SUMMARY REPORT

LEVERAGING LCA TO STRENGTHEN GHG PROTOCOL CORPORATE ACCOUNTING

1 Comparison of the GHG Protocol and LCA frameworks

2 Life Cycle Data and its Use for Corporate GHG Accounting

3 Guidelines for Improved Corporate GHG Accounting

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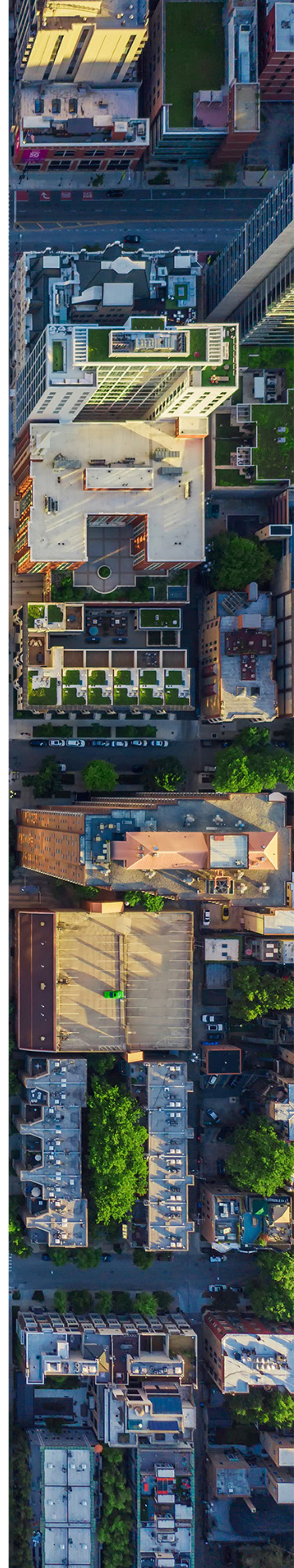

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ABBREVIATIONS AND ACRONYMS

AR	Assessment report
CFC	Chlorofluorocarbon
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	CO_2 equivalent
CO	Carbon monoxide
CPI	Consumer Price Index
dLUC	Direct land use change
EEIO	Environmentally extended input-output
EPD	Environmental product declarations
GHG	Greenhouse gas
GTP	Global Temperature change Potential
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
IEA	International Energy Agency
ILCD	International Reference Life Cycle Data System
iLUC	Indirect land use change
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
LUC	Land use change
MRIO	Multi-regional input-output
NF_3	Nitrogen trifluoride
N_2O	Nitrous oxide
O-LCA	Organizational life cycle assessment
PEF	Product Environmental Footprint
PCR	Product Category Rules
PFC	Perfluorocarbon
RECs	Renewable energy certificates
RNG	Renewable natural gas
sLUC	Statistical land use change
SF_6	Sulphur hexafluoride
U.S. EPA	United States Environmental Protection Agency

INTRODUCTION

The development of organizational greenhouse gas (GHG) inventories has experienced significant growth in recent years. The GHG Protocol has established itself as the primary reference framework for guiding organizations in conducting such assessments. However, despite its widespread adoption, the GHG Protocol presents certain limitations, and several operational challenges arise when implementing GHG inventories in accordance with its standards and guidelines.

The main objective of this work is to identify how life cycle assessment (LCA) practices and tools can support the quantification of GHG emissions at the organizational level and strengthen its methodological robustness.

This document is a summary report of the work conducted. It is based on the content of three technical reports, each with a specific objective:

1 **Comparison of the GHG Protocol and LCA frameworks**

This report aims to examinate the conceptual and methodological differences and overlaps between the GHG Protocol and LCA frameworks.

2 **Life Cycle Data and its Use for Corporate GHG Accounting**

This report aims to present and describe the different types of data typically used to develop organizational GHG inventories.

3 **Guidelines for Improved Corporate GHG Accounting**

This report aims to provide guidelines for improving the consistency, transparency, and robustness of organizational GHG inventories, drawing on life cycle thinking and practices.

The three technical reports, published in parallel with this document, provide a more comprehensive and technical analysis of the topics discussed here. Readers are encouraged to consult them for a more detailed examination of specific topics.

1 | COMPARISON OF THE GHG PROTOCOL AND LCA FRAMEWORKS

1.1 OVERVIEW OF THE COMPARED APPROACHES

1.1.1 GHG Protocol

The GHG Protocol is a widely used accounting framework for businesses and governments to understand, quantify, and manage their greenhouse gas (GHG) emissions. Its development began in the late 1990s, and the first version of the *GHG Protocol Corporate Accounting and Reporting Standard* (hereinafter referred to as the "*Corporate Standard*") was released in 2001. The *Corporate Standard* provides guidelines for companies and other organizations (e.g., Non-Governmental Organizations government agencies) to measure and report their GHG emissions.

While the GHG Protocol remains widely adopted globally as a standard for corporate GHG accounting, the organization has published multiple standards and guidance documents. These resources apply to different actors – companies, cities, government bodies, etc. – and subjects (products, organizations, projects, etc.). In this document, the term "GHG Protocol" refers to the set of standards and guidelines provided by the entity that relate to the quantification of corporate GHG emissions, especially:

- The *Corporate Standard* (GHG Protocol, 2015a);
- The *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (hereinafter referred to as the "*Scope 3 Standard*") (GHG Protocol, 2011a);
- The *Land Sector and Removals Standard* (GHG Protocol, 2026).

1.1.2 Life cycle assessment

Life cycle assessment (LCA) is a method used to evaluate the potential environmental impacts of a product, process, service or organization throughout its entire life cycle, from raw material extraction to end-of-life. The concept of LCA emerged in the 1970s as a response to growing environmental concerns and the need for a systematic approach to assess the environmental performance of products.

The International Organization for Standardization (ISO) played a crucial role in the standardization of LCA methodologies. In 1997, ISO published the first LCA standard, *ISO 14040* (ISO, 2022), providing guidelines for conducting life cycle assessments. This was followed by *ISO 14044* (ISO, 2006), which further refined the LCA methodology. More recently, various industries and sectors have developed their own LCA standards and guidelines to address specific challenges and nuances in their respective domains. Despite a significant increase in the number of LCA-related standards, *ISO 14040* and *ISO 14044* (hereinafter referred to as « *ISO 14040/44* ») remain the core and most widely used LCA standards.

1.1.3 Scope of the comparison

Comparing the GHG Protocol and LCA is a challenging exercise, as these two frameworks differ both in their objectives and in their contexts of application. More specifically, two key distinctions stand out in this comparison.

First, they each apply to different subjects. The specific approach of the GHG Protocol studied in this report – the *Corporate Standard* and underlying standards and guidance – applies only to organizations. Conversely, LCA applies to a multitude of subjects, such as products, services, processes and organizations. The *ISO 14072* standard (ISO, 2024), covering organizational LCA, could be specifically compared to that of the GHG Protocol. Nevertheless, this report aims to demonstrate more broadly how LCA approaches can facilitate the process of quantifying organizational GHG emissions and improve its robustness. As such, it is the overall LCA approach that is compared with the requirements and recommendations of the GHG Protocol.

Second, given its specific application scope, the GHG Protocol describes a relatively detailed approach and prescribes certain methodological choices (e.g., on boundaries). Conversely, a wide range of standards and approaches exist within the LCA community, making it impossible to capture all of them within this analysis. For this reason, the **general LCA framework** – *ISO 14040/44* – is used here as the main point of reference, while also taking into account certain underlying approaches (e.g., *ISO 14072* for organizational LCA). As a result, there is a notable disparity in the level of detail and methodological requirements provided by each framework. Nonetheless, the comparison focuses on the range of practices and considerations outlined in the general LCA framework against those of the **GHG Protocol**.

The following sections compare both approaches regarding the methodological aspects summarized in Table 1.

TABLE 1 • METHODOLOGICAL ASPECTS COMPARED IN THIS REPORT

Methodological aspect	Description
Reporting unit	The unit of analysis to which results are scaled.
Boundaries	Categorization of activities and inclusion requirements.
Capital goods	Treatment of assets that have an extended lifetime.
Greenhouse gases and indicators	Included greenhouse gases and studied indicators.
Electricity accounting	Treatment of electricity flows (i.e., location-based and market-based methods).
Biogenic carbon	Accounting methods for biogenic carbon flows (removals and biogenic carbon dioxide [CO_2] emissions) and reporting requirements.
Land use change	Inclusion of land use change (LUC) metrics and reporting requirements.
Multifunctionality	Treatment of multifunctionality for co-products and end-of-life allocation.
Avoided emissions	Inclusion and treatment of avoided emissions and reporting requirements.
Reporting and results interpretation	Main reporting requirements and main analyses supporting results interpretation.

1.2 REPORTING UNIT

In the **GHG Protocol**, the reporting unit is one year of an organization's activities, referred to as the *reporting year*, which can follow either the calendar or financial year. Organizations may also define a base year, against which future emissions are compared to track progress and set reduction targets.

In **LCA**, reporting units depend on the type of study. In product LCA, the reporting unit is the *functional unit*, which describes the function provided by the product or system (e.g., performance, capacity, or lifespan). This unit allows meaningful comparisons between products that fulfill the same function by considering performance characteristics. For example, when comparing products with different lifespans, the functional unit ensures that the comparison reflects the same level of service delivered.

In **organizational LCA**, the reporting unit corresponds to a defined period during which the organization's activities are assessed. Similar to the GHG Protocol, organizational LCA results are not intended for comparison between organizations.

Overall, the main distinction lies in comparability. Organizational approaches (GHG Protocol and organizational LCA) use time-based reporting units primarily to monitor emissions over time within the same organization. These approaches are not intended for comparison between organizations, due to differences in organizational boundaries, activities and outputs. In contrast, product LCA uses a functional unit designed to enable comparisons between products or services delivering the same function. Considering the function of a system also places product LCA within a fundamentally different conceptual framework than organizational assessments: the same action can increase impacts in one approach while reducing them in the other. For example, extending a product's lifespan would typically reduce impacts in a product LCA, as fewer products are needed to deliver the same function. In contrast, within an organizational inventory, a longer product lifespan may lead to higher reported emissions if the product emits GHGs during its use phase.

1.3 BOUNDARIES

1.3.1 Overall boundaries

In the **GHG Protocol**, boundaries are defined through *organizational boundaries* – determining which operations and assets are owned or controlled by the organization – and *operational boundaries*, which determine which emissions are reported and how they are categorized.

The GHG Protocol divides an organization's emissions into three scopes. *Scope 1* represents *direct* emissions, that is, those originating from sources owned or controlled by the organization (e.g., its vehicle fleet). *Indirect emissions* are those that originate from sources owned or controlled by another organization but that occur as a consequence of the reporting organization's activities. They are divided into scopes 2 and 3: *scope 2* corresponds to emissions associated with the generation of the electricity, steam, heat, and cooling purchased by the organization, while *scope 3* covers all other emissions across the organization's value chain, which are themselves divided into 15 categories. The *Corporate Standard* requires the inclusion of scopes 1 and 2 emissions and recommends including relevant scope 3 emission sources. However, the *Scope 3 Standard* is significantly more demanding, requiring organizations to account for all scope 3 emissions and provide justification for any exclusions.

In **LCA**, *system boundaries* determine which life cycle stages and activities are included within the study. For example, system boundaries may be defined as *cradle-to-gate*, covering all activities from raw material extraction to the point where the product leaves the manufacturer, though other system boundary types may be defined. There is therefore flexibility regarding the life cycle stages covered, which can be defined based on the context and objectives of an LCA study. The activities included are those required to deliver the functional unit. Certain life cycle activities, inputs or outputs may be excluded from system boundaries if they are considered negligible. A common approach is to use a *cut-off criterion* – such as X% of the input mass, X% of energy consumption, etc. – allowing for the exclusion of activities that fall below these thresholds.

Overall, the approaches used to define included activities and processes differ. The GHG Protocol disaggregates an organization's value chain emissions into scopes and categories, with specific inclusion requirements depending on the standard applied. In contrast, in LCA, boundaries are defined to include all activities necessary to fulfill a function, as defined by the functional unit.

In **organizational LCA** more specifically, *ISO 14072* requires the inclusion of all activities within the organization's value chain, including the use phase and end-of-life of its sold products whenever the organization has influence on these life cycle stages. As a result, its requirements for defining system boundaries tend to lead to more comprehensive boundaries than those typically established under the *Corporate Standard*. Conversely, the *Scope 3 Standard* requires the inclusion of use-phase and end-of-life emissions of sold products, regardless of the organization's level of influence, thereby resulting in overall boundaries that may be more complete.

A notable difference between organization-level approaches and product-level approaches is that the former include auxiliary activities that are not directly attributable to the products or services provided by the organization. For example, organizational assessments account for emissions from employee commuting and office energy use, which are typically excluded from product-level LCAs.

1.3.2 Boundaries of included activities

A central question when defining boundaries – and when modelling or calculating emissions – is determining which emission sources (e.g., inputs, outputs) associated with the included activities should be accounted for. For example, if an analysis includes the transportation of goods by a diesel truck, which life cycle emissions associated with this activity should be included within the boundaries? The extent to which the life cycle of included activities and processes is covered differs between the GHG Protocol and LCA.

In the **GHG Protocol**, the *Scope 3 Standard* defines *minimum boundaries* that specify which emission sources must at a minimum be accounted for in each scope 3 category. Minimum boundaries cover cradle-to-gate emissions for purchased goods and services (category 1) and capital goods (category 2). For most other categories, they cover scope 1 and scope 2 emissions associated with the activity under consideration (e.g., the supplier, the vehicle)[1]. In the previous example of freight transportation using a diesel truck, the minimum boundaries would include emissions from diesel combustion, while other emissions – such as those associated with diesel production or truck manufacturing – are outside the minimum boundaries and are therefore optional to include. For most categories, minimum boundaries capture the largest emission contributors. However, in certain specific cases or categories, they exclude significant sources of emissions. For instance, emissions associated with the construction of renewable energy infrastructure are not included in the minimum boundaries of the fuel- and energy-related activities category (category 3), though they typically are the dominant contributor to the life cycle emissions of renewable energy.

In **LCA**, at both the product and organizational levels, system boundaries are defined using a life cycle perspective, meaning that they typically capture an extensive network of interconnected processes, effectively representing entire value chains rather than isolated activities. Returning to the example of diesel truck transportation, an LCA study would typically include the full life cycle of the process: diesel combustion, diesel production, truck manufacturing, maintenance, end-of-life, and potentially even the construction and maintenance of road infrastructure.

1.4 CAPITAL GOODS

Capital goods refer to fixed assets, property or equipment (e.g., manufacturing machines, buildings, facilities, and vehicles) that typically have extended lifespans, differentiating them from other purchased goods that are typically consumed within the same year.

Although a capital good may be used over several reporting years, the **GHG Protocol** recommends not to “depreciate, discount, or amortize the emissions from the production of capital goods over time” (GHG Protocol, 2011a). This means that all emissions associated with the production (cradle-to-gate) of capital goods are reported in the year of their acquisition. The emissions associated with their use (e.g., energy consumption) and their end-of-life treatment will be reported in the years they occur, as part of other scopes/categories.

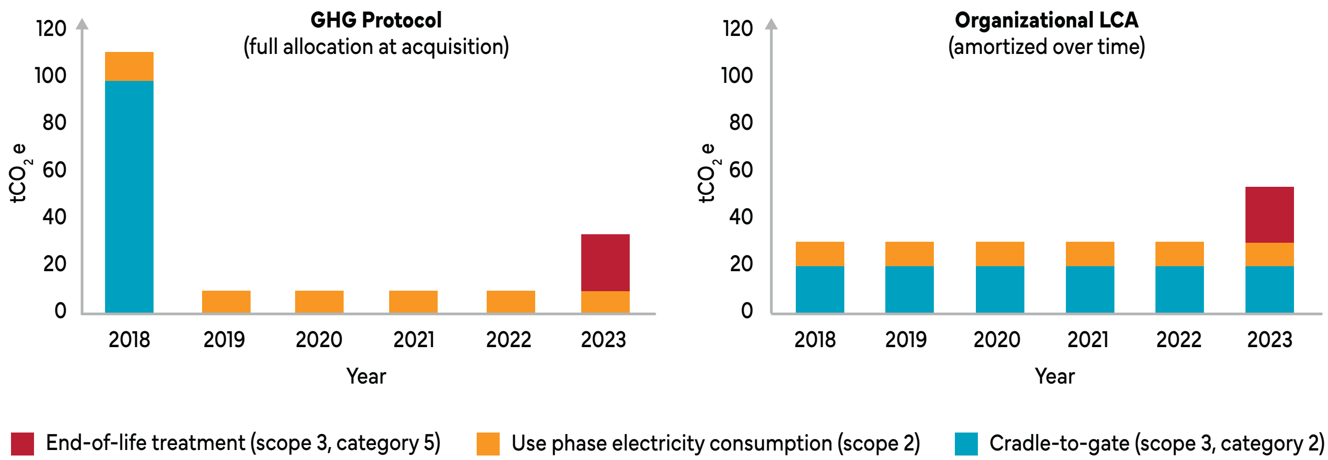
In **LCA**, any system (e.g., machinery, plant) providing various outputs (e.g., products) is typically partitioned among the outputs. The production of capital goods is usually distributed across all the products they manufacture over their useful lifetime. Common allocation methods include attribution

[1] Minimum boundaries are described for each scope 3 category in Table 5.4 of the *Scope 3 Standard* (GHG Protocol, 2011a).

based on the total number of units the good can produce, the total mass produced, or the time each product uses the equipment. Similarly, in **organizational LCA**, emissions associated with the production of capital goods should be amortized over their years of use (ISO, 2024). Thus, emissions are partitioned proportionally to the reporting period (typically one year) relative to the total lifetime of the equipment.

Figure 1 illustrates the typical treatment of equipment purchased in 2018, used for six years, and then decommissioned and sent to a landfill at the end of 2023, under both the GHG Protocol and organizational LCA approaches.

FIGURE 1 • DISTRIBUTION OF EMISSIONS ASSOCIATED WITH THE LIFE CYCLE OF CAPITAL GOODS IN THE GHG PROTOCOL AND PRODUCT LCA



Note: The categorization used in the legend is that of the GHG Protocol. Emission values are shown in tonnes of CO_2 equivalent (tCO_2e).

The depreciation of emissions associated with the production of capital goods is a central difference between the GHG Protocol and LCA approaches. Since the lifespan of capital goods can be uncertain, the GHG Protocol's approach of reporting all their upstream emissions in the year of purchase ensures that the totality of these emissions is accounted for. However, when capital goods with large cradle-to-gate emissions are only purchased periodically (e.g., buildings), this can cause large fluctuations in an organization's GHG inventory year to year, therefore complicating the tracking of emissions over time and its consistency. This approach also has the advantage of being relatively simple in an organizational context, as it avoids the need for organizations to track all capital assets, their lifespans, and their depreciation status.

In contrast, LCA's approach of partitioning emissions across products (in product LCA) or reporting years (in organizational LCA) avoids year-to-year variations, allowing for more consistent emission tracking, especially in organizational LCA. However, since the total lifespan or outputs produced over the lifetime of a piece of equipment is often unknown, this can introduce uncertainty into the modelling.

1.5 GREENHOUSE GASES AND INDICATORS

1.5.1 Included greenhouse gases

The **GHG Protocol** requires the quantification of emissions of the seven GHGs covered in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) (GHG Protocol, 2013b). These GHGs must be included in the calculations of scope 1, 2, and 3 emissions to ensure compliance with both the *Corporate Standard* and the *Scope 3 Standard*. Additionally, the *Corporate Standard* stipulates that "[…] emissions of GHGs other than the [seven] Kyoto gases may be reported separately from the scopes […]" (i.e., as supplementary information).

Tracking whether specific GHGs are included or excluded from scope 3 emissions is often more difficult than for scope 1 and 2 emissions. Indeed, it is often difficult to determine which GHGs are included in the emission factors[2] used to calculate scope 3 emissions and to adjust them. As a result, more or fewer than the seven required GHGs may be accounted for.

In **LCA**, all substances emitted by the system under study should be included. LCA studies can therefore account for the radiative forcing of a wide range of substances, depending on the specific *life cycle impact assessment* (LCIA) method used. GHGs that are beyond the scope of the GHG Protocol but typically included in LCA are:

- Carbon monoxide (CO);
- Hydrochlorofluorocarbons (HCFCs);
- Chlorofluorocarbons (CFCs);
- Other fluorinated compounds (trifluoromethylsulfur pentafluoride, sulfuryl fluoride, etc.);
- Chlorocarbons and hydrochlorocarbons (methyl chloroform, carbon tetrachloride, etc.);
- Bromocarbons, hydrobromocarbons and halons (halon-1201, methyl bromide, etc.);
- Halogenated alcohols, ethers, furans, aldehydes and ketones.

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Most of these substances are GHGs that exert radiative forcing once emitted, but some are also precursors to GHGs – that is, substances that undergo chemical reactions in the atmosphere and lead to the formation of GHGs. For example, CO reacts with the hydroxyl radical (a key atmospheric oxidant) to form CO_2.

GHGs covered by the GHG Protocol account for the vast majority of radiative forcing from human activities. Additional GHGs and their precursors that can be accounted for in LCA generally have a limited impact on a system's total emissions. Nevertheless, exceptions can occur, particularly at the product level, in certain sectors or under specific circumstances.

1.5.2 Included indicators

To evaluate the emissions of different GHGs on a common basis, the **GHG Protocol** requires converting emissions of individual GHGs into tonnes of CO_2 equivalent (CO_2e) by using the Global Warming Potential (GWP) values provided by the Intergovernmental Panel on Climate Change (IPCC). More precisely, the GHG Protocol requires the use of the 100-year time horizon GWP values (GWP100), which should be sourced from the latest IPCC Assessment Report.

By contrast, **LCA** enables the assessment of a wide range of indicators that represent the potential environmental impacts of the system under study on different environmental issues. To estimate the system's potential contribution to climate change, different metrics can be used:

- The GWP, which measures the radiative forcing potential of a gas emitted into the atmosphere from the time of emission over a certain period, relative to that of CO_2. It is therefore an integrative measure, assessing the impact over a defined time frame instead of at a specific point in time (IPCC, 1990).

[2] An emission factor is a calculated ratio relating GHG emissions to a given measure of activity.

- The Global Temperature change Potential (GTP), which measures the global average temperature increase at a certain future time point caused by a gas emission into the atmosphere, relative to the temperature increase that would be caused by an equivalent mass of CO_2 (Shine et al., 2005).

These metrics can be assessed over different time frames: 20, 100, or 500 years for the GWP, and 20, 50, or 100 years for the GTP. In general, the use of two metrics is advocated for in LCA: GWP for short-term impacts on climate change and GTP100 for long-term impacts.

In practice, climate change metrics are embedded in LCIA methods implemented in LCA software tools (e.g., SimaPro, openLCA). All LCIA methods include at least the GWP100 metric, but its values are not always sourced from the latest IPCC Assessment Report. Many LCA standards and frameworks recommend calculating potential impacts using the GWP100 metric, such as *ISO 14067* (ISO, 2018) and *PAS 2050* (BSI, 2011). However, it is also common practice to test other metrics, such as GWP20, in sensitivity analyses to assess how the choice of metric influences the study's conclusions.

Overall, the GHG Protocol and LCA approaches are consistent in that both use the GWP100 metric, although other metrics (e.g., GTP) and time horizons may be applied in LCA depending on the study's context and objectives. In LCA, the impacts of mechanisms affecting the climate beyond GHG emissions may be included in some studies. Although rare, some practitioners may incorporate the effects of a system on albedo or contrail formation when the study's context and objectives warrant it. Additionally, LCA's multi-indicator approach is important, as focusing solely on climate change impacts can solve one problem while inadvertently creating another, effectively shifting environmental burdens from one impact category to another.

1.6 ELECTRICITY ACCOUNTING

Emissions associated with purchased electricity, heat, steam, and cooling are treated in a specific way under the GHG Protocol. First, this treatment addresses how the life cycle emissions of these energy carriers are disaggregated and reported in different categories. Second, emissions from these sources are subject to specific accounting methods, particularly to account for market instruments linked to energy purchases. For simplicity, this section refers only to "electricity", as it is the most common energy type in scope 2, though steam, heat, and cooling are also included.

1.6.1 Disaggregation and reporting

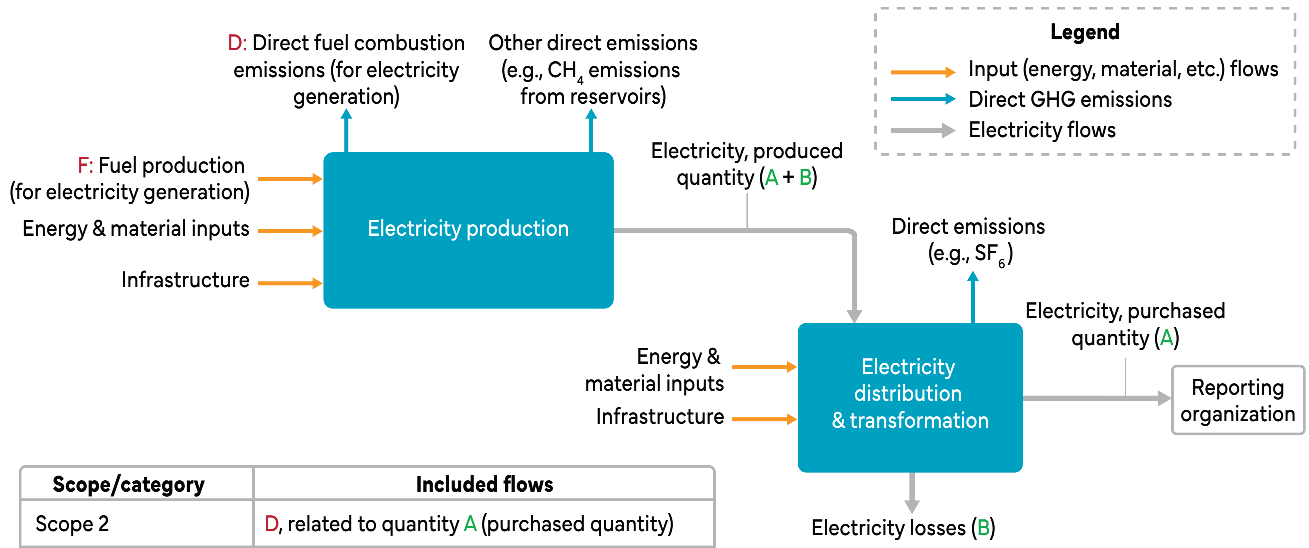
Electricity purchases are often a significant source of indirect emissions and a key lever for decarbonization. For this reason, the **GHG Protocol** introduced scope 2 with the publication of the *Corporate Standard* in 2001, to require their inclusion in corporate GHG inventories.

However, scope 2 only covers part of the life cycle emissions from purchased electricity – specifically, the emissions from fuel combustion at the power generation site. Other life cycle emissions are reported under the category 3 of scope 3 (fuel- and energy-related activities [not included in scope 1 or scope 2]). For electricity purchases from end users, the minimum boundaries of this category cover:

- The upstream emissions of fuels (i.e., extraction, production and transportation) consumed in the generation of the quantity of electricity purchased by the reporting company.
- The upstream emissions and combustion emissions of fuels used in the generation of electricity that is lost or consumed during transmission and distribution.

Figure 2 illustrates emissions that are part of scope 2 and the minimum boundaries of scope 3 category 3, specifically for energy purchases from end users.

FIGURE 2 • DISAGGREGATION OF EMISSIONS ACROSS SCOPES AND CATEGORIES FOR END USERS OF ELECTRICITY



Scope/category	Included flows
Scope 2	D, related to quantity A (purchased quantity)
Scope 3 category 3 (minimum boundaries)	- F, related to quantity A (purchased quantity) - D + F, related to quantity B (electricity losses)
Life cycle perspective	All flows, scaled to produced quantity (A + B)

As a result, renewable electricity typically has an emission factor of zero for scope 2 and, when minimum boundaries are applied, for scope 3 as well, since no fuel combustion is required for its generation. However, a common approach for electricity purchases is to account for all life cycle emissions – including infrastructure emissions, for example – as many emission factors are developed accordingly.

In contrast, in **LCA**, both at the product and organizational levels, the full life cycle emissions of electricity are attributed to the consuming system. Emission factors from LCI databases (e.g., ecoinvent) or LCA studies generally include all flows illustrated in Figure 2. Therefore, their use in GHG inventories calculated in accordance with the GHG Protocol requires a disaggregation between scope 2 and scope 3, which can present challenges. As of this writing, ecoinvent is the only LCI database to disaggregate electricity emissions between scope 2 and other life cycle emissions[3].

1.6.2 Calculation method

In the **GHG Protocol**, two methods can be used to calculate emissions from electricity purchases: the *location-based* method and the *market-based* method. On the one hand, the location-based method uses average emission factors from the electricity grid in a defined geographic area (local, sub-national, or national).

On the other hand, the market-based method allows organizations to use emission factors from their specific electricity supplier, provided the purchase is backed by an energy attribute certificate. Under this method, the organization applies the emission factor associated with the instrument – such as *Renewable Energy Certificates* (RECs) in the United States or *Guarantees of Origin* in the EU – provided the instrument meets certain quality criteria[4]. These criteria generally ensure temporal and geographic

[3] Scope 3 emission factors provided by ecoinvent adopt a life cycle perspective, and not minimum boundaries. They correspond to life cycle emissions from which scope 2 emissions have been substracted.

[4] Scope 2 Quality Criteria are listed in Table 7.1 of the *Scope 2 Guidance* (GHG Protocol, 2015b).

correlation with the organization's context and require exclusivity to prevent double counting. A key component of the market-based approach is the use of the residual mix for any electricity purchases not covered by certificates, specified-source contracts, or supplier-specific data. This ensures that renewable claims made through contractual instruments are not double counted.

Regarding method selection, the presence of energy attribute certificates in any market where the reporting organization operates triggers the requirement to report emissions using the market-based method for the entire organization, in addition to the location-based method. This means that once an organization operates in such a market, it must report both location-based and market-based electricity-related emissions. Conversely, if the organization operates only in markets where these instruments are not available, it may report only location-based emissions.

In **LCA**, the practice of accounting for the attributes of a purchased product or energy source when backed by economic instruments is well established, whether for electricity or other certified products (e.g., Forest Stewardship Council certified wood).

Overall, regarding calculation methods, the GHG Protocol and LCA approaches are similar. However, the location-based approach remains predominant and is generally recommended, if not required, by most LCA-related standards and frameworks. While the methods endorsed by the GHG Protocol are not inherently different from those used in LCA, the GHG Protocol has played a key role in formalizing and standardizing the market-based approach.

1.7 BIOGENIC CARBON

Biogenic carbon refers to carbon atoms (typically in the form of CO_2, CH_4, or CO) that have been transferred from the atmosphere to the biosphere through biological processes such as photosynthesis. This carbon is contained in, or derived from, living organisms or biological processes, but does not include fossilized materials or those from fossil sources (GHG Protocol, 2026). When biogenic carbon is released back into the atmosphere, it has the same effect on climate (i.e., radiative forcing) as carbon from fossil sources.

The main difference between biogenic and fossil carbon lies in the timescales of their cycles. Biogenic carbon is part of a relatively short cycle – usually years to decades (SCORE LCA, 2024) – in which CO_2 absorbed during biomass growth is returned to the atmosphere through decomposition or combustion. In contrast, fossil carbon originates from biological material that was sequestered over geological timescales (centuries to millions of years) and has remained outside the active carbon cycle ever since.

As a result, the CO_2 removal associated with fossil carbon is not accounted for in GHG accounting, as it is considered geologically removed and unrelated to contemporary human activity. Conversely, for bio-based products, the removal of atmospheric CO_2 through photosynthesis is generally induced by human activities and is therefore attributed to these products. This temporal distinction between biogenic and fossil carbon has led to the development of specialized accounting methods to characterize and report biogenic carbon emissions and removals arising from the life cycle of bio-based products.

1.7.1 Treatment of biogenic carbon within LCA

Within the **LCA** field, three main approaches are used to account for biogenic carbon: the *carbon neutrality approach* (also known as the *0/0 approach*), the *-1/+1 approach*, and the *dynamic approach*.

The **carbon neutrality (0/0)** approach assumes that biogenic CO_2 flows to and from the atmosphere are balanced over the product life cycle (i.e., the carbon sequestered in biomass is fully released during use or at end-of-life). Under this assumption, net biogenic CO_2 emissions are considered zero. As a result, this approach does not account for either permanent or temporary carbon storage. Today, while this approach is still implemented in many LCIA methods, it has been widely criticized, notably because removals and emissions are often not equivalent – for example, when carbon is emitted in different forms (e.g., CH_4, CO) or when it is permanently stored (e.g., through landfilling).

The **-1/+1 approach** inventories and characterizes all biogenic GHG flows across the product life cycle, assigning a factor of -1 to flows entering biomass (i.e., CO_2 removals) and +1 to flows released to the atmosphere. These flows are then characterized using the same GWP values as for fossil GHGs and summed over the life cycle. This approach addresses the main limitations of the 0/0 approach and is required by several LCA standards, including *ISO 14067*, *PAS 2050*, and *EN 15804+A2* (CEN, 2019). While it captures permanent carbon storage (when removals exceed emissions), it does not reflect the timing of emissions and therefore does not account for temporary storage.

The **dynamic approach** explicitly tracks biogenic carbon removals and emissions over time throughout the product life cycle and applies time-dependent characterization factors (i.e., adapted GWP values). By accounting for the timing of flows, it can capture both temporary and permanent carbon storage and is particularly relevant for systems with long biogenic carbon cycles (e.g., forest-based systems). However, due to its greater data requirements and methodological complexity, it is rarely applied in practice, with most studies relying on the two static approaches described above (0/0 and -1/+1).

1.7.2 Treatment of biogenic carbon within the GHG Protocol

Requirements and guidance on accounting for biogenic carbon within the GHG Protocol are distributed across several documents. The *Corporate Standard* and the *Scope 3 Standard* outline the prevailing recommendations and requirements, reflecting historically established and widely adopted practices for reporting biogenic emissions at the organizational level. In contrast, the *Land Sector and Removals Standard*, published in early 2026, introduces updated requirements and guidance specifically for organizations engaged in land-based activities within their value chains.

On the one hand, the ***Corporate Standard*** requires that direct CO_2 emissions from biologically sequestered carbon (e.g., those from burning biomass or biofuels) be reported, but separately from the scopes (i.e., from the GHG inventory results). The ***Scope 3 Standard*** builds on this by also requiring the separate reporting of indirect biogenic CO_2 emissions. Both standards allow for the reporting of GHG removals, but they must also be reported separately from the scopes.

As a result, biogenic CO_2 flows are treated as carbon neutral in the main inventory results, meaning that both CO_2 removals and emissions are excluded from scope 1, 2, or 3 emissions. To maintain consistency with this treatment, the GHG Protocol (2024) recommends using the GWP for non-fossil methane when characterizing biogenic CH_4 emissions. This GWP value excludes the climate effect associated with methane's eventual oxidation into CO_2, which is consistent with the principle that biogenic CO_2 flows are not included within the inventory results.

For example, the CO_2 removal that occurs during biomass growth for biofuel production should not be included in the biofuel production emission factor (scope 3, category 3). Instead, a reporting organization using this fuel could report the CO_2 removal separately, outside its scope 3 inventory. Likewise, any CO_2 emissions resulting from the combustion of the biofuel must also be reported separately, outside of the scopes. In contrast, biogenic CH_4 emissions from combustion must still be included, using the non-fossil methane GWP value to ensure consistency with the GHG Protocol's treatment of biogenic carbon flows.

On the other hand, the ***Land Sector and Removals Standard*** (2026) introduces a more granular and structured framework to account for emissions and removals associated with land-based activities and carbon removal technologies. The standard requires organizations to report emissions across distinct accounting categories that reflect different types of emissions, removals or metrics, such as land use change (LUC), land management, and biogenic product emissions and storage. Emissions and removals associated with these accounting categories are either reported within a "*Physical GHG inventory*", which is the main GHG inventory, or within additional accounting categories that act as supplementary information.

Notably, organizations following this new standard are required to report net biogenic CO_2 emissions from land management within the main (or *Physical*) GHG inventory and may report net land management removals when specific requirements related to traceability, data quality, permanence and allocation are met. The standard therefore incorporates biogenic carbon flows associated with land management, rather than simply excluding them and treating them as carbon neutral, as was previously the practice. In addition, although removals are reported in a distinct accounting category, they are, for the first time, integrated within the main GHG inventory and included in the total emissions balance. As a result, they may contribute to the achievement of emission reduction targets, for example under frameworks such as the Science Based Targets initiative.

Conversely, the standard's treatment of biogenic product emissions and removals more closely reflects a carbon neutrality (0/0) approach. CO_2 removals associated with the carbon contained in bio-based products (i.e., biogenic product removals) are not included in any accounting category of the *Physical GHG inventory*. They may optionally be disclosed separately in an additional accounting category (called "*Product carbon storage*"). In contrast, biogenic product CO_2 emissions are either reported within the *Physical GHG inventory* or, if specific conditions are met, in an additional accounting category (i.e., separately). As a result, when these emissions are included in the main GHG inventory, a mass balance inconsistency arises because the corresponding removal is not accounted for.

1.7.3 Comparison of approaches

Overall, the approaches proposed by the GHG Protocol and those commonly used in LCA to account for biogenic carbon flows show no fundamental differences. The approach prescribed by the *Corporate Standard* and the *Scope 3 Standard* is akin to a carbon neutrality approach, in which biogenic CO_2 flows are either reported separately or excluded from the main inventory. In contrast, the *Land Sector and Removals Standard* introduces a structured emissions reporting framework that disaggregates an organization's emissions into distinct accounting categories. These categories rely on accounting approaches widely used in LCA, notably the -1/+1 approach – particularly for land management biogenic CO_2 – and the carbon neutrality (0/0) approach (for biogenic product CO_2 emissions and removals).

Nevertheless, it is important to emphasize that the *Land Sector and Removals Standard* provides a framework for reporting emissions and removals that is primarily accounting- and disclosure-oriented. In contrast, LCA typically aims to model all flows within a system, seeking, for example, to establish a mass balance for biogenic carbon flows. As such, LCA generally focuses on the system's overall potential impacts, rather than on disaggregating emissions into distinct reporting categories.

1.8 LAND USE CHANGE

Land use change (LUC) refers to the conversion of land from one land use category (i.e., purpose) to another as a result of human activities. In **LCA**, emissions related to LUC are generally included. Nearly all LCA standards (e.g., *ISO 14067, PAS 2050*) require the inclusion of *direct LUC* (dLUC) emissions, which are those that occur directly on the land used by the system under study. Moreover, most LCI databases include dLUC emissions within their datasets – this is the case for ecoinvent, Agri-footprint (Blonk et al., 2025), Agribalyse (Cornelus et al., 2024), and the Sphera Managed LCA Content Database (Sphera, 2026), among others. The inclusion of removals associated with LUC is also common practice in LCA, particularly when agricultural systems are modelled using LCI data, which may already account for them.

Organizations following the **GHG Protocol** have often omitted LUC emissions from their inventories, mainly because LUC is not addressed in the *Corporate Standard*. However, the *Agricultural Guidance* (GHG Protocol, 2014), which supplements the *Corporate Standard*, does include guidance on LUC. It recommends accounting for and reporting scope 1 CO_2 emissions when LUC leads to a reduction in carbon stocks, and reporting LUC removals separately when there is an increase in carbon stocks.

The new *Land Sector and Removals Standard* requires the inclusion of both direct (scope 1) and indirect (scopes 2 and 3) emissions associated with LUC. These emissions form a distinct accounting category that is reported within the *Physical GHG inventory*. The standard requires organizations to select the most accurate calculation method based on data availability and the level of traceability back to the land associated with their value chain. Where possible, organizations should calculate LUC emissions using primary data from the specific land areas from which products are sourced. When such traceability is limited, they may instead rely on more generic approaches, such as a *statistical land use change* (sLUC) approach.

From a methodological standpoint, the approaches promoted by this new standard are broadly aligned with those used in LCA. These include the assessment period (i.e., the timeframe over which emissions from a land conversion are allocated to cultivated products) and the discounting approach (i.e., how these emissions are distributed over time).

However, a key difference lies in how each framework treats CO_2 removals associated with LUC. The *Land Sector and Removals Standard* does not comprehensively address these removals, and they would typically be excluded from GHG inventories developed under this framework. In contrast, LCA studies may include such removals, particularly when agricultural stages are modelled using LCI data. For example, LUC-related removals are embedded in certain LCI data for specific bio-based products in some geographies. As a result, practitioners preparing GHG inventories in accordance with the new GHG Protocol standard should exercise caution when using these datasets.

Another difference, although minor, lies in how the term *direct LUC* (dLUC) is defined across the two approaches. In LCA, dLUC generally refers to any LUC emissions directly linked to a sourced product, regardless of whether these emissions are calculated using primary data (i.e., directly tied to the specific field where the LUC occurred) or derived from statistical approaches that provide a proxy, such as those used in LCI databases. In contrast, the GHG Protocol places stronger emphasis on causation: LUC is considered "direct" only when the emissions are demonstrably caused by the product itself. As a result, sLUC is not considered a form of dLUC under the GHG Protocol definitions.

1.9 MULTIFUNCTIONALITY

A multifunctional system is one that delivers more than one output, whether products or services. In product LCA, multifunctionality is frequently addressed to isolate one of a system's functions and assess its potential environmental impacts. The presence of *co-products* and recycling activities within a product system generally requires dealing with multifunctionality.

A corporate organization is also a multifunctional system; it generally markets several products, offers various services, and performs other secondary functions, such as employing people. In quantifying organizational GHG emissions, the aim is to establish the environmental profile of the whole organization, without isolating any particular function. Multifunctionality in the foreground system – i.e., within the organization itself – is therefore not addressed in organizational GHG accounting. For this reason, managing multifunctionality is a much less central issue in organizational assessments compared to product LCA. In specific cases, however, it may be appropriate to address multifunctionality, particularly when organizations collect primary data from suppliers or when there are recycling activities in their supply chain.

1.9.1 Use of primary data from suppliers

Multifunctionality can arise when an organization collects primary data (either inputs and outputs, or emissions data) from suppliers that operate a single facility or system producing multiple outputs (i.e., co-products). For example, a reporting organization may need to calculate the emissions associated with a purchased product (category 1) using the supplier's GHG inventory. If the supplier manufactures multiple products, the emission data in its GHG inventory refer to all these outputs, and multifunctionality must therefore be addressed.

In the **GHG Protocol**, the *Scope 3 Standard* recommends following a hierarchy of approaches for addressing multifunctionality:

1. **Avoiding allocation**, for example by obtaining product-level GHG data (e.g., a product LCA);
2. **Allocating emissions using physical factors** (i.e., based on physical properties of outputs such as mass, volume, etc.). Allocation consists of distributing the impacts generated by a process (and its upstream processes) among its various co-products;
3. **Allocating emissions using economic factors or other relationships**.

In **LCA** – at both the product and organizational levels – *ISO 14044* also provides a hierarchy of approaches for addressing multifunctionality, which is often recommended or required by other LCA standards:

1. ***Subdivision***, which consists of separating a multifunctional process into monofunctional processes, for example by disaggregating flows pertaining to the different outputs;
2. ***System expansion***, also called *substitution*, which involves subtracting the impacts of products substituted by the process' co-products in order to create a monofunctional process. For example, a combined heat and power plant produces electricity and heat. The heat replaces boiler heat, so the impacts of that avoided boiler heat are subtracted from the system to render it monofunctional;
3. ***Allocation*** according to a defined allocation rule:
    a. When possible, allocation should reflect **underlying physical relationships**, based on the principle of physical causality between co-products. This type of allocation must reflect the actual cause-and-effect relationships within the system. For example, in milk production, allocation between milk and meat is generally based on how the cow partitions feed energy among different physiological functions, reflecting physical cause-and-effect relationships;
    b. If such an allocation is not feasible, *ISO 14040/44* recommends using **other allocation keys**, such as economic, mass, or energy relationships between co-products, without ranking them hierarchically.

The procedures proposed for addressing multifunctionality, as well as the hierarchy of their application, differ between the two approaches. *ISO 14044* recommends system expansion as the preferred approach when subdivision is not feasible. In contrast, the GHG Protocol does not allow system expansion as a mean to address multifunctionality, which is consistent with its broader approach of not considering avoided emissions in organizational GHG inventories. The organizational LCA standard, *ISO 14072*, is aligned with this and also does not allow system expansion.

When allocation is required, LCA prioritizes allocation based on underlying physical relationships, emphasizing the principle of physical causality between co-products and requiring that allocation reflect the actual cause-and-effect relationships within the system. In contrast, although the GHG Protocol emphasizes selecting an approach that best reflects the causal relationship between the production of outputs and the resulting emissions, it does not explicitly promote this type of allocation. Instead, it interprets "underlying physical relationships" as the use of physical properties of outputs, such as mass, volume, or energy, etc.

Finally, the GHG Protocol prioritizes allocation based on physical properties over economic allocation, where relevant. By contrast, *ISO 14044* does not prioritize allocation based on physical properties of outputs (e.g., mass or energy) over economic allocation. Instead, the choice depends on the context of the study.

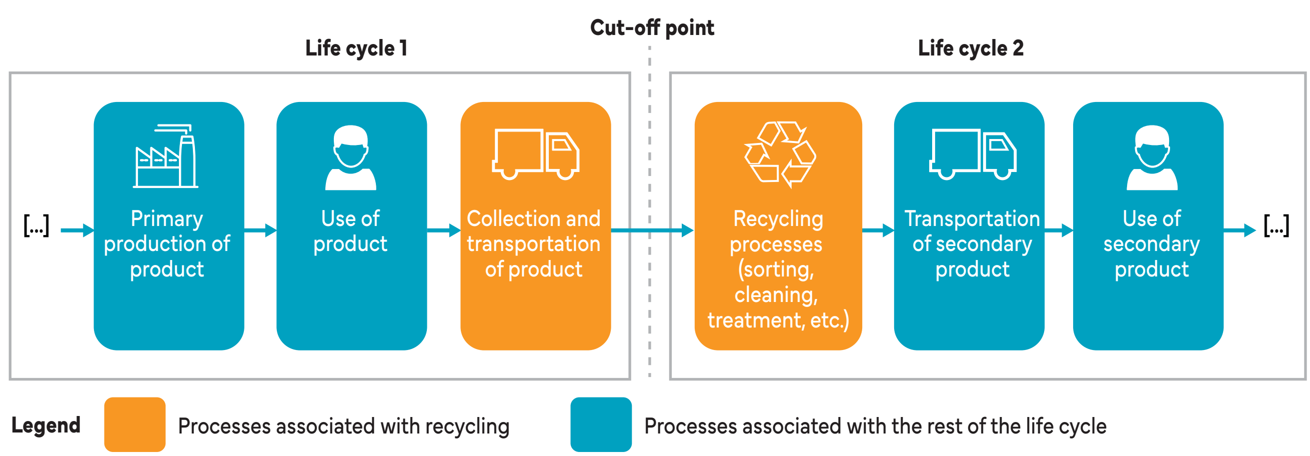
1.9.2 End-of-life allocation procedures

Recycling processes are multifunctional: they treat waste and generate a secondary product. Thus, in an organizational GHG inventory, the impacts of recycling processes must be split between the upstream organization, which generates the waste, and the downstream organization, which uses the secondary product.

For recyclable materials, the **GHG Protocol** recommends using the *recycled content* (or *cut-off*) approach but does not require it. This approach involves drawing a "line" (cut-off point) in the life cycle of a recyclable material, between the primary and secondary systems. The system that generates the waste bears the burden upstream of that cut-off point, and the system that uses the secondary material bears the burden downstream of that cut-off point.

This approach can be applied with different cut-off points. The GHG Protocol suggests placing the cut-off point after waste collection, meaning that organizations generating recyclable materials must account for the transportation emissions associated with delivering them to the processing site. The recycled content approach and this specific cut-off point are illustrated in Figure 3. However, the GHG Protocol allows flexibility in defining the cut-off point, emphasizing the need for consistency between its placement for both purchases of secondary products (scope 3, category 1) and generated recyclable materials (scope 3, category 5).

FIGURE 3 • ILLUSTRATION OF THE RECYCLED CONTENT (CUT-OFF) APPROACH



Note: "Life cycle 1" corresponds to the life cycle of the primary product, whereas "Life cycle 2" corresponds to the life cycle of the secondary product. The "cut-off point", according to the recommendation of the GHG Protocol, is placed after the collection and transportation of the primary product at its end-of-life. Thus, the organization generating the recyclable material accounts for emissions associated with its collection and transportation up to the processing site, in scope 3, category 4 (waste generated in activities). The organization purchasing the secondary product accounts for emissions associated with its recycling (sorting, cleaning, treatment, etc.) in scope 3, category 1 (purchased goods and services). The transportation of the secondary product between recycling facilities and the purchasing organization is accounted for in scope 3, category 4 (upstream transportation and distribution).

The GHG Protocol also permits organizations to apply alternative approaches if they better suit specific materials within their supply chains. For instance, it refers to the *closed-loop approximation* method, noting it can be relevant when a recycled material output retains the same inherent properties as its virgin material input. However, the GHG Protocol explicitly prohibits the use of system expansion (i.e., substitution) to calculate and report avoided emissions from generated recyclable materials.

In **LCA**, the multifunctionality resulting from incoming or outgoing recyclable materials is often addressed using specific approaches. One of the most commonly used approaches in LCA is the cut-off approach, which is widely applied in LCI databases. However, the cut-off point is often placed before the collection and transport of residual materials, rather than after these stages, as recommended by the GHG Protocol. The LCA community uses a wide range of other methods tailored to the objectives of different types of studies, such as the *50/50*, *closed-loop approximation* and system expansion approaches, among others. One key difference with the GHG Protocol is the use of system expansion, as well as end-of-life allocation approaches that partly rely on it (i.e., through crediting), such as the *Circular Footprint Formula*.

1.10 AVOIDED EMISSIONS

Avoided emissions represent the difference between the GHG emissions associated with a given solution (e.g., a product or service) and those that would have occurred under an alternative baseline scenario. In other words, they capture the "positive" impact (i.e., benefit) of displacing a more emissions-intensive option.

In the **GHG Protocol**, avoided emissions are not part of the main GHG inventory, which is limited to emissions and removals within defined organizational and operational boundaries (i.e., scopes 1, 2 and 3). Avoided emissions typically relate to emission reductions enabled by the use of sold products or services compared to a counterfactual baseline (e.g., more efficient tires reducing fuel use compared to conventional tires). These impacts are assessed using intervention-based approaches (e.g., the *Project Protocol* [GHG Protocol, 2006]), which estimate system-wide consequences relative to what would have happened in the absence of the intervention. Although sometimes referred to as *scope 4*, avoided emissions must be reported separately and cannot be aggregated with GHG inventory results.

In product **LCA,** the treatment of avoided emissions is less explicit and depends on the type of study. In comparative LCAs, they are inherently captured in the difference between systems delivering the same function, defined by a common functional unit. In non-comparative LCAs, they may be excluded, included, or reported separately (e.g., as "benefits beyond the system boundary" in Module D of the *EN 15804* standard), depending on the context and objectives of the study. Additionally, when multifunctionality is addressed through system expansion, avoided emissions can be credited to the system by accounting for displaced products or functions. These credits reflect system-level effects and may not be directly attributable to a single function of the system.

For example, in the case of electricity produced through cogeneration, the system expansion approach attributes a credit to the product system for displacing conventional heat generation. This credit reflects avoided emissions, but it pertains to the overall cogeneration process, not to the electricity alone. In contrast, an example of avoided emissions specifically related to electricity would be those that occur when the electricity displaces a more carbon-intensive energy source, for instance when it is supplied to a remote area that previously lacked access.

Overall, avoided emissions in organizational approaches are counterfactual impacts occurring outside the inventory boundary, most often linked to the use phase of sold products or services, and are always reported separately. In contrast, in product LCA, avoided emissions are not treated as a standalone concept and are handled differently depending on the type of study: in comparative LCAs, they are implicitly captured through the difference between functionally equivalent systems, while in non-comparative LCAs they may be integrated into the results, excluded, or reported separately as additional information.

1.11 REPORTING AND RESULTS INTERPRETATION

In terms of reporting, the **GHG Protocol** is more specific regarding the quantitative and qualitative elements to include in a report**.** For instance, it requires reporting emissions by individual GHGs, for each scope, and for each scope 3 category. Organizations are also required to disclose a variety of qualitative information, including the list of included and excluded scope 3 categories, a description of data sources, the calculation methods used, etc. This is to be expected, as the GHG Protocol outlines a more targeted type of study than the general LCA framework set out in ISO *14040/44*. However, the reporting requirements of the GHG Protocol are not necessarily more detailed than specific LCA frameworks (e.g., Product Category Rules [PCRs]).

A key difference between the two approaches lies in the **emphasis placed on result interpretation**. LCA frameworks typically require more complementary analyses to better interpret results and identify their limitations (e.g., data quality assessments, sensitivity analyses, and uncertainty analyses). This reflects the GHG Protocol's goal of simplifying the process of conducting a GHG inventory. Reducing the need for additional analyses is consistent with that objective. Conversely, *ISO 14072* explicitly requires sensitivity and data quality analyses.

Finally, one notable difference is that LCA requirements vary depending on the **intended use of the report.** The level of disclosure and interpretation required is less stringent for internal reports than for those intended for third parties. LCA standards even include specific requirements for comparative studies disclosed to the public, which are generally less relevant for organizational studies, whose goal should not be to compare two different organizations.

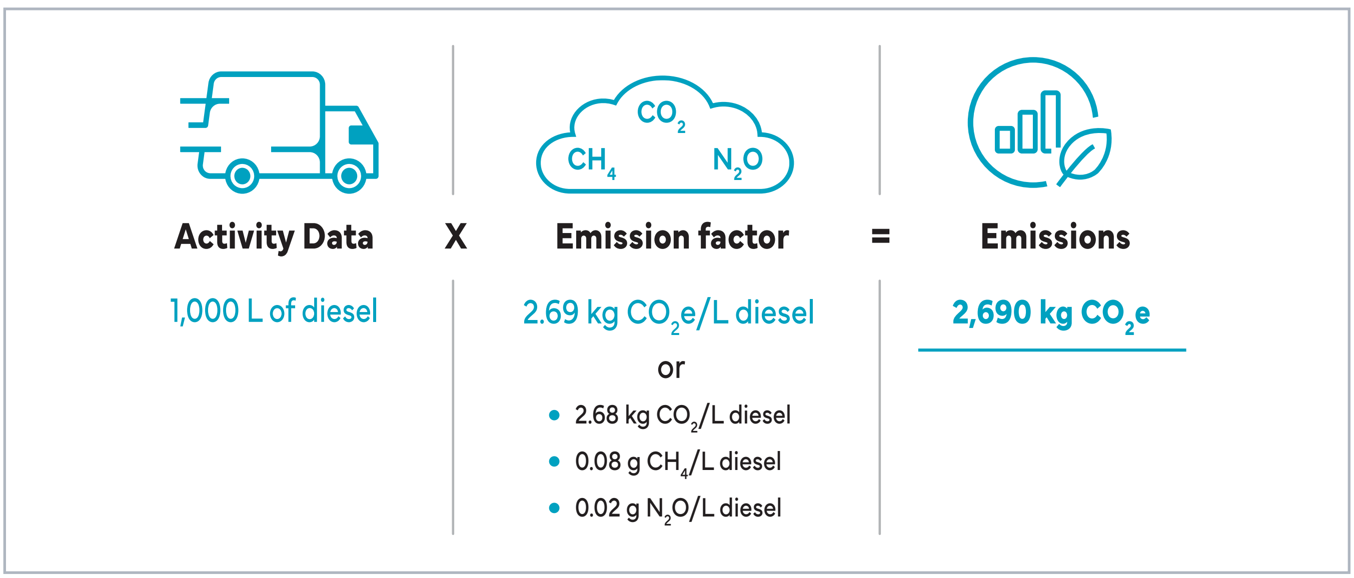
2 | LIFE CYCLE DATA AND ITS USE FOR CORPORATE GHG ACCOUNTING

This second section briefly presents the different approaches for quantifying GHG emissions and situates the use of emission factors within these approaches. It then proposes a categorization of the various types of emission factors based on four characteristics. Finally, it provides a brief analysis of the advantages and limitations of the main types of emission factors used in organizational GHG inventories. For a more comprehensive assessment of the different types of emission factors, readers may refer to *Technical Report 2*.

2.1 EMISSION QUANTIFICATION APPROACHES

Different approaches can be used to quantify GHG emissions. Direct measurement (e.g., concentration monitoring at a smokestack exit), while the most accurate, is often impractical for organizations. Alternatively, calculation-based approaches using a mass balance or stoichiometric basis (e.g., estimating CO_2 emissions from fuel combustion based on its carbon content) may be applied. Nevertheless, the most commonly used approach for organizations to estimate GHG emissions associated with an activity is to multiply *activity data* by *emission factors*. This approach is summarized in Figure 4.

FIGURE 4 • GENERAL GHG EMISSIONS CALCULATION APPROACH



An **activity data** is a quantitative measure of an activity that generates GHG emissions. For example, when calculating emissions from a truck, activity data may be expressed as the quantity of fuel consumed (e.g., litres of diesel), the distance travelled (e.g., kilometres driven), or the mass of goods transported over a given distance (e.g., tonne-kilometres).

An **emission factor** is a calculated ratio relating GHG emissions to a given measure of activity. As illustrated in Figure 4, an emission factor can be expressed either in CO_2e, thereby aggregating multiple GHGs, or for an individual GHG. When expressed for a specific GHG (e.g., kg CH_4/L diesel), the resulting emissions must then be multiplied by the corresponding GWP to obtain a value expressed in CO_2e.

Since activity data are typically obtained directly from the reporting organization's records, and the choice of GWP values is prescribed by standards or limited to a small number of options, the main methodological decision for organizations is usually the selection of appropriate emission factors. Therefore, the remainder of this section focuses on emission factors.

2.2 CHARACTERISTICS OF EMISSION FACTORS

A wide range of characteristics can be used to describe emission factors. Some relate to the extent to which an emission factor matches the activity being modelled. Among these, **representativeness** describes how well the emission factor reflects actual activities and real-world conditions over time (temporal representativeness), across locations (geographical representativeness), and within the relevant technological context (technological representativeness). Another relevant characteristic is **completeness** (coverage), which indicates whether the emission factor accounts for all relevant emissions, processes, and life cycle stages required to adequately represent the activity.

Other characteristics describe practical attributes of an emission factor, such as its **accessibility** (e.g., whether it is openly available or requires a specific tool), **affordability** (i.e., the cost of accessing the data), **adaptability** (i.e., whether the underlying model can be refined to improve representativeness), and **transparency** (i.e., whether the methodology, data, assumptions, and modelling choices are clearly documented and easily accessible).

Finally, some characteristics relate specifically to how an emission factor is developed and expressed, including its **data origin**, **modelling approach**, **level of disaggregation**, and **reference unit**. These characteristics are defined in Table 2 and used to classify the different types of emission factors in the next subsection.

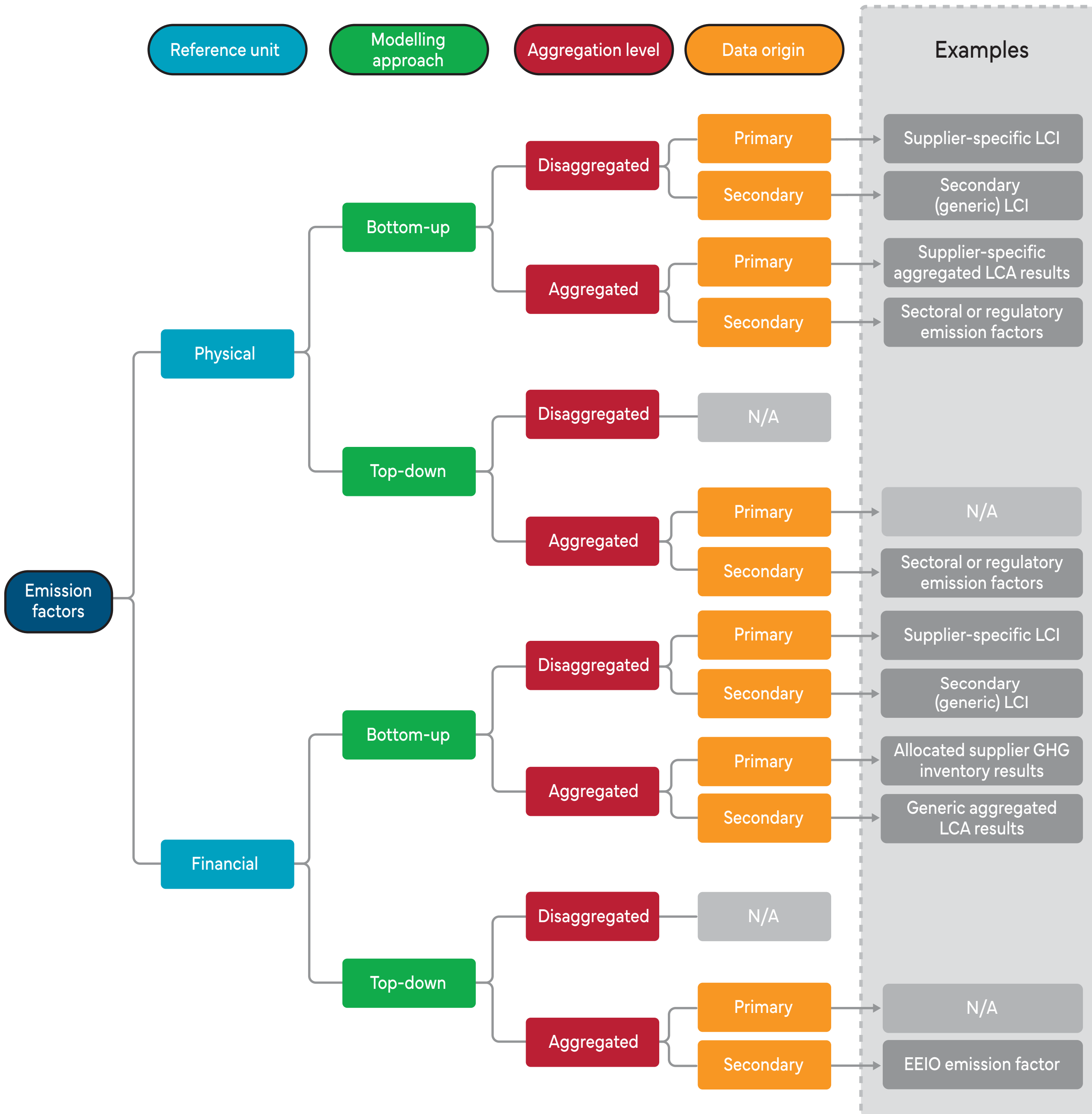
TABLE 2 • CHARACTERISTICS USED TO CLASSIFY EMISSION FACTORS

Characteristic	Description
Data origin	The data origin describes the level of specificity of the emission factor and can be viewed along a spectrum. At one end, an emission factor is based on *primary data* when it is developed using data collected directly from the reporting organization's own operations or from partners within its value chain. At the other end, an emission factor is based on *secondary data* when it relies on information that does not come from the specific activities of the organization or its value chain. Between these two ends of the spectrum, an emission factor may also be considered *hybrid*. For example, a generic emission factor may be adapted by replacing default energy inputs with the specific quantities consumed by the organization.
Modelling approach	The modelling approach describes the analytical method used to develop an emission factor and estimate the emissions associated with a given activity. A *bottom-up* modelling approach estimates emissions through detailed process-level modelling by representing the specific processes, and their associated input and output flows, required to deliver a product or service (e.g., LCA). A *top-down* modelling approach estimates emissions by allocating high-level emission data, usually at the level of entire sectors, industries, or regions, to a specific unit of product or service. For instance, this approach is used in environmentally extended input-output (EEIO) models.
Disaggregation level	The level of disaggregation describes the level of detail that an emission factor makes visible to the user. *Disaggregated* emission factors provide access to the underlying model (i.e., a chain of interconnected processes) and the different GHGs included, and may allow users to adapt the emission factor to better reflect their specific activity. They provide *inventory data*, i.e., the input and output flows associated with the activity. *Aggregated* emission factors typically provide only a single value (e.g., kg CO_2e/kg product), without access to the underlying modelling structure or assumptions. They provide only *emissions data*. Between these two levels lies a broad range of *semi-aggregated* emission factors. These do not provide access to the full underlying modelling details, but they may present emissions broken down by scope, scope 3 category, emission source, or GHG.
Reference unit	The reference unit corresponds to the denominator of the emission factor. *Physical* emission factors use measurable physical quantities, such as mass, volume, energy or distance, as reference units. They are often conflated with *process-based* emission factors. *Financial* emission factors are expressed with a monetary reference unit, typically one unit of currency (e.g., per euro). They are also referred to as *spend-based* emission-factors. EEIO emission factors are a common example of *financial* emission factors.

2.3 TYPES OF EMISSION FACTORS

A wide variety of emission factor types exist, which can be categorized according to the characteristics and attributes described in Table 2. Figure 5 presents a categorization of emission factors based on the four characteristics defined previously and provides specific examples. Although these characteristics are presented here as binary options – for example, a *bottom-up* or *top-down* modelling approach – in reality, many emission factors fall along a continuum between these two ends of the spectrum.

FIGURE 5 • CLASSIFICATION OF EMISSION FACTORS BASED ON FOUR CHARACTERISTICS



Note: Emission factors associated with a "physical" reference unit have a physical denominator (e.g., one unit of mass, volume, energy, etc.). In contrast, emission factors associated with a "financial" reference unit have a monetary denominator (i.e., one unit of currency).

2.4 ADVANTAGES AND LIMITATIONS OF THE DIFFERENT TYPES OF EMISSION FACTORS

2.4.1 Overview

Table 3 presents a high-level analysis of different types of emission factors, assessed against a set of criteria describing certain attributes (e.g., level of specificity, coverage) as well as data quality (e.g., representativeness). It does not include all existing types of emission factors, but rather focuses on the main types used in organizational GHG inventories.

It should be emphasized that this analysis is generic and that, in practice, the performance achieved by a given type of emission factor for any specific criterion depends on a wide range of factors.

For example, the activity represented by an emission factor – whether it corresponds to a direct emission source (e.g., combustion) or an indirect one (e.g., procurement) – can influence several criteria, including its specificity, representativeness, and consistency with GHG Protocol requirements. As such, Table 3 is provided for informational purposes only, and readers are encouraged to consult *Technical Report 2* for a more detailed assessment of the different types of emission factors. The following subsections briefly describe their main advantages and limitations.

TABLE 3 • GENERIC ASSESSMENT OF CRITERIA ASSOCIATED WITH DIFFERENT TYPES OF EMISSION FACTORS

Criterion	Supplier-specific LCI	Secondary (generic) LCI	Supplier-specific allocated GHG inventory results	Sectoral or regulatory default emission factors	EEIO emission factor
Specificity	Very high	High, Medium	High, Medium [7]	Low	Very low
Coverage of the emission factor	Very high, High	High	High, Low [8]	High, Low [9]	Very high
Geographical representativeness	Very high, High	High, Low	Very high, High	High, Low [9]	High, Low [10]
Technological representativeness	Very high, High	High, Low	High, Low [7]	High, Low [9]	Low, Very low
Temporal representativeness	Very high, Low [1]	Low	Very high, Low [1]	Medium	High, Medium
Adaptability	Very high, Low [2]	High [5]	High, Low [2]	Very low	Very low
Transparency	Very high, Low [2]	High [5]	High, Low [2]	Low	Low
Consistency with GHG Protocol	Very high, Medium [3]	High, Low [6]	High	High, Low	Medium [11]
Affordability	Low, Very low [4]	Low	Low [4]	Very high	High
Accessibility	Medium, Low	High, Medium	Medium	Very high	Medium

● Very high ● High ● Medium ● Low ● Very low

[1] Depends on update frequency; [2] Depends on whether the supplier-specific data is aggregated or disaggregated; [3] Mostly depends on the system boundaries of the LCI and their consistency with the boundaries of the assessed scope 3 category. If the emission factor is disaggregated, it may be adapted to ensure consistency; [4] For the value chain partner providing the data or emission factor; [5] Secondary LCI data are generally disaggregated; [6] System boundaries of secondary LCI data may or may not be consistent with those of the emission scopes and categories of the GHG Protocol; [7] Depends on the type of allocation (i.e., generic allocation resulting in an overall carbon intensity of the supplier or allocation between the supplier's products and services); [8] Depends on the boundaries of the underlying GHG inventory and whether they were adapted; [9] Mostly depends on the activity represented by the emission factor. Sectoral or regulatory default emission factors may have good representativeness, especially for scope 1 activities (e.g., fuel combustion); [10] Depends on the geography selected for the EEIO emission factor relative to the geographic characteristics of the modelled activity (i.e., production location, supplier location). This aspect is addressed in section 3.4; [11] EEIO emission factors may not include all GHGs required by the GHG Protocol and are not consistent with the minimum boundaries.

2.4.2 Supplier-specific life cycle inventory

LCI data are structured as a network of unit processes, each representing an individual activity (e.g., electricity generation, steel production, transportation) and its associated input and output flows. By linking multiple unit processes together, LCI data capture the full supply chain required to deliver a given product or service.

Accordingly, LCI data are developed using a *bottom-up* modelling approach and are generally *disaggregated*. They typically represent one or more life cycle stages of a product or service (e.g., cradle-to-gate), while capturing the full value chains associated with those stages. For this reason, they are relatively **comprehensive** in terms of coverage and are particularly useful for quantifying indirect emissions.

Supplier-specific LCI data (or primary LCI data) are developed using data from the reporting organization itself or from a partner within its value chain. They also typically use a *physical* reference unit, although they may be converted and expressed in a *financial* unit. For example, supplier-specific LCI data may consist of an LCA study provided by a value chain partner.

Supplier-specific LCI data generally offer **strong representativeness** and a **high level of specificity**, as they seek to accurately model the various processes and flows associated with the product or activity. Furthermore, their disaggregated nature makes them a **transparent** and **adaptable** type of emission factor, facilitating compliance with GHG Protocol requirements.

However, supplier-specific LCI data are often **limited in availability** and **resource-intensive to develop**, as they require access to extensive data, significant time, and expertise in LCA modelling. This also tends to result in relatively **infrequent updates**. Finally, because they are often developed according to LCA approaches, they may raise consistency issues with GHG Protocol requirements, particularly regarding system boundaries and the included GHGs.

2.4.3 Secondary (generic) life cycle inventory

Secondary LCI data (or generic LCI data) are also modelled using a *bottom-up* approach. They are generally *disaggregated* and expressed in a *physical* reference unit. However, they are developed using secondary data sources or directly derived from the literature or existing LCI databases.

Their level of **specificity and representativeness can vary significantly**, ranging from high to low depending on the dataset and the activity being modelled. Nevertheless, their disaggregated structure provides a generally acceptable level of transparency and enables adaptability, thereby allowing improvements in specificity. In this sense, secondary LCI data can be adjusted using primary data (e.g., by modifying input or output flows), thereby becoming a hybrid dataset combining primary and secondary elements.

The existence of multiple LCI databases makes this type of emission factor relatively **accessible**, although access often comes at a **cost**. However, LCI databases frequently **lack comprehensive coverage** of processes across sectors, technologies, and regions.

As with supplier-specific (primary) LCI data, secondary LCI data are **sometimes inconsistent** with GHG Protocol requirements. This can particularly pose challenges for organizations seeking to comply with the GHG Protocol's minimum boundaries.

2.4.4 Allocated supplier GHG inventory results

A reporting organization may need to use the results of a value chain partner's GHG inventory to represent emissions associated with an activity within its own value chain. Typically, this involves estimating the emissions related to the production of a purchased good and therefore obtaining data from a supplier.

In such cases, the emission factor is derived by dividing the supplier's total emissions by a unit representing its outputs, such as the total mass of products sold or the associated revenues. This type of emission factor – an allocated supplier GHG inventory result – is therefore primarily *bottom-up*[5], may be *semi-aggregated* (e.g., results by scope or category) or *aggregated* (e.g., kg CO_2e/$), and may be expressed in either *physical* or *financial* reference units.

One advantage of an allocated supplier GHG inventory result is its potential **specificity** to the reporting organization's value chain, as it is based on primary data. However, the actual **level of specificity may vary** considerably depending on the supplier's accounting approach and operating context. For instance, if a supplier produces several significantly different products, a generic allocation (i.e., division of total emissions by total outputs) based on the total mass of outputs may not provide a sufficiently product-specific result. Conversely, if the emissions of the supplier are allocated to each of its products, thereby addressing multifunctionality, this may lead to a more specific emission factor than a generic allocation.

However, the *aggregated* or *semi-aggregated* nature of these factors may **limit transparency** regarding what is included (e.g., boundaries, GHGs covered) and the underlying methodological choices (e.g., allocation methods). For example, if an allocated supplier GHG inventory result is used to represent the procurement of a product, it should exclude downstream activities of the supplier (e.g., downstream transportation, use of sold products). If the emission factor provided by the supplier is fully aggregated and no information regarding its boundaries is provided, there may be a risk of double counting for the reporting organization.

2.4.5 Sectoral or regulatory default emission factors

Sectoral or regulatory default emission factors are provided by international organizations (e.g., IPCC), government agencies (e.g., United States Environmental Protection Agency [U.S. EPA]), or industry associations (e.g., World Steel Association). They are *secondary* data sources typically available online. They are generally expressed in *physical* units and are *aggregated*, although they may sometimes be disaggregated by individual GHG (e.g., fuel combustion emission factors).

They may be developed using either a *bottom-up* or *top-down* approach. The completeness of their coverage varies: some adopt a life cycle perspective (e.g., an LCA-based emission factor for a commodity developed by an industry association), while others focus only on the direct emissions of an activity. Indeed, *direct emission factors* are a subset of this category. These factors capture only the direct emissions associated with an activity (e.g., vehicle use considering only combustion emissions) and are particularly **useful for quantifying scope 1 emissions**.

Because they are developed by large organizations, often under significant scrutiny, and frequently cover simpler processes or narrower system boundaries (as is often the case for direct emission factors), they tend to be **relatively robust** and **updated on a regular basis**. They are also generally **free** and **easily accessible**.

[5] It is primarily a *bottom-up* emission factor as the modelling approach of the underlying GHG inventory is *bottom-up*. However, it also incorporates a *top-down* approach, as emissions of a higher-level system (i.e., organization) are allocated to its outputs.

However, in some instances, their *aggregated* nature makes them difficult to use in a manner that ensures **consistency with certain GHG Protocol requirements** (e.g., separate reporting by GHG). In addition, their level of specificity is often limited, depending on the activity represented, since many of these emission factors reflect regional or sectoral averages and therefore may not accurately represent the actual performance or practices of individual organizations within a sector. Finally, they are **only available for certain activities**, which can make it difficult to conduct an organizational GHG inventory relying exclusively on this type of emission factor.

2.4.6 Environmentally Extended Input-Output emission factors

EEIO models combine national input-output tables, which describe monetary flows between sectors of an economy, with environmental accounts, which quantify emissions (or other environmental flows) attributable to each economic sector. Their use results in emission factors that reflect the average emission intensity of commodities (products and services) and/or sectors (hereinafter "commodities"), which can then be linked to expenditure categories within an organization's procurement data.

EEIO emission factors are *secondary* data developed using a *top-down* modelling approach and are *aggregated*. They generally cover the production stages of goods and services (i.e., cradle-to-gate boundaries) and therefore exclude downstream stages such as product transformation, use, and end-of-life treatment. Depending on the database, these emission factors may be provided at either the subnational or national level. The level of sectoral granularity also varies significantly across databases: some provide only a few dozen emission factors (i.e., commodities), while others include several hundred.

One of the main advantages of EEIO emission factors is their **ease of use**. Most EEIO databases are **freely accessible** and express emission factors in financial units, enabling direct matching with an organization's procurement expenditures, which are generally readily available within organizations.

They also provide **extensive coverage**. First, EEIO databases are inherently comprehensive, as they represent the **entire economy**. This broad coverage facilitates the inclusion of emissions associated with a wide range of commodities for the reporting organization, including services, which are often difficult to assess using physical emission factors. Second, this comprehensive coverage enables EEIO databases to **capture entire value chains** associated with commodities, including intangible inputs such as services. For instance, an EEIO emission factor for steel products typically includes the services purchased by the steel manufacturer, such as insurance, banking, and professional services. In contrast, physical emission factors are often truncated and exclude these intangible inputs.

The main limitation of EEIO emission factors lies in their **high level of sectoral aggregation**. As they correspond to relatively high-level commodities, they do not adequately capture the specific technological characteristics of individual commodities. As a result, they generally **lack technological representativeness**. This issue is particularly significant for heterogeneous economic sectors or when the purchase corresponds to a niche commodity. Box 1 provides an example illustrating this limitation.

EEIO emission factors also **do not support adequate tracking of emissions over time**. Because of their low level of specificity, changes in sourcing may not be reflected in emissions results if the newly sourced product remains within the same commodity category. Similarly, emissions results derived from EEIO emission factors are **not always well aligned with the physical reality** of the reporting organization. For instance, if an organization replaces an input with an equal quantity of a lower-carbon alternative that happens to be more expensive, the organization's calculated emissions will increase.

Finally, although EEIO emission factors are relatively easy to use, **several important considerations** must be taken into account to ensure their appropriate application. These considerations mainly stem from the fact that the reference unit of these emission factors – a unit of currency – does not necessarily correspond to the organization's expenditure data, either in terms of the price components included (e.g., taxes, margins, transportation costs) or the reference year of the expenditure value. These considerations are discussed further in section 3.4.

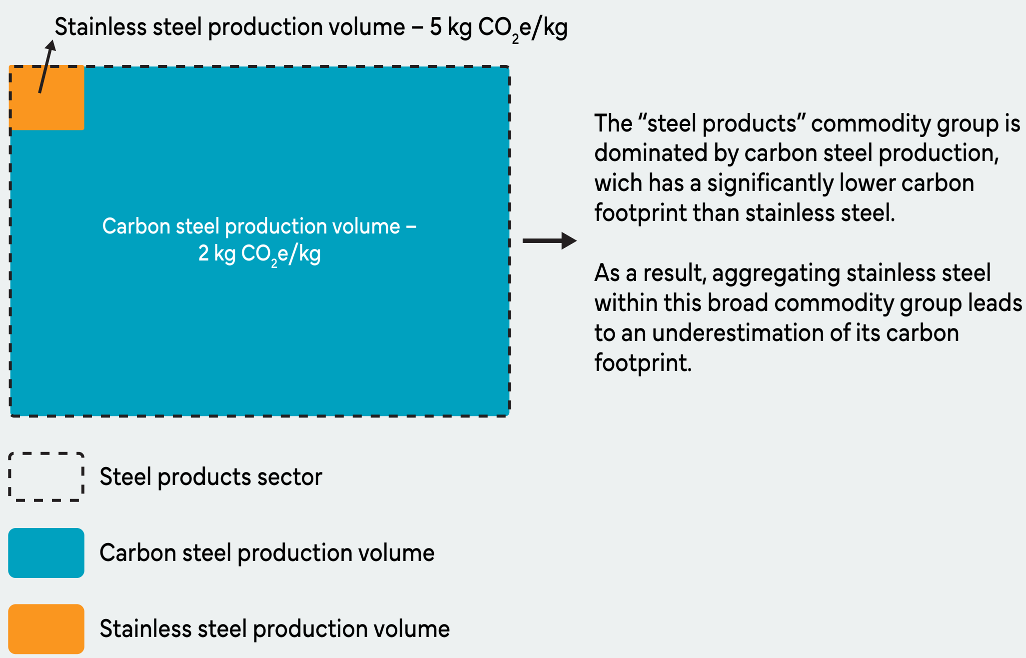
BOX 1 • EXAMPLE OF SECTORAL AGGREGATION OF EEIO EMISSION FACTORS

An EEIO database provides one emission factor for "Steel products", a group of commodities that includes both **carbon steel** and **stainless steel** products.

According to product-specific studies (e.g., LCA studies), the carbon footprint of stainless steel production is around 2.5 times greater than that of carbon steel, at around 5 kg CO_2e/kg compared to roughly 2 kg CO_2e/kg, respectively.

In Canada, roughly 40 tonnes of carbon steel are produced for every tonne of stainless steel. In a simplified example where this EEIO "Steel products" emission factor covered only these two products and both had the same price*, the sector-average emission factor would be calculated as a production-weighted average.

Using the carbon footprint values above, this would yield an average emission factor of 2.07 kg CO_2e/kg of steel, as illustrated in the figure below. Applying this aggregated emission factor to stainless steel would therefore underestimate the emissions by almost a factor of 2.5.



**Note: In reality, stainless steel is significantly more expensive than carbon steel. This simplification is used to illustrate more clearly the aggregation issue associated with EEIO emission factors.*

3 | GUIDELINES FOR IMPROVED CORPORATE GHG ACCOUNTING

This third section aims to provide guidance to support practitioners in improving the robustness of organizational GHG inventories, focusing on aspects related to the development, selection, adaptation and application of emission factors, and the sharing of emissions data (i.e., GHG inventory results) with partners along the value chain.

Technical Report 3 also provides guidance on aspects related to defining the goal and scope, collecting activity data, performing emissions calculations for specific activities, and interpreting and reporting results, which are not detailed here for the sake of brevity. Readers are encouraged to consult this document for a more comprehensive set of recommendations.

As outlined in previous sections, emission factors can originate from either *primary* or *secondary* data sources and may vary in their *modelling approach* and *reference unit*. The following sections are therefore structured accordingly. Section 3.1 addresses data collection for developing supplier-specific (primary) emission factors. Sections 3.2, 3.3 and 3.4 focus on the selection of the main types of *secondary* emission factors, specifically process-based (i.e., *physical*) and EEIO emission factors. Finally, section 3.5 presents good practices for sharing emissions data along the supply chain.

3.1 COLLECTING PRIMARY DATA FROM VALUE CHAIN PARTNERS

Data can be collected from the reporting organization's value chain partners (e.g., suppliers, clients) with the aim of creating or adapting an emission factor based on their specific (primary) data. For example, primary data may be collected directly from the supplier of a good to calculate the emissions associated with its production.

This approach is valuable because collecting primary data improves the representativeness of the emission factor relative to the organization's actual activities. However, it would be very difficult, if not impossible, for an organization to collect primary data from all its suppliers such that secondary emission factors (e.g., from databases) would no longer be needed.

Therefore, organizations should **collect or use primary data for emission factors whenever such data are available, particularly for emission sources that are significant contributors to the GHG inventory results**. In general, this is especially relevant for purchased goods and services (scope 3, category 1), which often represent a significant share of emissions and for which organizations may have greater opportunity to obtain data directly from their suppliers. This section therefore focuses on collecting data from suppliers of products and services, but it also applies to other situations – for example, collecting primary data from a client to assess emissions associated with the processing of sold products.

3.1.1 Level of detail of collected data

Data can be collected at varying levels of detail, depending on what is available from the value chain partner. At one end of the spectrum, data may be provided at the product level, which offers the highest level of detail. This typically takes the form of an LCA study or a product carbon footprint assessment. At the other end of the spectrum, data may be provided at the organizational level, for example when a supplier shares the results of its organizational GHG inventory, which offers a lower level of detail. Whenever possible, **primary data used to develop emission factors should be collected at the highest level of detail available**. The different levels of detail of collected primary data are presented in Table 4.

TABLE 4 • LEVELS OF PRIMARY DATA

Data type	Description
Product-level data	Cradle-to-gate GHG emissions for the product of interest.
Activity-, process- or production line-level data	GHG emissions and/or activity data for the activities, processes, or production lines that produce the product of interest.
Facility-level data	GHG emissions and/or activity data for the facilities or operations that produce the product of interest.
Business unit-level data	GHG emissions and/or activity data for the business units that produce the product of interest.
Corporate-level data	GHG emissions and/or activity data for the entire corporation.

Note: Reproduced from the *Scope 3 Standard* (Table 7.7, p.80), by GHG Protocol, 2011a. Copyright 2026 by World Resources Institute and World Business Council for Sustainable Development. *https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf*

The level of detail at which data are collected influences how the reporting organization subsequently uses those data, particularly with respect to the need for allocation. Product-level data refer specifically to the product under study. If that product originates from a multifunctional system, the multifunctionality has already been addressed. By contrast, data collected at a lower level of detail may relate to a broader system that generates multiple products or services, such as a company. As a result, the organization receiving the data may need to perform an allocation to address the multifunctionality of that system. Collecting data at the finest possible level of detail therefore minimizes the need for allocation.

However, reporting organizations **should ensure that data collected at a finer level of detail are still complete**. For example, while data at the production line level are preferred over organization-wide data, they must still include all relevant processes, and not only certain flows associated with this more detailed system (e.g., only energy inputs). If not, additional data collection or supplementation may be required, which can be complex for the reporting organization.

3.1.2 Aggregation level of collected data

The collected data may vary in their level of aggregation. They may be fully *disaggregated*, meaning they correspond to *inventory data*, namely the inputs (products, energy, etc.) and outputs (waste, direct emissions, etc.) associated with the activity. They may also consist of *aggregated emissions data* expressed as total CO_2e. Emissions data may also be *semi-disaggregated*, when broken down by scope, category, emission source, or individual GHGs.

Reporting organizations **should prioritize the collection of inventory data from suppliers** (i.e., inputs and outputs) when possible, instead of emissions data (e.g., in kg CO_2e). This enables the reporting organization to make methodological choices consistent with those applied in its GHG inventory and with GHG Protocol requirements. These choices include the boundaries (e.g., using minimum boundaries), the specific GHGs included, the GWP100 values used, and other aspects such as the emission factors used (e.g., the choice of LCI database). Moreover, this enables the separate reporting of different types of emissions data, such as biogenic CO_2 emissions, as required by the *Corporate Standard* and the *Scope 3 Standard*.

Although it is desirable to collect inventory data whenever possible, it should be noted that doing so requires more effort from the reporting organization than collecting emissions data. Indeed, this approach involves identifying appropriate emission factors for the inventory data received (i.e., inputs and outputs).

If inventory data are unavailable or their use is not relevant or possible, collecting emissions data is acceptable, though this may limit the ability to make subsequent methodological adjustments. In such cases, reporting organizations **should request emissions data in the most disaggregated form possible** – ideally broken down by individual GHG, by emission category, or even by emission source.

Alternatively, if the reporting organization has sufficient influence, it **should consider requiring its suppliers to follow specific methodological practices** (e.g., using specific GWP100 values, including specific GHGs, etc.). This can help ensure the methodological consistency of the data collected with the reporting organization's GHG inventory and avoid the need to develop an emission factor from inventory data.

3.1.3 Boundaries of collected data

Once appropriate data have been collected, the first step is to adjust the system boundaries. This adjustment is possible only when the data are collected with a certain degree of disaggregation, whereas this step is not possible when the data are fully aggregated (e.g., as a single CO_2e value). This highlights the importance of prioritizing the collection of data at the highest possible level of disaggregation.

First, some activities may be missing, requiring the reporting organization to collect additional primary data or supplement them with secondary data. For example, for a purchased good, the data should cover the full cradle-to-gate stage. If plant-level data are provided but do not include upstream transportation of inputs, these transport emissions should be added to meet the boundaries of category 1 (purchased goods and services).

Second, some activities included in the supplier's data may go beyond the category's boundaries. For example, if a product supplier provides a GHG inventory that includes downstream categories[6] (e.g., downstream transportation, use of sold products), these should be removed by the reporting organization to avoid double counting. More specifically, **the following scope 3 categories should be excluded to avoid double counting when developing an emission factor associated with a purchased good or service**:

- Category 9: Downstream transportation and distribution
- Category 10: Processing of sold products
- Category 11: Use of sold products
- Category 12: End-of-life of sold products

Other categories are defined by the GHG Protocol as "downstream" but are not physically downstream of the value chain. Therefore, their inclusion would not result in double counting. These include downstream leased assets (category 13), franchises (category 14), and investments (category 15). In the absence of clear GHG Protocol guidance on whether these categories should be included within the boundaries of emission factors, reporting organizations **should include them in the calculated emission factors**.

Boundary adjustment is particularly important when the reporting organization is required to adhere to minimum boundaries. In this specific case, the collected data may cover activities that fall outside the minimum boundaries, particularly when the data are derived from a corporate-level GHG inventory. This applies to all scope 3 categories except categories 1 and 2, namely purchased goods and services

[6] Categories that are physically downstream in the value chain are not the same as those that the GHG Protocol defines as "downstream". The GHG Protocol defines downstream categories as those related to products that are sold or distributed by the reporting organization (e.g., including downstream leased assets, investments).

and capital goods, as their minimum boundaries already have comprehensive coverage (i.e., cradle-to-gate boundaries). For example, if an organization uses the GHG inventory of a freight transportation provider to develop an emission factor for category 4 (upstream transportation and distribution), it will need to exclude emission sources such as the production of fuels used in transportation, which fall outside the minimum boundary for this category.

When the reporting organization must follow minimum boundaries, it **should ensure that the collected data can also reflect the full life cycle of the activity**[7], enabling dual reporting as recommended in *Technical Report 3.* In this case, dual reporting consists of reporting a second GHG inventory in which a life cycle perspective is applied to all scope 3 categories, rather than using the minimum boundaries.

3.1.4 Included GHGs in collected data

Reporting organizations **should ensure that the data collected are consistent with GHG Protocol requirements regarding the GHGs included and the metric used to convert them into CO_2e**. When sufficiently disaggregated data are collected, such as inventory data or emissions data disaggregated by GHG, the reporting organization should ensure that only the seven GHGs required by the GHG Protocol are included and apply the most recent GWP100 values to convert these emissions into CO_2e.

Conversely, when fully aggregated emissions data are collected, such as a single CO_2e value, the reporting organization cannot adjust the GHGs included or recalculate the CO_2e value using different GWP100 values. In such cases, the reporting organization should verify that the methodology used by its value chain partner is consistent with GHG Protocol requirements regarding the GHGs included and the GWP values applied. If inconsistencies are identified, these **should be documented, along with their potential influence on the results**.

3.1.5 Allocation of collected data

As mentioned previously, the level of aggregation of the data collected may determine whether allocation is required. When product-level data are collected, the reporting organization typically has no control over the allocation method applied by the supplier if the product originates from a multifunctional system. Therefore, for emission sources that contribute significantly to the inventory, reporting organizations should **document the allocation method used and, where possible, assess the impact of alternative allocation methods on the results**.

By contrast, data collected at a lower level of detail (e.g., organizational-level data) may need to be allocated. Where applicable, this involves allocating emissions or inventory data (i.e., inputs and outputs) among the different products of the system from which the data are collected.

The first type of allocation simply consists of dividing the collected data by the supplier's total number of output units – for example, the number of products sold, total mass produced, or even the revenue generated. The second type relates to the treatment of a multifunctional system, that is, when the system from which the data are collected generates different outputs (i.e., multiple products). It is this second type of allocation, associated with multifunctional systems, that is addressed below.

A typical example of allocation is when the reporting organization receives a supplier's GHG inventory, but the supplier produces more than one product. The reporting organization must allocate the supplier's emissions across all outputs to isolate the emissions associated with the specific purchased product.

[7] Excluding life cycle stages and processes that are included in other scope and categories.

The **choice of allocation method should follow the GHG Protocol guidance**[8]. Although the GHG Protocol presents economic allocation as a last resort in its decision tree, it is important to note that this type of allocation is often more appropriate than allocation based on the physical attributes of outputs (e.g., mass). Indeed, the primary driver of a production process is generally the economic value of its outputs, rather than their physical quantities alone. As such, economic allocation often better reflects the underlying drivers of a multifunctional system, particularly when its outputs differ significantly in value or function.

In addition, in certain specific situations, an allocation based on the underlying physical relationships – not explicitly addressed in the GHG Protocol – may be preferable (see section 9 of *Technical Report 1* for more detail). **The choice of allocation method should also consider sector-specific practices**, as reflected in applicable Product Category Rules (PCRs).

Organizations may also want to report product removals, i.e., CO_2 removals where the carbon is stored in products. Under the *Corporate Standard* and the *Scope 3 Standard*, these removals may be reported separately as supplementary information. In such cases, when allocation is required for a bio-based product, **product removals should be allocated in proportion to the carbon content of each product**, rather than using allocation factors that may not accurately reflect how the carbon is distributed between products (such as when economic allocation is applied). In contrast, other types of removals (e.g., land-based removals), if reported, should be allocated using the same method as that used for emissions.

Under the *Land Sector and Removals Standard*, reporting product removals is optional and disclosed separately, in the "*Product carbon storage*" accounting category. This accounting category relies on a stock-change accounting approach that directly quantifies carbon stored in products, making allocation methods unnecessary.

3.1.6 Decision tree – Collecting primary data from suppliers

The decision tree in Figure 6 summarizes the recommendations in section 3.1. It provides guidance on the key choices involved in collecting primary data from value chain partners to develop more specific emission factors. Additional notes related to the decision tree are detailed in Table 5. In the decision tree, these notes are identified using numbers in brackets (e.g., [1]).

[8] See section 8 of the *Scope 3 Standard* (GHG Protocol, 2011a).

FIGURE 6 • DECISION TREE TO SUPPORT THE COLLECTION OF PRIMARY DATA USED FOR EMISSION FACTORS

TABLE 5 • NOTES ASSOCIATED WITH THE DECISION TREE IN FIGURE 6

Note	Description
[1]	This approach involves recalculating emissions using the collected activity data. Although more complex, it offers the advantage of allowing the reporting organization to apply methodological choices that are consistent with those used elsewhere in its GHG inventory (i.e., included GHGs, GWP values, allocation method, selection of emission factors, etc.). When the collected data are subject to an underlying allocation, the reporting organization should gather the information related to that allocation (allocation method, allocation factor) and, where possible, the results obtained using an alternative allocation method.
[2]	In this case, it is impossible to collect emissions data derived from a methodological approach that is fully consistent with that of the reporting organization. Therefore, the organization should collect a description of the methodology applied by its value chain partner (standard followed, boundaries, included GHGs, etc.). If the reporting organization has sufficient influence, it may be appropriate to request that its value chain partner adopt specific methodological choices, particularly those that have a significant impact on the results.
[3]	In this case, the organization has collected inventory data that may need to be allocated. If applicable, the reporting organization may either: • Allocate the inventory data (inputs and outputs) and then quantify emissions based on the allocated inventory data; or • Quantify emissions using the "unallocated" inventory data and then allocate the resulting emissions.
[4]	If not, the organization should request data from its value chain partner with appropriate boundaries or, alternatively, the information required to make the necessary adjustments. Here, the "no" branch of the decision tree should only be followed when this is also not possible.
[5]	For example, where cradle-to-gate boundaries are required, inclusion of the use phase of sold products (category 11) is outside the boundaries and likely to significantly influence the results. By contrast, inclusion of downstream transportation and distribution (category 9) is unlikely, in most cases, to significantly affect the results.
[6]	This approach essentially consists of using secondary data to quantify the emissions associated with the activity, since the primary data are not considered adequate. Because the activity may be a significant contributor, this estimate based on secondary data can provide an order of magnitude and help determine whether obtaining primary data (with appropriate boundaries) is necessary, depending on the contribution of the activity's emissions relative to the reporting organization's total emissions.

3.2 SELECTING THE TYPE OF SECONDARY EMISSION FACTORS

Selecting secondary emission factors is a critical step in developing a GHG inventory. As discussed in *Technical Report 2*, many specific types of emission factors exist. However, they can be categorized into two broad categories: process-based (i.e., *physical*) and spend-based (i.e., *financial*) emission factors. Within the category of spend-based emission factors, EEIO emission factors are specifically included in the following subsections, as they represent the predominant type of spend-based emission factor.

As outlined in section 2, process-based emission factors offer several advantages over EEIO emission factors, including much better technological representativeness and improved tracking of emissions over time. For this reason, reporting organizations **should prioritize the use of process-based emission factors whenever possible**.

Nevertheless, using process-based emission factors to calculate emissions across all organizational activities can be challenging, primarily due to the limited availability of physical data – both activity data and emission factors. Therefore, certain criteria can help organizations decide when it is worthwhile to invest additional resources in adopting a process-based rather than an EEIO approach.

First, the use of EEIO emission factors is only relevant for activities that the reporting organization pays for. The GHG Protocol recommends a spend-based approach only for certain categories: purchased goods and services (category 1), capital goods (category 2), upstream transportation and distribution (category 4), business travel (category 6), downstream transportation and distribution (category 9), and investments (category 15). Therefore, reporting organizations **should limit the use of EEIO emission factors to these categories, in line with the GHG Protocol's guidelines**.

However, even for scope 3 categories for which the use of EEIO emission factors is applicable, **using a process-based approach rather than a spend-based approach is recommended when**:

- The emission category or source under consideration is an important contributor to the overall GHG inventory. A category representing more than 10% of total emissions is generally considered significant. That said, this threshold may vary depending on the characteristics of the GHG inventory – such as its operational boundaries or the organization's sector. Moreover, the relative contribution of a specific emission source also depends on how it is defined and aggregated (e.g., aggregated transport of all inputs vs. transport of a single input) and should thus be evaluated on a case-by-case basis.
- The emission category or source is targeted for future emission reductions as part of the organization's mitigation strategy (e.g., reduction targets, net-zero commitments). In this case, a process-based approach allows for better tracking of how the organization's actions affect its emissions.
- The reporting organization has significant influence over the emission category or source.
- The reporting organization is required to apply minimum boundaries, and the assessed emission source is part of categories 4 (upstream transportation and distribution) or 6 (business travel) of scope 3. In these cases, EEIO emission factors extend beyond the minimum boundaries, although this does not necessarily have a significant impact on results.
- Sufficient activity data and emission factors are available, or can be made available, to support a process-based approach.

By contrast, EEIO emission factors are particularly relevant for purchased services (category 1), where emissions are often difficult to calculate using a process-based approach. In addition, EEIO emission factors can be particularly useful for organizations with a large number of inputs, where applying a process-based approach would be overly complex and time-consuming. In such cases, **a spend-based approach should be applied as an initial screening step**. This allows for the rapid identification of potentially significant purchases, for which a process-based approach should then be applied to improve data quality.

3.2.1 Converting spend-based activity data into physical activity data

Often, a spend-based approach is appropriate when physical activity data are simply unknown to the reporting organization – for example, when it does not know the mass of purchased goods. In such cases, a common practice is to convert spend-based activity data (expenditures) into physical activity data (e.g., mass) using conversion factors (e.g., commodity prices) and then apply process-based emission factors.

However, difficulties often arise when organizations attempt to convert spend-based activity data into physical quantities (e.g., price variability, inflation). For this reason, it is always preferable to obtain physical quantities directly (e.g., from invoices) rather than converting expenditures using a price per physical unit.

If physical activity data are not readily available, **converting spend-based activity data into physical activity data, while time-consuming, should still be prioritized over an EEIO approach given the**

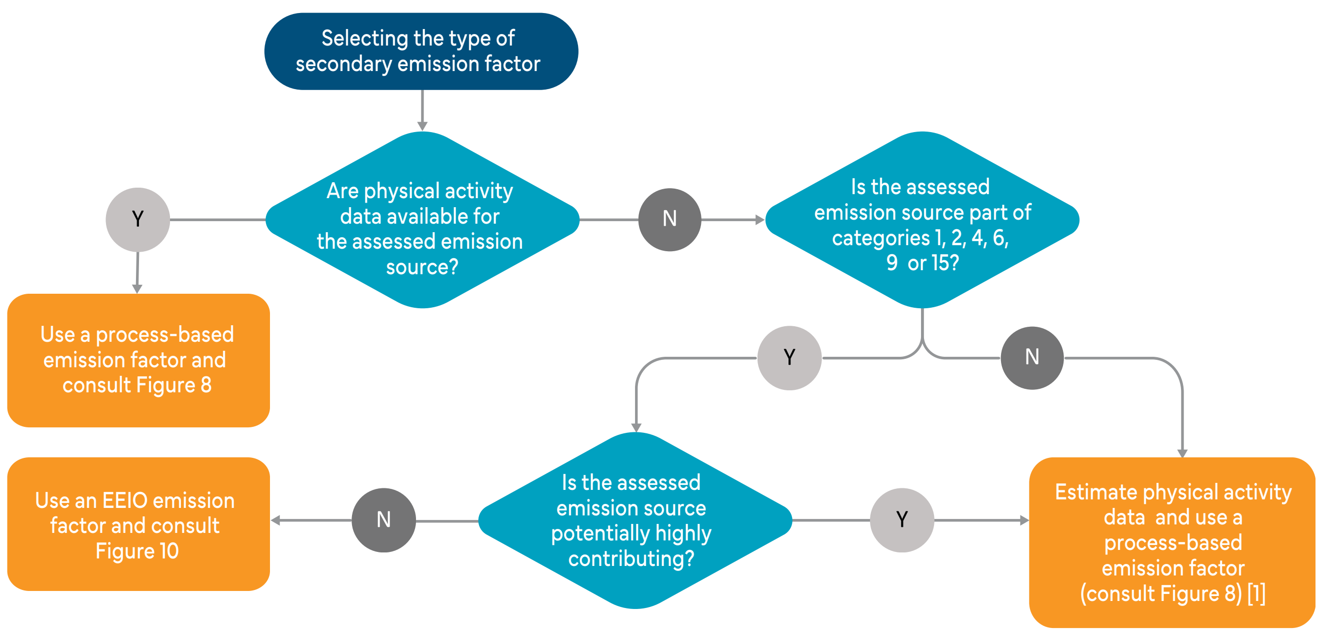
significant uncertainties associated with the latter. This conversion from expenditures to physical quantities should be performed for specific commodities rather than broad product families (e.g., metals). If the conversion can only be carried out at the level of large product categories, an EEIO approach is more appropriate.

If the reporting organization chooses to perform such a conversion, practitioners should take certain precautions. First, the conversion ratio (i.e., $/product unit [kg, L, etc.]) can vary over the reporting period due to changes in the price of the good, inflation, or exchange rate fluctuations. **Practitioners should use the most representative ratio for the reporting period and assess the potential impact of such variations on the results** (ISO, 2024). Additionally, **the ratios used should be as specific as possible to the products purchased**. If generic ratios are used – for example estimating the quantity of electronic equipment purchased based on the average price of this broad product category – organizations should refine these ratios and/or assess the influence of such assumptions on the results (ISO, 2024).

3.2.2 Decision tree – Selecting the type of secondary emission factor

Figure 7 provides guidance for selecting between the two main types of secondary emission factors, namely process-based and EEIO emission factors. The categories presented correspond to the scope 3 categories of the GHG Protocol.

FIGURE 7 • SELECTING THE TYPE OF SECONDARY EMISSION FACTOR



[1] Here, a non-EEIO spend-based emission factor could also be applicable, e.g., an emission factor established with primary data and expressed per financial unit (e.g., kg CO_2e/$ of data storage).

3.3 SELECTING AND APPLYING PROCESS-BASED EMISSION FACTORS

As highlighted in the previous section, process-based emission factors should be prioritized whenever possible. Nevertheless, different types of process-based emission factors exist, and their suitability may vary depending on the context of application. This section provides guidance on the selection and application of process-based emission factors from secondary sources, in order to ensure methodological consistency with the GHG Protocol and to prioritize the selection of robust emission factors. For further guidance on important considerations when applying these emission factors, refer to section 3.1 of *Technical Report 3*.

3.3.1 Emission factor boundaries

In terms of boundaries (i.e., the activities covered), process-based emission factors can be classified into two broad categories:

- *Direct emission factors*, which have narrow boundaries and account only for direct emissions associated with a specific activity (e.g., combustion emission factors).
- *Life cycle emission factors*, which capture the full supply chain required to deliver a product or service (e.g., LCI data). They do not necessarily capture all life cycle stages (i.e., cradle-to-grave), but they adopt a life cycle perspective within the stages considered. For instance, for a transportation activity, a life cycle emission factor would include not only fuel combustion emissions, but also emissions from other processes associated with the life cycle of the activity, such as fuel production, vehicle production, vehicle maintenance, etc.

For the assessment of direct emissions (scope 1), reporting organizations should use direct emission factors that cover only the scope 1 activity (e.g., combustion emission factors). Such emission factors are widely available and can be used as they are. In contrast, life cycle emission factors, such as LCI data, often require adaptation to isolate and represent only direct emissions.

For the assessment of indirect emissions (scopes 2 and 3), **reporting organizations should use life cycle emission factors**. Such data enable the assessment of the total contribution of activities along the value chain by adopting a life cycle perspective.

The reporting organization **should also ensure that the system boundaries of the emission factors align with the boundaries of the scope and category being assessed and, where applicable, adapt the emission factors**. Indeed, life cycle emission factors, typically LCI data, may have boundary inconsistencies relative to the activities being modelled. First, these inconsistencies may relate to the life cycle stages included within a given category or scope. For example, in the case of electricity procurement, the scope 2 emission factor should include only the power generation phase, rather than all cradle-to-gate emissions.

Second, inconsistencies may also arise from the application of minimum boundaries, which, for several categories, are not aligned with the boundaries of LCI data. Typically, LCI data used for categories 1 and 2 do not need to be adapted, as they have cradle-to-gate boundaries, which correspond to the minimum boundaries for these categories. In contrast, LCI data used for most other scope 3 categories generally require adaptation to ensure consistency with the minimum boundary requirements. As such, the use of direct emission factors may be appropriate for organizations that need to adhere to minimum boundary requirements, or for calculating emissions from specific scope 3 categories (e.g., processing of sold products).

Table 3-1 of *Technical Report 3* indicates whether LCI data need to be adapted to comply with minimum boundary requirements of scope 3 categories, and provides important boundary considerations per category.

3.3.2 Emission factor aggregation level

Process-based emission factors from secondary sources may exhibit different levels of aggregation. In general, there are two main types:

- *Aggregated emission factors*: Emission factors that do not provide access to the detailed model underlying them. As a result, they often lack transparency regarding system boundaries (i.e., included processes) and the GHGs included. They are generally expressed in CO_2e.
- *LCI data*: Emission factors that are generally disaggregated and therefore provide access to the underlying network of processes. Even when LCI data are aggregated in terms of included processes (i.e., when they do not provide access to the underlying process network), they provide GHG emission quantities disaggregated by individual GHG.

LCI data, by their disaggregated nature, offer a range of advantages that support compliance with certain GHG Protocol requirements and, more generally, better methodological alignment across the GHG inventory. **LCI data should therefore be prioritized when assessing scope 3 emission sources**.

First, when a reporting organization uses aggregated emission factors expressed in CO_2e, limited transparency and documentation can hinder the understanding of which GHGs are included and which metric was used to calculate the CO_2e value. Moreover, the aggregated nature of this type of data makes it difficult to modify, even if the practitioner is aware of the GHGs considered and the metric applied. In contrast, LCI data are more flexible and can be converted into CO_2e using different metrics (i.e., GWP100, GWP20, GTP500) and values from different IPCC assessment reports (AR) (e.g., IPCC 2021 [AR6], IPCC 2013 [AR5]). In addition, their use in LCA software can enable the accounting of only the seven Kyoto Protocol GHGs, without omitting any or including additional ones[9].

Second, LCI data allow different emissions associated with a given activity to be reported separately. For example, the *Corporate Standard* and the *Scope 3 Standard* require that biogenic CO_2 emissions be reported separately from the emissions reported under the scopes. Similarly, the *Land Sector and Removals Standard* requires that emissions associated with LUC be reported separately from other emissions related to a bio-based product. The disaggregated nature of LCI data helps ensure that separate reporting can be achieved, while also preventing the emission factor from including flows that should be excluded (e.g., CO_2 removals in bio-based products).

Finally, one of the main advantages of the disaggregated nature of LCI data is that it allows for their adaptation, which is addressed in the following section.

3.3.3 Adaptation of emission factors

Adapting emission factors is particularly relevant when their representativeness is limited, which is frequent when using secondary data. This reinforces one of the key recommendations presented in this section: **prioritizing the use of LCI data**. LCI data generally offer sufficient flexibility to be adapted within LCA software, unlike aggregated emission factors.

Adaptations of emission factors can be complex and time-consuming, so they should be carried out strategically First, **it is recommended to adapt data with limited representativeness** – whether the gap is temporal, geographic, or technological. Second, **priority should be given to adapting data used for activities that make a significant contribution to the GHG inventory results**.

[9] Practical guidance is available in section 3.1.3 of *Technical Report 3*.

LCI data are represented as a set of input and output flows associated with the activity. Therefore, adapting LCI data can target either the flows included or the quantities of those flows:

- **Adapting the flows** typically involves adjusting the geography of a flow or modifying the flow itself:
    a. Adjusting the geography of a flow is relevant when the flow is appropriate but could be linked to a more representative geographical context. For example, LCI data can be partially *regionalized* by modifying electricity flows to reflect the region under study.
    b. Modifying the flow itself is relevant when one of the flows is known to be inappropriate. This could involve removing a flow (e.g., waste generation that does not occur in reality) or replacing it – for instance, substituting natural gas consumption with electricity use. In the latter case, modifying the flow generally requires adjusting its quantity as well.
- **Adapting the quantities** of flows involves changing the numerical value assigned to a given flow. For example, adjusting the quantity of a specific input required to produce the product represented by the LCI data. It is important to note that some parameters may affect the quantities of multiple flows simultaneously. For instance, in LCI data for agricultural products, adjusting the yield of a crop would modify the quantities of many flows, since such LCI data are typically scaled to 1 kg of the agricultural product.

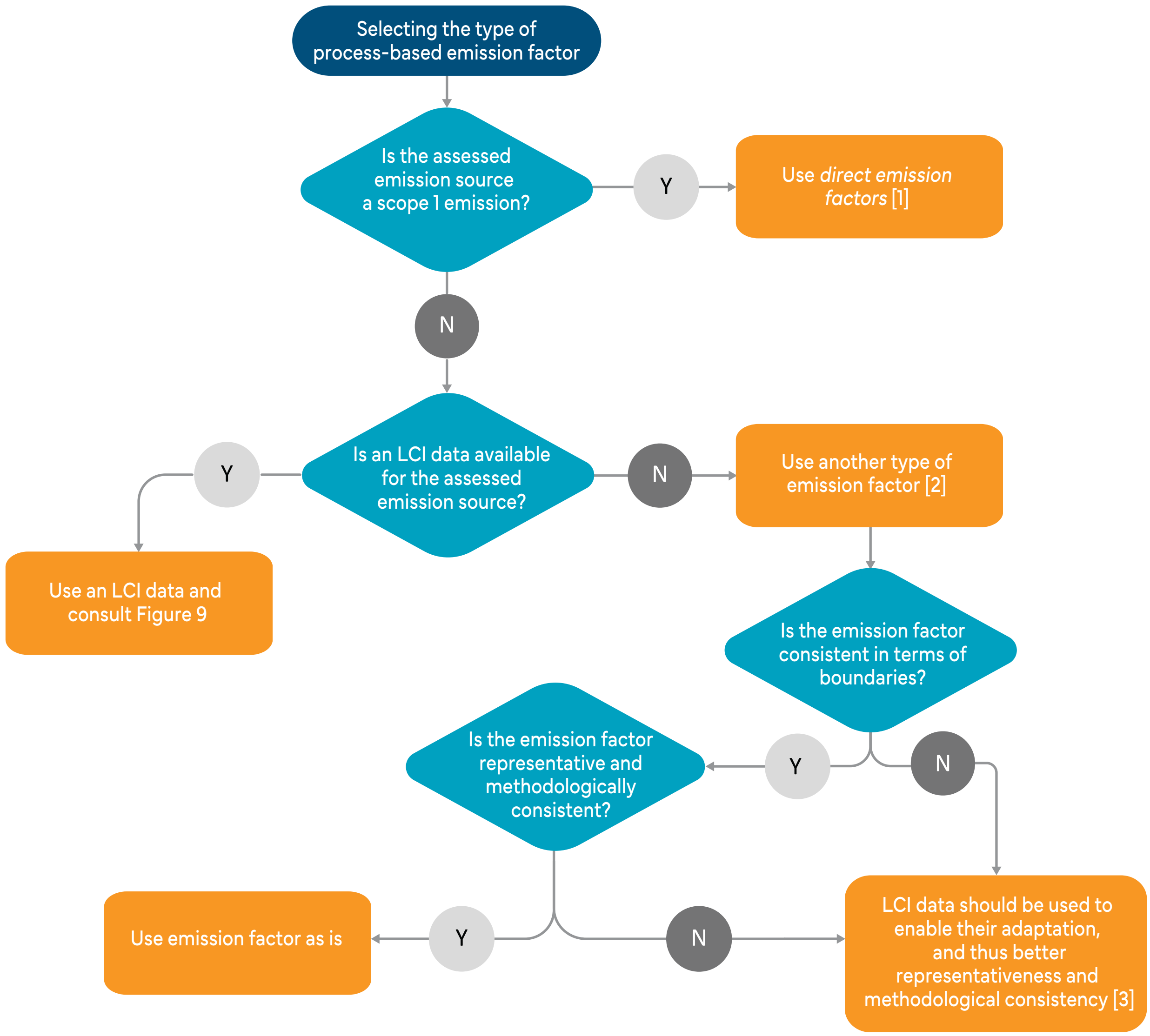
In practice, adjusting a given parameter (e.g., input quantity, load factor) can trigger changes in other parameters within an activity. For instance, increasing the load factor of a freight truck raises its fuel consumption because of the heavier load. Therefore, **reporting organizations should systematically assess the potential impacts that adjustments may have on other flows within LCI data**.

3.3.4 Decision trees – Selecting and applying process-based emission factors

Figure 8 provides guidance to support the choice of process-based emission factors based on their methodological consistency and the boundaries of the assessed emission source. In the following figures, *methodological consistency* refers to all methodological aspects discussed in more details in *Technical Report 1*: boundaries, included GHGs, climate change metric applied, end-of-life allocation approach, treatment of biogenic carbon, and LUC emissions.

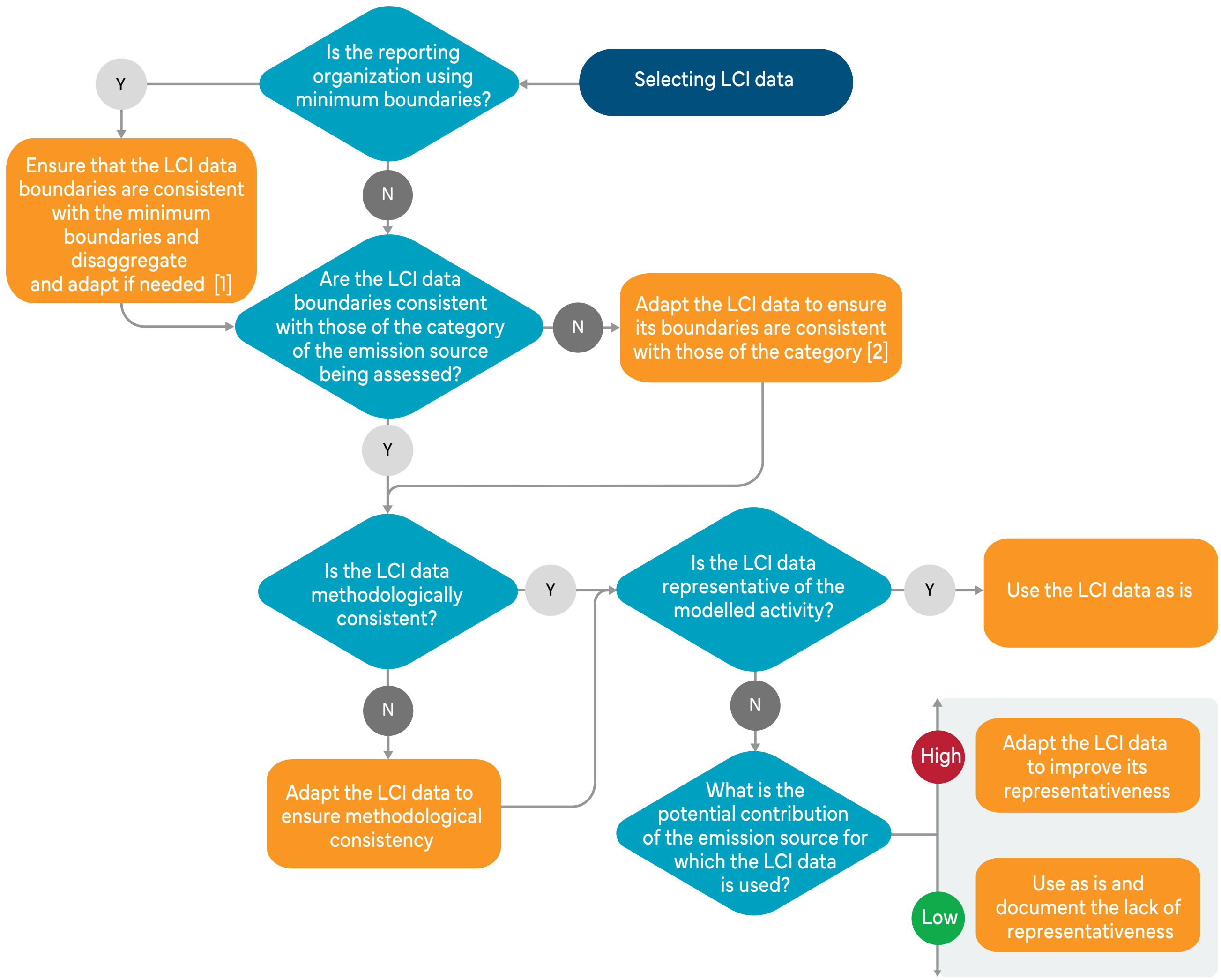
Figure 9 presents a decision tree to guide the selection of LCI data and the decision on whether adjustments are needed to improve them. In this figure, representativeness is presented as a binary criterion – the LCI data being representative or not. In reality, however, the representativeness of LCI data relative to the modelled activity lies on a spectrum. This is therefore a simplification, and practitioners should critically assess the representativeness of the LCI data they use.

FIGURE 8 • SELECTING THE TYPE OF PROCESS-BASED EMISSION FACTORS



[1] "Direct emission factors" are defined as those with narrow boundaries, which account only for direct emissions associated with a specific process (e.g., emission factors representing fuel combustion). [2] Here, this refers to any other type of secondary and process-based emission factors (e.g., aggregated emission factors). [3] If not possible, document the inconsistencies and their potential influence on results.

FIGURE 9 • SELECTING LCI DATA



[1] For this, see Table 5. [2] For this, see section 3.1.1 of this report and section 3.1 of Technical Report 1 (for boundaries of scope 3 categories).

3.4 SELECTING AND APPLYING ENVIRONMENTALLY EXTENDED INPUT-OUTPUT EMISSION FACTORS

Section 3.2 emphasized that EEIO emission factors should not be prioritized over process-based emission factors, but highlighted that their use remains relevant in certain cases. The following subsections provide guidelines to ensure the appropriate use of EEIO emission factors.

3.4.1 Reference unit of the EEIO emission factor

The reference unit of an emission factor corresponds to its denominator. For an EEIO emission factor, this is typically one unit of currency (i.e., one dollar, one euro, etc.). However, certain considerations must be made to ensure consistency between this unit of currency – on which the emission factor is based – and the unit of currency used in the reporting organization's activity data.

First, **the currency should be the same**. If the EEIO emission factor is not expressed in the same currency as the spend-based activity data, the organization should convert its activity data to the same currency as the emission factor. The conversion should use the exchange rate for the year in which the expenditure was made (i.e., the reporting period).

Second, the monetary unit in which EEIO emission factors are expressed may include different price components, and therefore incorporate different activities in the value chain. More precisely, EEIO emission factors are generally expressed either in *basic price* or *purchaser price*:

- The basic price (or producer price) is the amount received by the producer, excluding retail margins and taxes. The corresponding EEIO emission factor therefore includes processes up to the factory gate of the producer.
- The purchaser price is the amount paid for the purchase of a ready-to-buy product or service. It includes the basic price, transportation costs, retailing, and retail margins and taxes. The corresponding EEIO emission factor therefore includes processes up to the reporting organization's site.

Therefore, **the reporting organization should ensure that the emission factor is expressed in a monetary unit consistent with its spend-based activity data**. Typically, organizations use their expenditures for scope 3 calculations, which include costs beyond the factory gate (e.g., retailing), and **should therefore select EEIO emission factors expressed in purchaser price** (except for category 15 [investments] of scope 3).

Finally, EEIO emission factors are expressed in the currency unit of a specific reference year, which does not necessarily correspond to the year of data publication. Therefore, **the reference year of the EEIO emission factors should first be verified**. Then, organizations **should adjust their spend-based activity data to account for the time difference between the reporting period and the reference year of the EEIO emission factors**. Otherwise, inflation over this period may affect the validity of the results. Typically, organizations use EEIO emission factors from a previous year, because input-output data (i.e., economic exchanges between sectors) are usually published with a delay of a few years. This results in a potential overestimation of emissions, with the magnitude depending on inflation.

Adjusting spend-based activity data essentially consists of converting the reporting organization's expenditures, expressed in a monetary value corresponding to the reporting period, into a monetary value corresponding to the reference year of the EEIO emission factors used. This ensures that the activity data and emission factors are expressed in consistent terms, accounting for changes in the value of money over time (e.g., due to inflation). The adjustment can be done according to Equation 1 and is illustrated by an example in Box 2.

EQUATION 1 • ADJUSTMENT OF SPEND-BASED ACTIVITY DATA FOR INFLATION

$$V_{t0} = V_t \times \frac{CPI_{t0}}{CPI_t}$$

Where:

V_{t0} = value expressed in prices of reference year t0

V_t = value expressed in current prices of year t

CPI_{t0} = Consumer Price Index (CPI) for the reference year

CPI_t = CPI for the year of the expense

BOX 2 • EXAMPLE OF ADJUSTING SPEND-BASED ACTIVITY DATA FOR INFLATION

An organization prepares its GHG inventory for 2024 using Canadian EEIO emission factors with a reference year of 2021. It must convert 2024 expenditures into 2021 amounts using CPI values published by Statistics Canada. For a 1 Canadian dollar expenditure, the parameters are:

- V_t = 1 CAD
- CPI_{t0} = 141.6 (Statistics Canada, 2025)
- CPI_t = 160.9 (Statistics Canada, 2025)

$$V_{t0} = 1\,\$ \times \frac{141.6}{160.9} = 0.88\,\$$$

Thus, 1 Canadian dollar spent in 2024 corresponds approximately to 0.88$ in 2021. The organization can multiply all its expenditures by this conversion factor to adjust them. For a more detailed analysis, it is also possible to calculate values expressed in previous years by commodity type, when CPI values are published at this level of detail. For example, Statistics Canada publishes CPI values for about ten categories of commodities.

3.4.2 Mapping activity data to EEIO emission factors

Mapping the reporting organization's spend-based activity data to the EEIO emission factors (i.e., commodities) is a crucial step. Since the level of detail and the structure of EEIO databases vary, it is difficult to propose a universal mapping methodology. However, the following generic steps can be followed:

1. **Collect spend-based activity data (e.g., procurement expenditures) at a level of detail consistent with the resolution of the commodities in the chosen EEIO database(s)**.
2. **Disaggregate spend-based activity data by geographic region** to enable an adequate choice of geography of the EEIO emission factor (described below), where relevant.
3. **Avoid double counting** by excluding spend-based activity data that correspond to activities already accounted for in other scope 3 categories using another approach (i.e., process-based approach). The main potential cases of double counting when assessing emissions associated with expenditures include:
    a. Expenditures related to transport activities that are already covered in another category through a process-based approach (e.g., category 4 [upstream transportation and distribution], category 6 [business travel]);
    b. Expenditures related to waste treatment and associated transport, which should instead be included in category 5 using a process-based approach;
    c. Expenditures related to energy, for which emissions are already reported under another scope (1 or 2) or another category of scope 3 (category 3);
    d. Expenditures related to building leasing. Lease payments primarily reflect the construction, maintenance, and operation of the building. The relevant emissions associated with these activities should be captured under another scope (1 or 2) or another category (upstream leased assets), depending on the consolidation approach chosen by the reporting organization.

4. **Exclude non-relevant expenditures** that do not represent payments to a sector of the economy. In most cases, these correspond to transfers to individuals or accounting adjustments, such as:
    a. Payroll-related expenses (e.g., wage supplements, bonuses), as well as other employee benefits;
    b. Scholarships and grants;
    c. Bad debt.
5. Using metadata (if available), **perform the mapping** between spend-based activity data and the EEIO commodities, either by:
    a. Establishing an overall correspondence between all purchasing categories and the EEIO commodities; or
    a. Conducting a more detailed, line-by-line mapping (i.e., expenditure by expenditure).
6. **Document assumptions and uncertainties**, including sectoral mismatches.

When mapping expenditures to EEIO commodities, organizations may find that some expenses overlap multiple EEIO commodities. For example, an information technology (IT) contract may bundle both equipment and services, while the EEIO database may distinguish between IT equipment production and IT services. In such cases, **reporting** organizations **should select the EEIO commodity that best reflects the activity associated with the expenditure**, particularly by examining the expense details (i.e., the share attributable to each sub-activity). For expenditures that are **potentially significant contributors, organizations should disaggregate the expense and perform a more specific mapping to the corresponding EEIO commodities**. In addition, this is considered good practice when a single expenditure covers two or more commodities with potentially substantially different emission intensities.

3.4.3 Choosing the geography of EEIO emission factors

Another important consideration when mapping expenditures to EEIO emission factors is the choice of geography. In general, EEIO emission factors are *production-based* rather than *consumption-based*. This means that they represent the production of a commodity within a given region, rather than the mix of that commodity consumed in the region, including imports and exports.

For example, if a reporting organization selects an EEIO emission factor for “fruits” in the “Quebec, Canada” geography, the emission factor will generally represent fruit production in Quebec. It will not represent a weighted average of the fruits consumed in Quebec, which may include both local production and imports. By selecting this emission factor, the reporting organization assumes that the product was produced using the energy mix, technologies, yields, production systems, industrial structure, supply chain characteristics, and environmental performance representative of that region. If the reporting organization is based in Quebec but purchases fruits that are produced overseas and imported into Quebec, this would result in very low geographic representativeness.

Although it may not be feasible to disaggregate all expenditures by production region, organizations should do so where practicable, particularly for emission sources that are significant contributors to the inventory and for which geographic representativeness could significantly influence the results.

In such cases, reporting organizations **should consider the geography of EEIO emission factors by adopting the following hierarchy:**

1. **Use a production-based EEIO emission factor and the production region as the geography**. If the region where the commodity was produced is known, the reporting organization should select the EEIO emission factor corresponding to that region. Importantly, this refers to the commodity’s production location, not the supplier’s location, as the supplier may source products manufactured elsewhere.

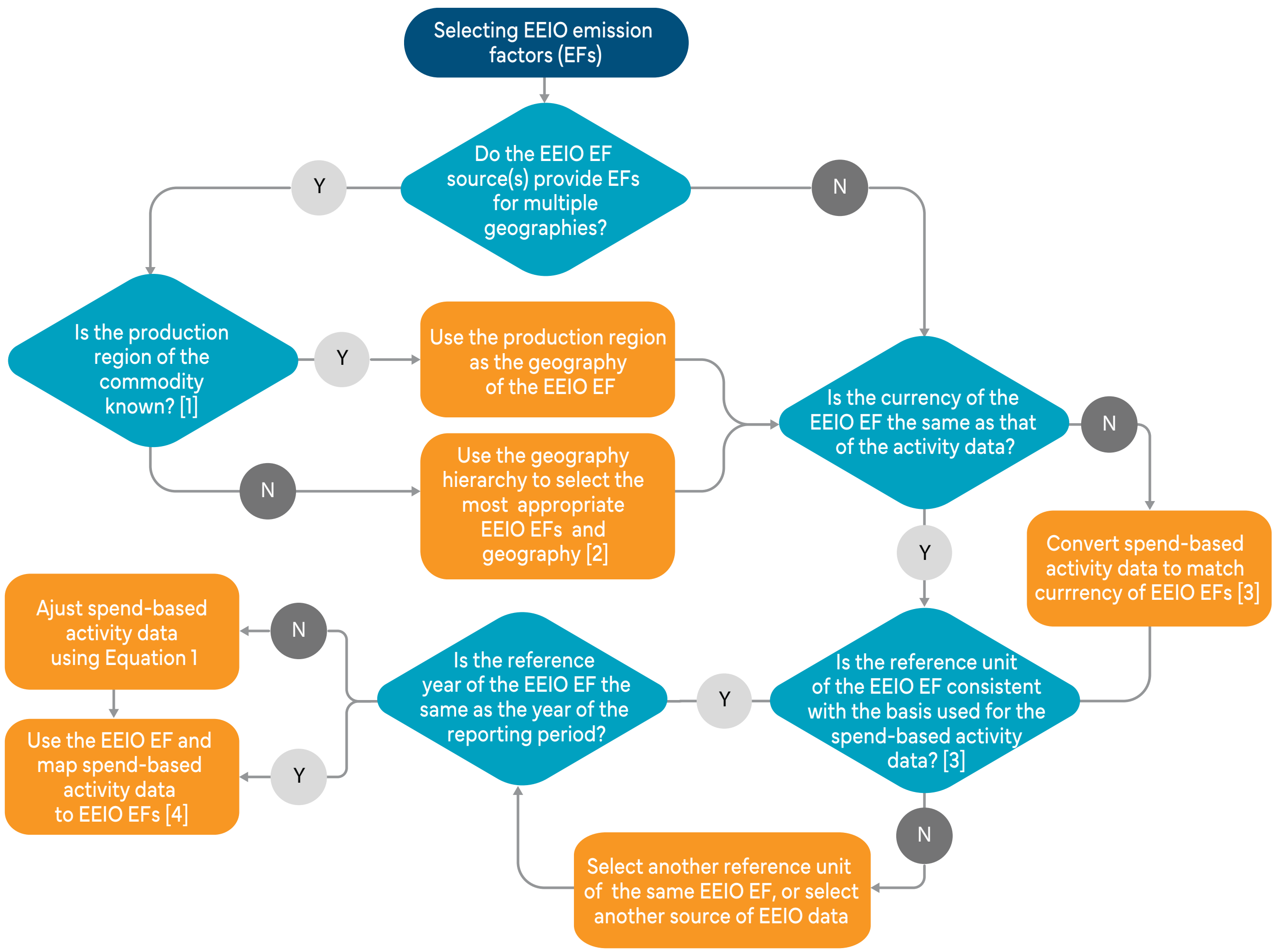
2. **Use a consumption-based EEIO emission factor where available**. If the production region is not known, the reporting organization should use consumption-based EEIO emission factors where available. *Consumption-based* EEIO emission factors may come from either EEIO databases that are *consumption-based* by default or *production-based* EEIO emission factors recalculated to represent a consumption market (e.g., using Exiobase). In this case, the geography of the emission factor should correspond to:
   a. The supplier's location, where possible; or
   b. The region where the purchase occurred.
3. **Use a production-based EEIO emission factor and a proxy for the geography**. If the production region is not known and the use of consumption-based EEIO emission factors is not possible (or if regionalization is not relevant or feasible), the reporting organization may select the geography using one of the following proxies, in order of preference:
   a. Import statistics to estimate the most likely sourcing region;
   b. The supplier's location as a proxy for the production region;
   c. The region where the purchase occurred.

Finally, this approach is generally only relevant when using multi-regional input-output (MRIO) databases, which include several regions at the subnational or national level. If the EEIO database only provides emission factors for a single country, regionalization efforts will generally not be useful because alternative regional emission factors are unavailable. For this reason, reporting organizations **should prioritize EEIO emission factors from MRIO databases where available**.

3.4.4 Decision tree – Selecting and applying EEIO emission factors

The decision tree in Figure 10 is intended to guide the reporting organization in selecting appropriate EEIO emission factors. These guidelines should be applied at the level of selecting the data source (e.g., database) to ensure consistency between the EEIO emission factors and the organization's activity data.

FIGURE 10 • SELECTING EEIO EMISSION FACTORS



[1] As mentioned in section 3.4.2, the production region refers to the geography where the commodity is produced, not the supplier's location, as the supplier may source products manufactured elsewhere. [2] See section 3.4.3. [3] See section 3.4.1. [4] For this, see the generic steps described in section 3.4.2.

3.5 SHARING EMISSIONS DATA ALONG THE SUPPLY CHAIN

The results of an organization's GHG inventory are not necessarily directly usable by its partners along the value chain. Indeed, the boundaries defined in such an inventory may not be suitable for another organization's needs – for example, if the latter uses the results to estimate the emissions associated with the supply of a product (category 1). Moreover, the GHG inventory results generally need to be allocated.

If the reporting organization has already conducted product-level studies, such as an LCA, it would not necessarily need to share its organizational GHG inventory results along the supply chain. However, if no product-level study has been conducted and the reporting organization does share its GHG inventory results with partners, it **should perform the necessary adjustments to make the results directly usable**

by stakeholders. This involves adjusting how emissions are disaggregated and allocating the results among the organization's various products.

3.5.1 Disaggregating emissions data

The GHG Protocol has not yet published specific guidance on the appropriate system boundaries when emission data are shared along the supply chain. Nonetheless, the emission data that an organization shares along the value chain should be usable by the receiving organization in a way that is consistent with the methodological choices applied in its own GHG inventory. These methodological choices mainly concern the boundaries used to construct emission factors – in particular, whether minimum boundaries or a life cycle perspective is applied. However, even when a life cycle perspective is adopted, emissions related to auxiliary services such as employee commuting or office operations may be excluded by the receiving organization. Indeed, such activities are typically omitted from process-based emission factors.

In the GHG Protocol *Product Standard* (GHG Protocol, 2011b), these activities are referred to as non-attributable processes. They are defined as services, materials, and energy flows not directly connected to the studied product during its life cycle because they do not become the product, make the product, or directly carry the product through its life cycle (GHG Protocol, 2011b).

Therefore, two important questions arise:

1. Which emission categories of a GHG inventory should be included in an emission factor developed with primary data from a GHG inventory?
2. Within scope 3 categories, should non-attributable processes be included in emission factors?

The first question has been addressed in section 3.1, which covered the use of primary data to develop emission factors. From the perspective of the organization sharing its emission data, the key priority is to disaggregate the data in a way that enables its customers or suppliers to use them appropriately. To begin with, the organization providing emission data should **disaggregate them by scope 3 category**. This allows the receiving organization to select the relevant categories – for instance, whether or not to include those related to auxiliary services (e.g., employee commuting, downstream leased assets) – and also to exclude categories that are downstream in the value chain (relative to the reporting organization).

Next, to address the second question, the organization providing emission data **should further disaggregate emissions within each category between those from attributable and non-attributable processes**. This additional level of disaggregation enables the receiving organization to develop an emission factor that either includes or excludes non-attributable processes, depending on its own methodological approach. It is important to note that the emissions from several scope 3 categories are entirely non-attributable, whereas other scopes and categories contain both attributable and non-attributable processes. More specifically, the emissions from the following categories are entirely non-attributable:

- Category 2: Capital goods
- Category 6: Business travel
- Category 7: Employee Commuting
- Category 13: Downstream leased assets
- Category 14: Franchises
- Category 15: Investments

Finally, one last adjustment to make when sharing emission data along the value chain concerns the treatment of capital goods. Including unamortized emissions from the acquisition of capital goods can bias the results for the organization using the data. In process-based emission factors, when capital goods are included, their emissions are always amortized over their expected lifetime. Therefore, it would be inappropriate to allocate all emissions from the construction of a plant to the products manufactured during a single year, given that the facility will most likely operate for several decades.

The emission data shared along the value chain should therefore include amortized capital goods emissions. If amortization is not possible, the organization sharing its emissions data should still include them, but should clearly indicate that these emissions are not amortized. This approach ensures that the transmitted emission data remain complete, while allowing the receiving organization to exclude those emissions when developing emission factors.

Table 6 provides an example template for reporting emissions disaggregated in accordance with the above recommendations, intended to be shared with value chain partners. It is important to emphasize that this reporting template represents what organizations should ideally aim for when sharing their emission data with partners along the value chain. In practice, achieving such a level of disaggregation can be challenging. Nevertheless, it would enable value chain partners to make optimal use of the data, in a way that aligns with their own methodologies and allows for sensitivity analyses.

3.5.2 Allocating emissions

The second step consists of allocating the organization's emissions among its different outputs. First, the reporting organization **should minimize the need for allocation by subdividing processes wherever possible**. For example, a food processor could assign to each product the inputs used in its production (and, where possible, the associated transport). Similarly, it may be possible to attribute to each product the waste treatment processes associated with its production.

However, subdivision is more difficult for other emission sources where such disaggregated accounting is less feasible. This is particularly the case for emissions from non-attributable processes (in all three scopes), which can rarely be directly linked to specific products (e.g., production of cleaning products used in facilities). For these emission sources, emissions must be allocated among the various outputs.

The choice of allocation method should follow the GHG Protocol guidance. This choice depends on individual circumstances but should be made to best reflect the causal relationship between the production of outputs and the resulting emissions. Finally, where applicable, **emissions should be allocated and reported using a second allocation method**. For example, if economic allocation is selected as the primary approach, a second allocation based on a relevant physical property (e.g., mass or energy content) should also be performed. This allows the value chain partner to more easily conduct sensitivity analyses and, where appropriate, select the allocation approach that is most consistent with other choices made in its own GHG inventory. To ensure transparency, organizations should disclose the allocation factors applied under both allocation procedures and for all products.

Table 6 provides an example template for reporting emissions disaggregated in accordance with the recommendations outlined above.

TABLE 6 • REPORTING TEMPLATE FOR SHARING INVENTORY RESULTS ALONG THE SUPPLY CHAIN

Scope	Category	Process type	Total	Economic allocation						Mass allocation
				Product A			Product B			[...]
				Subdivided	Allocated	Total	Subdivided	Allocated	Total	
1	Stationary combustion	Attributable								
		Non-attributable								
	Mobile combustion	Attributable								
		Non-attributable								
	Fugitive emissions	Attributable								
		Non-attributable								
2	Purchased electricity	Attributable								[...]
		Non-attributable								
3	Purchased goods and services	Attributable								
		Non-attributable								
	Capital goods	Non-attributable								
	Fuel- and energy-related activities	Attributable								
		Non-attributable								
	[...]									
	Employee commuting	Non-attributable								[...]
	Business travel	Non-attributable								
	[...]									

CONCLUSION

This work examines how LCA approaches, practices, and data can support and strengthen corporate GHG accounting under the GHG Protocol. *Technical Report 1* first compares the conceptual and methodological foundations of the GHG Protocol and LCA, highlighting both complementarities and differences across a range of methodological aspects.

Technical Report 2 then examines the role of life cycle data in organizational GHG accounting. It shows that emission factors vary significantly across several dimensions, including their modelling approach, level of aggregation, reference unit, representativeness, transparency, and consistency with GHG Protocol requirements. No single type of emission factor is universally preferable in all situations. Rather, effective GHG accounting requires practitioners to understand the strengths and limitations of available data sources and to select or adapt them according to data availability, the contribution of the emission source, methodological requirements, and the intended use of the inventory.

Finally, *Technical Report 3* proposes practical guidance to refine corporate GHG accounting. The guidance focuses on key methodological choices related to collecting primary data from value chain partners, selecting and applying secondary emission factors, using process-based and EEIO data appropriately, and sharing emissions data along the supply chain. Taken together, these elements aim to help reporting organizations develop inventories that are more transparent, more consistent with the GHG Protocol, and better suited to support decision-making.

Looking ahead, several avenues remain open for further work. Because these reports sought to cover a broad range of methodological aspects, they remain at a relatively high level and do not provide detailed operational guidance for every issue addressed. Future work could therefore support practitioners more directly through practical procedures for adapting emission factors, sector-specific guidance, or the development of tools and datasets that facilitate the practical implementation of the recommendations outlined here.

In addition, the continued evolution of the GHG Protocol, notably through the recently published *Land Sector and Removals Standard*, signals a broader trend toward greater methodological sophistication in corporate GHG accounting. This evolution may create new opportunities to further integrate LCA perspectives into future versions of GHG Protocol standards and, more broadly, to strengthen alignment between the GHG accounting and LCA communities around shared methodological challenges. As corporate inventories are increasingly expected to support credible decision-making and transition planning, closer integration between these approaches can contribute to more robust, transparent, and actionable GHG accounting practices.

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APPENDIX A – GLOSSARY

Avoided emissions	GHG emissions that are prevented as a result of an organization's action(s), compared to alternative scenarios without the action(s) (GHG Protocol, 2022).
Base year	A historic datum (a specific year or an average over multiple years) against which an organization's emissions are tracked over time (GHG Protocol, 2026).
Biogenic carbon	Carbon in, or derived from, living organisms or biological processes, but not including fossilized materials or those from fossil sources (GHG Protocol, 2026).
Biogenic product emission	CO_2 emissions from combustion or biodegradation of biogenic products.
Biogenic product removal	CO_2 removals where the carbon is stored in biogenic products.
Carbon offset	Quantified mitigation outcomes of projects or broader interventions which are credited for GHG claims to be transferred between entities, and which are generated from projects or interventions that reduce emissions or increase removals outside the reporting organization's value chain (GHG Protocol, 2026).
Consolidation	Combination of GHG emissions data from separate operations that form part of one organization or group of organizations (GHG Protocol, 2015a).
Co-product	Any of two or more products coming from the same unit process or product system (ISO, 2022).
Cradle-to-gate	An assessment that includes part of the product's life cycle, including material acquisition through the production of the studied product and excluding the use or end-of-life stages (Life Cycle Initiative, n. d.).
Cradle-to-grave	A cradle-to-grave assessment considers impacts at each stage of a product's life cycle, from the time natural resources are extracted from the ground and processed through each subsequent stage of manufacturing, transportation, product use, recycling, and ultimately, disposal (Life Cycle Initiative, n. d.).
Direct emissions	Emissions from sources that are owned or controlled by the reporting organization (GHG Protocol, 2015a).
Direct emission factor	An emission factor that has narrow boundaries and accounts only for direct emissions associated with a specific process (e.g., combustion emission factors).
Emission factor	A calculated ratio relating GHG emissions to a given measure of activity.
Indirect emissions	Emissions that are a consequence of the activities of the reporting organization, but occur at sources owned or controlled by another organization (GHG Protocol, 2015a).
Land use	Use of a specific area of land for a particular purpose with a certain level of intensity that reflects land management practices.
Land use change	A transition from one land use category to another, such as from forest to grassland or forest to cropland (GHG Protocol, 2026).
Land management emissions	Emissions resulting from ongoing land management practices.
Life cycle emission factor	An emission factor that adopts a life cycle perspective and captures the full supply chain required to deliver a product or service.

Life cycle inventory (LCI) data	A dataset that represents interconnected unit processes and their associated intermediate and elementary flows, capturing the full supply chain required to deliver a given function (e.g., producing a good).
Minimum boundaries	Boundaries defined by the GHG Protocol to indicate the minimum emission sources to be included for each scope 3 category.
Operational boundaries	The boundaries that determine the direct and indirect emissions, removals, and other accounting categories associated with operations owned or controlled by the reporting organization (GHG Protocol, 2015a).
Organizational boundaries	The boundaries that determine the operations owned or controlled by the reporting organization, depending on the consolidation approach taken (equity or control approach) (GHG Protocol, 2015a).
Pool	A physical reservoir or medium where a GHG or its constituent elements are stored (GHG Protocol, 2026).
Reporting period	Period for which organizational GHG emissions are accounted for.
Scope	Defines the operational boundaries in relation to indirect and direct GHG emissions (GHG Protocol, 2015a).
Scope 1 emissions	A reporting organization's direct GHG emissions (GHG Protocol, 2015a).
Scope 2 emissions	A reporting organization's emissions associated with the generation of electricity, heating/ cooling, or steam purchased for own consumption (GHG Protocol, 2015a).
Scope 3 emissions	A reporting organization's indirect emissions other than those covered in scope 2 (GHG Protocol, 2015a).