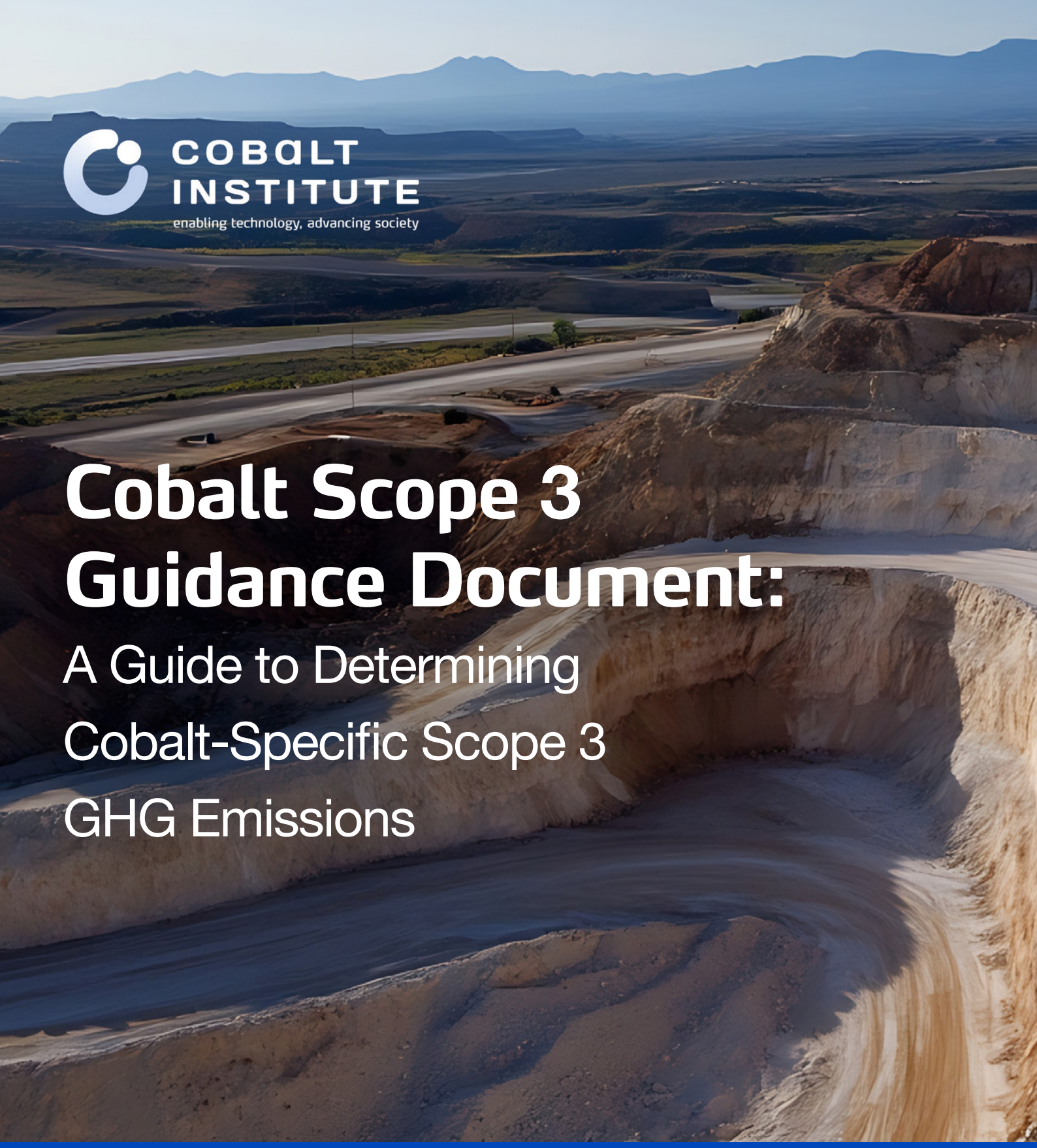


COBALT INSTITUTE
enabling technology, advancing society

Cobalt Scope 3 Guidance Document:

A Guide to Determining Cobalt-Specific Scope 3 GHG Emissions

November 2026

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About Cobalt Institute

The Cobalt Institute is the global trade association representing the cobalt industry and its entire value chain, including producers, refiners, traders, users and recyclers. The Institute promotes the safe, responsible and sustainable production and use of cobalt in all its forms. Acting as the industry's voice and a leading knowledge centre, the Institute engages with governments, regulators, industry, academia and the media on issues shaping the cobalt sector. Its work spans chemicals management, health, safety and the environment, responsible sourcing, sustainability and global advocacy, helping to support a responsible cobalt value chain and ensure cobalt continues to play a vital role in enabling technologies and advancing society.

This Document

This document provides companies operating in the cobalt value chain with practical guidance for calculating and reporting their corporate Scope 3 greenhouse gas (GHG) emissions. While the primary audience is cobalt producers, processors, and downstream manufacturers, the guidance may also be of interest to policy makers and other stakeholders.

The document is intended to be read in conjunction with the GHG Protocol Corporate Accounting and Reporting Standard (“GHG Protocol”) and the International Council on Mining and Metals (ICMM) Scope 3 Emissions Accounting and Reporting Guidance. It does not replace or reinterpret those frameworks. Rather, it provides cobalt-specific clarification and application guidance to address characteristics of cobalt production, intermediate products, downstream processing routes, and recycling pathways that may not be fully captured in more general standards.



A hotspot analysis, conducted in line with the ICMM methodology, was used to identify the Scope 3 categories most relevant to cobalt value chains and to prioritise data collection and methodological effort. Where data gaps are commonly encountered, particularly for certain intermediate products and downstream processing steps, this guidance provides structured approaches for estimation. In the absence of higher-quality, supplier- or customer-specific data, industry-average or activity-based values consistent with the GHG Protocol and ICMM hierarchy may be applied, provided that assumptions are transparently documented and disclosed.

The content of this guidance is informed by discussions with members of the Cobalt Institute and technical experts, a review of publicly available literature, and analysis of accessible datasets. As Scope 3 accounting methodologies, regulatory requirements, and data availability continue to evolve, the Cobalt Institute anticipates that this guidance will be reviewed and updated periodically to ensure continued alignment with recognised standards and emerging best practice.

This document was subject to an independent peer review by Johannes Drielsma of Drielsma Resources Europe, who provided expert feedback on its technical content, clarity and readiness for publication. www.resources-europe.eu



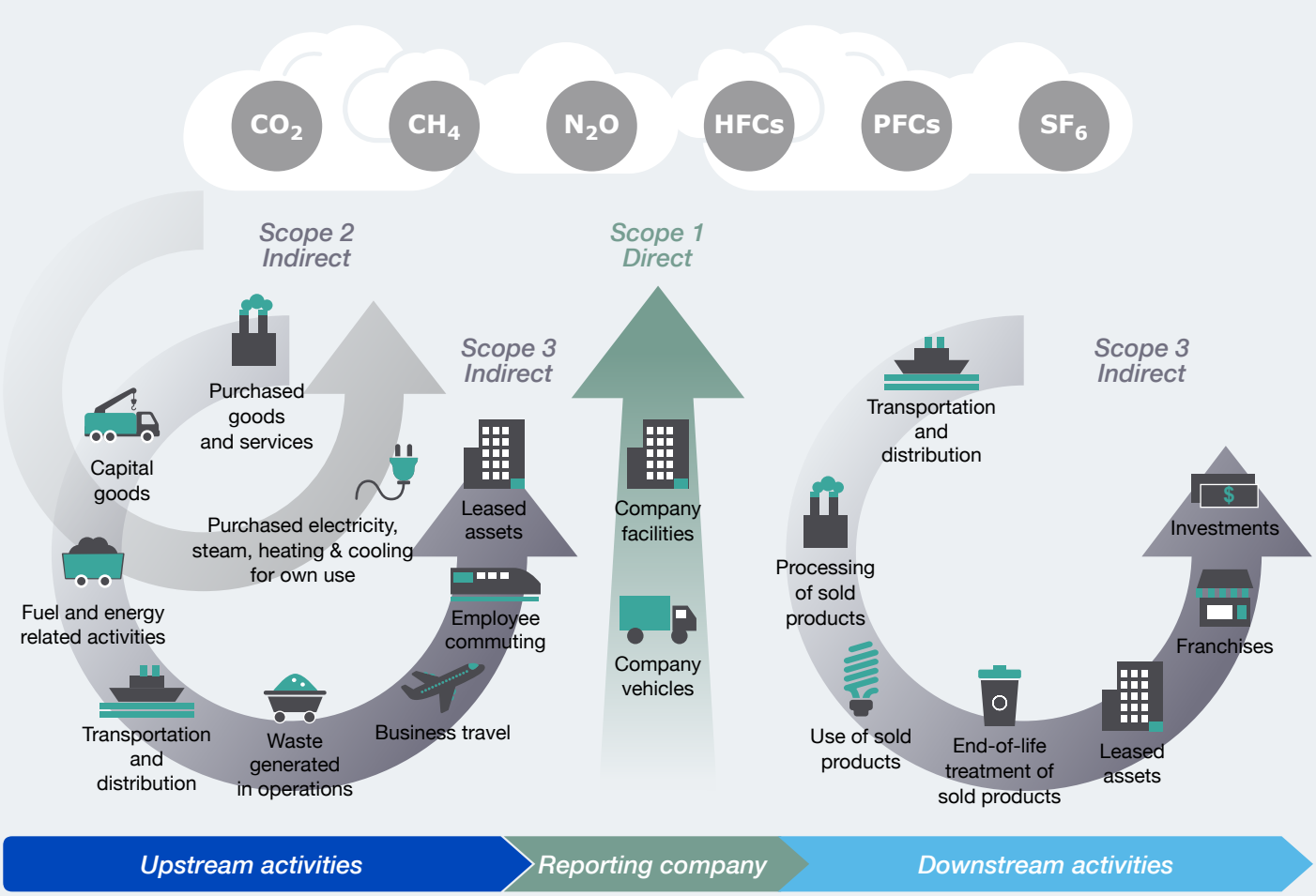
1. Introduction



This document builds on widely used greenhouse gas (GHG) accounting frameworks. It assumes a general understanding of how emissions are classified as Scope 1, Scope 2, and Scope 3 across the value chain. To support a consistent interpretation, selected concepts are revisited where they are particularly relevant to cobalt products and cobalt value chains.

Figure 1 provides a commonly used overview of the value chain components that comprise Scope 1, 2 and 3 emissions.

Figure 1: Overview of GHG Protocol scopes and emissions across the value chain.



Source: Reproduced from WRI & WBCSD (2011), The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition).

The GHG Protocol provides the overarching framework for corporate GHG accounting. It is supplemented by the Corporate Value Chain (Scope 3) Accounting and Reporting Standard, which supports the identification, quantification, and management of indirect emissions across the full value chain.

Scope 3 emissions are indirect emissions that occur outside the organisational boundary of the reporting company and are not included in Scope 2. These emissions are classified as either upstream or downstream. Upstream emissions relate to the extraction, production, and transportation of purchased goods and services used in the company's operations. Downstream emissions arise from the processing, distribution, use, and end-of-life treatment of products sold by the reporting company.

The GHG Protocol defines fifteen Scope 3 categories, comprising eight upstream and seven downstream categories. Table 1 lists these categories.

Table 1. Overview of the fifteen Scope 3 categories included in the GHG Protocol.

Upstream Scope 3 Emissions	Downstream Scope 3 Emissions
1. Purchased Goods and Services	9. Downstream Transportation and Distribution
2. Capital Goods	10. Processing of Sold Products
3. Fuel- and Energy-Related Activities (not included in Scope 1 or Scope 2)	11. Use of Sold Products
4. Upstream Transportation and Distribution	12. End-of-Life Treatment of Sold Products
5. Waste Generated in Operations	13. Downstream Leased Assets
6. Business Travel	14. Franchises
7. Employee Commuting	15. Investments
8. Upstream Leased Assets	

Source: Reproduced from World Resources Institute (WRI) & World Business Council for Sustainable Development (WBCSD) (2011), Corporate Value Chain (Scope 3) Accounting and Reporting Standard.

2. A deep dive on Cobalt Scope 3 GHG emissions

Scope 3 GHG emissions are particularly relevant to the mining and metals sector, where the production and transport of purchased goods and services including capital equipment, reagents, consumables, and intermediate materials can result in greenhouse gas emissions that exceed those arising directly from on-site fuel combustion (Scope 1) and purchased electricity (Scope 2).

Across the mining sector, Scope 3 emissions frequently represent the majority of total value-chain emissions. For cobalt-specific value chains, from mining through to first-use products, Scope 3 emissions in 2023 are estimated to account for approximately 65% of total emissions across Scopes 1, 2 and 3 combined (Cobalt Institute, 2024). This reflects both upstream emissions embedded in purchased inputs and downstream emissions associated with further processing of cobalt-containing products.

At the mining stage, Scope 3 emissions typically arise from purchased operational inputs, capital equipment, upstream fuel and energy supply chains, and the downstream processing of cobalt-containing products.

As cobalt moves downstream into refining, chemical production, and precursor manufacturing, the relative contribution of Scope 3 categories shifts. Refiners and chemical producers typically have greater upstream emissions associated with purchased intermediates, while downstream emissions depend on the extent of subsequent processing undertaken by customers.
For manufacturers producing first-use products (for example battery materials, alloys and catalysts), Scope 3 emissions are generally dominated by purchased cobalt-containing materials, while downstream emissions are often less significant because most cobalt applications do not generate greenhouse gas emissions during use.

Because the significance of individual Scope 3 categories depends on a company's position in the value chain, companies should undertake a structured assessment of category relevance. To support this process, a cobalt-specific hotspot analysis was undertaken using the ICMM Scope 3 methodology. The results are presented in Section 4 and provide the basis for the category-specific guidance in this document.

3. A deep dive on cobalt value chains

3.1. How cobalt is processed

Primary cobalt production is predominantly derived as a by-product of copper or nickel production and is therefore embedded within broader copper and nickel extraction and refining value chains.

Drawing on publicly available process descriptions, including those set out in the British Geological Survey (BGS) Commodity Review on Cobalt, three principal ore mineralogies are identified for the purposes of this guidance as illustrated in Figure 2:

- Copper–cobalt sulphidic ores
- Nickel–cobalt sulphidic ores
- Nickel–cobalt lateritic ores

In 2024, these routes accounted for approximately 99% of global cobalt production, with around 76% originating from copper–cobalt sulphide deposits and approximately 23% from nickel–cobalt sulphidic and lateritic deposits. Figure 2 provides a high-level overview of these production routes and illustrates typical cobalt content at key stages of processing.

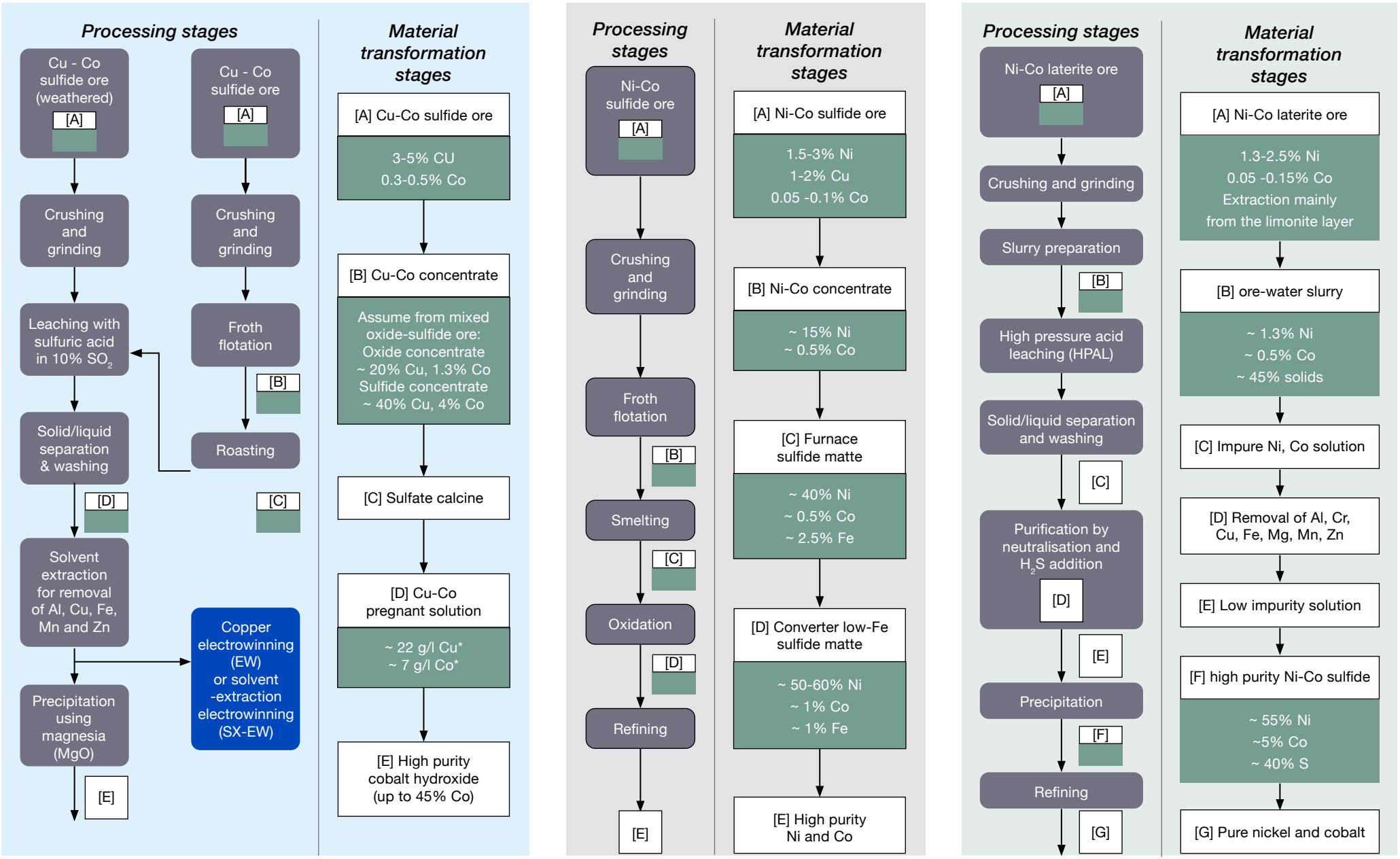
Across these routes, cobalt is present in a range of intermediate products generated during mining, concentration, smelting and crude refining. These include but are not limited to:

- Crude cobalt hydroxide
- Cobalt-bearing nickel matte
- Mixed sulphide precipitate (MSP)
- Mixed hydroxide precipitate (MHP)

Such intermediates are typically sold to refiners, where further purification and chemical conversion yield market-ready cobalt products, including cobalt metal and cobalt chemicals supplied to first-use industries.



Figure 2. Overview of processing stages in the cobalt value chain for different principal ore mineralogies.



Source: Reproduced from Petavratzi, E., Gunn, G., & Kresse, C. (2019), BGS Commodity Review: Cobalt.

3.2. Emissions related to cobalt processing

The cobalt value chain comprises multiple processing steps and frequent transfers of materials between mining operations, crude refiners, and fine refiners before reaching first-use applications. This structural complexity has important implications for GHG accounting, as emissions may arise at several stages outside the reporting company's operational boundary.

To support consistent identification and attribution of emissions, the value chain up to first-use products is divided into discrete process stages reflecting typical production routes across copper–cobalt and nickel–cobalt systems.

Table 2 summarises these stages, including the principal activities undertaken, associated Scope 1 and Scope 2 emissions from on-site fuel use and electricity consumption, relevant upstream and downstream Scope 3 emissions, and the main intermediate or finished products generated at each stage.

This staged representation provides a practical basis for distinguishing between emissions occurring within operational control and those arising elsewhere in the value chain and underpins the hotspot analysis and data quality considerations presented in this guidance.



Table 2. Summary of process stages and outlines of the cobalt value chain up to first-use products

Process Stage	Process (Scope 1 and 2)	Inputs (Upstream Scope 3)	Effluents, emissions, waste	Finished products
Mining / Beneficiation / Ore Concentration	Extraction of copper-cobalt or nickel-cobalt containing ores followed by beneficiation/ore preparation	Fuels (e.g. diesel, natural gas, coal); cement; electricity; explosives; grinding media; heat; quicklime; reagents; steam; tires	GHG emissions; effluents; mining waste; tailings	Cu or Ni concentrates containing cobalt (~0.05-0.5% cobalt contained)
Smelting	Pyrometallurgical smelting of copper-cobalt or nickel / cobalt concentrates and conversion into alliage blanc or nickel / cobalt matte respectively	Copper concentrates; Nickel concentrates; fuels (e.g., diesel, natural gas, coal); electricity; electrodes; heat; lime; oxygen; reductants; steam	GHG emissions; other emissions; slags	Nickel / cobalt matte (~1% cobalt contained)
Leaching - e.g. HPAL	Hydrometallurgical extraction of nickel / cobalt intermediates	Ammonia; H2SO4; electricity; fuels (e.g., diesel, natural gas, coal); heat; hydrogen; steam; sulphur; limestone; nitrogen; other reagents; oxygen	GHG emissions; leaching residues; effluents	Crude cobalt hydroxide; mixed sulphide precipitate (MSP); mixed hydroxide precipitate (MHP) (~5% cobalt contained)
Leaching - MgO	Hydrometallurgical extraction of cobalt intermediates (after solvent extraction / electrowinning of copper)	Ammonia; H2SO4; electricity; fuels (e.g., diesel); heat; steam; limestone; other reagents	GHG emissions; leaching residues; effluents	Crude cobalt hydroxide (~30% cobalt contained)
Refining: Cobalt Sulphate	Conversion of alliage blanc / cobalt metal / crude cobalt hydroxide / MHP / MSP to cobalt sulphate heptahydrate	Electricity; fuels (e.g. diesel / LNG / hydrogen); H2SO4; extractants (e.g., N902, P204, P507); heat; HCl; hydrogen; NaOH; NaClO3; H2O2; nitrogen; oxygen; steam	GHG emissions; leaching residues; effluents	Cobalt sulphate heptahydrate (~21% cobalt contained)
Refining: Tricobalt Tetraoxide	Conversion of cobalt metal / cobalt chloride / cobalt sulphate to tricobalt tetraoxide	NH4HCO3; H2O2; Na2CO3; NaOH; electricity	GHG emissions; leaching residues; effluents	Tricobalt tetraoxide (~71% cobalt contained)
Refining: Cobalt Metal	Refining of impure cobalt metal or cobalt chemicals to pure cobalt metal	Electricity; H2SO4; extractants (e.g., N902, P204, P507); HCl; NaOH; NaClO3; H2O2; heat and steam; technical gases	GHG emissions; leaching residues; spent electrolyte; effluent	Cobalt metal (99.9% cobalt contained)
Recycling / Secondary Materials	Collection, preparation and processing of cobalt-containing secondary materials, including battery black mass, cobalt-containing alloys and catalysts, through mechanical, pyro and/or hydrometallurgical recycling processes	Recycled cobalt-containing materials (e.g., battery black mass, cobalt-containing alloys and catalysts); electricity; fuels; heat; acids; alkalis; reducing agents; other process reagents	GHG emissions; process residues; slags; leach residues; effluents; waste	Recovered cobalt intermediates or refined cobalt products, including cobalt sulphate, cobalt metal and other cobalt-containing products

4. ICMM Hotspot Analysis for Scope 3 Emissions

The ICMM Scope 3 Emissions Accounting and Reporting Guidance sets out a structured approach for screening and identifying materially relevant Scope 3 categories. This supports companies in determining which categories are likely to be significant and therefore require more detailed calculation and reporting, as well as which may be considered less material following a documented assessment.

ICMM guidance also illustrates how materiality may vary across different stages of a metal value chain, including through indicative heat maps that distinguish between low, medium, and high relative contributions. These tools are intended to guide prioritisation rather than define fixed thresholds.

For the purposes of this cobalt-specific guidance, a hotspot analysis was conducted consistent with the ICMM screening approach. The analysis considered representative cobalt value chains from mining through to first-use products and drew on member company input, publicly available literature, and relevant datasets. Its objective was to identify categories that are typically material and therefore warrant prioritisation in data collection and methodological rigour.

The results are intended as an initial reference point. Companies should conduct their own category screening based on their specific business model, organisational boundary, and geographic footprint. Consistent with the results of the hotspot analysis, Category 1 (Purchased Goods and Services) and Category 10 (Processing of Sold Products) are the most consistently material Scope 3 categories across cobalt value chains.



Category 1 reflects emissions embedded in purchased intermediates, reagents, energy supply chains, and contracted services, while Category 10 reflects emissions arising from downstream processing of cobalt-containing products following sale.

Category 10 is particularly significant in cobalt value chains due to the frequent transfer of intermediate products (such as cobalt matte, mixed sulphide precipitate (MSP), mixed hydroxide precipitate (MHP), and crude cobalt hydroxide) between miners, crude refiners, and fine refiners prior to first-use applications. These transfers typically involve additional processing outside the reporting company's control, giving rise to downstream Scope 3 emissions.

Given both their recurring materiality and methodological complexity, this guidance places emphasis on improving data quality and calculation approaches for Categories 1 and 10. Table 3 provides a summary of the hotspot analysis.



Table 3. Hotspot analysis of Scope 3 category emissions in cobalt production

	Mining / Beneficiation / Ore Concentration	Smelting (e.g., producing matte)	Leaching - HPAL (e.g., producing MHP / MSP)	Leaching - MgO (e.g., producing crude cobalt hydroxide)	Refining: Cobalt Sulphate	Refining: Tricobalt Tetraoxide	Refining: Cobalt Metal
1. Purchased Goods and Services	High	High	High	High	High	High	High
2. Capital Goods (during expansion / capital investment cycles)	High	High	High	High	High	High	High
3. Fuel- and Energy-Related Activities (not included in Scope 1 or Scope 2)	Mid	High	High	Low	Mid	Mid	Low
4. Upstream Transportation and Distribution	Mid	Mid	Mid	Mid	Mid	Mid	Mid
5. Waste Generated in Operations	Low	Low	Low	Low	Low	Low	Low
6. Business Travel	Low	Low	Low	Low	Low	Low	Low
7. Employee Commuting	Low	Low	Low	Low	Low	Low	Low
8. Upstream Leased Assets	Mid	Low	Low	Low	Low	Low	Low
Downstream Scope 3 Emissions							
9. Downstream Transportation and Distribution	Low	Mid	Mid	High	Low	Low	Low
10. Processing of Sold Products	High	High	High	High	High	High	High
11. Use of Sold Products	Low	Low	Low	Low	Low	Low	Low
12. End-of-Life Treatment of Sold Products	Low	Low	Low	Low	Low	Low	Low
13. Downstream Leased Assets	Low	Low	Low	Low	Low	Low	Low
14. Franchises	Low	Low	Low	Low	Low	Low	Low
15. Investments	Low	Low	Low	Low	Low	Low	Low

High = typically >10%; Mid = typically 5–10%; Low = typically <5% of total Scope 3

4.1. Data Quality and Calculation Methods

- *Building on the hotspot analysis described above, companies should apply the highest quality data reasonably available when calculating Scope 3 emissions, with the level of methodological rigour reflecting the materiality of each category.*

- *Scope 3 emissions may be calculated using primary data, hybrid approaches, or secondary data. While supplier- or customer-specific data are preferred, these are not always available, particularly for downstream processing stages. In such cases, industry-average activity-based emission factors may be applied, provided that system boundaries and assumptions are clearly documented and disclosed.*

- *Where higher-priority data are not yet reasonably available, companies may temporarily use a lower-priority calculation method, provided that the approach is appropriate to the category and materiality of the emissions, the assumptions and limitations are transparently documented, and reasonable steps are being taken to obtain higher-quality data. Lower-priority methods should be progressively replaced as more representative primary, hybrid or industry-average data become available.*



Table 4. Hierarchy of data quality for calculating Scope 3 emissions

	Calculation Approach	Description	Applicability in Cobalt Value Chains
1	Primary data	Primary data obtained directly from suppliers or customers (e.g., attributable Scope 1 and Scope 2 emissions)	Preferred for material Categories 1, 2 and 10 where available
2	Hybrid approach	Primary activity data combined with secondary emission factors	Common for transport, energy modelling, defined processing routes
3	Industry-average activity-based emission factors (secondary data)	Representative emission factors per unit mass or activity	Recommended for material categories where supplier-specific primary data are not available. Use representative industry-average, activity-based emission factors for the relevant material, production route and geography, where available. This approach should be used for material Category 1 and Category 2 sources before considering spend-based methods.
4	Spend-based methods	Financial expenditure multiplied by sector-average factors	Limited application; may be required for MSP, MHP, or matte inputs until higher priority methods are made available. Permitted as a fallback where no suitable activity-based data/factor is reasonably available and the method is appropriate to the category.
5	Proxy or extrapolation	Use of analogous products or process modelling	Last resort where representative data are unavailable; assumptions and limitations must be documented.

4.2. Specific Considerations for Category 10

Category 10 presents particular data challenges in cobalt value chains due to the transfer of intermediate products between miners, crude refiners, and fine refiners prior to first use.

Unlike Category 1, where product carbon footprint (PCF) data are increasingly available, Category 10 depends on downstream processing data that are often outside the reporting company's visibility. As a result, the range of data options is more constrained.

In practice, Category 10 calculations may rely on:

1. Customer-specific primary Scope 1 and Scope 2 data attributable to the first external processing step (preferred);
2. Hybrid modelling based on known processing routes and regional electricity factors;
3. Industry-average activity-based emission factors for identified first finished goods (provided in this guidance).

For certain intermediates, notably cobalt matte, mixed sulphide precipitate (MSP), and mixed hydroxide precipitate (MHP), publicly available industry-average data are limited. Where customer-specific primary data are unavailable, companies should use process-based or hybrid modelling where sufficient information is available to estimate emissions for the relevant processing route. Spend-based methods and proxy approaches should not be used for material Category 10 emissions.



4.3. System Boundaries of Scope 3 emissions across the cobalt value chain

The attribution of upstream and downstream Scope 3 emissions depends on a company's position within the cobalt value chain, including mining, intermediate processing, refining, chemical conversion, and first-use manufacturing.

For mining companies, there are typically no cobalt-specific upstream Scope 3 emissions associated with earlier processing stages. Downstream Scope 3 emissions arise from the subsequent processing of sold cobalt-containing products and are reported under Category 10.

For companies operating at later stages (e.g., crude or fine refining), upstream Scope 3 emissions include earlier production stages, while downstream emissions relate to further processing of their products following sale.

In most cases, Category 10 emissions are calculated for the first external processing step (i.e. Tier 1 customers). For the purposes of this guidance, this is the minimum Category 10 boundary because emissions associated with subsequent processing stages can be difficult to attribute to the reporting company's sold product and may introduce risks of double counting, particularly where the same intermediate product passes through multiple processing stages. Companies may extend the assessment beyond the first external processing step where subsequent emissions are material, relevant to the cobalt product being assessed, and supported by sufficiently robust data. Any extension should clearly define the system boundary, avoid double counting, and document the basis for including or excluding subsequent processing stages. The organisational boundary selected by a company, whether operational control, financial control, or equity share, determines which activities are included within Scope 1 and Scope 2, and therefore which emissions are classified as Scope 3. Companies should ensure that boundary definitions are applied consistently and transparently documented and disclosed.



Table 5. System boundaries for actors in the cobalt value chain

Reporting Company	Mining	Smelting	Leaching - HPAL	Leaching - MgO	Refining: Cobalt Sulphate	Refining: Tricobalt Tetraoxide	Refining: Cobalt Metal	First Product use	Second Product use
Mining Output: cobalt ores and concentrates Customer: Smelter/leacher	Scope 1 & 2	Scope 3 Cat.10 (minimum boundary) crude cobalt hydroxide, MHP, MSP			Beyond minimum Cat.10 boundary; may be included where material and supported by robust data (See Section 4.3)	Beyond minimum Cat.10 boundary; may be included where material and supported by robust data (See Section 4.3)	Beyond minimum Cat.10 boundary; may be included where material and supported by robust data (See Section 4.3)		
Smelting Input: cobalt ores and concentrates from mines Output: cobalt containing matte Customer: refiners	Scope 3 Cat.1-8	Scope 1 & 2	N/A	N/A	Scope 3 Cat.10 (minimum boundary)	Scope 3 Cat.10 (minimum boundary)	Scope 3 Cat.10 (minimum boundary)	Optional inclusion in Scope 3 Cat.10	
Leaching - HPAL Input: cobalt ores and concentrates from mines Output: MHP / MSP Customer: refiners	Scope 3 Cat.1-8	N/A	Scope 1 & 2	N/A	Scope 3 Cat.10 (minimum boundary)	Scope 3 Cat.10 (minimum boundary)	Scope 3 Cat.10 (minimum boundary)	Optional inclusion in Scope 3 Cat.10	
Leaching - MgO Input: cobalt ores and concentrates from mines Output: crude cobalt hydroxide Customer: refiners	Scope 3 Cat.1-8	N/A	N/A	Scope 1 & 2	Scope 3 Cat.10 (minimum boundary)	Scope 3 Cat.10 (minimum boundary)	Scope 3 Cat.10 (minimum boundary)	Optional inclusion in Scope 3 Cat.10	
Refining: cobalt sulphate Input: cobalt intermediate from smelting / leaching or cobalt metal Output: cobalt sulphate Customer: cobalt oxide refiner, first use (e.g. pCAM)	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 1 & 2	Scope 3 Cat.10 (minimum boundary) when feedstock for oxide	Scope 3 Cat.1-8 Sulphidation of cobalt metal	Scope 3 Cat.10 (minimum boundary)	Optional inclusion in Scope 3 Cat.10
Refining: tricobalt tetraoxide Input: cobalt intermediate from smelting / leaching, cobalt metal, cobalt sulphate Output: tricobalt tetraoxide Customer: first use (e.g. pCAM)	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8 (cobalt carbonate and analogous route)	Scope 1 & 2	Scope 3 Cat.1-8 (metal route)	Scope 3 Cat.10 (minimum boundary)	Optional inclusion in Scope 3 Cat.10
Refining: cobalt metal	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.1-8	Scope 3 Cat.10 (minimum boundary) when feedstock for sulphate	Scope 3 Cat.10 (minimum boundary) when feedstock for oxide	Scope 1 & 2	Scope 3 Cat.10 (minimum boundary)	Optional inclusion in Scope 3 Cat.10

Notes: Integrated operations: Scope 3 reporting shall commence from the final process stage within the reporting entity's organisational boundary. Earlier value chain stages under the same boundary fall within Scope 1 and 2. Emissions may be calculated at site level and aggregated, provided a consistent boundary approach is applied.

Indicative feedstocks: The table is illustrative, not exhaustive. Feedstocks and conversion routes for refined cobalt products vary by operation and region. Companies shall apply the principles in this guidance to their specific process pathways and document and disclose material deviations.



4.4. Additional Technical and Reporting Considerations

This guidance provides cobalt-specific clarification and default emission factors to support consistent Scope 3 reporting. However, several structural characteristics of cobalt value chains warrant additional technical consideration when applying the methodologies described above.

4.5. By-Product Allocation

Cobalt is predominantly produced as a by-product of copper or nickel mining and refining operations. As a result, upstream emissions from extraction, concentration and smelting are typically allocated across multiple metals. The allocation method applied, whether mass-based, economic, or (in limited cases) system expansion, can materially influence reported emissions, particularly for Scope 3 Category 1 (Purchased Goods and Services).

The Cobalt Institute Product Carbon Footprint (PCF) Guidance addresses allocation at the product level, determining how emissions are assigned to a unit of cobalt product. In corporate Scope 3 reporting, those allocated product-level emissions are incorporated into a company's organisational inventory. While the reporting objective differs, the underlying principles remain consistent with ISO 14044 and the GHG Protocol.

Allocation decisions are typically applied at the product or process level (e.g., within product carbon footprint methodologies). For corporate Scope 3 reporting, companies generally rely on supplier-specific or industry-average emission factors that already reflect these approaches, rather than applying allocation directly at the asset or site level.

Where supplier-specific or industry-average emission factors are used, companies should understand the allocation basis underpinning those data. Differences in allocation methodology across

suppliers or datasets may materially affect reported Scope 3 emissions and should be transparently documented.

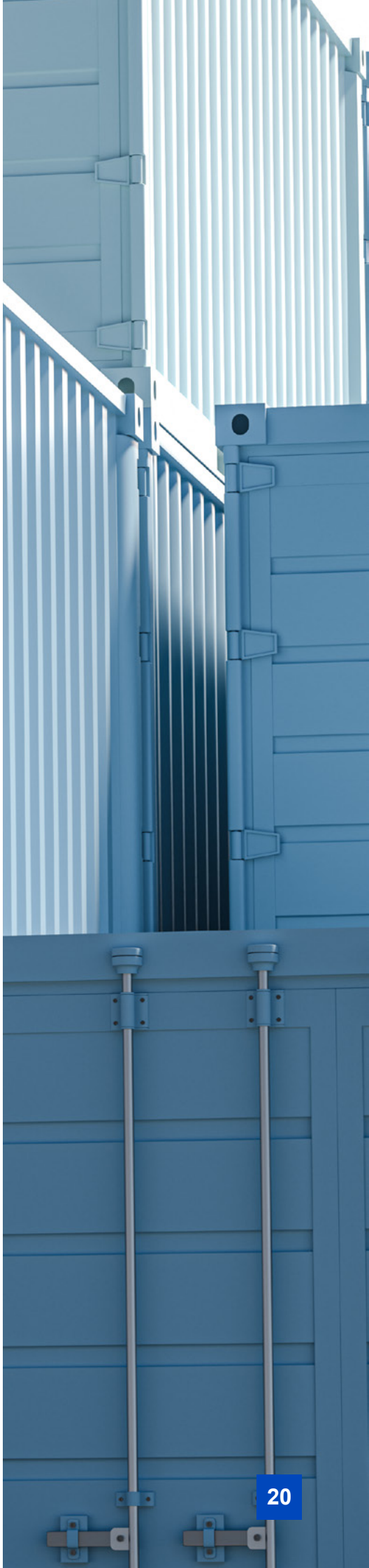
In practice, allocation approaches in cobalt value chains commonly reflect either physical relationships (e.g., metal content) or economic value, depending on the characteristics of the co-production system. For base-metal systems, mass-based allocation is often applied where price ratios are relatively stable, while economic allocation may be more representative in systems involving precious or platinum group metals.

System expansion may be applied in limited cases for non-metal co-products, provided double counting is avoided, but is generally not appropriate for metal co-products.

4.6. Intermediate Product Transfers

Cobalt value chains frequently involve the sale and transfer of intermediate products such as cobalt matte, mixed sulphide precipitate (MSP), mixed hydroxide precipitate (MHP), and crude cobalt hydroxide prior to final refining or chemical conversion. These transfers can create complexity in Scope 3 reporting, particularly under Category 10.

Category 10 emissions should reflect the first external processing step following sale as the minimum reporting boundary. The cut-offs shown in Table 5 reflect the point at which downstream processing is attributed to the reporting company and are intended to avoid double counting and attribution uncertainty. Subsequent stages may be included where material and supported by sufficiently robust data, as described in Table 5 and Section 4.3. Embedded upstream emissions contained within intermediates should not be re-attributed under Category 10, as this would result in double counting across reporting entities. Companies should clearly define the point of sale and subsequent processing boundary when applying default emission factors or modelling downstream emissions.



4.7. Recycling and Secondary Materials

Cobalt is recyclable and may enter production systems through both pre-consumer and post-consumer scrap streams. The Cobalt Institute PCF Guidance applies a cut-off (recycled content) approach for modelling recycled inputs in product carbon footprints. Under this approach, end-of-life scrap entering a production system carries no prior environmental burden; only the impacts of collection, preparation, and reprocessing are assigned to the recycling system.

For corporate Scope 3 reporting, companies should ensure consistency between product-level assumptions and Scope 3 accounting boundaries. Recycled cobalt entering a refining process is treated as an input under Category 1 (Purchased Goods and Services), and associated emissions should reflect scrap collection and refining processes only, not original primary production. Where cobalt is sold into applications that may later be recycled (e.g., batteries or superalloys), end-of-life treatment may be relevant to Category 12 (End-of-Life Treatment of Sold Products).

Recycling rates, recycled content assumptions, and allocation methods can materially influence reported Scope 3 results and should be transparently documented and disclosed. As recycled cobalt supply increases, particularly from lithium-ion battery recycling, companies are encouraged to periodically review their modelling approach to ensure alignment with the GHG Protocol, ICMM guidance, and sector best practice.

4.8. Organisational Boundary Effects

The organisational boundary approach selected by a company (operational control, financial control, or equity share) will influence whether emissions from certain activities are reported under Scope 1 and 2, or under Scope 3.

For example, emissions from a jointly operated refinery may fall within Scope 1 and 2 under an operational control approach, but may be reported as Scope 3 under an equity share approach. Companies should ensure that Scope 3 boundary definitions are applied consistently with their chosen organisational boundary methodology and that any material implications are documented and disclosed.

4.9. Regional Electricity Assumptions

Electricity carbon intensity is a significant driver of emissions from cobalt refining, chemical conversion, and first finished goods manufacturing. The emission factors provided in this guidance differentiate Scope 2 emissions by region to reflect variations in grid carbon intensity.

Companies applying alternative electricity emission factors should ensure that such factors are based on credible, current datasets and are geographically representative of the downstream processing location. Where processing occurs across multiple regions, a weighted average approach may be applied, provided that assumptions are documented.

4.10. Data Gaps for Certain Intermediates

Publicly available, industry-average emission factors are currently limited for cobalt matte, MSP, and MHP. These intermediates often exhibit significant variability in composition and downstream processing pathways, particularly where produced within integrated copper or nickel operations.

For intermediates such as cobalt matte, MSP and MHP, companies should prioritise customer-specific primary data where available. Where such data cannot reasonably be obtained, process-based or hybrid modelling approaches should be used for Category 10, where sufficient information is available to estimate emissions for the relevant processing route. Spend-based methods may be used as a fallback for Category 1 where suitable activity-based data are not reasonably available, consistent with the data quality hierarchy described in this guidance.

4.11. Ongoing Data Development

Data availability for cobalt value chains continues to evolve, particularly in the context of battery supply chain transparency, product carbon footprinting, and regulatory developments. As new datasets, methodologies, and reporting standards emerge, companies are encouraged to periodically review their Scope 3 calculation approaches to ensure continued alignment with recognised best practice and sector guidance.

4.12. Transparency and Disclosure

Scope 3 calculations, particularly for Category 10, rely on assumptions regarding processing routes, regional electricity intensity, and product applications. Transparent disclosure of methodological choices, data sources, allocation approaches, and known limitations is essential to ensure comparability and credibility.

Where practicable, companies are encouraged to disclose whether primary data used in Scope 3 calculations have been independently verified, internally reviewed, or remain unverified. Such information enhances transparency and supports users in understanding the level of assurance associated with reported emissions. Where material assumptions or proxy methods are applied due to data limitations, companies should document the affected product flows, the calculation approach adopted, and any resulting limitations.

This guidance provides a structured framework for calculation; however, responsibility for accurate, representative reporting remains with the reporting company.

4.13. Scope 3 Categories for Cobalt: Cobalt specific notes and Data Quality Alignment Table

(For corporate Scope 3 inventories; aligned with the GHG Protocol and ICMM Mining & Metals Guidance)

Table 6 summarises the expected materiality and recommended data quality hierarchy for each Scope 3 category in the context of cobalt value chains, building on the ICMM screening approach and the cobalt-specific hotspot analysis presented above.

Table 6. Summary of expected materiality and data hierarchy for assessing Scope 3 emissions from cobalt production

Scope 3 Category	Typical Relevance in Cobalt Value Chains	Minimum Acceptable Method	Target Method (where Material)	Cobalt-Specific Notes
Category 1 – Purchased Goods & Services	High	Activity-based or material-intensity-based emission factors. Where representative industry-average factors are available, these should be used. Where they are not available, a spend-based method may be used as a fallback for material sources, provided that the use of the method and its limitations are transparently documented.	Supplier-specific cradle-to-gate EFs or PCFs used as emission factors	Includes purchased intermediates (MHP, MSP, matte, hydroxide, sulphate) and reagents. Toll refining as a service is considered Cat.1.
Category 2 – Capital Goods	Medium to High (investment-cycle dependent)	Where supplier-specific embodied carbon data are unavailable, companies should use representative industry-average activity-based or material-intensity-based emission factors where available. Where no suitable activity-based factor is available and the capital good is material, a spend-based method may be used as a fallback, with its use and limitations transparently documented.	Supplier-specific embodied carbon data for major equipment	Particularly relevant for new mines, HPAL plants, refinery builds
Category 3 – Fuel- and Energy-Related Activities	Medium to High (diesel-intensive mining, carbon-intensive grids)	National/regional lifecycle fuel factors	Supplier-specific lifecycle factors	Often material in open-pit mining and smelting
Category 4 – Upstream Transport	Medium	Distance × mode-based industry averages	Shipment-specific routing & carrier fuel data	Important for cross-border concentrate flows where the reporting company does not have financial control over the downstream transport activity; otherwise, medium or low.
Category 5 – Waste Generated in Operations	Low to Medium	Industry-average waste treatment factors	Contractor-specific treatment data	Tailings; slags; chemical residues
Category 6 – Business Travel	Low	Spend- or distance-based factors	Travel-mode-specific activity data	Typically immaterial

Category 7 – Employee Commuting	Low	Average commuting assumptions	Survey-based data	Typically immaterial
Category 8 – Upstream Leased Assets	Low	Industry-average factors	Asset-specific data	Context-dependent
Category 9 – Downstream Transport & Distribution	Medium (global trade flows)	Distance × mode-based averages	Customer or contract-specific logistics data	Particularly relevant for intercontinental shipping. Considered where the customer has financial control over the transport activity.
Category 10 – Processing of Sold Products	High (consistently material)	Industry-average activity-based EFs (including default EFs provided in this guidance)	Customer-specific Scope 1 and 2 emissions attributable to first external processing step	For mining companies, the minimum Category 10 boundary is the first external processing stage following sale. Subsequent refining stages may be included where emissions are material, relevant to the cobalt product sold, and supported by sufficiently robust data. See Section 5.3 for the boundary rationale.
Category 11 – Use of Sold Products	Typically Low	Qualitative justification of non-applicability	N/A	Most cobalt applications do not emit during use. Use phase of, say, an electric vehicle battery would be in the scope of the OEM.
Category 12 – End-of-Life Treatment	Low to Medium (battery recycling pathways)	Industry-average recycling/ disposal factors	Process-specific recycling data	Emerging importance with circular economy[1]
Category 13 – Downstream Leased Assets	Low	Industry-average operational factors	Asset-specific data	Rare in cobalt chains, however warehousing would be covered by this category
Category 14 – Franchises	Typically Not Applicable	Qualitative justification	N/A	Not generally relevant
Category 15 – Investments	Medium (JV mining/refining)	Public investee disclosures	Pro-rata investee Scope 1 and 2 data	Depends on organisational boundary approach

[1] End-of-life recycling and secondary materials are addressed in Section 4.7 and are outside the value-chain stages shown in this table.

5. Downstream scope 3 emissions – uses of cobalt

Scope 3 Category 10 emissions refer to the processing of sold products. In the case of cobalt, Category 10 emissions arise from downstream processing of an intermediate or refined cobalt product following sale. This typically involves the transformation of cobalt metal or cobalt chemicals into precursor materials, alloys, pigments, catalysts, magnets, or other first-use products.

For the purposes of this guidance, the first external processing step following sale is used as the minimum reporting boundary. This provides a consistent and practicable boundary for downstream processing while limiting attribution uncertainty and the risk of double counting across subsequent processing stages. The specific cut-offs applied to different cobalt products and processing routes are set out in Table 5. Subsequent processing stages may be included where they are material and supported by sufficiently robust data. Based on representative cobalt value-chain flows, the principal first-use applications of cobalt are summarised below.



5.1. Precursor Cathode Active Materials (pCAM) – Batteries

Cobalt is used in several lithium-ion battery chemistries. Its principal battery applications are in consumer electronics and electric vehicle (EV) batteries.

- **Lithium Cobalt Oxide (LCO)** batteries, widely used in portable consumer electronics, contain high proportions of cobalt in the cathode.

- **Nickel Manganese Cobalt (NMC) and Nickel Cobalt Aluminium (NCA)** batteries, commonly used in EV applications, incorporate cobalt in lower proportions as part of multi-metal cathode formulations.

For LCO batteries, cobalt intermediates are typically converted to tricobalt tetraoxide before further processing into cathode materials. For NMC and NCA chemistries, cobalt intermediates are generally converted into cobalt sulphate heptahydrate, which is then combined with nickel, manganese and/or aluminium to produce precursor cathode active materials.

These chemical conversion steps represent the principal Category 10 emissions for cobalt sold into battery markets.

5.2. Pigments

Cobalt has been used as a blue pigment in ceramics and glass for centuries. Modern cobalt pigments are typically derived from cobalt oxides, cobalt carbonates, or cobalt sulphate, produced from refined cobalt intermediates.

The conversion of cobalt chemicals into pigment-grade oxides or compounds constitutes the relevant Category 10 processing step.

5.3. Catalysts

Cobalt is used in a range of catalytic applications, including:

- Hydrodesulphurisation of fossil fuels
- Production of synthetic fuels and biofuels
- Manufacture of polyethylene terephthalate (PET) plastics

Emerging applications include hydrogen production and fuel cells. Cobalt oxide and refined cobalt hydroxide are commonly used as catalyst precursors. The chemical preparation and activation of these materials represent Category 10 processing activities.

5.4. Nickel Based Alloys

Cobalt is used as an alloying element in high-performance nickel-based alloys and cobalt-based superalloys used in aerospace, power generation, and other demanding industrial applications.

Cobalt metal is melted and alloyed to produce materials capable of maintaining mechanical strength and corrosion resistance at elevated temperatures. The alloying and melting processes constitute the Category 10 processing stage for cobalt sold into these applications.

5.5. Tool materials

Cobalt metal is used in:

- High-speed steels, where it improves hardness and wear resistance
- Cemented carbide tools, where cobalt acts as a binder for tungsten carbide particles

The metallurgical processing required to produce tool steels or carbide materials represents the downstream Category 10 emissions.

5.6. Magnets

Samarium–cobalt magnets are high-performance rare-earth magnets used in applications requiring stable magnetic properties at elevated temperatures. The production of magnet alloys and sintered magnetic materials from cobalt metal powder constitutes the relevant processing step under Category 10.

5.7. Soaps and Dryers

Organometallic cobalt compounds are used as driers in oil- and alkyd-based paints and coatings. Cobalt compounds are also used in tyre manufacturing to promote adhesion between rubber and steel reinforcement.

The chemical conversion of refined cobalt into these organometallic compounds represents the relevant downstream processing activity.



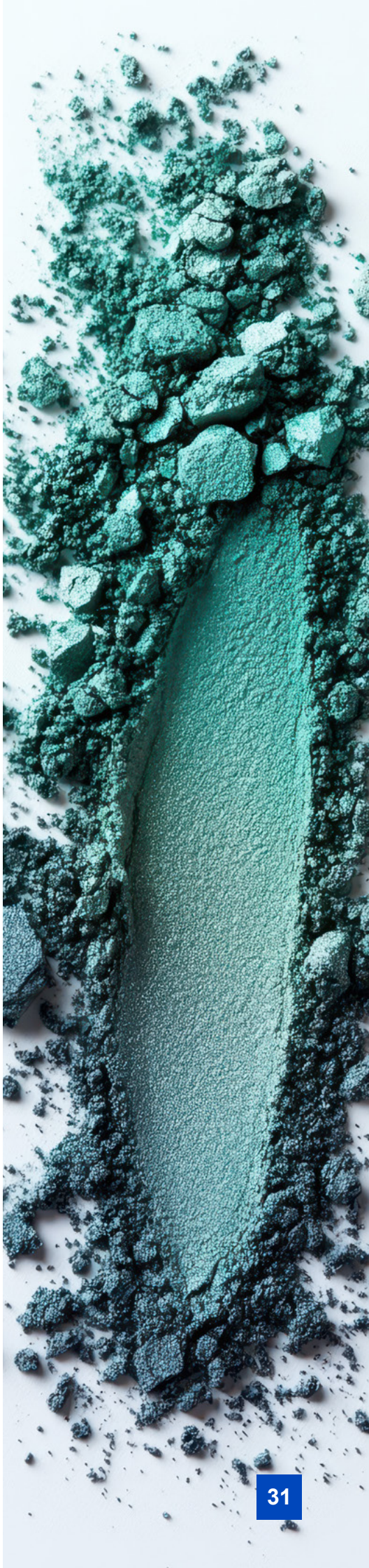
6. Category Specific Application Guidance

Building on the hotspot analysis (Table 3) and data quality hierarchy (Table 4), this section provides practical guidance on how these principles are applied across Scope 3 categories in cobalt value chains. While Tables 3 and 4 indicate which categories are likely to be material and the expected level of data quality, the following guidance focuses on how emissions should be interpreted and calculated in practice.

While this document provides an indicative assessment of Scope 3 hotspots across representative cobalt value chains, companies seeking alignment with the GHG Protocol remain responsible for conducting their own category screening and materiality assessment. This should reflect the company's specific organisational boundary, geographic footprint, product mix, and customer base, and inform the selection of appropriate calculation methods for each category.

Consistent with the hotspot screening approach set out by the ICMM Scope 3 Emissions Accounting and Reporting Guidance, several Scope 3 categories are typically material across cobalt value chains and therefore warrant cobalt-specific clarification.

The following sections provide category-specific guidance for the most relevant upstream and downstream Scope 3 emissions in cobalt value chains, with particular emphasis on those categories most commonly identified as material.



6.1. Category 1 – Purchased Goods and Services

Category 1 covers the cradle-to-gate emissions associated with goods and services purchased by the reporting company. In cobalt value chains, this category is typically material due to:

- Purchased cobalt intermediates (e.g., matte, MHP, MSP, crude hydroxide, sulphate)
- Reagents used in hydrometallurgical and refining processes (e.g., sulphuric acid, lime, solvents)
- Explosives and consumables used in mining operations
- Contracted processing or tolling services

Where supplier-specific cradle-to-gate emission factors (or PCFs) are available, these should be prioritised. In their absence, industry-average, activity-based emission factors should be applied. Spend-based approaches may be used as a fallback where the Category 1 source is material and suitable industry-average, activity-based emission factors are not available. Their use and limitations should be transparently documented.

6.2. Category 2 – Capital Goods

Category 2 includes emissions associated with the production of capital equipment and infrastructure acquired by the reporting company.

For cobalt operations, material sources may include:

- Heavy mining equipment and mobile fleets
- Smelting, leaching, and refining plant infrastructure
- Chemical processing equipment
- Major site construction and expansion projects

Where capital investments are material, practitioners should use industry-average embodied emission factors for relevant materials

(e.g., steel, concrete, process equipment). Supplier-specific primary embodied carbon data may be used where available. Spend-based approaches may be used as a fallback where capital goods are material and suitable industry-average, activity-based emission factors are not available. Their use and limitations should be transparently documented.

6.3. Category 3 – Fuel and Energy-Related Activities

Category 3 captures upstream emissions from the extraction, production, and transport of fuels and purchased energy.

In cobalt value chains, Category 3 may be material where:

- Diesel consumption is high (e.g., open-pit mining operations)
- Heavy fuel oil or coal is used in smelting
- Electricity is sourced from carbon-intensive grids

Practitioners should apply lifecycle emission factors for fuels and electricity supply, using national or regional datasets. Supplier-specific primary fuel lifecycle data may be used where available.

6.4. Category 9 – Downstream Transportation

Category 9 includes emissions from the transport and distribution of sold products where these activities are not paid for or controlled by the reporting company.

Cobalt value chains are often geographically dispersed, with intermediates shipped between continents prior to refining or first use. As a result, Category 9 may be material where:

- Long-distance marine shipping is involved
- Products are transported across multiple logistics modes
- Freight emissions are not included in Scope 1 or 2

Distance- and mode-based activity data should be used as a minimum. Shipment-specific logistics data should be applied where available.

6.5. Category 10 – Processing of Sold Products

Category 10 captures emissions from the downstream processing of intermediate products sold by the reporting company.

For cobalt value chains, this category is typically the most material downstream Scope 3 category. Emissions arise from the conversion of cobalt intermediates or refined products into:

Battery precursor materials (e.g., pCAM)
- Pigments and oxides
- Catalysts
- Alloys and superalloys
- Tool materials and magnets
- Organometallic compounds

These processes frequently involve energy-intensive chemical, thermal, or metallurgical conversion steps undertaken outside the reporting company's organisational boundary.

Where customer-specific primary Scope 1 and Scope 2 emissions attributable to processing are unavailable, industry-average, activity-based emission factors — including those provided in this guidance — may be used, with transparent disclosure of assumptions and limitations.

7. Emission Factors for Downstream Processing of Cobalt Intermediate

As illustrated in Table 5, downstream Scope 3 emissions may arise at multiple stages of the cobalt value chain where an intermediate product is sold for further processing prior to first use. These emissions are typically reported under Scope 3 Category 10 (Processing of Sold Products) and reflect the energy- and process-related emissions associated with the next external processing step.

Where customer-specific primary data — such as attributable Scope 1 and Scope 2 emissions from downstream processors — cannot reasonably be obtained, practitioners may use secondary data to estimate Category 10 emissions. In accordance with the data quality hierarchy set out in this guidance, industry-average, activity-based emission factors represent the minimum recommended approach where higher-quality data are unavailable.

The Cobalt Institute has developed industry-average life cycle assessment (LCA) data for several cobalt products, publicly available via the Cobalt Institute website[1]. These datasets provide representative cradle-to-gate emission factors for selected cobalt intermediates and refined products and may be used, where appropriate, to support Scope 3 Category 10 calculations in the absence of customer-specific primary data. A summary can be found in Table 7.

[1] https://www.cobaltinstitute.org/responsible-sustainable-cobalt/life-cycle-assessment/cobalt-lca/



Reporting companies shall assess the applicability and representativeness of these data for their specific product flows. In particular:

- Industry averages may reflect multiple production routes (e.g., copper-cobalt sulphidic and nickel-cobalt lateritic pathways);
- Data may represent a weighted average across different geographic regions and energy mixes;
- Processing routes for the same nominal product may vary in energy intensity and configuration;
- The system boundary of the dataset should be verified to ensure consistency with the Scope 3 Category 4, 9 (i.e., transport of fuels & materials to site) and 10 boundaries (i.e., attribution to the first downstream processing step).

Where industry-average data are applied, the methodology, assumptions, and limitations should be transparently documented and disclosed. Companies are encouraged to progressively replace secondary data with customer-specific primary or hybrid data for material product flows.

IMPORTANT LIMITATION REGARDING INTERMEDIATES

Table 5 identifies separate Category 10 reporting requirements for mining, smelting/leaching and refining companies. However, robust industry-average downstream processing factors are currently only available for crude cobalt hydroxide, cobalt sulphate, tricobalt tetraoxide and cobalt metal.

Representative industry-average factors for cobalt matte, MSP and MHP could not be developed due to variability in composition, downstream processing routes and limited publicly available data.

Companies selling these intermediates should therefore apply:

- customer-specific data where available;
- process-based modelling using publicly available technical literature and regional energy emission factors where suitable; or
- hybrid modelling where appropriate and sufficient information is available.

Table 7. Available industry-average LCA datasets relevant to Category 10 calculations

Cobalt Product	Cobalt Content (%)	Scope 1 (kg CO_2e/kg Co)	Scope 2 (kg CO_2e/kg Co)	Scope 3 (kg CO_2e/kg Co)	Total (kg CO_2e/ kg Co)
Cobalt Metal	99%	17.1	2.3	9.0	28.4
Crude Cobalt Hydroxide	35% (assumed mid-point)	2.6	2.0	14.3	18.9
Tricobalt Tetraoxide	73%	7.9	3.0	22.1	33.0
Cobalt Sulphate Heptahydrate	21%	3.6	2.1	13.4	19.1
Cobalt in MHP / MSP	30–60%	Not available	Not available	Not available	Not available
Cobalt in Matte	20–40%	Not available	Not available	Not available	Not available

1. Cobalt content values are indicative and may vary depending on ore body, processing route, and impurity levels.

2. The values in this table represent cradle-to-gate emissions for the production of each cobalt product and are not Scope 3 Category 10 emission factors.

3. Scope 1 and Scope 2 emission factors referenced as “available via Cobalt Institute LCA dataset” refer to publicly reported industry-average cradle-to-gate results for selected refined products.

4. Disaggregated Scope 1 and Scope 2 emission intensities for MHP, MSP, and cobalt matte are not currently available in the public domain in a sufficiently representative and comparable form to allow robust industry-average factors to be published in this guidance (Table 5).

5. Where such intermediates are sold, practitioners should apply:

- Customer-specific primary data where available; or
- Process-based modelling using publicly available technical literature and regional energy emission factors.

The datasets presented in Table 7 provide cradle-to-gate emissions for selected cobalt products and may support Category 1 calculations or development of proxy approaches. However, they do not represent Category 10 emission factors.

For Category 10 reporting, companies should use the first-finished-good emission factors presented in Table 8, which estimate the Scope 1 and Scope 2 emissions associated with the first external processing step following sale.

8. Emissions factors of downstream processing of cobalt products

The emission factors presented in Table 8 are provided to support consistent estimation of Scope 3 Category 10 (Processing of Sold Products) emissions for cobalt value chains. They represent industry-average Scope 1 and Scope 2 greenhouse gas emissions associated with the first external processing step following the sale of cobalt metal or cobalt chemicals into identified first finished goods, including batteries and cathode active materials, pigments, catalysts, nickel-based superalloys, tool materials, and soaps and driers. The minimum system boundary covers conversion of cobalt products into the first finished goods. Subsequent refining and manufacturing stages may be included where material and supported by sufficiently robust data, consistent with Section 4.3. Upstream emissions embedded in cobalt inputs are accounted for under Category 1.

Scope 2 emission factors are differentiated by region to reflect material differences in electricity carbon intensity, with values provided for the EU, US and Asia. Practitioners should apply the regional factor most representative of where downstream processing occurs, or use a weighted average where processing spans multiple regions, ensuring assumptions are transparently documented and disclosed. These emission factors are intended for use where customer-specific primary processing data are not reasonably available and represent the minimum recommended activity-based approach under the data quality hierarchy. Where primary or hybrid data are available, they should be prioritised.



Table 8. Emission factors (EFs) for the identified first finished goods for categories for use in Scope 3 category 10 (Ecomatters, 2026)

Category	First finished good	Scope 1	Scope 2 (EU)	Scope 2 (US) EF	Scope 2 (Asia)	Total (EU)	Total (US)	Total (Asia)
		[kgCO2eq/ kg Co content]	[kgCO2eq/ kg Co content]	[kgCO2eq/ kg Co content]	[kgCO2eq/ kg Co content]	[kgCO2eq/ kg Co content]	[kgCO2eq/ kg Co content]	[kgCO2eq/ kg Co content]
Batteries cathode active materials	Lithium Cobalt Oxide	0.204	1.280	2.301	3.438	1.484	2.505	3.642
	pCAM for NMC	2.414	0.000	0.000	0.000	2.414	2.414	2.414
Pigments	Cobalt blue (cobalt aluminate)	1.521	5.250	9.440	14.104	6.771	10.961	15.625
Catalyst	Fischer-Tropsch activated catalyst	0.000	0.184	0.331	0.495	0.184	0.331	0.495
Nickel-based superalloys	Hot rolled alloy plate	0.584	1.625	2.922	4.366	2.209	3.506	4.950
Nickel-based alloy / tool materials / magnets	Metal powder	0.040	2.371	4.264	6.370	2.412	4.304	6.411
Soaps & dryers	Cobalt octoate	0.091	0.000	0.000	0.000	0.091	0.091	0.091

The emission factors in Table 8 include Scope 1 and Scope 2 emissions of the first finished good only and exclude embedded upstream emissions from cobalt production.

Regional electricity emission factors are based on Our World in Data (2023) and represent average grid intensity.

Table 9 summarises the methodology used to derive the Scope 1 and Scope 2 emission factors for each selected first finished good. The calculations are based on representative production routes observed in cobalt value chains, typical process energy intensities derived from publicly available technical literature, and regionally differentiated electricity emission factors. The methodology description sets out the rationale for inclusion of each production route, the calculation approach, the principal input data used, and key limitations. The resulting values are industry averages, which tend to obscure significant variation within the sector, and do not reflect site-specific performance. Companies applying these factors remain responsible for assessing their representativeness, documenting assumptions, and disclosing limitations in their Scope 3 reporting.



Table 9. Summary of methodology for the calculation of Scope 1 and 2 EFs per selected first finished good for use in Scope 3 category 10 (Ecomatters, 2026)

Category	First finished good	Production route	Rationale for inclusion	Calculation method	Input data used	Limitations
LCO battery	**Lithium Cobalt Oxide**	Solid-state via reaction of cobalt (III,IV) oxide with lithium carbonate	Main production route, with real-life and state of the art data availability	The data is based on factory data from a leading cathode materials producer in China.	Dai & Kelly 2018	Single representative producer
NMC battery	**pCAM for NMC**	Precursor Cathode Active Material (pCAM) for NMC811 via co-precipitation	Main production route, recent and real-life data for pCAM production	Average of two sources, for which relevant energy input data (natural gas use) was available.	Bridges 2024, Dai & Kelly 2018	Specific for NMC811, representative for NMC variations
Pigment	**Cobalt blue (cobalt aluminate)**	Solid-state reaction with aluminium oxide (ceramic pigment route)	Main production route, recent study on energy data	Data is based on a single study with energy consumption estimated using thermodynamic calculations.	Ungureanu 2025	Energy calculation based on study specification
Catalysts	**Fischer-Tropsch activated catalyst**	Impregnation-calcination-reduction route	Representative type of catalyst, recent study with energy data	Data is based on a single study providing mass and energy balances based on lab-scale and pilot-scale processes.	Aromaa-Stubb 2024, Gholami 2020	Unclear constituents off-gas, aggregated data
Nickel-based alloy	**Hot rolled alloy plate**	Vacuum Induced Melting (VIM) + Secondary refining (ESR) + Hot rolling	Many different types of alloys, average alloy has the most reliable data	Data is based on Best Available Techniques (BAT) documents from the European Commission, and 2 applicable studies.	EC Best Available Techniques (BAT), Schneider 2022, Ehmsen 2025	Average for steel industry, not cobalt alloy specific
Nickel-based alloy / tool materials / magnets	**Metal powder**	Vacuum Induced Melting (VIM) + Gas atomization	Main production route, recent reliable study with energy data	Data is based on a single study providing energy and environmental impact for industrial production in a site.	Ehmsen 2025	Generic data for powder with average particle size
Soap/dryer	**Cobalt octoate**	Average of solution-based neutralisation and precipitation routes. Both reactions with 2-EHA.	Low data availability, therefore lab data and thermodynamic calculation provide best estimate	Data is based on a single study providing data for a lab-scale experimental setup, for which stoichiometric calculations are conducted.	Zabarjad 2013	Thermodynamic and stoichiometric calculation based on lab study

9. References

Aromaa-Stubb, R., Rinne, M. & Lundström, M. (2024) Life cycle assessment of cobalt catalyst production and recycling. Journal of Sustainable Metallurgy, 10, pp.1795–1806. Available at: https://link.springer.com/article/10.1007/s40831-024-00897-0 *[Accessed 18 February 2026]*

Cobalt Institute (2024) Battery Life Cycle Assessment Report (Version 5.2). Available at: https://www.cobaltinstitute.org/wp-content/uploads/2025/04/CI-Battery-LCA-Report-V5-2.pdf *[Accessed 21 October 2025]*

Cobalt Institute (2024) A Just Cobalt Decarbonisation Pathway. Available at: https://www.cobaltinstitute.org/wp-content/uploads/2025/02/A-Just-Cobalt-Decarbonisation-Pathway.pdf *[Accessed 21 October 2025]*

Cobalt Institute (2024) Climate change analysis of manufacturing and using lithium-ion batteries (Version 5.2). London: Cobalt Institute. Available at: https://www.cobaltinstitute.org/wp-content/uploads/2025/04/CI-Battery-LCA-Report-V5-2.pdf *[Accessed 18 February 2026]*

Cusano, G., Delgado Sancho, L., Farrell, F., Rodrigo Gonzalo, M. & Roudier, S. (2017) Best available techniques (BAT) reference document for the non ferrous metals industries. European Commission, Publications Office of the European Union. Available at: https://op.europa.eu/en/publication-detail/-/publication/c0bc6046-651c-11e7-b2f2-01aa75ed71a1 *[Accessed 18 February 2026]*

Dai, Q., Kelly, J.C. & Elgowainy, A. (2018) Cobalt life cycle analysis update for the GREET® model. Argonne National Laboratory. Available at: https://greet.anl.gov/publication-update_cobalt *[Accessed February 18, 2026]*

International Council on Mining and Metals (2023)
Scope 3 Emissions Accounting and Reporting Guidance: Mining & Metals Industry.
Available at: https://www.icmm.com/website/publications/pdfs/environmental-stewardship/2023/guidance_scope-3-reporting.pdf?cb=69120
[Accessed 21 October 2025]

Ecomatters (2026)
Downstream emission factors for cobalt first finished goods: For use in company Scope 3 calculations for Category 10 processing of finished goods calculations.
Utrecht: Ecomatters B.V. for Cobalt Institute.

Ehmsen, S., Conrads, J., Klar, M. & Aurich, J.C. (2025)
Environmental impact of powder production for additive manufacturing: Carbon footprint and cumulative energy demand of gas atomization. Journal of Manufacturing Systems, 82, pp. 13–25.
Available at: https://doi.org/10.1016/j.jmsy.2025.05.004
[Accessed 18 February 2026]

Gholami, Z., Tišler, Z. & Rubáš, V. (2020)
Recent advances in Fischer–Tropsch synthesis using cobalt-based catalysts: A review on supports, promoters, and reactors. Catalysis Reviews: Science and Engineering.
Available at: https://www.tandfonline.com/doi/full/10.1080/01614940.2020.1762367
[Accessed 18 February 2026]

Our World in Data: Carbon intensity of electricity generation, part of the following publication: Hannah Ritchie, Pablo Rosado, and Max Roser (2023)
"Energy". Data adapted from Ember, Energy Institute.
Retrieved from: https://archive.ourworldindata.org/20251014-145858/grapher/carbon-intensity-electricity.html

Petavratzi, E., Gunn, G. & Kresse, C. (2019)
BGS Commodity Review: Cobalt. British Geological Survey.
Available at: https://nora.nerc.ac.uk/id/eprint/534461/1/BGS_Commodity_Review_Cobalt.pdf
[Accessed 21 October 2025]

Schneider, R., Wiesinger, V., Gelder, S. & Reiter, G. (2023) Effect of the slag composition on the process behavior, energy consumption, and nonmetallic inclusions during electroslag remelting. Steel Research International, 94(4).
Available at:
https://doi.org/10.1002/srin.202200483
[Accessed 18 February 2026]

Sphera Solutions GmbH (2022) Life Cycle Assessment of Cobalt Products: Final Report (Version 5.02). Stuttgart: Sphera Solutions GmbH.

The Greenhouse Gas Protocol Initiative (2004), The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard – Revised Edition. World Resources Institute & World Business Council for Sustainable Development.
Available at:
https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf
[Accessed 21 October 2025]

The Greenhouse Gas Protocol Initiative (2013) Technical Guidance for Calculating Scope 3 Emissions: Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard. World Resources Institute & World Business Council for Sustainable Development.
Available at:
https://ghgprotocol.org/sites/default/files/2023-03/Scope3_Calculation_Guidance_0%5B1%5D.pdf
[Accessed 21 October 2025]

The Greenhouse Gas Protocol Initiative (2011) Corporate Value Chain (Scope 3) Accounting and Reporting Standard Supplement to the GHG Protocol Corporate Accounting and Reporting Standard. World Resources Institute & World Business Council for Sustainable Development.
Available at:
Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf
[Accessed 17 February 2026]

Ungureanu, A., Sola, A., Neri, P., Rosa, R. & Ferrari, A. (2025),

Systematic life cycle assessment of cobalt-based blue ceramic pigments: Evaluating $CoAl_2O_4$ and lower-cobalt alternatives. Green Chemistry, 27(41), pp.12946–12958.
Available at:
https://www.rsc.org/suppdata/d5/gc/d5gc02709h/d5gc02709h1.pdf
[Accessed 18 February 2026]

World Business Council for Sustainable Development (2023)

Pathfinder Framework Version 2.0: Guidance for the Accounting and Exchange of Product Life Cycle Emissions.
Available at:
https://www.wbcsd.org/resources/pathfinder-framework-version-2-0/
[Accessed 21 October 2025]

Zabarjad Shiraz, N. et al (2013)

Synthesis and improvement of activity of cobalt organic salts as drier. ISRN Inorganic Chemistry, 2013, pp. 1–4.
Available at:
https://doi.org/10.1155/2013/167206
[Accessed 18 February 2026]

10. Glossary

Activity Data	Quantitative measure of a level of activity that results in greenhouse gas emissions (e.g., tonnes of cobalt processed, kWh of electricity consumed). [ICMM]
Allocation	The process of partitioning GHG emissions from a single facility or other system (e.g., activity, vehicle, production line, business unit, etc.) among its various outputs (e.g., between copper and cobalt in a co-production system). [GHG Protocol]
Battery Chemistries (LCO, NMC, NCA)	Lithium-ion battery cathode chemistries that incorporate cobalt: • LCO (Lithium Cobalt Oxide) • NMC (Nickel Manganese Cobalt) • NCA (Nickel Cobalt Aluminium)
By-Product	A product occurring together with the main product as an integral part of a production process. An output with an economic value above zero, for which demand at the specific production site is available (i.e., further use is certain), and evidence can be given that the by-product is used directly as intended without any further processing other than normal industrial practice. This term is used to distinguish from waste. Cobalt is commonly produced as a by-product of copper or nickel mining. [CI, 2023]
Category 1 – Purchased Goods and Services	Scope 3 category covering all upstream emissions from purchased products (e.g., materials, intermediates) and services. [ICMM]
Category 2 – Capital Goods	Emissions from the production of capital goods purchased in the reporting year. [ICMM]
Category 10 – Processing of Sold Products	Scope 3 category covering emissions from downstream processing of intermediate products sold by the reporting company.
Cathode Active Material (CAM)	The chemically active material used in the cathode of a battery.
Co Content (%)	The percentage of elemental cobalt contained within a compound or intermediate product.

Cobalt Matte	An intermediate product produced during smelting of sulphidic ores, containing cobalt along with nickel, copper, and sulphur.
Cobalt Sulphate Heptahydrate ($CoSO_4 \cdot 7H_2O$)	A refined cobalt chemical compound commonly produced from cobalt intermediates such as crude cobalt hydroxide, MHP, MSP, or cobalt metal.
Cradle-to-Gate	All emissions that occur in the life cycle of purchased products, up to the point of receipt by the reporting company (excluding emissions from sources that are owned or controlled by the reporting company).[ICMM]
Crude Cobalt Hydroxide	An intermediate cobalt product typically produced during hydrometallurgical processing.
Data Quality Hierarchy	The structured ranking of calculation methods based on reliability and specificity, ranging from primary data to proxy or spend-based methods.
Downstream Emissions	Indirect GHG emissions from sold goods and services. Downstream emissions also include emissions from products that are distributed but not sold (i.e. without receiving payment). They occur after a product leaves the organisational boundary of the reporting company. [ICMM]
Emission Factor (EF)	A coefficient that converts activity data into GHG emissions data (e.g., kg CO2e emitted per litre of fuel consumed, kg CO2e emitted per kilometre travelled, etc). [ICMM]
Emission Factor [Industry-average Activity-based]	A secondary emission factor that converts activity data such as units or weight of a product purchased into GHG emissions, based on the average GHG emissions rate of a given source relative to the units, and based on representative industry data, academic sources and other publications. These factors are the preferred form of secondary data where primary data are unavailable. [ICMM]
Equity Share Approach	A consolidation approach whereby a company accounts for GHG emissions from operations according to its share of equity in the operation. The equity share reflects economic interest, which is the extent of rights a company has to the risks and rewards flowing from an operation. [ICMM]

First Finished Good	The first product manufactured from a cobalt-containing intermediate following sale (e.g., precursor cathode active material, pigment, alloy).
GHG Protocol	The Greenhouse Gas Protocol, the globally recognised framework for greenhouse gas accounting and reporting.
Global Warming Potential (GWP)	A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of CO2. [ICMM]
Hybrid Method	A calculation approach combining primary activity data with secondary emission factors.
ICMM	International Council on Mining and Metals.
Integrated Operation	An operation where multiple stages of production (e.g., mining and refining) occur within the same organisational boundary.
Intermediate Product	Goods that are inputs to the production of other goods or services that require further processing, transformation before becoming or being included in a first-use or end-use product (e.g., MHP, MSP, cobalt matte). [ICMM]
Life Cycle Assessment (LCA)	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. [ICMM].
Materiality	Concept that individual or the aggregation of errors, omissions and misrepresentations could affect the GHG inventory and could influence the intended users' decisions. [ICMM]
Mixed Hydroxide Precipitate (MHP)	An intermediate cobalt-nickel product typically produced from lateritic ores through hydrometallurgical processing.
Mixed Sulphide Precipitate (MSP)	An intermediate cobalt-nickel sulphide product typically produced during hydrometallurgical processing of sulphidic ores.
Operational Control	A consolidation approach whereby a company accounts for 100 percent of the GHG emissions over which it has operational control. It does not account for GHG emissions from operations in which it owns an interest but does not have operational

	control.[ICMM]
Precursor Cathode Active Material (pCAM)	A precursor material used to manufacture cathode active material for lithium-ion batteries.
Primary Data	Data from specific activities within a company's value chain. Primary data may include supplier-specific or customer-specific data collected directly from the relevant activity, facility, product, or process. [GHG Protocol]. For corporate Scope 3 reporting, examples may include supplier-specific cradle-to-gate emission factors, product carbon footprints, or customer-specific Scope 1 and Scope 2 emissions attributable to downstream processing. [CI, 2023]
Primary Data [Customer-specific]	Primary data obtained directly from downstream customers and specific to the processing of sold products. These data are the preferred basis for calculating Category 10 emissions where available.
Primary Data [Supplier-specific]	Primary data obtained directly from suppliers and specific to purchased goods or services. These data are typically used for upstream Scope 3 categories such as Category 1 (Purchased Goods and Services).
Proxy Method	A last-resort calculation approach using emission factors or process models from an analogous product, technology, or process where neither primary data nor representative industry-average activity-based emission factors are reasonably available.
Scope 1 Emissions	Emissions from sources owned or controlled by the reporting company (i.e., direct emissions). [ICMM]
Scope 2 Emissions	Emissions from purchased electricity, steam, heating, or cooling consumed by the reporting company (i.e., indirect emissions). [ICMM]
Scope 3 Emissions	All other indirect emissions that occur in the value chain of the reporting company. [ICMM]

Secondary Data	Data that is not from specific activities within a company's value chain. Secondary data may include industry-average data, published emission factors, government statistics, and other publicly available or third-party data. [GHG Protocol]
Spend-Based Method	A calculation method using financial expenditure multiplied by an average sector emission factor.
System Boundary	The defined limits based on a set of criteria specifying which unit processes are part of the system under study. [ISO 14050:2020]
Tier 1 / Tier 2 / Tier 3 Customers	Downstream customers representing successive stages in the value chain beyond the reporting company.
Tricobalt Tetraoxide (Co_3O_4)	A cobalt oxide compound commonly used in battery materials, pigments and catalysts.
Upstream Emissions	Indirect GHG emissions from purchased or acquired goods and services. [ICMM]
Value Chain	All of the upstream and downstream activities associated with the operations of the reporting company, including the use of sold products by consumers and the end-of-life treatment of sold products after consumer use. [ICMM]

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enabling technology, advancing society

Contact us if you have any questions

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