LEVERAGING LCA TO STRENGTHEN GHG PROTOCOL CORPORATE ACCOUNTING

Technical Report 3: Guidelines for Improved Corporate GHG Accounting

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NOTE TO READERS

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ABBREVIATIONS AND ACRONYMS

CH_4	Methane
CO_2	Carbon dioxide
CO_2e	CO_2 equivalent
CPI	Consumer Price Index
dLUC	Direct land use change
EEIO	Environmentally extended input-output
EF	EF
GHG	Greenhouse gas
GTP	Global temperature potential
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
IEA	International Energy Agency
iLUC	Indirect land use change
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
jdLUC	Jurisdictional direct land use change
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
LUC	Land use change
NF_3	Nitrogen trifluoride
N_2O	Nitrous oxide
O-LCA	Organizational life cycle assessment
PCR	Product Category Rules
PFC	Perfluorocarbon
REC	Renewable energy certificate
RNG	Renewable natural gas
SBTi	Science Based Targets Initiative
SF_6	Sulphur hexafluoride
sLUC	Statistical land use change

GLOSSARY

Aggregated emission factors	Emission factors that do not provide access to the detailed model underlying them, and therefore generally provide a single aggregated value in CO_2e.
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 CO_2 emission	CO_2 emissions from combustion or biodegradation of biogenic products.
Biogenic product CO_2 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 company or group of companies (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 distribution, use and 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 emission factor	An emission factor that has narrow boundaries and account only for direct emissions associated with a specific process (e.g., combustion emission factors).
Direct emissions	Emissions from sources that are owned or controlled by the reporting organization (GHG Protocol, 2015a).
Disaggregated emission factors	Emission factors that provide access to the underlying model (i.e., a chain of interconnected processes), the different GHGs included, and may allow an adaptation.
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 company (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 provided by the GHG Protocol to indicate the minimum emissions sources to be included for each of the scope 3 categories.
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 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).

INTRODUCTION

The development of organizational greenhouse gas (GHG) inventories has experienced remarkable growth in recent years. The GHG Protocol has established itself as the primary reference framework 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 work is structured into four documents, each with the specific objectives:

- *Technical Report 1: Comparison of the GHG Protocol and LCA frameworks*. This report aims to compare the GHG Protocol and LCA frameworks across a wide range of methodological aspects, highlighting their differences, similarities, and potential inconsistencies.
- *Technical Report 2: Life Cycle Data and its Use for Corporate GHG Accounting*. This report aims to present and describe the different types of data (i.e., emission factors) typically used to develop organizational GHG inventories, outlining their respective strengths and limitations.
- *Technical Report 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.
- *Summary Report*. This report summarizes the main aspects of the three technical reports.

The previous documents of this work focused on the differences between organizational carbon accounting – as applied under the GHG Protocol – and life cycle assessment (LCA)[1], as well as on the different types of data used to model activities, namely process-based and environmentally extended input-output (EEIO) emission factors (EFs).

This document constitutes *Technical Report 3*. It aims to provide guidance to support practitioners in improving the robustness of GHG inventories, particularly from the perspective of LCA best practices. Its content builds on the concepts covered in the first two sections; reading those sections beforehand is therefore recommended.

This document is structured into several subsections, each addressing key steps in the development of a GHG inventory where methodological challenges frequently arise. Specifically, it covers:

1. Definition of the goal and scope of the study;
2. Data collection;
3. Selection of emission factors;
4. Emissions calculation;
5. Interpretation of results.

[1] Both product and organizational LCA.

For some of these steps, decision trees are provided to help users apply the recommended methodological guidance and make informed decisions throughout the process.

The recommendations set out in this document are intended to reflect good practice and remain applicable at the time of writing. However, the GHG Protocol is currently in the process of updating its suite of corporate standards and guidance. Once published, the revised standards and guidance should supersede the recommendations presented herein where differences or inconsistencies arise.

1 DEFINITION OF THE GOAL AND SCOPE OF THE STUDY

Defining the objectives is the first step in preparing a GHG inventory, followed by establishing its scope. The following subsections offer recommendations for both of these steps. Regarding boundaries, this section addresses inventory-level considerations, while category-specific boundary issues are discussed in sections 3 and 4.

1.1 Definition of the goal of the study

1.1.1 Defining the intended application

In LCA, defining the intended application of the study is a critical step that influences several subsequent methodological (e.g., system boundaries) and operational (e.g., level of detail) choices. The same principle applies when conducting a GHG inventory. **Practitioners should therefore consider the following questions**:

- What are the intended applications of the GHG inventory? (e.g., setting reduction targets, complying with program requirements, etc.)
- What is the purpose of conducting the GHG inventory? (e.g., establishing an emissions profile, enabling emissions data transfer to stakeholders within the value chain, etc.)
- Who are the intended users of the GHG inventory results? (e.g., investors, clients, the public, etc.)

The answers to these questions – similar to those considered in the goal and scope definition phase of an LCA – will directly influence key methodological decisions throughout the GHG inventory process. This includes the required level of detail, the determination of boundaries for scope 3 categories, and how results will be communicated and shared.

1.1.2 Iterative nature of the study

Conducting an LCA is an iterative process: practitioners are expected to refine earlier stages as new insights emerge. In practice, the goal and scope, methodological choices, data collection, and result interpretation may be progressively refined to ensure the consistency, robustness, and relevance of the study.

The same principle applies when conducting an organizational GHG inventory. This may lead to changes based on newly available data, the interpretation of preliminary results (e.g., sensitivity analyses), or limitations, inconsistencies, or uncertainties identified during the analysis. These new insights may prompt adjustments to the goal and scope of the study (e.g., intended application, standard followed, etc.), as well as methodological choices (data selection, system boundaries, etc.) and operational aspects (level of detail, format of results, etc.).

1.2 Definition of organizational boundaries

1.2.1 Consolidation approaches

LCA provides limited support in choosing a consolidation approach and defining organizational boundaries. These decisions should instead be guided by the organization's context and objectives.

Depending on these factors, organizations may lean toward either the control approach or the equity-share approach[2]. For example, the control approach is often more suitable when data accessibility and the ability to influence included emission sources are key considerations. In contrast, the equity-share approach can be particularly useful for risk management, as it captures operations over which the reporting organization may not exercise direct control but for which it remains accountable or liable.

When defining organizational boundaries, emissions from entities and operations outside those boundaries may still need to be included in the GHG inventory. Specifically, an organization's scope 3 emissions include:

- Emissions from value chain activities of entities within the organizational boundaries;
- Emissions associated with leased assets, investments and franchises that fall outside the organizational boundaries but are partially or wholly owned or controlled by the organization.

For instance, under the financial control approach, an organization may determine that a leased building falls outside its organizational boundaries. Nonetheless, emissions from operating that building (i.e., the asset's scope 1 and scope 2 emissions) should still be included in the organization's scope 3 emissions, under category 8: Upstream leased assets.

When defining organizational boundaries, practitioners should therefore take care **not to exclude activities that fall outside the boundaries but over which the reporting organization retains partial or full ownership or control**. Emissions associated with these activities may still need to be reported under the organization's scope 3: leased assets (categories 8 and 13), franchises (category 14), or investments (category 15). Further guidance is provided for leased assets in section 1.3.5.

1.3 Definition of operational boundaries

1.3.1 Inclusion of indirect emissions

When defining operational boundaries, organizations should align more closely with the requirements of the *Scope 3 Standard* (GHG Protocol, 2011) rather than those of the *Corporate Standard* (GHG Protocol, 2015a). This means that organizations should aim to comprehensively include scope 3 emissions and transparently disclose and justify any exclusions in the GHG inventory report.

However, including the full range of scope 3 emissions can be challenging, and in some cases, certain categories may be of limited relevance. As such, organizations may adopt a materiality threshold approach. It is recommended to **include all scope 1, scope 2, and scope 3 emissions that together account for at least 95% of the organization's total GHG emissions**.

Validating whether this threshold has been met can be difficult, as it requires estimating emissions that may ultimately be excluded. For this reason, it is recommended **to use simplified screening-level approaches to estimate these emissions, such as environmentally extended input-output (EEIO) emission factors (EFs), and verify whether the 95% threshold is met**.

[2] These approaches are described in section 3.1 of *Technical Report 1*.

1.3.2 Scope 3 boundaries

Choices regarding which activities to include or exclude apply both to activities within the value chain of the reporting organization (i.e., the scopes and emission categories) and to activities underlying those value chain activities (i.e., the processes included within each scope 3 category).

For example, an organization may choose to include upstream transportation and distribution (category 4), but it must still make a methodological choice about which background activities to include within a freight transportation activity. This may involve including fuel alone, both fuel production and combustion, or even the construction and maintenance of the truck and road infrastructure.

In general, the GHG Protocol gives organizations significant flexibility in determining the boundaries to apply for each of the 15 scope 3 categories. The *Scope 3 Standard* defines minimum boundaries, covered in *Technical Report 1*, which specify the minimum activities that must be included for each scope 3 category. Although these minimum boundaries capture the major emission sources for most categories, **it is recommended to adopt a life cycle perspective**. Expanding beyond minimum boundaries:

- Ensures completeness (i.e., major contributors are included). Minimum boundaries may be incomplete for specific activities (e.g., transport using electric vehicles, wastewater treatment) or for some scope 3 categories (e.g., use of sold products).
- Simplifies the development of the GHG inventory, as the availability of EFs aligned with the minimum boundaries is often limited.
- Allows the use of life cycle EFs when using secondary data (i.e., life cycle inventory [LCI] data), which offer several advantages (adaptability, transparency, etc.) compared to other types of secondary EFs. These aspects are discussed in section 3.1.

However, in some cases, the reporting organization may be required to use the minimum boundaries – for instance, when participating in certain programs such as the Science Based Targets Initiative (SBTi). In such situations, **it is recommended to prepare two GHG inventories: one using the minimum boundaries and another using a full life cycle perspective**. The former ensures compliance with certain programs while the latter provides a more comprehensive and robust basis for decision-making.

1.3.3 Inclusion of land use change emissions

In the past, the GHG Protocol has provided very little guidance regarding the inclusion of emissions associated with land use change (LUC). However, the *Agricultural Guidance* recommends that agricultural enterprises account for these emissions. In practice, though, few organizations include LUC-related emissions in their GHG inventories. The recent publication of the *Land Sector and Removals Standard* (GHG Protocol, 2026) should lead more organizations to include those emissions, which is one of its requirements.

Where relevant, it is recommended **to include emissions from LUC in both scopes 1 and 3**[3], regardless of whether the organization operates in the agricultural sector or follows the *Land Sector and Removals Standard*. Globally, LUC accounts for an estimated 9-19% of anthropogenic emissions, highlighting the

[3] LUC emissions are not relevant to scope 2, which focuses on combustion emissions associated with electricity production.

importance of including these emissions to inform decisions and drive meaningful action (Forster et al., 2023). In practice, organizations should rely on the requirements and recommendations of the *Land Sector and Removals Standard* to quantify emissions associated with LUC. However, the standard does not address removals associated with LUC (e.g., when agricultural land is converted into secondary forest). Where relevant, it is recommended **to calculate LUC removals and report them separately**. More practical guidelines for assessing LUC emissions in the supply chain are addressed in section 3.1.5.

1.3.4 Treatment of electricity

As required by the GHG Protocol, organizations operating in regions where contractual instruments for renewable energy exist must report two scope 2 emission values: one using the location-based method and the other using the market-based method. The location-based value is recommended as the primary reference for decision-making. This is particularly important when the GHG inventory is used to set reduction targets and track progress, ensuring that emission reductions reflect actual physical changes than hypothetical claims. Evidence shows that the presence of renewable energy certificates (RECs) in a market does not lead to significant emissions reductions (Langer et al., 2024). Further guidance on scope 2 emission calculations is provided in section 4.2.

1.3.5 Consideration of leased assets

The treatment of leased assets – and whether the associated emissions fall under scopes 1 and 2 or in scope 3 – is often a source of confusion. The guidance on this topic comes not from LCA but rather from the GHG Protocol, and is frequently overlooked or misinterpreted.

Whether an organization controls a leased asset depends on both the type of leasing arrangement (capital or operating lease) and the consolidation approach it uses. A capital lease "[...] enables the lessee to operate an asset and also gives the lessee all the risks and rewards of owning the asset", whereas an operating lease "[...] enables the lessee to operate an asset [...] but does not give the lessee any of the risks or rewards of owning the asset (GHG Protocol, 2006). Further details on both lease types are provided in Appendix F of the *Corporate Standard* (GHG Protocol, 2006). **Organizations should categorize emissions from leased assets by scopes in accordance with Table 1-1 below**.

For example, as a lessee, an organization using the operational control approach controls the assets it leases, meaning that their direct emissions are reported under scope 1 and electricity-related emissions[4] under scope 2. Conversely, when acting as a lessor, the organization does not control those assets regardless of the lease type, and emissions from operating them are reported under scope 3 (category 13: downstream leased assets).

If an organization can demonstrate it lacks operational control over an asset held under an operating lease, it "may report emissions from the leased asset as scope 3 but must state clearly in its GHG inventory report the reason(s) that operational control is not perceived" (GHG Protocol, 2006).

[4] More specifically, combustion emissions occurring at the electricity generation facility.

Table 1-1: Categorization of emissions from leased assets

Consolidation approach used	Type of leasing arrangement	
	Financial/capital lease	Operating lease
Lessee's perspective (reporting organization is the lessee)		
Equity share or financial control	Lessee has control	Lessee does not have control
Operational control	Lessee has control	Lessee has control
Lessor's perspective (reporting organization is the lessor)		
Equity share or Financial control	Lessor does not have control	Lessor has control
Operational control	Lessor does not have control	Lessor does not have control

Note: Reproduced from *Categorizing GHG Emissions with Leased Assets: Appendix F to the GHG Protocol Corporate Accounting and Reporting Standard – Revised Edition* (Table 1, p.3; Table 2, p.4), by GHG Protocol, 2006. https://ghgprotocol.org/sites/default/files/2022-12/Categorizing%20GHG%20Emissions%20from%20Leased%20Assets.pdf

1.4 Greenhouse gases and climate impacts

1.4.1 Included greenhouse gases

The GHG Protocol requires the inclusion of the Kyoto Protocol gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). According to the *Corporate Standard*, emissions of other gases may optionally be reported separately but should not be included within the three scopes.

At a minimum, organizations should include the Kyoto gases and account for any other greenhouse gases (GHGs) that are relevant to the inventory. When preparing an inventory that must comply with GHG Protocol requirements (e.g., as part of a formal reporting program), these additional gases should be reported separately. Conversely, for voluntary disclosures, including such additional gases – either within the inventory itself or in a separate supplemental inventory – is good practice to provide a more comprehensive emissions profile of the organization and to support informed decision-making. Certain other GHGs may also be relevant because they can contribute significantly to the emissions inventory. For example, this is true in some healthcare organizations that use anesthetic gases, which are typically halogenated ethers – a family of GHGs not covered by the Kyoto Protocol. In such cases, the organization should clearly disclose its methodological choices.

For scope 3 emissions, the GHG Protocol also requires the inclusion of the seven Kyoto GHGs. However, meeting this requirement can be more challenging. On the one hand, some EFs are expressed in CO_2e, without sufficient transparency to determine which gases are included. On the other hand, LCI data often cover many more GHGs than those required. In such cases, the organization should still use these data (LCI data or EFs) and go beyond the strict GHG Protocol requirements, while clearly disclosing this choice. Another possible approach – when practitioners use LCA software and disaggregated LCI data – is to create a custom impact assessment method that characterizes only the seven Kyoto GHGs (this is further discussed in section 3.1.3). This option may be appropriate when the use of LCI data is prioritized and strict compliance with the GHG Protocol is desired.

These considerations are addressed in greater detail in the section on the choice of EFs (section 3).

1.4.2 Climate impacts and mechanisms

As recommended by the GHG Protocol, the global warming potential (GWP) with a 100-year time horizon (GWP100) metric from the latest IPCC assessment report should be used. However, when using EFs expressed in CO_2e for scope 3, it is sometimes difficult to determine which method was used to calculate the value. In such cases, efforts should be made to use EFs based on the latest GWP100 values and ensure consistency across all emission sources (this topic is discussed further in section 3).

In some instances, it may also be useful to conduct a sensitivity analysis using an alternative metric, such as GWP20. This can help confirm or challenge the study's conclusions, particularly for organizations where gases other than CO_2 make a significant contribution to the GHG inventory. This recommendation is discussed in more detail in the section on interpretation of results (section 5.3).

The GHG Protocol focuses exclusively on the radiative forcing of GHG emissions. However, as explained in *Technical Report 1*, several other anthropogenic mechanisms also contribute to radiative forcing, and including some of these can be relevant in specific contexts. For example, an agricultural company might consider how its activities affect surface albedo, and how this change has a warming or cooling impact on the climate. Similarly, in the case of aviation, condensation trail formation is estimated to have a warming effect comparable to that of CO_2 emissions, and metrics are available to account for this effect (Lee et al., 2021).

Limited data and methods are available to easily integrate these mechanisms. Nevertheless, it is recommended, where relevant and feasible, to include the potential impacts associated with these mechanisms and report the results separately. The relevance of such mechanisms should be assessed based on their relative contribution compared to the radiative forcing of GHG emissions. At present, the radiative forcing related to contrails provides an example of a mechanism that can be calculated using these approaches:

- Multiplication factors from Lee et al. (2021) for non-CO_2 emissions from aviation (contrail formation, NOx emissions, etc.).
- The pycontrail Python library for a more detailed assessment of contrail formation from aviation (Contrails.org, 2025).

1.5 Summary of recommendations

The recommendations put forward in this section are summarized in Table 1-2. Users of the report should consult the relevant subsections for additional detail.

Table 1-2: Summary of recommendations for the definition of the goal and scope

Subject	Section	Recommendation	
Goal and scope of the study	1.1	#1	In the beginning of a GHG inventory study, considering and answering key questions related to the goal and scope of the study.
Definition of organizational boundaries	1.2.1	#2	When defining organizational boundaries, being careful not to exclude activities that fall outside the boundaries but over which the reporting organization nonetheless exercises partial or full ownership or control.
Definition of operational boundaries	1.3.1	#3	Including all scope 1, scope 2, and scope 3 emissions that together account for at least 95% of the organization's total GHG emissions.
		#4	If needed, using simplified screening-level approaches to estimate emissions and verify whether the 95% threshold is achieved (recommendation #3).
	1.3.2	#5	Going beyond minimum boundaries and adopting a life cycle perspective for boundaries of scope 3 categories.
		#6	When required to follow minimum boundaries, preparing two GHG inventories: one using minimum boundaries, and another using a full life cycle perspective.
	1.3.3	#7	Including LUC emissions in scopes 1 and 3, regardless of whether the organization operates in the agricultural sector or not.
		#8	If relevant, calculating and reporting removals resulting from LUC separately from the main inventory results.
	1.3.4	#9	For electricity flows, using the location-based value as the primary reference for reporting and decision-making.
	1.3.5	#10	Categorizing emissions from leased assets across the different scopes in accordance with the guidelines of the GHG Protocol and the selected consolidation approach (see Table 1-1).
Included GHGs and climate impacts	1.4.1	#11	Including the seven Kyoto GHGs and accounting for any other GHGs that are relevant to the organization, and reporting these emissions separately or not depending on the context, goal and scope of the study.
		#12	Ensuring consistency in the choice of metric (i.e., mainly the assessment report from which GWP100 values are taken from) across the different emission sources.
	1.4.2	#13	If relevant, including other mechanisms that lead to radiative forcing and reporting metrics separately.

2 DATA COLLECTION

Data collection generally concerns either activity data or EFs. Section 2.1 highlights key considerations when collecting activity data; section 2.2 discusses the collection of primary data for developing or improving EFs; and section 3 addresses the selection of secondary EFs.

2.1 Collection of activity data

Activity data represent the measured level of the activity for which emissions are being quantified. When a process-based EF is used, the activity data are typically physical, as it is expressed in a physical unit (e.g., mass, distance). In contrast, when a spend-based (e.g., EEIO) EF is applied, the activity data correspond to an expenditure and is therefore financial in nature. The following subsections outline key considerations for collecting both types of activity data.

2.1.1 Activity data aggregation level

The calculation of GHG emissions can be carried out at different levels of specificity. For example, when an organization estimates the emissions associated with employee commuting, it can either account for the specific practices of each employee (e.g., distance travelled, mode of transport) or apply generic assumptions – such as assuming an average distance and a modal split representative of all employees.

The choice of calculation precision applies across all scopes and emission categories and determines how activity data will subsequently be collected. The more granular the emissions calculation, the more granular the data collection must be. For this reason, defining the level of aggregation at which activity data will be collected is a critical step.

It is generally recommended to aim for the highest feasible level of precision, supported by granular data. However, it is also recognized that highly detailed calculations are not always necessary or relevant. Therefore, **the level of aggregation for data collection should be determined based on the objectives of the study, the relative contribution of the emission category or source, the organization's ability to influence that source, the availability of EFs, and any other criteria deemed relevant by the reporting organization**. For example, it is recommended to collect granular data – and thus improve calculation accuracy – for a highly contributing emission category where the organization has leverage to implement reduction actions and where granular EFs are available.

As a general guideline, a category contributing more than 10% of total emissions can typically be considered to be highly contributing. However, this threshold depends on the specific context and configuration of the GHG inventory (e.g., operational boundaries, sector of activity, level of uncertainty). Furthermore, whether an individual source is considered significant depends on its level of granularity (e.g., aggregated transport of all inputs vs. transport of a single input) and should therefore be assessed on a case-by-case basis.

Table 2-1 provides an example of different levels of aggregation of activity data for business air travel, assuming a physical (i.e., process-based) approach. For instance, in a consulting firm whose employees frequently travel by air and where business travel makes up a substantial share of emissions, it may be relevant to adopt the highest level of detail (#4 in Table 2-1). This would allow the organization to design reduction actions that go beyond simply minimizing total distance travelled and incorporate considerations such as distance brackets (e.g., to account for landing and takeoff cycles) and seat class (economy, business, etc.). These specificities can then be reflected in subsequent GHG inventory results. For such an organization, it is therefore advisable to assess in advance the desired level of precision and to organize data collection accordingly.

Conversely, for an organization where business air travel represents only a small share of emissions and where the organization has little influence over these emission sources, collecting more aggregated data may be sufficient to meet the study's objectives (e.g., level #1 or #2 in Table 2-1).

Table 2-1: Example of aggregation levels for business air travel

Aggregation level		Activity data	Emission factor(s)[5]
#1	Fully aggregated	Total distance travelled (person-km [p-km])	Passenger transportation, aircraft, unspecified distance
#2	Disaggregated per distance range	Total distance (p-km), per distance range	• Passenger transportation, aircraft, < 500km • Passenger transportation, aircraft, 500-1000 km • etc.
#3	Disaggregated per distance range and class	Total distance (p-km), per distance range and class	• Passenger transportation, aircraft, < 500km, economy • Passenger transportation, aircraft, < 500km, business • etc.
#4	Disaggregated per distance range, class and aircraft type	Total distance (p-km), per distance range, class and aircraft type	• Passenger transportation, aircraft, < 500km, economy, narrow-body aircraft • Passenger transportation, aircraft, < 500km, business, wide-body aircraft • etc.

2.1.2 Considerations for physical activity data

Once the level of aggregation for data collection has been determined, the organization must then collect the highest-quality data possible. Ideally, activity data should reflect actual, empirically observed figures – but in practice, organizations often lack access to measured data and must rely on estimates. Nonetheless, **the goal remains to minimize the gap between the collected data and the actual observed data**.

To achieve this, several aspects can be considered, including the specific characteristics of the modelled activity and the boundaries of the EF used. For example, EFs for purchased goods typically cover the cradle-to-gate stage – ending at the factory gate. Therefore, the organization's activity data should theoretically correspond to the quantity of goods leaving their supplier's gate. If the organization instead uses the quantity it receives on-site, a good practice in this case, would be to adjust the activity data to account for transport losses between the supplier's gate and the organization's facilities.

[5] These EFs are fictitious and are listed for illustrative purposes only.

There are numerous good practices aimed at narrowing the gap between the activity data used and the "actual" observed data, covering a variety of activity types. Table 2-2 summarizes some of these practices. Its purpose is not to provide an exhaustive overview of all possible approaches to improving activity data quality (e.g., through the choice of calculation method), but rather to highlight specific practices related to how activity data are collected or adjusted – as well as common pitfalls to avoid. It should be noted that these practices are not necessarily relevant in all cases, and their implementation depends, among other factors, on the potential contribution of the associated emission sources and on the aggregation level of calculations (as discussed in section 2.1.1).

Some of the considerations listed in Table 2-2 refer to characteristics of the modelled activity (e.g., the load factor of a freight transport truck), rather than to the activity data itself. In such cases, EF adaptation may be required. Sections 3.1.6 and 3.1.7 address, respectively, the representativeness of EFs and their adaptation.

Table 2-2: Data collection considerations for physical activity data

Activity type	Good practice
Purchased goods (categories 1 and 2)	Adjust the quantities of consumed goods to account for transportation and distribution losses.
	Collect physical properties (e.g., moisture content, solids content, concentration, purity) for materials where these parameters significantly affect EFs. This may enable the selection of an EF with better representativeness or the adaptation of generic EFs.
	Collect disaggregated composition for composite products rather than using aggregated item weight. For example, for cleaning products, collect mass of active ingredients and packaging separately.
	Disaggregate complex assets such as capital goods into major components (steel frame, electronics, batteries, etc.) when EFs depend heavily on material composition (e.g., medical devices).
Energy-related activities (scope 1, scope 2 and scope 3 category 3)	For electricity, collect hourly consumption to improve matching with time-varying grid mixes (if available).
	For fuels, collect actual fuel characteristics (heating value, biogenic vs. fossil fraction, etc.).
Transportation activities (categories 4, 6, 7 and 9)	When feasible, collect fuel consumption instead of transported weight and distance.
	Use primary data collected from suppliers or employees for distances (i.e., actual distances travelled).
	When relying on theoretical shortest distances (e.g., from Google Maps), apply correction factors to better estimate actual distances. Whenever possible, these correction factors should be both mode-specific and region-specific.
	Record exact transport modes, sub-modes, vehicle classes and characteristics. For example: • Freight truck: gross vehicle weight, motorization (e.g., diesel, hydrogen), refrigerated or unrefrigerated, etc. • Air travel: travel class (economy, business), type of aircraft, etc.

Activity type	Good practice
Freight transportation (categories 4 and 9)	For exclusive transportation[6], where distance-based EFs (CO_2e/km) are used, collect or estimate distances that include empty returns and detours.
	For non-exclusive transportation, where distance- and weight-based EFs (CO_2e/t-km) are used, collect or estimate distances specific to the segments over which goods are actually transported, excluding empty returns. Freight transportation EFs expressed per t-km are generally based on a load factor that generically incorporates empty returns.
	For non-exclusive transportation, collect load factors when possible. Load factors may then be used to develop or adapt EFs expressed in CO_2e/t-km, which are based on generic load factors.
	When using distance- and weight-based EFs (CO_2e/t-km), disaggregate all routes to calculate tonne-kilometers (t-km) for each route individually and sum them. This approach is more accurate than estimating t-km using aggregated routes (e.g., by multiplying total weight by average distance). This is illustrated in Box 2-1.
	For the transportation of purchased goods, ensure that all transport segments between the reporting organization and the point where the cradle-to-gate EF ends are accounted for. In some cases, this requires going beyond Tier 1 suppliers – for example, when the organization purchases products through distributors, but the cradle-to-gate EF only covers emissions up to the producer's gate.
Waste-related activities (categories 5 and 12)	Collect waste quantities by material type and waste-treatment process (incineration, landfill, recycling, composting).
	Collect properties of waste (composition, carbon content, etc.) to enable a potential adaptation of direct emissions from waste treatment.
	For recycling, collect recycling rates (actual or theoretical) for each recyclable material, by region, to reflect the share of recovered materials that is not ultimately recycled (e.g., landfilled or incinerated).
Processing and use phase of sold products (categories 10 and 11)	For electricity, quantities consumed should be properly regionalized based on where sold products are processed or used. When regions are unknown – for example, for organizations selling intermediate products – the use of secondary data on consumption markets (e.g., input-output tables) can be relevant.

At the GHG inventory level, a **good practice is to collect the total mass of products sold to perform mass-balance checks**. In principle, the total mass of sold products should roughly match the mass of the organization's inputs[7], accounting for waste, direct emissions (e.g., CO_2) and product inventory. This may, however, be impossible for organizations in some specific sectors, like agriculture. Along the same lines, the total mass of sold products should be consistent with the mass used when quantifying downstream transportation of products. Such mass-balance checks are common in product-level system analysis and

[6] Exclusive transportation refers to the transport of goods in which all the goods being transported belong to the reporting organization. In this case, it is possible for the organization to account for emissions based on the distance travelled, since allocating vehicle impacts based on weight is not necessary.

[7] Including water that is incorporated into products.

can also be valuable at the organizational level to help ensure the completeness and consistency of the GHG inventory.

Box 2-1: Calculating t-km values

Leg	Mass (t)	Distance (km)	t-km
#1	10	100	1 000
#2	20	40	800
#3	5	200	1 000
#4	15	300	4 500
Total	50	640	7 300
Average	13	160	

The table above presents data related to a company's freight transport activities, assuming only four transport legs over the year. It includes the masses transported, the transport distances (excluding empty return trips), and the t-km associated with each leg, calculated by multiplying the transported mass by the distance.

In this case, the preferred approach is to sum the t-km calculated for each route, resulting in a total of 7,300 t-km. This value accurately reflects the transport activity associated with the four legs.

When disaggregated data for each leg are not available, particular care should be taken to avoid multiplying the total mass transported (across multiple legs) by the total transport distance (across all legs). In the example above, this would result in a total of 32,000 t-km, significantly overestimating the activity data. Instead, the company should either multiply the total transported mass by the average distance, or the average mass by the total distance. Both approaches yield a value of 8,000 t-km, which serves as a reasonable proxy for the actual value.

The approach of multiplying total annual mass by the average transport distance is commonly used by organizations quantifying emissions associated with the transport of purchased goods, as transport data are often aggregated at the supplier level (i.e., total mass purchased and distance between the supplier and the organization), without information on the number of trips.

2.1.3 Considerations for spend-based activity data

The collection of spend-based activity data used to calculate emissions for certain categories also presents methodological challenges.

One common approach is to use spend-based data to estimate the physical quantities of purchased goods or services, and then calculate emissions using process-based EFs. However, issues often arise when organizations attempt to convert spend-based data into physical flows (e.g., variation of the cost of products, consideration of inflation). For this reason, obtaining physical quantities directly (e.g., from invoices) is always preferable to converting monetary values using a price per unit. Moreover, **converting expenditures into physical flows, while time-consuming, should still be prioritized over an EEIO-based approach given the significant uncertainties associated with the latter**. However, this conversion from expenditures to physical flows 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 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 stainless steel purchased based on the price of generic steel – it is recommended to **adjust these ratios and/or assess the influence of such assumptions on the results** (ISO, 2024).

When using an EEIO-based approach, the main consideration is to ensure that the collected spend-based activity data align properly with the system boundaries of the EFs applied. In practice, organizations often use expenditures that include margins over the value chain, taxes, or even transportation costs up to the reporting organization's facility. Therefore, the EEIO factors used must be constructed with these same boundaries – otherwise, the activity data will need to be adjusted. Practitioners must ensure that the spend-based activity data are expressed consistently with the EEIO EFs they intend to apply (see section 3.2.2 for more details).

Finally, it is important to ensure that the spend-based activity data reflect the same time period as the EFs. A temporal mismatch between the collected data and the EEIO EFs can significantly bias the results, particularly if substantial inflation has occurred during that time. However, it is **recommended to adjust the spend-based data** to obtain an expenditure consistent with the unit of the EF. This aspect is further addressed in section 3.2.2. For this reason, it is also recommended to use the most up-to-date EEIO EFs available in order to minimize the uncertainty introduced by such adjustments.

2.2 Collection of 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 EF[8] 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.

[8] The adaptation of generic EFs (i.e., from secondary sources) is detailed in section 3.1.7. The current section instead focuses on the process of collecting primary data to create or adapt EFs.

2.2.1 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 2-3.

Table 2-3: 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.

2.2.2 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.

2.2.3 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[9] (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

[9] 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).

- 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 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**[10], 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.

2.2.4 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**.

2.2.5 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**.

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[10] Excluding life cycle stages and activities that are included in other scope and categories.

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.

The **choice of allocation method should follow the GHG Protocol guidance**[11]. 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).

2.2.6 Allocation of product CO_2 removals

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).

For example, a reporting organization may collect primary data from a supplier that produces both wheat and straw. The reporting organization may apply an economic allocation to distribute the supplier's emissions between the two products. Reporting product removals separately requires a different approach, however, since economic factors do not reflect the actual carbon sequestered in each product. Therefore, product removals should be allocated based on the carbon content of each product. In contrast, **other types of removals (e.g., land-based removals), if reported, should be allocated with the same method as emissions**.

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

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

2.2.7 Decision tree – Collecting primary data from value chain partners

The decision tree below summarizes the recommendations in section 2.2. It provides guidance on the key choices involved in collecting primary data from value chain partners to develop more specific EFs. Such data collection should be prioritized for significant emission categories, when feasible, such as for purchased goods and services. Additional notes related to the decision tree are detailed in Table 2-4. In the decision tree, these notes are identified using numbers in brackets (e.g., [1]).

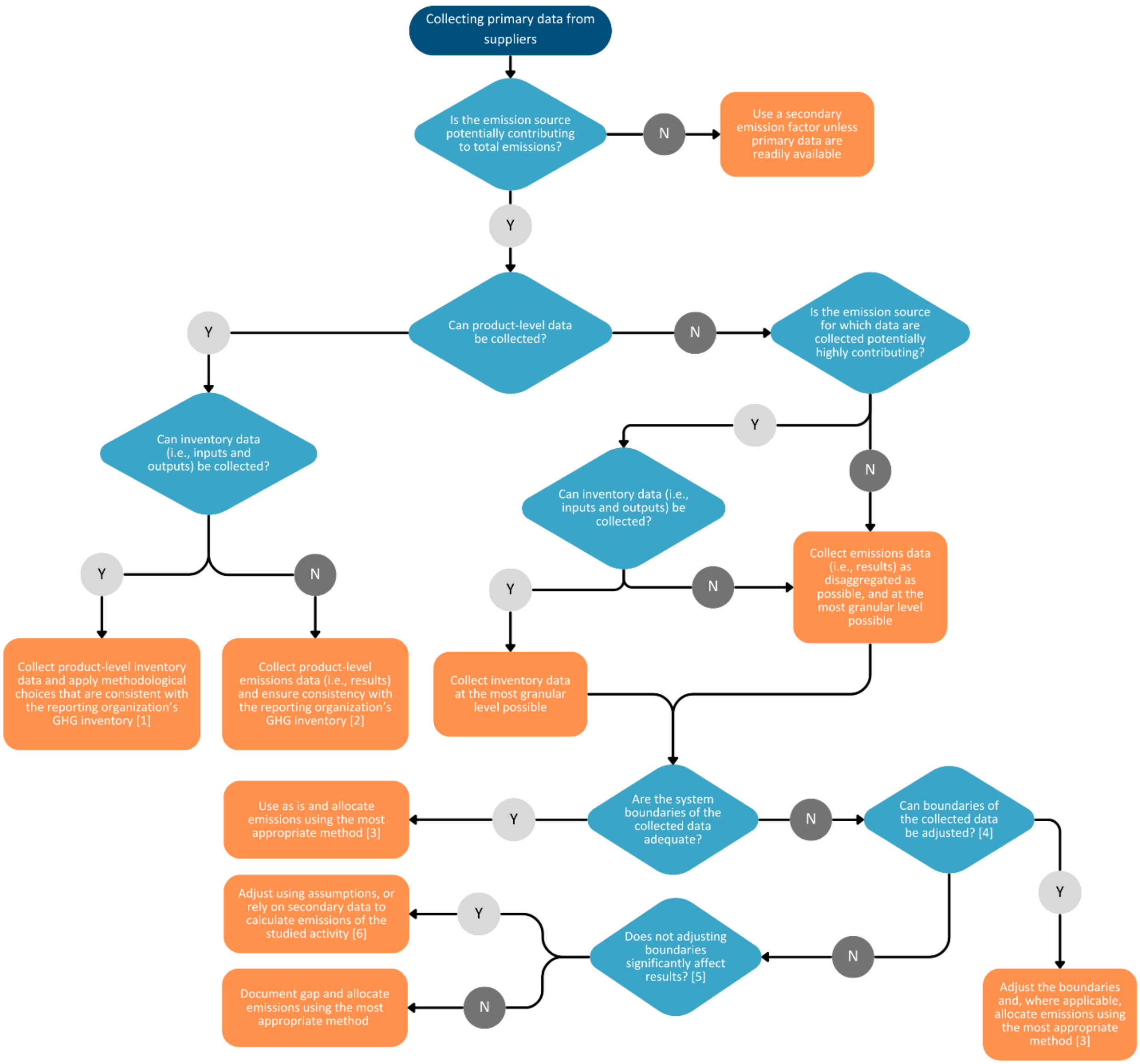


Figure 2-1: Decision tree to support the collection of primary data used for emission factors

Table 2-4: Notes associated with the decision tree in Figure 2-1

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 EFs, 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 SELECTION OF EMISSION FACTORS

The selection of EFs is a critical step in developing a GHG inventory. This section focuses on the selection and adaptation of EFs based on secondary data, including those drawn from LCI databases, the literature, standards, and other sources. Two main types of secondary-data EFs are commonly used: process-based (i.e., physical) and environmentally extended input-output (EEIO) EFs (i.e., financial), as discussed in *Technical Report 2*. The following sections are structured accordingly, first outlining the criteria that determine when each type of data is appropriate and then providing practical recommendations for their use.

3.1 Selection of process-based emission factors

The advantages and limitations of process-based EFs are discussed in *Technical Report 2*. In general, they offer several significant benefits over EEIO EFs, notably much better technological representativeness and improved tracking of emissions over time. For this reason, it is recommended to prioritize the use of process-based EFs whenever possible.

Nevertheless, using process-based EFs to calculate emissions across all of an organization's activities can be challenging, primarily due to the limited availability of physical data – both activity data and EFs.

Therefore, certain criteria can help organizations decide when it is worthwhile to invest additional resources in adopting a process-based (physical) rather than an EEIO (financial) approach. It should be noted that the use of EEIO EFs is recommended by the GHG Protocol 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). For these categories, a process-based approach is recommended over a financial approach 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 value may vary depending on the characteristics of the GHG inventory – such as its operational boundaries or the organization's sector. Moreover, the relevance of a specific source also depends on how it is defined (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 physical 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 **emission category or source is deemed critical by the organization or its stakeholders**. For example, if the packaging used by a manufacturing company is considered critical by consumers – despite its low contribution to the overall GHG inventory – it is good practice to assess its production using a physical approach to improve the accuracy of results.
- **Sufficient activity data and EFs are available**, or can be made available, to support a physical approach.

The following subsections provide practical recommendations for the use of process-based EFs.

3.1.1 Boundaries

In terms of system boundaries (i.e., the activities covered), process-based EFs can be classified into two main categories:

- *Direct EFs*, which have narrow boundaries and account only for direct emissions associated with a specific process (e.g., EFs representing fuel combustion).
- *Life cycle EFs*, 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 EFs that cover only the scope 1 activity** (i.e., EFs with narrow boundaries). Such EFs are widely available and can be used as is. In contrast, life cycle EFs, such as LCI data, require adaptation to isolate and represent direct emissions only.

For the **assessment of indirect emissions (scopes 2 and 3), reporting organizations should select and use life cycle EFs**. Such data enable the assessment of the total contribution of activities along the value chain by adopting a life cycle perspective. They also provide better transparency and flexibility and enable greater consistency across the GHG inventory (regarding aspects discussed in the following sections). Nonetheless, the use of direct EFs can be appropriate for some specific scope 3 categories or for organizations that need to adhere to minimum boundary requirements – something that can be more complex to achieve when using LCI data (this point is discussed in more detail below).

The reporting organization should also ensure that the system boundaries of the EFs align with the boundaries of the category being assessed. A common example of such misalignment arises with electricity. In this case, the reporting organization should ensure that scope 2 emissions include only the combustion emissions at the power generation site associated with the purchased quantity of electricity – while all other life cycle emissions associated with electricity are reported under scope 3. Accordingly, the organization should select EFs that reflect this distinction. Important boundary considerations, per scope 3 category, are presented in Table 3-1.

When an organization aims to comply with specific programs, it may be required to adhere to minimum boundary requirements, meaning that optional emission sources must be excluded. In such cases, organizations using life cycle EFs may need to adapt these data to ensure compliance with the prescribed boundaries. Therefore, it is recommended to prioritize the use of disaggregated EFs (i.e., LCI data), as this allows them to be adapted when relevant.

Based on the main LCI databases, Table 3-1 indicates whether LCI data from common sources need to be adapted to comply with minimum boundary requirements of scope 3 categories. However, the necessity and extent of the adaptation depend on the specific system boundaries of each LCI data, and the context and objective of the GHG inventory, and should be assessed on a case-by-case basis.

Table 3-1: Key boundary considerations for scope 3 categories when using LCI data

Category	Minimum boundaries	Key considerations
1. Purchased Goods and Services **2.** Capital Goods	Cradle-to-gate of good or service	For **minimum boundaries**, adaptation of the dataset is generally **not necessary**. Other boundary considerations include: • The **end-of-life** of the good may be included in some LCI data and should be removed. For example, the "computer production, laptop" dataset in ecoinvent 3.11 includes the end-of-life treatment of the good. It should not be reported in category 1. • The **upstream transportation** (i.e., between the organization's supplier and its own operations) may be included in some LCI data. It should be removed as it is reported in category 4. For example, in ecoinvent, "market" activities generally include upstream transportation. • For **secondary products**, the end-of-life allocation procedure used should be consistent with the one used for the disposal of recyclable waste (the cut-off approach is recommended).
3. Fuel-and-Energy Related Activities	**Fuels**: upstream emissions of purchased fuel (extraction, production and transportation)	For **minimum boundaries**, adaptation of the dataset is generally **not necessary**. Other boundary considerations include: • The **transportation** of fuels should be accounted for in this category, and not in category 4 (upstream transportation and distribution). Most LCI databases include transportation in fuel production datasets.
	Purchased electricity, steam, heat and cooling: • Purchased energy: upstream emissions of fuels consumed in the generation; • T&D losses: all upstream emissions of energy consumed in a T&D system (upstream emissions of fuels and combustion)	For **minimum boundaries**, adaptation of the dataset is **necessary**. LCI data are typically available for heat and electricity and usually represent the complete life cycle emissions of the energy (scope 2 and scope 3 category 3). Scope 3 EFs aligned with minimum boundaries must only account for the **production** of fuels consumed in energy generation, and the **transmission and distribution losses** (fuel production and combustion for energy losses). For more details, see section 6 of *Technical Report 1*. Other boundary considerations include: • When adopting a life cycle perspective (i.e., going beyond minimum boundary requirements), the infrastructure associated with energy generation and distribution should be included. This is particularly important for renewable energy sources, which are otherwise considered carbon neutral – or nearly so. • For heat, steam and cooling, distribution losses should also be estimated and accounted for. They are generally excluded in LCI data, which represent the generation of energy (e.g., heat), and do not include its distribution.

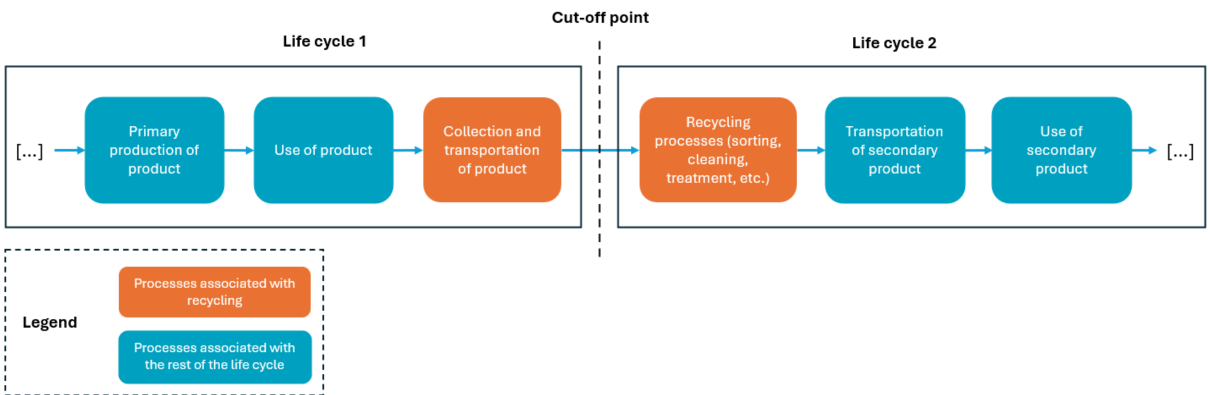
Category	Minimum boundaries	Key considerations
4. Upstream Transportation and Distribution **6.** Business Travel **7.** Employee Commuting **9.** Downstream Transportation and Distribution	Scope 1 and scope 2 emissions of the service provider	For **minimum boundaries**, adaptation of the dataset is **necessary**. Transportation LCI data typically include fuel combustion emissions and other processes (fuel production, vehicle construction, vehicle maintenance, infrastructure, etc.). Only fuel combustion emissions and electricity generation (scope 2) emissions must be accounted for. For example, a hybrid electric vehicle would account for both fuel combustion emissions and electricity generation emissions. For **storage and retail** (categories 4 and 9), only scope 1 and 2 emissions should be accounted for (fuel combustion, fugitive emissions from cooling, electricity generation).
5. Waste Generated in Operations **12.** End-of-Life Treatment of Sold Products	Scope 1 and scope 2 emissions from the service provider	For **minimum boundaries**, adaptation of the dataset is **necessary**. Waste treatment LCI data typically include processes beyond scopes 1 and 2 emissions, like fuel production, machinery, infrastructure, etc. Other boundary considerations include: ● **For recycling activities**, the end-of-life allocation procedure used should align with the one used for purchased secondary products (the cut-off approach is recommended). ● **Transportation**: emissions associated with waste transportation can optionally be included and should be reported in this category. They are outside of the minimum boundaries.
8. Upstream Leased Assets **13.** Downstream Leased Assets	Asset lessor's scope 1 and scope 2 emissions	Typically, for these categories, practitioners will use energy-related LCI data (e.g., fuel combustion, electricity production). In this case, for **minimum boundaries**, adaptation of the dataset is **necessary**, as detailed for category 3 (fuel-and-energy related activities). Practitioners may also use LCI data associated with operating an asset. For example, the "machine operation, diesel" dataset in ecoinvent, which is expressed per hour. In this case, for **minimum boundaries**, adaptation of the dataset is **necessary**. These operation datasets indeed include processes beyond scopes 1 and 2, like fuel production and infrastructure. Other boundary considerations include: ● For **downstream leased assets**, special care should be taken when using LCI data related to the operation of an asset to avoid double counting its production. The manufacturing of the asset should be reported under category 2 (capital goods), but LCI data often include this by default – since they typically account for infrastructure. As such, the production of the asset should be excluded from these datasets to prevent overlap.

Category	Minimum boundaries	Key considerations
10. Processing of Sold Products	Scope 1 and Scope 2 emissions from product processers	Typically, for these categories, practitioners will use energy-related LCI data (e.g., fuel combustion, electricity production). In this case, for **minimum boundaries**, adaptation of the dataset is **necessary**, as detailed for category 3 (fuel-and-energy related activities). Practitioners may also use LCI data that represent a transformation process, for example the "injection moulding" dataset in ecoinvent. In this case, for **minimum boundaries**, adaptation of the dataset is **necessary**. These transformation datasets include processes beyond scopes 1 and 2, like fuel production, material inputs, treatment of waste, etc. Other boundary considerations include: ● When using LCI data representing a transformation process (e.g., metalworking, plastic extrusion), special care should be taken to exclude the input of the material being transformed (e.g., metal, plastic) if it is already included in the dataset. These datasets sometimes account for the material being transformed, which can lead to double counting if not adjusted.
11. Use of Sold Products	Scope 1 and scope 2 emissions associated with the direct-use phase of products	For **minimum boundaries**, adaptation of the dataset is **necessary** for both energy-related (e.g., "diesel, burned in machinery") or product use (e.g., "fertilizer application") LCI processes. Minimum boundaries cover direct-use phase emissions only, i.e., products that directly consume energy during use (motors, lighting, etc.), fuels and feedstock, and products that contain or form GHGs that are emitted during their use (fertilizers, refrigerants, etc.).
14. Franchises	Franchisee's scope 1 and scope 2 emissions	Typically, energy-related datasets are used for this category. For **minimum boundaries**, their adaptation is **necessary**, as detailed for category 3 (fuel-and-energy related activities).
15. Investments	Proportional scope 1 and scope 2 emissions of equity investments, debt investments and project finance	*LCI data are generally not used to estimate emissions from investments.*

3.1.2 End-of-life allocation

Particular attention must be paid to the system boundaries of EFs when dealing with multifunctional activities. In the context of a GHG inventory, this concern primarily arises in the case of the procurement of secondary materials (category 1) and the treatment of recyclable waste or residues (categories 5 and 12).

As a general rule, it is recommended to follow the GHG Protocol's guidance and adopt the recycled content (cut-off) approach by default (as described in section 9.1 of *Technical Report 1*), placing the cut-off point after the transport of recyclable materials. This approach is illustrated in Figure 3-1. Applying the cut-off approach, as recommended by the GHG Protocol, should not lead to the selection of EFs for the end-of-life treatment of recyclable materials. Under this approach, only the transport of recyclable materials to the point of recovery is included. Therefore, the appropriate EFs to select are those related to the transport of the materials, not to their end-of-life treatment (i.e., recycling).



"Life cycle 1" refers to the primary product, while "Life cycle 2" refers to the secondary product. As recommended by the GHG Protocol, the cut-off point is set after the collection and transportation of the primary product at its end-of-life. Thus, the organization generating the recyclable material accounts for emissions from its collection and transportation to the processing site, in scope 3 category 5 (waste generated in operations). 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), unless the purchasing organization controls these processes. The transportation of the secondary product between recycling facilities and the organization is accounted for in scope 3 category 4 (upstream transportation and distribution).

Figure 3-1: Illustration of the recycled content (cut-off) approach

However, certain conditions may justify placing the cut-off point elsewhere in the life cycle, such as prior to the collection and transport of recyclable waste. The main factors justifying this choice are:

- Consistency with the EF database used: For instance, the "cut-off, by classification" system model in the ecoinvent database places the cut-off point before transportation of the recyclable material.
- Relevance to the organization's context: The materiality of transport processes may vary depending on the nature of the organization's activities. For example, if an organization primarily manufactures goods from recycled materials and generates only a small amount of recyclable waste, it may be more relevant to place the cut-off before the collection and transport of waste, thus including this transport in category 4. This ensures that the GHG inventory captures emissions from the transport of key inputs – an important emission source over which the organization may have influence – while excluding negligible emissions from the downstream transportation of minor waste streams.

The organization must also ensure consistency in the application of the cut-off point between the procurement of secondary materials and the treatment of recyclable waste. This is essential to avoid double counting or omissions of relevant processes. The same approach should be applied across all secondary products and recyclable material streams within the GHG inventory. Ensuring consistency may be challenging when using EFs from different sources, particularly when they are not derived from LCI databases, which typically offer greater transparency and methodological alignment.

Alternative methods may be appropriate where they better reflect the organizational context, as acknowledged by the GHG Protocol. The closed-loop approximation method, for instance, may be used for closed-loop recycling – or for open-loop scenarios where the recycled material retains its original properties. The 50/50 allocation approach may also be appropriate in the context of GHG inventories. These end-of-life allocation approaches are described in section 9 of *Technical Report 1*.

Conversely, the *allocation at the point of substitution* (APOS) method is not recommended due to its complexity and limited adoption. Likewise, the *Circular Footprint Formula* (CFF) method should not be used, as it involves system expansion, which is not permitted under the GHG Protocol. Both of these end-of-life allocation approaches are also described in section 9 of *Technical Report 1*.

Finally, for organizations where the use of secondary materials or the generation of recyclable waste represents a significant share of activities (e.g., construction sector, manufacturing company heavily reliant on recycled inputs), it is recommended to conduct a sensitivity analysis to assess how the choice of end-of-life allocation approach affects results. For example, the cut-off approach can be used as the default method, while the 50/50 method can be tested as a sensitivity analysis.

3.1.3 Included GHGs and assessment metric

Another important aspect to consider when selecting EFs is the set of GHGs included and the metric used to calculate the resulting CO_2e value. These considerations may vary depending on the type of process-based EFs being used. As noted earlier, LCI data should generally be prioritized. Their greater transparency and flexibility allow for better alignment with the GHG Protocol requirements and help ensure consistency across the GHG inventory. The following subsections provide recommendations based on the level of aggregation of secondary EFs:

- Aggregated EFs: EFs that do not provide access to the detailed model underlying them, and therefore, often lack transparency regarding system boundaries (i.e., included activities) and the GHGs included. They are generally expressed in CO_2e.
- LCI data: EFs that are generally disaggregated and therefore provide access to the underlying network of processes. Even when the underlying process network is not available due to their level of aggregation, they typically provide GHG emission quantities disaggregated by individual GHG.

a) Aggregated emission factors

When a reporting organization uses aggregated EFs expressed in CO_2e, limited transparency and documentation can make it difficult to determine which GHGs are included and which metric was used to calculate the CO_2e value. Moreover, this type of data is also difficult to modify – even if the practitioner is aware of the GHGs considered and the metric applied.

For these reasons, LCI data should generally be preferred whenever feasible. That said, the use of aggregated EFs may still be appropriate in some cases – for instance, when adhering to minimum boundaries, as these EFs are often those capturing only the direct emissions of an activity (i.e., *direct EFs*). In such cases, **the reporting organization should aim to select EFs that are consistent with the GHG Protocol's requirements as well as with the methodological choices made elsewhere in the inventory**.

If this is not possible, the organization should assess the sensitivity of the results to the choice of EFs to ensure that the overall conclusions are not significantly impacted. For example, using an EF based on GWP100 values from an older IPCC assessment report for a major emission source could significantly affect results – particularly if the activity involves large emissions of non-CO_2 gases. In such situations, a more appropriate EF should be used given its potential influence on the results. The use of EFs that are not aligned with the GHG Protocol or the methodological choices made elsewhere in the inventory **should be clearly documented**.

b) LCI data

LCI data are more flexible and can be converted into CO_2e using different metrics (i.e., GWP100, GWP20, global temperature potential [GTP], etc.) using values from different IPCC assessment reports (ARs) (e.g., IPCC 2021 [AR6], IPCC 2013 [AR5]). This flexibility makes it easier to ensure consistency across the inventory.

However, ensuring that only the GHGs required by the GHG Protocol are included can be more challenging. LCI data typically cover an extensive chain of background processes, including a wide variety of GHGs. In general, LCI data include all GHGs characterized by the selected impact assessment method or metric – GWP100, for inventories aligned with the GHG Protocol. While this goes beyond the seven GHGs covered under the Kyoto Protocol, the contribution of additional gases is generally negligible.

If the organization must comply with the GHG Protocol's requirements regarding included GHGs (e.g., if it reports emissions under a program), it is recommended to use LCI data in LCA software and create a custom impact assessment method that includes only the seven GHGs covered by the Kyoto Protocol. This method can then be used to calculate the CO_2e values.

In the case of voluntary reporting, it may be appropriate to use the data as-is – even if this means including GHGs beyond those required. These values can be calculated either using LCA software or directly from Excel files or web interfaces (e.g., ecoQuery for ecoinvent). In such cases, the GWP100 values from the latest IPCC assessment report should be used. The organization should then be transparent about this choice and clearly document that its indirect emissions include GHGs beyond those required by the GHG Protocol.

3.1.4 Biogenic carbon

As discussed in *Technical Report 1*, the *Corporate Standard* and *Scope 3 Standard* require that biogenic CO_2 emissions and removals be reported separately from the emission scopes. The *Land Sector and Removals Standard* also requires that biogenic CO_2 emissions, whether from land management or biogenic products (e.g., biofuel combustion), and removals be reported in separate categories. This is relatively straightforward for scope 1, as EFs used typically correspond to specific activities (e.g., fuel combustion, fugitive emissions), making it generally straightforward to identify and account for biogenic flows separately.

In contrast, for indirect emissions, process-based EFs may cover a wide range of activities across the value chain. For instance, the EF associated with the production of a biofuel includes the cultivation stage of the biomass, and a CO_2 removal may be embedded in the EF (as a negative CO_2 emission), depending on the methodology applied. The implications and practical guidance vary according to the type of process-based EFs used.

This section focuses on biogenic CO_2 emissions and removals that are associated with land management practices and biogenic products. It excludes LUC CO_2 emissions and removals, which are addressed in the next section. Biogenic carbon monoxide (CO) emissions are not addressed in this section, as CO is not covered by the seven GHGs required under the GHG Protocol. Biogenic CH_4 emissions are not discussed in detail, as they are reported within the scopes in the same way as fossil-derived CH_4, with the exception that a specific GWP value applies.

a) Aggregated emission factors

When using aggregated EFs, practitioners should ensure that these factors do not include biogenic CO_2 emissions or removals. The only exception is when an aggregated EF is used specifically to quantify biogenic CO_2 emissions or removals that will be reported separately, for example, biogenic CO_2 emissions associated with biofuel combustion. This recommendation applies particularly to EFs used to quantify emissions from activities within the scopes. It is especially important for the supply of bio-based products (categories 1 and 3) and waste treatment activities (categories 5 and 12), where such flows can be significant contributors.

Aggregated EFs, by nature, do not allow for separate reporting of these flows. If biogenic CO_2 emissions and removals are not embedded within the factor, they are generally excluded entirely. This reinforces the importance of prioritizing LCI data to meet the requirements of the GHG Protocol, especially if the reporting organization goes beyond minimum boundaries.

If the reporting organization follows the *Land Sector and Removals Standard*, aggregated EFs are not appropriate for reporting net biogenic CO_2 emissions and removals from land management, as the values associated with these accounting categories must be reported separately. Moreover, aggregated EFs does not reflect situations in which the reporting organization meets the requirements to account for land management CO_2 emissions or removals (e.g., accounting approach, level of traceability, data quality, etc.).

b) LCI data

LCI data, on the other hand, allow users to ensure that biogenic CO_2 emissions and removals are excluded from the emission scopes. This can be achieved by selecting a metric that does not characterize biogenic CO_2 flows. The GWP100 metric used by default (e.g., in LCA software) does not characterize biogenic CO_2

– though practitioners should remain vigilant on this point.

Nonetheless, the GHG Protocol requires separate reporting of indirect biogenic CO_2 emissions and recommends separate reporting of CO_2 removals, although this is more complex than for direct emissions or removals. First, these flows are not always included in LCI databases. Some databases adopt the "0/0" approach (carbon neutrality assumption for biogenic CO_2) and do not report these flows. Table 3-2 presents how biogenic CO_2 flows are handled in some of the main LCI databases. It is recommended to use databases that include biogenic CO_2 emissions and removal flows. The emission and removal flows mentioned here refer mostly to biogenic product CO_2 emissions and removals. Other types of removals, such as those in land-based reservoirs (e.g., below-ground biomass or soil), are generally excluded from LCI databases unless they result from LUC.

Table 3-2: Treatment of biogenic carbon flows in the main LCI databases

LCI Database	Treatment of biogenic CO_2 flows
ecoinvent	• Biogenic CO_2 flows included • Carbon content of product as additional information • Carbon correction flows for allocated products
Base Carbone & Base Empreinte	• Biogenic CO_2 flows are generally included • Biogenic CO_2 flows excluded (0/0 approach) for some wood products
Sphera LCI database (GaBi)	Biogenic CO_2 flows included
Agribalyse	Biogenic CO_2 flows included
Agrifootprint	Biogenic CO_2 flows excluded (0/0 approach)
USLCI	Biogenic CO_2 flows included

When using databases that include biogenic flows, these flows are likely to be present in most, if not all, LCI data, since LCI data represent extended background systems. Reporting biogenic CO_2 emissions and removals for all LCI data used would be time-consuming and would add little value to the GHG inventory. Therefore, biogenic CO_2 emissions and/or removals should be reported separately for categories or activities where biogenic CO_2 emissions or removals are likely to be significant. These mainly include upstream supply chain categories (categories 1, 2, and 3) and waste treatment (categories 5 and 12), though other categories – particularly in the context of bioenergy (e.g., all transport-related categories) – may also be relevant.

In practice, the approach for separately accounting for and reporting these flows depends on how the GHG inventory is prepared and on the data provided by the LCI database used. For example, if the practitioner works in Excel, **the relevant biogenic CO_2 flows, both emissions and removals, should be identified for each relevant emission source** (i.e., LCI data used). In this case, the practitioner can extract the flows associated with the LCI data from the documentation provided by the database provider, whether in Excel format or through a web interface. If the organization uses ecoinvent, for example, the practitioner can consult the dataset in ecoQuery and extract the flows as follows:

- **Biogenic CO_2 emissions:** Sum the different biogenic CO_2 emission flows in the "LCI results" tab. For example, in ecoinvent 3.12, these correspond to the "Carbon dioxide, non-fossil" flows.

- **CO_2 removals:** Follow the same approach as above using the “Carbon dioxide, in air” flow, or consult the “Impact assessment” tab and use the result for the “climate change: biogenic removals (incl. CO_2)” impact category from the “IPCC 2021 (incl. biogenic CO_2)” LCIA method.

In contrast, if the GHG inventory is modelled in an LCA software, practitioners should analyze the elementary flow inventory (LCI results) and identify relevant flows. This can be done at the individual LCI data level, or at the level of an entire scope 3 category – for example, by identifying biogenic CO_2 emissions associated with purchased goods (category 1). In general, separate reporting should be prioritized at the individual emission source level when these flows are significant – especially for the production and end-of-life or combustion of bio-based products. In other cases, category-level reporting may be sufficient if the contribution of these flows is minor.

When analyzing the LCI results, biogenic CO_2 removals and emissions can generally be identified by the name of the flows. In ecoinvent 3.12, for example, the following flows correspond to biogenic removals into products:

- "Carbon dioxide, in air"
- "Carbon dioxide, non-fossil, resource correction", when positive[12]

The sum of these two flows represents the total CO_2 removal associated with the LCI data. In ecoinvent 3.12, biogenic CO_2 emissions correspond to the flow "Carbon dioxide, non-fossil".

c) Correction for allocated bio-based products

The biogenic product CO_2 removal embedded in an LCI data for a bio-based product typically corresponds to the amount of carbon sequestered in the product itself. However, for products resulting from multifunctional processes, this sequestration is allocated according to the allocation procedure used in that dataset. In many cases, this is an economic allocation, which does not accurately reflect the actual CO_2 removal associated with the product. The product's carbon content would better represent this removal, but it is not the basis of the allocation.

To address this, ecoinvent introduced the flow "Carbon dioxide, non-fossil, resource correction" to correct the distribution of removals among co-products following economic allocation. At the time of writing, ecoinvent is, to the authors’ knowledge, the only database to provide this correction. Therefore, **for bio-based products derived from multifunctional processes, it is recommended to use ecoinvent to report removals separately based on LCI data**. Otherwise, removals embedded in other databases may not accurately reflect the carbon content of the product, which could lead to under- or overestimation of separately reported removals.

This issue is less critical in databases that use or offer a mass allocation version. For instance, Agri-footprint provides a version based on mass allocation. In such cases, mass allocation more closely reflects how sequestered carbon is distributed across co-products.

3.1.5 Land use change

The *Corporate Standard*, through the *Agricultural Guidance* (GHG Protocol, 2014), recommends including LUC-related scope 1 emissions within the scopes and reporting LUC-related scope 1 removals separately.

[12] If this flow is negative, it actually represents a biogenic CO_2 emission. It is discussed in the following point (c).

Regarding scope 3, the *Scope 3 Standard* provides very limited guidance on how to account for and report LUC-related impacts, even though these impacts can be significant – particularly for the sourcing of bio-based products and fuels (categories 1 and 3).

By contrast, the *Land Sector and Removals Standard* provides a much more comprehensive framework for accounting for LUC-related emissions, covering both direct and indirect emissions. For this reason, it is considered good practice to follow the recommendations and requirements of this standard, even if the reporting organization does not conduct a full GHG inventory in accordance with it.

First, from a methodological standpoint, the *Land Sector and Removals Standard* requires organizations to prioritize primary data when quantifying LUC impacts. In such cases, the calculated values represent direct land use change (dLUC) emissions, where LUC impacts are directly attributed to the products that cause them. In other words, these impacts correspond to changes occurring on the land where the product was produced. However, this approach requires traceability back to the production site, which can be very challenging, particularly for processed goods.

When limited traceability prevents the collection of primary data, a jurisdictional dLUC (jdLUC) approach is recommended. This approach estimates emissions for a given commodity at the scale of a group of farms, a sourcing region (i.e., supply shed), or a jurisdiction. Under this approach, impacts are still directly attributed, but at a lower level of geographic resolution. In practice, LUC events are attributed to the products that drive them, but are averaged across production within a given region. Tools such as Orbae (AdAstra Sustainability, n.d.) or Satelligence (Satelligence, n.d.) can support this type of assessment by estimating dLUC emissions for specific commodities at various levels of aggregation. The resulting LUC values can then be incorporated into a product's EF, whether calculated internally or sourced from databases.

Finally, when an organization lacks the data required to calculate dLUC impacts, it may apply a statistical land use change (sLUC) approach. sLUC relies on data with limited geographic resolution – typically at the national level. Unlike dLUC, it does not attribute LUC impacts to specific commodities, but rather allocates them based on national production trends (i.e., to crops for which cultivated area is expanding). LCI databases that include LUC impacts generally follow an sLUC methodology; therefore, using EFs derived from such databases typically implies the application of sLUC.

Other key recommendations related to LUC emissions from the *Land Sector and Removals Standard* include:

- **Amortization period ("LUC assessment period")**: 20 years for annual crops and those with a cultivation cycle or rotation period of less than 20 years. For crops with a longer cycle or period, the duration of that cycle or period should be used as the amortization period.
- **LUC allocation method**: LUC-related emissions should be amortized using a linear discounting approach. Where applicable, the organization should justify the use of an alternative approach (e.g., equal discounting).
- **sLUC allocation method**: When using the sLUC approach, organizations should apply the production expansion allocation method.

a) Selection of emission factors

In practice, the approaches described above may involve either calculating LUC-related emissions directly (i.e., dLUC) or extracting them from a tool or database (sLUC).

When the organization does not follow the *Land Sector and Removals Standard*, LUC emissions are reported within the scopes, without being separated from other types of emissions. As a result, there is typically no issue related to data disaggregation: the organization can combine LUC emissions – whether calculated or taken from a secondary data source – with the other emissions associated with the bio-based product, or simply use EFs that already integrate LUC emissions.

However, if the organization follows the *Land Sector and Removals Standard*, it must report LUC emissions separately from the other emissions associated with the bio-based product under assessment, such as fossil and industrial emissions and land management emissions. Under a dLUC or jdLUC approach, this is straightforward since the value is either calculated or obtained independently from other emissions. However, if a secondary EF (e.g., LCI data) is used to represent the other emissions associated with the production of a bio-based product (i.e., cradle-to-gate), it may need to be disaggregated and adjusted to remove any LUC emissions already included, thereby avoiding double counting.

An sLUC approach is typically applied using LCI data that already include LUC emission values calculated according to that method. For this reason, if the organization adopts this approach while following the *Land Sector and Removals Standard*, it will need to disaggregate and adjust the EF in order to report the different types of emissions separately, including LUC. Therefore, **when the reporting organization uses this approach (sLUC), it is recommended to use disaggregated LCI data to enable this adjustment**.

How LUC emissions are disaggregated and reported separately depends on the LCI database and tool used to access the data, such as LCA software or a web interface. For example, in the ecoinvent 3.12 database, this may involve extracting the absolute value, in CO_2e, of the LUC flow or flows – which, in this case, are intermediate flows – from the LCI data. If the practitioner uses the ecoQuery web interface, for instance, this involves going to the “Impact assessment” tab of the dataset and extracting the value associated with the “climate change: direct land use change” impact category under the “IPCC 2021” LCIA method.

b) Land use change removals

LUC can also lead to CO_2 removals, for example when annual cropland is converted into secondary forest. In such cases, the *Agricultural Guidance* requires LUC removals to be reported separately, outside the scopes.

However, the *Land Sector and Removals Standard* is not explicit on how LUC removals should be accounted for and reported. It states: "When LUC results in net removals or removals following an initial conversion that resulted in emissions, organizations shall first account for the gross LUC emissions of the initial land use change, and then may separately account for the land management net CO_2 removals of the subsequent land use […]" (GHG Protocol, 2026).

In other words, the standard indicates that LUC removals may optionally be reported as "Land management net CO_2 removals", provided that any emissions from the conversion are first accounted for and reported, where applicable. In practice, the ease of complying with this requirement depends on the LUC calculation approach used:

- **dLUC**: Under this approach, LUC impacts are calculated using primary data. The reporting organization can therefore track emissions and removals throughout the assessment period and report LUC removals under the accounting category "Land management CO_2 removals" where applicable.
- **jdLUC**: A jdLUC approach may or may not include LUC removals, depending on the methodology. As a result, an organization can generally only ensure that LUC removals are excluded from the net emission values used if the tool used actually excludes them. Therefore, a practitioner using a tool that provides emissions under a jdLUC approach should verify that the reported emission value is not a net value with removals already included in the background.
- **sLUC**: sLUC approaches may include removals, depending on the data source and implementation. This is the case for the ecoinvent database, for instance: some processes may have a negative value associated with LUC, meaning that LUC removals are greater than LUC emissions. However, even when the net LUC value is positive, indicating net emissions, removals may still be included in the background. It is therefore difficult to comply with the requirement not to account for removals within LUC emissions when using an sLUC approach.

If the organization must follow the *Land Sector and Removals Standard* and uses an sLUC approach, one option is to create a custom LCIA method in LCA software that characterizes only LUC emissions and does not characterize any other flows, including LUC removals. For example, in the ecoinvent 3.12 database, the LUC emissions are the elementary flows "Carbon dioxide, from soil or biomass stock" and "Methane, from soil or biomass stock," while the removal flow is "Carbon dioxide, to soil or biomass stock." For these three flows, the characterization factors in the custom LCIA method should be 1 kg CO_2e/kg, 29.8 kg CO_2e/kg, and 0 kg CO_2e/kg, respectively.

3.1.6 Representativeness

EFs should be selected based on how well they represent the activity being modelled. Representativeness is assessed along three dimensions: technological, geographical, and temporal.

- **Technological representativeness** refers to the extent to which the EF reflects the technological characteristics of the modelled activity. These characteristics vary depending on the activity but may include process design, material inputs, production scale, operating conditions, and more.

- **Geographical representativeness** refers to the extent to which the EF reflects the geographical characteristics of the modelled activity. These may include climate conditions, the energy mix, applicable regulations, market conditions (supply and demand), etc.
- **Temporal representativeness** refers to the extent to which the period covered by the EF aligns with the timeframe of the modelled activity. It is generally assessed based on the time gap between the two periods.

These three types of representativeness are interrelated. For example, data related to a rapidly evolving technology should be updated more frequently than that related to a mature technology – highlighting the link between temporal and technological representativeness. Similarly, geography is closely tied to production technologies. For instance, agricultural practices vary from one region to another.

When selecting EFs, **it is recommended to assess and optimize their representativeness relative to the modelled activities**. For temporal representativeness, the time gap between the data and the organization's reporting period should be minimized.

For technological representativeness, the choice should be based on the key relevant characteristics of the activity, which vary by sector. For example, in agriculture, the type of production (conventional, organic, etc.) and yield are critical technological characteristics. In freight transport, engine type, fuel consumption, and load factor are three important technological characteristics.

For geographical representativeness, the data should ideally correspond to the same geographical region as the activity. If that is not possible, the choice should be guided by the most relevant geographical characteristics of the activity to select the most suitable factor available, even if it originates from another region (i.e., type of climate, electricity mix, consumer behaviours, etc.).

At the scale of a corporate GHG inventory, achieving high geographical, technological, and temporal representativeness for all EFs is often very difficult – if not impossible. Therefore, **efforts should be prioritized toward improving the representativeness of data associated with activities that contribute significantly to overall results**. Improving representativeness can be achieved not only by selecting better data but also by adapting existing data. This aspect is addressed in the following section.

3.1.7 Data adaptation

Since the availability of EF data is limited, achieving better representativeness of the modelled activities often requires adapting EF data. This reinforces one of the key recommendations presented in this section: **prioritizing the use of LCI data**. LCI data offer sufficient flexibility to be modified within LCA software, unlike aggregated EFs.

Adaptations of EFs can be complex and time-consuming and should be carried out strategically, prioritizing data with limited representativeness – whether the gap is temporal, geographical, or technological. Second, priority should be given to adapting data used for activities that contribute significantly to the GHG inventory results. Conversely, using non-representative EFs to quantify emissions from an activity that is negligible is less problematic. Other criteria may also be considered when deciding whether to adapt an LCI data, such as the organization's level of influence over the emission source, data availability, or any other relevant criteria determined by the organization.

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 region of a flow is relevant when the flow is appropriate but could be linked to a more geographically representative context. For example, an LCI data can be partially regionalized by modifying energy-related flows to reflect the region under study (since the impact of such flows, particularly electricity, varies greatly across regions).
  b) Modifying the flow itself is relevant when one of the flows in the dataset is known to be inappropriate. This could involve removing a flow (e.g., a waste stream that does not actually occur) 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. Note that some parameters may affect the quantities of multiple flows simultaneously. For instance, in an 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.

The main potential adaptations of LCI data are presented by activity type in Table 3-3. These are provided for informational purposes and should be interpreted generically; practitioners consider the specific characteristics of the activities under study when deciding how to adapt LCI data. As previously noted, some of these adaptations are complex and time-consuming; they should therefore be prioritized for activities with a significant contribution to overall results. Factors that are typically already accounted for when selecting LCI data are not listed in Table 3-3. For example, fuel type is not included for a passenger transportation process, as databases usually already provide different LCI data for different fuel types.

Table 3-3: Main potential adaptations of LCI data for GHG inventories

Activity type	Specific activity type	Adaptation
Procurement	All purchased goods	• Geography of electricity inputs • Energy mix at the process scale (i.e., adjusting energies used within the LCI data) • Process efficiency (waste and energy) • Direct emissions
	Agricultural products	• Yield of crop • Fertilization practices (types and quantity applied) • Land use change emissions (based on types of land use change, quantity and resulting emissions) • Type of on-site energy used and quantity of energy
	Fuels	• Flaring and venting emissions based on specific practices (of a specific supplier or geography of suppliers) • Transportation and distribution leaks (CH_4)
	Capital goods	• Composition of the good (e.g., types of materials and quantity for buildings) • Energy consumption for construction (for buildings) • Adding land use change emissions for buildings (based on types of land use change, quantity and resulting emissions)
Freight transportation	Lorry transportation	• Load factor • Fuel consumption of vehicle • Fuel type and resulting combustion emissions
Passenger transportation	Car transportation	• Specific fuel consumption of vehicle • Specific lifetime of vehicle (for vehicle production flow) and components (e.g., battery for an electric vehicle)
	Public transportation and train	• Load factor (i.e., capacity utilization) • Fuel type and resulting combustion emissions or upstream emissions (i.e., for electric vehicles)
	Air transportation	• Occupied space (i.e., type of seat) • Load factor • Fuel consumption of specific aircraft and route
Waste treatment	Landfilling	• Biogas capture rate or flaring practices • Specific potential CO_2 and CH4 emissions for material type and landfill type

In practice, adjusting a given parameter (e.g., input quantity, load factor, etc.) 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. Similarly, higher agricultural yields may require greater amounts of fertilizers. Therefore, when adjusting EFs, it is recommended to systematically assess the potential impacts that such adjustments may have on other flows within an LCI data.

Finally, adjustments made to LCI data should be thoroughly documented – including in the GHG report – to ensure transparency and reproducibility. The following good practices are recommended:

- Using a specific nomenclature for modified LCI data so they can be easily identified. For instance, a code can be added at the beginning of the dataset's name to distinguish modified data from the default datasets in the LCI database.
- Briefly describing the adjustment in the name of the modified dataset. For example, by adding "_energy flows regionalized to FR" at the end of the process name to represent the adaptation of this dataset to a French context.
- Providing a general description of the modification in the dataset's documentation so that other practitioners can quickly understand the change that was made.
- For flows that need to be removed, not deleting them; instead, multiplying their quantity by 0. This preserves a trace of all flows present in the original dataset and their quantities.
- For flows whose quantities must be adjusted, first multiplying the original quantity by 0, then duplicating the flow and entering the new value. This ensures the original flow value remains traceable.
- When entering adjusted quantities, using parameters to document the source of the values used.

3.2 Selection of environmentally extended input-output emission factors

As previously mentioned, EEIO EFs should not be prioritized over process-based EFs. Nevertheless, their use remains relevant in certain cases. The following subsections elaborate on these situations and provide guidelines to ensure the appropriate use of EEIO EFs. For a more detailed analysis of the advantages and limitations of EEIO EFs, readers are referred to *Technical Report 2*.

3.2.1 When to use EEIO emission factors

The use of EEIO EFs is only relevant for activities that the reporting organization pays for. In fact, the GHG Protocol recommends a spend-based approach only for categories 1, 2, 4, 6, 9 and 15 of scope 3. **It is therefore recommended to limit the use of EEIO EFs to these categories, in line with the GHG Protocol's guidelines**. For other categories where the reporting organization also pays (e.g., category 5: waste generated in operations), physical activity data are generally easier to collect or estimate.

EEIO EFs are particularly relevant for purchased services (category 1), for which emissions often cannot be estimated using a process-based approach. It is therefore **recommended that reporting organizations account for purchased services using an EEIO approach**. However, other approaches may sometimes be applicable to assess emissions associated with purchased services and should be prioritized over EEIO EFs where applicable. First, a process-based approach may be relevant for services that can be translated into physical units, such as data storage, where emissions may be expressed in kg CO_2e per GB of stored data. Second, a spend-based approach using primary data (e.g., data from the service provider) may be relevant, particularly for services that make a significant contribution to total emissions. For example, the reporting organization could develop an EF per dollar spent on a given service based on the supplier's GHG inventory.

EEIO EFs can also be particularly useful for organizations with a very large number of inputs, where applying a physical approach would be overly complex and time-consuming. In such cases, a spend-based approach should be applied as a first screening step. This allows for the rapid identification of potentially significant purchases, for which a physical approach should then be applied to improve data quality.

Similarly, it is recommended to limit the use of EEIO EFs to emission sources with relatively low contributions to total emissions. This is due to the significant limitations of EEIO EFs, particularly their poor technological representativeness.

As discussed in *Technical Report 2*, EEIO EFs represent groups of commodities (products and services) and/or sectors (hereinafter "commodities") that aggregate a wide range of underlying activities with varying degrees of heterogeneity. As a result, an EEIO EF may encompass activities with highly variable carbon intensities. For this reason, EEIO EFs should be limited to expenditures on activities that are, on average, well represented by the EEIO EF, especially when the expenditure contributes significantly to the results. For example, if an organization has substantial spending on stainless steel, and none on carbon steel, using an EEIO EF that generically represents the steel production sector would significantly underestimate its emissions. In such cases, additional effort should be made to use a process-based approach.

The **use of EEIO EFs should also be avoided when tracking emissions over time is important** – for example, when the emission source is linked to a reduction target or reduction measures are being planned. This is because emission results based on EEIO EFs do not necessarily reflect physical reality, as they are tied to expenditure amounts rather than physical flows.

Finally, **the use of EEIO EFs is not recommended for organizations that are required to apply minimum boundary rules**, especially for categories 4, 6 and 9. In these cases, EEIO EFs exceed the minimum boundaries, although this does not necessarily have a significant impact on results.

3.2.2 Reference unit of the EEIO emission factor

The reference unit of an EF corresponds to its denominator. In the case of EEIO EFs, this is typically one unit of currency (i.e., one dollar, one euro). However, certain considerations must be made to ensure consistency between this unit of currency – on which the EF 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 reporting organization should convert its activity data to match the currency in which the emission factor is expressed. The conversion should use the exchange rate for the year in which the expenditure was made (i.e., the reporting period).

Second, as explained in *Technical Report 2*, 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 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 installations of the reporting organization.

Therefore, the reporting organization must ensure that the EF 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) or correct their activity data to express them in basic price. Table 3-4 shows how the data are presented in the main EEIO databases.

Table 3-4: Reference unit of main EEIO databases

EEIO database	Reference unit
CEDA (Comprehensive environmental data archive)	Different currencies; basic price and purchase price available
Exiobase	Different currencies; basic price
OpenIO-Canada	Different currencies; purchaser price
UK Defra	GBP; purchaser price
USEEIO (US Environmentally-Extended Input-Output Models)	USD; purchaser price
WIOD (World Input-Output Database)	USD; basic price

Finally, EEIO EFs 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 EF should first be verified**. As mentioned in section 2.1.3, it is then **recommended to adjust the organization's activity data to account for the time difference between the reporting period and the EEIO reference year**. Otherwise, inflation over this period may affect the validity of the results. Typically, organizations use EEIO EFs 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 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 EF used. This ensures that the activity data and EFs 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 using Equation 3-1.

Equation 3-1: Adjustment of expenditures according to inflation

$$V_{t_0} = V_t \times \frac{CPI_{t_0}}{CPI_t}$$

Where:

V_{t0} = value expressed in prices of reference year t_0
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 expenditure

An example is detailed in Box 3-1.

Box 3-1: Adjustment of spend-based activity data

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

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

$$V_{t_0} = 1\ \$ \times \frac{141.6}{160.9} = 0.88\ \$$$

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 in this way. For example, Statistics Canada publishes CPI values for about ten categories of commodities.

3.2.3 Mapping EEIO emission factors to activity data

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
    b. 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.

3.2.4 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.

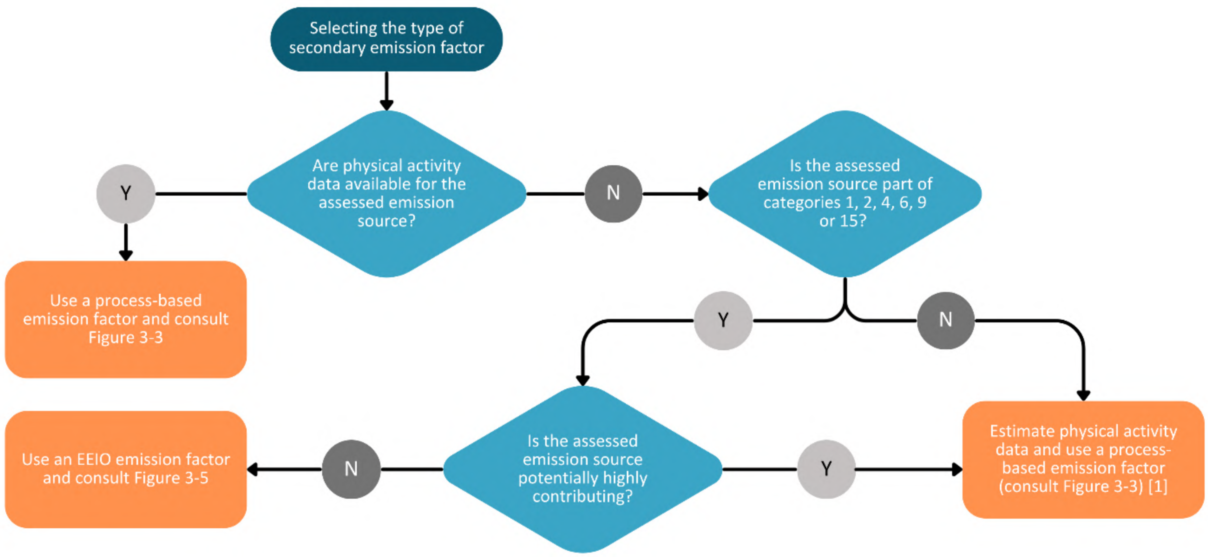
Finally, this approach is generally only relevant when using multi-regional input-output (MRIO) databases, which include several regions at the subnational or national level. If the EEIO database only provides emission factors for a single country, regionalization efforts will generally not be useful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

3.3 Decision trees

The following sections present decision trees to help guide the selection of secondary EF data. These should be considered guidelines rather than strict rules. In these decision trees, notes are identified using numbers in brackets (e.g., [1]) and are detailed below figures.

3.3.1 Selecting the type of emission factors

First, Figure 3-2 provides guidance on the general choice between the two main types of EFs: process-based and EEIO EFs. The categories shown correspond to the scope 3 categories of the GHG Protocol. Whether a given emission source is significant or not depends on several factors, including the context of the study and the level of aggregation of the emission source. Practitioners should therefore assess this on a case-by-case basis.

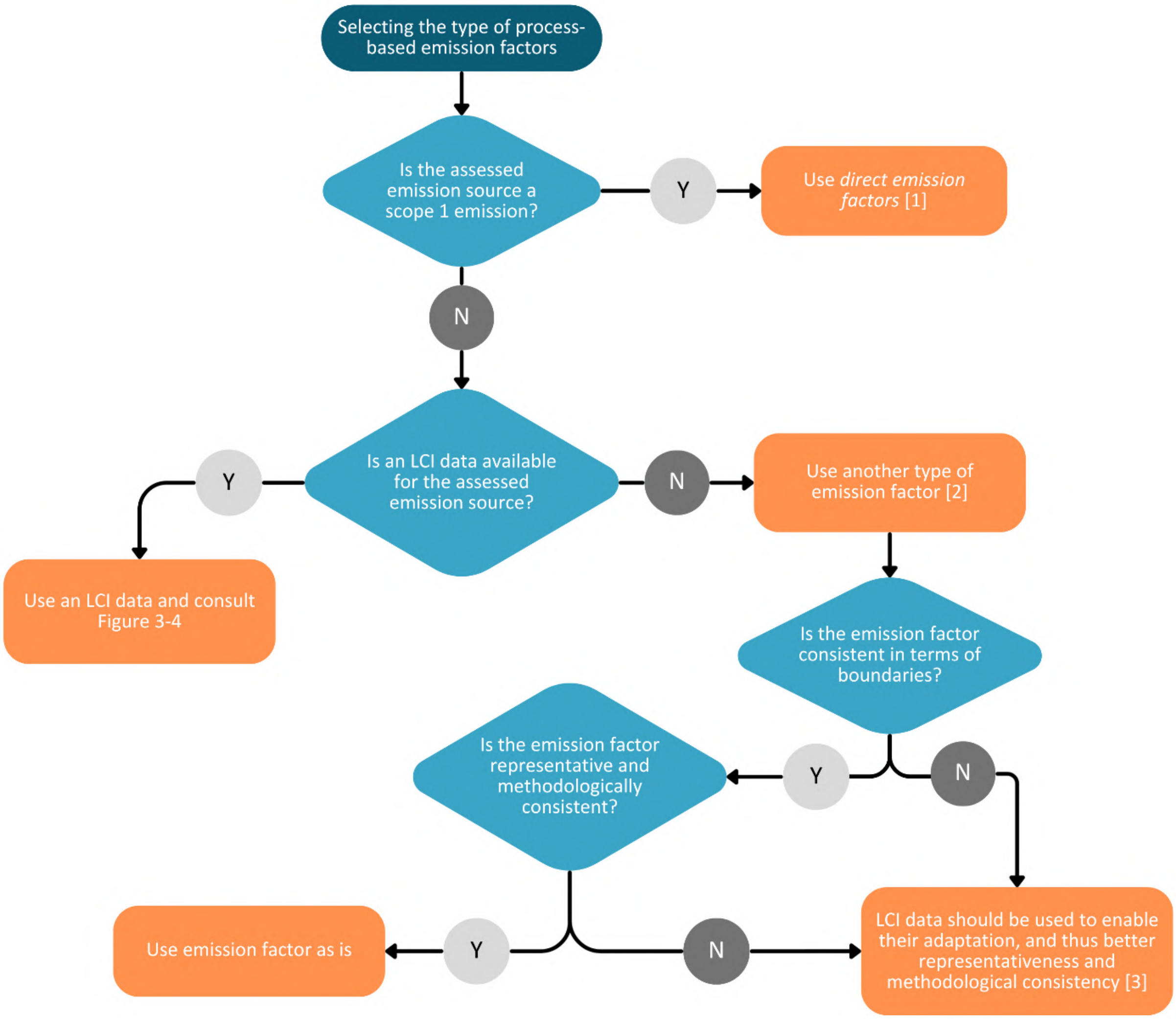


[1] Here, a non-EEIO spend-based EF could also be applicable, e.g., an EF established with primary data and expressed per financial unit (e.g., kg CO_2e/$ data storage).

Figure 3-2: Selecting the type of emission factor

3.3.2 Selecting process-based emission factors

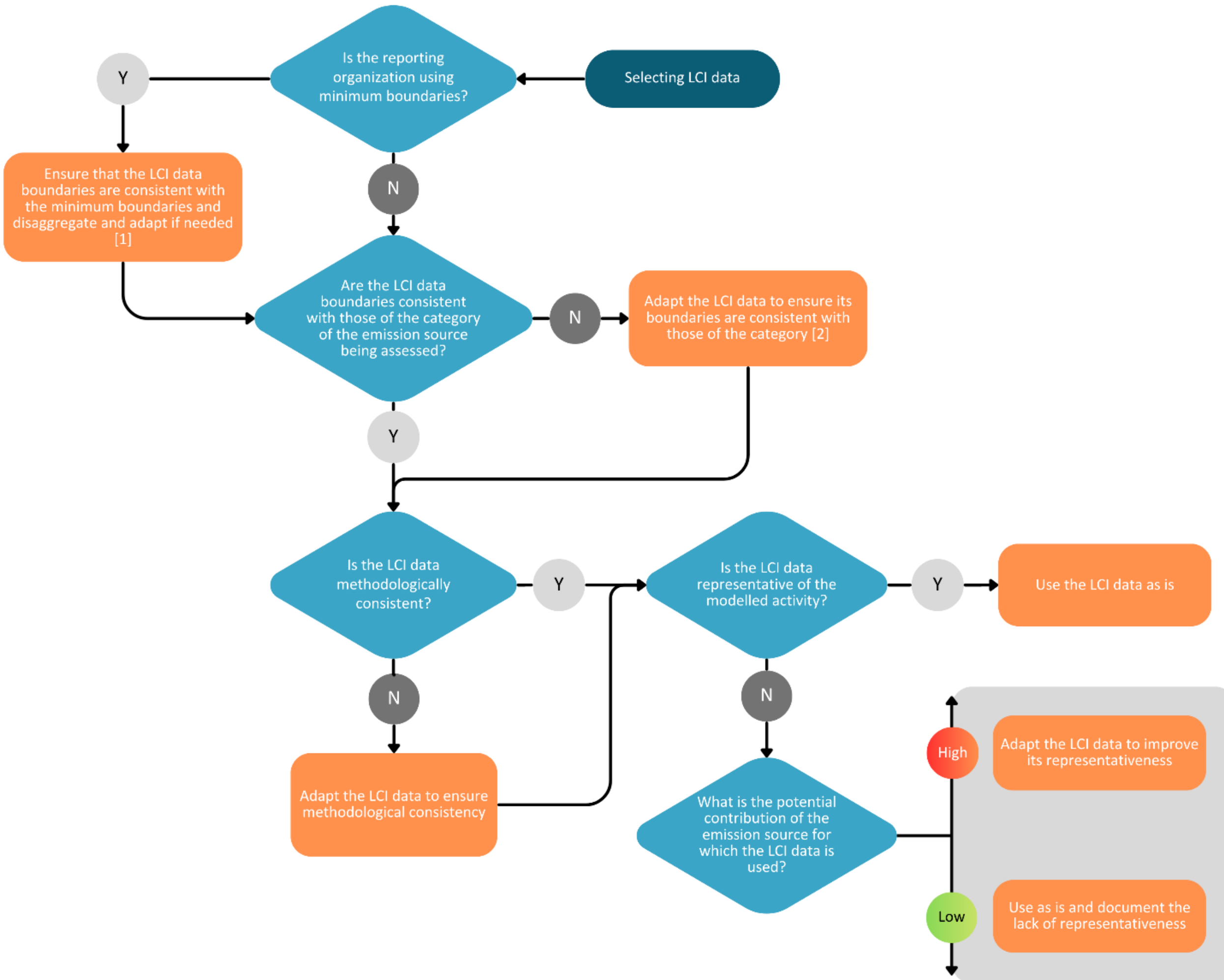
Figure 3-3 guides the selection of process-based EFs based on their methodological consistency and the boundaries of the assessed emission source. In the following figures, methodological consistency refers to all methodological aspects discussed in this section (except system boundaries, which are addressed separately in the decision tree): included GHGs, climate change metric applied, end-of-life allocation approach, and treatment of biogenic carbon.



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

Figure 3-3: Selecting the type of process-based emission factors

Section 3.1 has shown that several aspects can influence the quality, representativeness, and consistency of LCI data. Figure 3-4 presents a decision tree to guide the selection of LCI data and determine whether adjustments are needed to improve them. Representativeness is treated as a binary criterion in the decision tree. In reality, however, the representativeness of LCI data relative to the modelled activity falls along a spectrum. This is a simplification: in practice, practitioners should critically assess the representativeness of the LCI data they use.

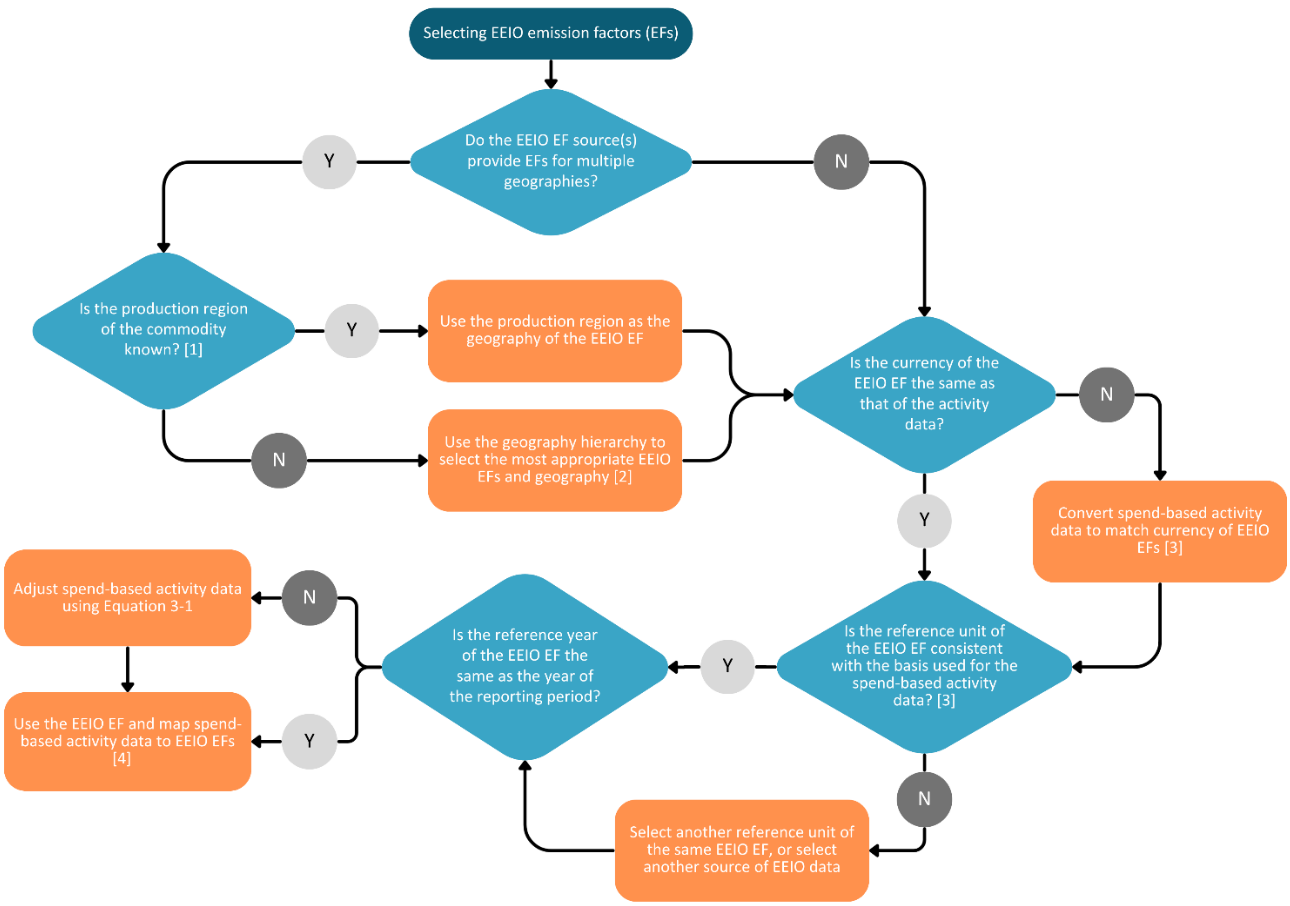


[1] For this, see Table 3-1. [2] For this, see section 3.1.1 of this report and section 3.1 of Technical Report 1 (for boundaries of scope 3 categories).

Figure 3-4: Selecting LCI data

3.3.3 Selecting EEIO emission factors

When using EEIO EFs, the first step is to select the data source (typically a specific database). For scope 3 calculations, an organization may draw on more than one data source, although in practice multiple EFs are usually taken from the same database. The decision tree in Figure 3-5 is intended to guide the reporting organization in selecting appropriate EEIO EF sources (i.e., EEIO databases). The selection of EFs (i.e., commodities) in each specific EEIO database can be supported by guidance in section 3.2.



[1] As mentioned in section 3.2.3, the production region refers to the geography where the good or service is produced, not the supplier's location, as the supplier may source products manufactured elsewhere. [2] See section 3.2.4. [3] See section 3.2.2. [4] For this, see generic steps described in section 3.2.3.

Figure 3-5: Selecting an appropriate source of EEIO emission factors

4 EMISSION CALCULATIONS

The previous sections provided recommendations on collecting activity data and selecting EFs. This section addresses specific considerations for emissions calculation. Rather than covering all scope 3 categories comprehensively, it focuses on calculation aspects where LCA practices can strengthen a corporate GHG inventory.

Topics related to calculating emissions from primary supplier data – such as allocation methods and boundary considerations – are covered in section 2.2.

4.1 Capital goods and amortization

As discussed earlier, the GHG Protocol recommends not amortizing (or depreciating) capital goods in scope 3, category 2. In other words, all emissions associated with producing a capital good (e.g., a building) should be reported in the inventory year in which the good is acquired. It is important to emphasize that this is a recommendation, not a requirement. Organizations may therefore choose to amortize emissions from capital goods and still remain in accordance with the GHG Protocol standards.

For this reason, organizations should select one approach – amortizing capital goods emissions or not – based on their objectives and context, and apply that approach consistently across all capital goods.

Not amortizing simplifies the calculation of emissions from capital goods: only the year of acquisition needs to be considered, with no need to track assets or make assumptions about their useful lives. The drawback, however, is that this method can create "spikes" in reported emissions in the year of acquisition, making it harder to consistently track emissions over time.

The non-amortization approach raises an important question: should organizations include emissions from buildings that were purchased but originally constructed for another organization? Emissions from the initial construction may already have been accounted for in another organization's inventory at the time of the first purchase, potentially leading to double counting. The GHG Protocol does not specifically address this situation, referring generically to capital goods that are "purchased" or "acquired." **If the reporting organization chooses not to amortize its capital goods, it is recommended to include both new assets and those previously used by other organizations**. However, in the latter case, **only the remaining share of the asset's useful life should be considered**. For example, if an organization acquires a building with a total useful life of 100 years that was constructed 50 years ago, it would account for the share of emissions corresponding to the remaining 50 years of use – i.e., half of the emissions associated with its construction.

Amortizing capital goods, on the other hand, avoids emission spikes but makes calculations more complex. It requires knowing or assuming the asset's lifetime and amortizing emissions across that period. Amortization also limits reported emissions to the period during which the asset is actually in use, which mitigates the double-counting concern described above.

Finally, capital goods should always be amortized in the background system, i.e., in scope 3 categories other than category 2. Amortization in these cases should be based on the total functional output of the activity over the asset's lifetime, not merely on its lifetime in years. For example, for a purchased product reported in category 1 (expressed per kg of product), if the EF includes construction of the production facility, the facility's emissions should be amortized over the total mass produced during its entire lifetime. This is the default practice in LCI databases that include infrastructure.

Special care is needed, however, when an organization collects primary data from a supplier to calculate an EF and those data include emissions from the production of capital goods. If the supplier provides a full GHG inventory, capital good emissions are most likely not amortized. If the inventory results are directly allocated to the product of interest, capital goods emissions may be overestimated. In such cases, it is recommended – when possible – to amortize those emissions by collecting information on the asset's lifetime, or, if that is not feasible, to exclude them altogether.

4.2 Scope 2 emissions

4.2.1 Boundaries

The system boundaries for scope 2 emissions are often a source of confusion under the GHG Protocol. The GHG Protocol's guidance on this point is not always consistent across documents. As a result, organizations may apply different boundaries for scope 2, such as:

- Combustion emissions from electricity generation (i.e., emissions from the combustion of fuels directly used to produce electricity);
- Direct emissions from electricity generation (i.e., including all direct emissions associated with electricity generation, such as emissions from hydroelectric reservoirs);
- Direct emissions from the electricity generation phase (i.e., the electricity producer's scope 1 emissions, including other direct emissions such as those associated with transportation at the electricity generation site);
- Emissions that include additional life cycle stages or the full life cycle.

Similarly, the boundaries applied for scope 3 electricity emissions (category 3: Fuel- and energy-related activities not included in scope 1 or scope 2) are often inconsistent with those used for scope 2often resulting in scope 2 and scope 3 boundaries that are inconsistent with each other.

For scope 2, organizations should use the first approach where possible, i.e., including combustion emissions associated with electricity generation. Otherwise, the second approach should be used, which additionally includes hydroelectric reservoir emissions.

The choice between these options should depend primarily on the data source used and should be clearly stated in the GHG inventory report. For example, the ecoinvent database provides EFs disaggregated by scope, in which hydropower reservoir emissions are classified as scope 2 (ecoinvent, 2025). If the practitioner relies on this data source, using these scope 2 boundaries is therefore appropriate. The EF used for scope 3 should then be consistent with the boundaries selected for scope 2 – for instance, by excluding hydropower reservoir emissions if they are included under scope 2.

Recall that the minimum boundaries for scope 3 category 3, specifically for electricity, focus mainly on upstream emissions of fuels consumed in the generation of electricity. Under these boundaries, only emissions from fuel production and combustion — including transformation and distribution losses — are considered for electricity generation. As a result, under this approach, electricity from renewable sources is typically considered carbon neutral, as infrastructure is excluded. This underscores the recommendation in section 1.3.2 to adopt a life cycle perspective when defining scope 3 boundaries.

Furthermore, if the reporting organization is required to use the minimum boundaries (e.g., if it has committed to the SBTi), it is recommended that a second GHG inventory be prepared using a life cycle perspective.

4.2.2 Methods

a) Consideration of attributes for electricity

As required by the GHG Protocol, organizations operating in regions where contractual instruments for renewable energy exist must report two scope 2 emission values: one using the location-based method and the other using the market-based method. As stated in section 1**, it is recommended to use the location-based value as the primary reference for decision-making**.

When the market-based method is applied to scope 2 electricity purchases, the same approach should, in principle, be applied to electricity used in the background system, such as in scope 3 emissions. For example, the EFs used for purchased goods (category 1) should reflect the residual mix for the electricity associated with the production of purchased goods, unless suppliers themselves hold contractual instruments. When using the market-based method, practitioners should try to apply the same method to the background system, to the extent possible. At present, LCI data built on residual mixes do not exist (e.g., a version of ecoinvent in which the system model is based on a market-based method). However, the market-based method can still be applied in the background system in some cases:

- When developing supplier-specific EFs based on primary data. In this case, the reporting organization should determine whether its supplier purchases energy attribute certificates that comply with the Scope 2 Quality Criteria and assess emissions accordingly.
- When assessing emissions from categories involving electricity flows that are modelled directly by the practitioner rather than embedded in EFs (e.g., in LCI data). Some categories – such as category 8 (upstream leased assets), 10 (processing of sold products), 11 (use of sold products), 13 (downstream leased assets), and 14 (franchises) – may be largely driven by electricity consumption. In such cases, modelling typically relies on an EF for electricity generation. Practitioners should apply the market-based method in these situations if it is also applied to the foreground system (scope 2). If the reporting organization cannot determine whether the modelled activity uses qualifying energy attribute certificates, it should assume that this is not the case and apply EFs reflecting the residual mix (when available).

In short, from a theoretical standpoint, the treatment of electricity in the foreground and background systems should be consistent, and this consistency should be prioritized in the scope 3 assessment where possible (i.e., examples above), and in the complete scope 3 assessment once suitable data become available (e.g., a market-based version of an LCI database).

b) Consideration of attributes for fuel procurement

Organizations may purchase fuels with specific attributes, for example, renewable natural gas (RNG), through contractual instruments. While the GHG Protocol Scope 2 Guidance (GHG Protocol, 2015b) established a market-based method for electricity, steam, heat, and cooling, no equivalent guidance currently exists for fuels in scope 1. Therefore, emissions from fuels delivered via a common carrier pipeline should be accounted for using the same logic as in the location-based approach defined by the GHG Protocol for scope 2. When sourcing fuels from a shared distribution network, organizations should reflect the network's average fuel mix, even if they hold contractual instruments. If the network's fuel mix cannot be determined, organizations should assume that the fuel is 100% fossil-based.

The only situation in which an organization can reflect the characteristics of a specific fuel purchase is when the fuel is physically delivered to the facility (e.g., by truck) or when the organization is connected to the supplier through a dedicated pipeline or direct line. Until the GHG Protocol provides formal guidance on this matter, organizations should apply the same principles as the location-based approach for electricity.

4.3 Use phase of sold products

4.3.1 Boundaries

As recommended in section 1.3.2, organizations should go beyond minimum boundaries when defining the boundaries for scope 3 categories. This is particularly relevant for the use of sold products (category 11). For this category, minimum boundaries include only what the GHG Protocol defines as direct use-phase emissions. Products with direct use-phase emissions are those that:

- Directly consume energy (fuel or electricity) during their use (e.g., machinery);
- Are fuels or feedstocks whose use generates emissions (e.g., fossil fuels);
- Are GHGs emitted during use (e.g., refrigerants) or products that contain or form GHGs during use (e.g., fertilizers).

In contrast, indirect use-phase emissions fall outside the minimum boundaries and are considered optional. These emissions are associated with products that indirectly consume energy during use - for example, food products that require energy consumed by another product (e.g., oven, refrigerator).

Under the minimum boundaries for vehicle use phase, only the vehicle manufacturer and the engine manufacturer would report emissions in this category. Manufacturers of all other vehicle components would not report emissions in this category, even though their products affect the vehicle's energy consumption through their contribution to vehicle weight – something they can directly influence. The indirect use phase is therefore highly relevant for many sectors and should be included.

Similarly, **it is recommended to include non-energy-related flows associated with the use phase of sold products**. While the GHG Protocol focuses primarily on energy flows and products that directly emit GHGs (e.g., refrigerants, fertilizers), many products require material inputs and generate waste during use.

For example, an industrial machine consumes energy but also requires inputs such as lubricants, machining fluids, and abrasives, and can generate wastes such as used filters. These flows can be significant, and manufacturers may have influence over them.

4.3.2 Methods

Estimating emissions from the use of sold products under the GHG Protocol typically relies on a static-world assumption, where use-phase emissions are calculated using current energy mixes, fuel characteristics, and user behaviour. Although simple, this approach may not reflect real conditions over a product's lifetime – especially for long-lived products such as appliances, IT equipment, vehicles, or medical devices. Because future energy systems, regulations, and user practices may differ substantially from current ones, static modelling can misrepresent the true magnitude of use-phase emissions.

The LCA community increasingly addresses this limitation through prospective approaches that integrate expected technological, economic, and policy developments (e.g., grid decarbonization, renewable fuel uptake, behavioural changes). While these methods introduce additional assumptions, they generally yield a more realistic representation of future impacts, strengthening decision-making particularly for sectors in rapid transition. A prominent example is the *premise* framework (Sacchi et al., 2024), which applies projections – such as those from the International Energy Agency (IEA) – to generate scenario-specific, future-oriented LCI databases. This enables alignment of both background and foreground processes with defined transition pathways (e.g., IEA Announced Policies, Net Zero Emissions).

Category 11 is one of the GHG Protocol categories where a prospective approach is especially relevant. For many products, use-phase emissions dominate total climate impacts, and these products will often operate under substantially different future energy and technology conditions. Relying solely on static values can therefore systematically over- or underestimate organizational emissions.

For values reported within the scopes, organizations should use a static approach, as recommended by the GHG Protocol and typically applied to quantify emissions associated with the use of sold products. However, for organizations selling long-lived products, it is recommended to perform a scenario analysis using a prospective approach to assess the influence of this modelling choice on the results. The following elements can guide the implementation of a prospective approach:

- **Time horizon and product lifetime**: Define the expected lifetime of the product or service (e.g., a medical device operating for 10 years). The modelling period should cover this full duration.
- **Projected energy mixes**: Replace current electricity and fuel mixes with future projections over the modelling horizon. Sources may include national energy regulators, IEA scenarios, or datasets generated through *premise*.
- **Future fuel pathways**: When relevant, account for planned transitions in fuel compositions (e.g., increasing biofuel blend levels, hydrogen deployment, phase-out of certain fuels).
- **Expected user behaviour**: If use patterns are likely to change over time, these should be reflected in the modelling.
- **Technology efficiency trends**: When efficiency improvements are expected to affect energy consumption, draw from government standards, industry roadmaps, or premise outputs.
- **Scenario analysis**: Present a base-case scenario but consider additional scenarios (e.g., accelerated decarbonization or a conservative scenario) to capture the range of plausible outcomes.
- **Documentation and transparency**: Clearly document data sources, assumptions, scenarios, and modelling limitations so results remain traceable and reproducible.

5 INTERPRETATION AND REPORTING OF RESULTS

This final section provides guidance on interpreting and reporting results to ensure they are complete, nuanced, compliant with requirements, and useful to stakeholders. It does not address internal organizational practices, such as data retention or archiving.

5.1 Separate reporting

This subsection does not introduce new recommendations; rather, it reiterates certain GHG Protocol reporting requirements and recommendations. Specifically, certain emission data must be reported separately from the GHG inventory – that is, apart from scope 1, 2, and 3 emissions:

- Biogenic CO_2 emissions shall be calculated and reported separately, for both direct and indirect emissions. For organizations following the *Land Sector and Removals Standard*, biogenic CO_2 emissions may be reported as part of the main GHG inventory results, but they must still be reported in a separate category.
- CO_2 removals may be calculated and, where applicable, shall be reported separately. This applies both to removals within the organizational boundary (scope 1) and within the organization's value chain (scope 2 or 3). As with biogenic CO_2 emissions, organizations following the *Land Sector and Removals Standard* may report removals, provided they meet the requirements, as part of their GHG inventory results, but in a separate category.
- **Emission reductions outside the value chain**, such as purchased carbon offsets, shall be reported as supplementary information and not aggregated with the emissions inventory.
- **Emission reductions within the organizational boundary** that are sold or traded as offset credits shall also be disclosed separately.
- Emissions of GHGs other than CO_2, CH_4, N_2O, HFCs, PFCs, NF_3, and SF_6 shall be reported separately. As mentioned in section 1.4.1, for voluntary disclosures not subject to GHG Protocol requirements, including such additional gases – either within the inventory itself or in a separate supplemental inventory – is good practice to provide a more comprehensive emissions profile and to support informed decision-making.
- **Radiative forcing from non-GHG mechanisms** – such as condensation trails (contrails) or changes in surface albedo – may be calculated but shall be reported separately.

5.2 Dual reporting

Emission reductions or removals associated with the sale of credits used as offsets (within the organizational boundary or value chain) shall be deducted when accounting for progress towards the organization's GHG targets. Organizations should therefore calculate two inventories: one conventional and one adjusted for sold credits. When accounting for progress toward a target, it is recommended to use the emission and removal values adjusted for sold credits. This prevents the double counting of reductions or removals that have been sold as offsets.

In addition, when a reporting organization follows the minimum boundaries of the GHG Protocol to quantify its scope 3 emissions, it is recommended to prepare a second scope 3 inventory using a life cycle perspective. In this case, the organization should go beyond the minimum boundaries and, where possible, include all life cycle activities associated with the covered categories, for example by using LCI data. Reported in parallel, this approach allows the organization to confirm or challenge the conclusions drawn from the inventory conducted using the minimum boundaries.

Finally, as required by the GHG Protocol, organizations operating in regions where contractual instruments for renewable energy exist must report two scope 2 emission values: one using the location-based method and the other using the market-based method.

5.3 Scenario and sensitivity analyses

Sensitivity analyses help deepen the interpretation of results by assessing the robustness of the conclusions. In LCA, the term sensitivity analysis is often used broadly to also include scenario analyses. The purpose of these analyses is to evaluate how methodological choices, assumptions, or variations in input parameters influence the study results, and to identify the parameters or assumptions that have the greatest influence on the outcomes. Highly uncertain parameters, "rule-of-thumb" assumptions, and subjective choices are often good candidates for sensitivity analysis, especially when they are related to emission sources that contribute significantly to the inventory.

Changes in the value of a given parameter can also be quantified to assess their effect on the results. Since each organization and study is unique, it is difficult to provide generic guidance on how to select sensitivity analyses. The general recommendation is to review the preliminary results to identify the most relevant analyses. This can help highlight methodological choices that may significantly influence the results and test their impact.

In an organizational GHG inventory, relevant sensitivity analyses include:

- Testing **alternative climate change metrics** (e.g., GWP20 or GTP500) may be especially relevant for GHG inventories where non-CO_2 gases account for a substantial share of total emissions.
- Testing an alternative allocation procedure for scope 3 emissions for which primary data are collected and allocation is performed. Conducting such an analysis may be particularly relevant when the emission source subject to allocation is a significant contributor and the chosen allocation approach could influence the results.
- Testing an alternative end-of-life allocation procedure (e.g., closed-loop approximation, 50/50) when secondary material inputs and/or recyclable material outputs are significant contributors to the GHG inventory.
- Testing the **underlying assumptions of categories that require the development of scenarios** (particularly use of sold products and end-of-life of sold products).
- Using a prospective approach for the use of sold products (category 11), as detailed in section 4.3.2.
- Including emission sources that were excluded from the GHG inventory, particularly due to high uncertainty or lack of data.
- Using different EFs for emission sources that contribute significantly to the inventory, especially when values vary significantly across EF sources.
- Using an alternative amortization approach for capital goods (i.e., not amortizing if capital goods are amortized in the GHG inventory).

5.4 Transparency good practices

This section does not seek to restate all reporting requirements of the GHG Protocol. Rather, it highlights recommendations based on best practices often implemented in LCA studies.

5.4.1 Public report

Organizations should make a comprehensive report publicly available to support the results. A good practice is to provide both a concise summary for non-technical stakeholders and a detailed technical report containing full methodological documentation.

The technical report should include, at a minimum, the following elements:

1. Goal and scope definition:
    - Standard(s) followed;
    - Objectives of the study;
    - Intended audience;
    - System boundaries: scopes and categories included, as well as the underlying activities and emission sources;
    - List of exclusions (categories and emission sources) with justification;
    - Cut-off criteria applied, where relevant.
2. Data documentation:
    - Sources of activity data (e.g., procurement data) and data type (measured, calculated, assumption, etc.);
    - Sources of EFs (database, version, and name of the EF/process);
    - Clear distinction between primary and secondary data for both activity data and EFs;
    - Activity data values and EF values, where possible;
    - Proxies used;
    - Key assumptions and parameters, including their sources where applicable;
    - Documentation of data quality (data quality assessment is briefly discussed in section 5.4.2);
3. Methodological choices for emissions calculation:
    - GHGs included, by scope, category, or source where relevant;
    - Allocation rules applied, including justification for their selection and resulting allocation factors;
    - End-of-life allocation approach and details of its implementation (e.g., position of the cut-off point in the recycled content [cut-off] approach), along with justification that the approach is applied consistently across incoming and outgoing by-products, where applicable;
    - Source of GWP100 values used (i.e., IPCC assessment report version) and associated values;
    - Tools used for modelling and quantification (e.g., Excel, LCA software, etc.).

The ultimate objective of this documentation is to ensure that the GHG inventory is reproducible – that is, that an independent practitioner could replicate the study and obtain consistent results.

5.4.2 Data quality assessment

A key best practice for ensuring transparency is to conduct a data quality assessment. This analysis relates data quality – including technological, geographical, and temporal representativeness, completeness, and reliability – to each emission source's contribution to total emissions. This helps organizations prioritize for data improvements for their most significant emission sources. Organizations can then iteratively refine their GHG inventory or integrate these improvements into future inventories. In practice, the pedigree matrix approach is generally well-suited for GHG inventories. It is briefly described in section 7.3 of the *Scope 3 Standard* (GHG Protocol, 2011a) and described in greater detail in Weidema and Wesnæs (1996). This method can be applied at the level of individual data points, where feasible, or at a more aggregated level (e.g., packaging purchases).

5.5 Sharing results along the supply chain

As discussed earlier, an organization's GHG inventory results are not necessarily directly usable by its value chain partners. The boundaries of such an inventory may not be suitable for another organization's needs – for example, if the receiving organization uses the results to estimate the emissions associated with the supply of a product (category 1). Moreover, the results generally need to be allocated to a single unit of product or service.

If the reporting organization has already conducted product-level studies, such as an LCA, it may not need to share its organizational GHG inventory results along the supply chain. However, if no product-level study has been conducted and the organization shares its GHG inventory results with partners, it is recommended to perform the necessary adjustments to make the results directly usable by value chain partners. This involves adjusting how emissions are disaggregated and allocating the results among the organization's various products. Guidance on developing EFs from collected primary data is provided in section 2.2.

5.5.1 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, emission data shared along the value chain should be usable by the receiving organization in a manner consistent with its own methodological choices. These methodological choices mainly concern the boundaries used to construct EFs – in particular, whether minimum boundaries or a life cycle perspective are applied. However, even when a life cycle perspective is adopted, emissions from auxiliary services such as employee commuting or office operations may be excluded, as these are typically omitted from process-based EFs.

In the GHG Protocol Product Standard, these activities are referred to as non-attributable processes. They are defined as services, materials, and energy flows not directly connected to the product's life cycle – i.e., flows that neither become the product, make the product, nor directly carry the product through its life cycle (GHG Protocol, 2011b).

This raises two important questions:

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

The first question was addressed in section 2.2. For the organization sharing its emission data, the key priority is to disaggregate it in a way that enables customers or suppliers to use it appropriately. The organization providing the data should first disaggregate it by scope 3 category. This allows the receiving organization to select the relevant categories – for instance, whether to include those related to auxiliary services (e.g., employee commuting, downstream leased assets, etc.) – and 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 into attributable and non-attributable processes. This additional level of disaggregation enables the receiving organization to develop an EF that either includes or excludes non-attributable processes, depending on its own methodological approach. Several scope 3 categories are entirely non-attributable, whereas other scopes and categories contain both attributable and non-attributable processes. 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

Emissions from other scopes and categories may include both attributable and non-attributable processes. Table 5-1 provides examples of attributable and non-attributable processes for different scopes and categories.

Table 5-1: Examples of attributable and non-attributable processes

Scope and/or category	Examples
Attributable processes	
Scope 1	Emissions associated with the application of fertilizers used to produce a bio-based commodity.
Scope 2	Combustion emissions associated with the energy used to manufacture a product.
Scope 3, category 1 (purchased goods and services)	Emissions associated with the production of material inputs used to manufacture a product (e.g., product components, chemicals, etc.).
Scope 3, category 5 (waste generated in operations)	Emissions associated with the treatment of production losses.
Non-attributable processes	
Scope 1	Refrigerant leaks in administrative spaces.
Scope 2	Electricity consumption associated with lighting.
Scope 3, category 1 (purchased goods and services)	Emissions associated with the production of cleaning products.
Scope 3, category 5 (waste generated in operations)	Emissions associated with the treatment of waste generated in corporate activities (e.g., research and development, marketing, etc.).

One final 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 EFs, 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 is likely to operate for several decades.

It is therefore recommended that the emission data shared along the value chain 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 shared emission data remain complete, while allowing the receiving organization to exclude those emissions when developing EFs.

Table 5-2 provides an example template for reporting emissions disaggregated according to the above recommendations, intended to be shared with value chain partners. 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.

5.5.2 Allocating emissions

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

However, subdivision is not always feasible. This is especially true for emissions from non-attributable processes (across 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 best reflect the causal relationship between outputs and their associated 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 enables the value chain partners to conduct sensitivity analyses and to select the allocation approach most consistent with their own methodological choices. To ensure transparency, organizations should disclose the allocation keys (i.e., allocation factors) applied under both allocation procedures and for all products.

Table 5-2 provides an example template for reporting emissions disaggregated in accordance with the recommendations outlined above.

Table 5-2: Reporting template for sharing inventory results along the supply chain

Scope	Source/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								
	[...]									

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