprint and meet global emissions reduction goals. Emissions reductions in the value chain could translate into the substitution of commodities and/or circular economy models that reduce demand for virgin input and increase reused, refurbished and recycled input.

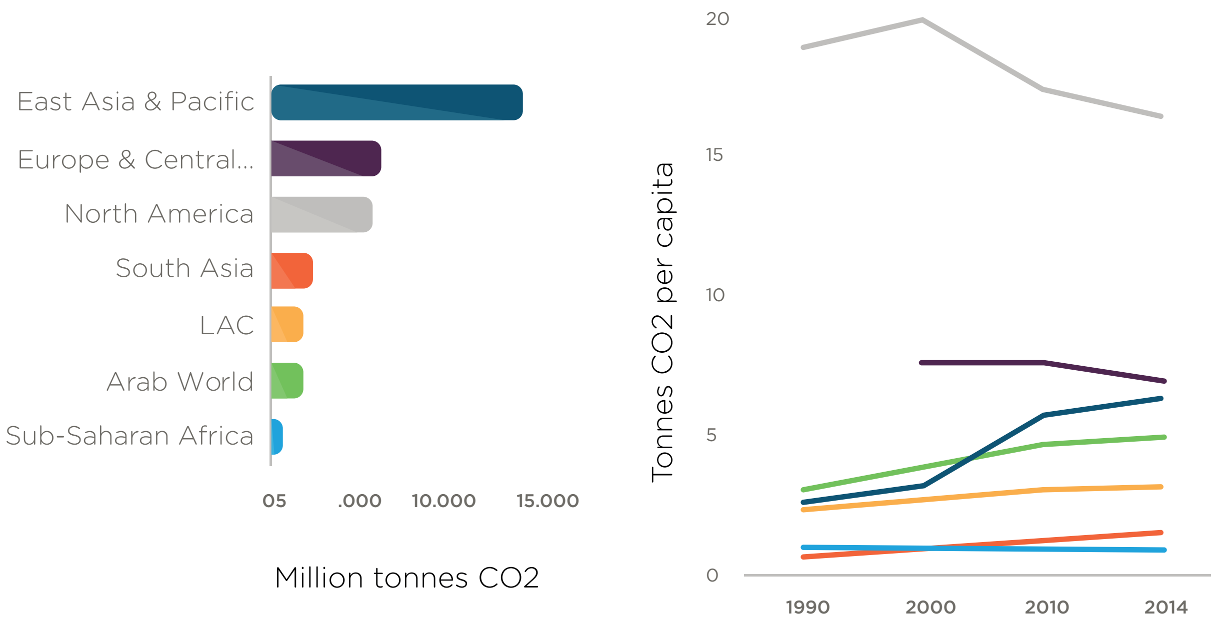


Figure 4 Left: 2014 CO_2 emissions by region; Right: Growth in CO_2 emissions per capita (Source: World Development Indicator dataset).

These changes could be particularly relevant for countries in the region, where growth has been fuelled predominantly by commodity exports. If harnessed properly, these innovations and new business models and regulations could yield significant benefits for LAC countries.

However, as GDP in LAC has grown, so has its climate impact. As Figure 4 shows, it remains one of the lower-emitting regions, although emissions per capita have increased by 26% over the past 50 years.[18] Equally, governments in the region have already started to implement policies that support emissions reductions, but these are not sufficient to achieve alignment with the Paris targets. Governments are not engaging quickly or deeply enough to establish the right context and incentives that will, in turn, attract investments to foster a low-carbon mining industry. These are crucial to enable this resource-rich region to maintain growth and development so that it can gradually catch up with advanced economies over the next 25 to 50 years.

> **In contrast, key mineral and metal markets have started to establish the conditions needed to reduce emissions. Achieving a net-zero emissions materials sector by 2050 is possible through a combination of efficient use of materials, low-carbon metal and mineral technologies, demand management and increased recycling.[19]**

This misalignment in emissions trends between mineral and metal-producing countries in LAC and some of the world's largest markets can be developed into two different outcomes that should be explored in more detail. On the one hand, it could present a risk: markets could start diverting demand to low-carbon sources of supply. On the other hand, it could represent a major opportunity: LAC countries can build on their existing relationships to jointly develop the markets for low-carbon minerals, metals, and solutions. These low carbon solutions represent new industries that enable the mining value chain to reduce their emissions, for example, renewable energy, green hydrogen, traceability, natural based solutions (forestry and regenerative agriculture) among others. These solutions should be mapped alongside the value chains of key minerals and metals to fully capture the opportunity beyond the extractive stage (scope 1 and 2) and into the processing, use and recovery phase (scope 3).

It is important to clarify that, in all likelihood, scope 3 emissions from the sector will likely not represent a significant implementation problem for the region but could become a fiscal or economic problem later. As emissions are successfully tackled in "processing" and "use" countries through efficiency measures, material substitution and circular business models, extraction of virgin resources could decline, affecting the fiscal balance of the countries supplying the raw materials.

The effect on fiscal revenues could take longer to materialize if current trends in demand and extraction of commodities persist. However, if efforts to meet the Paris targets are stepped up, this effect could be felt much earlier. Meeting the Paris targets represents a significant challenge, but it is one which most countries and companies in the world have committed to meet.

Given the challenges relating to scope 3 emissions, players in the mining value chain – particularly in resource-rich LAC countries – should begin considering the following questions.

In terms of context:

- What is the trajectory of scope 1, 2 and 3 emissions today and what is the contribution of the mining industry, as compared to other industries, to this trajectory? Is the mining industry aligned with the Paris targets; and if not, is the gap significant?

- What are the main drivers of scope 3 emissions in the mining value chain today? And how are players in those industries looking to tackle their own emissions? What would be the impact on players in the mining value chain if consumers of metals and minerals aligned to a Paris 1.5°C scenario?

In terms of opportunities:

- Would a successful reduction in emissions across the value chain lead to a significant change in the distribution of value generated by the industry in LAC countries? Which commodities are most exposed? Which suppliers to the mining industry and downstream value chain markets are growing and which are declining?

- Are circular economy business models a value-creation option to outperform the current model (focused on resource extraction), and lead the mining value chain to a net-zero carbon pathway? How could resource-rich countries retain or increase value in a circular/net-zero carbon scenario?

In terms of challenges for the region:

- Should governments and mining companies work together to identify models that retain ownership of the commodity and extract value from its productive use over its lifecycle? How could they prevent this from being misunderstood as an attempt to nationalize resources?

- What key policy mechanisms should governments explore to support radical alignment with the Paris Agreement that includes scope 3 emissions and simultaneously support growth at the rates required to catch up with advanced economies? What would this policy package look like beyond resource efficiencies, carbon taxes and carbon trading schemes?

- How can governments encourage technology adoption and development to support new business models that can significantly reduce emissions and foster new low-carbon industries in the region using the mining industry as a key enabler (eg, nature-based solutions, EPR)?

The Energy Transitions Commission (ETC) has started to lay the groundwork for understanding and mapping out how to decarbonize “harder-to-abate” sectors in heavy industry and heavy-duty transport.

> The ETC’s recent report, *Mission Possible*[20], outlines how to decarbonize cement, steel, plastics, trucking, shipping and aviation, which together represent 30% of global energy emissions today, and could increase to 60% by mid-century as other sectors reduce their emissions. Under current projections for cumulative emissions to 2100, emissions from steel and aluminum alone could exhaust the notional carbon budget for all materials combined.

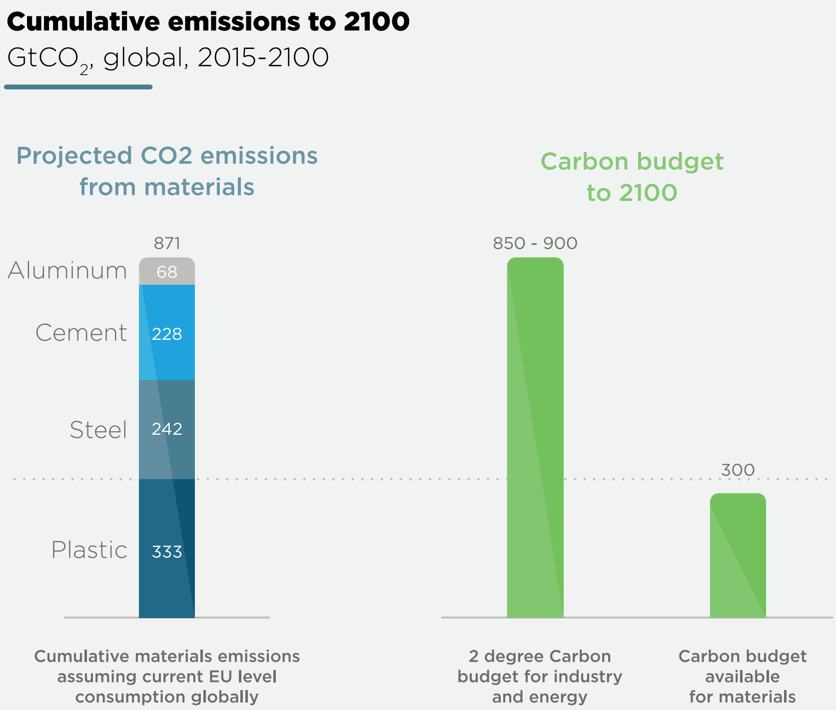


Figure 5 - Emissions from "hard-to-abate" sectors, 2015 – 2100. Source: Energy Transitions Commission

Mission Possible shows that emissions from steel and aluminum production could be cut by 37% and 40% respectively, compared to BaU levels, by making better use of existing material stocks through recycling and reuse, and by reducing material requirements in value chains through improved product design, longer product lifetime, and service-based business models.

The solution for decarbonization lies in the value chain. Downstream consumers of commodities are already transitioning to increased efficiency, recycling, reuse and repurposing of the minerals and metals they use. For example:

- Apple has stated its intent to eliminate reliance on mined resources and has set a goal to make all its products with recycled metals;

- Renault is designing "circular batteries" to maximize the productivity of the metals they use; and

- Maersk and Tata have introduced "material passports" to recover high-value steel from vessels and buildings.

The nature of scope 3 emissions means that no single part of the value chain can address them alone. Metals and mining companies must work with customers and technology disruptors to explore how best to address demand and supply-side issues. They must also work closely with multilateral institutions and governments to design new models for sustainable and equitable growth in resource-rich developing countries.

Value chain emissions and the role of the circular economy as an abatement option

> The circular economy (CE) focuses on designing out waste and pollution, keeping products and materials in use, and regenerating natural systems, to reduce the pressure on the finite resources of our planet and the ecosystems on which they depend.

How the circular economy reduces CO2 emissions

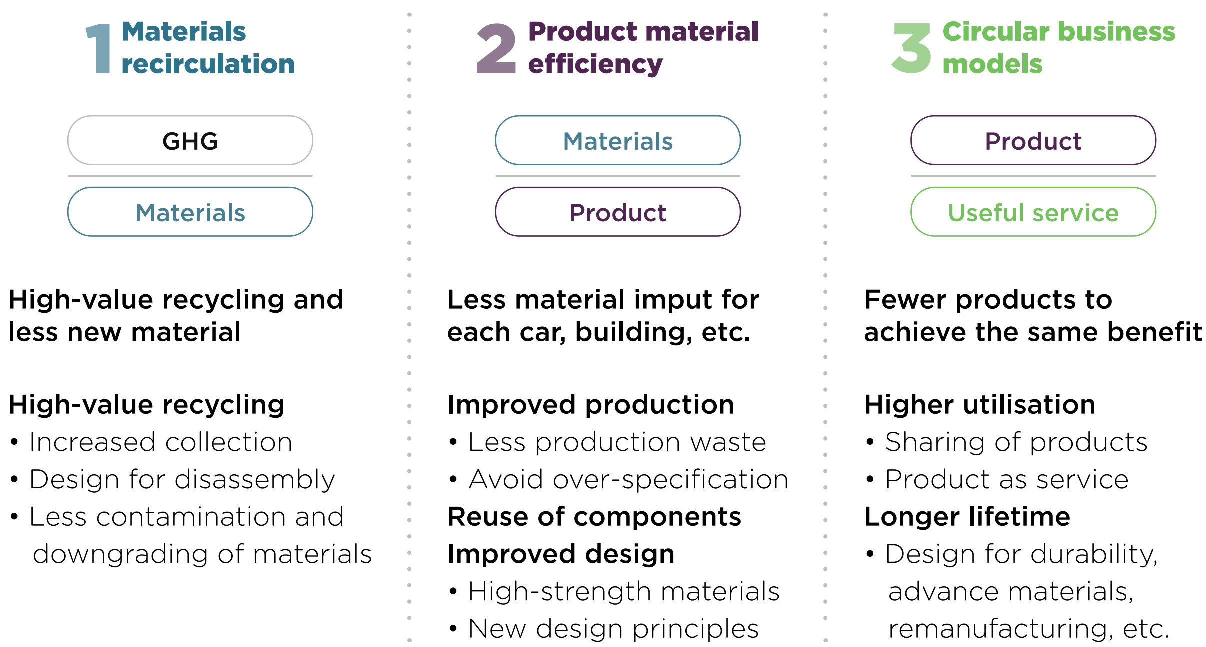


Figure 6 - Carbon emissions reduction in the circular economy. Source: Materials Economy

Analysis published by the World Economic Forum indicates that by changing how we make and use products, we could reduce global greenhouse gas emissions by 45%. The circular economy offers a $4.5 trillion economic opportunity by avoiding waste, making businesses more efficient and creating new employment opportunities.[21]

The circular economy is rapidly gaining momentum in a growing number of industries. For example, circular models underpin the urgent changes that are emerging in the plastics packaging sector – a $400 billion industry that is experiencing increasing disruption. As consumers and regulators exert mounting pressure, plastics producers are waking up to the risk and opportunity of applying circular approaches to their business models.

Unlocking the potential of the circular economy requires a system-level shift for business, beyond a simplistic view of "more recycling". In the case of the mining value chain, some companies are already implementing new circular business models. For example, Mitsubishi Material, JX Nippon Mining & Metals and Sumitomo Metal Mining are all ramping up their recycling initiatives, finding value from resources that previously would have ended up in landfill. ArcelorMittal is working with Lanza Tech to build a plant that uses the waste gases from steelmaking to produce ethanol on a commercial basis. Caterpillar has designed circular business models which are increasing profit margins by creating products intended to be remanufactured several times. Rio Tinto (Alcoa) has also started to explore circular business models via a partnership with Apple to develop a new aluminum-making process that eliminates greenhouse gases. Yet despite these promising examples, the mining industry lags behind other industries when it comes to circular economy innovation.

Copper and steel are widely recycled, but there is significant potential for a broader circular approach. For example, primary steel production could be cut by 37% versus BaU levels via circular strategies, through reduced losses across the value chain, reduced downgrading in the recycling process, greater reuse of steel-based products and a shift to new car-sharing systems.[22]

LAC countries need to better understand the incentives for end users of steel and copper to apply circular models in order to identify the impacts on primary production of copper and iron ore. **Most importantly, LAC leaders should seize the opportunities arising from a more circular world – for example, by supporting the development of a local green hydrogen industry, participating in reuse models in destination markets, modernizing the local refurbishing industry and participating in the global advanced recycling industry.**

The COVID-19 pandemic as an accelerator of change in global value chains

To some degree, COVID-19 has served as a natural experiment on what a radical emissions abatement strategy might look like. During the first week of April, daily emissions dropped by 17%; and the International Energy Agency expects that emissions will be down 8% in 2020 compared to 2019 – the largest one-year reduction since the Second World War.[23,24]

However, one of the key insights is that while curtailing transport, significantly reducing power generation and minimizing world trade have made great contributions to short-term carbon emissions reductions, this is not enough to align the world economy to a B2DS scenario. In addition, emissions may rebound, putting us back on a trajectory that plays against the Paris targets, the SDGs, and planetary boundaries.[25]

What the COVID-19 crisis is telling us in the climate space is that we need to go faster and deeper in how we reduce emissions. We must think systemically and stimulate structural changes, instead of pushing for the "optimization" of current production and consumption models. This is an opportunity to effect this change, building on the commitments of a large number of countries to establish COVID-19 recovery budgets, many prioritizing a green investment-led recovery.

Size of COVID-19 Stimulus Packages as Share of GDP (%)

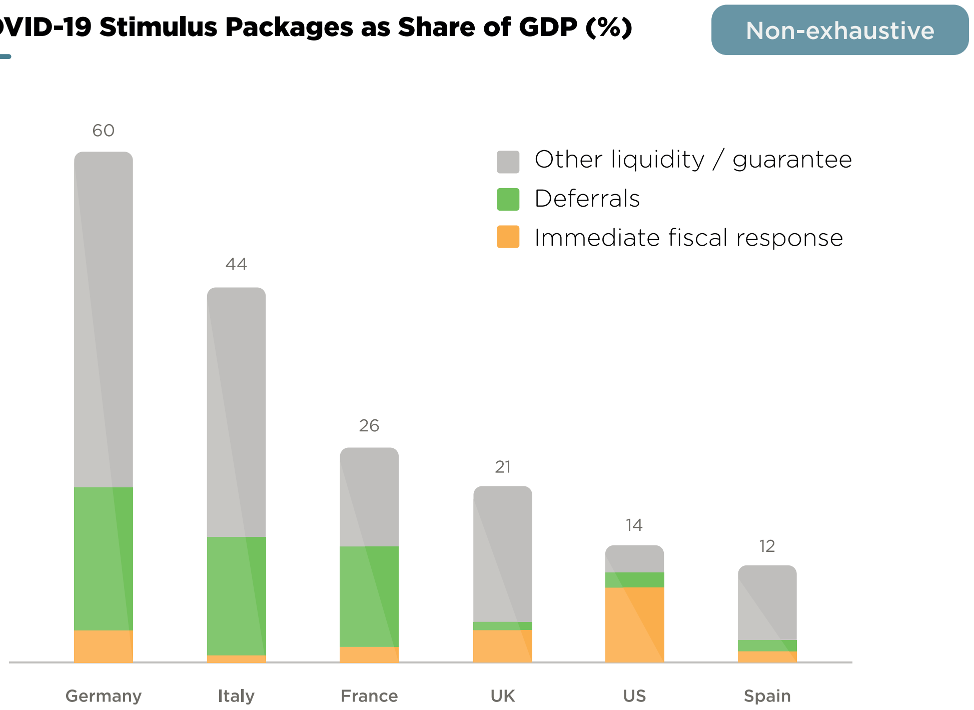


Figure 7 - COVID-19 stimulus packages. Note: As of 23rd April 2020. Source: The Energy Transitions Commission based on Bruegel (www.bruegel.org).

Many of the countries that have made available vast amounts of funding to support the economic recovery from COVID-19 are also key markets for copper and iron ore produced in LAC. How governments and mining companies operating in LAC engage with these major markets to connect recovery plans and investments in the next 18 to 24 months may define the shape of economic recovery in LAC and the region's carbon emissions pathway.

COVID-19 has also shone a spotlight on the role of local and decentralized supply chains. This could be a great opportunity for LAC. Positioning knowledge and innovation-based local suppliers to drive the COVID-19 recovery – and longer term, the low-carbon economy – may be crucial to realize the region's development potential. This should be understood as a dynamic process as other regions and countries start thinking about their own local supply base. How large markets such as China and the European Union orchestrate policies with LAC governments to support the deployment of a low-carbon supplier base may become a defining competitive regional factor.

Climate change, the circular economy, and COVID-19 are creating major disruption and presenting major opportunities for the LAC region. Having clarity on the different impacts and opportunities under different scenarios is key to make the most of the current context.

An understanding of the different impacts and opportunities under different scenarios is key if stakeholders are to make the most of the current context.

The following chapter explores various scenarios for the LAC copper and iron ore supply chains:

1. "BaU" – Business as Usual with no progress towards climate goals;
2. "BaU Possible" - BaU considering the current technical potential and climate goals;
3. "BaU Paris" - BaU with Paris-aligned emissions intensities; and
4. "Decoupled" – abatement generated through reductions in carbon intensity and primary supply.

Chapter 2 – Enabling the Transition to a Low-Carbon Economy

To understand the pathways to Paris alignment for the LAC mining sector, we must first understand the emissions profiles of the copper and iron ore supply chains, and determine the intensity of carbon emissions along the lifecycle, from extraction to processing, use and recycling. This chapter describes our approach to evaluating emissions from now to 2060,[26] the year by which the International Energy Agency predicts we can reach net-zero carbon emissions, and how these emissions are mapped to expected production volumes under BaU conditions (ie, primary production increasing over time to meet demand growth). Through this process, we can evaluate the impact of emissions reduction requirements for the LAC mining sector in order to meet global climate goals. This provides a lens through which to view both the challenge and the opportunity that lie ahead.

Defining 2060 Scenarios

In this section, we consider three scenarios for emissions reduction, summarized in Figure 8. These scenarios offer a spectrum of potential emissions reductions, ranging from zero progress towards climate goals to a stark reduction in carbon intensities, under a business as usual demand leading to increased production volumes in LAC.

The three scenarios are described as follows:

1. **BaU – Business as Usual with no progress towards climate goals:** This scenario reflects a trajectory where copper and iron supply chain emissions and production volumes continue as predicted and current carbon intensities remain the same until 2060. This is a scenario where the least climate action is taken, one where economic limitations from COVID-19 or other market forces restrict the ability of companies and/or countries to make the necessary investments to meet their climate goals.

2. **"BaU Possible" - BaU considering the current technical potential and climate goals:** In this scenario, we play out the reduction of emissions intensities based on the existing initiatives of stakeholders along the supply chain, coupled with projections reflected in studies for the uptake of lower carbon processes, fuels and technologies. These trajectories are combined with BaU production volumes to determine emissions until 2060.

3. **"BaU Paris" - BaU with Paris-aligned emissions intensities:** In this scenario, we take the BaU production volumes as in the previous scenarios, but "flex" the emissions intensities to the level required to meet the B2DS. To set

emissions reduction targets out to 2060, we looked to leading reports and platforms that have begun to establish reduction pathways for materials value chains:

- An 87% intensity reduction (58% absolute emissions reduction) is required across industrial sectors (including copper) – Science Based Target Initiative[27]

- A 55% intensity reduction (31% absolute emissions reduction) is needed for the steel sector – Science Based Targets Initiative

- A 45% absolute reduction in steel emissions compared to 2014 levels is aligned with a 2C scenario - Energy Transitions Commission[28]

- With a 56% increase in crude steel volumes, intensity will need to reduce 90% by 2050 to align with the Paris targets – Material Economics[29]

With these figures as a starting point, it is important to consider the variability when establishing material volumes and emissions trajectories over a 50-year period. When considered alongside the more ambitious commitments of WEF's Net Zero Steel Initiative and other projects aimed at bringing industrial emissions to net zero by 2050, further work is clearly needed to align on decarbonization goals and pathways is apparent.

This report does not seek to set out a definitive pathway for copper and steel emissions reductions, but rather to understand the effects of technology, policy, and consumer choice on decarbonization. By assuming an aggressive, Paris-aligned target of a 90% reduction in emissions, along the value chain, for both copper and steel by 2060, our modelling is positioned to provide insight on the order of scale of the impacts of changing volumes and technologies in these supply chains.

Three Business as Usual Emissions Scenarios

"BAU" - Business as usualbwith no progress towards climate goals

"BaU Possible" - BaU considering the current technical potential and climate goals

"BaU Paris" - Business as usual with Paris-aligned emissions intensities

Figure 8 - A summary of the three business as usual scenarios evaluated by this study. Source: Authors' work.

Defining emissions from iron ore and copper supply chains

Defining carbon emissions from LAC iron ore and copper supply chains, is a challenge. Data can be hard to come by and is often not specific to the region or the supply chain in question. Furthermore, carbon emissions accounting practices are often misaligned, inconsistently applied or reliant on outdated information, making comparisons between companies, regions or products a difficult exercise.[30,31] Further work should be done to characterize and quantify these emissions to provide the full picture of supply chain impacts, and to encourage the disclosure of emissions by suppliers and producers.

This report attempts to provide a meaningful assessment of carbon emissions for LAC iron/steel and copper using publicly available information from mining companies, governments, academia, and industry groups. Corporate disclosures to CDP formed the backbone of the study; 28 metal and mineral-related companies reported nearly 2 billion tonnes of CO_2 in 2019.[32] As shown in Figure 9, CDP reports provide an outlook on a company's annual carbon emissions, divided according to the Greenhouse Gas Protocol into three primary categories: scope 1 (direct emissions), scope 2 (electricity used in scope 1), and scope 3 (upstream and downstream supply chain).[33,34] This study used data from relevant companies for the categories of scope 1, scope 3 Purchased Goods & Services, scope 3 Processing of Sold Products, and scope 3 Use of Sold Products.

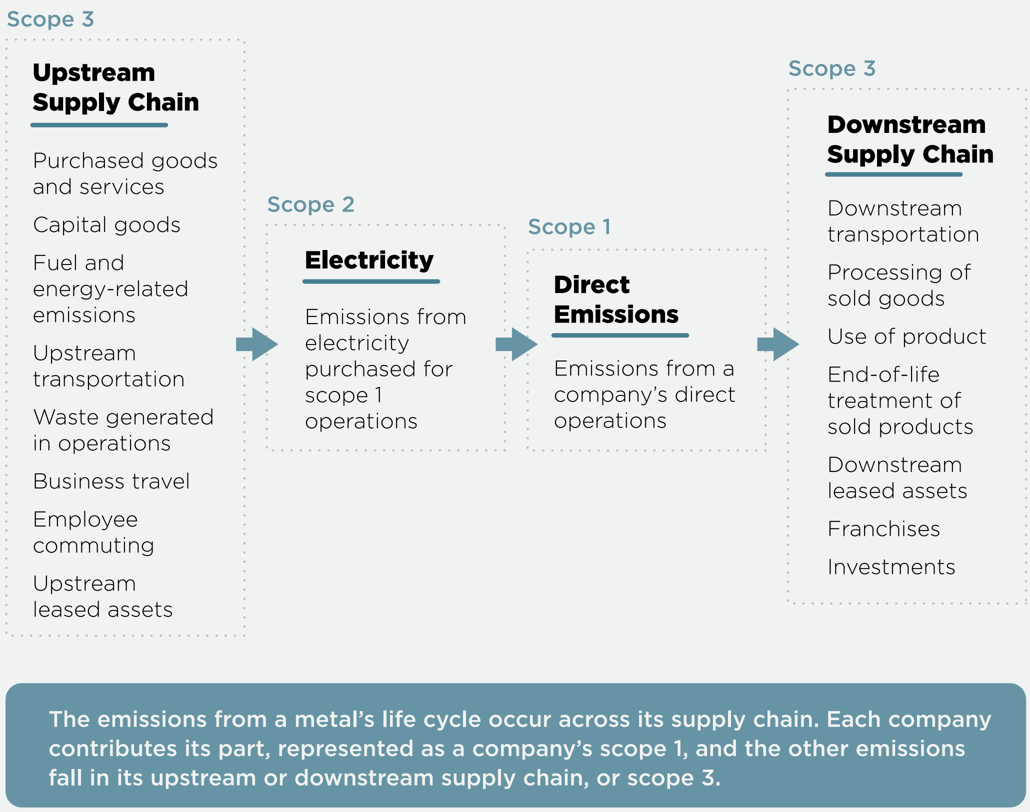


Figure 9 - This figure shows the tri-partition of emissions put forth by the Greenhouse Gas Protocol (World Resources Institute and World Business Council for Sustainable Development).

CDP reports are useful, but often not comprehensive or specific enough to fully explain a material's emissions.[35,36] To apply CDP disclosure data on a product level, we converted CDP emissions to carbon intensity (CO2/ tonne of product) using publicly available data on materials output in the year that the disclosed carbon was emitted. To fill additional data gaps, we leveraged academic studies, emissions databases, and corporate sustainability reports to calculate average carbon intensity values and to provide a sense-check for CDP disclosures.[37 to]

We covered six lifecycle phases in this study: upstream emissions from mining companies, mining operations, smelting, transportation, forming and use, and end-of-life. A summary of the lifecycle emissions is included in Figure 10 and more detail is included for each metal in the following sections. These emissions should be considered a simple snapshot of the scale of lifecycle emissions, not an exhaustive study. The reality is that the processing, transportation, processing, use, and recycling of ores mined in LAC follow myriad paths and are conducted by countless producers with variable emissions intensities.

For example, transportation was considered in only two elements of the downstream supply chain: the trip from mine to processor, and transportation to the first phase of manufacturing. Likely additional emissions occur for transportation activities along the lifecycle, particularly as the materials become finished goods. Similarly, the manufacturing and use phases of metals and minerals are complex and dynamic, especially for more complicated products such as cars and technological devices.[38]

> The study takes a simplified view of these emissions, which captures only the first stage of manufacturing. For example, the emissions generated in making tubes or wire are not included in this study; nor are further upstream emissions, such as from the operation of buildings or cars. Reflecting the circular economy, however, we do consider recycling and landfill emissions, in order to account for the role of circularity in supply chain lifecycle emissions.

As such, the lifecycle emissions estimated in this report provide a sense of the order of magnitude of the climate impact of these supply chains. Additional work should be done to understand in more detail the supply chain emissions of ores mined in LAC.

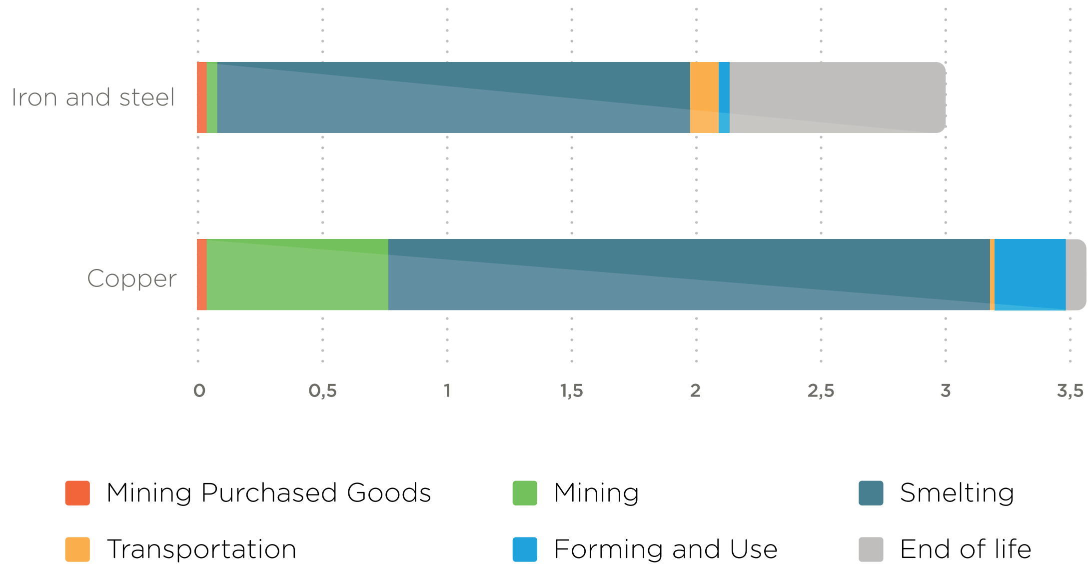


Figure 10 - The share of iron and copper's carbon emissions by lifecycle phase (based on Azadi et al, 2020)

Iron and steel supply chains originating in LAC

From the global BaU perspective, global steel consumption growth is based on crude steel production growth of 1.4% per annum over the 2020–2060 period. By 2060, it is assumed that global basic oxygen furnace (BOF)/electric arc furnace (EAF) production will transition to a 42%/58% breakdown of total crude steel. Underpinning this is the assumption that the expanding scrap supply globally, especially in China, will see scrap usage rise (3.1% per annum) more sharply than iron ore (0.2% per annum). Rising scrap consumption at BOFs, coupled with the emergence of alternative fuel sources (non-coal based), helps to support the blast furnace to BOF process.[39]

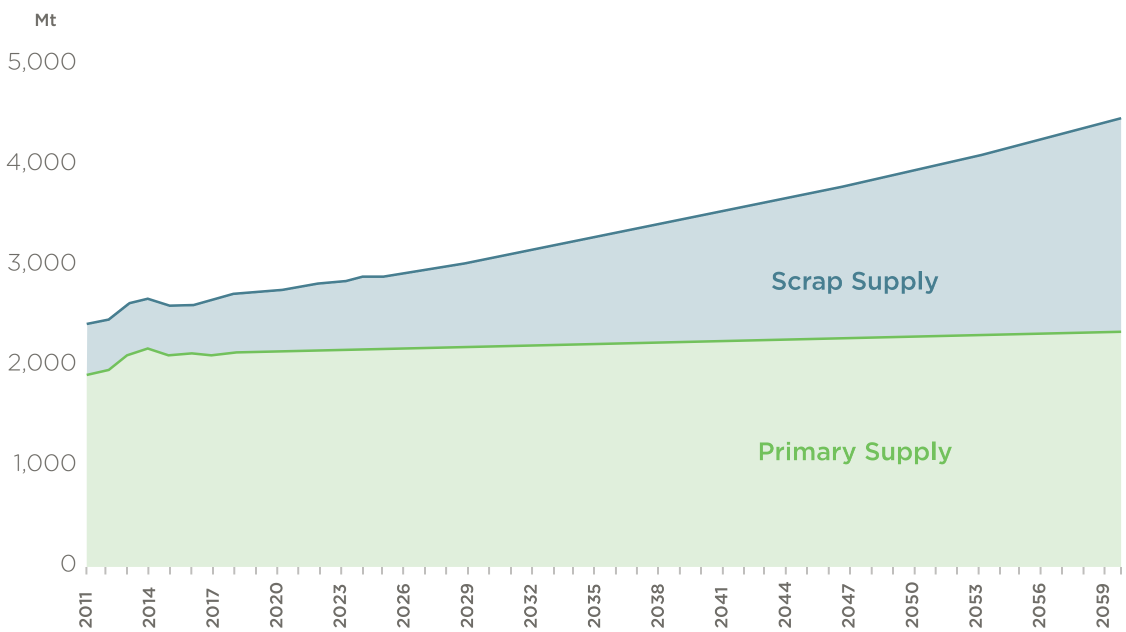


Figure 11 - Business as Usual global steel consumption scenario (MT of metal), based on the authors' calculations.

Roughly 25% of global iron ore production originates in LAC, the majority from Brazil, and a smaller component from the rest of the region.[40] Brazil's iron ore production was severely impacted by two major tailing dam failures; however, multimillion-dollar investments in Brazil have reactivated the market, making it plausible to assume that Brazil will maintain its iron ore production until 2060.[41] With these parameters in mind, complemented by current industry perspectives, a BaU scenario could see annual production of iron ore in LAC grow by 23% by 2060.

Considering carbon emissions, the limited data available on emissions from iron ore mining operations in LAC point to mining as a relatively minor part of steel's life cycle emissions, 3%, as shown in Table 1. The majority of emissions are from downstream steelmaking activities that take place predominantly outside LAC. End-of-life treatment of steel is the second-most emissions-intensive lifecycle phase, driven by the high-energy processes required to recycle steel, which again mostly take place outside LAC. While recycled steel has a significantly lower emissions intensity compared with virgin steel – largely due to the primary use of EAFs – it still represents a relatively high emissions-intense process in the iron and steel supply chain.[42,43]

Beyond the emissions highlighted in this study, additional emissions certainly occur within the lifecycle, relating to processing, use, transportation and so on. This assessment should be considered as partial and used as a guideline, rather than a comprehensive answer.

Table 1 Basis for the calculation of iron and steel lifecycle emissions

Process	t CO2/t	Explanation	Sources
Mining company's purchased goods	0.03 5	Value calculated based on the average of emissions reported in 2018 to CDP for Vale and BHP for the scope 3 category, Upstream Purchased Goods & Services. These emissions were normalized by the tonnes of ore disclosed in 2019 by each company; the calculated value was 0.04 for Vale and 0.03 for BHP.	Vale and BHP CDP Disclosure 2019
Mining	0.0442	This is an average value for open pit iron ore mining based on three data points: 1) Norgate 2007 study (0.011); 2) Samarco's 2014 sustainability report (0.0915); 3) Vale's 2019 scope 1 emissions reported to CDP normalized by tonnes of ore produced (0.03).	1. Norgate, T. E. et al. 'Assessing the environmental impact of metal production processes'. Journal of Cleaner Production. 2007. Samarco. Annual Sustainability Report. 2014. Vale CDP Disclosure 2019.
Steelmaking + metallurgical coal mining	1.893	This study used the World Steel's Association 2020 global average value for steelmaking (1.85) plus BHP's high-end value for metallurgical coal mining (0.043). It should be noted, however, that emissions from steelmakers can vary between producers and regions, showing the potential for differentiation in the marketplace for producers with lower intensity values.	1.World Steel Association. Sustainability Indicators 2003-2018. (2020). BHP Mitsubishi Alliance. Greenhouse Gases: Assessment for the Caval Ridge Mine. (nd)
Transportation	0.113	Transportation is considered on a limited basis. This value covers an average journey of iron ore by train from the mining region of Brazil to port, then to Asia by ship. To represent further downstream transport, 30% of ore is shipped further from China to Europe. No additional road or rail transport is considered, such as bringing finished goods to market, thus emissions are likely underestimated. Average emissions factors are taken from the 2019 Global Logistics Emissions Council Framework.	Smart Freight Centre. Global Logistics Emissions Council Framework (2019).
Forming and use	0.045	The emissions related to the forming and use of steel products vary widely. This value is calculated based on the average of emissions reported in 2018 to CDP by Hyundai Steel Co., Vale, and Tata Steel for the scope 3 categories of Processing of Sold Goods and Use of Sold Products. These emissions were normalized by the tonnes of ore disclosed in 2019 by each company.	Hyundai Steel Co, Vale, and Tata Steel CDP Disclosure 2019.
End of life	0.8697	This study assumed that 85% of steel was recycled and 15% was landfilled. The emissions factor for each process was based on the US Environmental Protection Agency's (EPA) Greenhouse Gas Emissions Factors database.	1. Broadbent et al. World Steel Association. 2016.2. US EPA, Greenhouse Gas Emissions Factor Database, 2018.
Total tonnes of CO2	**3.0**		

Emissions from copper supply chains originating in LAC

The BAU global copper consumption scenario assumes growth of 1.5% p.a. over the 2020-60 period. By 2060 demand is forecast to reach 46,000 kilotonnes (kt). The electric vehicle boom will be a key demand driver going forward, in addition to the broader electrification of the economy. The scrap/virgin copper split should hold broadly constant, averaging 37%/63% over the 2020–2060 period – largely because of the under-developed state of copper scrap supply. By 2060, total scrap usage is expected to reach 20,850 kt. Scrap usage in smelters and refining accounts for 11% and 7% of the feedstock, respectively.[44]

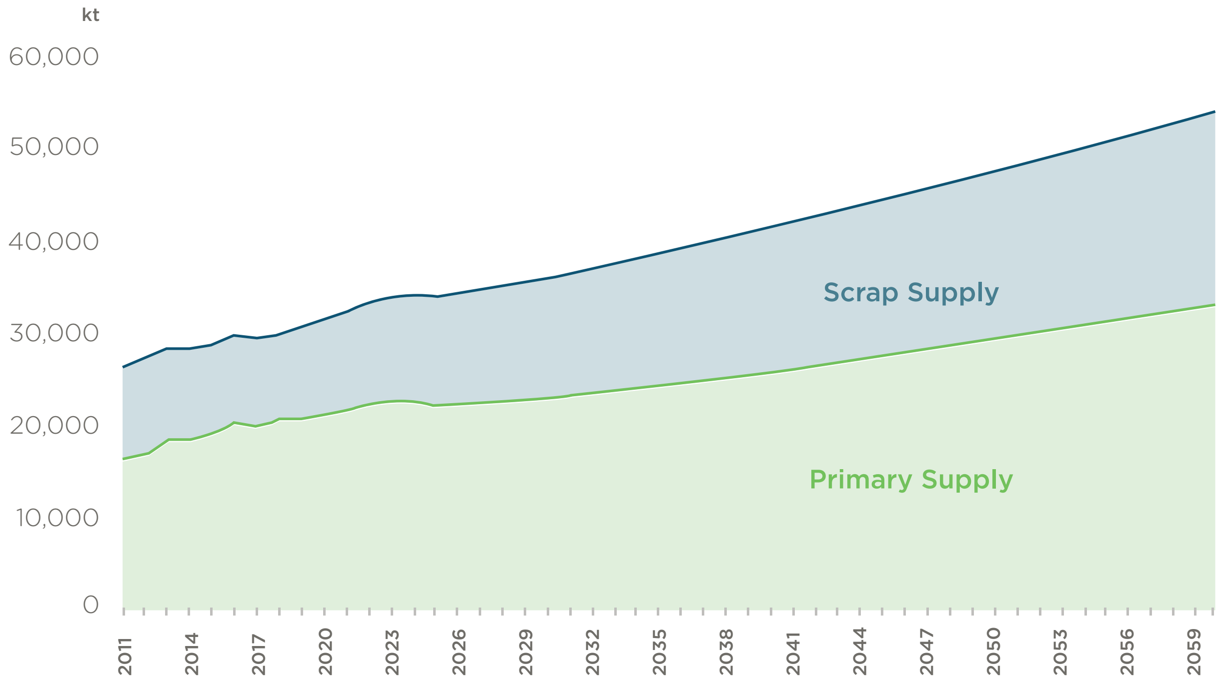


Figure 12 - Business as Usual global copper consumption scenario (MT of metal), based on the authors' calculations.

Chile and Peru have the world's largest copper reserves and Chile is the largest producer of copper, generating 21.5% of global production.[45] The majority of copper mining projects under development today are in LAC, and their output is expected to double the primary copper production in the region over the next decade.[46] It is uncertain whether investment projects will keep a higher concentration of production in the region after 2030, and therefore we assume that production growth will be the same for both LAC and the rest of world until 2060. Following this approach, annual production of copper from LAC is expected to more than double by 2060, with capacity to recycle scrap being of particular importance.

The supply chain carbon intensity of copper is quite similar to that of iron ore – 3.5 tonnes CO2/tonne of copper compared to 3.0 tonnes CO2/tonne of steel – though the distribution of emissions along the supply chain varies, as shown in Table 2. This value is similar to, but lower than, the International Copper Association's lifecycle assessment for global copper emissions of 4.2 tonnes CO2/tonne, published in 2017.

Compared with iron ore, our study found that copper mining is about 16 times more emissions intensive (0.727 tCO2/t for copper, compared to 0.0442 tCO2/t for steel). That said, more data points are available for individual copper mining operations from academia and CDP reports, increasing confidence in our results.[47]

The transparency in mine-level emissions from copper is commendable and provides a guiding light for iron ore extraction to replicate. On the other hand, smelting emissions have less than half the carbon intensity of steelmaking, reflecting a higher rate of efficiency as well as less carbon-intensive processes, given the absence of steel's high carbon input: metallurgical coal. Despite its value, less copper is recycled – just between 35%[48] and 45% of global copper production comes from scrap.[49]

The emissions intensity of the copper recycling process, however, is an order of magnitude less than steel.

Unlike for iron and steel, more of the emissions in the copper lifecycle take place in LAC; 85% of copper produced in the region is exported as 30% concentrate. The volume of concentrate exported contributes significantly to emissions from transportation, which could be reduced by increasing refinement capacity within the region.

Table 2 Basis for the calculation of copper lifecycle emissions.

Process	t CO2/t	Explanation	Sources
Mining company's purchased goods	0.03 5	Due to limited information on upstream emissions, the same value was adopted for copper as for iron ore.	Vale and BHP CDP Disclosure 2019
Mining	0.727	These figures are from a 2020 study by Azadi et al that includes data from mining operations in Chile. The study includes data on underground and open pit mining activities; direct (operational) emissions are from 2017 and indirect (electricity generation) emissions are from 2009. Our value assumes that underground mining makes up 30% of production and open pit, 70%.	Azadi, M, et al., Transparency on GHG emissions from mining to enable climate change mitigation. Nature Geoscience, 13(2), 100–104. (2020)
Smelting	2.410	These figures are from the Azadi 2020 study. This value covers concentrating and smelting activities in Chile, bringing the ore to the cathode stage. Direct (operational) emissions are from 2017 and indirect (electricity generation) emissions are from 2009. The Chilean value is used throughout the study; though emissions likely vary by geography, additional research is needed to define the split of activities, and subsequent emissions, by region.	Azadi et al (2020)
Transportation	0.021	Transportation is considered on a limited basis. This value covers an average journey of copper by truck from the mining region of Chile to port, then to Asia by ship. To represent further downstream transport, 30% of copper is shipped further from China to Europe. No additional road or rain transport is considered, such as bringing finished goods to market, thus emissions are likely underestimated. Average emissions factors are taken from the 2019 Global Logistics Emissions Council Framework.	Smart Freight Centre, Global Logistics Emissions Council Framework, 2019.
Forming and use	0.28	The emissions related to the forming and use of copper products vary widely. This value is calculated based on the average emissions reported in 2018 to Aurubis for the scope 3 categories Processing of Sold Goods and Use of Sold Products.	Aurubis CDP disclosure 2019.
End of life	0.0846	The emissions related to the use of copper products vary widely. This value is calculated based on the average emissions reported in 2018 to CDP by Hyundai Steel Co, Vale and Tata Steel for the scope 3: Processing of Sold Goods and Use of Sold Products categories. These emissions were normalized by the tonnes of ore disclosed in 2019 by each company.	1. Simon Glöser et al. Dynamic Analysis of Global Copper Flows, 2013. 2. US EPA. Greenhouse Gas Emissions Factor Database, 2018.
Total tonnes of CO2	**3.56**		

Emissions trajectories of LAC iron and steel supply chains by 2060

Following the three scenarios described above, we can explore the evolution of iron and steel supply chains until 2060. While there are a number of expected improvements along the supply chain, the first scenario considers a situation where there is no progress towards decarbonization, and production continues according to our BaU projections. This scenario reflects a baseline; but also an outlook where the capital required to make these changes is lacking, or where pressure from investors or end users to realize decarbonization goals wanes, due to an economic downturn or other unforeseen circumstance – or the lasting effects of the COVID-19 pandemic.

As Figure 13 demonstrates, a lack in progress would nearly double supply chain emissions from LAC iron ore by 2060.

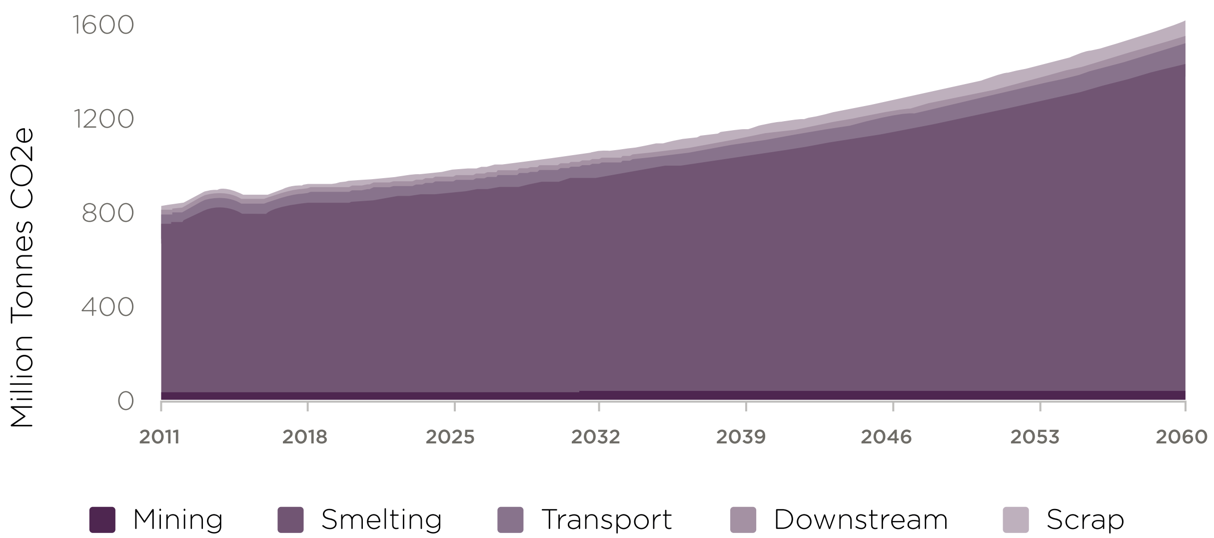


Figure 13 - LAC iron ore supply chain emissions with no implementation of climate goals under current demand projections, based on the authors' demand calculations and the emissions estimates shown in tables 1 and 2.

The second scenario reflects the decarbonization potential if expected efficiency and technology advancements are fully played out under projected demand scenarios. For example, we expect a formidable 50% reduction in iron ore mining intensity based on the expected uptake of renewable energy in mining operations.[50] We also consider a 20% intensity reduction in long distance transportation following Mission Possible's projection for improved efficiency; however, it should be noted that no uptake of low carbon fuels is considered here.[51] For the lifecycle emissions hotspot, steelmaking, we take a 10% reduction based on trends in the steel sector.[52] Even with impressive intensity reductions from LAC miners, limited advancements in low-carbon steelmaking limit the reduction in carbon intensity of LAC iron and steel supply chains to 11% of current values by 2060. This will lead to a 72% growth in emissions from LAC iron and steel supply chains by 2060, putting them seriously out of alignment with the Paris Agreement.

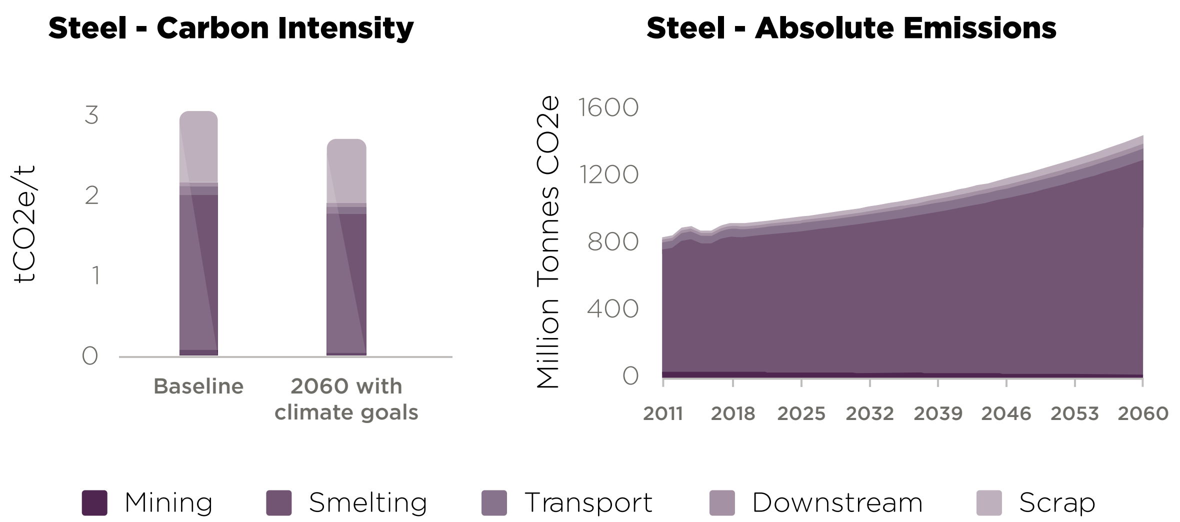


Figure 14 - Emissions intensity reductions across the iron and steel lifecycle according to projected decarbonization, based on the sources shown in table 1 (left); total emissions from steel with the implementation of decarbonization strategies under business as usual demand scenarios, based on table 1 and the authors' demand calculations (right).

In the final scenario for iron and steel, we work backwards from the iron and steel sector's B2DS budget to determine how emissions intensities must change in response. We find that in order to achieve the 90% global reduction in sector emissions,[53] the emissions intensity of steel must decrease to 0.13 tonnes CO2/tonne – a reduction of more than 95% in emissions intensity across the supply chain from today's values. This type of reduction would imply major technology breakthroughs, substantial deployment and uptake of policy measures, and extensive response from consumers to demand and pay for low-carbon steel.

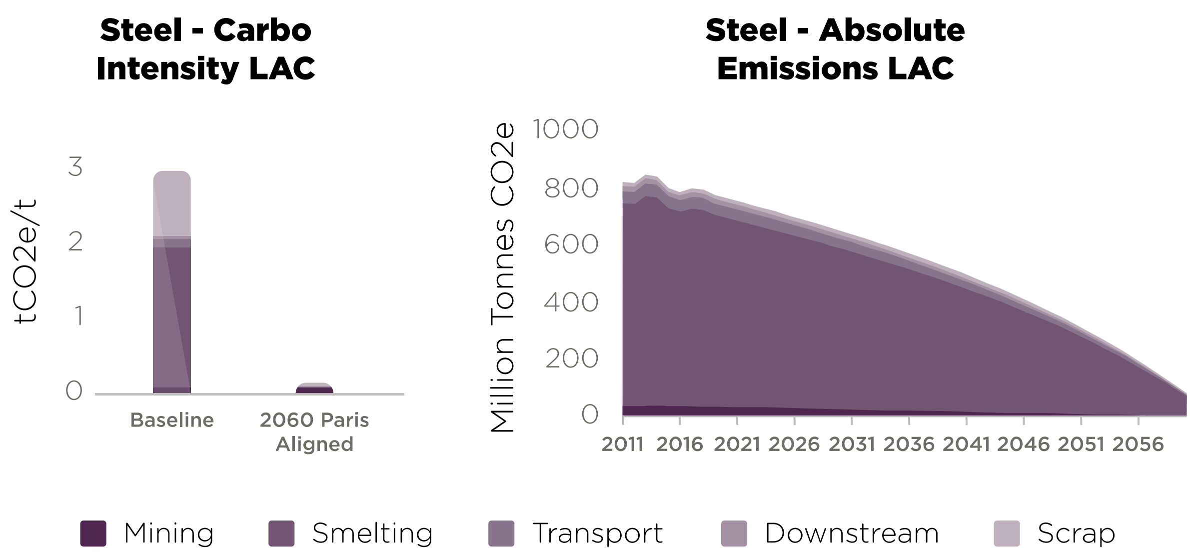


Figure 15 - Emissions intensity reductions across the iron and steel lifecycle required to meet Paris targets at BaU volumes, based on the sources shown in table 1 (left); total emissions from iron and steel under BaU demand scenarios aligned with Paris, based on table 1 and the authors' demand calculations (right).

Emissions trajectories of LAC copper supply chains by 2060

Replicating the three trajectories for emissions reductions discussed for iron/steel, we first consider the scenario in which today's emission intensities are extended to meet BaU demand until 2060. Here we see the same trend as with steel, where an increase in global demand would more than double annual emissions by 2060, demonstrated in Figure 16 below.

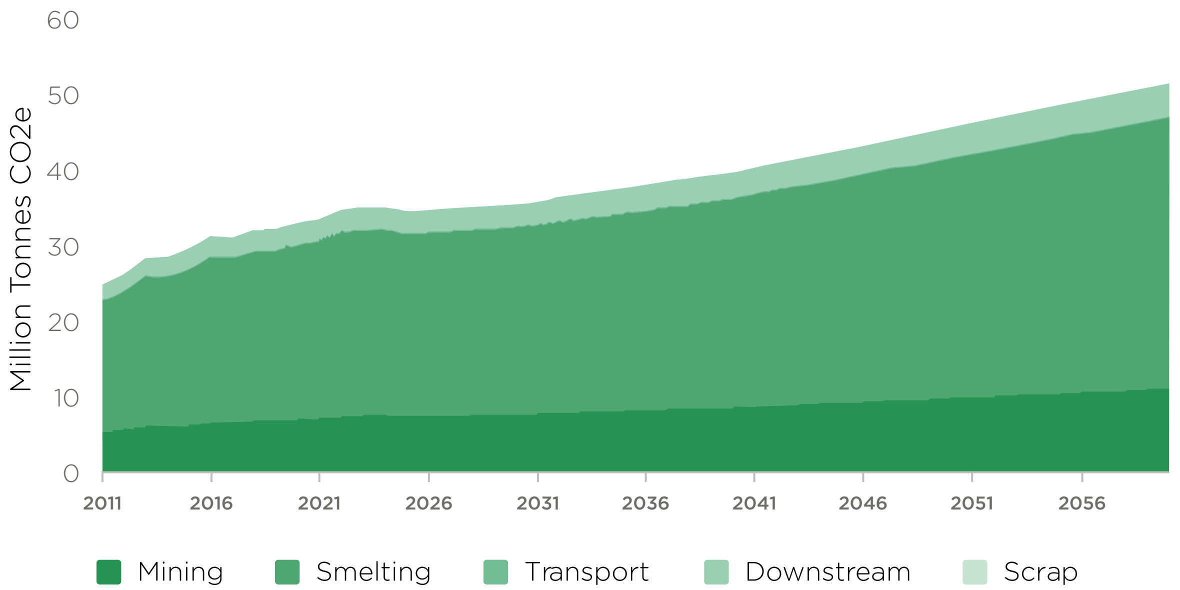


Figure 16 - Total emissions from LAC copper with no progress towards climate goals, based on the sources shown in table 2 and the authors' demand calculations.

In the second scenario, we estimate the potential emissions intensity reductions based on projections for low-carbon energy and technologies, like a 50% reduction in mining intensity by 2060. Similar to steel, renewable energy is set to be adopted across mining operations and smelting operations, while transportation emissions will be reduced through demand management and efficiency measures. The implementation of these levers has the potential to reduce the carbon intensity of copper by 19% by 2060. While this is a significant improvement, given the growth in global demand, the end result is a net increase in emissions of 68% for the LAC copper sector.

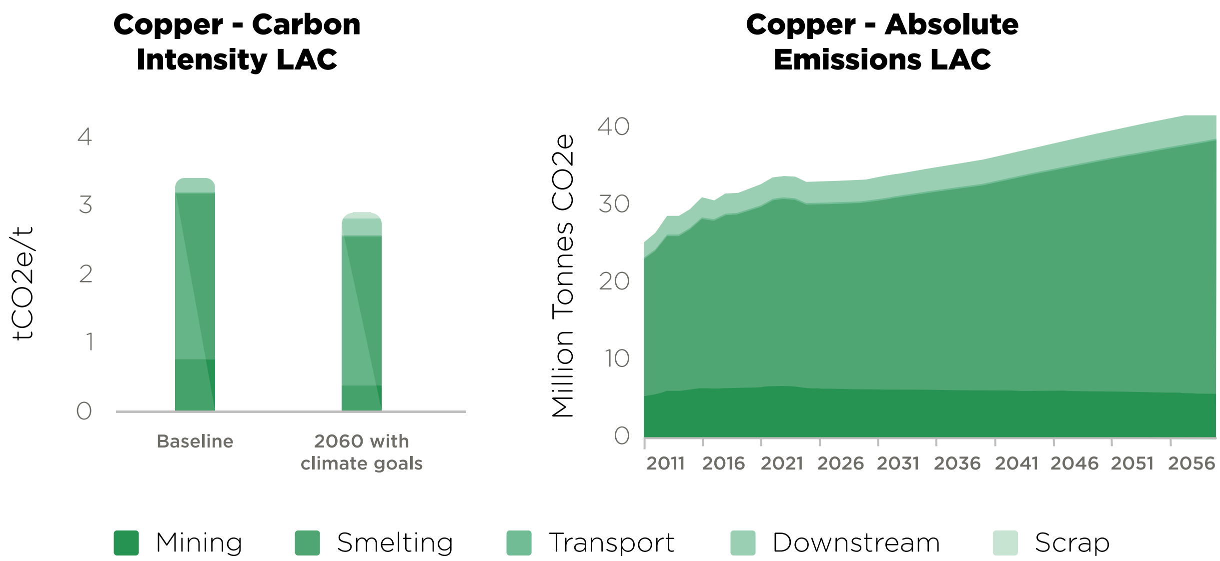


Figure 17 - Emissions intensity reductions across the copper lifecycle according to projected decarbonization, based on the sources shown in table 2 (left); total emissions from copper with the implementation of decarbonization strategies under BaU demand scenarios based on table 2 and the authors' demand calculations (right).

Finally, we consider the emissions intensity reductions required for the LAC copper sector and its supply chain to achieve the Paris targets. Here we see, to reach the 90% materials sector reduction targets, copper supply chains originating in LAC will need to collectively decrease their intensity by 96% to 0.13g CO2/tonne to reach projected demand and meet the Paris goals. Note that intensity is reduced by the same percentage across process steps.

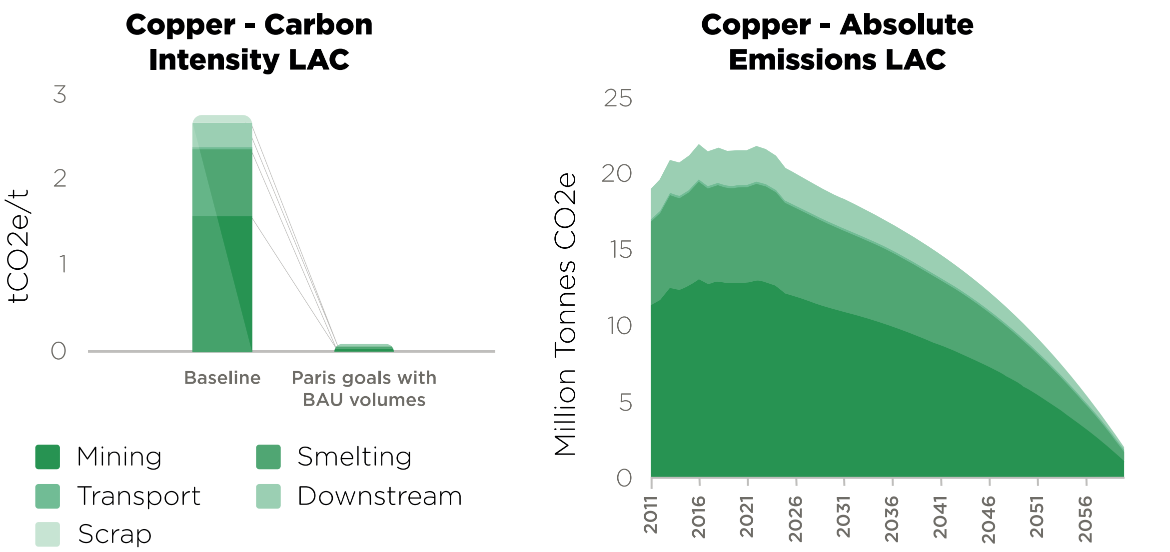


Figure 18 - Emissions intensity reductions across the copper lifecycle required to meet Paris goals at BaU volumes, based on the sources shown in table 2 (left); total emissions from the copper sector under BaU demand scenarios aligned with Paris, based on table 2 and the authors' demand calculations (right).

Key takeaways from the business as usual demand scenarios

Increased demand translates into growing primary supply from LAC. However, this growth in production leads to an untenable increase in global climate impacts, even if emissions intensity reductions are achieved as projected by key players across the supply chain.

> **A carbon intensity reduction strategy delivers substantial emissions reduction at the product level, but it does not provide certainty of alignment of the absolute emissions from the LAC copper or steel supply chain to the Paris targets given the growth in production volumes.**

To imagine a scenario that does not rely so heavily on carbon offsets to achieve global climate goals, we must envision a world in which energy supply chains are dramatically decarbonized. A shift to hydropower, nuclear power or green hydrogen would need to be fully realized by all miners, manufacturers, steelmakers and transportation companies; and nearly all fossil fuel-based equipment would have to be decommissioned. This is technically possible but requires significant commitment from the public and private sector, and a speed and scale of deployment across the value chain rarely experienced before.

The following chapter quantifies the emissions reductions that are possible by following a "decoupled" approach that emphasizes primary supply reduction and circular economy strategies such as efficiencies, reuse, and recycling as key levers.

Chapter 3 – The Opportunity of a Global Decoupled Scenario for the Latin American and Caribbean Mining Value Chains

The previous chapter showed that the "BaU Paris" scenario can result in an emissions profile that is aligned with the Paris targets but it will require a level of effort and commitment across players in the value chain never experienced before. Yet, the "BaU" and the "BaU Possible" scenarios still fail to meet Paris targets. Beyond the climate impacts, these scenarios could have countless other environmental and social impacts that jeopardize global progress towards the SDGs.

This chapter lays out an alternative vision: **a "Decoupled" scenario that reinvents BaU to create a new normal, in which demand for primary materials declines and efficient use, reuse and recycling of materials become key strategies for meeting global demand and emissions targets.**

This means that global primary consumption of copper and steel would decline to reflect a more productive use of materials through circular economy principles; but use of these metals would increase through the more efficient design of products and new business models that allow for effective reuse, repurposing and recovery.

While a decoupled scenario may seem radical at the global level, decoupling will not severely impact primary copper and iron ore production from LAC immediately – given the position of the mining operations in LAC. Both copper and iron ore mines in Chile, Peru and Brazil can still operate and grow in a global decoupled world.

In fact, LAC has the opportunity to become a major player in a resource decoupled economy which is aligned with planetary boundaries, the SDGs and the Paris Targets. In a decoupled scenario, LAC has the conditions to transform itself into a global low-carbon mining and solutions hub. This hypothesis is based on two factors:

- LAC copper and iron ore mining is positioned primarily at the very beginning of the supply costs curve; and
- LAC has key conditions to support a low carbon pathway such as, for example, competitive access to nature-based solutions, renewable energy capacity and the potential to produce green hydrogen.

To better understand the emissions landscape within a resource decoupled scenario, we build on the scenarios discussed in the previous chapter to develop a fourth scenario that offers a preliminary estimate of the emissions reductions that could be realized as a result of these paradigm shifts. Here, we keep the emissions intensities reflected in the technical potential supported by mining companies and think tanks (Scenario 2: “BaU Possible”), but allow the volume of primary metal to reduce and the stock of metal in the economy to be shared, reused and recycled at much higher rates building on the analysis made by the United Nations International Resource Panel, 2019 Global Resource Outlook.

Forces potentially driving a decoupled scenario

If the world decided to pursue a radical decoupling agenda, in which increased GDP does not translate into increased consumption of primary metal, key global players could choose to make the following decisions:

- **Corporates -** Apple, Tesla and others follow Coca-Cola into a “take-back” or “one-out/one-in” world, in which 100% recovery of after-use products is the norm.
- **Policy -** EPR schemes impose fees based on product recyclability, driving radical redesigns of vehicles, electronic products and batteries to allow for disassembly and high-quality recycling and reuse.
- **Regulations -** The construction and infrastructure sector regulates waste generation, with material passports, that track materials from the source to the end product, the new norm; buildings become registered “material banks” designed for disassembly and reuse.
- **Procurement -** Stringent procurement rules from are adopted first by government and then by large corporates with green credentials, stipulating recycled content standards in buildings and products.
- **Politics -** “[My Country] First” politics becomes increasingly prevalent, rewarding the domestic supply of recycled materials (and jobs) over imported sources of virgin materials.
- **Climate -** A 1.5°C science-based target for the mining industry is established, underpinned by a carbon price and subsidies for recycled, reused, and repurposed materials.

Whether or not LAC embraces a decoupled approach, end-consumers of LAC copper and iron ore will be looking to align their products, activities, and supply chains with their climate goals. Looking down the steel supply chain, end users planning for 2050 might note CDP's observations that, while 60% of steelmakers have set climate goals, just two are on track to meet them.[54] Realizing that their material supply chains will not meet their expectations, companies are likely to look for alternative materials and designs that will facilitate decarbonization – which could be perceived as putting LAC mining operations at risk.

LAC leaders should now begin to consider what the most radical value-generating strategy for the region would look like if the world started to adopt the behaviour described in the above scenario.

In 2019, the United Nations International Resource Panel (IRP) – the pre-eminent global scientific authority on resource use – published the most comprehensive analysis to date on global resource extraction and consumption patterns, the associated environmental socio-economic impacts and the market levers for increasing efficiency and reducing waste.[55]

Its conclusions were clear: if growth is decoupled from consumption of primary resources, the world has a clear chance of meeting the Paris targets and the SDGs, and remaining within planetary boundaries.

To reach these conclusions, the IRP modelled a variety of levers that would reduce demand and consumption of resources (biomass, fossil fuels, metals and non-metal minerals) by 25% by 2060 (relative to a scenario based on historical trends), while at the same time supporting economic growth of 8% year on year. At the heart of its decoupling thesis is the circular economy, with primary supply reductions arising from resource efficiencies achieved through strategies of dematerialization (savings, reduction of material and energy use) and re-materialization (reuse, remanufacturing and recycling).

To many, the term "circular economy" equates simply to recycling. But look a little further and one finds a myriad of innovative new business models and practices, all designed to maximize the value of materials through multiple use cycles. The emergence of a sharing economy in the automotive sector, for example, has challenged long-held notions of the need for car ownership. Recovery and refurbishment in the electronics and battery sectors will result in the metal in products being "sold" multiple times. Advanced construction methods will greatly facilitate the reuse of materials through pre-configured "modular" construction units. Meanwhile, new technology such as 3D printing is already enabling up to 70% reductions in virgin material inputs and cost reductions of up to 40%.

Consider the following existing trends:

- **Policy –** Key markets such as China, Japan, and India are implementing low-carbon policies, and the European

Green Deal will mobilize €10 billion for natural capital and circular economy investments by 2030.[56] Further, more than 370 EPR schemes have been introduced across all continents and in all key end markets since 1990, improving waste management and recycling.[57]

- **Large consumers –** The market capitalization of large metal consumers that have already implemented advanced low-carbon strategies, driven by the circular economy, stands at an estimated $3 trillion. Companies are looking for ways to reduce the sustainability risks in their supply chain. For example, Apple has committed to use 100% recycled aluminum in its products and no mined materials longer term; BMW is partnering with Umicore to trace battery materials to the mine level; and Volkswagen is seeking a five-year supply of sustainable cobalt.[58]

- **Finance –** More than 1,000 companies have declared their support for the Task Force on Climate-related Financial Disclosures (TCFD), a program to advance climate transparency in financial reports.[59] There was a 77% increase in global assets managed through sustainable strategies from over the last decade. Large financial institutions such as ING, BNP Paribas and Blackrock are already using a CE lens to develop new financial products and instruments that will enable the transition.

- **Technology –** The World Economic Forum has identified 100 potential 'unicorns' with the capacity to significantly disrupt the mining sector (eg, Desktop Metal in 3D printing, Sunray Ventures in advanced recycling, and Minespider in blockchain protocol for sourcing.

To illustrate the scale of the opportunity, it is estimated that the circular economy could generate $4.5 trillion in economic growth by 2030 and as much as $25 trillion by 2050.[60] The Ellen MacArthur Foundation - a British-based think tank researching the circular economy - estimates that the full value of circular opportunities globally could be as much as US$700 billion per annum in material savings. As such, it is the opportunity for new growth rather than the threat of regulation that is driving those seeking to secure first-mover advantage.

The potential overall effect of the circular is modelled as a reduction in the overall sum of supply from scrap and primary mineral while consumption of metals could keep growing as BaU. These "wedges" reflect supply that could be progressively substituted by aspects of reuse, repurposing and reduction (efficiencies), and other resource productivity solutions supported by policies, technology, finance and new business models.

> Based on Hatfield-Dodds (2017), the basis for its modelling, the IRP 2019 Global Resource Outlook breaks down the total impact of these circular economy wedges as follows:

- 7% through resource efficiency;
- 46% through resource extraction tax (as a proxy for any potential policy on primary materials linked to the evolution of ERP schemes, for example); and
- 47% through demand shifts caused by circular economy policies.

Whether, when and to what extent these decoupling forces emerge will be dictated by the societal, political and commercial appetite to deliver the Paris targets. LAC has a clear strategic choice and a unique opportunity to better understand the winning conditions in a decoupled scenario and establish the conditions to build optionality across a number of alternative scenarios.

A decoupled steel sector

In steel, the conditions for transition to a decoupled world are already emerging. Scrap is increasingly becoming available and being used increasingly in BOF (integrated steelmaking). EAF is improving the quality of steel it can deliver and its capacity in the market is likely to grow. Beyond recycling and scrap, the biggest players in the automotive, construction and technology sectors are already applying circular models that prioritize efficiencies, reuse, repair and recycling.

In this context, iron ore and metallurgical coal are increasingly perceived as "harder to abate" and over the next decade will drive billions of carbon costs to steel manufacturers. This creates strong incentives for large producers such as POSCO, Arcelor, Tata and Nippon Steel to deploy transition strategies including efficiency measures, carbon capture and storage (CCS) and substitutes (eg, scrap, charcoal and hydrogen). The figure below shows some of the existing areas in which key steelmakers are already taking action to exploit the circular economy as an abatement mechanism for scope 3 emissions.

https://www.wri.org/resources/charts-graphs/wedges-concept

Company and sales (m CAD)		Scope 3 emissions (m tones CO2)*	Low-carbon (Scope 3) activities
ChinaSteel	336	5.2	• **Limited** • However, iron and steel enterprises are still the main targets of rectification for China to reach its objective of emissions reduction, as the CCS is still a new technology • Steel industry targeted in China carbon trading scheme
FHS	333	4.4	• Limited low carbon initiatives
JFE	236	3.1	**Participant in the industry COURSE50 initiative:** • Eco process – improving energy efficiency • Eco products – contribute reductions when steel used in final products • Eco solution – tech. transfer and diffusion • **Hydrogen** - Long term move to
HYUNDAI STEEL	236	3.1	• **Offsets:** Participating in overseas clean development mechanism (CDM) projects
KOBELCO KOBE STEEL GROUP	230	3.0	• Limited. Aligned with Japanese industry COURSE50
NIPPON STEEL & SUMITOMO METAL	979	12.8	**Participant in the industry COURSE50 initiative:** • Eco process – improving energy efficiency • Eco products – contribute reductions when steel used in final products • Eco solution – tech. transfer and diffusion • **Hydrogen** - Long term focus
posco	762	9.9	• Four implementation areas - Green Steel, Green Business, Green Life and Green Partnership - the goal is to become the "Global Green Growth Leader • **Hydrogen** – pilots from 2018 to 2024, partnership with Sweden's SSAB • **Offsets:** plan to reach 1.2 million tons of overseas credits through 19 CDM projects in Asia by 2023
JSW	448	5.9	• **Limited** • Highlight 'Corex' technology as their leading sustainability initiative - low grade coal use - eliminating the need for coke making units
ArcelorMittal	335	4.6	• By far leader in space • €250 million research and demonstration programme for low-carbon steel • **CCU** (LanzaTech) • **Electric:** ΣIDERWIN EU project- CO2 free steel • **BioChar:** Torero – bio-waste 1st $40m pilot under construction • $\mathbf{H_2}$ pilot • Scrap metal inclusion

Table 3 - Summary of key steel makers actions and plans to reduce emissions. Source: Authors' work.

The steel decoupled scenario is based on the "Sustainable Scenario" presented in the IRP Global Resource Outlook 2019. Using the IRP's general assumptions as a starting point, we assume that total raw materials (iron ore and scrap) consumption increases by 0.2% per annum from 2020 to 2060. Primary iron ore declines at -2.1% per annum, while scrap rises at 3.0% per annum. It is assumed that primary iron ore falls to 30% of demand by 2060. Scrap usage is projected to rise from 23% in 2020 to 70%[61] of total raw material demand by 2060. Crude steel production rises at 1.02% per annum over the 2020-2060 period.

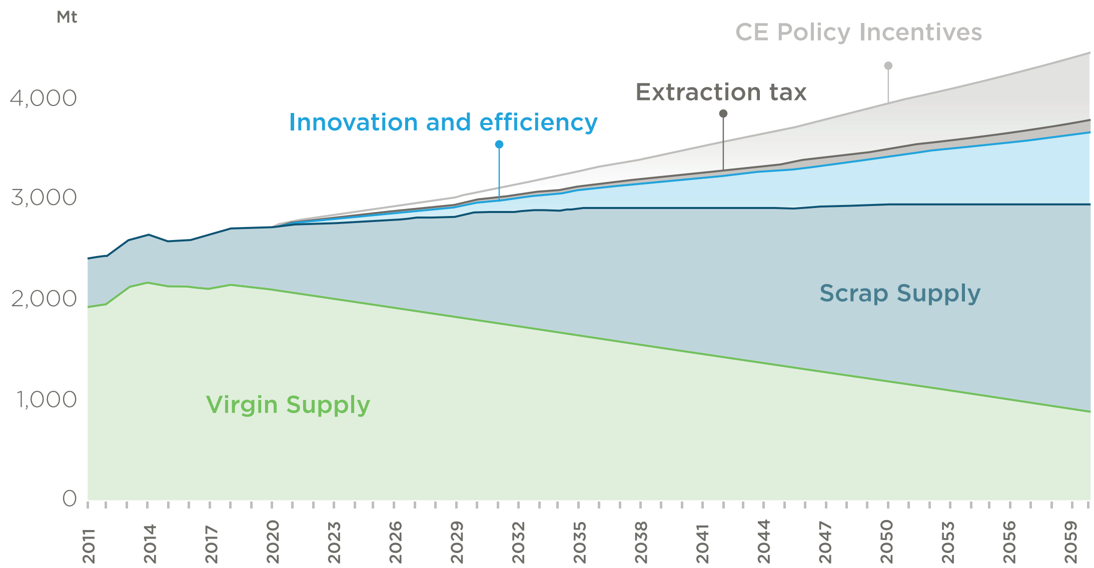


Figure 19 - Global steel - decoupled scenario, according to the authors' demand calculations.

In the Decoupled scenario, we aligned with the required 90% reduction in steel lifecycle emissions to meet Paris Targets. This will require a 93% reduction in emissions intensity across the supply chain compared with 2010 levels – lower than the 95% reduction required by Scenario 3 – "BaU Paris", the Paris-aligned scenario with no volume reductions. Reducing primary supply of iron to reduce total emissions still requires a substantial effort in reducing carbon intensity to be aligned with Paris targets.

While the difference between the required reduction in emission intensity from "BaU Paris" and the "Decoupled" scenarios is a small absolute change when striving to achieve such an ambitious goal, the emissions savings from decoupled volumes are more apparent when a range of emissions targets are considered, as illustrated below:

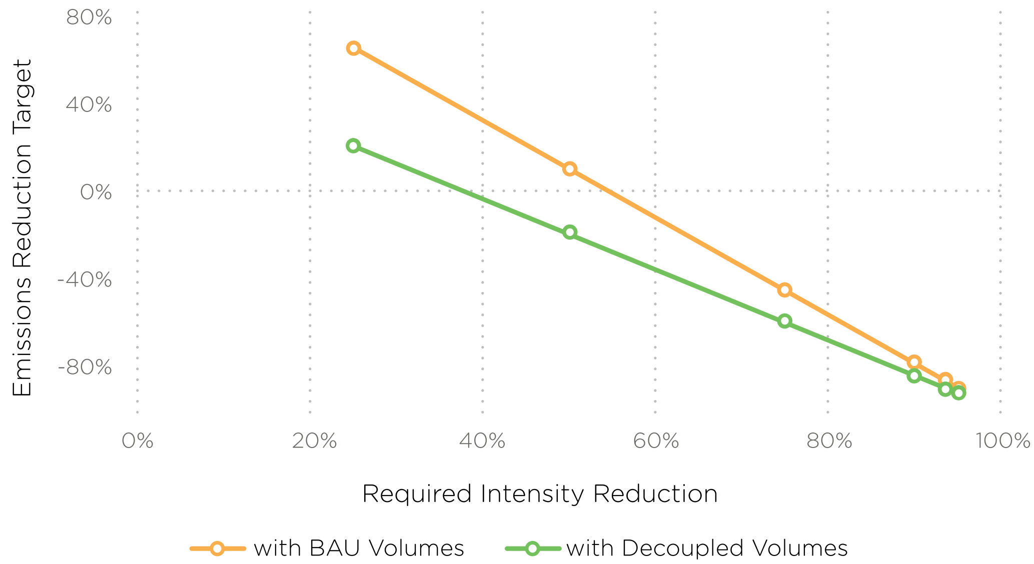


Figure 20 - The relationship between emissions and intensity reduction using BAU and decoupled volumes for steel, according to the authors' demand calculations.

LAC primary iron ore producer, Vale, has pledged to reduce the emissions from its mining operations by 33% before 2030, and to net zero by 2050.[62] For end consumers to achieve their climate goals, however, the mining sector will need to build on these commitments, emissions will have to be reduced, either by using less steel, more recycled steel, less carbon-intense virgin steel, and/or new steel substitutes like graphene-based materials. The table below shows the differences in volume for the scenarios examined in this paper:

	2020 Volume (MT)	2060 Volume (MT)	Percentage Difference
Virgin BAU	2136	2356	9%
Virgin Decoupled	2104	891	-136%
Percentage Difference	**-2%**	**-164%**	
Scrap BAU	613.49	2087	71%
Scrap Decoupled	515.05	2078	75%
Percentage Difference	**-19%**	**0%**	

Table 4 - Summary of changes in virgin & scrap volumes for global steel scenarios, according to the authors' demand calculations.

Non-coal-based options for steel will likely rely on natural gas in the short-term, transitioning to biomass as an interim fuel until the hydrogen economy matures and eventually overtakes other fuels. We understand that biomass as a source for low-carbon steel may generate different reactions from stakeholders. We are scanning all alternatives available and biomass is one of them, at least in the short term and as a transition.

Current producers – primarily in Asia and Europe – rely heavily on coal and do not seem to have the conditions to develop gas-based, biomass-based, or competitive hydrogen-based steel at the scale and speed required. LAC may be able to exploit this situation and establish the conditions to support the production of green steel. Brazil has the potential to supply the biomass needed for green steel to succeed, if issues relating to land use change and deforestation are properly addressed.

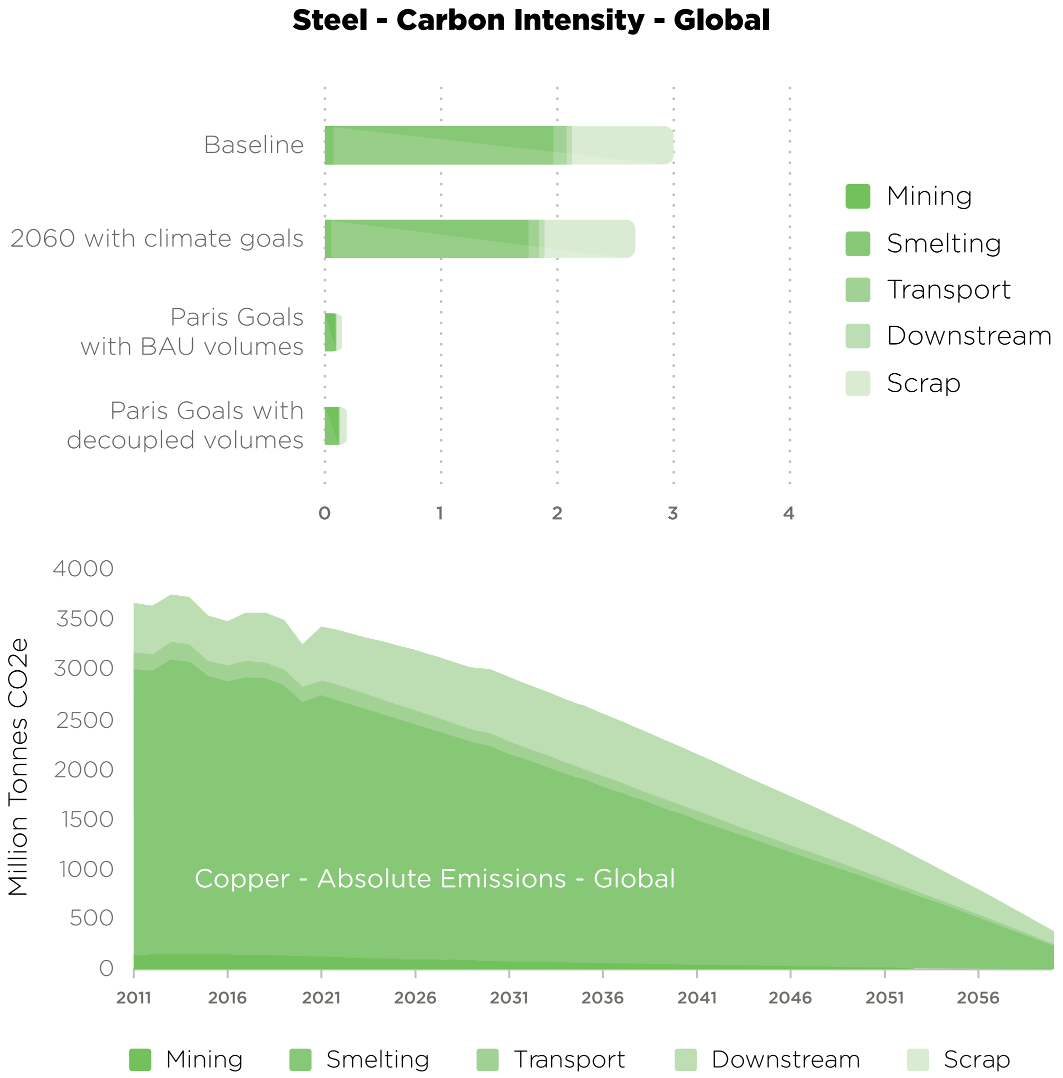


Figure 21 – Summary of the emissions intensity reductions required by each scenario, with the decoupled scenario on the top , based on the sources listed in table 1 ((top); the potential for emissions reduction for iron and steel in the decoupled scenario, based on table 1 and the authors' demand calculations (bottom).

A decoupled copper sector

Copper is a different story from iron and steel. Copper is required in large volumes to electrify the low-carbon economy. In many BaU scenarios, supply of primary copper more than doubles by 2040. In contrast to steel, most emissions in the copper value chain take place during mining. Emissions from recycling remain low in terms of carbon intensity per tonne processed. If the decoupling forces explained above mature and consolidate fast enough (ie, between 2030 and 2040), recycling could find enough support to play a much bigger role than today. In addition, new recovery, reuse and refurbishment (repair) models could develop. Some of these trends are already taking shape today. For example, Audi has recently partnered with Umicore and Aurubis with Grillo Werke AG and Deutsche Telekom AG, indicating the market's appetite to explore closed-loop recovery models. The tables below show how some copper players across the value chain are already acting:

Company and sales '000 T		Scope 3 emissions (tones CO2)*	Low-carbon (Scope 3) activities
Aurubis	262 Aurubis	299,873	• Recycling solutions: • Have set a target of using a larger volume of complex secondary raw materials in addition to copper raw materials, extracting many metals apart from copper in order to make these metals useful for society • Largest copper recycler worldwide • Circular economy initiatives • CO2 emissions: reduction target > 100,000 t by FY 2022/23 (base FY: 2012/13)
CHINALCO	61 Yunnan	79,146	• Member of Copper Alliance • Advanced copper smelting technologies • Other
祥光铜业 XIANGGUANG COPPER	61 Xiangguang	70,210	• Advanced copper smelting technologies • Other
SUMITOMO	58 Sumitomo	66,890	• Advanced copper smelting technologies • Other
LS-Nikko Copper	48 LS-Nikko	55,083	• Advanced copper smelting technologies • Materials solutions provider R&D focus –energy efficiency and environmentally-friendly focus
JINLONG COPPER CO.,LTD	48 Jinlong	54,348	• Advanced copper smelting technologies • Other

Table 5 - Summary of key copper smelters and intermediate product manufacturers actions and plans to reduce emissions. Source: Authors' work.

	Company	Description	Potential for Teck
Industry associations	IRMA Initiative for Responsible Mining Assurance	1. Institute for Responsible Mining Assurance – focus on responsible sourcing and certification/ industry standards	Investigate collaboration to define 'scope 4 / carbon avoided' potentia for copper products
Built environment	Nexans BRINGS ENERGY TO LIFE; CODELCO	1. Nexans partnered with Codelco to create a more traceable and transparent copper market. 2. Aim is to develop and implement environmental, community-friendly and ethical processes in the copper industry, promoting sustainable practices.	Focus areas worth exploring: • Potential to position Teck as th preferred supplier of copper to forward thinking companies • Sell to the most efficient copper manufacturers only
Automotive	BMW; CODELCO	1. BMW & Codelco partnership for sustainable and transparent copper 2. VW targets €2bn in savings by 2025 to accelerate recycling and reuse in electric cars 3. Tesla looking at going straight to source for critical materials – i.e. Lithium mining in Bolivia	• Teck partners with refiners and end customers to provide lowest intensity copper – building off of Teck's existing low production intensity.
Technology	hp; DELL; MITSUBISHI ELECTRIC	1. Apple: target of 100% non-mined products. Increase and certify the recycled content in the metals we source. Also looking at buying metals directly from miners to assure providence (Cobalt) 2. HP will continue to transition our company and our customers to a circular "make, use, reuse" and aim to be a key player in metal 3D printing 3. By 2020, Dell Technologies will close the loop on all used Dell equipment 4. Mitsubishi: By 2021: Fully close the loop and 50% revenue from 'product as a service model"	Large push from tech. players to circular economy products and services: • How can Teck position itself in this growing business sector? • What partnerships with existing refiners and potentially with recyclers is required?

Table 6 - Summary of cross value chain partnerships to reduce emissions through circular economy measures. Source: Authors' work.

Similar to the steel decoupled scenario, we use IRP's base assumptions as a starting point to define the global copper decoupled scenario. In this scenario, total copper primary and scrap consumption rises at 0.2% per annum from 2030 to 2060. Primary copper declines at -2.2% per annum and scrap rises at 2.3% per annum. It is assumed that primary copper will decline to 30% of total copper demand over the 2030–2060 period. Scrap usage is projected to rise from 37% in 2030 to 70% of copper demand by 2060. Refined copper demand is forecast to grow at 0.8% per annum over the 2030–2060 period.

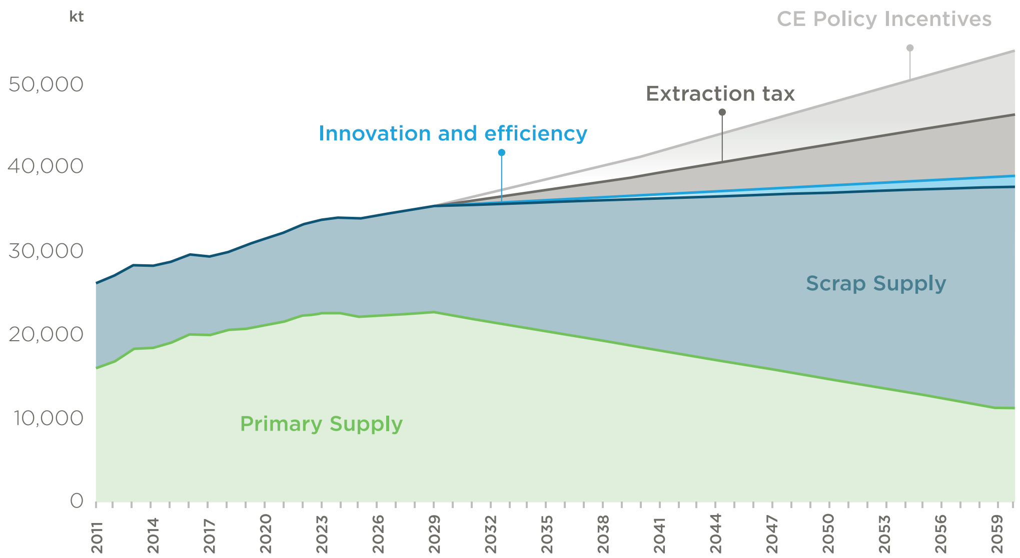


Figure 22 - Global copper decoupled scenario, according to the authors' demand calculations.

Our study shows that a Decoupled scenario for copper would require a carbon intensity reduction of 87% compared to 2010 values, lower than the 95% reduction required by the Paris-aligned BaU scenario ("BAU Paris"). Again, while an absolute difference of 8% does not seem large, the difference is more pronounced when viewed as a relationship between targets and intensity reduction, as show below.

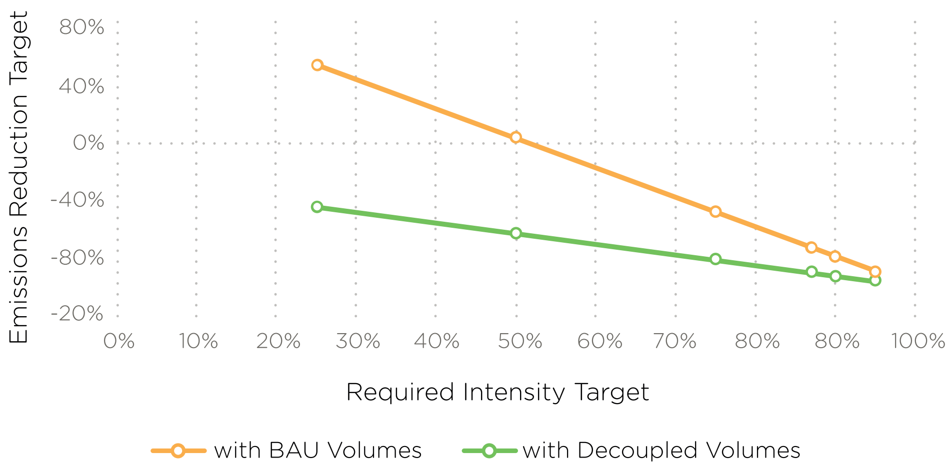


Figure 23 - Showing the relationship between emissions & intensity reduction using BAU and decoupled volumes for copper, according to the authors' demand calculations.

As discussed in more detail in the following section, the most emissions-intensive copper mining activities stem largely from fossil fuels used for materials transportation. Compared with the technological developments required for low-carbon steel production, decarbonized transportation options are much more advanced. Sustainably produced biofuels could serve as a low-carbon fuel source, mirroring the solutions proposed for Brazilian steel, as well as the battery and solar panel products for which the region is known.[63] Overhead catenary wires are also an option for copper transportation, and are already being deployed in pilot projects for heavy-duty truck transport.

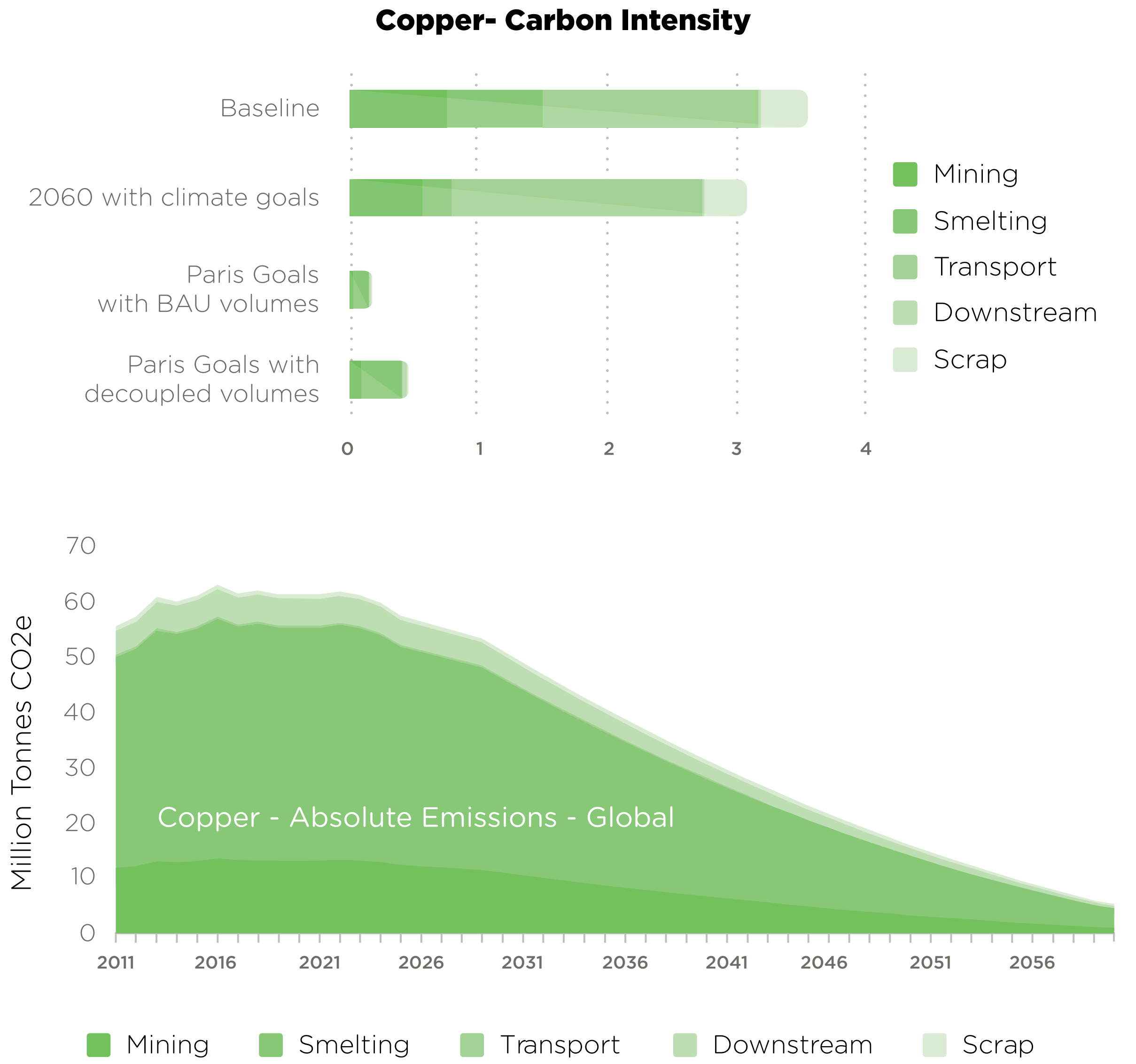


Figure 24 - Summary of the emissions intensity reductions required by each scenario, with the decoupled scenario on the top, based on the sources shown in table 2 (top); and potential for emissions reduction for copper in the decoupled scenario, based on table 2 and the authors' demand calculations (bottom).

Key takeaways from the decoupled scenario

Contrary to what might be expected, decoupling will not have a severe immediate impact on primary copper and iron ore production from LAC, given the position of mining operations in the region. Both copper and iron ore mines in Chile, Peru and Brazil can still operate and grow in a global decoupled world. However, the transition to a decoupled world will open many more opportunities than merely sustaining primary production. To fully capture these new opportunities, a low carbon local value chain in LAC needs to be developed while driving towards swift emissions intensity reduction which the next section explores in more detail.

Decoupling growing consumption of metal from primary supply does not lead to the required reduction of absolute emissions to meet Paris Targets – unless emission intensities are also substantially reduced. While we do not define which supply chain partners are responsible for decarbonization, there are clear hotspots in the copper and iron/steel lifecycles. For iron and steel, these are the steelmaking and recycling processes; while for copper, they are mining and smelting. Learnings can be shared between the two industries, particularly around renewable energy options for mining equipment and transportation.

Chapter 4 – Can Latin America and the Caribbean become a Global Low-Carbon Metals and Solutions Hub?

> Globally, LAC is a key region in terms of mining reserves and production. Chile is the world's leading producer of copper, Brazil is the world's third-largest producer of iron, Mexico is the world's leading producer of silver, fifth-largest producer of molybdenum and lead, and Peru is one of the leading producers of silver, copper, gold and lead.

Global Mineral Reserves by Region

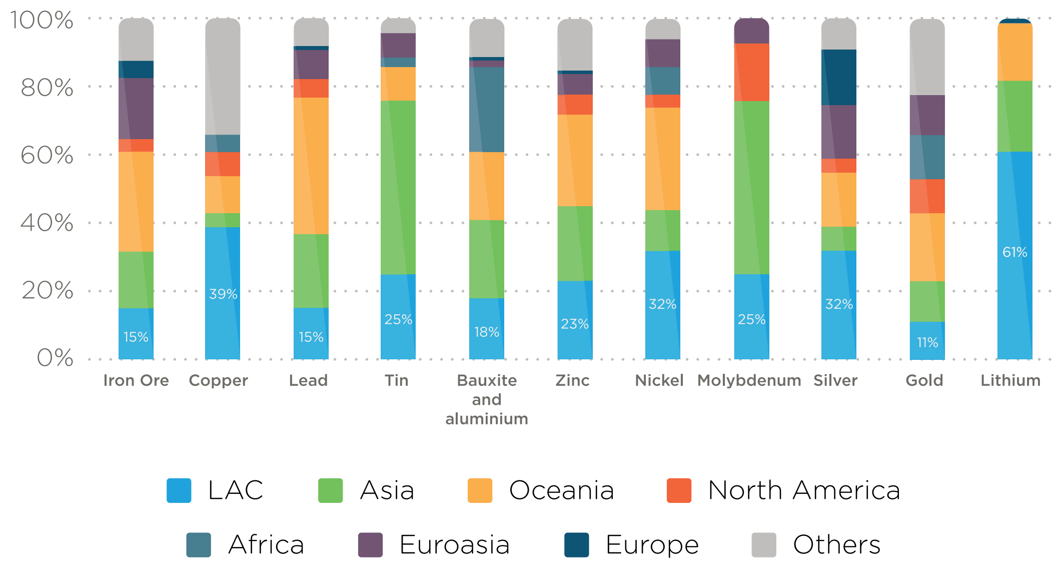


Figure 25 – Global mineral reserves by region. Source: Eclac, 2018

Between 2004 to 2014, investment in exploration for non-ferrous minerals in the region increased from US$2 billion to US$18 billion,[64] and between 2003 and 2017, US$171 billion of FDI in mining entered the region, especially concentrated in Chile (40%) and Brazil (24%).

Mining exports from LAC were valued at US$170 billion dollars in 2017 representing 17% of total regional exports. Exports related to copper, iron and steel represented 57% of the region's mining exports for 2015-2017.[65]

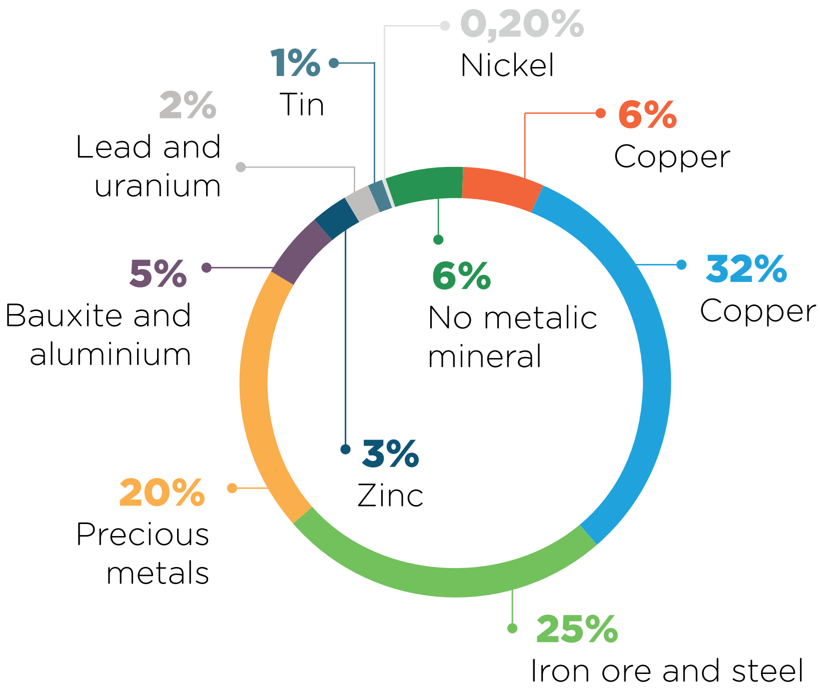


Figure 26 – Importance of minerals in total LAC mining exports. Source: Eclac, 2018

Additionally, mining accounts for over 10% of Gross Domestic Product (GDP) of countries including Chile, Peru, Bolivia and Colombia, and it is a source of significant government income.

The last commodity price super-cycle improved terms of trade, increased exports volumes and income, generated extraordinary revenues and boosted economic growth, but did not lead to productive diversification. As such, the region's position as a net exporter of minerals has remained true over time.

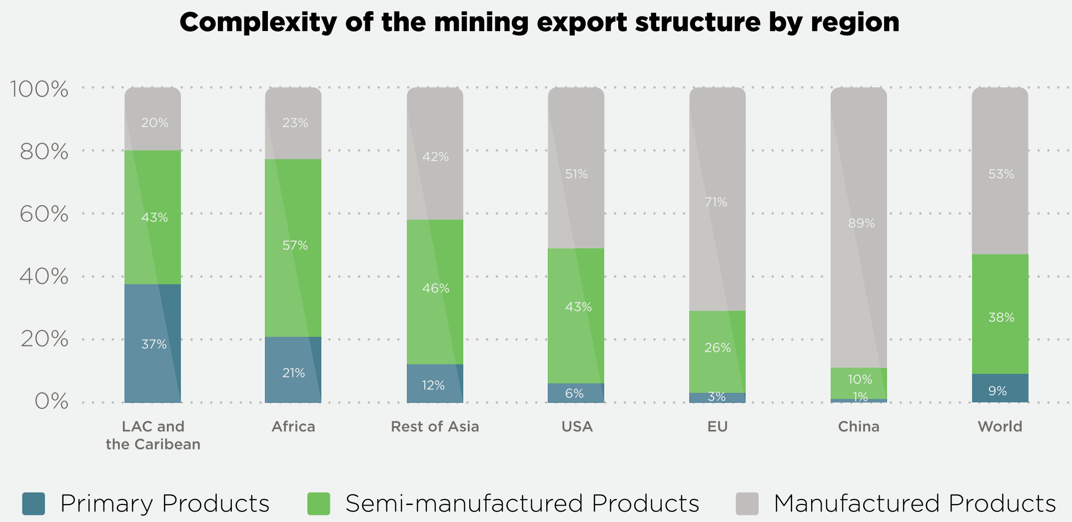


Figure 27- Complexity of the mining export structure by region. Source: Eclac, 2018

At the same time, the LAC mining sector has created a large-scale industrial base, which comprises sophisticated productive linkages that are key to the development of mining clusters. This includes services and products that generate higher productivity, with better environmental performance and solutions for low-emission mining. In Chile, for instance, the mining sector comprises more than 5,000 suppliers, which in 2018 sold more than US$35,000 million and exported more than US$500 million.[66]

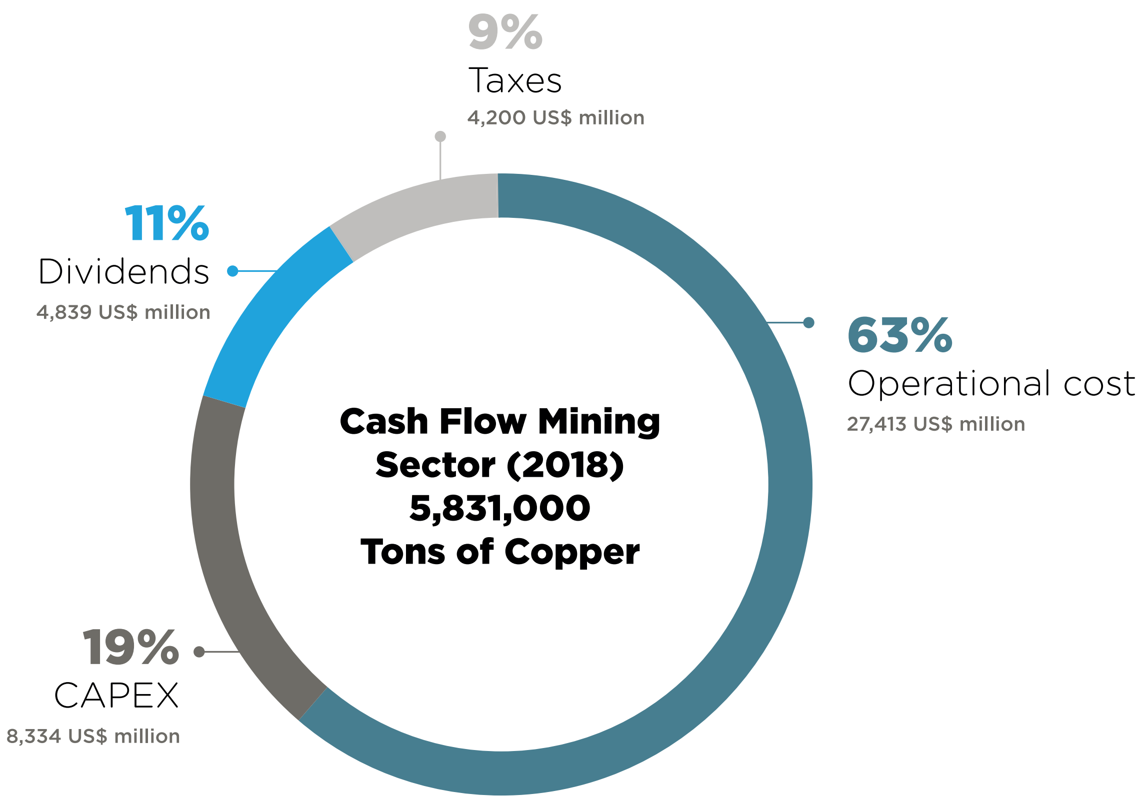


Figure 28 - Cash Flow Chilean Mining Sector (2018) Source: Chilean Mining Council (2019) "Cifras Actualizadas de la Minería"

> Fostering these knowledge-based mining clusters is a crucial process for resource-lead countries in LAC to evolve towards more sophisticated and productive economies. This evolution would include low-carbon mining processes and low-carbon solutions such as nature-based services, green hydrogen, or traceability services, as this chapter describes.

	Low Income Region Eclave economy - based on use of existing resources	**Middle Income Region** Investment lead economy	**High Income Region** Economy lead by innovation and sustainable models of growth
	Comparative Advantage	**Mining Latam**	**Competitive Advantage**
	Phase I Basic capabilities	Phase II Basic Productive Base	Phase III Innovation Ecosystem
Main Source of Competitive Advantage	• Abundant endowment of high quality mineral	• Efficiency gains due to large scale investments (⟶ scale, new practices, equipment)	• Large endowments but decreasing quality • Institutional and technological capabilities at international standards
Productive and technological capacities	• Scalable productive capacity and vertically integrated	• Large scale production capacity • Local suppliers start to be developed	• Mining extraction expands to a larger portfolio of minerals • Local suppliers gain sophistication - knowledge and innovation lead
Origin of advance solutions	• Imported	• Imported • Presence of local OEMs *Original Equipment Manufacturer. Local capacities expand*	• Imported • OEMs at international competitiveness levels • Local suppliers develop innovation capacity at global best practice level
Exports	• Minerals as main exports	• Minerals as main exports • Local suppliers start to export (international competitiveness starts to develop)	• Broader mineral portfolio exports • Service, solutions and technology exports grow faster than mining
	1965 1975 1985	1995 2005 2015 2025	2035 2045 2050

Figure 29 – From basic productive base to an innovation ecosystem. Source: Adapted from Urzúa, O (2020)[67]

LAC mining competitive position to lead the transition to a global low-carbon mining and solutions hub

Early analysis suggests that if the world decides to reduce emissions by both reducing carbon intensity per tonne produced and reducing the consumption of metals from primary production (in this report, copper and iron ore), the LAC mining sector would be at an advantage. Indeed, **given its competitive position on the cost curve and the abundance of low-carbon enabling factors, the region can turn the threats of any of the scenarios presented in this report into an growth option – provided that the region is proactive in implementing the right set of actions.**

Even in the extreme case of a “Decoupled” scenario, the reduction in global volumes would, counter-intuitively, translate into a greater market share from copper and iron ore supply from LAC. As primary supply declines in the long term, the operations leaving the supply curve would be from outside the region. This allows supply from LAC operations to keep growing as expected in a BaU scenario until the late 2030s; it also allows the region to grow its long-term market share in the global primary supply market.

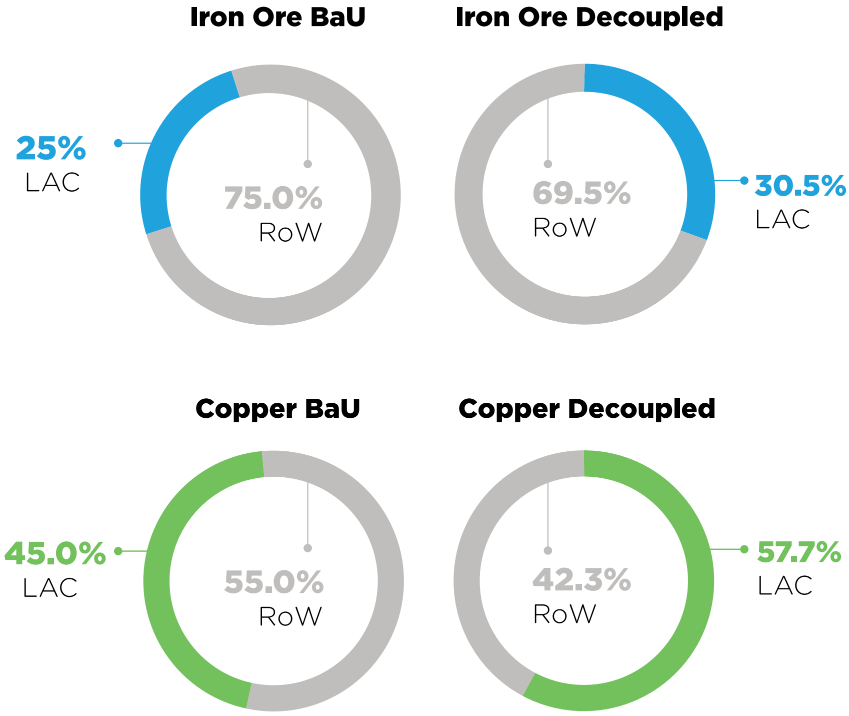


Figure 30 - A Global Copper and Iron Ore Market share between LAC and the Rest of the World

Given the competitive position of LAC mining operations in the cost curve, a global reduction in primary consumption would translate into a greater market share for LAC suppliers, both in both copper and iron ore, as Figure 31 shows. This would make its mining production more relevant from a purely competitive point of view; more importantly, given the environmental endowment in LAC representing the basis to develop low carbon services competitively - it could turn traditional primary supply into a unique type of low-carbon, low-cost primary supply.

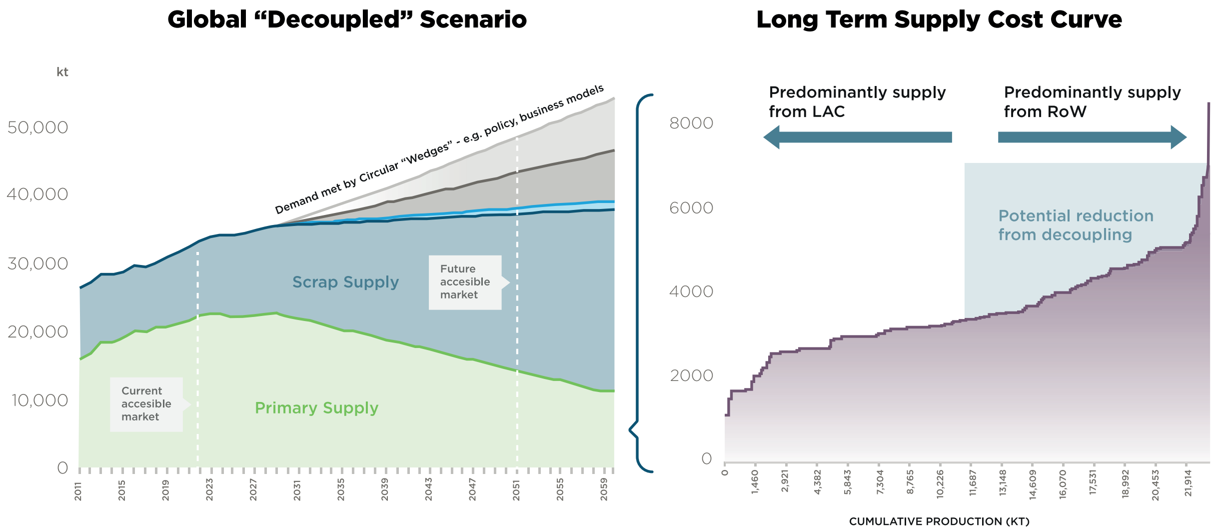


Figure 31 - A reduction in global copper primary supply impacts production of metal elsewhere before significantly affecting supply from LAC. Until the 2030s LAC grows as in the BaU scenario. Source: Authors' work.

In a decoupled scenario, the LAC region can become a more prominent supplier of primary minerals. It can also reap the benefits of developing the infrastructure and capabilities to meet the increasing demand for "low-carbon solutions", serving the mining industry and beyond. **LAC has the necessary conditions to become a competitive global supplier of these low-carbon solutions.**

The combination of its competitive position in the global supply cost-curve and the availability of low-carbon enabling factors, such as low-cost renewable energy, may allow the LAC region to access not only the primary mineral market but also a much larger and growing low-carbon metal market and low-carbon solutions market. This is obviously attractive from a fiscal and job creation point of view, but it may also serve as a platform for a structural transition of the regional economy, allowing it to better leverage its valuable resource base. **Potentially, LAC can transition from a resource-led economy to an innovation-led, de-commoditized economy.**

As a source of green minerals, the region can provide the supply that green products need. However, it also creates an opportunity to build up the capabilities to embrace other key efforts in the circular, low-carbon economy – which in turn will further improve green mining practices. To reduce risks and capitalize on the opportunities within the transition, mining companies operating in the region must embrace the complete lifecycle approach and look for ways to reduce emissions along the supply chain. Developing new, local low-carbon industries will protect against the eventual stagnation of primary production during the 2040s that, without proper planning, could result in economic hardship, political turmoil and social unrest in the region.

Despite the potential threat that a decoupled scenario may represent for the mining industry in LAC, there are a number of opportunities that regional industry has not fully embraced or not even yet considered. These would provide 'quick wins' to support investment and growth in the region, promoting long-term growth and, more immediately, a resilient recovery from the COVID-19 crisis.

Next, we present key areas of opportunity to reduce emissions from the LAC mining sector. These opportunities allow for the region to develop new sectors that provide services and products linked to lowering emissions in the processing and consumption of the extracted minerals – and, more broadly, in the low-carbon economy. These are the opportunities that represent the pillars of a low-carbon minerals and solutions hub in LAC by 2050.

Becoming a low-carbon metals and solutions hub

Although a "low-carbon metals and solutions hub" may seem a distant prospect, LAC mining sector has already started the journey. Important mitigation initiatives have already begun to be implemented, including the establishment of specific carbon reduction goals and the adoption of internal carbon prices (including, for example, Vale and BHP). There are important advances in clean energies, such as solar and wind, and nature-based solutions; these are specially focusing on scope 1 and 2 emissions, with some initial actions towards scope 3, such as traceability services. This is a significant first step which, in addition to starting to position the region as a competitive source of low emission primary materials, is triggering a process that can lead to the creation of other critical opportunity areas such as developing the capacity to supply broader low carbon solutions for those players processing, consuming, using and recovering the metals extracted in LAC.

There are enormous opportunities, within reach now, to develop a green hydrogen sector, new services around value-chain green traceability, and the deployment of a differentiated green steel and copper sectors. All of these, in addition to facilitating solutions for high-carbon intensity phases upstream and downstream of the mineral supply chain, have the potential to bring new investment, high qualified jobs, and prosperity to the region. Nonetheless, these benefits will not come automatically, and countries must take a proactive attitude to capture them.

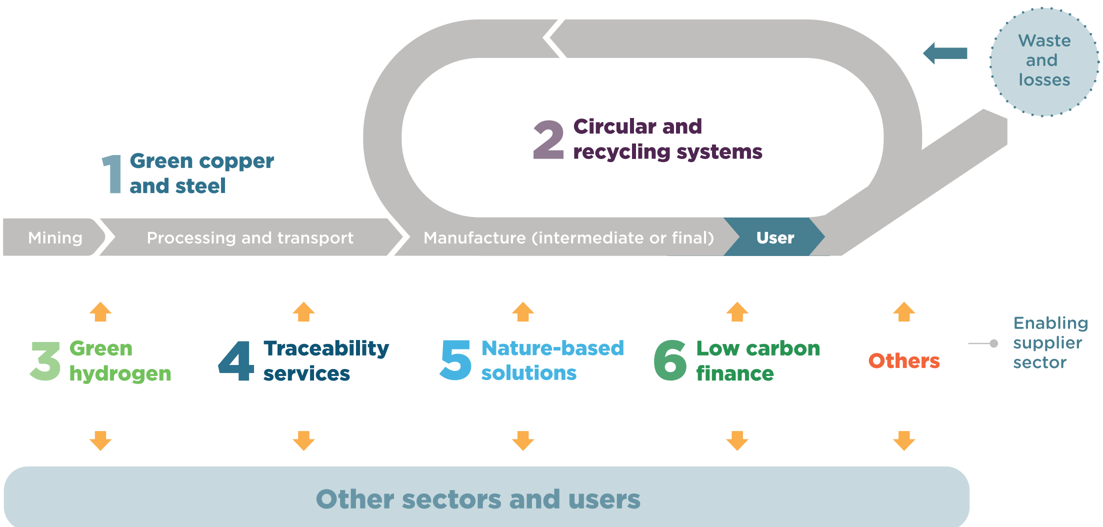


Figure 32 - Conditions and areas that could support the transition of the LAC region to a Global low carbon metals and solutions hub. Source: Adapted from Urzúa, O (forthcoming)"

Green copper and steel (mining and processing)

Greening mining processes

Under the decoupled scenario, there are several solutions that LAC mining companies will need to embrace in order to decarbonize their processes. Change in feedstocks, the electrification of thermal processes together with the introduction of electromobility are short-term solutions, although the right approach depends on the type of mineral and the prevailing conditions. **In the long term, solutions will come from a combination of electrification,**

electromobility and 'green hydrogen' (ie, hydrogen made using clean electricity from renewable energy technologies to electrolyze water without generating CO2).

Regarding copper, 47% of copper emissions in Chile - the largest global producer - comes from fuel use, with 88% of this coming from the trucks used to transport materials.[68,69] Therefore, there are significant opportunities to optimize material transport routes and substitute the fuels used in material transport. For a fleet of 1,600 off-road trucks at 50+ tons capacity, each consuming an average of $3m^3$ of diesel per day and emitting over 3,000 tonnes CO2e a year, the reduction potential is about 4.8 million tonnes CO2e per year, about 40% of CO2 emission derived from the use of fuel use in mining.[70] Several mining companies are starting to embrace electromobility as an option for the high-tonnage trucks that transport the ore.

Brazil is the world's biggest iron ore miner. Its steel plants are integrated mills that emit 2.5 times as much carbon as recycled metal facilities. 35% of the steel relies on charcoal to produce pig iron - it was introduced with the aim of reducing emissions under commitments made to the UN's Clean Development Mechanism (CDM). However, given that the industry did not source charcoal from plantations, the amount of carbon emissions produced by the sector doubled in less than a decade, remaining a key climate challenge for the industry. Key short-term options for decarbonization include increases in energy efficiency measures,[71] which are cost-effective in cutting fuel consumption for energy use by 15 to 20% across industrial sectors globally. Emissions from the use of fossil fuels or charcoal to generate heat can be abated by switching to furnaces, boilers and heat pumps that run on zero-carbon electricity, the electrification and replacement of fossil fuels in transport (eg, electrifying trucks and railroads); the introduction of biofuels to pelletize iron ore instead of charcoal is a viable solution, provided that these biofuels are not linked to deforestation.[72,73] Considering the limited availability of sustainable feedstocks for biofuel production, green hydrogen will be a key long-term solution.[74] This opportunity is expanded below.

Investment in renewable power

Access to abundant and competitive renewable energy is an underlying factor to reduce scope 1, 2 and 3 emissions.

LAC has exceptional conditions for renewable energy, with 55% of its power installed capacity coming from renewables (compared with a world average of 25% in 2014).[75] A recent trend in the region is the rapid growth of non-hydropower renewables, the installed capacity of which has more than tripled between 2006 and 2015, from 10GW to 36GW. As a result, the relative share of hydropower in the region's renewable capacity is declining (83% in 2015, down from 95% in 2000). The decline in cost of renewable energy, together with the need to mitigate reputational risks for companies linked to their carbon footprint, are among the key drivers behind the adoption of renewables by several mining companies in LAC.

As such, renewable energy is playing a central role in mining decarbonization strategies. Since 2012, copper mining companies (eg, in Chile) have started to be supplied through solar power contracts and several mining companies will become 100% supplied with renewable energy from 2020 (this is calculated on the basis of the mining company's power consumption and the amount of renewable energies purchased for a given period of time). Mining's big pull for new renewable energy is a driving factor behind the fact that new renewables now represent more than 20% of power generation in the country, enabling an US$15 billion investment - expected to generate 25,000 jobs during the next decade.[77,78] Iron mining in Brazil is also investing in renewables in order to reduce global emissions; in the case of Vale has the target to produce 100% of the electricity consumed from renewable sources by 2025.

> In the decoupled future, pressure on mining companies to increase their climate ambitions will grow. This will channel greater investment in innovation to improve extraction and processing and to mitigate the effects of climate change. In this regard, the competitiveness of renewable energies will be a key factor in mining companies' decision making.

Recycling and circular systems

The circular economy is a cyclical approach to manufacturing and resource management that offers to mining industry an opportunity to continue growing sustainably. **Metals are infinitely recyclable. The high value of many metals and minerals also incentivizes the right design of products, extending the life of the material and the efficient recovery of such materials at the end of a product's life cycle.** In the EU – already meeting 50% of copper demand with recycled metal - circular economy measures seek to increase EU's GDP by 0.5% by 2030 and creating 700,000 new jobs.[79]

There are two dimensions of the circular economy approach that will shape the mining industry in different ways. One relates to increase the efficiency of materials and reducing waste produced in the mining process. The mass of material waste can be several times that of the base metals themselves, which is a particular concern due to its toxic content and accident risks. The mining industry also uses large tires on mining trucks: an estimated 500,000 tonnes of scrap tires have been disposed of over the past three decades in Chile alone.[80] **LAC countries are just beginning to introduce policy tools such as Extended Producer Responsibility (EPR) Laws to incentivize companies towards circular approach:** in Chile, for example, oils, electrical and electronic equipment, batteries and tires must meet EPR requirements, and there is collection target for tires of 50% by 2021. We are also seeing the beginning of countries identifying and initiating opportunities for a circular economy along the mining supply chain.

The other dimension relates to mining as part of a circular production system of user industries (eg, car manufacturers). A circular economy could reduce global CO2 emissions from cement, steel, plastic and aluminum by 40%, or 3.7 billion tonnes, by 2050, thereby achieving almost half of the zero emissions target.[81] Circular approaches shift carbon emissions away from hard-to-abate activities to others that are easier to decarbonize. Notably, recirculation bypasses the emissions of new production as well as end-of-life incineration. Designing products with alternative (eg, low-carbon or renewable) feedstock materials ensures that emissions are avoided from the outset. Reduction in steel and copper use are cost-effective measures of the circular approach.[82] Other processes crucial to a circular economy, such as remanufacturing and refurbishing, can be powered by renewable electricity or increasing energy efficiency. There is an opportunity for mining companies in LAC to increasingly participate in business models that extend the life of their metals and recover their metals in the use markets. There is also an opportunity for miners to provide solutions to customers demanding low-cost offsets or traceability services.

Green hydrogen, produced through renewable energy, has emerged as a promising energy vector to decarbonize energy, especially for "difficult to electrify" sectors such as mining, industry and transport; it also has the potential to improve energy security conditions and open up new markets.

Green hydrogen

Short-term possibilities for green hydrogen in mining can be realized by retrofitting internal combustion diesel engines using a diesel-hydrogen blend, or by substituting a percentage of diesel combustion engines with fuel cells electric propulsion.[83] In the long term, fossil fuels can be substituted by renewable hydrogen together with renewable electricity, and solar thermal process heat, for all applications.

Globally, countries are giving green hydrogen a prominent role in their carbon reduction strategies and, in order to satisfy the projected hydrogen global demand by 2040, the world must double the provision of hydrogen each 2-4 years.[84] In addition to curbing carbon emission, green hydrogen offers the possibility to seize new markets opportunities, given that global hydrogen market and the associated technologies forecast revenues of more than 2.5 trillion USD/year and jobs for more than 30 million people by 2050.[85] COVID-19 pandemic recovery packages are devoting large sums for hydrogen development.

LAC has exceptional conditions to produce a low-cost green hydrogen for internal and external markets at highly competitive prices, thanks to the region´s green energy mix, availability of space, and water sources. Whilst some LAC countries such as Chile are already deploying an ambitious plan to channel investment to develop a highly competitive 100% renewable hydrogen to become a key global player by 2030, others mining countries need to take a more proactive attitude.

Traceability services

Global demand for minerals driven by the clean energy industry and the digital revolution provide an opportunity to embrace new advanced traceability services. Under a decoupled scenario, there will be a growing pressure from consumers, NGOs, global investors among other key stakeholders for mining value chain to demonstrate, through robust and credible certification systems, the environmental and social sustainability credentials of production process, both upstream and downstream. At present, companies like Tesla have already committed to ethically and locally sourced materials; BMW verifies the origin and modes of extraction of the mineral embedded in its batteries; and Samsung requires its suppliers to be certified through the Responsible Minerals Assurance Process (RMAP).[86]

> Mining companies in the region have started to embrace traceability to track scope 3 emissions. Whilst copper mining started with a pilot for green copper certification in Chile, iron mining companies in Brazil are staring to introduce contractual clauses related to greenhouse gas management for suppliers.[87,88]

A key barrier undermining the green copper project is the lack of capabilities for traceability certification for external markets.[89] To seize opportunities, LAC needs to build capabilities to embrace new digital technologies such as blockchain, which offer the opportunity to mask traceability along the chain of custody of minerals, delivering several benefits. The use of traceability may reduce risks (full end-to-end upstream-downstream traceability between untrusted participants, focusing due diligence on areas of concern or nonconformance, and cutting waste fraud); reduce costs (avoiding audit data duplication costs, inefficiencies, double counting); on the top of contributing to carbon reduction and other SDGs.[90]

Considering the global blockchain supply chain market size valued US$93 million in 2017 and is projected to reach US$9,852 million by 2025 with the traceability segment as the highest contributor to the global blockchain supply chain market.[91] There are currently few deployed solutions, and none related to carbon tracking has fully entered the marketplace. Considering LAC has one of the best mining reserves and metal district in the world, traceable commodities can reap opportunities to serve its own domestic industry, and to reach other material and non-material sectors, as well as external end-use markets.

Nature-based solutions

A decoupled scenario involves a combination of both mitigation efforts and natural-based climate solutions. **LAC countries such as Brazil, Mexico, Ecuador, Peru and Chile, nature-based solutions are a very important share of their carbon emissions reduction ambition.** Nature-based solutions can curb carbon emission in three ways: rethinking land use and changes in land use; capturing and storing carbon dioxide from the atmosphere; and improving resilience of ecosystems, thereby helping communities adapt to the increase in flooding and dry spells associated with climate change.[92]

By 2030, up to a third of global annual land-based emissions reductions targets could be achieved at a cost of US$20/ tonne of carbon. LAC countries are very cost-competitive, the average cost in Brazil is US$8/ tonne of carbon. Its potential is massive.

Nature-based climate solutions are cost-effective and readily available options. Their benefits go beyond reducing carbon emissions and they have lower initial capital, operating, and maintenance fees than clean energy solutions. On the other hand, they represent about 40% of all carbon reduction potential, suggesting that LAC countries need to take some steps in order to reap the underlying benefits and become a global leader in providing these services.

Though mining companies in the region are starting to invest in protected areas, both tropical and template rainforest for carbon sequestration and forest restoration and reforestation projects, LAC countries need to further permeate the business sector with natural-based options as concrete and cost-effective carbon mitigation solutions.[94] Governments and industry should reach out to the financial community so that project developers identify the revenue streams generated by the natural-based solutions component and incorporate them into the project's financial structure. Also, stakeholders must advance the development of clear and easily replicable assessments methodologies that increase the credibility and transparency of solutions.

Low-carbon finance

Financial sector actors in LAC are becoming increasingly involved in mandatory and voluntary initiatives that focus on sustainability, new circular business models and climate-related risks (e.g. Task Force on Climate-related Financial Disclosures). Green bonds are slowly becoming a mainstream investment option in LAC – and new products are being brought to market (e.g. transition and sustainability-linked instruments). In 2019, LAC and Caribbean countries issued close to $5 billion in green bonds, bringing the region's overall historic total to $13.6 billion[95] - facilitating spending on sustainable infrastructure and low-carbon transport systems.

But financial institutions in the LAC region need to strengthen their toolbox, both, to identify the opportunities related with a more circular world and to understand the portfolio risks associated with remaining dependent on a non-climate aligned linear economy. In recent surveys it was found that the uptake of methodologies for the assessment of risk associated with climate change in financial portfolios in LAC region is relatively weak. In Colombia, only 31% of financial institutions have methodologies to assess implications of climate change and 20% have used some form of scenario analysis. In Chile, only 8% of banks, 25% of asset managers and no insurance or pension fund have used methodologies for climate-related risks. In Mexico, only 14% of banks and 29% of asset managers have undertaken forward-looking assessments of environment-related risks, and while other financial institutions are incorporating qualitative assessment of exposure to environmental risks.[96] The shift towards circular business practices, like product-as-a-service models, has a direct impact on the financials of a company, including different cash flow profiles and balance sheet composition compared to a model of selling products which in turn will impact financial structuring. Several international financial institutions are actively engaging with clients on CE – launching products and exploring it as a risk-mitigation strategy. For example, **ING**, launched circular economy finance guidelines, **BNP Paribas,** launched a global "circular economy ETF" and **Blackrock**, launched a Circular Economy Fund in 2019 in partnership with the Ellen MacArthur Foundation.

Beyond climate change, there is a growing need for financial sector actors both in LAC and internationally to better understand how CE is transforming industries and how finance can help companies anticipate or even lead and accelerate such change.

Guidance such as the EU Taxonomy, and the 'Circular Economy Finance Guidelines' help to facilitate a common language and understanding.[97] As financing needs change, active collaboration with corporates should be encouraged so that the finance sector (including (re)insurance) can develop solutions that can release value creation and innovation.

COVID-19 – from recovery to long term prosperity

The health emergency caused by COVID-19 has not only put the capacity of health systems to the limit and claimed the lives of thousands of people. Confinement is causing a worldwide economic crisis from which LAC countries have not been exempt. Globally, never have so many countries entered into recession at the same time and the estimate of the global economic downturn – 5.2% by 2020 - far exceeds the 2008 financial crisis. In LAC, the multiple domestic and external shocks stemming from the pandemic will have a severe impact with a projected contraction of regional economic activity of 7.2 percent, much more steeply than during the global financial crisis or the 1980s LAC debt crisis. Exports will be sharply curtailed with the global economy in recession. Regional domestic demand is projected to slow dramatically in 2020, despite increased government spending, as shuttered businesses result in lower wages and private consumption. Fixed investment will be particularly hard hit by tighter financing conditions and deep uncertainty about the trajectory of the COVID-19 pandemic. Exports will be sharply curtailed with the global economy in recession.[98]

> As mitigation measures are scaled back and financing, commodity price, and external demand conditions become more supportive, regional growth is projected to recover to 2.8 percent in 2021.[99]

At the same time, the scale of the economic response being deployed by countries to address the crisis caused by the pandemic is unprecedented and far outpaces the fiscal stimuli of the 2008 financial crisis. Lessons from the financial crisis suggest that the implications of the quality of the decisions and measures taken for the recovery have long short and long-term economic, social and environmental dimensions. In particular, countries should avoid repeating the experience of the recovery programs for the 2008 crisis, whose measures encouraged investments that were inconsistent with decarbonization goals and resulted in technological lock-in that leading to increased GHG emissions. Countries, therefore, should manage the multidimensional crisis with a strategic approach that combines a rapid response to the crisis, but assertive in its solutions and with the potential to redirect development towards economic recovery goals that strengthen productivity integrated with social and environmental sustainable goals.[100]

In this context, COVID-19 recovery initiative opens important investment opportunities linked to transitioning LAC to a low carbon metals and solutions hub. For instance, governments from key markets are setting up ambitious green stimulus packages in line with the Paris Agreement, new regulations for big investors for disclose environmental and social risks in their investments from 2021.[101] Taking actions in order to align mining value chains with the Paris Agreement is an opportunity for LAC. For instance, according to International Renewable Energy Agency (IRENA) the energy transition is an integral part of the wider recovery with an expected global GDP gain of almost US$100tn between now and 2050.[102] Governments in LAC have to seize the opportunity and develop partnerships to participate of the COVID-19 recovery packages. This can not only fast-track the deployment of low-carbon solutions for the mining value chain in LAC but most importantly redefine its relationships with critical partners in markets currently transitioning at a faster pace to a low carbon model of development.

Chapter 5 - Conclusions and recommended next steps

This report presents four emission scenarios along the iron ore and copper value chains, providing initial insight on the necessary conditions for LAC to start building optionality for a global circular economy that is fully aligned with the Paris targets. All scenarios require LAC leaders to consider investments in low-carbon technology in different degrees. However, investments required in the Decoupled scenario are also compatible with the BaU scenarios and would add greater flexibility and resilience to the region. **The core preliminary conclusions of this report are as follows:**

- In the "BaU" and "BaU Possible" scenarios the supply chains of LAC copper and iron ore will exceed the carbon budgets required for a B2DS world. This would set LAC on a difficult trajectory, involving a constant battle against climate and circular barriers, both locally and internationally.

- Mineral supply in LAC is largely positioned at the beginning of the cost curve, affording a significant advantage in any primary demand scenario. In a decoupled scenario, supply from LAC would continue to grow as per BaU scenarios until the 2030s and the region would gradually increase its global market share over time.

- Beyond its competitive position on the primary cost curve, LAC has the conditions to support the transition of the local mining value chain to a low-carbon status. Most importantly, the development of new low-carbon sectors could also provide solutions and services for international players along the value chain, thus capturing a share of a much larger, growing market.

- The forces that will potentially drive a decoupled scenario are already present in the key consuming markets for LAC minerals. They include increased customer demand for low-carbon circular products; policy and regulations; technological developments; and financial and investor commitments. It would not be unlikely that these forces become central to the growth models of these economies and to the business models of large consumers across numerous industries.

> Building on the points above, if leaders in LAC would decide to support a low carbon metals and solutions hub model in the next few decades, the region would have greater optionality across several scenarios gaining resilience and competitiveness.

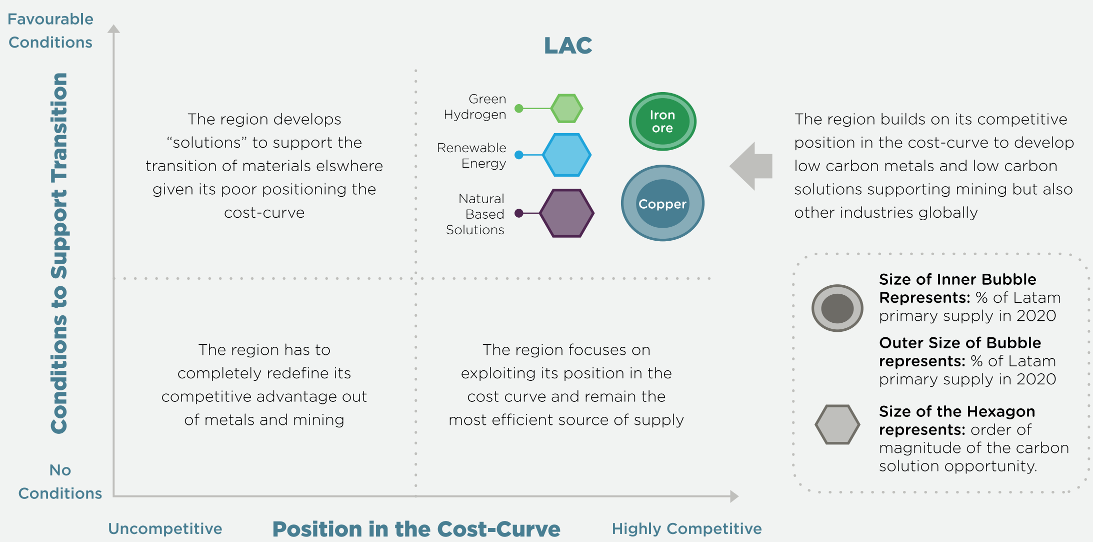


Figure 33 - A Low Carbon Transition Matrix shows different strategic options depending of a region's supply competitiveness and the existence of low-carbon conditions to support the transition. Source: Authors' work.

Myriad opportunities exist for LAC, including new business models, technologies and products; but these can be realized only with support from government, investors and consumers. Adopting this new trajectory could potentially yield a greater economic and social contribution to the region than then the BaU trajectories. Deeper analysis is needed to clearly assess the size of the opportunity, the key areas representing the highest value – from both a sector and country perspective – and the most effective pathways to start building optionality for the region.

Through our analysis presented in this report, we would consider the following areas crucial to develop the necessary analysis further:

1. Carbon target alignment: achieve clarity on carbon targets across the mining value chain. The emissions reductions projections defined in this project should be further developed using Science Based Targets' Sectoral Decarbonization Approach, to set B2DS emissions trajectories for the global copper and steel supply chains.

2. Clarity on carbon methodology: improve carbon accounting and data sharing to allow governments, investors, materials buyers and consumers to track progress towards agreed climate goals. Making better data available gives all stakeholders a deeper understanding of the viable pathways and makes it easier to identify the optimal solutions in each case.

3. Deeper understanding of the potential impact: conduct further research to quantify the financial and physical risks to the LAC mining value chain if the Paris targets are not reached.

Suggested Next Steps – towards implementation:

Based on our analysis and conclusions, but most importantly the engagement with the expert network supporting this project we would suggest the following next steps:

1. Keep working in close cooperation with the established expert advisory network to guide progress and further develop the opportunities identified in this report to start the transition of the LAC region to a low-carbon mining and solutions hub.

2. Building on the deeper engagement and analytics suggested in point 1 above, we would suggest as immediate next step the creation of smaller working groups from the broader expert network. These groups would be focused on establishing implementation vehicles to start piloting at commercial scale the solutions with the highest potential, for example:

- Establishing a **dedicated (blended) fund** – that can take more risk on both tech and new (circular) models.

- Explore **cap market instruments** (eg, green/transition bonds) or other green (sustainability-linked) **finance products** to create a facility to support corporates on this journey.

- Consider establishing a **project development facility** that can provide technical assistance.

The smaller working groups would shape the architecture of the selected implementation vehicles through a series of workshops, for example over a period of six months working group members could gather to decide:

- **Session 1:** the preferred implementation vehicle(s) and basic components
- **Session 2:** roles and responsibilities of key working group members in the implementation of the chosen implementation vehicle(s)
- **Session 3:** the role of governments in the region, as well as Development Agencies (and IFIs), in the chosen implementation vehicle(s)
- **Session 4:** the role of commercial capital in scaling up investment in the chosen portfolio
- **Session 5:** to agree and commit to the chosen implementation roadmap and capital allocation

These sessions would give the key players in the working groups the necessary time and shared knowledge to jointly translate this report's findings into a tangible reality in LAC.

Glossary

Absolute emissions: The total carbon emissions from a certain source over time, such as the annual carbon emissions from a company, sector, or region.

Beyond 2° Scenario (B2DS): Emissions and activity projections used to compute sectoral pathways aligned with limiting warming to 1.75°C by 2100, according to the International Energy Agency.[4]

Decoupled economy: An economy that can grow without corresponding increases in environmental pressure.

Emissions intensity: The carbon emissions associated with a particular product or activity. In this report, emissions intensity is often applied to the carbon emissions per tonne of metal.

Extended producer responsibility: A policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products.

Greenhouse gases (GHGs): Gases identified by the United Nations Framework Convention on Climate Change/Kyoto Protocol as responsible for global warming. These include carbon dioxide (CO2), methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride, which are often combined as CO2-equivalents (CO2e).

Science Based Targets: According to the Science Based Targets initiative, targets adopted by companies to reduce GHG emissions are considered "science-based" if they are in line with what the latest climate science says is necessary to meet the goals of the Paris Agreement – to limit global warming to well below 2°C above pre-industrial levels and pursue efforts to limit warming to 1.5°C.

Scope 1: Direct GHG emissions that occur from sources that are owned or controlled by a company.

Scope 2: GHG emissions from the generation of purchased electricity consumed by a company.

Scope 3: Scope 3 emissions occur in a company's upstream or downstream supply chain; activities or products that are not owned or controlled by the company.

Supply chain: A system of organizations, people, activities, information, and resources involved in supplying a product or service to a consumer.

Tonnes (t): Metric tonnes or tons. MT denotes million metric tonnes.

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Annex

Methodology

We have assessed the case for LAC to become a hub for low carbon metals by examining the relationship between changing volumes for steel and copper and the GHG intensities of their production. For each year of the model, the sectoral carbon footprint is determined by multiplying the volume produced in a given year by the change in production intensity. For allocating a portion of global emissions to LAC, sectoral cost curves were analyzed to determine LAC current market share and how that share changes over time in different volume scenarios, for both scrap and virgin material.

The baseline production intensity was determined by building a supply chain map of relevant inclusions, populated mainly via corporate disclosures to CDP by 28 metal and mineral-related companies which, together, reported nearly 2 billion tonnes of CO2 in 2019. For steel, we used data from World Steel Association; AME; Wood Mackenzie; ABM; Oldendorff; BHP; BMO; Citi; Mysteel; SMM. For copper, we used data from ICSG; Ocean Partners; BMO; Citi; BHP; Rio Tinto; Wood Mackenzie; Investiv; USGS. Due to the site specific conditions that drive production intensity, and the lack of harmonized reporting methodology, meaningful detail could not be brought to LAC current production intensities compared to the rest of the world. As such, production intensity baselines for copper and steel supply chains in LAC were not adjusted from global figures.

The BaU scenarios 1, 2, and 3, discussed in Chapter 2 are based off of business as usual volumes, with intensity reduction (for scenarios 2 & 3) applied linearly year over year. The Decoupled scenario discussed in Chapter 3 relies on decoupled volumes, and intensity reduction is also applied linearly. The two volume scenarios used in this report are from the United Nations International Resource Panel Global Resource Outlook 2019; Business as usual, based on consistent year over year growth, and decoupled volumes, in which resource efficiency, extraction tax, and demand shift are applied to BAU volumes, leading to a net decrease in volumes of copper and steel by 2060. For the overall effect of the circular economy wedges as relation to demand shifts caused by circular economy policies, Hatfield-Dodds (2017) was the basis for the IRP modeling.

The case for LAC to become a low-carbon hub for mining, presented in Chapter 4, rests on the conclusions of the scenarios combined with considerations about the relative importance of steel and copper in the regional economy, as well as its export structure relative to other regions (Eclac 2018). Our conclusion, which calls for a search for new comparative advantage in product diversification - of which low-carbon commodities is a key example - rests on the projection of the relative positions of LAC producers in the cost curves for iron ore and copper, which we have used to produce estimates of the future market share for LAC in both commodities, in which a particular advantage for LAC emerges when based on the decoupled volume scenario.