Alternative 1.5°C Decarbonization Framework for Diversified Mining and Metals

White paper

27/06/2025

Because our **impact** matters

TABLE OF CONTENTS

1. Introduction

1.1. Context and rationale

Similar to the steel, cement, and chemical industries, the **diversified mining and metals sector** is widely recognized as a **hard-to-abate industry**. These sectors face structural decarbonization challenges due to their heavy reliance on fossil fuels, long asset lifecycles, and the substantial capital investments required to deploy low- and zero-emission technologies. Furthermore, their emissions are often process-related and highly dependent on current energy systems, making them particularly difficult to reduce with today's available technologies.

To support decarbonization in such sectors, the **Science-Based Targets initiative (SBTi)** has developed **Sectoral Decarbonization Approaches (SDAs)** for the most carbon-intensive and homogeneous industries, such as steel and cement. These intensity-based trajectories reflect the realistic deployment of low-carbon production technologies in hard-to-abate sectors, offering greater accuracy and sectoral relevance compared to the standard Absolute Contraction Approach (ACA). However, **SDAs remain unavailable for many sectors**, not due to scientific limitations but rather because of resource constraints within the SBTi. As a result, companies in these uncovered sectors are compelled to adopt a **generic Absolute Contraction Approach**, which does not consider sector-specific characteristics. Meanwhile, **stakeholder expectations** (e.g., CSRD, SBTi, CDP) are increasingly **pushing for 1.5°C alignment**, creating significant tension for companies that fall outside the scope of existing SDA methodologies.

Specific to **diversified mining and metals companies**, their multi-dimensional activities require **sector-specific approaches**:

- **Pyrometallurgical processes,** in particular, are hard to abate and require SDA-like approaches, similar to those applied in the steel and cement industries. However, under the current SBTi framework, companies like Eramet are required to follow the **generic Absolute Contraction Approach (ACA)**, which entails a **4.2% annual linear emissions reduction target**[1] (dependent on base year), an ambition considered unrealistic due to sector-specific constraints. In contrast, an **intensity-based approach** better reflects operational realities, as it accounts for increased production volumes at existing sites and the integration of new projects. The ACA does not consider **production variations**: an increase in output makes the target harder to achieve, while a decrease can make it easier without necessarily reflecting genuine emissions reductions. Moreover, as the base year moves further away from 2021, the ACA becomes increasingly stringent in the short term, without taking into account sector-specific decarbonization potential or cost-efficiency.

[1] Science-Based Targets Initiative, Corporate Net-Zero Standard Version 1.2, March 2024

- Additionally, the **growing demand for transition metals** such as lithium and nickel should be acknowledged and integrated into corporate climate alignment strategies. This **lack of recognition of so-called "transition enablers"** is not unique to mining and metals, but is also observed across other climate solutions (e.g., heat pumps, bicycles, EV batteries).

In response to these gaps, Eramet, in collaboration with the I Care consulting team, developed a **science-based, tailored 1.5°C Alternative Decarbonization Framework (ADF)**. This framework was specifically designed to address the limitations of the current SBTi methodology as applied to the diversified mining and metals sector. It was developed to remain **scientifically robust** and **aligned with a 1.5°C-compatible pathway**, while better reflecting the hard-to-abate nature of the sector and the enabling role of key materials, which are currently underrepresented in existing frameworks. While the initiative was **commissioned by Eramet**, the framework was **developed independently**, with a strong commitment to **scientific rigor** and **alignment with established frameworks**, ensuring both methodological robustness and credibility. **The ADF is not intended to weaken ambition;** on the contrary, it represents a **credible yet demanding science-based framework to which Eramet intends to voluntarily commit and hold itself strictly accountable in setting its GHG reduction targets.** Importantly, although the framework was developed based on Eramet's operational scope, it is **designed to be fully applicable to other industrial players**. Any company with similar business activities—whether focused on mining, alloy production, or both—can adopt or adapt the framework to support their own decarbonization pathway. Mining companies can directly apply the pseudo-SDA for mining, while metallurgical players can either adopt the transformation SDAs developed for manganese, nickel, and lithium, or extend the underlying methodology to other metals and processes. As such, the ADF offers a sector-relevant, science-aligned reference framework that supports **ambitious and credible decarbonization planning across the broader mining and metals industry.**Ultimately, this framework will enable **Eramet**, in a second step, **to define science-based, credible CO_2 reduction targets**, targets the company can realistically commit to, and which are aligned with the **Paris Agreement's 1.5°C objective**, unlike those derived from the strict application of the ACA under the current SBTi system

1.2. Eramet's business activities and emissions structure

The Alternative Decarbonization Framework for diversified mining and metals companies addresses both **mining and pyrometallurgical operations within Scopes 1 and 2**, with a particular focus on developing **dedicated Sectoral Decarbonization Approaches** for the transformation of **manganese, nickel, and lithium**, as well as a **pseudo-SDA for mining activities**. To clarify this scope and introduce the activity-based decarbonization approaches detailed in the following sections, Figure 1 presents a **high-level overview**

of Eramet's greenhouse gas emissions structure, segmented by core business activities and value chain stages.

Figure 1: Overview of Eramet's greenhouse gas emissions structure, broken down by business activity and value chain

As of 2024, 60% of Eramet's revenue is generated by its **manganese operations**, split between mining activities at Comilog in Gabon (33%) and the transformation of ore into alloys in six pyrometallurgical plants located in Norway, France, the United States, and Gabon (27%). Nickel accounts for 31% of group revenue, driven by two main production hubs: **Weda Bay Nickel in Indonesia**, one of the world's largest nickel deposits, operated in partnership with Tsingshan for low-grade nickel ore and ferroalloy production and **SLN in New Caledonia**, focused on nickel ore and ferronickel production. In addition, Eramet Grande Côte in Senegal produces titanium-bearing **mineral sands** (ilmenite, rutile, leucoxene) and zircon. The Group is also expected to reach full production capacity for **lithium carbonate by late 2025 at its site in Argentina**. Accordingly, the ADF covers all **four of Eramet's major business activities**. It incorporates tailored SDA methodologies for manganese, nickel, and lithium transformation activities, while applying the diversified mining pseudo-SDA for mining operations across all sites.

From a GHG perspective, **Scope 1 and 2 emissions account for around 16%** of Eramet's total footprint, primarily driven by **pyrometallurgical operations (83%)**, followed by mining (11%) and sintering (11%). However, the vast majority of the company's carbon footprint lies within the **upstream and downstream value chain** (Scope 3), with emissions concentrated in shipping and processing of sold products. . As such, the framework introduces differentiated approaches across key value chain stages, specifically mining, transformation (pyrometallurgy), scope 3 Category 10 – Use of Sold Products and Categories 4 & 9 – Upstream and Downstream Transportation.

Within this context, some materials play a **key enabling role in the energy transition**, requiring special treatment. For example, lithium produced in Argentina is used in lithium-ion batteries for electric vehicles and will be considered a **"transition enabler**

metal" in this framework. A dedicated methodological adjustment will be introduced in **Section 2.1.2**, allowing for recalibrated absolute targets in case of perimeter changes or production increases of transition enabler metal. While nickel is predominantly used in stainless steel production, part of the nickel ore extracted in Indonesia supplies the EV battery component industry, justifying a partial enabling-material treatment. By contrast, less than 5% of the manganese produced by Eramet in Gabon is currently used in battery technologies and is therefore not treated as an enabler metal within this framework.

Although this framework has been tailored around **Eramet's specific operational profile**—particularly its manganese, nickel, and lithium value chains—it is **designed to be directly applicable as such to other diversified mining companies** for their mining operations. Furthermore, it lays the **groundwork for the development of additional metal-specific SDAs for pyrometallurgical activities**, following the same methodological principles.

1.3. High-level overview of the framework's architecture

The 1.5°C Alternative Decarbonization Framework for diversified mining and metals companies is structured around **two pillars:**

1) Pillar 1 - Reducing Induced Emissions (see Section 2.1)
2) Pillar 2 - Enabling Climate Solutions (see Section 2.2)

Figure 2 below presents a high-level overview of the overall architecture of the framework.

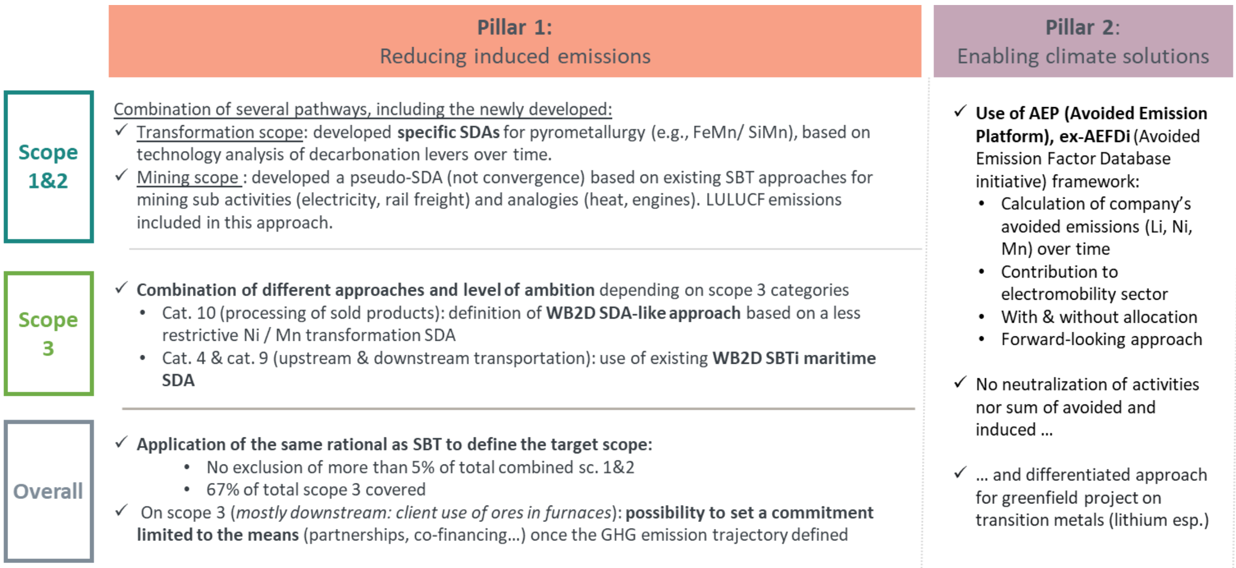

Figure 2: High-level overview of the 1.5°C Alternative Decarbonization Framework for diversified mining and metals companies

Pillar 1 focuses on **defining short-, medium-, and long-term emission reduction targets** for companies in the diversified mining and metals sector, in alignment with SBTi's 1.5°C ambition and target scope.

Target setting for Scopes 1 and 2 combines several decarbonization pathways:

- **Mining activities**: A **pseudo-SDA** (combining convergence and contraction logic), developed in Section 2.1.1.1, based on existing pathways for mining sub-activities (e.g., electricity use, rail freight) and analogies (e.g., heat production, engines), including LULUCF emissions.
- **Transformation activities**: **Tailored SDAs for pyrometallurgy** (e.g., FeMn, SiMn, FeNi), developed in Section 2.1.1.2, based on technology roadmaps and analysis of decarbonization levers and their deployment over time.

Scope 3 target setting is based on a combination of approaches and levels of ambition depending on the scope 3 category, as detailed in Section 2.1.1.4:

- **Category 10 (Processing of sold products)**: Introduction of a **Well-Below 2 Degrees (WB2D) SDA-like approach**, based on a less restrictive aforementioned pyrometallurgy SDA.
- **Categories 4 and 9 (Upstream and downstream transport):** Application of the existing **WB2D maritime SDA from the SBTi maritime transport tool.** In fact, **only shipping-related emissions are included in the scope**, as they are by far the most significant transport-related source for a mining company. Emissions from air and road transport are comparatively marginal and therefore excluded from target coverage.

Pillar 2 addresses the need to recognize the **climate-enabling role of transition materials** (e.g., lithium, nickel) by incorporating **avoided emissions** into corporate alignment strategies. The company's contribution to avoided emissions over time, as well as the corresponding induced vs. avoided emissions ratio at company level, is calculated using the **Avoided Emission Platform** methodology[2], focusing exclusively on the share of transition metals used in Battery Electric Vehicle (BEV) batteries.This approach, including **forward-looking quantification** (with and without allocation), is detailed in Section 2.2 below. In addition, **greenfield projects involving transition metals** (such as lithium or a portion of nickel, as illustrated by their unfulfilled demand in transition scenarios (e.g., for electromobility applications) and further supported by the previously described avoided emissions quantification) are granted **special treatment in the recalculation of absolute emissions targets** (see Section 2.1.2).

For each pillar and the associated methodologies, **key limitations** are identified throughout this white paper, and the **gaps with the current SBTi framework** are addressed in Section 3.

---

[2] The Avoided Emissions Platform, url : https://aefdi.io/

2. The 1.5°C Alternative Decarbonization Framework – Methodological overview across three pillars

2.1. Pillar 1 – Reducing induced emissions

Pillar 1 aims to establish a **1.5°C-aligned decarbonization pathway for the induced emissions** of companies in the diversified mining and metals sector. As illustrated in Figure 3, the Alternative Decarbonization Framework covers **all emission scopes**, ensuring a minimum of 95% coverage of combined Scope 1 and 2 emissions, and at least 67% of Scope 3 emissions, in line with SBTi requirements. It includes a **range of metals such as nickel, manganese, mineral sands, and lithium**, using multiple tailored emission trajectories, which are further detailed in the following sub-sections.

Although the framework was initially designed to reflect **Eramet's business activities**, the underlying methodological principles are intended to be applicable more broadly and could be extended to cover additional materials. Furthermore, its differentiated approach across various points in the value chain (e.g., mining, sintering, metal transformation) allows for flexible application to all business models, including **non-integrated players.**

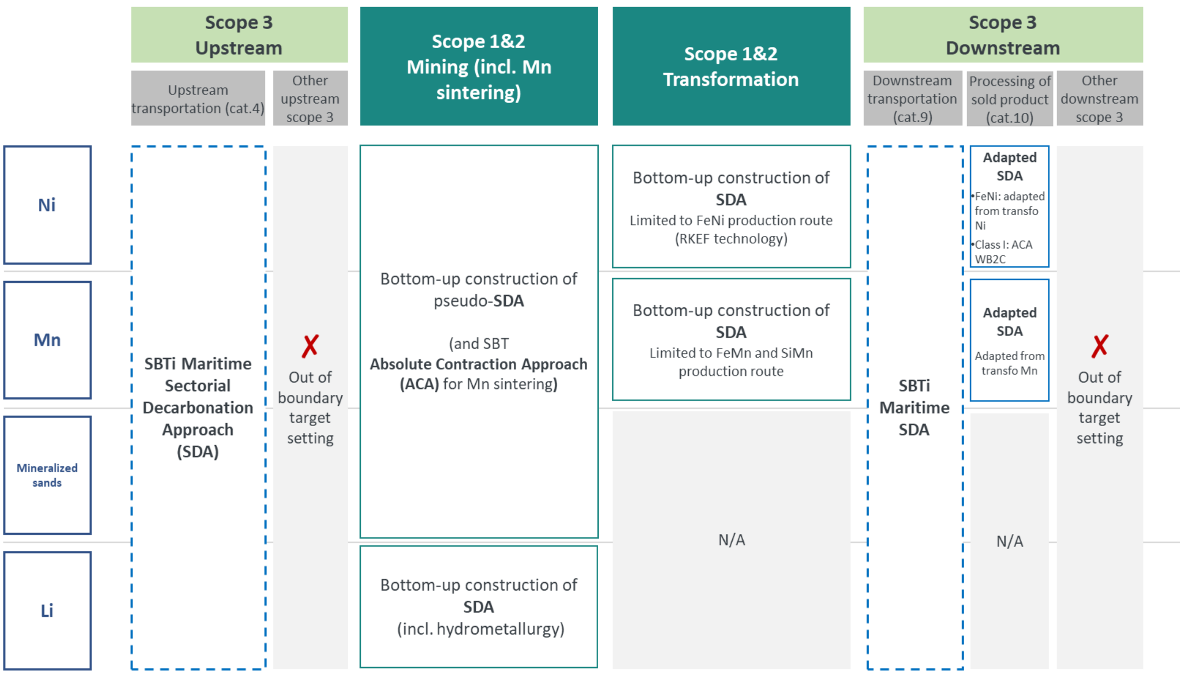

Figure 3: Mapping of the metals value chain and key principles developed in the 1.5°C Alternative Decarbonization Framework for the diversified mining and metals sector

2.1.1. Development of sector-specific Sectoral Decarbonization Approaches (SDAs)

To reflect the specific characteristics of the diversified mining and metals sector, characterized as a **hard to abate sector with multi-dimensional activities**, tailored methodological approaches are applied to both mining and transformation scopes. For mining operations, a **bottom-up construction of pseudo-SDAs for each metal** is detailed in Section 2.1.1.1. For transformation processes, including **manganese and nickel metallurgy**, **dedicated SDAs** are designed based on technological roadmaps and aligned with SBTi ambition levels, as presented in Section 2.1.1.2. Both **Lithium SDA and sintering** are addressed separately in Sections c and 2.1.1.3 respectively.

2.1.1.1 Pseudo-SDA for diversified mining (by metal)

The approach developed for the mining scope covers all emissions related to **ore extraction and transportation.** Exploration activities are excluded due to their marginal emissions, transformation processes are addressed through separate SDAs (see Section 2.1.1.2), and commercialization is not included in the perimeter.

For this defined perimeter, a **pseudo-SDA is built for each metal** by **splitting up emission sources among mining sub-activities** and applying **existing SDAs or benchmark decarbonization trajectories** to each emission source. The mapping of site-specific emissions sources and corresponding reference trajectories includes:

- **Electricity**: Refers to electricity consumed on-site, whether generated on-site or purchased. The benchmark trajectory used is based on the electricity generation intensity from the IEA Net Zero Emissions (NZE) scenario[3].
- **Engines**: Refer to worksite engines (e.g., dumpers, excavators) and heavy trucks. The corresponding sectoral intensity trajectory for heavy-duty trucks is derived from final energy consumption (in exajoules) and associated emissions under the IEA Net Zero Emissions (NZE) scenario[3]. This involves a methodological approximation whereby non-road worksite engines are treated as equivalent to road heavy-duty trucks in their decarbonization pathway.
- **Rail Transport**: Concerns freight trains used for ore transportation. The benchmark is adapted from the “Below 2°C” scenario in the SBTi SDA Transport Tool, based on the IEA Mobility Model[4], and adjusted for 1.5°C alignment using IEA NZE data.
- **Drying**: Refers to fuel consumption for ore drying, benchmarked against the IEA trajectory for the heat sector in the NZE scenario[3].
- **Land-Use Change and Rehabilitation**: Emissions induced by **land-use change** (e.g., land clearing) and emissions stored via **land rehabilitation** (e.g., biomass) **follow the**

[3] International Energy Agency, World Energy Outlook 2023

[4] Science-Based Target Initiative, SDA Transport tool, 2018. (Based on IEA Mobility Model, 2017)

SBTi ACA for FLAG[5]**.** For companies that have a base year in 2021 or later, the SBTi requires the minimum ambition for reduction in absolute emissions to be based on the equation: % Linear Annual Reduction (LAR) x (Target year-2020).

This mapping along with the corresponding intensity variations relative to a 2023 baseline in benchmark trajectories are given in Figure 4.

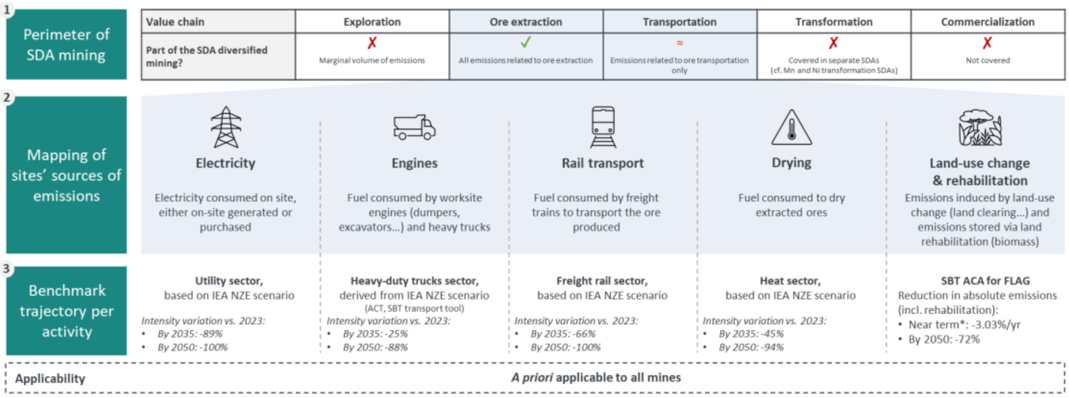

Figure 4: Mapping of mining value chain, sources of emissions and corresponding benchmark decarbonization trajectories

Once the **benchmark trajectories** (expressed in $MtCO_2e/MJ$) are established for each activity (electricity, rail) and analogies (engines, heat), **pseudo-SDAs** (in $MtCO_2e/t$) are calculated per metal by applying **metal-specific energy intensities** (in MJ/t) for each sub-activity, except land-use change and rehabilitation for which SBT ACA for FLAG is applied. **Energy efficiency gains** (excluding electrification and building sector) are also integrated, based on IEA data: -0.8% per year from 2023 to 2030 and -0.6% per year from 2030 to 2050.

The analysis reveals that **electricity decarbonization is the primary driver of emissions reduction in the short term** (with a projected zero emission target by 2040). **Electrification of engines and freight** contributes significantly to **Scope 1 reductions post-2035**, as electricity's share in the transport sector grows from 17% in 2035 to 51% in 2050 under the IEA NZE scenario. Emissions from land-use change also decline rapidly with a linear annual reduction (LAR) of 3.03%.

Finally, this approach combines elements of **contraction** (as the starting point heavily influences the reduction trajectory) and **convergence** (via standardized sectoral SDAs for sub-activities), which is why it is referred to as a **"pseudo-SDA"** in this framework. It is, in principle, **applicable to all mines**, provided their energy intensity by sub-activity is known for the base year. The **distribution of emissions across sub-activities in the reference year determines the slope of the decarbonization pathway**, i.e., sites with already low emissions in certain sub-activities will face lower reduction requirements. Specifically for **electricity**, where the effort required is very significant in the near-term, the starting point has a strong impact on the

[5] Science-Based Targets Initiative, Forest, Land and Agriculture science-based target-setting guidance Version 1.1, December 2023

reduction target. For example, a highly emissive electricity mix results in a more aggressive reduction trajectory in the short to medium term.

However, this hybrid approach entails **methodological limitations** and heterogeneity and requires **several approximations** (e.g., non-road worksite engines such as extractors assimilated to road heavy-duty trucks, energy efficiency gains excluding electrification and buildings recalculated from IEA data, etc.). Another notable limitation is that the pseudo-SDA for mining activities overlooks **external dependencies** affecting the availability of decarbonization levers and the feasibility of implementation for specific assets. For example, **the global average electricity pathway is applied uniformly to all mines, including off-grid sites**, which makes targets particularly challenging for locations with limited alternative options. In fact, the approach lacks differentiated electricity SDAs for isolated areas, as decarbonizing electricity generation is considerably more difficult in such contexts due to the absence of flexibility, smoothing effects from renewable sources, and distributed energy users. Therefore, to improve the robustness and applicability of this pseudo-SDA, future refinements should include the development of dedicated SDAs for non-road worksite engines and for isolated/off-grid electricity systems.

In summary, the mining scope is covered in this framework by metal-specific pseudo-SDAs **aligned with the SBTi's ambition level for each mining sub-activity**. As a qualitative loopback, since these pseudo-SDAs are based on combinations of existing SDAs or IEA trajectories, the resulting carbon budgets are inherently aligned with the overall global 1.5°C carbon budget.

2.1.1.2 Sector-specific SDAs for transformation processes

Once the metal is extracted, it undergoes several **transformation processes** that account for the majority of value chain emissions. This framework develops **specific Sectoral Decarbonization Approaches**, i.e., intensity-based trajectories, for two metals: **manganese and nickel**, aligned with SBT ambition levels, although based on different data sources. The application for companies follows a similar logic, with the definition of a targeted intensity trajectory and a convergence approach.

a Manganese pyrometallurgy (FeMn & SiMn)

The **specific SDA for manganese pyrometallurgy** is **limited to FeMn and SiMn production routes** (excluding electrolytic manganese metal), while assuming that FeMn and SiMn will remain the primary transformation routes, as they already account for 90% of global Mn transformation. The scope includes all value chain steps **from post-enrichment to the production of 1 ton of final product** (i.e., FeMn and/or SiMn alloys). **Pre-treatment such as via sintering** is covered by a separate approach in Section 2.1.1.3. Scope 3 emissions are not covered.

This SDA results from a **bottom-up construction** considering **seven transformation technologies, inspired by Mission Possible Partnership's "Steel Net Zero" model**[6] (and specifically its *carbon cost* scenario) since steelmaking and manganese pyrometallurgy rely on similar transformation routes and decarbonization levers: average blast furnaces (BF), electric arc furnaces (EAF) for the steel industry and submerged arc furnaces for manganese pyrometallurgy (SAF), their best available techniques (BAT) versions, bio-reductants in SAFs, and carbon capture and storage (CCS). Most **technology deployment timelines** in the Mn SDA are based on the MPP Steel model but **adapted to manganese-specific context** (and its differences from steel sector in terms of technical constraints, lower scale effects, innovation maturity and sectoral R&D investment capacity), according to the proxies in Table 1. The strength of the sourcing indicates the robustness of each assumption, reflecting the confidence level in using steel industry proxies to model manganese technology deployment, based on data reliability, technological similarity, and expert validation.

Table 1: Proxies with MPP's "Net Zero Steel" model for Mn transformation technologies deployment pace

Mn technology concerned	Proxy from MPP's Steel model	Assumption made	Strength of the sourcing
Blast Furnace	Blast Furnace – Basic Oxygen Furnace (BF-BOF)	The decommissioning rate of steel BF-BOF is used as a proxy for the decommissioning rate of Mn BF, (with a time delay).	Medium
BAT versions of BF and SAF	BAT – BF-BOF	The share of BAT in steel BF-BOF production is used as a proxy for the deployment of BAT versions in Mn BF and SAF production routes (with a time delay).	Medium
Bio-reduction	BAT BF-BOF route using pre-treated biomass to replace PCI (Pulverized Coal Injection) in blast furnace	The deployment rate of bio-PCI in steel BAT BF-BOF routes is used as a proxy for the deployment of bio-reduction in Mn SAF routes (with a time delay and specific technical limitations).	Low
CCS	CCS	The deployment pace and rate of CCS across the entire steel production route is used as a proxy for its deployment in the Mn production route (with a time delay).	Strong

An **additional "net zero" Mn transformation technology** was also introduced. Industry experts have been exploring alternative production routes to carboreduction. Several ways are being investigated: carbon free metallothermic reduction, molten oxide electrolysis,

[6] Mission Possible Partnership, Making Net-Zero steel possible. An industry-backed, 1?5°C aligned transition strategy, 2022

electrowinning, hydrogen based technologies to name a few[7]. These new production routes are at low TRLs and the first industrial deployment cannot be expected before the end of the next decade. This transformative "net zero" Mn production technology is introduced in the model, with a gradual introduction starting in 2040. The assumptions are not derived from MPP approach, but they can be compared to the assumptions made by MPP for the deployment of low TRL production technologies for steel (e.g. electrolysis or electrowinning).

Other assumptions (technology availability, energy efficiency gains, bioreductant share limits, etc.) are derived from **analogies with the steel industry**, but include **Mn-specific adjustments** (e.g., delays in technology availability, smoother deployment curves, lower maximum bio-reductant inputs), based on expert insight. These are summarized in Table 2**.**

Table 2: Main model assumptions for Mn pyrometallurgy SDA

Technology concerned	Hypothesis perimeter	Value	Source	Strength of the sourcing	Model's sensitivity to the hypothesis
BF	BOF decommissioning - Delay vs. Steel (years)	5 years	Expert opinion *(based on current delay in BF production share vs. in steel value chain)*	Medium	Low
BAT versions	BAT - Delay vs. Steel (years)	5 years	Expert opinion *(historical and current delay in furnace efficiency optimization in Mn vs. steel, mainly due to R&D investment gaps)*	Medium	Low
	BAT- Reductant requirement vs. theory (no units)	1,15 (vs. 1.30 currently)	Expert opinion	Low	Very Low
	BAT- Energy efficiency gain (%)	+10%	Expert opinion, based in particular on the potential improvement of carbon efficiency through pre reduction, and MPP steel model assumptions	Low	Very Low

[7] References : Karen S. Osen, Halvor Dalaker, Ana Maria Martinez, Henrik Gudbrandsen, Zhaohui Wang and Ida Kero 2023: *CO2 free FeMn/Mn production through Molten Oxide Electrolysis*. Accepted for publication at "Advances in Pyrometallurgy: Developing Low Carbon Pathways", TMS 2023, March 19-23, San Diego, USA. ; Kero, Ida Teresia and Dalaker, Halvor and Sende Osen, Karen and Ringdalen, Eli 2021: *Some Carbon-Free Technologies for Manganese Ferroalloy Production*. Proceedings of the 16th International Ferroalloys Congress (INFACON XVI, (September 12, 2021).

Bio-reduction	Bio-reduction - Delay vs. Steel (years)	5 years	Expert opinion *(current delay in biomass use in Mn vs. Steel value chain)*	Medium	Very High
	Bio-reduction – Maximum share of bio-reductant per furnace	Progressive increase (from 60% in 2030 to 70% by 2040)	Expert opinion *(based on current existing maximal share of ~60% bio-reductant feedstock in some Mn transformation furnaces)*	Low	Very High
CCS	Delay vs. Steel (years)	5 years	Expert opinion *(positive profitability of a CCS deployment in Mn smelters will be reached later than for steel making, due to smaller unit size and lower GHG emissions per unit*	Medium	High
	Capture efficiency (%)	90%	Inspired from MPP Steel model assumptions	Strong	High
	Additional electricity consumption (add. kWh / kCO2 absorbed)	0,5 kWh	Expected value based on benchmark of applicable technologies	Strong	Low

Among these assumptions, the chronology of technologies (or versions of) deployment is illustrated in Figure 5. It is assumed that the latest technological developments are first adopted in the steel sector, before gradually benefiting the manganese value chain, with a time lag reflecting the differences between both sectors mentioned above: maturity, scale, R&D expenses and innovation dynamics.

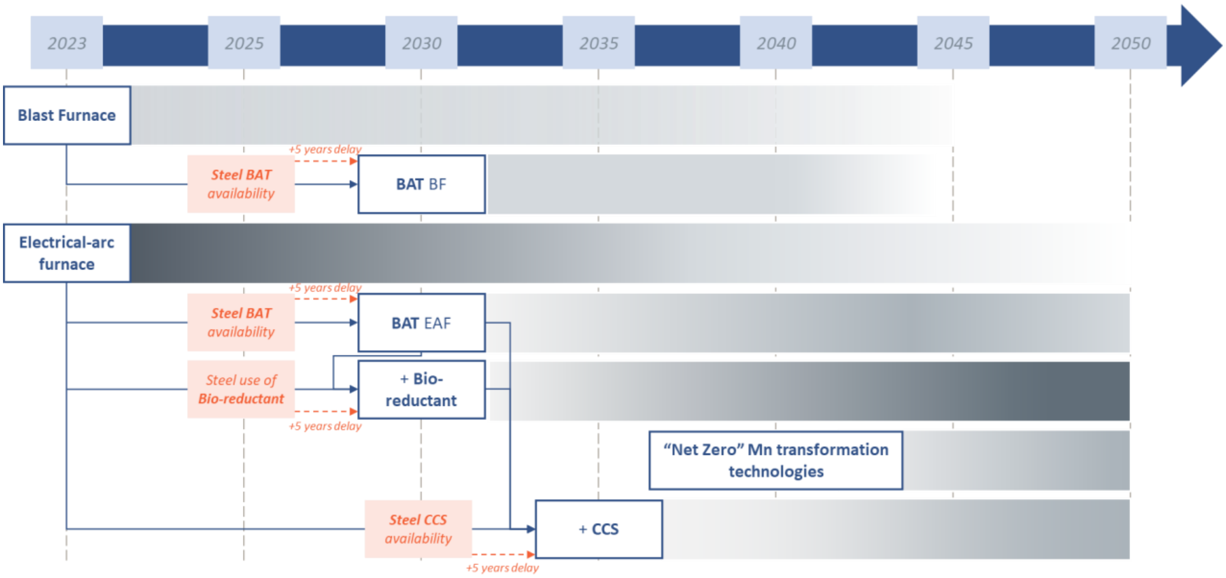

Figure 5 : Chronology of technologies (or versions of) deployment

The Mn pyrometallurgy SDA leads to a **Scope 1 & 2 CO_2 intensity reduction from 3.9 in 2023**[8] **to 0.3 tCO_2/t MnAll by 2050**, as shown in Figure 6**.**

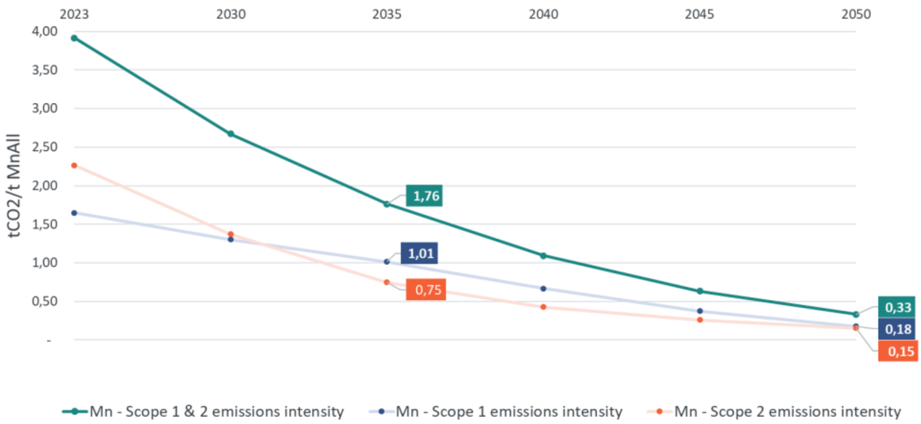

Figure 6: Evolution of CO2 emission intensity by scope for Mn pyrometallurgy

Between 2023 and 2050, this represents a **-92% reduction in intensity (12x fewer emissions per ton)**, first driven by electricity decarbonation until 2030, followed by Scope 1 emissions reduction. The evolution of the reduction effort needed compared to 2023 is plotted in Figure 7 and can be compared to:

- **Primary steel SDA:** –95% (20× fewer emissions per ton)

---

[8] Computed from a model of the sector's 2023 Scope 1 and 2 absolute emissions, based on the technology mix and associated emissions factors, and production volumes of manganese alloys (HC FeMn, R FeMn, SiMn, and LC SiMn) given by CRU. This figure was validated by a recent CRU Consulting study, url: [Understanding manganese products emissions can unlock decarbonisation options - CRU Group]

- **ACA approach**: –97% (33× fewer emissions per ton)

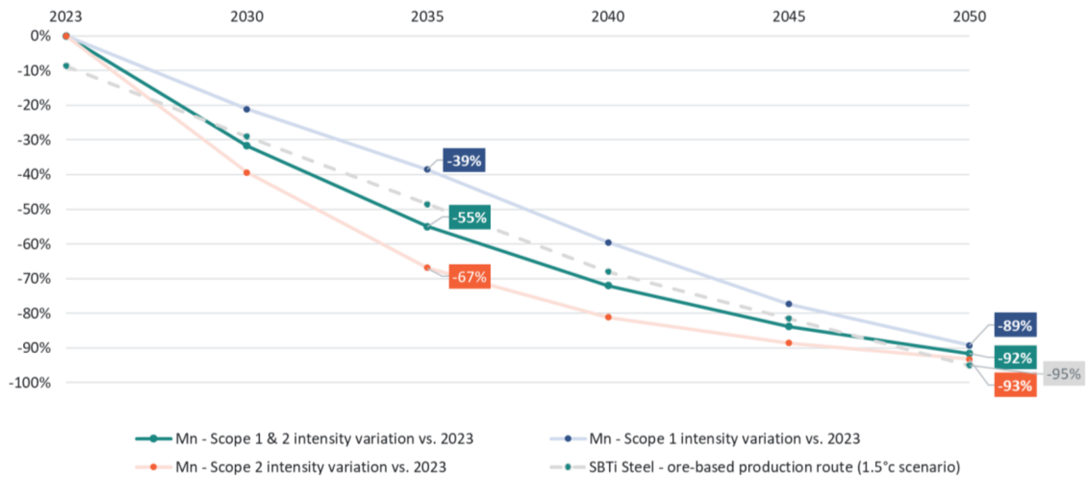

Figure 7: Evolution of CO2 emission intensity by scope for Mn pyrometallurgy (comparison, with 2023 value)

Finally, from a **qualitative loopback perspective considering carbon budget values**, the manganese pyrometallurgy SDA leads to a $GtCO_2$ carbon budget for the period 2020-2050. This is 34% higher than what an absolute contraction approach would yield. However, within sectors lacking specific SDA frameworks, manganese represents about 1.5% of 2019 global emissions but **claims only 1.3–1.9% of the carbon budget**, despite its limited electrification potential. Therefore, the manganese 1.5°C SDA does not impose undue burden on other sectors' carbon budgets, supporting a positive conclusion on the qualitative loopback.

b Nickel pyrometallurgy (FeNi & NPI)

The specific SDA for nickel pyrometallurgy focuses exclusively on **FeNi and NPI** (Nickel Pig Iron) production routes and is **limited to the RKEF** (Rotary Kiln-Electric Furnace) technology. This scope was defined based on Eramet's current asset portfolio and the dominant role of RKEF in its nickel transformation operations. It encompasses **all steps of the value chain from post-ore extraction to the production of one ton of final alloy product** (i.e., FeNi and/or NPI). Downstream refining processes occurring after alloy production are excluded from this scope.

This SDA is the result of a **bottom-up construction**, following the same methodological foundation as that used for manganese transformation. Decarbonization technologies have been adapted from the manganese SDA where relevant, itself derived from the MPP's "Steel Net-Zero" model, and further enriched with technologies outlined in MPP's report "Making Net-Zero Concrete and Cement Possible."[9]

As a result, four technological evolutions have been selected:

[9] Mission Possible Partnership, Making Net-Zero concrete and cement possible. An industry-backed, 1.5°C aligned transition strategy, 2023

Table 3 : Proxies with Mn Transformation SDA and MPP's "Making Net-Zero Concrete and Cement Possible" report for Ni transformation technologies deployment pace

Ni technology concerned	Proxy used	Assumption made
BAT version of RKEF	Mn Transformation SDA	The share of BAT in Mn BF and EAF production routes is used as a proxy for the deployment of BAT versions in Ni RKEF production routes (no time delay).
Bio-reduction	Mn Transformation SDA	The deployment rate of bio-reduction in Mn EAF routes is used as a proxy for the deployment of bio-reduction in Ni RKEF routes (no time delay).
Switching from coal fuel to less emissive energy	MPP's cement and concrete report	The share of cement switching from coal to lower-emission energy sources (gas, waste fuels, biomass or green hydrogen) in rotary kilns & dryers is used as a proxy for the deployment in Ni BAT RKEF production route (no time delay)
CCS	Mn Transformation SDA	The deployment pace and rate of CCS across the Mn production route is used as a proxy for its deployment in the Ni RKEF production route (no time delay).

The Ni pyrometallurgy SDA leads to a **Scope 1 & 2 CO_2 intensity reduction from 51 in 2023**[10] **to 7.6 tCO_2/t Ni by 2050**, as shown in Figure 8.

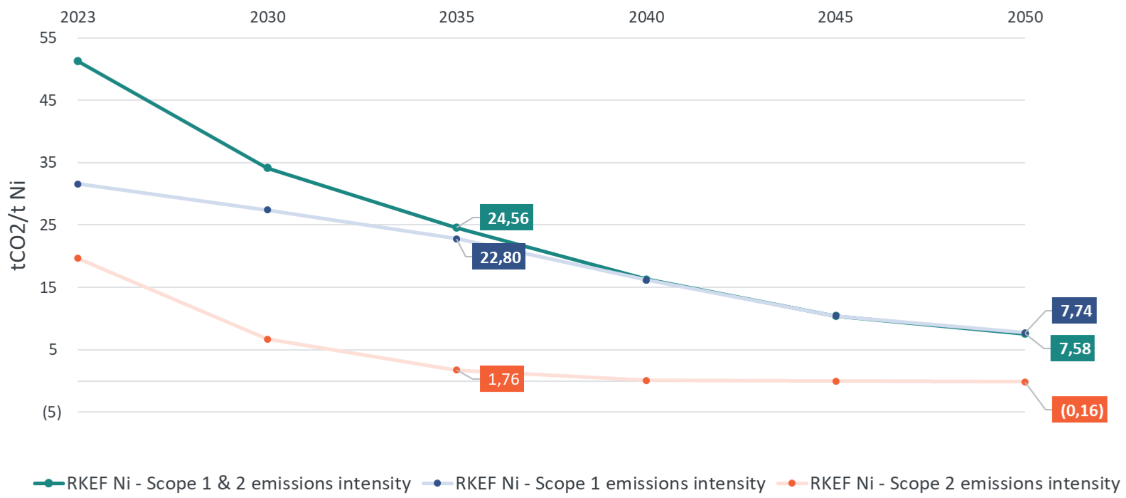

Figure 8 : Evolution of CO2 emission intensity by scope for Ni RKEF

[10] Adapted from WEI, Wenjing, SAMUELSSON, Peter B., TILLIANDER, Anders, *et al.* Energy consumption and greenhouse gas emissions of nickel products. *Energies*, 2020, vol. 13, no 21, p. 5664. with I Care & Eramet's experts calculations.

Scope 1 & 2 GHG intensity is projected to **decrease by 52% between 2023 and 2035, reaching an overall reduction of 85% by 2050** (relative to 2023 levels). This trajectory is primarily driven by the following levers:

- Global decarbonization of electricity, as the main lever of carbon intensity decline, addressing nearly 40% of current GHG emissions in the RKEF process,
- Bio-reduction highly contributes to reduce scope 1 emissions – covering approximately 50% of production by 2035 and up to 90% by 2050,
- Fuel switching in furnaces, with a progressive shift toward lower-emission alternatives such as LNG and green hydrogen—rising from 7% in 2035 to 30% by 2050,
- CCS having a significant impact from 2040.

c Lithium bottom-up SDA

Following the same approach as for nickel, the SDA for lithium is limited to **Direct Lithium Extraction (DLE) technology,** in line with Eramet's current asset portfolio.

In DLE processes, the two main sources of emissions are:

- **Process-related emissions**, primarily from HCl treatment used to remove bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions;
- **Energy-related emissions**, stemming from electricity and heat consumption.

Based on current emission intensities, a decarbonization trajectory was established by combining:

- For energy-related emissions: the IEA Net Zero Emissions (NZE) scenario[3] for electricity generation intensity.
- For process-related emissions: the application of the SBTi Absolute Contraction Approach (ACA), targeting a 42% absolute reduction by 2030.

Considering the initial distribution of emissions between these two sources, this methodology leads to an estimated 74% reduction in intensity by 2035, and nearly 100% by 2050, for a project starting in 2025.

2.1.1.3 Application of SBTi Absolute Contraction Approach on sintering

Sintering is a **highly emissive process**, typically operated **in-house** by diversified mining and metals companies. As such, it cannot be overlooked in climate planning. However, it should not be grouped within broader categories, as **sintering is not exclusive to either the mining or transformation stages**, i.e., it can occur at various points along the value chain.

Given its **unique positioning** and **emissions profile**, the standard SBT **Absolute Contraction Approach** is applied wherever sintering operations are present. This method entails a **linear**

annual emissions reduction of 4.2% until 2035, leading to a **90% absolute reduction by 2050 compared to baseline year 2020**[11].

2.1.1.4 Scope 3 emissions

Finally, target setting for Scope 3 emissions is based on a combination of different approaches and ambition levels, depending on the specific Scope 3 categories:

- **Category 10 – Processing of Sold Products**: The target setting is based on intensity trajectories derived from previously designed transformation SDAs (aligned with the 1.5°C pathway), **adapted to reflect a WB2D level of ambition**. As a result, the WB2D-aligned effort for Scope 3 Category 10 is 56% less ambitious between 2023 and 2030, and 2% less ambitious between 2023 and 2050.
- **Categories 4 & 9 – Upstream and Downstream Transportation**: These categories directly apply the existing WB2D maritime SDA as defined in the SBTi Maritime Transport Tool.

In contrast, the following categories are **excluded from the target boundary**:

- **Category 1 – Purchased Goods and Services**
- **Category 3 – Fuel- and Energy-Related Activities**
- **Other downstream and upstream Scope 3 categories**

remaining compliant with the SBTi requirement to cover **at least 67% of total Scope 3 emissions**.

2.1.1.5 Aggregation of various approaches across the value chain

Finally, the **global emissions trajectory (covering Scope 1, 2 & 3) and target** is computed through the **aggregation of several targets calculated for each activity** (e.g., mining, sintering, processing, etc.) **and emission source** (e.g., transport, heat, power, etc.).

2.1.2. Target recalculation to account for production volume changes

Production volume changes, such as the **acquisition, development, or divestment of mining or transformation assets**, can significantly alter a company's initial operational perimeter. These changes may require **a reassessment of absolute emissions reduction targets** to ensure continued alignment with a 1.5°C pathway. **Three main cases** are identified and illustrated in Figure , depending on whether the asset in question qualifies as an **enabler of the energy transition**. For example, lithium qualifies as enabler, as demonstrated by its projected

[11] For companies that have a base year in 2021 or later, the SBTi requires the minimum ambition for reduction in absolute emissions to be based on the equation: % Linear Annual Reduction (LAR) x (Target year-2020).

demand (e.g., for electromobility applications) in transition scenarios, and further supported by the avoided emissions quantification presented below.

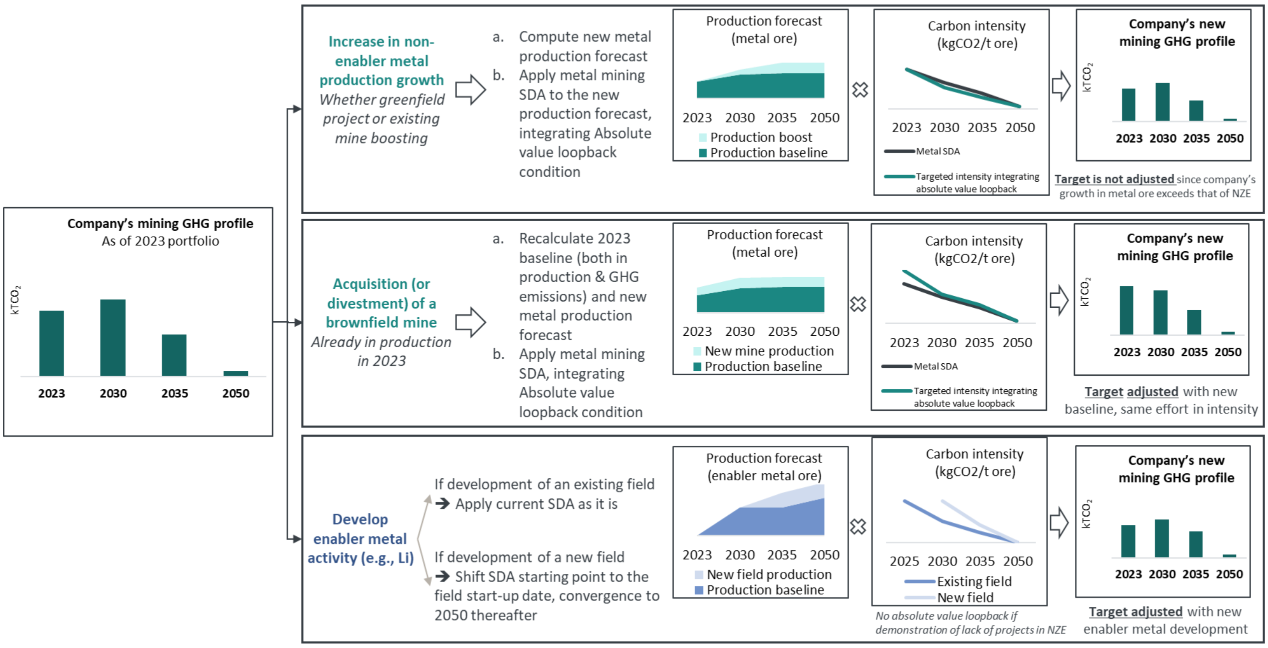

Figure 9: Illustration of target recalculation to account for production volume changes in a mining company's initial perimeter

However, **a binary classification (enabler / non-enabler) may be too simplistic—**especially for **metal assets with diversified end uses, such as nickel,** which is used in both the steel and battery manufacturing industries. In such cases, a more granular approach can be applied by **assessing the extent to which an asset qualifies as "enabler of the energy transition,"** based on the proportion of its production that contributes to the transition. This leads to the definition of a **fourth distinct case** in Section 2.1.1.9, acknowledging assets with mixed transition potential.

2.1.1.6 Increase in production of non-transition-related metals (e.g., manganese) whether through greenfield projects or the expansion of existing mines

In cases where **production of non transition-related metal** expands due to **greenfield projects or the extension of existing operations**, a revised production forecast must be established. The relevant sectoral decarbonization approach trajectory is then applied to this updated production forecast to recalculate a new absolute emissions target.

To maintain consistency with a 1.5°C scenario (e.g., IEA Net Zero Emissions Scenario), a constraint is introduced: the **absolute value loopback condition**. This ensures that the company's **production assumptions and associated market shares are aligned with projected transition metal production levels under a 1.5°C pathway**, particularly for intensity-based approaches. This condition adjusts a company's allowable emissions based on the relationship between its projected market share and that consistent with a net-zero pathway. Specifically, the revised emissions target is determined according to the following formula and illustrated in Figure 10 :

$$\textbf{Absolute Target} = \textbf{Intensity trajectory} \times \textbf{Min}\left(\mathbf{1}\,;\,\frac{\mathbf{1}}{\textbf{normalized market share}}\right) \times \textbf{projected production}$$

Where “normalized market share” equals to the ratio between the market share at the given year and the initial market share of the company at the reference year.

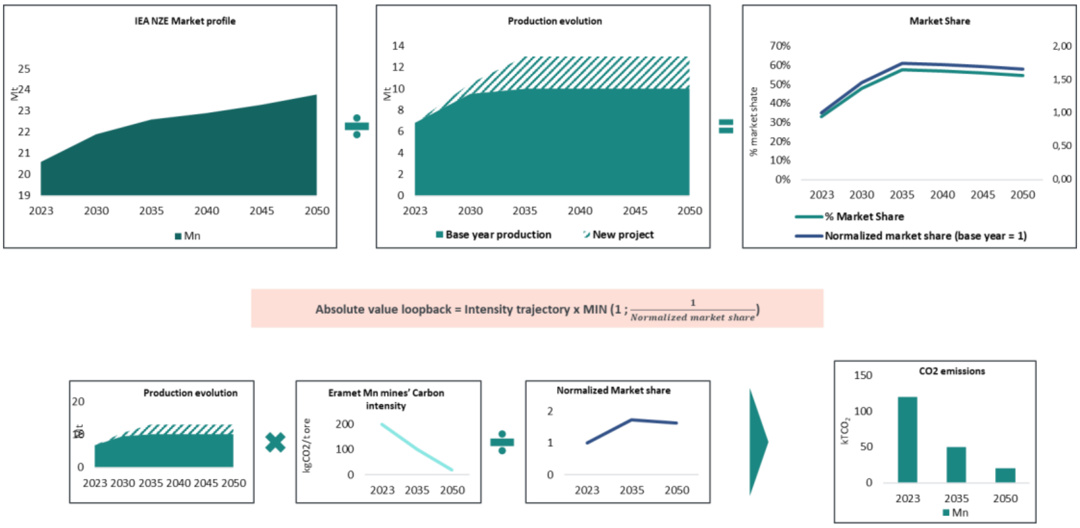

Figure 10: Application of the Absolute value loopback condition in new SDA-addressed activities (e.g., FeMn, diversified mining)

This approach ensures that **companies growing faster than the market must deliver proportionally greater reductions in emissions intensity**. It draws on similar guidance found in the **SBTi's SDA methodologies** (e.g., Cement science-based target setting guidance) and applies to newly SDA-covered activities, such as diversified mining or manganese pyrometallurgy.

2.1.1.7 Acquisition or divestment of a brownfield mine

When a company acquires or divests a brownfield mining asset (e.g., a manganese mine already operational in the baseline year, such as 2023), the **historical baseline must be recalibrated** to reflect the new perimeter in terms of **both production volumes and associated emissions**, and the SDA is applied on this new baseline, including absolute value loopback condition (except for enabler assets when the NZE demand is unmet, as explained in following sub-section).

2.1.1.8 Organic development of a new asset in a key transition metal (e.g., develop Li activity)

The third case concerns the development of new assets considered **key to the energy transition**, such as lithium. These "enabler metals" are treated with **greater flexibility** within this framework, recognizing their **role in decarbonizing other sectors**. In such cases, companies may **revise both their near- and long-term targets to incorporate these activities** (not specified in SBTi framework).

If the project expands an already existing site, the current SDA may be applied directly, based on new production volumes production. For entirely new (greenfield) developments, the SDA start date is shifted to the asset's commissioning year, with convergence to 2050 endpoint in the current SDA still required.

Importantly, target recalculation is only allowed if the company can demonstrate that the new asset addresses **unfulfilled demand under a 1.5°C-aligned scenario**. For example, the IEA's Global Critical Minerals Outlook 2024 and associated Figure 11 highlights a gap between expected lithium supply (including all announced projects) and projected demand under the NZE scenario. This gap justifies excluding the absolute value loopback condition in this specific case.

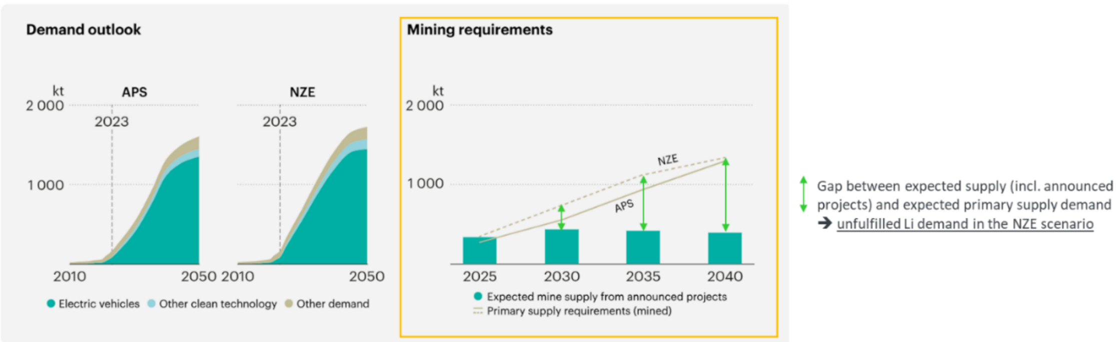

Figure 11 : Unfulfilled demand of Lithium as a key transition metal in IEA NZE scenario

2.1.1.9 Development of a new asset both enabler and not-enabler

An asset can produce **materials that serve multiple value chains**—some critical to the energy transition (e.g., nickel for electromobility), and others that are not (e.g., nickel for stainless steel). In such cases, a **less binary approach** is required, building on the principles described previously:

- **If less than 10%** of the asset's production is dedicated to low-carbon value chains, the whole asset is considered **non-transition-related**. *Example:* This applies to manganese (Mn), for which only a limited share is used in NMC batteries for electromobility. The principles outlined in Section 2.1.1.6 (for production growth and greenfield projects) and 2.1.1.7 (for brownfield projects) apply.
- **If more than 80%** of the asset's production is dedicated to low-carbon value chains (as demonstrated by robust avoided emissions calculations for example) the whole asset is considered a **transition enabler**.

Example: This is the case for lithium (Li), for which the vast majority is used in mobility and stationary battery applications. The principles of Section 2.1.1.8 (for production growth and greenfield projects) and 2.1.1.7 (for brownfield projects) apply.

- **If between 10% and 80%** of the asset's production supports low-carbon value chains, a **hybrid approach** must be applied. The asset's emissions reduction target is then computed as if it were composed of **two virtual sub-assets**: a transition-enabling portion and a non-transition-related portion.
These are weighted according to the (evolving) share of production serving low-carbon end uses.

2.2. Pillar 2 – Enabling climate solutions

Thanks to a portion of their metal production being used in climate solutions, such as batteries for electric vehicles, diversified mining and metals companies can significantly contribute to overall economy decarbonization (assessed through **avoided emissions**), in addition to their own direct emissions reduction efforts.

This pillar relies on the **calculation of avoided emissions at both the asset and company levels**. However, under the application of this framework for some transition metals, the scope of avoided emissions is deliberately limited:

- Only the share of key transition metals used in **batteries for electromobility** is considered. Stationary batteries and other transition-related applications are excluded. This constitutes a simplification, as other uses, including stationary storage, also contribute to overall decarbonization. However, the selected end-use is deemed sufficient to demonstrate avoided emissions, and therefore justify a specific treatment in the recalculation of absolute reduction targets for enabler assets, adapting the absolute value loopback condition under certain circumstances, as detailed in Section 2.1.2.
- Only **battery electric vehicles (BEVs)** are considered; plug-in hybrids (PHEVs) and other types are excluded.

Avoided emissions are calculated following the **Avoided Emissions Platform (AEP)** methodology, as partially illustrated in Figure 12.

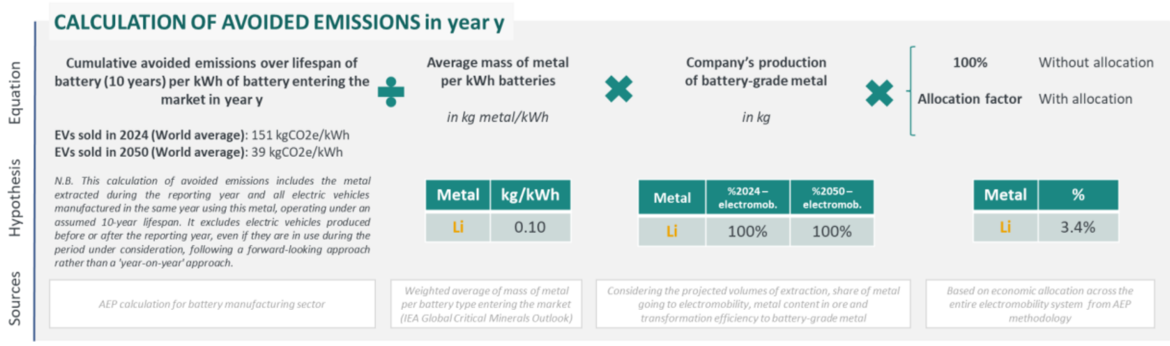

Figure 12: Main equation and assumptions for avoided emissions calculation for lithium production

Particular care must be taken in assessing the **share of a company's metal production that actually ends up in transition-related end uses.** This task often requires strong assumptions, especially concerning the proportion of each metal actually used in electromobility. In practice, metal ores are traded on a **global market**, and data on final use is rarely available or traceable. Moreover, not all lithium produced is used in **batteries for electromobility**, and an even smaller fraction is used specifically in **batteries for battery electric vehicles (BEVs).** In Figure 12, the share of lithium used in electromobility is assumed to be 100% for illustrative purposes.

Finally, the contribution to avoided emissions can be calculated either **with or without applying an allocation factor**, based on the Avoided Emissions Platform's economic allocation methodology applied across the entire electromobility value chain. Since diversified mining and metals companies operate at the upstream end of this chain, they may account for a significant amount of unallocated avoided emissions. For instance, one kg of Lithium can contribute to avoid up to 1.5 tCO2 in electromobility as it enables the production of 10 kWh of battery and each kWh of battery capacity avoids over 150 kgCO2e over 10 years by substituting a mix of mobility dominated by petrol cars.

However, once emissions are economically allocated across the full range of actors involved the company's effective contribution is reduced. This approach better reflects the shared responsibility across all segments of the system. For instance, the production of battery-grade lithium only represents 3% of the cost of dedicated activities of electromobility (including other materials sourcing, battery, powertrain & vehicle manufacturing, car maintenance over its lifetime, provision of electricity and charging station infrastructure, etc.), each essential for the overall contribution to avoided emissions. The economic attribution enables to share the contribution in a way that prevents double-counting among the different contributive activities.

At the company level, one can compute both allocated avoided emissions (by summing its allocated avoided emissions by product or activity) and unallocated avoided emissions: however for this last case, in order to prevent double-counting avoided emissions from multiple activities contributing to the same avoided emissions (here several metals used in a single battery), only the highest annual value of unallocated avoided emissions from a single metal is retained: the overall avoided emissions by all lithium, nickel & manganese activities cannot be higher than the highest individual contributor. By contrast, when applying the allocation factor, the avoided emissions attributed to the company correspond to the sum of the economically allocated values for each relevant metal.

Finally, there are two main uses of Pillar 2:

- To **demonstrate the company's contribution to the transition**, by calculating its **avoided emissions** and corresponding induced vs. avoided emissions ratio at the company level
- To justify a differentiated approach on greenfield project volume loopback for the enabling metals (e.g., lithium or a portion of nickel), which are recognized as climate solutions due to their unfulfilled demand in transition scenarios (e.g., for electromobility applications) (see Section 2.1.2).

3. Gap with SBTi approach and conclusion

To conclude, this methodological framework introduces a **series of adaptations and extensions to the current Science-Based Targets approach**, in order to better reflect the specificities and decarbonization challenges of the diversified mining and metals sector. While firmly grounded in the **scientific rigor, ambition, and principles of the SBTi**, this framework departs from its standard formulation to ensure **greater sectoral relevance**, operational feasibility, and credible alignment with real-world transformation pathways supported by robust data and transparent methodologies.

3.1. Extension of SBTi principles

Firstly, the Alternative 1.5°C Decarbonization Framework expands the catalogue of available SBT options through the **development of sector-specific trajectories**. For transformation processes such as ferronickel and manganese metallurgy, dedicated Sectoral Decarbonization Approaches have been designed, aligned with the ambition levels of the SBTi. Although these SDAs are based on alternative reference scenarios, they replicate the same methodological logic, namely an intensity trajectory and convergence approach for companies in hard-to-abate sectors. For mining activities, which are currently not covered by official SDAs, pseudo-SDAs were constructed based on a bottom-up approach, combining elements from existing SBTi methodologies—such as the power generation and transport SDAs, and the FLAG approach—with equivalent levels of ambition.

The framework also integrates the **WB2D SBTi's maritime SDA** to address Scope 3 Category 4 and 9 emissions (i.e., upstream and downstream shipping), which represent the most significant transport-related emissions in the mining value chain. For Scope 3 Category 10 (i.e., processing of sold products), transformation SDAs were adapted to align with a less ambitious well-below 2°C-aligned trajectory. Across these categories, the framework remains consistent with the principles and ambition of the SBTi.

Moreover, the **absolute value loopback condition,** inspired by the SBTi's sectoral guidance, is applied across new SDA-covered activities (e.g., diversified mining, Mn pyrometallurgy) and ensures that companies whose production growth exceeds market growth maintain a level of climate effort proportional to their increasing market share. It translates into more stringent emission intensity trajectories to preserve alignment with global 1.5°C-compatible carbon budgets.

3.2. Deviations from SBTi approach

In parallel, the framework also departs from and complete the SBTi approach on some points. Notably, it allows for **greater flexibility in the recalculation of near- and long-term targets when companies expand into key transition metals** such as lithium. These metals, considered "enabler" assets due to their essential role in the energy transition, may justify the recalculation of global emissions targets, provided that the company can **demonstrate that the**

project addresses unfulfilled demand in 1.5°C-aligned scenarios. In such cases, the SDA for the relevant metal is applied, but the loopback condition may be ignored due to the absence of overcapacity in the IEA Net Zero Emissions (NZE) scenario.

Finally, the approach allows for the **definition of a global absolute emissions trajectory, covering Scope 1, 2, and 3, by combining several methodologies**. Rather than applying a single SDA/ACA per scope as required by the SBTi, this methodology aggregates differentiated trajectories for each emission source: specific SDAs for transformation, pseudo-SDAs for mining, and adapted approaches for Scope 3. While this introduces complexity and deviates from the SBTi's formal structure, it offers a more holistic and representative decarbonization pathway for diversified mining and metals companies.

In conclusion, this framework maintains a high level of ambition consistent with the SBTi while introducing necessary adaptations to account for the structural complexity of the mining and metals sector. By extending the range of available methodologies and incorporating mechanisms to manage structural growth and enabler assets, it offers a robust, science-based pathway for companies seeking to align with global climate goals in diversified mining and metals sector.