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Determining the Global Warming Potential of cobalt

The product carbon footprint guidance
document for cobalt metal and cobalt
sulphate heptahydrate.

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1. Purpose

Environmental Life Cycle Assessment (LCA) is a globally accepted tool to measure, amongst other things, climate change impacts of an individual product. Specifically, this can be done using the Climate Change environmental impact category as defined within the practice of LCA. This guidance describes the principles, requirements and methodologies for quantifying and communicating GHG emissions from processes used to produce refined cobalt metal ([London Metal Exchange \[LME\] traded Cobalt](#)) and cobalt sulfate heptahydrate ($\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$), including the associated cradle-to-gate carbon footprints of their precursors (e.g., cobalt ores from mining, cobalt concentrates from beneficiation & ore preparation, cobalt solutions from leaching & solvent extraction and cobalt intermediates from smelting, and refining).

The application of this guidance allows producers and purchasers of cobalt ores and concentrates, cobalt intermediates, and cobalt metal products, as well as stakeholders, to calculate the climate change impact of refined cobalt metal or cobalt sulfate heptahydrate production, i.e., the “product carbon footprint” (PCF) of refined cobalt metal or cobalt sulfate heptahydrate, respectively.

1.1 Reference to existing standards and methodologies

The guidance is an addition to and precision of ISO 14044 Environmental management — Life cycle assessment — Requirements and guidelines, which does not provide sufficient detail for direct application to cobalt products and their characteristics. It is applicable to the production of refined cobalt metal (LME traded Cobalt with a cobalt content of 99.8%) and cobalt sulfate heptahydrate ($\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$) and aligned with the GHG protocol Product Life Cycle Accounting and Reporting Standard.

For methodological aspects of GHG calculation not explicitly defined in this guidance, please refer to the most recent versions of the standards and guidance documents listed in Annex A.

1.1.1 Corporate Scope 3 emissions and Product Carbon Footprint

While, for declaring the carbon footprint of a company, the Corporate Accounting and Reporting Standard by Greenhouse Gas Protocol is a widely accepted methodology, the calculation of the carbon footprint of an individual product level is more appropriately based on the Product Life Cycle Accounting and Reporting standard published by Greenhouse Gas Protocol, which in turn is based on ISO Standards for Life Cycle Assessment 14040, 14044 and 14067. If the product is an intermediate product, like refined cobalt metal or cobalt sulfate heptahydrate, the Product Life Cycle Accounting and Reporting Standard allows for a partial (cradle-to-gate) approach which does not include specific emissions such as “final product use” and “end-of-life processes.” Accordingly, this guidance covers cradle-to-gate production only.

The GHG Protocol’s Corporate Accounting and Reporting Standard categorises GHG emissions into three main types (scope 1, scope 2 and scope 3 emissions). It defines scope 1-3 emissions as follows:

- Scope 1: *“Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment”.*
- Scope 2: *“Scope 2 accounts for GHG emissions from the generation of purchased [energy] consumed by the company. Purchased [energy] is defined as that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where [energy] is generated”.*
- Scope 3: *“Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services”.*



The above GHG Protocol definitions are based on ownership and control over emissions by companies, whereas ISO 14044 refers to the specific production processes being assessed. To maintain data consistency and comparability across metals industries, it is recommended where necessary to classify emissions as GHG Protocol Scope 1,2 or 3 according to the production processes that generate them (for example, as shown in Table 1 below).

Table 1 GHG emissions in cobalt production according to the GHG Protocol.

Process step	Description	Scope emission
Direct activities	Combustion emissions associated with fuels, reductants, and other process emissions (air and water emissions)	Scope 1
Electricity onsite	Emissions associated with electricity generated on site	Scope 1
Electricity	Electricity from the national or local electricity grid	Scope 2
Raw materials	Cobalt-bearing raw materials sourced from third parties (e.g., ore concentrates, mattes, MSP, MHP, black mass)	Scope 3
Auxiliaries	GHG emissions associated with production of auxiliary raw materials such as e.g., chemicals	Scope 3
Sulfur	Production of sulfur used in the process	Scope 3
Fuels, reductants	Production of fuels and reductants used in the process	Scope 3
Lubricants	Production of lubricants used in the process	Scope 3
Explosives	Production of explosives in the process	Scope 3
Wastewater	Wastewater treatment by third parties (emissions associated with onsite water treatment fall under direct activities)	Scope 3
Water	The upstream production of tap water	Scope 3
Transport	Includes the fuel for transport (the production thereof), transport of raw materials, human resources, and combustion of associated fuels	Scope 3
Credit	Impact associated with the credit for co-production assuming a well-characterised representative production route for respective co-products	Scope 3

In some jurisdictions, the classification of GHG emissions to the GHG Protocol emission types may need to follow mandatory country- or region-specific standards. For example, according to the US Environmental Protection Agency (USEPA, 2022), “Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling.”

Scope 3 emissions as defined in the GHG Protocol can cover a wide range of upstream and downstream activities, such as distribution, processing, and use of sold products, business travel, or end-of-life treatment. For cobalt and cobalt sulfate production, this means that scope 3 emissions include those from production of input materials (e.g., fuel, auxiliaries, sulfur, reductants, explosives, lubricants), upstream water production, waste and wastewater treatment and transport taking place within or in between production sites.



2. Goal and scope

The goal of this guidance is to provide LCA practitioners, auditors, commodity traders, consultants, customers, industry associations, investors, service providers, standard-setters, and those responsible for corporate reporting with a standardized approach to calculating the climate change impact of producing refined cobalt metal and cobalt sulfate heptahydrate.

The climate change impact of a product is the radiative forcing in the present-day atmosphere following all greenhouse gas emissions over the production stages of the product, expressed as CO₂ equivalents, e.g., (CO₂eq)/kg metal. Greenhouse gases include, besides carbon dioxide (CO₂), other so-called “climate relevant gases” (see Section 4).

2.1 Cobalt products covered

This specific guidance harmonises the calculation of greenhouse gas emissions for refined cobalt metal (LME traded Cobalt) and cobalt sulfate heptahydrate. It ensures that data communicated by cobalt producers are coherent and based on the same calculations, methods, and parameters.

2.2 Functional Units, Declared Units & Reference Flows

A functional unit is the quantified performance of a product system for use as a reference unit. Generally, the purpose of the functional unit is to specify the functions (performance characteristics) of the product system being studied, and to provide a reference to which input and output data can be normalised (ISO, 2006c). For example, a functional unit could be defined as “1 kg of cobalt sulfate heptahydrate; 21% Co”. Understanding the functional unit is essential for comparability between products with the same intended function.

A declared unit is the quantity of a product for use as a reference unit in a footprint communication based on Life Cycle Assessment (ISO, 2020) (ISO, 2022). For the cases of refined cobalt metal and cobalt sulfate heptahydrate covered by this guidance, the declared unit will be identical to the functional unit.

A reference flow is a measure of the outputs from processes within a given product system required to fulfil the function expressed by the functional unit (ISO, 2006b). The reference flow for raw materials refers to the material itself and not to the product for which they are used. Ideally, reference flows reflect the usual units in which the materials are traded between suppliers and users, e.g., 1kg or 1t cobalt contained in a given intermediate.

Cobalt content of the covered products are as shown in Table 2. Therefore, typical mass-based reference flows might be defined as follows:

- 1 kg of refined Cobalt Metal; ≥99.8% Co.
- 1 kg of cobalt sulfate heptahydrate; 21% Co.

Table 1 GHG emissions in cobalt production according to the GHG Protocol.

Cobalt product	Cobalt content	Material form	CAS No.
LME traded cobalt (refined Cobalt Metal)	≥ 99.8%	Cobalt Metal: powder, cathode (broken or cut), ingots, briquettes, rounds	7440-48-4
Cobalt sulphate	21%	Cobalt compound; Cobalt Sulphate Heptahydrate Chemical formula: CoSO ₄ ·7H ₂ O	10026-24-1



3. System boundaries

The system boundaries referred to in this guidance are shown schematically in Figure 1 below. Production from cobalt-only ores and ore concentrates is not shown since it represents a very minor technological route in terms of global volumes.

Economic concentrations of cobalt are currently found in three principal deposit types:

- stratiform sediment-hosted copper-cobalt deposits (Cu-Co sulfidic)
- nickel-cobalt laterite deposits (Ni-Co lateritic), and
- magmatic nickel-copper (cobalt-platinum-group metal [PGM]) sulfide deposits (Ni-Co sulfidic).

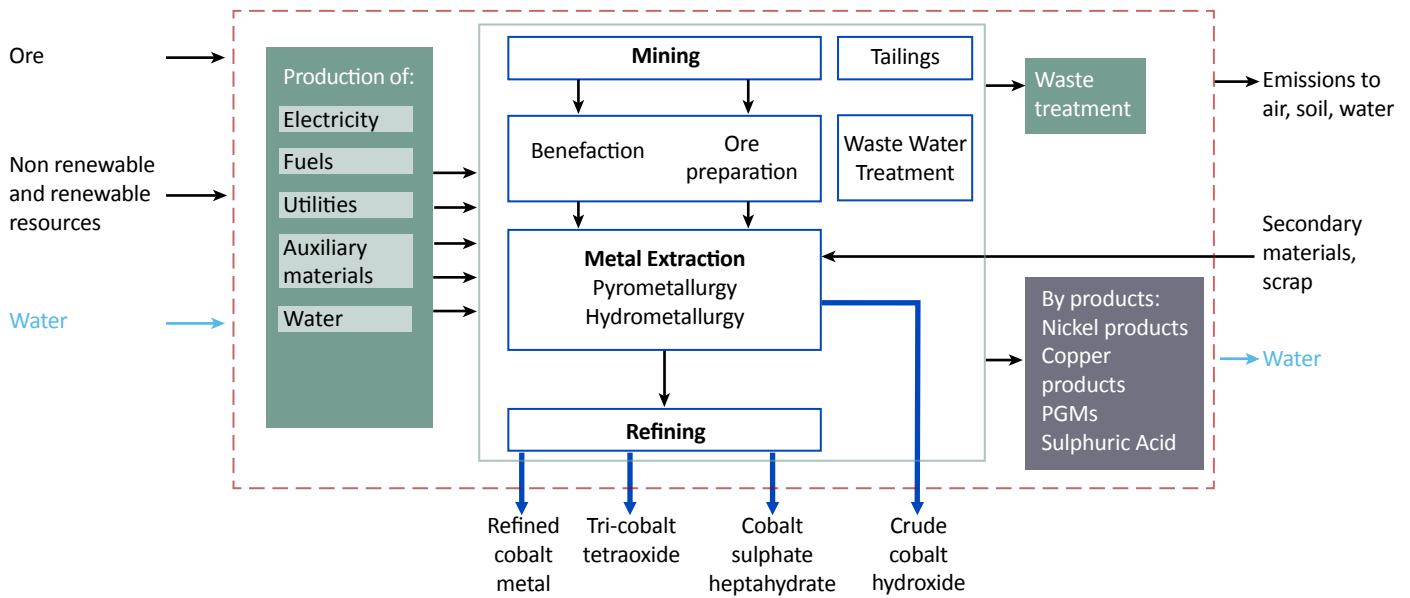


Figure 1 System boundary of refined cobalt metal (LME traded Cobalt) and cobalt sulfate heptahydrate production showing the processes, inputs, and outputs in scope. The system boundary is shown in dashed line (Cobalt Institute, 2022a).

The cobalt in copper and nickel ores tends to follow copper and nickel through the mining and extraction processes and is only separated in later refining stages. Due to its intrinsic value, cobalt is often recycled by processing alloy scrap into new alloy, or as an intermediate for refinement in the chemical sector. Cobalt-bearing scrap materials follow similar pyro- and hydrometallurgical processes to those used for metal extraction, followed by refining.

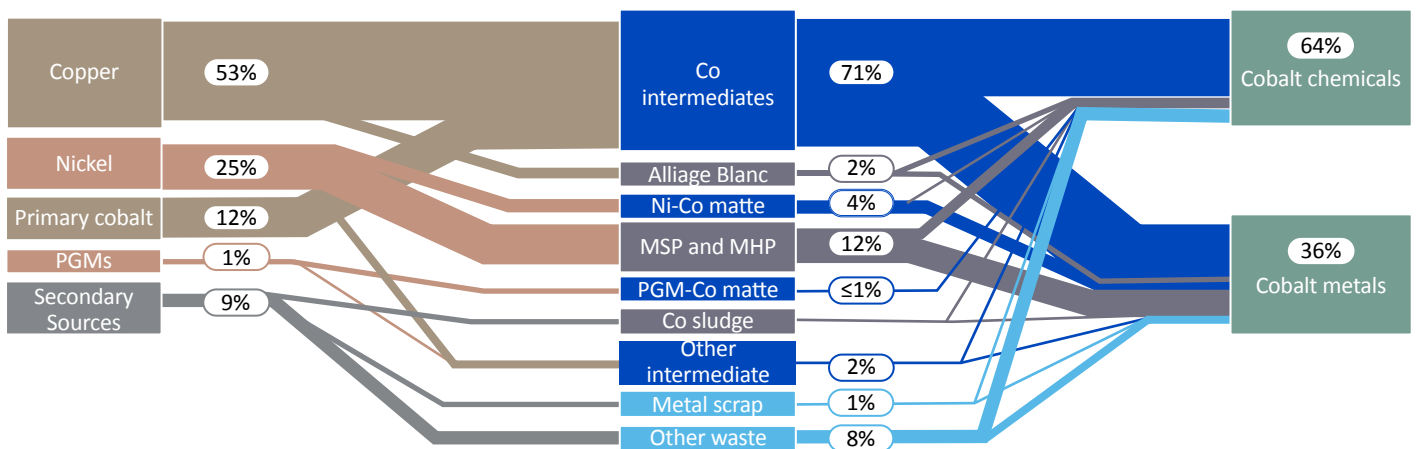


Figure 2 Cobalt flows from source to refined product before application (Cobalt Institute, 2022b).



3.1 Clustering of production routes

Refined cobalt is produced commercially using various technologies. To account for this variability in process flow sheets and thus in system boundary setting, a generic approach may be taken as follows. The system boundaries referred to in this guidance include five relevant clusters of unit processes and their sub-processes (see Table 3 below):

- mining (both open pit and underground)
- ore preparation (for lateritic nickel/cobalt ores) and beneficiation (for other ores)
- primary metal extraction comprising both hydro-metallurgical processes (leaching & solvent extraction) and pyrometallurgical processes (smelting and/or converting)
- refining and/or salts conversion
- finishing (to produce briquettes, ingots, or powder).

Table 3 Cobalt production processes from source to refined product before application

(RECHARGE, 2023). *PGM = Platinum Group Metals

Raw material Acquisition Processes	Ores (or equiv.)	Beneficiation & Ore Preparation Processes	Ore Concentrates (or equivalent)	Primary Metal Extraction Processes	Cobalt intermediates	Refining & Finishing Processes	Cobalt products in Scope
Mining	Copper ore	Beneficiation or Ore Preparation	Copper-Cobalt concentrate	Smelting	Alliage blanc	Refining &/ or Finishing (to metal)	Refined cobalt metal &/or cobalt sulfate heptahydrate
		Beneficiation	Copper-Arsenic concentrate	Leaching	Crude Cobalt Hydroxide & other cobalt intermediates		
Mining	Sulfidic Nickel ore	Beneficiation	Nickel concentrate (sulfidic)	Leaching	Mixed Sulphide Precipitate (MSP)	Refining or Co-Salts Conversion (to sulfate)	
Mining	Lateritic Nickel ore	Ore Preparation	Nickel concentrate (oxidic)		Leaching	Mixed Hydroxide Precipitate (MHP)	
				Smelting	Nickel matte		
				Converting			
			Other Co intermediates				
Mining	Sulfidic Nickel ore	Beneficiation	Nickel concentrate (sulfidic)	Smelting	Nickel matte		
Mining	PGM ore	Beneficiation	PGM-Cobalt concentrate	Smelting	PGM-Cobalt Matte		
Discarding of Waste	Secondary Sources	Collection	Cobalt sludge	Smelting &/or Converting &/or Leaching	(All of the above)	Smelting, Refining or Co-Salts Conversion	
			Metal scrap				
			Other waste				

The clusters shown above can be subdivided into sub-processes like crushing, grinding, slurry preparation, flotation, roasting, leaching, solvent extraction, precipitation, and purification by different means as shown in Figure 3.



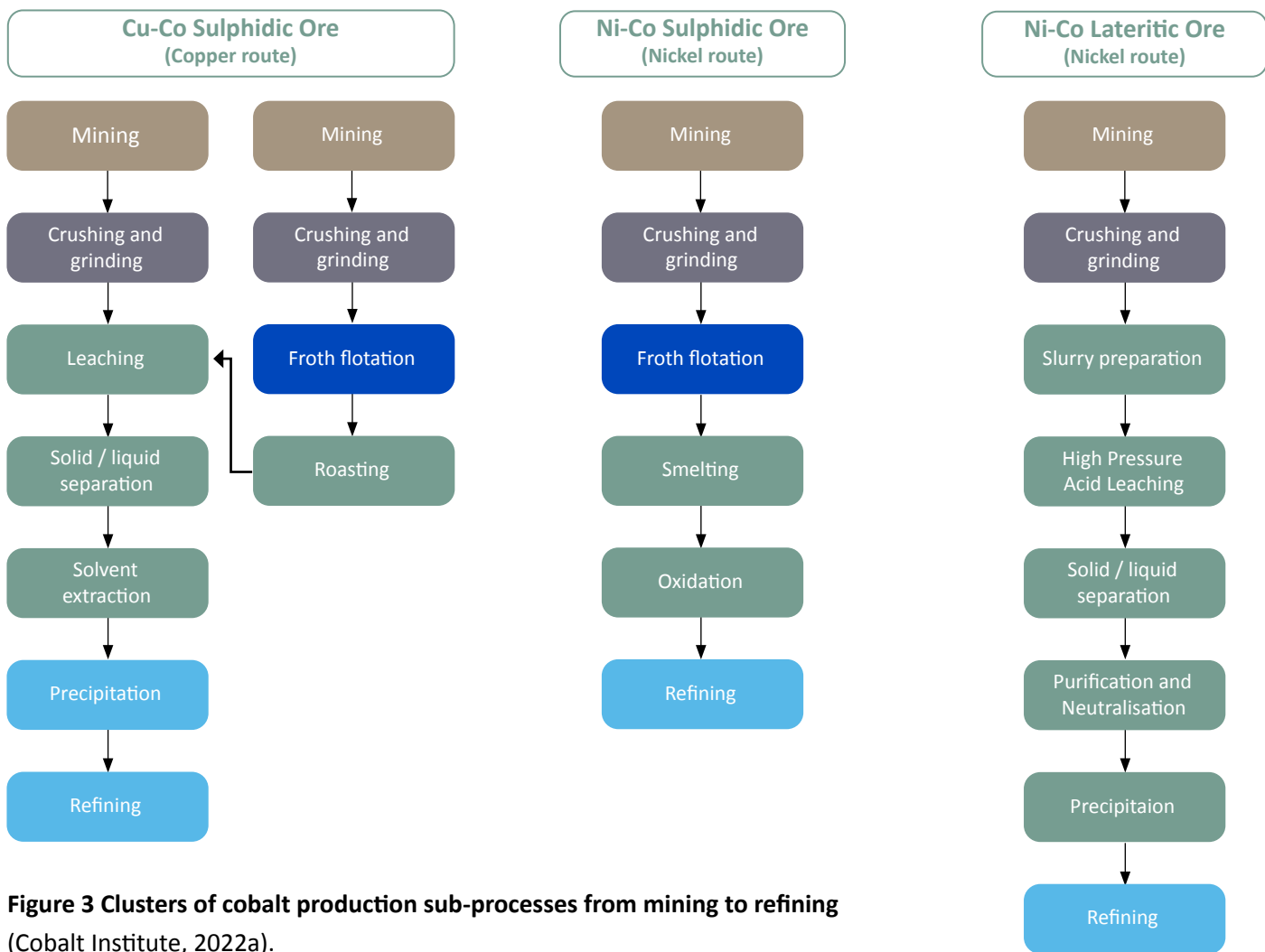


Figure 3 Clusters of cobalt production sub-processes from mining to refining (Cobalt Institute, 2022a).

3.2 Other system boundary inclusions & exclusions

The system’s boundaries referred to in this guidance also include:

- the transport of raw materials into and between the processes
- electricity generation (on- and offsite)
- wastewater treatment and waste processing.

The system’s boundaries also include the production of fuels, utilities and auxiliary materials which are required for production of refined cobalt metal (LME traded Cobalt) and cobalt sulfate heptahydrate. Co-production of other products and intermediates is also considered (this is further explained in Section 6.1).

Several processes are positioned outside the product system’s boundaries, such as the refining processes associated with further treatment of co-products, the transport of human resources to the site, transport of the refined cobalt products to the customer, waste transport and emissions associated with business administration.

The processes included within and excluded from the system boundaries are shown in Table 4.

Table 4: Processes included and excluded from the system boundaries (Cobalt Institute, 2022a)

Included	Excluded
✓ Mining (underground or open cast / surface including overburden and waste rock)	✗ Effect of potential volume of acid mine drainage from waste rock
✓ Beneficiation	✗ Packaging
✓ Ore preparation	✗ Transport of fuels / ancillary / auxiliary materials to site
✓ Metal extraction (pyrometallurgical and hydrometallurgical processes) - to hydroxides, matte, mixed sulfides, precipitates, leach solutions etc. Includes processes such as leaching and separation, reductive calcination, smelting, converting, etc.	✗ Transport to customer
✓ Refining - to the final cobalt products, including processes such as leaching, electro-refining, volatilizing, electrowinning, etc.	✗ Transport of waste
✓ Transport of ore, concentrates, mattes	✗ Production of capital equipment and infrastructure
✓ All associated energy and fuels	✗ Business travel
✓ Ancillary / auxiliary materials used on site	✗ Employee commuting
✓ All relevant water inputs and outputs	✗ Use phase
✓ On-site (direct) emissions to air	✗ End of Life stage
✓ Water treatment and water emissions	
✓ Overburden, tailings and other mining wastes that are deposited for disposal	
✓ Off-gas treatment	
✓ Waste and wastewater treatment	

The further refinement of materials, following the separation from cobalt, for production of other co-products is not part of the system boundary.

In case secondary datasets related to imported fuels/ancillary/auxiliary materials are used, necessary action shall be taken to exclude their transport to the site.

3.3 Cut-off criterion

Some of the exclusions shown in Table 4 are related to an applicable cut-off criterion. Processes which cumulatively contribute less than 3% to the total GHG emissions of the cobalt product being studied may be excluded. This cut-off criterion is intended to exclude processes known to be negligible and is aligned with the EU Product Environmental Footprint Recommendation (EC, 2021).

For example, transport of fuels / ancillary / auxiliary materials and production and maintenance of capital goods are excluded as their contributions to climate change per functional unit are negligible (below the above-mentioned cut-off criteria) compared to the impacts associated with other processes included within the product system's boundary. This is known from previous collection and updates of life cycle data for refined cobalt metal and cobalt sulfate heptahydrate (Cobalt Institute, 2016) (Cobalt Institute, 2022a).



4. Greenhouse Gases, Emissions and Global Warming Potentials

Several so-called greenhouse gases contribute to global warming. The predominant greenhouse gas emitted is carbon dioxide (CO₂). It enters the atmosphere through the combustion of fuels (coal, natural gas, oil), waste or other carbon-containing materials such as biomass. It can also result from chemical processes such as the manufacture of lime (CaO) from limestone (CaCO₃).

Other relevant gases contributing to the global warming potential include methane (CH₄), which is emitted during the production and transport of coal, natural gas, and oil. It might also be emitted from livestock and other agricultural practices. Nitrous oxide (N₂O) and fluorinated gases also contribute to climate change (USEPA, 2023).

An overview of selected greenhouse gases and their global warming potentials is shown in Table 5. The Intergovernmental Panel on Climate Change (IPCC) regularly publishes 100-year global warming potentials (GWPs) for different greenhouse gases. These values shall be used to convert life cycle inventory results to an expression in units of climate change impact (kg CO₂eq) as follows:

- As a priority, GWP-100 characterization factors shall be sourced from Table 7.15 of Chapter 7 of the IPCC's Sixth Assessment Report Climate Change 2021 Physical Science Basis (IPCC, 2021a).
- GWP-100 characterization factors for substances that are not listed in the Table 7.15 shall be sourced from Table 7.SM.7 in Chapter 7 Supplementary Materials of the IPCC's Sixth Assessment Report Climate Change 2021 Physical Science Basis (IPCC, 2021a).
- GWP-100 characterization factors for substances that are not listed in Chapter 7 Supplementary Materials shall be sourced from the IPCC's Fifth Assessment Report, Appendix 8.A (IPCC, 2013).

Table 5: GWPs for selected Greenhouse Gases (IPCC, 2021b)

Greenhouse Gas Name	Chemical Formula	GWP values for 100-year time horizon
Carbon dioxide	CO ₂	1
Methane (biogenic)	CH ₄	27
Methane (fossil)	CH ₄	29.8
Nitrous oxide	N ₂ O	273
Perfluorinated Compounds (PFC-14)		7380
Chlorofluorocarbons (CFC-11)		6226
Hydrofluorocarbon (HFC-32)		771
Hydrofluorocarbon (HFC-134a)		1526

5. Life Cycle Impact Assessment

According to ISO 14040 and 14044, life cycle impact assessment is built upon a life cycle inventory of inflows to, and outflows from, the product system. The greenhouse gases associated with the production processes, emissions of those greenhouse gases, and the GWPs used for each shall be reported (e.g., those shown in Table 5 above).

The potential impact of each GHG emitted and removed by the system under study (in this case, production of refined cobalt metal or cobalt sulfate heptahydrate) shall be calculated by multiplying the mass of GHG released or removed by the 100-year GWP for the particular gas in units of kg CO₂eq per kg gas emitted or removed. The total carbon footprint of the system under study is the sum of these calculated climate change impacts.



When comparing climate change impacts across time, the GWPs applied to emissions and removals shall be the same for all periods under study.

The carbon footprint data of refined cobalt (LME traded Cobalt) and cobalt sulfate heptahydrate should be updated at least every five years, or whenever a significant change occurs in the parameters affecting the emission intensity of their production. A five-year update frequency is in line with requirements formulated by e.g., the European Commission in their Product Environmental Footprint.

The following situations, as mentioned in the GHG Protocol, shall be considered to trigger a significant change:

- 1 Structural changes in cobalt production, including significant process changes in operation, technology advancement, raw material, or energy inputs/outputs.
- 2 Changes in calculation methodology, improvements in the accuracy of GWPs or inventory data, or inclusion of new types of sources that result in a significant impact on the emissions data.
- 3 Discovery of significant errors, or cumulative errors that are collectively significant.

The frequency of inventory data collection should be informed by the frequency of significant change in emissions intensity of the process(es) under study. These may be different for different emission sources. All inventory data shall refer to a one-year period.

5.1 Raw materials for refined Cobalt production

Most refined cobalt worldwide is produced from primary raw materials (ore). However, cobalt may also be produced from primary and secondary raw materials (recycled sources) together in one process.

Traditionally, the most widely used secondary raw materials for production of refined cobalt metal have been alloys and scrap. In 2021, cobalt contained in purchased scrap represented an estimated 24% of US consumption (USGS, 2022). Production of refined cobalt metal and cobalt sulfate heptahydrate from end-of-life waste, is so far less significant (Cobalt Institute, 2016). The global average recycled content in cobalt production is expected to increase with the introduction of Li-ion electric-vehicle batteries over time. Figure 2 and Table 3 (above) visualize how primary and secondary raw materials are processed together in smelting and refining processes.

Important auxiliary materials used for production of refined metal cobalt and cobalt sulfate heptahydrate include fuels, lime, sulfuric acid, and sodium hydroxide.

5.2 Mining

Cobalt is almost entirely produced as a by-product from three quite different ores: lateritic Nickel-Cobalt (Ni-Co) ores, sulfidic Ni-Co ores, and sulfidic Copper-Cobalt (Cu-Co) ores. Lateritic ores are normally found in tropical climates where natural weathering creates mineable deposits in layers at shallow depths below the surface. Lateritic ores are excavated using large earth-moving equipment and are screened to remove boulders. The metal bearing minerals are usually of oxidic nature.

More often, non-ferrous-metal-bearing minerals are sulfidic in nature, and mineable cobalt grades are therefore associated with copper-bearing ores or sulfidic nickel ores. These are typically mined in underground and/or open pit mines. The mining stage of cobalt production includes all processes to extract ore up to the point of delivery to beneficiation or ore preparation. It may be modelled with horizontal or vertical aggregation of data, with all energy and material inputs contributing to the full set of mining processes at a site, to the extent that it does not give rise to economic allocation amongst co-products. Process subdivision need only be performed to the extent required to implement allocation correctly (See Section 6.1).



Direct (Scope 1) GHG emissions tend to dominate in the mining cluster. These can result from electricity generated onsite for hoisting, cooling, lighting, etc., for under-ground mines, as well as from fuel consumption for excavators and haul-trucks, and explosives when used for breaking rock. For the mining process steps, GHG relevant input and output parameters shall be collected as listed, for example, in the [GBA GHG Rulebook](#) (GBA, 2023).

5.3 Beneficiation & Ore Preparation

After the ore has been mined, it is then either crushed, screened, and dried (ore preparation), or crushed, ground, and processed by flotation (beneficiation) to obtain a nickel-cobalt or copper-cobalt concentrate (sometimes also copper-arsenic concentrates or PGM-cobalt concentrates).

In general, lateritic ore undergoes ore preparation and sulfidic ore undergoes beneficiation. Lateritic ore generally has high moisture content. The principal component of the ore preparation is therefore removal of approximately half of the total moisture content of the lateritic ore. Beneficiation (also known as concentration, or minerals processing) separates ore minerals from gangue minerals by exploiting differences in their physical characteristics (e.g., grain size, density, or magnetic properties). Beneficiation may be applied to nickel-cobalt ore only (to produce nickel-cobalt concentrates) or to a mix of ores (to produce cobalt, nickel, copper, and precious metals-bearing concentrates).

Tailings consist of ground rock, water and process reagents that are used in the beneficiation step. The gangue minerals, unrecycled reagents and process water are discharged, normally as a slurry, to a final storage area commonly known as a Tailings Management Facility (TMF) or Tailings Storage Facility (TSF). Tailings are generally stored on the surface either within retaining structures or in the form of piles (dry stacks) but can also be sent underground to mined out voids by a process commonly referred to as backfilling.

For the purposes of this guidance, processing of lateritic and sulfidic ores is grouped together under “Beneficiation & Ore Preparation.” The individual beneficiation and ore preparation processes may be modelled with horizontal or vertical aggregation of data, with all energy and material inputs contributing to the full set of processes, to the extent that it does not give rise to economic allocation amongst co-products. Typically, producers are not able to separate data such as electricity for pumping, or fuels for vehicles used for tailings. Process subdivision need only be performed to the extent required to implement allocation correctly (See Section 6.1).

Direct (Scope 1) GHG emissions and those associated with imported electricity and auxiliaries tend to dominate in the beneficiation & ore treatment cluster. These can result from consumption of electricity and grinding media for comminution of the ore, and consumption of frothers, dispersants, flocculants and neutralisers for flotation, dewatering and thickening of ore concentrates. For the beneficiation & ore treatment process steps, GHG relevant input and output parameters shall be collected as listed, for example, in the [GBA GHG Rulebook](#) (GBA, 2023).

5.4 Leaching & Solvent Extraction

The main process routes for metal extraction of cobalt from concentrates begin by:

- Hydrometallurgical extraction (roasting &/or leaching plus solvent extraction) from copper-cobalt concentrates to produce crude cobalt hydroxide and other cobalt intermediates
- Hydrometallurgical extraction (leaching) from sulfidic nickel-cobalt concentrates to produce crude cobalt hydroxide, Mixed Sulphide Precipitate (MSP), or other cobalt intermediates
- Hydrometallurgical extraction (High Pressure Acid Leaching [HPAL]) from lateritic nickel-cobalt concentrates to produce Mixed Sulphide Precipitate (MSP), or Mixed Hydroxide Precipitate (MHP)



Leaching is a process for dissolution of metals (e.g., copper and cobalt) from a concentrate into a liquid medium. Solvent extraction is a subsequent process in which different metal compounds are separated by exploiting differences in their solubilities in a particular solvent. Extraction of cobalt from copper-cobalt concentrates is done by leaching, decantation to remove impurities, and solvent extraction to separate the cobalt from the copper. An initial roasting step is used to remove sulfur from sulfidic concentrates prior to leaching. Cobalt is then precipitated from the solvent, typically to produce crude cobalt hydroxide.

Lateritic ores for cobalt production are processed using hydrometallurgy based on ammonia or sulfuric acid leaching. The core operation of HPAL is reaction of a slurry with sulfuric acid in an autoclave (on average at 255°C and 4500kPa) to leach nickel and cobalt. A counter-current decantation wash process then removes a mostly iron oxide residue, before the slurry is neutralised using limestone, and MSP precipitated for further refining.

Direct (Scope 1) GHG emissions and those associated with imported electricity tend to dominate in the leaching & solvent extraction cluster. Additionally, the use of limestone (CaCO₃) can generate CO₂ emissions through its reaction with acid solutions and these shall be accounted for. For the leaching & solvent extraction process steps, GHG relevant input and output parameters shall be collected as listed, for example, in the [GBA GHG Rulebook](#) (GBA, 2023).

5.5 Smelting

Sulfidic concentrates are also often processed using a pyrometallurgical process, such as calcining and smelting or flash smelting. Roasting, followed by electric smelting can also be used for more complex concentrates. The reactions which take place are exothermic and provide enough heat to maintain the smelt. The resulting furnace matte still contains iron and sulfur and is therefore fed to a converter where these components are removed by oxidation.

- Smelting of copper-cobalt concentrates produces alliage blanc.
- Smelting of nickel concentrates produces ferronickel and nickel matte.
- Smelting of PGM-cobalt concentrates produces a PGM-cobalt matte.

Smelting is one of the major contributors to the carbon footprint of metals and their compounds. Direct (Scope 1) GHG emissions and those associated with imported electricity tend to dominate in the smelting cluster. Additionally, the use of reducing agents (reductants) and consumption of process electrodes (often graphite) can generate CO₂ emissions and these shall be accounted for (e.g., by stoichiometric calculation). If bio-reductants, like charcoal, are consumed, the biogenic CO₂ factor shall be reported separately from the fossil-based reductants. For the smelting process steps, GHG relevant input and output parameters shall be collected as listed, for example, in the [GBA GHG Rulebook](#) (GBA, 2023).

5.6 Refining

Various processes are used to refine alliage blanc, crude cobalt hydroxide, MSP, MHP, or cobalt-containing mattes. Refining involves the separation of cobalt from other metals, and results in the generation of diverse cobalt and other co-products. It may be modelled with horizontal or vertical aggregation of data, with all energy and material inputs contributing to the whole set of refining process (i.e., from the receipt of the matte / mixed sulfides to the production of refined cobalt metal), to the extent that it does not give rise to economic allocation amongst co-products. Process subdivision need only be performed to the extent required to implement allocation correctly (See Section 6.1).

Scope 3 GHG emissions associated with the production of imported auxiliaries tend to dominate in the refining cluster. Therefore, it is important to account for all bulk chemicals, fuel, heat & steam, hydrogen, nitrogen and oxygen usage and their associated carbon footprints. For the refining process steps, GHG relevant input and output parameters shall be collected as listed, for example, in the [GBA GHG Rulebook](#) (GBA, 2023).



5.7 Finishing

After precipitation, solvent extraction and/or ion exchange techniques have been applied, cobalt can be recovered as metal granules or powder using various combinations of leaching, purification, and transformation, or by hydrogen reduction. These processes can be site-specific and often commercially confidential (JRC, 2017).

The hydrogen reduction process is a batch process and takes place in autoclaves at an elevated temperature and pressure (about 200 °C at 30 bar). The hot, water-containing autoclave gases are treated in gas scrubbers using sulphuric acid as a washing reagent. The resulting cobalt powder can be subsequently sintered into briquettes (JRC, 2017).

Finishing processes may be modelled with horizontal or vertical aggregation of data, with all energy and material inputs contributing to the full set of refining process, to the extent that it does not give rise to economic allocation amongst co-products. Process subdivision need only be performed to the extent required to implement allocation correctly (see Sections 5.6 & 6.1).

Scope 3 GHG emissions associated with the production of imported auxiliaries tend to dominate these finishing processes. GHG relevant input and output parameters shall be collected as listed, for example, in the [GBA GHG Rulebook](#) (GBA, 2023).

6. Modelling parameters

6.1. Allocation of impacts to co-products

According to ISO 14044 (section 4.3.4.2), inputs and outputs to the product system shall be apportioned amongst the main product and its co-products according to clearly stated procedures. ISO standards propose a stepwise procedure:

- Step 1: where possible, allocation to co-products is to be avoided by either dividing the unit process into two or more sub-processes or expanding the product system to include the additional functions related to the co-products.
- Step 2: where allocation to co-products cannot be avoided, the inputs and outputs to a product system shall be partitioned between its various products in a way that reflects underlying physical relationships (e.g., by mass and/or energy balance).
- Step 3: where allocation to co-products cannot be avoided and no such physical relationships can be established, inputs and outputs shall be allocated to co-products in a way that reflects other relationships between the main product and its co-products, such as e.g., economic value.

Where a system generates products that have multiple functions (e.g., landfill gas, lime, sulfuric acid, sodium hydroxide), allocation procedures become more complex. A relevant example occurs in the metallurgical extraction of cobalt from ores and concentrates. Whereas pyrometallurgical processing of sulfidic concentrates generates sulfur-containing gases, which are typically converted into a sulfuric acid co-product, hydrometallurgical processing of oxidic nickel-cobalt concentrates may involve the use of sulfuric acid as a leachant. It follows that sulphuric acid derived from processing of sulfidic cobalt concentrates can either be used for processing of oxidic nickel-cobalt concentrates or sold to other industries. In both cases, this by-product shall receive an environmental credit by means of system expansion (see Section 6.1.1), as it replaces the environmental burden to produce an equivalent quantity of sulphuric acid elsewhere.

Following Step 1 of Figure 4, which requires avoiding allocation as much as possible by process subdivision, horizontal or vertical aggregation of data shall only be performed to the extent that it does not give rise to economic allocation



amongst co-products (e.g., aggregating processes such as mixing, chemical reactions, crushing, and transport, that either do not yield co-products or in which co-products all undergo the same processing steps). At the same time, process subdivision need only be performed to the extent required to implement allocation correctly (e.g., sub-processes either do not yield co-products or their co-products all undergo the same processing steps).

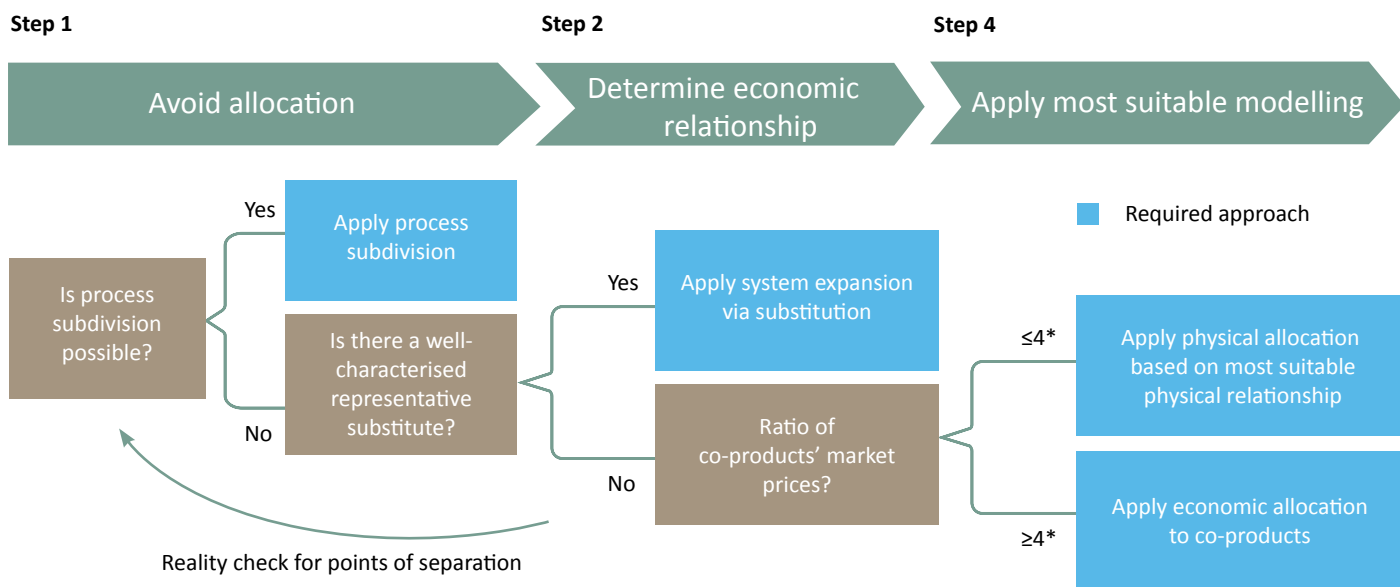


Figure 4 Decision-tree for modelling impacts of co-products adapted from (WBCSD, 2022) and * (Santero & Hendry, 2016).

6.1.1 Subdivision and System Expansion

If a multi-output process cannot be further subdivided, system expansion may be implemented.

For the purposes of this guidance, system expansion shall be used to allocate GHG emissions to sulfuric acid, ammonium sulfate, and sodium sulfate co-products of smelting and refining processes.

System expansion by substitution aims to credit a co-product with the avoided carbon footprint of the replaced material. This requires identification of a well-characterised representative alternative production route. In this context, well-characterised substitute processes are those that do not themselves require allocation to co-products, or for which partitioning between co-products is clear and consistent on a global basis (e.g., the chlor-alkali process for co-production of chlorine and sodium hydroxide). In this context, representative processes are those that are preponderant (of superior weight, influence, or prevalence) in the market (GBA, 2023).

The GHG calculation for cobalt products shall transparently disclose the credits used to implement system expansion, i.e., the well-characterised and representative alternative functional unit that the co-product is substituting in the market. A reliable, globally accepted data source for the well-characterised and representative alternative functional unit and its reference year shall be declared.

System expansion shall not be applied to metal co-products since, in most cases, metals are produced together with others from the same or different ore deposits. If these processes were included in the system, it could result in a double accounting of some cobalt production, which would unreasonably and unfavourably affect the overall carbon footprint result for cobalt. In other words, one alternative metal production route that is well-characterised and representative is not available and system expansion is therefore not recommended for metals.



6.1.2 Mass-based allocation to co-products

In the case of refined cobalt metal and cobalt sulfate heptahydrate, mass allocation shall be used where exclusively base metal co-products (i.e., excluding precious metals and platinum-group metals) are separated. Relative long-run price ratios of most pairs of base metals are reasonably stable. Therefore, for base metals, mass allocation adequately represents the motivation and rationale for establishing the production, and a basis for allocating climate change impacts. Mass allocation between metal by-products shall be based on mass of metal content.

In any case, mass allocation between co-products shall only be applied if the ratio of their long-term stable market prices is less than or equal to four (≤ 4) (Santero & Hendry, 2016).

In all cases, the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation.

6.1.3 Economic allocation to co-products

In the case of refined cobalt metal and cobalt sulfate heptahydrate, economic allocation shall be used where base metals and precious metals, or base metals and platinum group metals, are separated. In these cases, a mass allocation would mis-represent the motivation and rationale for establishing the production and would not be a sound basis for allocating climate change impacts. The prices used in this assessment shall be global, averaged over 10 years, and with sources documented (e.g., LME, The World Bank (World Bank, 2022)). The market price of each co-product shall reflect the specific properties of the co-product e.g., purity or point of sale that can impact its global market price.

In any case, economic allocation between co-products shall only be applied if the ratio of their long-term stable market prices is greater than four (>4) (Santero & Hendry, 2016).

In all cases, the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation.

Interpreting existing standards with respect to economic allocation:

As alluded to by (Santero & Hendry, 2016), NOTE 1 to EN15804 suggests “a 25 % difference” is a reasonable boundary between “high” difference and “low” difference. NOTE 1 to EN15804 is most commonly interpreted as a difference between the two quantities expressed directly as a ratio between them.

If one takes the product under study as the point of reference, and the co-product as the differing product, then:

$$25\% \text{ Difference} = \text{Co-product price} / \text{Studied product price}$$

This corresponds to a ratio of 1:4 (25%) between the two market prices (when the co-product is less valuable than the studied product), and a ratio of 4:1 (4) between the two market prices (when the co-product is more valuable than the studied product). Following this logic, a “high” difference, i.e., $>25\%$, would correspond to a ratio further away from – i.e., increasingly greater than – zero (0:1).

If the co-product is less valuable than the studied product, a higher difference (i.e., a higher ratio) will make the two market prices more similar. This is a perverse result and is therefore commonly excluded (see below). If the co-product is more valuable than the studied product, a higher difference (i.e., a higher ratio) will make the two market prices more dissimilar.

To avoid the perverse outcome mentioned above, existing global guidance (e.g., WBCSD, Together for Sustainability, Global Battery Alliance) has hitherto specified that the highest value product shall be used as the numerator of the ratio, regardless of whether it is the studied product or not.



6.1.4 Implications for modelling approach to waste streams

When outputs include both products and waste, the ratio between products and waste shall be identified and the inputs and outputs apportioned to the co-products only (not to waste streams). In case a non-zero price can only be charged for transportation of a material, the material shall be considered as a waste for this allocation purpose. In all cases, a third party shall verify the economic value of the claimed by-product with specific properties (e.g., purity/grade, net calorific value, water content, etc.) at the facility gate, as well as the share of the by-product for which the price is paid. If no economic value of the output can be proven, the output shall be considered a waste.

Allocation procedures shall be uniformly applied to similar inputs and outputs of the product under study. For example, if allocation is made to co-products leaving the system, then the allocation procedure shall be similar to the allocation procedure used for such products entering the system.

For the purposes of this guidance, waste streams exiting the product system shall be accounted following the approaches explained below:

Energy recovery & landfilling (avoided burden approach): to follow a polluter-pays principle, the system boundary shall include waste incineration and landfilling processes. Flows of waste sent to incineration may be linked to a life cycle inventory that describes regional efficiencies and heat-to-power output ratios associated with the composition and heating value of the waste. Flows of waste sent to landfills may, if relevant, be linked to a life cycle inventory that describes regional leakage rates, landfill gas capture and utilisation rates associated with the composition of the waste (flaring or power production from captured methane). If a third party can verify the economic value of claimed power or heat production from waste combustion or landfilling, credits may be assigned to the refined cobalt metal or cobalt sulfate heptahydrate product using the regional grid mix and, where needed, thermal energy from natural gas. If no economic value of the power or heat output can be proven, no credits shall be assigned.

Wastewater discharge (avoided burden approach): To follow a polluter-pays principle, the system boundary shall include wastewater treatment processes. In some cases, off-site third parties may provide relevant wastewater treatment processes. As no general process flow for water and wastewater treatment exists, water and wastewater treatment plants shall be modelled case by case.

Flows of wastewater sent for treatment may be linked to a life cycle inventory that describes impacts related to wastewater treatment for the country/region and, where relevant, includes the proportion of dry sludge that is used as fertilizer, incinerated, landfilled, or sent for composting. If a third party can verify the economic value of claimed by-products, credits for the sludge used as a fertilizer (where it replaces synthetic fertilizers), for electricity produced from the incineration of sludge and for electricity produced from landfill gas may be assigned to the refined cobalt metal or cobalt sulfate heptahydrate product. If no economic value of the sludge or landfill gas output can be proven, no credits shall be assigned.

Due attention shall be paid to correct allocation in cases where wastewater treatment, reuse schemes or recycling processes (and associated composting, energy recovery etc) also receive inputs from other product systems (i.e., shared processes) unrelated to the refined cobalt metal or cobalt sulfate heptahydrate products. In these cases, the outputs associated with unit processes for extraction, processing and/or final disposal are to be shared.

6.1.5 Implications for Modelling Approach to End-of-Life of Cobalt products

To be consistent with this guidance, it is implied that any modelling of end-of-life waste streams exiting the product system would be accounted following the approaches explained below:



Collection of end-of-life material for recycling (cut-off approach also known as 100:0 or recycled content approach):

To enable quantification of end-of-life collection rates, the system boundary for cradle-to-gate systems would be drawn after end-of-life scrap collection. This would involve accounting for these outputs (collected end-of-life waste) while assuming none of the inputs and outputs of the product system are allocated to them (they would still be considered waste streams). Processing and recycling of the end-of-life scrap would thus be dissociated from the product system, and equivalent processing and recycling processes would be included on the input side of the product system to represent the preparation and refining of secondary raw-materials.

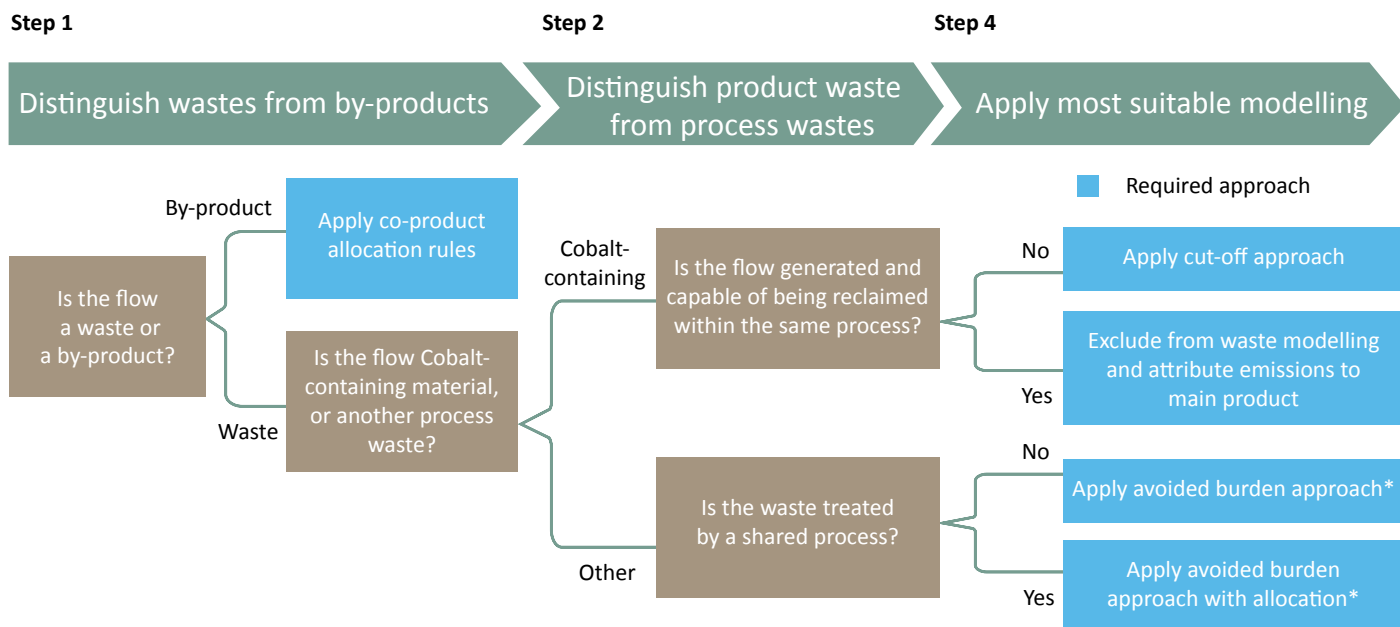


Figure 5 Decision-tree for modelling of Cobalt product (e.g., End-of-Life) outputs

*See Glossary for definitions of by-product, co-product, and waste.

End-of-life allocation approaches can significantly affect carbon footprint results. Cobalt Institute may prescribe other end-of-life allocation approaches for specific materials or jurisdictions in future versions of this guidance. The end-of-life allocation methods described in more specific guidelines, e.g., EU PEF Method, the Global Battery Alliance GHG Rulebook or others, may serve as the basis to decide if other end-of-life allocation methods shall be prescribed in specific circumstances.

Finally, if modelling complete cradle-to-grave systems, it is preferable to use the avoided-burden-of-net-scrap approach described in EN15804 (CEN, 2012), where credits are calculated as the flow of collected end-of-life scrap minus the flow of scrap used at the production stage.

6.1.6 Implications for modelling approach to recycled inputs

The cut-off approach (see above) shall be applied to all end-of-life waste streams entering primary production processes. This involves accounting for these inputs assuming they are no longer associated with environmental burdens, but also assuming they have not yet undergone any preparation or processing after waste collection.

Recycled content for each of the following three categories, and as a total, should be reported:

- Pre-consumer waste (manufacturing waste, excluding process scrap)
- Post-consumer waste (end of life waste)
- Waste from unknown origin.

Process scrap within the same plant shall not be considered in calculating the recycled content - only scrap or waste originating from outside the plant.



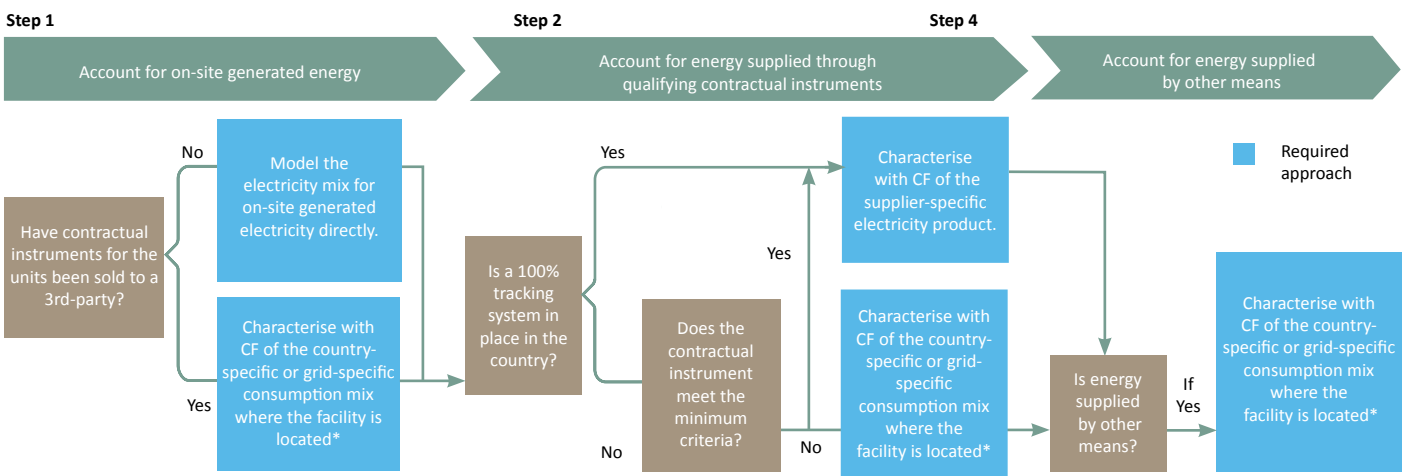
6.2. Electricity

Electricity is a major energy source in cobalt production processes. GHG emissions related to the production of electricity consumed in the cobalt production processes, waste and wastewater treatment processes, and any other processes included in the system boundaries shall be included in the life cycle inventory. GHG emissions of electricity supply can vary significantly, depending on the specific electricity power generation technology applied by a company onsite or by the upstream electricity supplier.

6.2.1 General hierarchical approach

With reference to existing global standards (e.g., ISO 14067), the EU Product Environmental Footprint method (PEF), and the GHG Rulebook of the Global Battery Alliance (GBA), electricity shall be included using the following hierarchical approach:

- a. On-site generated energy may be accounted for as the difference between the total energy demand of the production site and the amount of energy sourced from the grid. To the extent that no contractual instruments have been sold to a third party, the electricity mix for on-site generated electricity shall be modelled directly. Electricity from on-site facilities for which the attributes have been sold to a third party (via contracts or certificates) shall be characterised as having the environmental attributes of the country-specific or grid-specific consumption mix where the facility is located. (Companies should additionally provide a separately calculated PCF using country-specific residual grid mix, consumption mixes where they are available [See Section 7].)
- b. If the electricity is purchased from a supplier, the supplier-specific electricity product shall be used if, for a country, there is a 100% tracking system in place, or if
 - i. a supplier-specific electricity product is available, and
 - ii. the set of minimum criteria to ensure the contractual instruments are reliable (described in Section 6.2.2) is met.
- c. To the extent that a. and b. above are not applicable, the country-specific or grid-specific consumption mix where the facility is located shall be used. Country-specific means the country in which the life cycle stage or activity occurs. (Companies should additionally provide a separately calculated PCF using 'country-specific residual grid mix, consumption mix' where it is available [See Section 7].)
- d. Offsetting of GHG emissions may be reported in addition to the above but shall not be considered in the PCF calculation.



* Companies should additionally provide a separately calculated PCF using 'country-specific residual grid mix, consumption mix' where it is available [See Section 7].

Figure 6 Electricity Modelling Decision-tree.



6.2.2 Minimum criteria to ensure the contractual instruments are reliable

A supplier-specific electricity product may be used if the contractual instrument used for electricity modelling meets the following criteria:

Criterion 1 – the contractual instrument conveys attributes

- It conveys the energy type mix associated with the unit of electricity produced.

Criterion 2 – the contractual instrument establishes a unique claim

- It is the only instrument that carries the claimed environmental attribute associated with that quantity of electricity generated.
- Mechanisms are in place to ensure the instrument can be claimed only once
- The contracted attribute is tracked and redeemed, retired, or cancelled by or on behalf of the company.
- The quantity of generated electricity associated with the instrument and its energy type mix is reported and, where applicable, considered for the determination of publicly disclosed country- or grid- specific residual grid mixes.
- It allows for the unambiguous identification of the type, age and location and capacity of the energy generation facility to which it refers.
- In case the energy generation facility to which it refers is located in a country with a multi-certificate tracking system, it is accompanied by any additional contractual instruments from the supplier necessary to show and ensure there is no double counting.
- The energy generation facility to which it refers is located in a country with a tracking system in place and it is issued by a tracking system that fulfils the following criteria:
 - Tracking is based on objective, non-discriminatory and transparent criteria for the issuing of certificates;
 - Tracking is performed by a unique governmentally appointed entity per geographical area and per type of energy production;
 - Tracking relies on accurate, reliable and fraud-resistant mechanisms for the issuance, transfer, and cancellation of certificates;
 - Tracking is independent from the verifier;
 - Tracking entrusts the issuance of certificates, as well as the supervision of their transfer and cancellation of certificates, to an entity or entities who are independent from the production, trade of energy, and the corresponding certificates;
 - Tracking activities are governed by transparent rules and procedures;
- Tracking decisions may be challenged and reviewed in the context of proceedings before an independent judiciary;
 - Use of tracking is enforceable by national legislation for claims on the origin of consumed energy;
- Tracking works in interaction with the authority publishing residual consumption mixes in a way that prevents double claims of renewable energy sources and other environmental attributes.



Criterion 3 – the contractual instrument is issued as close as possible to the period to which the contractual instrument is applied

- It ensures that certificates are valid no longer than 12 months after the production of the relevant energy unit;

Criterion 4 – the contractual instrument is sourced from the same market in which the reporting entity’s electricity-consuming operations are located and to which the instrument is applied

- To claim the use of renewable electricity, companies shall source and consume the renewable electricity within a “market boundary” or area in which:
- There is a sufficiently sized HVDC and/or synchronous interconnection between the point of generation and the point of consumption of renewable electricity. When interconnection happens across different grids, there is an entity that coordinates and tracks the exchange between such grids.
- The utilities/energy suppliers present recognise each other’s energy sourcing instruments and have a system in place to prevent double counting of claims.

6.2.3 Emission factor references

If suitable data are not available from the electricity supplier, emission factors from recognized national sources for the national power grid or for the regional part of the grid shall be used. Country-level GHG emission factors and those for different electricity generation technologies can be found in life cycle databases or in available publications such as the International Energy Agency (IEA, 2023). Emission factors shall always include all GHGs listed in Table 5 and include emissions from all attributable upstream processes of an energy product, i.e.;

- emissions from the energy supply system (e.g., the mining and transport of fuel to the energy generator).
- emissions during generation of electricity or thermal energy, including losses during transmission and distribution.
- emissions from treatment and/or disposal of outputs from the energy generation (e.g., ashes from operation of coal fired power plants).

In all cases, if the used EF does not include all the above-mentioned emissions, the missing emissions shall be added to the EFs cited by the electricity supplier, third party source, or IEA database.

6.3. Fuel combustion

The greenhouse gas emissions related to the combustion of fuels consumed during the production process shall be calculated by using specific carbon content when available, or when not available, by default emission factors, which are published in the IPCC’s Fourth Assessment Report (IPCC, 2006). This typically covers fuel consumption associated with transport of functional units between processes on the same site. The emission factors used shall be mentioned in a summary report.

6.4. Secondary data & sources

Several auxiliary materials are used in the cobalt production processes for which the cobalt producer might not obtain primary data from its suppliers, such as fuels, lubricants, explosives, reducing agents, lime, sulfuric acid, sodium hydroxide or any other materials used in the production process, but whose production is not within the product system’s boundaries. For those materials, secondary data which can be commonly found in public and / or commercial databases may be used in the following order of preference:



- literature,
- scientific papers,
- emission inventory guidebooks (e.g., (IPCC, 2013) (EEA, 2019)), or
- other information sources.

An overview of commercial and public databases can be found on the [GHG Protocol website](#) (WRI & WBCSD, 2023)

7. Communication and third-party verification

Transparent communication and interpretation of PCF results is of critical importance. GHG emission calculations must always be presented with an overview of the methods and modelling parameters used, the distribution of emissions from different clusters or processes, any credits claimed, and the results of any sensitivity analyses performed. Any deviations to the inclusions and exclusions of Table 4 shall be highlighted and justified.

The GHG accounting and reporting of a product inventory shall follow certain principles of relevance, accuracy, completeness, consistency, and transparency. For reference, the GHG Protocol Product Life Cycle Accounting and Reporting Standard formulates several such principles. This shall also be applied for the communication of the refined cobalt metal and cobalt sulfate heptahydrate GHG emissions to third parties.

Specifically, Battery Carbon Footprint data included in communication to third parties with reference to the Global Battery Alliance Battery Passport shall consist of the dual, synchronous communication of its two mandatory Rule Sets for electricity modelling. Members of the GBA are unlikely to accept from vendors a cobalt sulfate heptahydrate carbon footprint calculation based on the use of only one type of electricity grid-mix to model GHG emissions from electricity consumption.

The results of the total greenhouse gas emissions from refined cobalt metal and cobalt sulfate heptahydrate production shall be reported by the product manufacturer. In case a third party does the calculations, this shall be declared in the report.

The report shall declare the cradle-to-gate GHG emissions from production of 1kg of refined cobalt metal (LME traded Cobalt) or 1 kg of cobalt sulfate heptahydrate; 21% Co. Reporting the percentage of product produced from primary and from recycled sources is mandatory. The report shall include:

- all relevant parameters chosen as listed in this guidance,
- allocation methods applied together with their justification and explanation,
- the electricity mix(es) underlying the calculations,
- the parameters used for fuel combustion,
- a distinction of primary and secondary data used, and their respective contributions to total climate change impact,
- a statement of the system boundaries applied, exclusions, and the estimated proportion of total climate change impact covered (See Section 3.3).

Credits included in the footprint of the refined cobalt or cobalt sulfate heptahydrate product should be disclosed in such way that the reader can easily calculate the footprint both with and without the inclusion of credits in the footprint.

The report shall indicate the reference year for which the data were collected.

The reported data shall be accompanied by a certificate granted by an independent third party confirming that the GHG data calculations were done in accordance with this guidance.



Glossary

Abbreviations

Co	Cobalt
CO ₂ ^{eq}	Carbon Dioxide equivalents
Cu	Copper
GHG	Greenhouse gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standardisation Organization
LCA	Life Cycle Assessment
MHP	Mixed Hydroxide Precipitate
MSP	Mixed Sulfide Precipitate
Ni	Nickel
PCF	Product Carbon Footprint
PEF	(European Union) Product Environmental Footprint
PEFCR	(European Union) Product Environment Footprint Category Rules
PGM	Platinum Group Metals

Terminology

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.

Co-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 a main product.

Refined cobalt metal: Cobalt with a metal content >99.8%

Declared unit: The quantity of a product for use as a reference unit in a footprint communication based on Life Cycle Assessment (ISO, 2020) (ISO, 2022)

Emission factor: Factor of CO₂eq per unit of fuels consumed, such as e.g., oil, gas, coal, including for generation of electricity

Functional unit: The quantified performance of a product system for use as a reference unit

Cobalt matte: An intermediate of the cobalt metallurgical process



Primary data: Data pertaining to a specific product or activity within a company's value chain. Such data may take the form of activity data, emissions, or emission factors. Primary data is site-specific, company-specific (if there are multiple sites for the same product) or supply chain– specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material or product balances, stoichiometry or other methods for obtaining data from specific processes in the value chain of the company (WBCSD, 2022). (Note that data sourced from information systems or engineering models that collect or obtain data directly from specific processes in the value chain of the company, shall be considered primary data)

Reference flow: A measure of the outputs from processes within a given product system required to fulfil the function expressed by the functional unit (ISO, 2006b)

Secondary data: Data that is not from specific activities within a company's value chain but from databases, based on averages, scientific reports, or other sources (WBCSD, 2022). In this guidance, secondary data are any data that are not primary data, i.e., all kind of data not directly measured or gathered from company owned information systems. Secondary data include e.g., life cycle inventory data from a third party, emission factors from inventory guidebooks, data from scientific papers and other kind of literature. (Note that data sourced from information systems or engineering models that collect or obtain data directly from specific processes in the value chain of the company, shall be considered primary data)

Waste: Any residue of a production operation, transformation or use, any substance, material, product or object that its holder discards or intends or is required to discard (e.g., for disposal) (ISO, 2007) (EU, 2008).

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Annex A

For methodological aspects of GHG calculation not explicitly defined in this guidance, please refer to the most recent versions of the standards and guidance documents listed in Annex A.

ISO 14025: 2006 – Environmental labels and declarations – Type III environmental declarations – Principles and procedures

ISO 14040: 2006 – Environmental management – Life cycle assessment – Principles and framework (ISO, 2006a)

ISO 14044: 2006 – Environmental management – Life cycle assessment – Requirements and guidelines (ISO, 2006b)

ISO 14049: Environmental management – Life cycle assessment – Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis (ISO, 2012)

ISO 14067: 2018 – Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification

Commission Recommendation of 16.12.2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations - Annexes 1 to 2 (European Commission, 2018)





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