

SCOPE 3 CATEGORY 1 GHG ASSESSMENT

GUIDELINE FOR THE SEMICONDUCTOR SECTOR



SEMI – Semiconductor Climate Consortium (SCC)

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NOTICE FROM ARTHUR D. LITTLE

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0. EXECUTIVE SUMMARY

The objective of the Guideline is to establish a comprehensive framework that promotes clarity and consistency in accounting for Scope 3.1 emissions across the semiconductor industry, and to provide guidance for overcoming shared challenges faced by companies in assessing Scope 3.1 emissions.

The Guideline's intended audience is SCC member companies and other organizations operating in the semiconductor industry, who seek to enhance their Scope 3.1 carbon footprint assessment. The

Guideline is founded upon established international standards, notably the GHG Protocol.

The following main considerations are emphasized in the Guideline:

- For the purposes of this Guideline, GHG accounting and reporting of a Scope 3 Category 1 inventory should be based on six GHG accounting principles: relevance, completeness, consistency, transparency, accuracy, and precision.
 - Companies shall account for all upstream (cradle-to-gate) emissions of purchased goods and services, accounting for all seven gases listed in the Kyoto Protocol, as well as for any other fluorinated GHG listed in Annex I and II of the European Regulation 517/2014 on F-gases.
 - Companies should disclose all information regarding the methodology, assumptions, exclusions, and limitations of their GHG inventory.
 - Companies should progressively shift from spend- or average-based to a hybrid method in order to improve the accuracy of emissions estimation and facilitate the identification of specific opportunities for reducing emissions through direct engagement with suppliers. Companies should acknowledge that the transition to using primary data for emissions calculations is not a swift process; it typically demands ongoing efforts over an extended time frame. Consequently, companies may prioritize primary data collection efforts on high-priority products/commodity groups. In this regard, spend-based analysis may be utilized as a screening technique to identify which products/commodity groups should be prioritized for primary data collection.
- Companies should strive not only to progressively expand and integrate supplier-specific emissions data in their GHG methodology, but also collect primary data with a higher degree of specificity – for example, at business unit level, especially when suppliers have a diversified business model.
 - A hybrid method entails allocating suppliers' emissions to the reporting company, while relying on secondary data for addressing data gaps and inconsistencies. Relying on suppliers' own allocation calculations may help address confidentiality concerns – which are common in the semiconductor industry – for suppliers that may be reluctant to disclose their allocation metric. However, the reporting company should assess the reliability of emission allocation and require suppliers to disclose the specific allocation methodology they have used.
 - The Guideline acknowledges that, given the intricate nature of the semiconductor value chain and the multitude of products it encompasses, widespread use of a supplier-specific method may not be practical or feasible, at least in the short term. However, the SCC could promote collective actions, such as engaging with industry efforts to develop life cycle assessments (LCAs) for

selected key products covering hot-spot emissions within the SCC ecosystem, to improve the viability of supplier-specific methods.

- Furthermore, other collective actions that could be implemented to facilitate companies within the semiconductor industry in their ongoing pursuit of enhancing the accuracy of Scope 3.1 estimation are:
 - Developing a standardized questionnaire for suppliers' data collection

- Providing guidance and training for GHG accounting
- Developing a common emissions factors database
- Facilitating an SCC emission data platform for collecting and managing confidential data
- Establishing a common third party for collecting and managing confidential data

1. INTRODUCTION

1.1 BACKGROUND AND CONTEXT

The Semiconductor Climate Consortium (SCC) is a global industry association representing over 80 companies worldwide within the semiconductor supply chain, focused on the challenges of climate change and working to speed up industry value chain efforts to reduce GHG emissions.

The consortium's members are committed to working toward the following pillars and objectives:

- Collaboration: align on common approaches, technology innovations, and communications channels to continuously reduce GHG emissions.
- Transparency: publicly report progress and Scope 1, 2, and 3 emissions annually.
- Ambition: set near- and long-term decarbonization targets with the aim of reaching net-zero emissions by 2050.

The SCC aims to drive progress on climate challenges within the semiconductor value chain and support the Paris Agreement and related accords driving the 1.5°C¹ pathway.

For this purpose, the consortium leverages subject-matter experts across the semiconductor value chain to lead and participate in working groups (WGs). The WGs have defined objectives and deliverables, and are the heartbeat of SCC.

The SCC has launched a WG on Scope 3 emissions, aiming to help the industry across the complete value chain prioritize key areas for emission reduction. Among the objectives related to Scope 3 Emissions, WG has requested the support of Arthur D. Little in developing a Guideline to support companies in all segments of the semiconductor industry in measuring and reporting their Scope 3 Category 1 emissions accurately and consistently.

The Guideline in this document fulfills this objective by providing a comprehensive framework that serves as a guiding resource for companies engaged in the process of Scope 3 Category 1 GHG accounting.

1. In this Guideline full stops are used for the decimal separator, while commas are used to separate thousands, millions, etc.

1.2 ABOUT THE SEMICONDUCTOR SECTOR

The semiconductor industry stands as a pivotal cornerstone of modern technological advancement, embodying a realm of remarkable intricacy and multifaceted operations. Characterized by its role in producing integrated circuits and electronic components, this industry operates within a landscape defined by rapid innovation, intricate supply chains, and global reach. Within this dynamic arena, a multitude of companies engage in the design, fabrication, and distribution of semiconductor products.

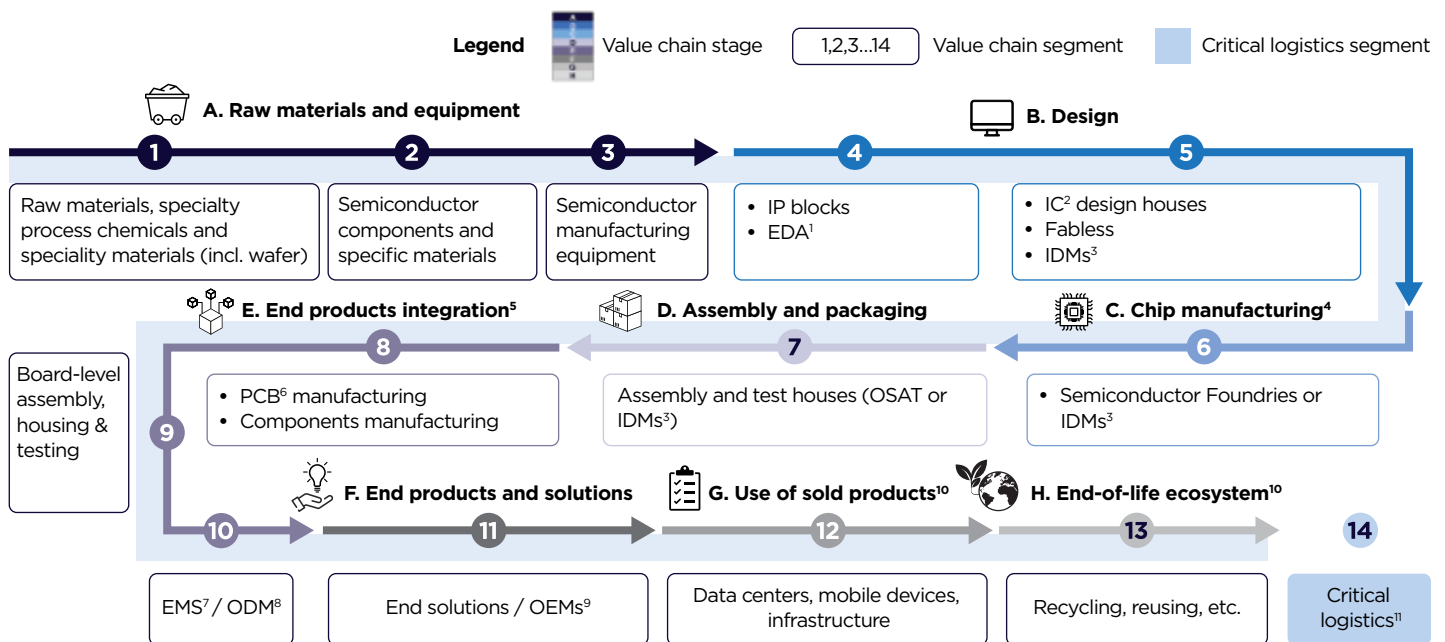
This intricate web of activity is further compounded by the involvement of diverse tiers of production, spanning from raw material suppliers to end-product manufacturers.

Comprehending the dynamics of companies' Scope 3 carbon footprint and identifying emissions hotspots and opportunities for improvement require a nuanced exploration of the intricate

and complex semiconductor value chain. A first step in understanding the semiconductor supply chain's intricate dynamics is to gain a clear understanding of the value chain map.

Designing a comprehensive map for the semiconductor value chain is a not a trivial task, primarily because of its inherent complexity. As a consequence, designing a visual representation of the semiconductor value chain necessitates the use of some simplifications. Figure 1 provides a simplified visual representation of the semiconductor supply chain, thoughtfully divided into eight supply chain stages, each consisting of specific supply chain segments.

Please note that stage G, "Use of sold products," and stage H, "End of life ecosystem," do not exert any influence on Scope 3.1 emissions, as they concern the downstream value chain. Consequently, emissions associated with these stages are not in the scope of this Guideline.



Note: 1) EDA = Electronic Design Automation; 2) IC = Integrated Circuits; 3) IDMs = Integrated Design Manufacturers; 4) Includes semiconductor and wafer testing equipment, deposition, ION implantation and lithography; 5) Includes software integration; 6) PCB = Printed Circuits Board; 7) EMS = Electronics Manufacturing Service; 8) ODM = Original Design Manufacturers; 9) OEM = Original Equipment Manufacturers; 10) Stage not in scope of Scope 3.1 Guideline; 11) Each supply chain stage encompasses a transversal segment that consists of the critical logistics

Figure 1 – Semiconductor value chain map

1.3 ABOUT THE GUIDELINES

Assessing Scope 3 Category 1 GHG emissions is absolutely critical for companies operating in the semiconductor sector, since these emissions may often account for a sizable portion of their overall carbon footprint. In an industry that constantly evolves, environmental sustainability and carbon footprint reduction have emerged as fundamental drivers for long-term success. By conducting a thorough assessment of Scope 3.1 emissions, companies gain a comprehensive understanding of their environmental impact and unveil opportunities for improvement.

Addressing Scope 3.1 emissions not only helps semiconductor companies align with regulatory frameworks and stay ahead of emerging environmental policies, but also bolsters their brand reputation and attractiveness to environmentally conscious stakeholders. By demonstrating a strong commitment to environmental stewardship through a robust Scope 3.1 assessment, semiconductor companies can solidify their position as responsible leaders in the industry and contribute significantly to a greener future.

The purpose of this Guideline is to establish a comprehensive framework that promotes clarity and consistency across the semiconductor industry in accounting for Scope 3.1 emissions, and to provide guidance for overcoming shared challenges faced by companies in assessing emissions. The Guideline is founded upon established international standards, notably the GHG Protocol. Its intended audience is SCC member companies and other organizations operating in the semiconductor industry, which seek to enhance their Scope 3.1 carbon footprint assessment.

The Guideline recognizes that some SCC members may participate in multiple supply chains and be subject to distinct sector-specific guidance for Scope 3.1 emissions accounting. This Guideline does not intend to impose any mandatory requirements in this area, and as a result, does not conflict with other sector-specific guidance. Nevertheless, it is strongly recommended that SCC member companies align their Scope 3.1 accounting methodology with the principles and content outlined in this Guideline. The remaining part of this Guideline is divided as follows:

- Chapter 2 introduces the Guideline's methodology, terminology, and six principles of GHG accounting, which serve as a guiding framework for the implementation of the Guideline.
- Chapter 3 explains a framework for the Scope 3 Category 1 GHG accounting process.
- Chapter 4 provides an in-depth description of four estimation methods.
- Chapter 5 includes an Annex section.
- Chapter 6 resumes external references for Guideline development.
- Chapter 7 consists of the glossary and describes the acronyms used in the Guideline.

2. METHODOLOGY, TERMINOLOGY & PRINCIPLES

2.1 APPROACH TO METHODOLOGY DEVELOPMENT

The development of the GHG Guideline for assessing Scope 3 Category 1 emissions has followed a comprehensive approach, encompassing the key three steps illustrated in Figure 2 below.

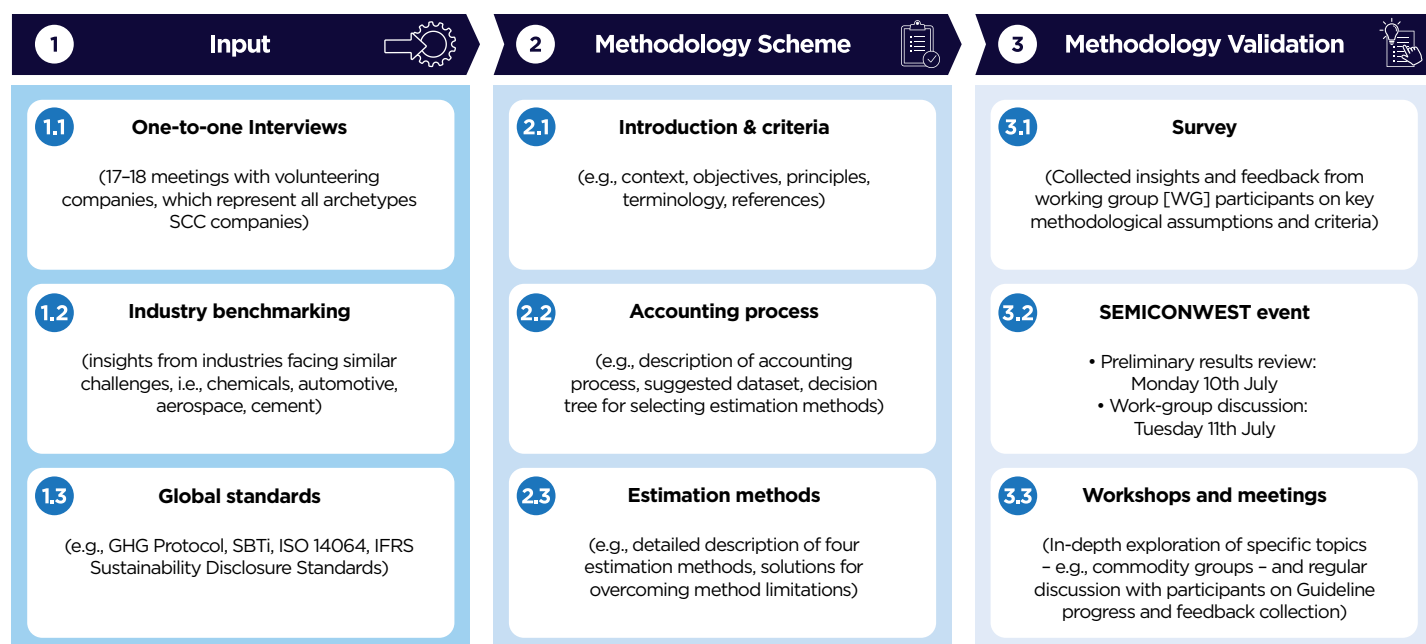


Figure 2 – Guideline methodology

2.1.1 METHODOLOGY INPUT

2.1.1.1 one-to-one interviews

Firstly, inputs were gathered through one-to-one interviews conducted with participating companies, allowing for a deep understanding of their specific challenges, concerns, and unique circumstances.

Figure 3 provides an overview of the main inputs gathered during the one-to-one interviews.

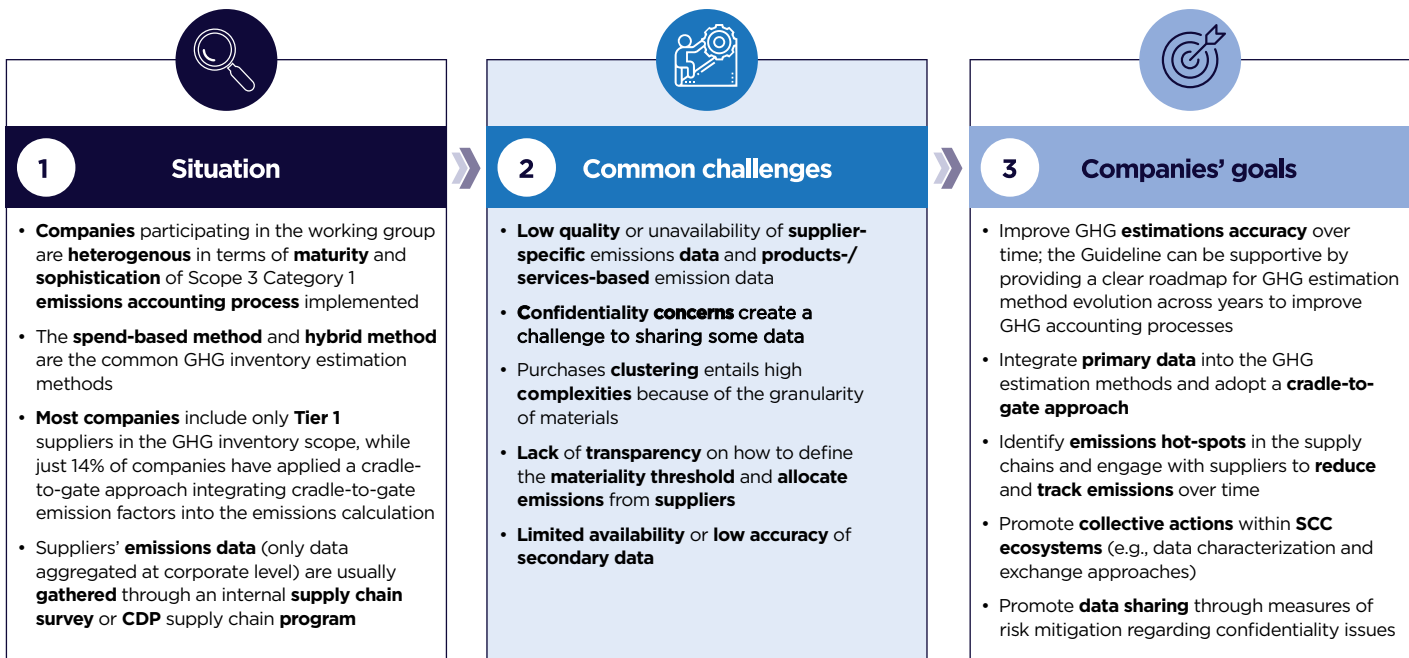
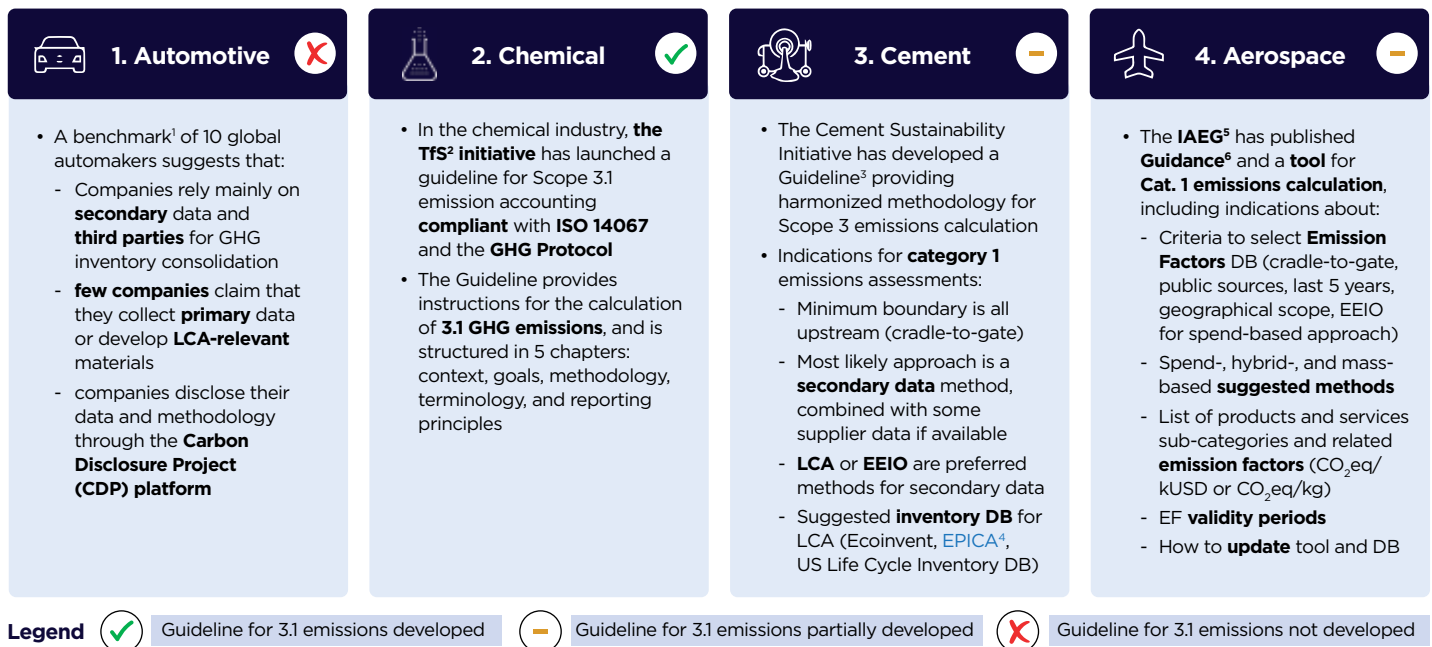


Figure 3 – Inputs gathered from the one-to-one interviews

2.1.1.2 Industry benchmark

Additionally, benchmarking (Figure 4) was carried out, considering best practices from sectors such as automotive, chemicals, cement, and aerospace, which face similar challenges to the semiconductor industry in computing Scope 3 Category 1 emissions because of the complexity of their value chain.



Source: Arthur D. Little, the Product Carbon Footprint Guideline for the Chemical Industry, IAEG, CSI, Green Piece.

Note: 1) Green Piece: A comparative analysis of decarbonisation efforts by global automakers; 2) Together for Sustainability; 3) Cement Sector Scope 3 GHG Accounting and Reporting Guidance; 4) European Platform on Life Cycle Assessment; 5) IAEG: International Aerospace Environmental Group; 6) GHG Reporting Guidance for the Aerospace Industry

Figure 4 – Industry benchmark in the development of Scope 3.1 sectorial Guideline

2.1.1.3 Global standard

To ensure the consistency and robustness of the Guideline content, the following standards have been reviewed:

- GHG Protocol Corporate Value Chain (Scope 3)
- GHG Protocol Scope 3 Calculation Guidance
- ISO 14064: 2019
- ISO 14067: 2019
- IFRS Sustainability Disclosure Standards

2.1.2 METHODOLOGY SCHEME AND VALIDATION

Building upon the insights gained from inputs and analysis, the content of the Guideline was developed, addressing the pertinent issues of semiconductor companies and incorporating practical recommendations raised during the one-to-one interviews.

Furthermore, validation exercises were conducted in close collaboration with the participating companies to test and refine the methodology, ensuring its practicality and effectiveness.

Companies' active involvement ensured their specific needs were met and enhanced the overall robustness and relevance of the methodology. Because of the collaborative approach, the developed GHG Guideline for assessing Scope 3 Category 1 emissions represents a comprehensive and industry-driven framework that reflects the diverse perspectives and needs of the companies involved.

2.2 TERMINOLOGY

The Guideline, in accordance with the GHG Protocol and ISO Standard, uses specific terms to connote GHG accounting requirements and recommendations. In particular:

- “Shall” is used to indicate a requirement.
- “Should” is used to indicate a recommendation.
- “May” is used to indicate an option that is permissible or allowable.

- “Can” is used to indicate that something is possible, for example, that an organization or individual is able to do something.

2.3 ACCOUNTING PRINCIPLES

For the purposes of this Guideline, GHG accounting and reporting of a Scope 3 Category 1 inventory should be based on the GHG accounting principles illustrated in the figure below.

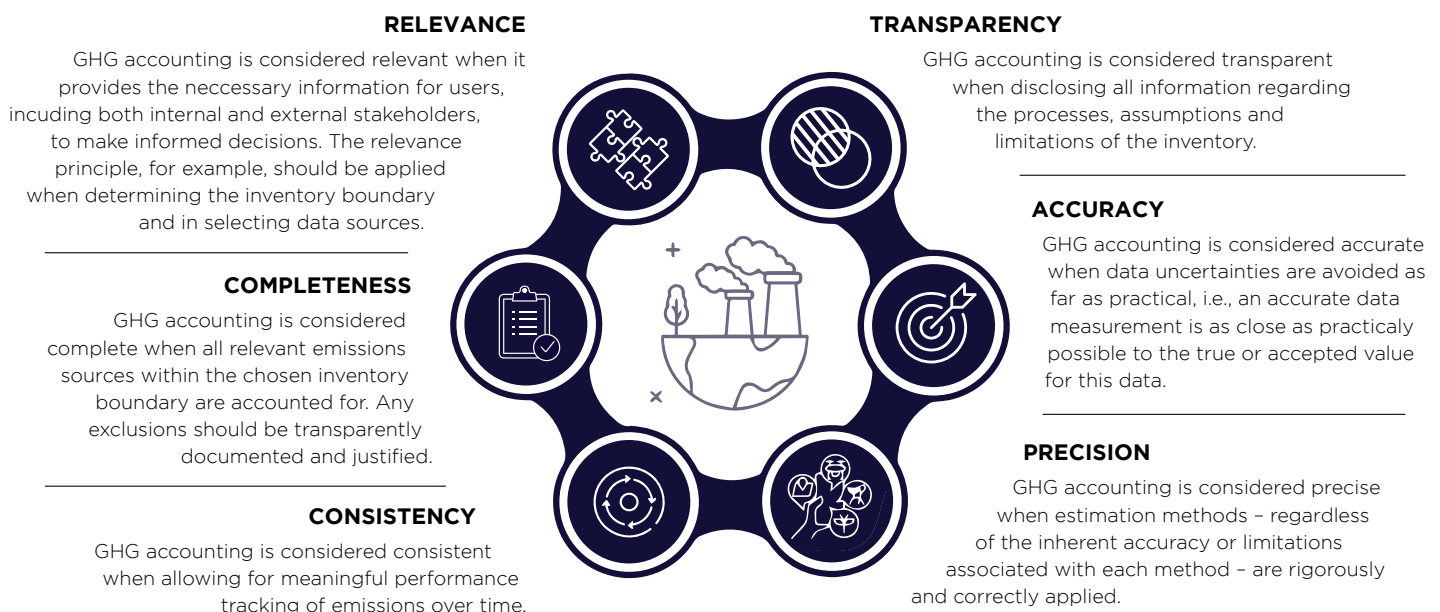


Figure 5 – Accounting principles

3. SCOPE 3 CATEGORY 1 GHG ACCOUNTING METHODOLOGY

For the purposes of this Guideline and aligned with the GHG Protocol, GHGs are the seven gases listed in the Kyoto Protocol: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and nitrogen trifluoride [NF₃].

According to the GHG Protocol², GHG emissions of a reporting company are categorized into three scopes illustrated in the figure below.

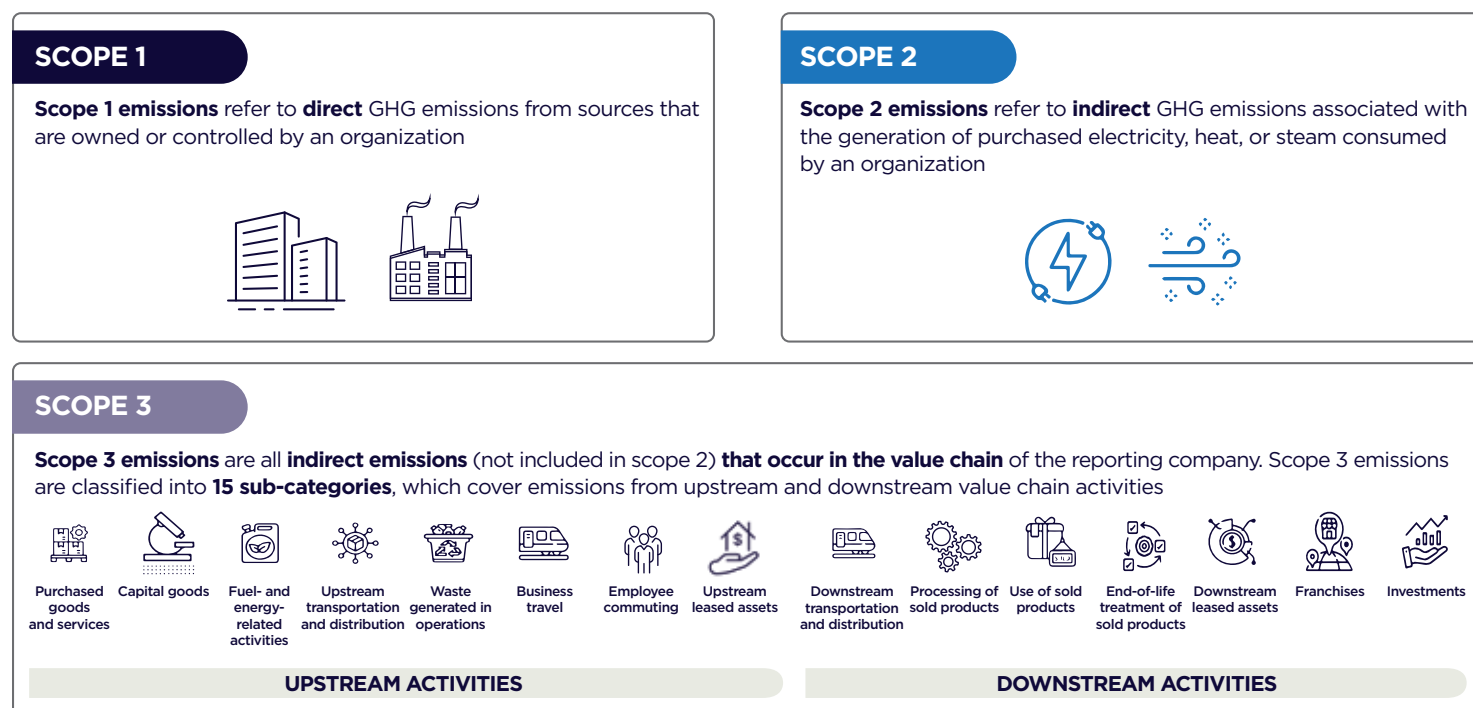


Figure 6 – GHG emission classification in Scopes

2. Refer to the GHG Protocol Corporate Accounting and Reporting Standard (reference link: <https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf>) and the Corporate Value Chain (Scope 3) Accounting and Reporting Standard (https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard_041613_2.pdf) for further details.

3.1 DESCRIPTION OF SCOPE 3 CATEGORY 1: PURCHASED GOODS AND SERVICES

This Guideline focuses on Scope 3 Category 1, which entails the estimation of emissions from purchased goods and services. According to GHG Protocol³, this category encompasses all upstream cradle-to-gate emissions from the production of products purchased by the reporting company in the reporting year. These products encompass both tangible goods and intangible services.

Cradle-to-gate emissions refer to all emissions occurring during the life cycle of purchased products, from raw material extraction up to the point of receipt by the reporting company. These emissions exclude any emissions originating from sources owned or controlled by the reporting company.

Please note that, according to the GHG Protocol, emissions from the transportation of purchased products from a tier one (direct) supplier to the reporting company (in vehicles not owned or controlled by the reporting company) are accounted for in Category 4 (upstream transportation and distribution).

When assessing Scope 3 Category 1 emissions, companies sometimes may encounter ambiguity in accurately distinguishing this category from Category 2 “Capital goods.” In determining the classification of purchased product emissions as Category 1 or Category 2 emissions, companies should rely on their internal financial accounting procedures. In general, capital goods refer to final products with a long lifespan, and in financial accounting, are typically treated as fixed assets; examples include machinery, equipment, facilities, and vehicles. Instead, purchases reported under Category 1 have a short lifespan, and in financial accounting, are typically treated as operating

expenditure (OpEx); examples include metals and alloys, chemicals and gases, specialty materials, plastics, cloud platform service, maintenance, and IT services.

3.2 GHG ACCOUNTING PROCESS

The GHG accounting process consists of a systematic approach for quantifying Scope 3 Category 1 GHG emissions. The process presents a clear and organized sequence of six steps that companies should follow when developing their Scope 3 Category 1 inventory, and entails the application of the six GHG accounting principles for each step.



3. Refer to the GHG Protocol Technical Guidance for calculating Scope 3 emissions, Chapter 1 for further details (reference link: https://ghgprotocol.org/sites/default/files/2023-03/Scope3_Calculation_Guidance_0%5B1%5D.pdf)

Figure 7 – GHG Accounting Process below provides an overview of the Scope 3 Category 1 GHG accounting process steps; each step is detailed in the following paragraphs.

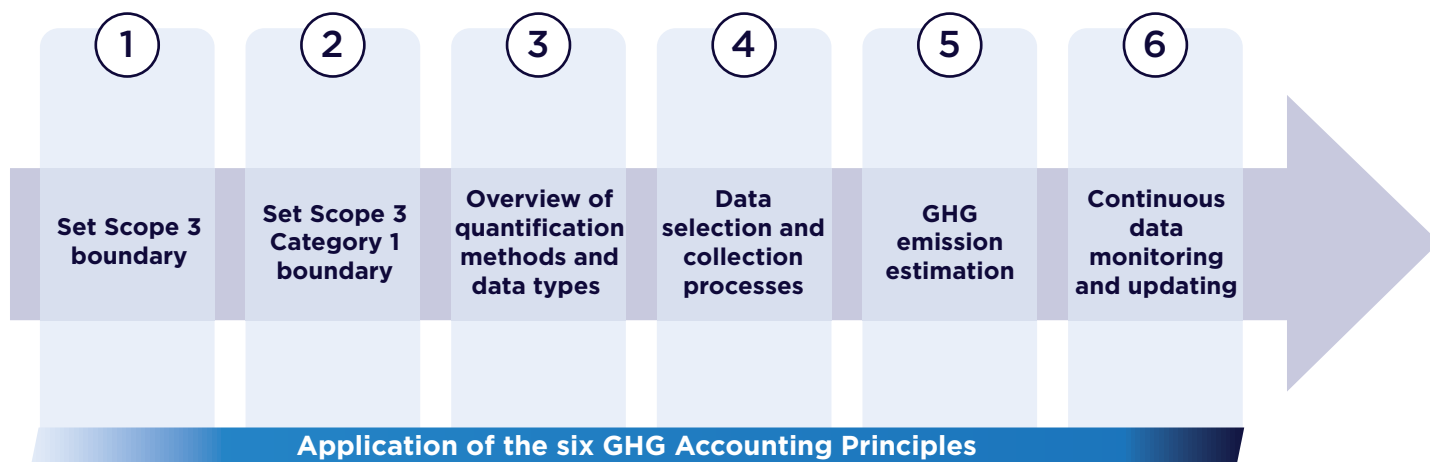


Figure 7 – GHG Accounting Process

3.2.1 SETTING SCOPE 3 GHG INVENTORY BOUNDARY

Defining the organizational boundary is a crucial step in the process of accounting for GHG emissions within a company. It determines which operations are considered part of the company's organizational boundary and how emissions from each operation are consolidated for reporting purposes.

To ensure consistency, companies should adopt a consistent approach for consolidating their inventories across Scope 1, Scope 2, and Scope 3 emissions. In particular, the consolidation approach chosen defines which activities within the company's value chain are considered either direct emissions (Scope 1) or indirect emissions (Scope 2 and Scope 3).

In accordance with the GHG Protocol⁴, companies can select three consolidation approaches:

- **Equity share approach:** under the equity share approach, a company accounts for GHG emissions from operations according to its share of equity in the operation.
- **Financial control approach:** under the financial control approach, a company accounts for 100 percent of the GHG emissions over which it has financial control.
- **Operational control approach:** under the operational control approach, a company accounts for 100 percent of the GHG emissions over which it has operational control.

4. Refer to the GHG Protocol Corporate Accounting and Reporting Standard (reference link: <https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf>) for further details.

3.2.2 SCOPE 3 CATEGORY 1 BOUNDARY

Scope 3 Category 1 includes GHG emissions from activities in the value chain of the entities included in the company's organizational boundary identified through the relevant consolidation approaches.

Companies shall account for all upstream (cradle-to-gate) emissions of purchased goods and services, accounting for all seven gases

listed in the Kyoto Protocol (carbon dioxide [CO₂], methane [CH₄], nitrous oxide [N₂O], hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], sulfur hexafluoride [SF₆], and nitrogen trifluoride [NF₃]) if they are emitted in the value chain.

Companies should report total Scope 3 Category 1 emissions in metric tons of CO₂ equivalent (CO₂e). It is not required to report CO₂e emissions from each of the seven GHG gases separately.

Biogenic CO₂ emissions, which refer to CO₂ released from biomass combustion, and any GHG removals (e.g., biological GHG sequestration) should be excluded from the scope of the reporting company and reported separately.

Companies should aim for completeness when accounting for Scope 3 Category 1 emissions by integrating a cradle-to-gate approach and including all upstream emissions of purchased goods and services. However, it is recognized that it may not always be feasible to include all the

emissions, and/or in certain situations following completeness, this entails trade-off between other accounting principles such as relevance, accuracy, consistency, and transparency. For example, companies may lack the necessary data or face other limitations that prevent them from estimating emissions accurately, or Scope 3 Category 1-related activities may not be as relevant as the company's other sources of emissions. In such cases, companies may choose to exclude some Scope 3 Category 1-related activities from their reports, but these companies should disclose and provide justification for any exclusions made transparently.

In general, in determining whether to exclude activities from the Scope 3 inventory, companies should not exclude any activities that would compromise the significance and relevance of the reported inventory as a whole. The following two sub-paragraphs aim to provide further details on fluorinated GHG⁵ and reused, refurbished, and repaired goods.



5. For the purposes of the present Guideline, fluorinated GHG means the hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other GHGs that contain fluorine, or mixtures containing any of these substances. The definition is based on the REGULATION (EU) No 517/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on fluorinated GHG and repealing regulation (EC).

3.2.2.1 Focus: fluorinated GHG relevance in semiconductor industry

Fluorinated GHGs are extensively used in the semiconductor industry (e.g., in the etching processes or CVD tool chambers). Overall, the use of fluorinated gases has significantly advanced semiconductor technology, but it has also raised environmental concerns due to their high global warming potential (GWP) and that for emissions release. For example, SF₆'s GWP is approximately 23,500 times more potent than CO₂, making it one of the most potent GHGs.

As a response to the environmental concerns and considering their wide application within the semiconductor industry, **companies shall comprehensively account in their GHG inventory for F-gas emissions, if these are emitted for their operations and/or value chain.**

Moreover, when assessing Scope 3.1 cradle-to-gate emissions, it is important to highlight that those fluorinated gases – being extensively used in the preliminary stages and segments of the semiconductor value chain – are likely to hold relevance for a significant majority of companies. Depending on the value chain stage to which it belongs, a company shall report F-gas emission within Scope 1 (e.g., in the case of semiconductor manufacturers) or Scope 3 category 1 (e.g., in the case of electronics manufacturers using semiconductor chips).

3.2.2.2 Focus: reused, refurbished, or repaired goods

Reused, refurbished, and repaired goods encompass goods that were formerly owned by a distinct entity and subsequently restored to a usable state, if required, before being purchased by the acquiring company. When reporting emissions arising from the purchasing of goods with recycled content, being repaired or refurbished, it is important to note that the reporting company's Scope 3.1 inventory boundary should not encompass the emissions arising from the initial extraction from raw materials, subsequent production, or transportation linked to the original manufacturing of the used goods. This can be particularly relevant, for example, when

fluorinated GHGs such as SF₆ are widely used within the original manufacturing of the used goods, e.g., in the preliminary stages of the semiconductor value chain.

However, the upstream emissions of the recycling/repairing/refurbishment processes are built into the cradle-to-gate emission factor for that product and would, therefore, be reflected in the Scope 3 Category 1 GHG inventory. Moreover, any emissions derived from further extraction, production, or transportation linked to these goods need to be accounted for by the company in the reporting year when the goods are procured.

No 842/2006. Refer to Annex I and II of the document for a complete list of F-gases; reference link: (<https://eur-lex.europa.eu/legalcontent/EN/TXT/HTML/?uri=CELEX:32014R0517#d1e32-217-1>)

After a company has identified the activities to include in its Scope 3 Category 1 boundary, the next step is to quantify GHG emissions through direct measurement or calculation methods.

In this regard, companies should review GHG accounting guidance (e.g., sector-specific guidance such as this Guideline and international standards such as GHG Protocol) to make informed decisions when implementing quantification methods, as well as when selecting and collecting data to compute their Scope 3 Category 1 GHG inventory. The following two sub-paragraphs will present an overview of quantification methods and data types.

3.2.3.1 Quantification methods

There are two primary approaches to quantify emissions: direct measurement and calculation.

a) Direct measurement

Direct measurement involves determining GHG emissions quantification using techniques such as direct monitoring, mass balance, or stoichiometry. An in-depth description of such techniques is provided by the latest version of GHG Protocol standards and guidance. Applying direct measurement methods in the case of Scope 3 emissions can be challenging and is often not practical; consequently, companies typically rely on calculation methods.

b) Calculation methods

Calculation methods refer to the quantification of GHG by applying three types of data: activity data, emission factors, and GWP values.

- **Activity data** for measuring GHG emissions refer to information about the specific activities or processes that generate emissions. These data provide details on the quantity and characteristics of the activities that contribute to GHG emissions. The nature of activity data depends on the specific activity being assessed. Here are some examples of activity data: information on fuel consumption (e.g., liter of fuel), electricity consumption patterns (e.g., kWh of electricity), production volume (e.g.,

square inches of silicon wafers), chemicals or gases consumption (e.g., metric tons of sulfuric acid), and economic spend and other financial data (e.g., dollars spent).

- **Emission factors** are numerical values that represent the amount of GHG emissions produced per unit of activity or input. They are used in GHG assessments to estimate emissions based on activity data. Emission factors vary depending on the specific type of activity being assessed. Here are some examples of emission factors: kg CO₂e per liter of fuel consumed, kg NF₃ per kg of products produced, and CO₂e per dollar of products purchased.
- **Global warming potential (GWP)** values represent the radiative forcing impact (or degree of potential contribution to GW) caused by a unit of a specific GHG compared to a unit of carbon dioxide. GWP values are used to convert emissions data of non-CO₂ gases into CO₂e units. To ensure accuracy and consistency, companies should utilize GWP values provided by the Intergovernmental Panel on Climate Change (IPCC) for a 100-year time frame. In particular, companies should use GWP values agreed upon by the United Nations Framework Convention on Climate Change (UNFCCC) or the most recent GWP values published by the IPCC. For companies that have already developed GHG inventories for Scope 1 and 2, it is recommended to employ the same GWP values for Scope 3 to ensure consistency throughout all scopes. “Table A-238” at the following link provides a comparison of GWP values and Lifetimes Used in the IPCC assessments AR4, AR5, and AR6 (most recent):

<https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-annex-6-additional-information.pdf> (accessed: 5 October 2023; data provided by EPA based on IPCC studies).

Figure 8 below gives an overview of a GHG quantification method using a general calculation approach based on activity data and emission

factors. Please note that in some cases, emissions factor may already account for GWP value, providing data in CO₂ eq.

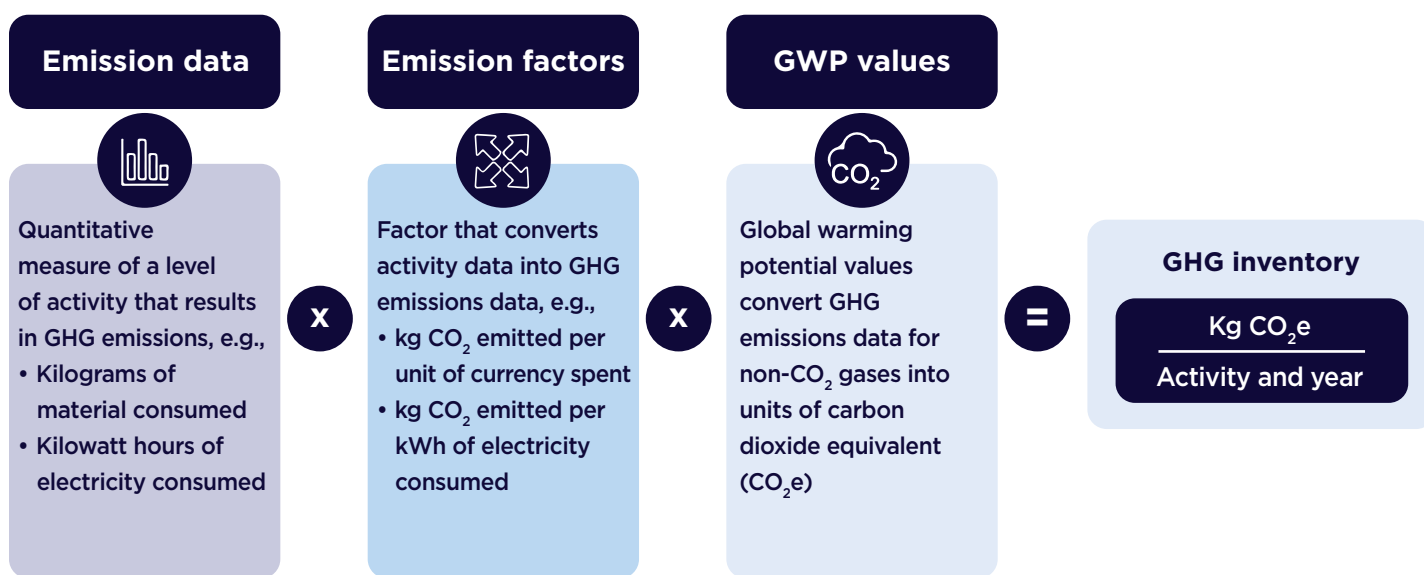


Figure 8 – GHG quantification method: calculation

3.2.3.2 Data type and the four calculation methods

Companies may utilize two types of data when computing Scope 3.1 emissions: primary data and secondary data.

- **Primary data:** data gathered directly from specific activities within a company's value chain or provided by suppliers or other value chain partners related to specific activities. Here are some examples of primary data: product-level, cradle-to-gate GHG data from suppliers calculated using site-specific data and energy use, or emissions data from suppliers
- **Secondary data:** generic data not gathered directly from specific activities within a company's value chain. Here are some examples of secondary data:

- **National or industry-average data** that may be obtained from published databases, government statistics, literature studies, and associations' industryaverage data
- **Proxy data** involve using data from one activity in the value chain to estimate emissions for another activity. Proxy data can be obtained through extrapolating or scaling up a given activity. For example, companies may estimate emissions for chemical vapor deposition (CVD) of silicon oxide films by using data from the CVD of silicon nitride films as a proxy, leveraging similarities in their processes and gas consumption.

The decision to use primary or secondary data or a combination of both is a critical step in the process of estimating Scope 3 Category 1 emissions. According to the type of data used in the calculation of GHG emissions, it is possible to

distinguish between four calculation methods (Figure 9 – Four calculation methods). Each method is detailed in Chapter 4.

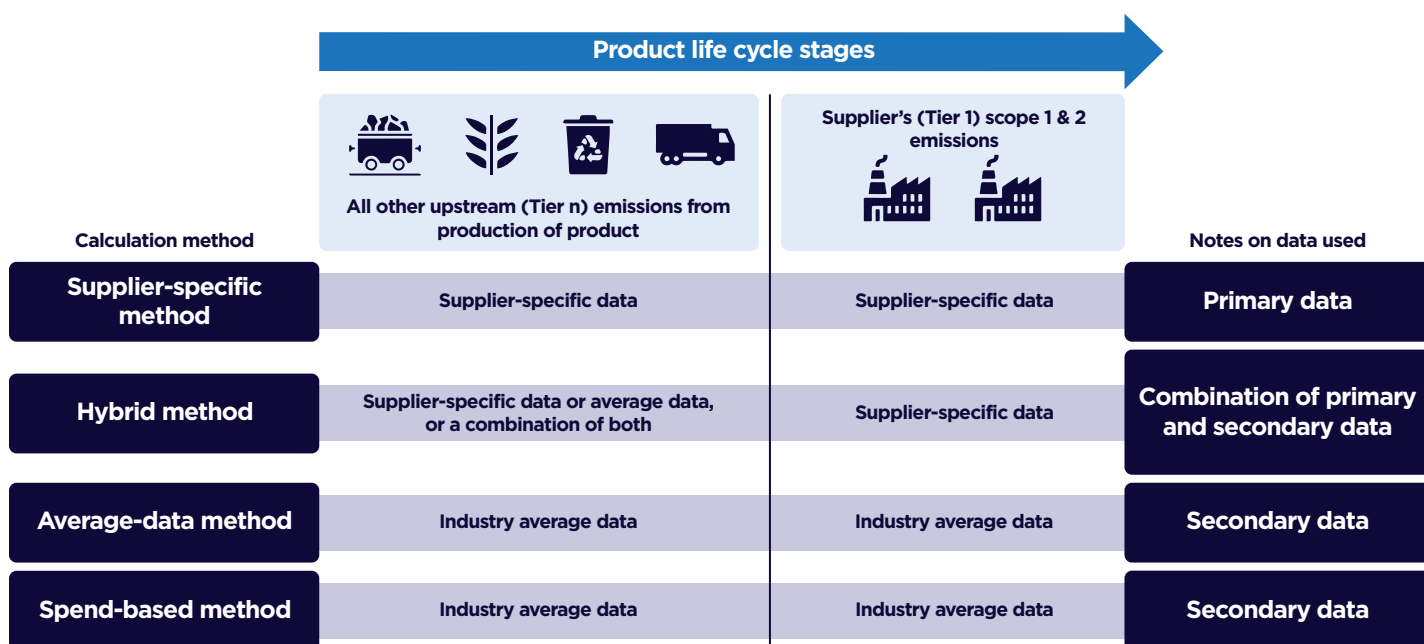


Figure 9 – Four calculation methods

3.2.4 DATA SELECTION AND COLLECTION PROCESSES

The data selection and collection processes for estimating Scope 3 emissions refer to the systematic procedures an organization follows to identify and gather the necessary data to calculate the company's Scope 3.1 emissions. The subsequent two sub-paragraphs provide a detailed account of data selection and collection processes, identifying key recommendations and suggestions for their optimal implementation.

3.2.4.1 Data selection

The accuracy of a company's Scope 3 Category 1 GHG inventory depends on the quality of the data used to calculate emissions. Companies should select data that is of sufficient quality to ensure that the inventory accurately reflects the company's GHG emissions and meets the decision-making

needs of both internal and external stakeholders.

In general, companies should prioritize primary data gathered directly from suppliers and other partners within their value chain. However, there may be instances where primary data is not available, lacks sufficient quality, or entails some disadvantages such as a large time requirement or a costly data collection process. Moreover, companies should acknowledge that the transition to using primary data for emissions calculations is not a swift process; it typically demands ongoing efforts over an extended time frame. Consequently, companies may initiate the process with limited primary data and gradually expand their data collection and integration over time. Figure 10 – Advantages and disadvantages of primary and secondary data below provides an overview that companies may consider when selecting between primary or secondary data.

	Primary data	Secondary data
Advantages 	- Provides a more specific representation of the company's activities and impacts throughout the value chain Enhances the ability to track and benchmark the performance of value chain partners by fostering a more informed and sustainable decision-making process Promotes engagement and collective actions to reduce GHG emissions within the supply chain Enables companies to effectively monitor their progress towards achieving GHG reduction targets	Can be more cost-effective and easier to collect Allows companies to compute GHG emissions and fill data gaps when primary data is not available, of insufficient quality, or not cost-effective - Can be useful to gain a first understanding of companies' GHG emissions, and allows companies to effectively prioritize their efforts in primary data collection, supplier engagement, and GHG reduction initiatives
Disadvantages 	- May be less cost-effective and more difficult to collect - May be challenging to assess data quality and verify data reliability, accuracy, and trust-worthiness May not be applicable when suppliers apply a GHG methodology that is not aligned with the reporting company's, such as when supplier emissions data pertain to a different GHG inventory boundary	Data may not be representative of the company's activities and impacts throughout the value chain May limit the ability of companies to track and benchmark the specific performance of value chain partners May limit the ability of companies to effectively monitor their progress towards achieving GHG reduction targets

Figure 10 – Advantages and disadvantages of primary and secondary data

To ensure the highest-quality data is selected for a particular emissions activity, companies should evaluate data according to the following five indicators:

- **Technological representativeness:** the degree to which the data accurately reflects the technology or technologies employed in the activity being assessed. It is crucial to ensure that the data aligns with the specific technology being used to achieve reliable results. Technological representativeness is especially critical for semiconductor companies involved in rapidly changing supply chains and navigating a dynamic and innovative landscape.
- **Temporal representativeness:** the degree to which the data corresponds to the actual time period or year during which the activity took place. Using data that is up to date and relevant to the specific time frame is important for accurate emissions calculations.
- **Geographical representativeness:** the degree to which the data reflects the precise geographic location of the activity, such as the country or site where it occurred. Geographically accurate data ensures that

regional variations and specific context are adequately captured. Geographical representativeness is particularly important (but also challenging) for the global and complex semiconductor industry, as companies may interact with suppliers across various regions worldwide.

- **Completeness:** the degree to which the data is statistically representative of the relevant activity being assessed. Statistical representativeness ensures that the data is derived from a sufficiently large and diverse sample size, enabling it to be generalized to the broader population or similar activities. Completeness encompasses multiple aspects, including the percentage of locations for which data is available and utilized out of the total number associated with a specific activity. It also accounts for seasonal variations and other regular fluctuations in the data, ensuring that all relevant dimensions are adequately covered.
- **Reliability:** the degree to which data sources, data collection methods, and verification procedures used to obtain the data are trustworthy and credible, and have a proven record of accomplishment of accuracy.

Figure 11 – Example of data-quality indicators application illustrates an example of using data-quality indicators.⁶

Score	Representativeness to the activity in terms of				
	Technology	Time	Geography	Completeness	Reliability
Very Good	Data generated using the same technology	Data with less than 3 years of difference	Data from the same area	Data from all relevant sites over an adequate time period to even out normal fluctuations	Verified data based on measurements
Good	Data generated using a similar but different technology	Data with less than 10 years of difference	Data from a similar area	Data from more than 50 percent of sites for an adequate time period to even out normal fluctuations	Verified data partly based on assumptions or non-verified data based on measurements
Fair	Data generated using a different technology	Data with less than 10 years of difference	Data from a different area	Data from less than 50 percent of sites for an adequate time period to even out normal fluctuations, or more than 50 percent of sites but for a shorter time period	Non-verified data partly based on assumptions, or a qualified estimate (e.g., by a sector expert)
Poor	Data where technology is unknown	Data with more than 10 years of difference or the age of the data are unknown	Data from an area that is unknown	Data from less than 50 percent of sites for shorter time period or representativeness is unknown	Non-qualified estimate

Figure 11 – Example of data-quality indicators application

3.2.4.2 Data collection

Data collection stands as a pivotal and critical step in the Scope 3.1 GHG accounting process. Moreover, it often becomes the most time-consuming and resource-intensive step.

The subsequent section investigates five distinct topics, namely:

- a) Purchases clustering
- b) Materiality threshold for prioritizing the data collection effort

c) Activity data collection

d) Primary data collection

e) Secondary data collection

The primary objective here is to provide insights into optimizing both the effectiveness and accuracy of the data collection process.

⁶ Source: GHG Protocol, adapted from B.P. Weidema and M.S. Wesnaes, "Data quality management for life cycle inventories – an example of using data quality indicators," Journal of Cleaner Production 4 no. 3-4 (1996): 167-174.

a) Purchases clustering

The semiconductor value chain is characterized by high complexity, and it is frequent that semiconductor companies manage an extensive array of purchased goods and services. In this context, clustering a company's internal purchases into distinct purchase categories, and identifying specific commodity and product groups, may serve as a valuable tool in expediting the data collection process. This may facilitate efficient sourcing of activity data, emission factors, and simplifying emissions calculations.

The tables in the section "MAIN COMMODITY GROUPS WITHIN SEMICONDUCTOR VALUE CHAIN" of the "ANNEX" serve the purpose of assisting companies in effectively clustering their procurement by providing a list of main commodity/product categories within each specific value chain stage, identifying each example of goods and services. The aim is to provide not exhaustive lists, but insights into relevant commodity and product groups for each supply chain stage that exerts any influence on Scope 3.1 emissions. Companies may establish more precise and specific categories that align with their organizational needs and structure (e.g., based on their internal procurement categories or purchasing divisions).

b) Materiality threshold for prioritizing the data collection effort

To be comprehensive, companies may seek to collect GHG emissions data for all product and commodity groups within the GHG Scope 3 Category 1 inventory boundary. However, this approach often may not be practical in terms of resources and time when the reporting company may purchase many varied products.

Consequently, companies may prioritize data collection efforts on collecting more detailed data and improving accuracy for high-priority product and commodity groups.

Companies may use a combination of approaches and criteria to identify priority products within the GHG Scope 3 Category 1 inventory boundary,

such as considering a materiality threshold when prioritizing data collection efforts based on GHG emissions and financial spend. In particular:

- When prioritizing data collection efforts based on the magnitude of GHG emissions (e.g., initial screening of emissions through basic estimation methods or proxy data), companies should account for at least 80 percent of the total GHG emissions within the Category 1 boundary, as well as any products or categories in the remaining 20 percent that were individually more than 1 percent of total GHG emissions.
- When prioritizing data collection efforts based on financial spend, companies should account for at least 80 percent of the total spend within the Category 1 boundary, as well as any products or categories in the remaining 20 percent that were individually more than 1 percent of total spend.

In addition, companies may choose other prioritization criteria, such as prioritizing data collection on products where the reporting company has a higher degree of influence on suppliers, or that contribute to the company's risk exposure.

After collecting data and calculating emissions for the prioritized purchases, companies can either extrapolate these emissions or use proxy techniques to estimate the total Scope 3.1 emissions. Please note that companies should provide a clear and transparent justification for assumptions used when estimating emissions.

c) Activity data collection

When assessing Scope 3.1 emissions, activity data typically refer to the physical quantities or monetary spend of purchased products in the reporting year.

Establishing a robust and reliable activity data collection process is essential to ensure the accuracy of emission estimations. To collect activity data more efficiently, companies may align or integrate the data collection process with existing procurement practices.

Typically, data sources for collecting spend activity data are enterprise resource planning (ERP) systems, purchasing records, or accounts payable records, while for physical activity data, the sources are ERP, bills of materials (BoMs), or purchasing records.

Some best practices to implement for collecting activity data are:

- **Enhance data collection** by considering the product attributes in addition to the actual activity data numbers. For example, companies should also consider the geographical location of suppliers (e.g., the US, Asia, Europe), type of products purchased (e.g., primary or secondary aluminum) or production methods involved (e.g., steel produced through the furnace-basic oxygen furnace [BF-BOF] or direct reduced iron-electric arc furnace [DRI-EAF] procedures). A granular categorization of procurement and collection of activity data may help companies select emission factors specific to the activity data being assessed. This will help capture a more accurate representation of emissions across the value chain.

- **Use software for data collection** to streamline data collection, analysis, and reporting processes. Automated systems can help manage large datasets, collect activity data based on physical activity, and track changes over time. Technology enabled solutions can improve the efficiency and accuracy of data collection processes.
- **Implement data-quality assurance** to ensure the accuracy and reliability of the data used. This can involve data validation checks, data cleansing, and addressing data gaps or inconsistencies. By maintaining high-quality data, companies can ensure the accuracy and completeness of the activity data collection process.

d) Primary data collection

Data specificity: primary data collection may be characterized by various levels of data specificity. In general, when collecting primary data from suppliers or other value chain partners, companies should seek to collect data as specific as possible to the product purchased. Moreover, in order to assess the quality of suppliers' data, companies should request that suppliers provide supporting documentation to explain their methodology, a description of the sources and data used, and certified assurance of whether a third party has verified the data.

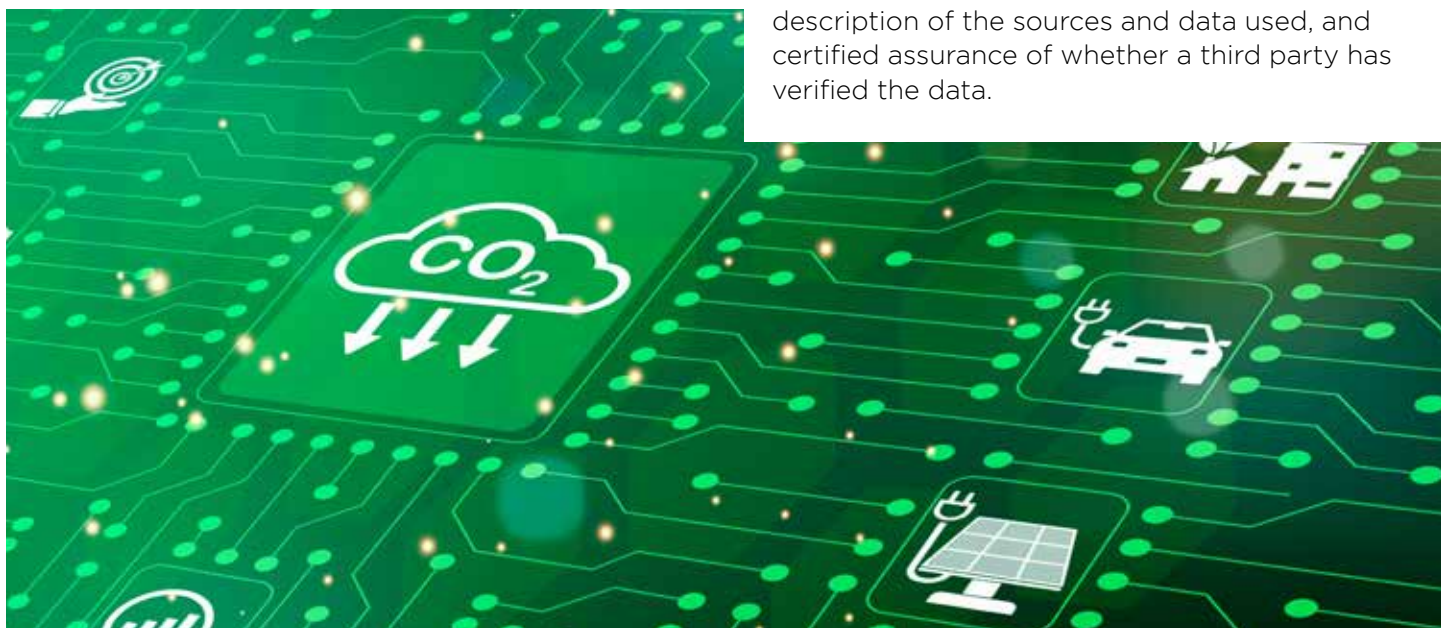


Figure 12 – Primary data specificity below provides a data hierarchy classification based on the degree of data specificity.

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

Figure 12 – Primary data specificity

The level of importance of collecting product-specific data from a supplier is influenced by the range and diversity of products it manufactures. For diversified companies, it becomes more crucial (albeit potentially more complex and challenging) to gather data at the product, production-line, or facility level to obtain representative GHG estimates. Conversely, homogeneous companies may obtain representative GHG estimates by utilizing data at the business unit or corporate level.

Furthermore, companies should consider the challenges, as well as the significant investments of time and resources, involved in the shift from corporate- to product-level GHG data. This is particularly pertinent in the semiconductor industry, where the availability of such data is currently quite restricted.

Collection period: along with data specificity, another crucial factor to consider when collecting primary data from suppliers is the data collection

period. In particular, it is possible that the reporting period of suppliers differs from that of the reporting company. For example, some suppliers may collect data on a fiscal-year basis, while the reporting company collects data on a calendar-year basis, or vice versa. Discrepancy between the reporting periods can lead to a challenge in collecting GHG data since suppliers' primary data may not be readily available for the reporting company's disclosure.

Reporting companies should, to the greatest extent possible, collect or adjust data to reflect a consistent 12-month period. For the purposes of this Guideline and aligned with the IFRS Sustainability Disclosure Standard, a company, in collecting primary data from suppliers, is permitted to use GHG information for reporting periods that are different from its own reporting period if that information is obtained from suppliers in its value chain with reporting periods that are different from its own reporting period, on the condition that:

- The company uses the most recent data available from those suppliers in its value chain without undue cost or effort to measure and disclose its GHG emissions.
- The length of the reporting periods is the same.
- The company discloses the effects of noteworthy events and changes in circumstances (relevant to its GHG emissions) that occur between the reporting dates of the suppliers in its value chain and the date of the company's general-purpose financial reports.

Suppliers' engagement: promoting supplier engagement practices to foster the development and reporting of GHG data is a pivotal and fundamental step in the primary data collection process. Some best practices to implement for engaging with suppliers and collecting primary data are:

- **Guidance and trainings:** provide clear and detailed guidance to suppliers regarding the specific data requirements and reporting expectations. Clearly define the scope and boundaries of the emissions to be reported and ensure suppliers understand the significance of accurate and complete data. Offer training programs, webinars, or workshops to improve their data collection and reporting practices.
- **Incentives and reward:** strengthen the collaboration with suppliers by providing incentives for data accuracy and completeness. Recognize and reward suppliers that consistently provide high-quality data.
- **Supplier data integration:** explore opportunities to directly collect supplier emissions data by reporting GHG data through a standardized and/or existing reporting framework or platform. This

integration ensures a seamless flow of data, reduces data-entry errors, and improves data accuracy and completeness by eliminating manual data-transfer processes.

- **Streamline emissions data collection in existing processes:** efficiently integrate emissions data collection into established operational processes. Leverage existing interactions with suppliers, such as audit activities or regular meetings, as opportunities to collect specific data on emissions. This approach ensures a seamless and cost-effective integration of GHG data gathering, reducing duplication of efforts and enhancing the overall effectiveness of the primary data collection process.
- **Standardization and consistency:** develop standardized templates, questionnaires, or data collection tools that suppliers can use to report emissions data. This helps ensure consistency in data collection and facilitates the aggregation and analysis of emissions data across suppliers.
- **Data validation and quality assurance:** implement rigorous data validation procedures to verify the accuracy and completeness of the supplier-provided data. Cross-check supplier data against industry benchmarks, or request third-party validation certification.
- **Sustainability culture:** foster a culture of sustainability and data transparency among suppliers through regular communication, knowledge sharing, and best-practice workshops. Active engagement motivates suppliers to improve their data collection and reporting processes.

Please refer to Exponential Roadmap Initiative's Supplier Engagement Guide⁷ and SBTi Supplier Engagement Guide⁸ for further details on engagement initiatives.

e) Secondary data collection

A secondary emission factors database can be classified into two categories:

- **Environmentally extended input-output (EEIO):** these models use input-output tables, which provide information on the interdependencies between sectors of the economy, to trace the flow of materials, energy, and emissions throughout the production and consumption chains. Emission factors are typically expressed as the amount of GHG emissions (e.g., carbon dioxide, methane, nitrous oxide) generated per unit of economic activity. These types of databases are used for estimating emissions through a spend-based method and allow for simple and quick access to GHG data. However, emissions estimation accuracy is typically due to the use emission factors aggregated across general product categories and derived from macro-economic statistics, which often become outdated and fail to reflect the actual emissions associated with specific materials or components. Table 8 – List of databases (environmental extended input-output) – (Accessed 20 July 2023) (refer to Annex in Chapter 5) provides an overview of a database that companies may use to collect emission factors based on spend activities.
- **Industry-average databases:** provide a comprehensive set of average emission factors based on aggregated data from LCI assessment of various industries and sectors. The data in these databases are often organized according to standardized

LCI methodology, allowing for consistent and comparable assessments across various products and industries. Emission factors are typically expressed as the amount of GHG emissions (e.g., carbon dioxide, methane, nitrous oxide) generated per unit of physical activity (e.g., kg of materials). These types of databases are used for estimating emissions through the average data method and are more accurate than EEIO models.

Table 9 – List of databases (life Inventory) (refer to Annex in Chapter 5) provides an overview of a database that companies may use to collect emission factors based on physical activity data. The quality of emissions factors in industry-average life cycle inventory (LCI) databases varies depending on the data source, with real industry data typically being more accurate than literature reviews.

Furthermore, the frequency of database updates, such as annual updates versus outdated information, significantly impacts their reliability.

Proficient utilization of databases demands specialized competencies. Therefore, in instances where internal expertise is insufficient, companies should consider seeking external expertise to ensure optimal utilization of database resources.

When collecting secondary emission factors, it is crucial for companies to prioritize the utilization of internationally recognized databases or publications that have undergone rigorous peer review processes. This approach ensures the credibility and reliability of the data used for decision-making and analysis. Among reliable and available databases, companies should use emission factors that are most representative of the geography and technology used to produce the specific product.

7. Reference link: <https://exponentialroadmap.org/supplier-engagement-guide/>

8. Reference link: <https://sciencebasedtargets.org/resources/files/Supplier-Engagement-Guidance.pdf>

Below are some best practices to implement in gathering emission factors:

- **Prioritize data collection efforts:** companies may prioritize data collection efforts on collecting more detailed data and improving accuracy for high-priority products. Refer to paragraph 3.2.4.2 b) Materiality threshold for prioritizing the data collection effort for insights on data collection effort prioritization.
- **Seek granular emission factors:** assigning emission factors that are specific to a particular emissions activity is crucial for improving emission estimation accuracy. For example, emissions can vary based on the energy mix and regulatory frameworks of different regions; consequently, companies can improve the accuracy of estimations by incorporating specific emission data for the areas where suppliers operate.
- **Consider data-quality indicators:** ensure the highest-quality data is selected for a particular emissions activity. Refer to the five data-quality indicators described in paragraph 3.2.4.1.

- **Adopt a cradle-to-gate approach:** extend Scope 3.1 boundaries using cradle-to-gate emission factors. This broader perspective allows for a more comprehensive assessment of emissions associated with Scope 3.1.

Moreover, the following criteria should be applied when collecting emission factors:

- If the production origin (region or country) and technology of the supplied product are known, prioritize regional or country-/technology-specific emission factors. This approach ensures the emissions are representative of the specific geography and production methods used: e.g., emission factors for furnace-basic oxygen furnace (BF BOF) steel production in Europe; emission factors for bio-based polyether ether ketone (PEEK) production in China.
- If the production origin (region or country) of the supplied raw material is known but the technology is not, opt for a regional- or country-specific production-mix emission factor. This approach considers the emissions associated with the specific region or country and the typical technology used in that region: e.g., emission factors for steel production in Europe; emission factors for PEEK production in China.
- If the production origin (region or country) of the supplied raw material is not known but the technology is, opt for a technology-specific production-mix emission factor. This approach considers the emissions associated with the specific technology used: e.g., emission factors for furnace-basic oxygen furnace (BF-BOF) steel production; emission factors for bio-based polyether ether ketone (PEEK) production.
- If the production origin (region or country) and production technology are unknown, choose a regional- or country-specific



consumption mix based on the location of your direct supplier. This approach accounts for the emissions associated with the region or country where the direct supplier is located: e.g., emission factors for the steel market in Europe; emission factors for the PEEK market in China.

- If no regional- or country-specific dataset is available, choose the same raw material from another country or region that has the most appropriate GHG emissions profile. This approach ensures the emission factors are still relevant, even if not specific to the intended region: e.g., emission factors for the steel market in the US; emission factors for PEEK production in other Asian countries.
- If the emission factor for a specific product is unavailable, collect an appropriate proxy, e.g., a similar product within the same product categories group. However, when relying on proxy data, companies should disclose all relevant information regarding the methodology and assumptions they have applied.

3.2.5 GHG EMISSIONS ESTIMATION

When estimating Scope 3 Category 1 emissions, companies should prioritize the adoption of an emissions calculation method that will ensure the highest level of accuracy in their estimations. The selection of an appropriate method should also reflect data availability and data-quality evaluation. Figure 13 – Decision tree for selecting estimation methods below illustrates a decision tree that companies should consider when selecting the appropriate emissions calculation method.

The illustrated decision tree may help companies in adopting the most robust emissions calculation method depending on the specific availability and quality of data.

In general, adoption of a robust estimation method offers several benefits to companies:

- It enhances transparency and credibility by providing stakeholders with accurate and reliable information about the company's climate impact. This, in turn, improves the company's reputation and strengthens its relationships with key stakeholders (e.g., investors and clients).
- Accurate Scope 3 Category 1 emissions estimations allow companies to make informed decisions when setting emission reduction targets. By understanding the full extent of their emissions, companies can establish an accurate GHG baseline, set realistic goals, and develop targeted strategies and initiatives to reduce their carbon footprint.

Chapter 4 will provide an in-depth description of four calculation methods (spend-based method, average data method, hybrid method, and supplier-specific method) by describing their implementation process and outlining best practices for each.



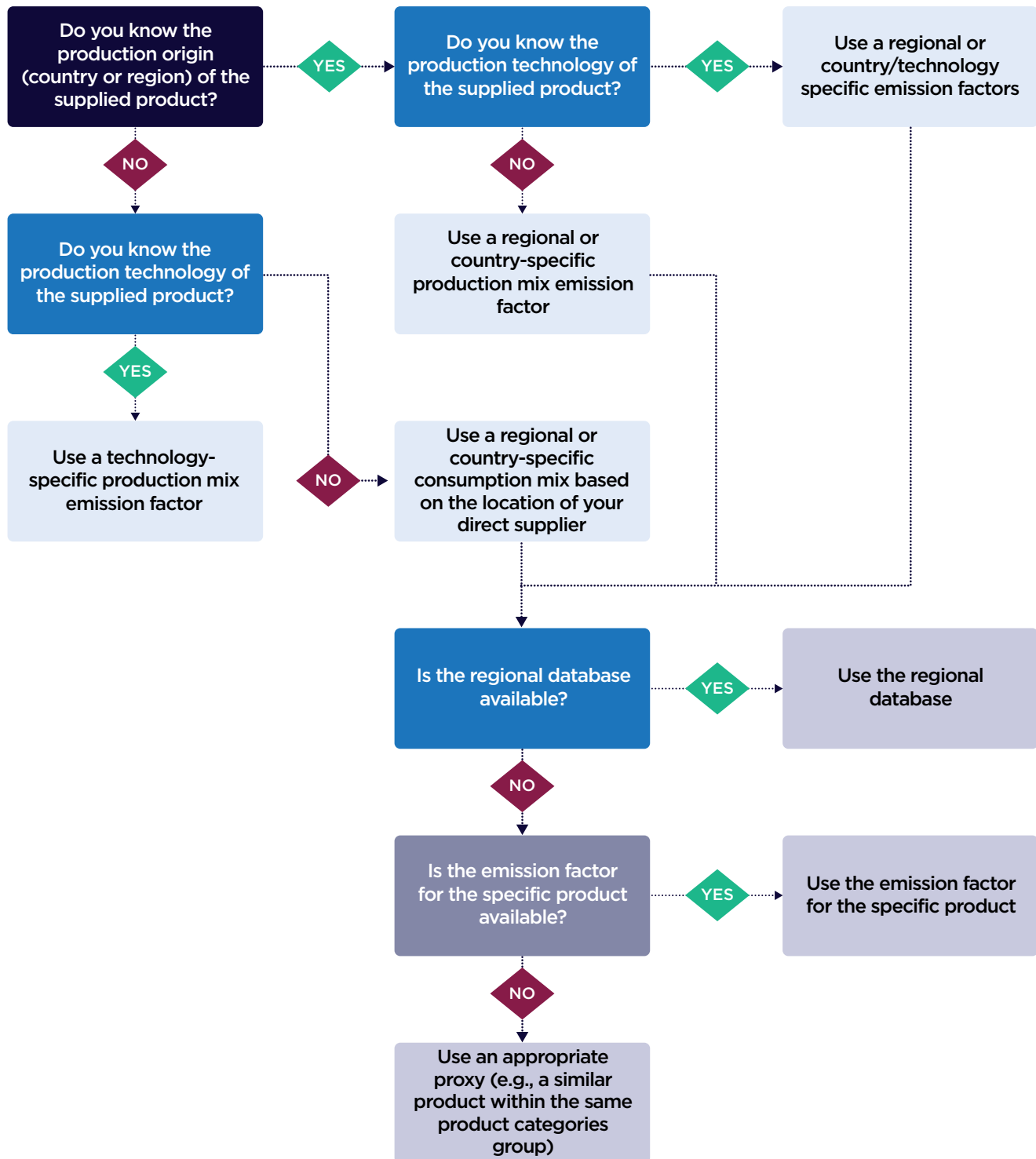


Figure 13 – Decision tree for selecting estimation methods

3.2.6 PERIODIC DATA MONITORING AND UPDATING

Establishing a system for periodic data monitoring and updating ensures that emissions estimations remain accurate and up to date. In particular, companies should monitor and update the estimation process as new or more granular data becomes available, and as the organization's procurement activities evolve. Some best practices to implement for continuous data monitoring and updating are:

- **Sensitivity analysis:** conduct a sensitivity analysis to assess the impact of uncertainties and variations in data on the emissions estimation results. This analysis helps identify key parameters and sources of uncertainty that may significantly influence the accuracy of the estimations. By understanding the sensitivity of the results, companies can focus efforts on improving data quality and reducing uncertainties.
- **Use software and tools** to track changes over time on procurement activities and emission factor data sources and datasets.
- **Verification and assurance:** implement verification and assurance processes to validate the accuracy of the estimation method. This can involve conducting periodic checks on the data collected or engaging third-party auditors to verify the emissions estimation process.

Please refer to Chapter 10 of Corporate Value Chain (Scope 3) Accounting and Reporting Standard (<https://ghgprotocol.org/corporate-value-chain-scope-3-standard>) for further details on assurance processes.



4. ESTIMATION METHODS

The choice of specific method depends on the reporting company's goals, as well as the availability of data or cost-effectiveness of data collection processes. The methods are characterized by different data selection and collection processes, leading to discrepancies in the level of effort required, data specificity, and accuracy achieved. In particular, as depicted in *Figure 14 – Estimation method roadmap*, as the degree of data specificity increases, so does the potential for enhanced accuracy in estimation. In looking at this figure, it is important to note that – although the four methods have been ordered

along the improvement roadmap – this does not mean a method that is more advanced in the roadmap on average can provide better estimation accuracy (e.g., in some cases a hybrid method can be more accurate than a supplier-specific method). This is reflected in the “S-shape” of the red curves in the Figure below: moving to a more advanced method along the improvement roadmap can be insufficient for improving emissions estimation accuracy if this is not combined with accurate implementation of the data collection and estimation process.

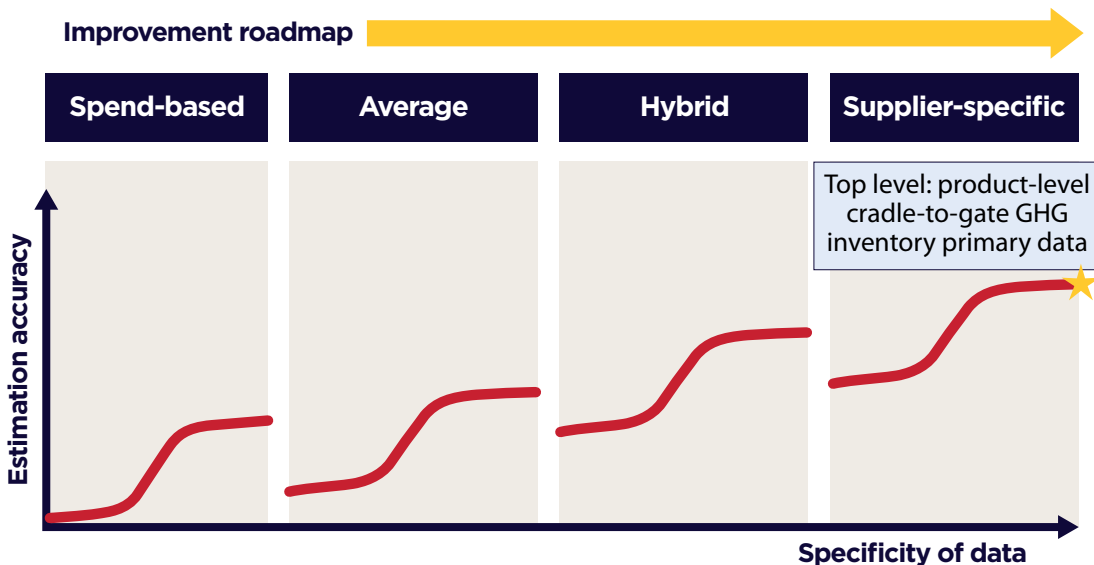


Figure 14 – Estimation method roadmap

Currently, companies within the semiconductor industries show high heterogeneity in terms of maturity and sophistication of Scope 3 Category 1 emissions accounting processes, with some primarily relying on spend-based methods, while others are gradually adopting a hybrid approach.

The present Guideline recommends that companies progressively shift from spend-based and average data to hybrid. Companies should strive to collect and integrate supplier-specific emissions data for more accurate emissions estimation and identifying specific opportunities for emission reductions through suppliers' engagement.

The Guideline acknowledges that, given the intricate nature of the semiconductor value chain and the multitude of products it encompasses, widespread use of a supplier-specific method may not be practical or feasible, at least in the short term. However, SCC's member companies are aware of the importance and benefits of relying on product-level primary data for emission

estimations, and they are committed to improving supplier-specific method viability by promoting collective actions throughout the value chain.

The following paragraphs will provide an in-depth description of each emission estimation method by describing their implementation process and highlighting some best practices to enhance emissions estimation accuracy within each.

4.1 SPEND-BASED METHOD

The spend-based method is a pragmatic and cost-effective approach to estimate Scope 3 emissions associated with purchased goods and services in the organization's value chain. The spend-based method entails collecting data on the economic value of goods and services purchased and multiplying it by relevant secondary emission factors (e.g., average emissions per monetary value of goods). Companies should implement the spend-based method following a four-step process, illustrated in Figure 15. Each step is detailed in the following paragraphs.

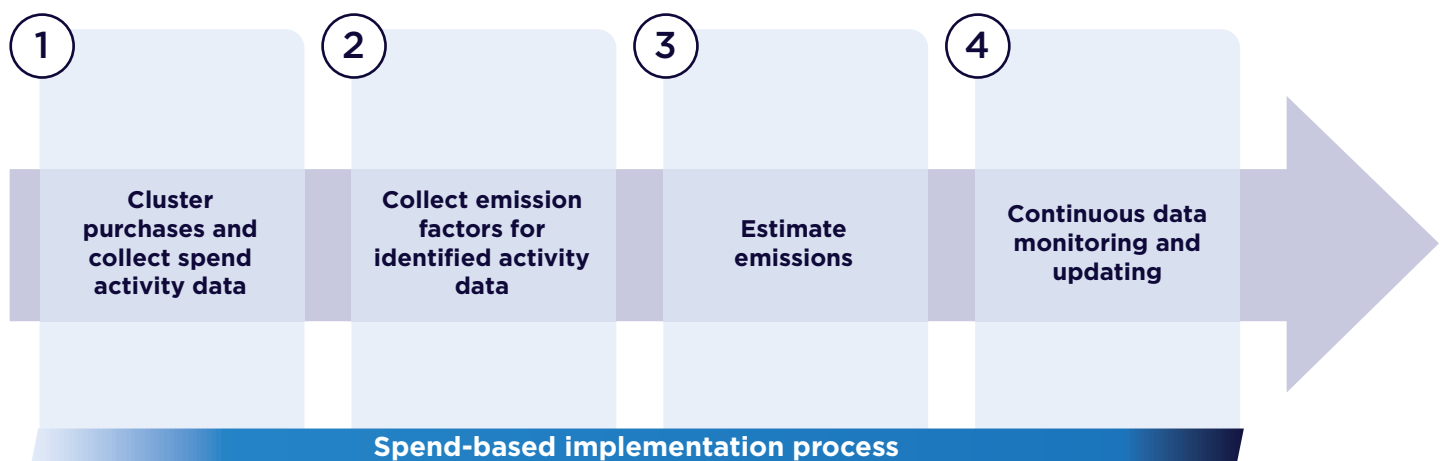


Figure 15 – Spend-based implementation process

4.1.1 CLUSTER PURCHASES AND COLLECT SPEND ACTIVITY DATA

Companies should systematically cluster their purchases and collect spend (economic) activity data. Refer to paragraphs 3.2.4.2a Purchases clustering and Activity data collection to review suggestions.

4.1.2 COLLECT EMISSION FACTORS FOR IDENTIFIED ACTIVITY DATA

Once companies have a clear picture of their purchases and collected the relevant activity data, they should gather relevant emission factors data. Data sources for emission factors include environmentally extended input-output (EEIO) databases or industry associations' and government agencies' studies. Table 8 – List of databases (environmental extended input-output) – (Accessed 20 July 2023) provides a list of EEIO databases that may help companies gather

emission factors. Refer to paragraph 3.2.4.2e Secondary data collection for further details on emission factors collection.

4.1.3 ESTIMATE EMISSIONS

Total Scope 3.1 emissions are calculated by summing emission estimations across all product types and/or spend categories. For each product type and/or spend category, emissions are calculated by multiplying the monetary value spent in each spend category/product type by the corresponding emission factor. The result is an estimation of emissions based on the financial expenditure.

Figure 1 and Table 1 below show the calculation formula and a numerical example, respectively, for estimating emissions using the spend-based method.

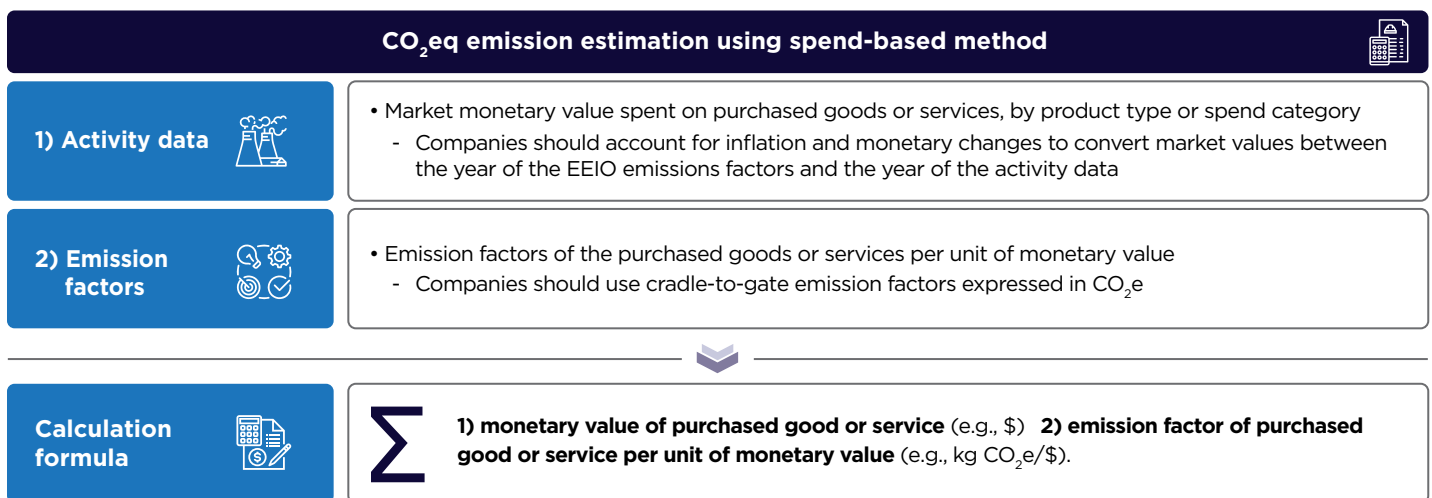


Figure 16 – Emission estimation using the spend-based method

Input data		
Product/commodity group	Activity data	Emission factors
#1	50,000 \$/year	5 kg CO ₂ e/\$
#2	40,000 \$/year	2 kg CO ₂ e/\$
#3	30,000 \$/year	7 kg CO ₂ e/\$
#4	20,000 \$/year	3 kg CO ₂ e/\$
Emission estimation results		
Total CO ₂ e = 50,000 \$ * 5 kg CO ₂ e/\$ + 40,000 \$ * 2 kg CO ₂ e/\$ + 30,000 \$ * 7 kg CO ₂ e/\$ + 20,000 \$ * 3 kg CO ₂ e/\$ = 600 tons of CO ₂ e		

Table 1 – Numerical example of estimating emissions using the spend-based method

4.1.3.1 Focus on data normalization: how to account for inflation

Companies should account for inflation rates when estimating emissions using the spend-based method. This ensures that emissions estimations remain up to date and accurately reflect the purchasing power and emission intensities associated with the relevant time period.

When using spend-based emission factors, companies should account for inflation by aligning expenditure market values with the specific year of the emission factor data.

To determine the inflation-adjusted emissions, companies should:

- Compute the compound inflation rate (CIR), i.e., the cumulative inflation rates between the year of the emission factor data and the year when spend occurred. The company should prioritize sector- or product-specific inflation data. Alternatively, companies may use country-specific inflation data as a proxy for sector- or product-specific inflation data. Examples of data sources for inflation data are sectorial association, or a national or international institution.

For example, the European Central Bank provides sector-specific inflation data (https://www.ecb.europa.eu/stats/macroeconomic_and_sectoral/hicp/html/index.en.html), and the World Bank provides country-specific inflation data (link: <https://www.worldbank.org/en/research/brief/inflation-database>).

- Divide the spend by the CIR to determine the inflation-adjusted spend amount.
- Estimate inflation-adjusted emissions by multiplying the inflation-adjusted spend amount by the emission factor.

Scenario: spend occurred in 2023 while the emission factor is from 2016			
Product	Activity data	Emission factors	Inflation rate
#1	50,000 \$	5 kg CO ₂ /\$ (2016)	2023 \$ = 1.26 X 2016 \$
Inflation-adjusted emissions			
Total CO ₂ eq = 50,000 \$ / 1.26 X 5 kg CO ₂ /\$ = 198 tons CO ₂ eq			

Table 2 – Example of estimation inflation-adjusted emissions using the spend-based method

An alternative approach that companies may take when accounting for inflation (or other monetary changes⁹) entails using historical price data to establish a baseline for assessing pricing fluctuations and determining a corrective factor when accounting for emissions based on spend data. In particular, companies may use the ratio between the current and historical price as a corrective factor to account for monetary changes in assessing spend-based emissions.

In implementing this approach, please note that:

- Historical price data should refer to the specific year of the emission factor data used
- Current and historical price data should refer to a homogeneous quantity of materials

4.1.4 CONTINUOUS DATA MONITORING AND UPDATING

Refer to paragraph 3.2.6 “Periodic data monitoring and updating 3.2.6”.

4.1.5 SPEND-BASED METHOD LIMITATIONS

While the spend-based method offers a cost- and time-efficient approach for estimating Scope 3 emissions, it is characterized by several limitations:

- **Simplified assumption and monetary value variations:** the spend-based method relies on the assumption that there is a direct correlation between financial expenditure and emissions. However, this assumption is sensitive to change in the monetary value of products, and consequently may not accurately capture the actual associated emissions.
- **Lack of specificity:** the spend-based method relies on generalized data that may not capture the specific emissions associated with individual suppliers or products. Relying solely on secondary data can lead to discrepancies between estimated and actual emissions performance.
- **Reliance on secondary emission factors:** the accuracy of the spend-based method depends on the availability and accuracy of emission factors used for each spend category. In some cases, reliable and up-to-date emission factors may be challenging to obtain, leading to potential inaccuracies in the estimation process. Using generic or outdated emission factors can further impact the reliability of the results.

9. Monetary changes (e.g., discounts) may occur in commercial transactions between companies and suppliers or for exogenous factors (e.g., change in exchange rates)

- Limited influence on emission reductions:** the spend-based method primarily focuses on estimating emissions using secondary data, and then identifying specific opportunities for emission reductions. While it provides insight into emission hotspots within the supply chain, lack of supplier engagement may undermine companies' ability to effectively reduce emissions or drive sustainability improvements over the value chain. Additionally, demonstrating progress in reducing emissions can be challenging when decarbonization initiatives are implemented.

Companies should consider these limitations when using the spend-based method, and consequently work towards shifting to more specific methods to obtain a more accurate and reliable representation

of the organization's Scope 3.1 emissions. In this regard, spend-based analysis may be utilized as a screening technique to identify which products/ commodity groups should be prioritized for primary data collection.

4.2 AVERAGE DATA METHOD

The average data method entails collecting data on the mass or units of goods and services purchased and multiplying it by relevant secondary emission factors (e.g., average emissions per kg of goods/units). The average data method enables companies to estimate emissions when specific supplier-level data is not readily available.

Companies should implement the average data method following a four-step process, illustrated in Figure 17; each step is detailed in the following paragraphs.

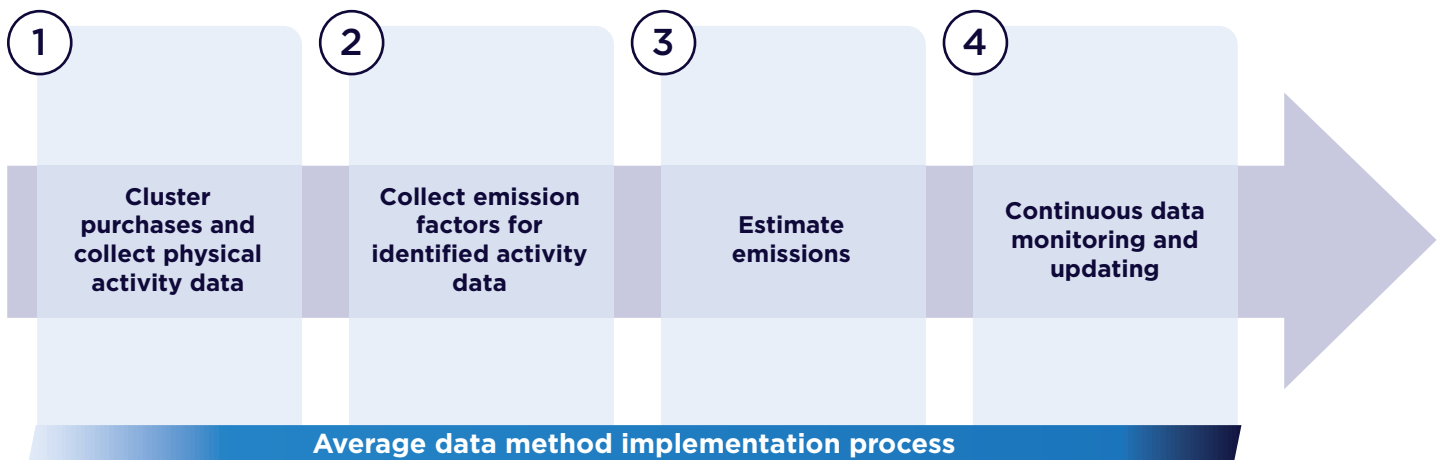


Figure 17 – Average data method implementation process

4.2.1 CLUSTER PURCHASES AND COLLECT PHYSICAL ACTIVITY DATA

Companies should systematically cluster their purchases and collect data on the mass (e.g., kilograms or pounds) or other physical units. Refer to paragraphs Purchases clustering and Activity data collection to review indications and suggestions.

4.2.2 COLLECT EMISSION FACTORS FOR IDENTIFIED ACTIVITY DATA

Once companies have a clear picture of their purchases and collected the relevant activity data, they should gather relevant emission factor data.

Data sources for emission factors include industry-average LCI databases, industry association and government agency studies, research studies, or academic journals.

Table 9 – List of databases (life cycle inventory)
– (Accessed 20 July 2023) provides a list of LCI

databases that may help companies gather emission factors. Refer to paragraph 3.2.4.2e Secondary data collection for further details on emission factor collection.

4.2.3 ESTIMATE EMISSIONS

Scope 3.1 emissions are calculated through the summation of emission estimations for each product category/commodity group. For each product type/commodity group, emissions are calculated by multiplying the physical activity data by the corresponding emission factor. The result is an estimation of emissions based on the physical consumption of products.

Figure 18 and Table 4 below show the calculation formula and a numerical example, respectively, for estimating emissions using the average data method.

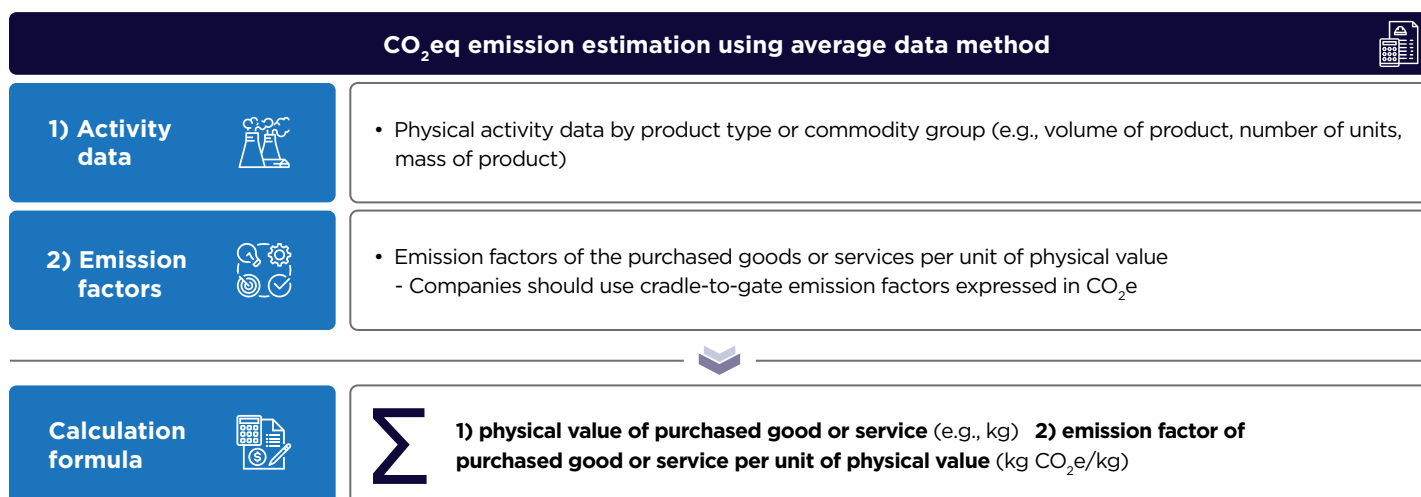


Figure 18 – Emission estimation using the average data method

Input data		
Product/commodity group	Activity data	Emission factors
#1	5,000 kg/year	5 kg CO ₂ e/kg
#2	400 kg/year	2 kg CO ₂ e/kg
#3	3,000 kg/year	7 kg CO ₂ e/kg
#4	2,000 kg/year	0.3 kg CO ₂ e/kg
Emission estimation results		
Total Annual CO ₂ eq = 5,000 kg * 5 kg CO ₂ e/kg + 400 kg * 2 kg CO ₂ e/kg + 3,000 kg * 7 kg CO ₂ e/kg + 2,000 kg * 0.3 kg CO ₂ e/kg = 52.8 tons of CO ₂ e		

Table 3 – Numerical example of emission estimation using the average data method

4.2.4 CONTINUOUS DATA MONITORING AND UPDATING

Refer to paragraph “Periodic data monitoring and updating 3.2.6”

4.2.5 AVERAGE DATA METHOD LIMITATIONS

While the average data method – as it is not sensitive to monetary changes – typically is a more robust approach to estimating GHG emissions than the spend-based, it is important to recognize its limitations:

- **Emission factors availability:** emission factors can change over time as technologies improve, regulations evolve, and industry practices shift. Organizations with rapidly changing supply chains may encounter difficulties in keeping the average data up to date and relevant. Moreover, for certain products, the availability of secondary data sets may be limited, and this issue is notably pronounced for semiconductor companies, especially those engaged in complex supply chain and procurement, such as equipment manufacturers.

- **Limited influence on emission reductions:** the average data method primarily focuses on estimating emissions using secondary data, then identifying specific opportunities for emission reductions. While it provides insight into emission hotspots within the supply chain, lack of supplier engagement may undermine companies’ ability to effectively reduce emissions or drive sustainability improvements over the value chain. Additionally, while using average methods may allow companies to demonstrate some progress on emissions reduction initiatives, such as differentiating emission factors, if available, for virgin and recycled materials, it can still be challenging to effectively demonstrate overall progress in decarbonization.

4.3 HYBRID METHOD

The hybrid method for estimating Scope 3 Category 1 emissions combines two sources of data: supplier-specific data and industry-average data. This approach allows organizations to leverage the benefits of both data types to obtain a comprehensive estimation of their upstream emissions.

Companies should implement the hybrid method following a five-step process, illustrated in Figure 19 – Hybrid method implementation process; each step is detailed in the following paragraphs.

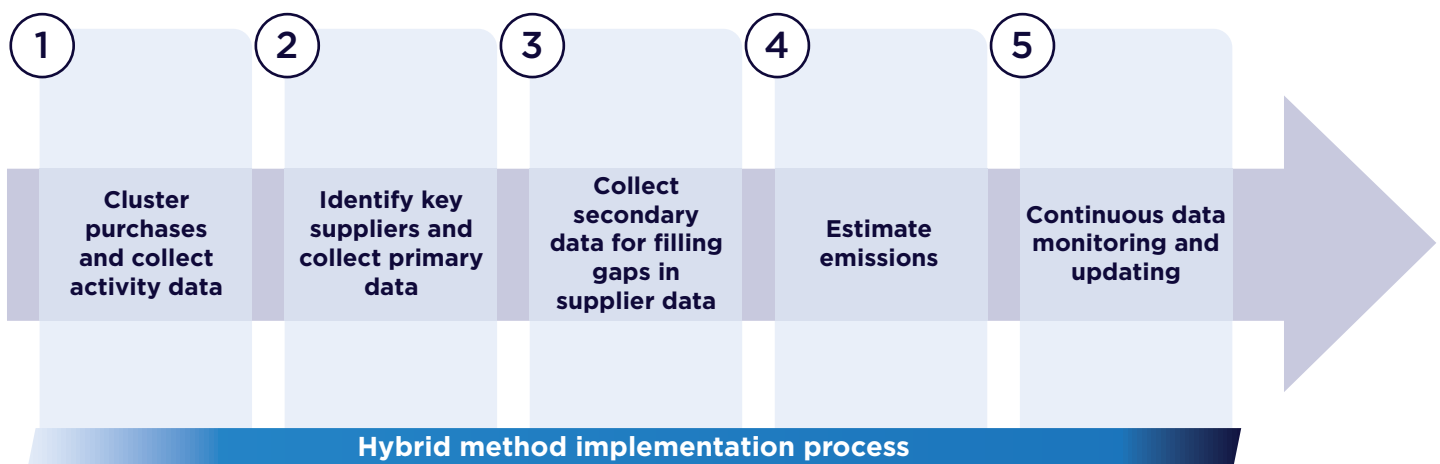


Figure 19 – Hybrid method implementation process

4.3.1 CLUSTER PURCHASES AND COLLECT PHYSICAL ACTIVITY DATA

Companies should systematically cluster their purchases and collect physical activity data (e.g., kilograms or pounds of purchased materials) and/or economic-activity data (e.g., spending amount \$). Refer to paragraphs 3.2.4.2a Purchases clustering and Activity data collection to review indications and suggestions.

4.3.2 IDENTIFY KEY SUPPLIERS AND COLLECT PRIMARY DATA

Companies should identify their supplier network, discerning pivotal suppliers through considerations such as financial spend, strategic importance, and potential environmental impact. Once these key suppliers are identified, engagement activities

should be prioritized for those companies to collect primary emissions data. Please refer to paragraph Primary data collection to review general instructions.

4.3.3 COLLECT SECONDARY DATA FOR FILLING GAPS IN SUPPLIER DATA

In general, companies should collect primary data directly from suppliers and other partners within their value chain, as much as is practically possible. However, there may be instances of gaps in supplier-specific data because of either incomplete information or lack of sufficient quality. In such cases, companies should rely on secondary data for addressing data gaps and inconsistencies. When possible, companies should prioritize collection of secondary emission factors based on

physical activity data over that based on spend activity data. Paragraphs 4.1.2 and 4.2.2 provide detailed information on emission factor collection for spend- and physical activity data, respectively.

4.3.4 ESTIMATE EMISSIONS

Scope 3.1 emissions are calculated through the summation of emission estimations for each product category/commodity group. Companies should utilize the supplier-specific data collected to estimate emissions for the corresponding products or services; they should then apply secondary emission factor data to the activity data for which there are gaps in supplier-specific data. The result is an estimation of emissions based on a combination of primary and secondary data. Companies should seek to collect primary data from suppliers that is as specific as possible to the product purchased. However, often suppliers' emission data are only available at a more general level (e.g., corporate-level emissions, business unit-level emissions). In such cases, using primary data from suppliers or other value chain partners entails allocating emissions to the reporting company.

4.3.4.1 Suppliers' emission allocation

Allocation is the process of partitioning general suppliers' GHG emissions to the specific products and services purchased by the reporting company from the supplier. It is possible to distinguish two approaches for allocating GHG emissions from suppliers:

- **Supplier allocation:** under this approach, suppliers report pre-allocated emissions data to the reporting company. This method relies on the suppliers' own allocation calculations. Consequently, it may help address confidentiality concerns – which are common in the semiconductor industry – for suppliers that may be reluctant to disclose allocation metrics, such as the proportion of their business that a specific client represents. However, reporting companies

should assess the reliability of emission allocation and require suppliers to disclose the specific allocation methodology they have used.

- **Reporting company allocation:** under this approach, the reporting company takes responsibility for allocating supplier emissions. In this case, companies should collect two types of data from suppliers: 1) GHG emissions data, preferably at the facility or production-line level, and 2) activity data for allocating emissions, such as physical or economic data related to the share of company purchasing in respect to the supplier's total production.

In general, when allocating emissions, companies may use two types of methods: 1) physical allocation and 2) economic allocation.

Physical allocation involves distributing the emissions of an activity by considering the inherent physical correlation between various inputs/ outputs and the quantity of emissions produced. Table 4 – Physical allocation factors below provides an overview of the main physical allocation factors and related formulas that companies may use when allocating supplier emissions.

Allocation factors	Allocation formula – e.g., supplier’s business unit (BU) emission
Number of units	Allocation factor = total BU emissions x number of purchased units / number of produced units
Mass	Allocation factor = total BU emissions x mass of purchased products / mass of produced products
Volume	Allocation factor = total BU emissions x volume of purchased products / volume of produced products
Energy	Allocation factor = total BU emissions x energy content of purchased products / energy content of produced products
Chemicals	Allocation factor = total BU emissions x chemical content of purchased products / chemical content of produced products

Table 4 – Physical allocation factors

Economic allocation¹⁰ involves distributing the emissions of an activity by considering the inherent economic correlation between various inputs/ outputs and the quantity of emissions produced. When allocating emissions using economic allocation, companies should use economic market value.

Allocation factors	Allocation formula – e.g., supplier’s business unit (BU) emission
Market value	Allocation factor = total BU emissions x market value of purchased products / market value of produced products

Table 5 – Economic allocation factor

¹⁰ Please note that allocating suppliers’ emissions using economic allocation factors – economic intensity metrics – could also be referred to as the “supplier-specific spend-based method”

The selection of a specific allocation method depends on the unique circumstances of each company. In general, companies should choose an allocation approach that meets the following criteria:

- **Reflects causal relationship:** the chosen method should accurately represent the causal relationship between the production of outputs and the resulting emissions. It should consider the specific activities and processes that contribute to emissions, ensuring a clear and direct linkage between production and emissions.
- **Accuracy and credibility:** the allocation method should result in the most accurate and credible emissions estimates. It should minimize uncertainties and potential biases, employing robust data and calculation methodologies to enhance the reliability of the reported emissions.
- **Support decision-making and reduction activities:** the selected method should provide information that supports effective decision-making and facilitates GHG reduction activities. It should generate insights into emission hotspots, identify opportunities for emissions reduction, and enable the evaluation of progress over time.
- **Adherence to principles:** the allocation method should adhere to key principles, including relevance, accuracy, completeness, consistency, and transparency.

4.3.4.2 Case study: example of applying the hybrid method

This paragraph aims to illustrate a case study in which estimating Scope 3.1 emissions entails allocating primary data collected from key suppliers and using secondary data to fill primary data gaps. The case study is referring to a reporting company named Company A.

Company A undertook a comprehensive data collection effort involving three principal suppliers, each corresponding to distinct products in the procurement portfolio, hereby referred to as Product # 1, Product # 2, and Product # 3.

Company A was able to collect the following primary data for each product:

1. Product # 1: supplier business unit's Scope 1 and Scope 2 emissions, but not Scope 3.1 emissions.
2. Product # 2: supplier business unit's Scope 1, Scope 2, and Scope 3.1 emissions, but Scope 3.1 emissions refer just to a tier 1 supplier.
3. Product # 3: supplier business unit's Scope 1, Scope 2, and cradle-to-gate Scope 3.1 emissions.

Allocation was necessary because the three suppliers provided aggregated emission data at the business unit level. Company A chose to allocate emissions using physical factors based on mass, since suppliers produced products characterized by homogeneous material content. Consequently, mass best reflects the causal relationship between products purchased and emissions.

Table 6 below illustrates how to combine primary

and secondary data in implementing the hybrid method, considering the specific circumstances described above. Please note that the input data considered in the table are example only.

It is important for companies to recognize that filling primary data gaps to attain a comprehensive emissions estimation through a cradle-to-gate approach, utilizing secondary data, relies on the availability of precise and granular secondary emission factors. Even when these emission factors are available, using them correctly requires expertise in database management and

semiconductor value chain dynamics. In cases where internal expertise is lacking, companies should consider seeking external help to ensure the effective utilization of secondary data in filling the primary data gap.

The case study does not investigate the circumstance in which no primary data is available. Companies may refer to paragraph 4.1.3 and 4.2.3 to review estimation methods using only secondary data.

	Allocation factor		Primary data availability		Secondary data for filling gaps	
Input data	Purchased products (Kg)	Produced products (Kg)	Scope 1 & 2 (tons CO ₂ e)	Scope 3.1 ¹¹ (tons CO ₂ e)	Data requirement	Emission factor (kg CO ₂ e/ kg)
Product # 1	100	1,000	50	Not available	Tier 1 cradle-to-gate emission factors	6
Product # 2	200	4,000	100	400 (Tier 1)	Tier 2 cradle-to-gate emission factors	4
Product # 3	500	8,000	2,000	18,000 (cradle-to-gate)	Not required	//
Emission estimation results						
Product # 1	Allocation factor: $100 \text{ (kg)} / 1,000 \text{ (kg)} = 10\%$ Total emissions: allocation factor x Scope 1 & 2 + physical activity data x secondary Tier 1 cradle-to-gate emission factors = $= 10\% * 50 \text{ (tons CO}_2\text{e)} + 6 \text{ (kg CO}_2\text{e/kg)} * 100 \text{ (kg)} = 11 \text{ tons CO}_2\text{e}$					
Product # 2	Allocation factor: $200 \text{ (kg)} / 4,000 \text{ (kg)} = 5\%$ Total emissions: allocation factor x Scope 1, 2, & 3.1 + physical activity data x secondary Tier 2 cradle-to-gate emission factors = $= 5\% * [100+400] \text{ (tons CO}_2\text{e)} + 4 \text{ (kg CO}_2\text{e/kg)} * 200 \text{ (kg)} = 33 \text{ tons CO}_2\text{e}$					
Product # 3	Allocation factor: $500 \text{ (kg)} / 8,000 \text{ (kg)} = 6.25\%$ Total emissions: allocation factor x Scope 1, 2, & 3.1 = $= 6.25\% * [18,000+2,000] \text{ (tons CO}_2\text{e)} = 125 \text{ tons CO}_2\text{e}$					
Total emissions	Total emissions: emissions Product # 1 + emissions Product # 2 + emissions Product # 3 = $(11 + 33 + 125) \text{ tons CO}_2\text{e} = 179 \text{ tons CO}_2\text{e}$					

Table 6 - Numerical example of applying the hybrid method

¹¹ Emissions from waste disposal and treatment, transportation, distribution and other upstream activities should be counted.

4.3.5 CONTINUOUS DATA MONITORING AND UPDATING

Refer to paragraph “Periodic data monitoring and updating 3.2.6.”

4.3.6 HYBRID METHOD LIMITATIONS

While the hybrid method represents a robust approach for estimating emissions, combining the advantages of both primary and secondary data, it is important to consider its potential limitations.

Here are some limitations of the hybrid method:

- **Supplier-specific data availability and quality:** the accuracy and completeness of the estimations heavily depend on the availability and quality of supplier-specific data. If suppliers do not have well-documented or reliable emissions data, it can introduce uncertainties and inaccuracies into the estimations. Incomplete or inconsistent data from suppliers can limit the effectiveness of the hybrid method. Moreover, suppliers may use different methodologies or reporting frameworks, making it challenging to compare and aggregate data accurately. Variability in reporting practices across suppliers can introduce inconsistencies and biases into the estimation process.
- **Lack of granularity:** the hybrid method may not capture emissions variations at a granular level because of limitations in available granular emission data. Supplier-specific data may not provide detailed insights into emissions associated with specific activities or processes within the supply chain. As a result, the hybrid method involves making interpretations and assumptions when integrating supplier-specific and industry-average data that can introduce biases or uncertainties into the estimations.

- **Dynamics of supplier data:** supplier-specific data can change over time because of factors such as organizational changes, innovative technologies, or modifications in supply chain processes. Keeping the supplier-specific data up to date and accurately reflecting these changes can be a significant challenge. Outdated or incomplete data can impact the accuracy and relevance of the estimations.

4.4 SUPPLIER-SPECIFIC METHOD

The supplier-specific method for estimating Scope 3 Category 1 emissions entails using product-level cradle-to-gate GHG inventory data collected directly from suppliers or other value chain partners. This is the most robust method for estimating Scope 3.1 emissions because it entails using specific emission data for goods or services purchased, avoiding the need for emission allocation.



Companies should implement the supplier-specific method following a four-step process, illustrated in Figure 20. Each step is detailed in the following paragraphs.

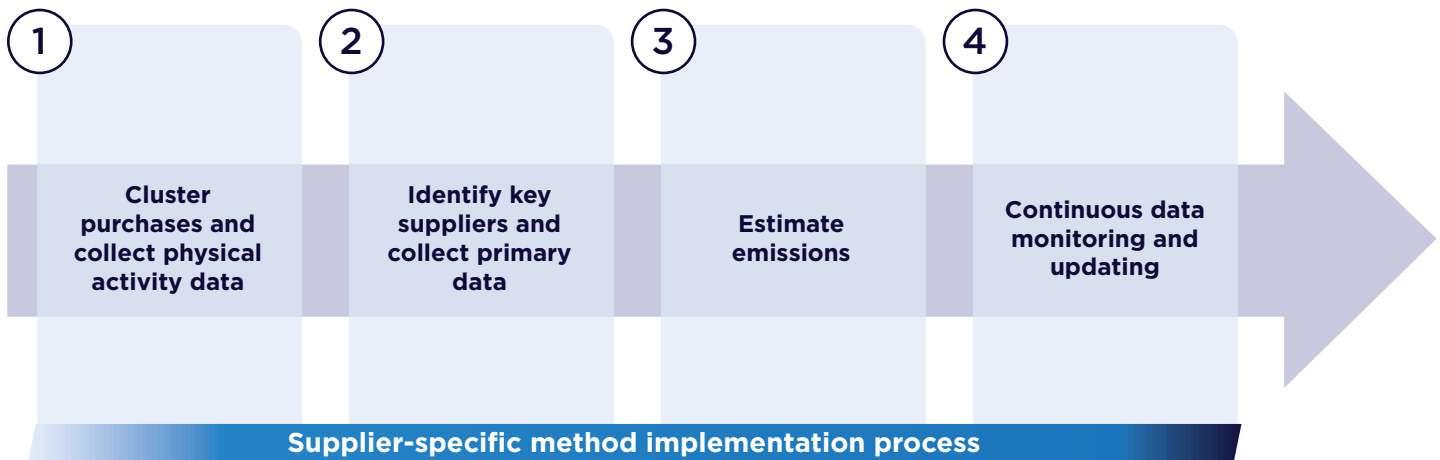


Figure 20 – Supplier-specific method implementation process

4.4.1 CLUSTER PURCHASES AND COLLECT PHYSICAL ACTIVITY DATA

Companies should systematically cluster their purchases and collect data on mass (e.g., kilograms or pounds) or other physical units. Refer to paragraphs 3.2.4.2c Purchases clustering and 3.2.4.2a Activity data collection to review indications and suggestions.

4.4.2 IDENTIFY KEY SUPPLIERS AND COLLECT PRIMARY DATA

Companies should identify their supplier network, discerning pivotal suppliers through considerations such as financial spend, strategic importance, and potential environmental impact. Once these key suppliers are identified, reporting companies should prioritize engagement activities to collect product-level cradle-to-gate GHG inventory data. Please refer to paragraph 3.2.4.2d Primary data collection to review some best practices to implement for engaging with suppliers.

4.4.3 ESTIMATE EMISSIONS

Scope 3.1 emissions are calculated through the summation of emission estimations for each product category/commodity group. For each product type/commodity group, emissions are calculated by multiplying the physical activity data by the corresponding emission factor and GWP value. The result is an estimation of emissions based on the physical consumption of products. Figure 21 and Table 7 on the next page show the calculation formula and a numerical example, respectively, for estimating emissions using the supplier-specific method.

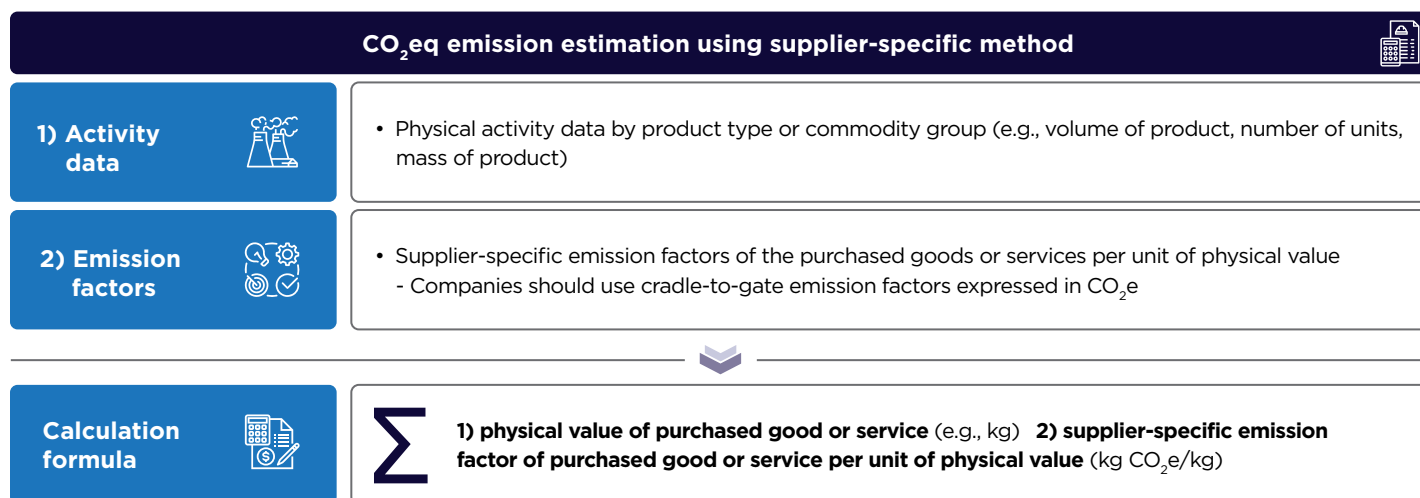


Figure 21 – Emissions estimation using the supplier-specific method

Input data		
Product/commodity group	Activity data	Supplier-specific product-level emission factors
#1	100 kg	10 kg CO ₂ e/kg
#2	8,000 kg	1 kg CO ₂ e/kg
#3	6,000 kg	8 kg CO ₂ e/kg
#4	4,000 kg	5 kg CO ₂ e/kg
Emission estimation results		
Total CO ₂ e = 100 kg * 10 kg CO ₂ e/kg + 8,000 kg * 1 kg CO ₂ e/kg + 6,000 kg * 8 kg CO ₂ e/kg + 4,000 kg * 5 kg CO ₂ e/kg = 77 tons of CO ₂ e		

Table 7 – Numerical example of emission estimation using the supplier-specific method

4.4.4 CONTINUOUS DATA MONITORING AND UPDATING

Refer to paragraph “Periodic data monitoring and updating 3.2.6”

4.4.5 SUPPLIER-SPECIFIC METHOD LIMITATIONS

While the supplier-specific data method is the preferable approach for estimating Scope 3 Category 1 emissions, it is important to acknowledge its limitations. Here are a few possible limitations:

- **Limited data availability:** supplier-specific emissions data at the product level are currently scarce in the semiconductor industry, and they may remain challenging to access in the near future because of the substantial time and resource investments required to develop such data.
- **Supplier confidentiality and intellectual property:** some suppliers may have concerns about sharing product-level data due to confidentiality issues and potential harm to their competitive advantage. Balancing the need for transparency and accurate emissions reporting with suppliers’ confidentiality requirements may require careful negotiation and agreement on data usage and sharing protocols.
- **Scalability challenges:** for companies dealing with a large number of suppliers and a diverse range of products, using supplier-specific data becomes less practical and scalable because of the sheer volume of data to be collected and managed.

4.5 SCC FUTURE COLLECTIVE ACTIONS

This paragraph aims to delineate a set of collective actions that may be further discussed and eventually implemented within the SCC ecosystem in the following years. These actions are strategically devised to facilitate the ongoing pursuit by companies within the semiconductor industry of enhancing the accuracy of emission estimation, thereby ensuring that such estimations consistently improve across years.

In pursuit of SCC commitment to assist member companies in measuring and reporting their Scope 3 Category 1 emissions, the following short- and medium-term actions are strongly suggested:

- Short-term actions (feasible in one to two years):
 - **Developing a standardized questionnaire for suppliers’ data collection:** develop standardized questionnaires and/or processes¹² to be used when collecting emissions data from suppliers. This harmonizes and facilitates the primary data collection process, ensuring time-efficiency, consistency, and accuracy in data gathering.
 - **Providing guidance and training for GHG accounting:** offer guidance and training on GHG accounting to support small suppliers, in particular, within the semiconductor ecosystem through regular training sessions and tailored training content. This ensures that all SCC members, regardless of size, have the proper competencies to accurately measure and report their emissions.

12. The implementation of existing framework could be also an opportunity.

An example of a training initiative may be organizing periodic interactive workshops and Q&A sessions with experts to address specific challenges and questions related to GHG accounting topics.

- Medium-term actions (feasible in 3+ years):

- **Developing a common emissions factors**

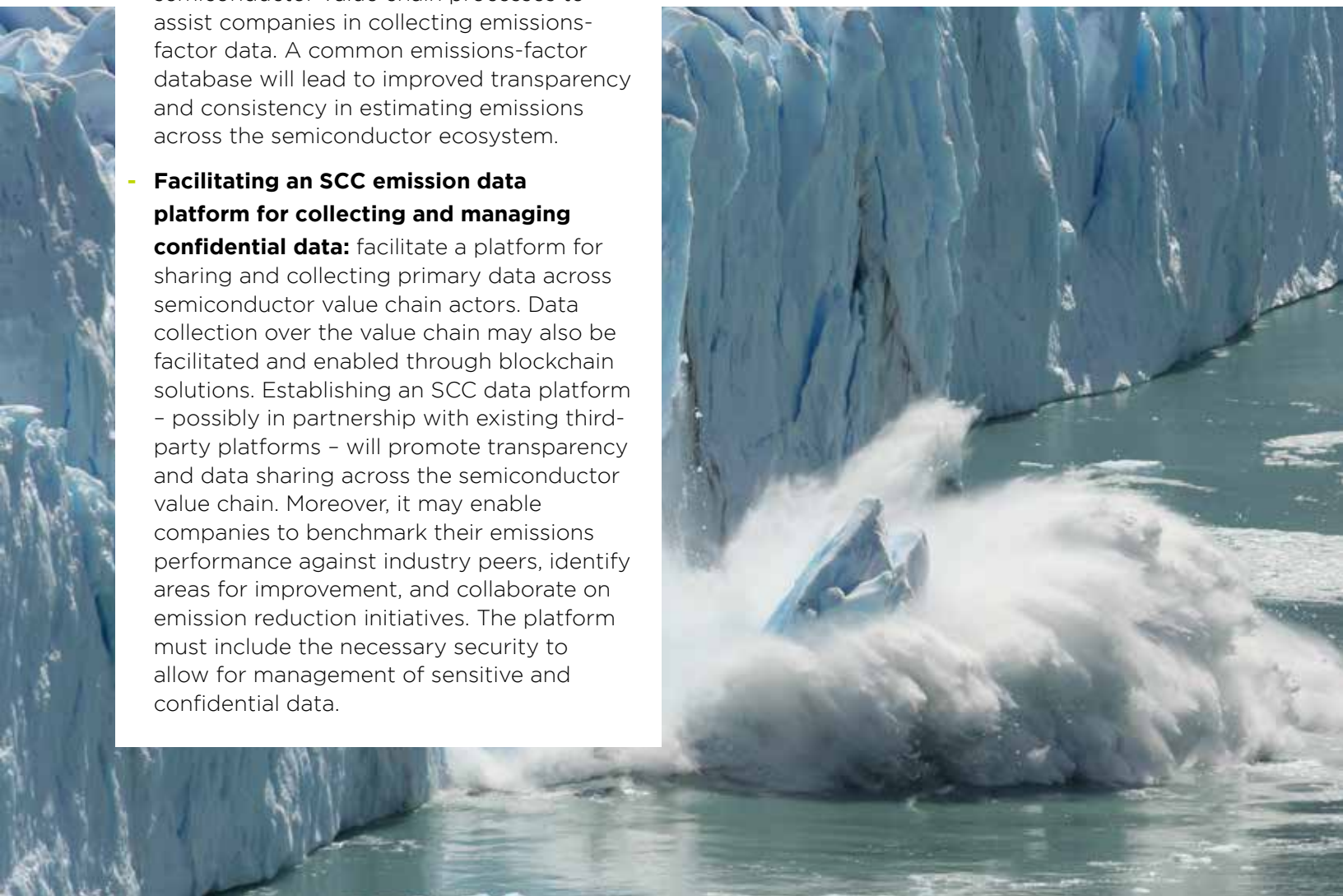
database: create a centralized database of accurate emissions factors specific to semiconductor value chain processes to assist companies in collecting emissions-factor data. A common emissions-factor database will lead to improved transparency and consistency in estimating emissions across the semiconductor ecosystem.

- **Facilitating an SCC emission data platform for collecting and managing confidential data:**

facilitate a platform for sharing and collecting primary data across semiconductor value chain actors. Data collection over the value chain may also be facilitated and enabled through blockchain solutions. Establishing an SCC data platform – possibly in partnership with existing third-party platforms – will promote transparency and data sharing across the semiconductor value chain. Moreover, it may enable companies to benchmark their emissions performance against industry peers, identify areas for improvement, and collaborate on emission reduction initiatives. The platform must include the necessary security to allow for management of sensitive and confidential data.

- **Developing life cycle assessments (LCAs):**

conduct LCAs for selected key products covering hot-spot emissions within the SCC ecosystem¹³. This will lead to significantly improved accuracy in emissions estimation, while enabling identification of areas with the most significant environmental footprint and prioritization of efforts to reduce emissions.



¹³ Possible collaboration with other SCC working group – such as BAR SCC – should be evaluated.

5. ANNEX

5.1 LIST OF EMISSION FACTOR DATABASES

Table 8 – List of databases (environmental extended input-output) – (Accessed 20 July 2023)

Database	Description	Link
US EEIO	US EEIO is an environmentally extended input-output model designed in the United States for assessing organization-wide impacts. All US EEIO files are publicly available, adding a level of transparency to the EEIO models. The dataset and its method provide useful lifecycle data per dollar (2013 USD) for a multitude of goods and services.	https://catalog.data.gov/dataset/useeio-v2-0-1-411
Japan Ministry (METI) & (MOE) database	The database is provided by the Japan Ministry (METI) & (MOE) and includes a large variety of emission factors. It is revised at the end of March every year, and the last version of the database, which was released in March 2023, is the 3.0.	https://www.env.go.jp/earth/ondanka/supply_chain/gvc/estimate.html
ADEME Base Carbone database	Base Carbone is a French public database of emission factors. The data of Base Carbone includes spend-based emission factors for the purchase of goods and is freely accessible.	https://www.data.gouv.fr/en/datasets/base-carbone-complete-de-lademe-en-francais-v17-0/
Carnegie Mellon database	The Economic Input-Output Life Cycle Assessment (EIO-LCA) method developed by Carnegie Mellon estimates the materials and energy resources required for, and the environmental emissions resulting from, economical activities.	https://db.cs.cmu.edu/
EXIOBASE Database	The EXIOBASE database is provided by Simapro. The latest version, EXIOBASE v3.3, is a global and multi-regional, environmentally extended supply and use/input-output database. The database provides data for 43 countries, 160 industry sectors, and 200 product categories	https://simapro.com/products/exiobase-database/

Table 9 – List of databases (life cycle inventory) – (Accessed 20 July 2023)

Database	Description	Link
Ecoinvent	The Ecoinvent Database is a life cycle inventory (LCI) database that supports several types of sustainability assessments. It currently contains more than 18,000 activities, otherwise referred to as datasets.	https://ecoinvent.org/the-ecoinvent-database/
Carbon Minds	Life Cycle Inventory (LCI) database for environmental assessments of chemicals and plastics. Highly regionalized, ISO-ready LCI datasets for 1,000+ products, all from a consistent methodology and direct in major software.	https://www.carbon-minds.com/lca-database-for-chemicals-and-plastics/
Managed LCA Content GaBi Databases)	Database provided by Sphera Solutions, provides LCA data and access to up-to-date information on energy mixes, raw materials, manufacturing processes, finished products, and waste treatment processes across a wide range of industries.	https://sphera.com/life-cycle-assessment-lca-database/
DoD Database	Database categorized according to the North American Industry Classification System (NAICS) nomenclature developed in 2016 by the US Department of Defense.	https://www.denix.osd.mil/esohacq/
IDEA	IDEA is a Japanese database that uses national statistics as its data source and aims to model the environmental impacts of all Japanese businesses comprehensively with a high resolution. IDEA is developed by JEMAI and AIST, which are both top organizations that have led LCA movements in Japan.	https://idea-lca.com/en/
Korea LCI DB	A life cycle inventory (LCI) database for Korean industry provided by Korea Institute of Industrial Technology and Ministry of Environment.	https://ghgprotocol.org/Third-Party-Databases/Korea-Life-Cycle-Inventory-Database
EMEP/EEA	It provides emission factors for inventory compilers for various sectors and at various levels of sophistication. Information is ordered by the respective Nomenclature for Reporting (NFR) source category code.	https://www.eea.europa.eu/publications/emep-eea-guidebook-2023
UK Defra's	The database provided by Department for Environment, Food, and Rural Affairs (Defra) in the United Kingdom provides emission factors to estimate GHG emissions from various sources.	https://www.gov.uk/government/publications/transport-energy-and-environment-statistics-notes-and-definitions
EPA	EPA's GHG Emission Factors include, but are not limited to, facilities that manufacture semiconductors (including light emitting diodes), micro-electromechanical systems (MEMS), liquid crystal displays (LCDs), and photovoltaic cells (PV).	https://www.epa.gov/ghgreporting/ghgrp-electronics-manufacturing-sector-profile

Table 9 – (continued)

ADEME Base IMPACTS database	Base IMPACTS® is the official, generic inventory database for the French government’s environmental labeling program for consumer products. The database provides information for sectors such as electronics, plastics, metals, and chemicals.	https://data.ademe.fr/
Open LCA	Open LCA is an open source and free software for sustainability and Life Cycle Assessment.	https://www.lcacommons.gov/
ILCD	The International Reference Life Cycle Data System (ILCD) is an initiative developed by JRC and DG ENV since 2005, with the aim to provide guidance and standards for greater consistency and quality assurance in applying LCA. Within ILCD, the “Global LCA Data Access” network (GLAD) aims to achieve better data accessibility and interoperability. The network will be comprised of independently operated LCA databases (nodes), providing users with an interface to find and access life cycle inventory datasets from different providers.	https://eplca.jrc.ec.europa.eu/globalLCA.html
Sustainable Minds	Sustainable Minds LCA is a web-based software that helps understand the impacts of products and their parts. SM LCA is a standardized and consistent process that provides a cost-effective alternative to full-scale LCAs.	http://www.sustainableminds.com/industry-blog-categories/life-cycle-assessment
EXIOBASE Database	EXIOBASE database is provided by Simapro. The latest version, EXIOBASE v3.3, is a global and multi-regional environmentally extended supply and use/input-output database. The database provides data for 43 countries, 160 industry sectors, and 200 product categories.	https://simapro.com/products/exiobase-database/

5.2 MAIN COMMODITY GROUPS WITHIN SEMICONDUCTOR VALUE CHAIN

Table 1-15 provide summaries of relevant product/commodity categories and related examples of goods and services. Table structure and contents have been derived from workshop discussions with Scope 3 Category 1 Working Group companies. Please note that in certain cases, there may be ambiguity over whether a particular purchased product is a capital good (i.e., to be reported in Category 2) or a purchased good (i.e., to be

reported in Category 1). In line with the GHG Protocol recommendations, companies should follow their own financial accounting procedures to determine whether to account for a purchased product as a capital good in this category or a purchased good or service in Category 1. Companies should not double-count emissions between Category 1 and Category 2.

Table 10 – Raw materials and equipment value chain stage: relevant commodity & product groups

Raw materials and equipment value chain stage	
Product/commodity categories	Examples of goods & services
Chemicals and gases	Wet chemicals, acids, bases, solvents, resist strippers, developers, etchants, cleaning, surface modifiers, bulk gases, fluorine, chlorine, bromine, Xe, SiF ₆ , CH ₄ , oxygen, nitrogen, hydrogen, hafnium, ozone, reactive gases such as ammonia (NH ₃), CF ₄ , SF ₆ , Cl ₂ , inert gases such as argon, carrier gases such as nitrogen and helium, precursor gases such as silane (SiH ₄), dichlorosilane (SiH ₂ Cl ₂), tungsten hexafluoride (WF ₆), and trimethylaluminum (TMA), inert gases such as neon (Ne) and Xenon
Wafers	Silicon, silicon carbide, gallium nitride, glass, InPh, SiGe, GaAs, SOI
Metals and alloys	Al, aluminum-silicon, Al-Cu, Cu, silver, platinum, chromium, nickel, stainless steel, lithium, cobalt, gold, silver, copper, metal substrates, metal lids
Specialty materials	Silicon, photomasks sputter targets, dopant (ion implantation) targets, Polytetrafluoroethylene (e.g., Teflon)
Plastics	HDPE, PVC, and additions, PVDF, PFA, PTFE, PEEK
Equipment	Lithography equipment, packaging, etching tool, ATP tools (OSAT/IDM), handlers & holders, deposition tool, pumps & compressors, HVAC systems, electrical modules & systems
Components	Probers, probe cards, control valves, regulators, interlock valves, indicators, gas compressors, water pumps, process fluid pumps, process fluid compressors, air conditioners, compressors, condenser, air handlers (including evaporator coil and blower), thermal expansion valves, interconnects and connectors, spare parts, photomasks, reticles, blanks, dicers, mold compounds, encapsulants (epoxies), ceramic impregnators, power generation, inverters
Services	Maintenance and repair, transportation, shipping

Table 11 – Design value chain stage: relevant commodity & product groups

Design value chain stage	
Product/commodity categories	Examples of goods & services
Equipment	EDA tools (IC design & simulation environment, PCB design) and IC design tools (cadence specter, synopsys)
Services	Cloud platform, IT services, logistics
Digital, other components	MCUs, CPUs, memory, logic, amplifiers
MEMS & sensors	Pressure, temperature, acceleration, microphone, gyroscope, magnetometers, gas sensors
IP cores & process design kit	ARM, imagination

Table 12 – Chip manufacturing value chain stage: relevant commodity and product groups

Chip manufacturing value chain stage	
Product/commodity categories	Examples of goods & services
Chemicals and gases	Wet chemicals, acids, bases, solvents, resist strippers, developers, etchants, cleaning, surface modifiers, bulk gases, fluorine, chlorine, bromine, Xe, SiF6, CH4, oxygen, nitrogen, hydrogen, hafnium, ozone, reactive gases such as ammonia (NH3), CF4, SF6, Cl2, inert gases such as argon, carrier gases such as nitrogen and helium, precursor gases such as silane (SiH4), dichlorosilane (SiH2Cl2), tungsten hexafluoride (WF6), trimethylaluminum (TMA), inert gases such as neon (Ne) and Xenon
Wafers	Silicon, silicon carbide, gallium nitride, glass, InPh, SiGe, GaAs, SOI
Metals and alloys	Al, aluminum-silicon, Al-Cu, Cu, silver, platinum, chromium, nickel, stainless steel, lithium, cobalt
Specialty materials	Silicon, photomasks sputter targets, dopant (ion implantation) targets, Polytetrafluoroethylene (e.g., Teflon), boron, phosphorous, arsenic, germanium, CMP slurry and CMP pad
Plastics	HDPE, PVC, additions, PVDF, PFA, PTFE, PEEK
Equipment	Lithography equipment, etching tool, ATP tools, handlers & holders, deposition tool
Components	Photomasks, reticules, blanks, probers, probe cards, spare parts
Maintenance and repair	Maintenance and repair, IT services, transportation, shipping

Table 13 – Assembly and packaging value chain stage: relevant commodity and product groups

Assembly and packaging value chain stage	
Product/commodity categories	Examples of goods & services
Metals and alloys	Al, aluminum-silicon, Al-Cu, Cu, gold, silver, platinum, tungsten, chromium, nickel, stainless steel, lithium, cobalt
Materials	Organic materials (EPS, PI, ABF), inorganic materials (TEOS), silicon, Polytetrafluoroethylene (e.g., Teflon)
Equipment	ATP tools (OSAT/IDM), handlers & holders, EDA and IC design tools, packaging (OSAT/IDM), electrical modules & systems, HVAC systems
Components	Dicers, mold compounds, encapsulants (epoxies), ceramic impregnators, metal substrates, metal lids, laminated substrates (LGA), PCB design, cadence specter, synopsis, spare parts, probers, probe cards, interconnects and connectors, air conditioner, compressor, condenser, air handler (including evaporator coil and blower), thermal expansion valve, power generation, inverters, IC design & simulation environment
Services	Maintenance and repair, IT services, transportation, and shipping

Table 14 – End-product integration value chain stage: relevant commodity and product groups

End-product integration value chain stage	
Product/commodity categories	Examples of goods & services
Metals and alloys	Al, aluminum-silicon, Al-Cu, Cu, gold, silver, platinum, tungsten, chromium, nickel, stainless steel, lithium, cobalt
Equipment	Electrical modules & systems, HVAC systems
Components	Interconnects and connectors, probers, probe cards, power generation, inverters, air conditioner, compressor, condenser, air handler (including evaporator coil and blower), thermal expansion valve
Resistors	Resistance values, thin-film, thick-film, integrated silicon resistors
Digital, analog, & others	MCUs, CPUs, memory, logic, amplifiers
MEMS & sensors	Pressure, temperature, acceleration, microphone, gyroscope, magnetometers, gas sensors
IP cores & process design kit	ARM, imagination
Services	Maintenance and repair, EMS, cloud platform, IT services, transportation, and shipping

Table 15 – End products and solutions value chain stage: relevant commodity and product groups

End products and solutions value chain stage	
Product/commodity categories	Examples of goods & services
Metals and alloys	Al, aluminum-silicon, Al-Cu, Cu, gold, silver, platinum, tungsten, chromium, nickel, stainless steel, lithium, cobalt
Equipment	Electrical modules & systems, HVAC systems
Components	Interconnects and connectors, spare parts, power generation, inverters, air conditioner, compressor, condenser, air handler (including evaporator coil and blower), thermal expansion valve
Resistors	Resistance values, thin-film, thick-film, integrated silicon resistors
Capacitors	Dielectric materials (silicon dioxide, silicon nitride, hafnium oxide), metal plates, electrodes
Digital, analog & others	MCUs, CPUs, memory, logic, amplifiers
MEMS & sensors	Pressure, temperature, acceleration, microphone, gyroscope, magnetometers, gas sensors
Services	EMS, maintenance and repair, IT services, transportation, and shipping

5.3 CASE STUDY: SCREEN SEMICONDUCTOR SOLUTIONS (SCREEN) – EMISSION ASSESSMENT CRITERIA AND METHODOLOGY

5.3.1 INTRODUCTION TO THE COMPANY

SCREEN is a global leader in semiconductor cleaning processes and equipment. In line with its commitment to reducing its ecological footprint, SCREEN has performed a life cycle (LC) CO₂ calculation analysis to identify the GHG emissions hot spots within its value chain.

SCREEN chose to focus on one of its most representative equipment offerings – SU-3200 Single Wafer Clean – considering two potential configurations: the results of this assessment will provide a robust reference to assess SCREEN's overall GHG emissions, identifying related hotspots (ref. Figure 21 on page 60). This Annex will focus on Scope 3 Category 1 emissions assessment.

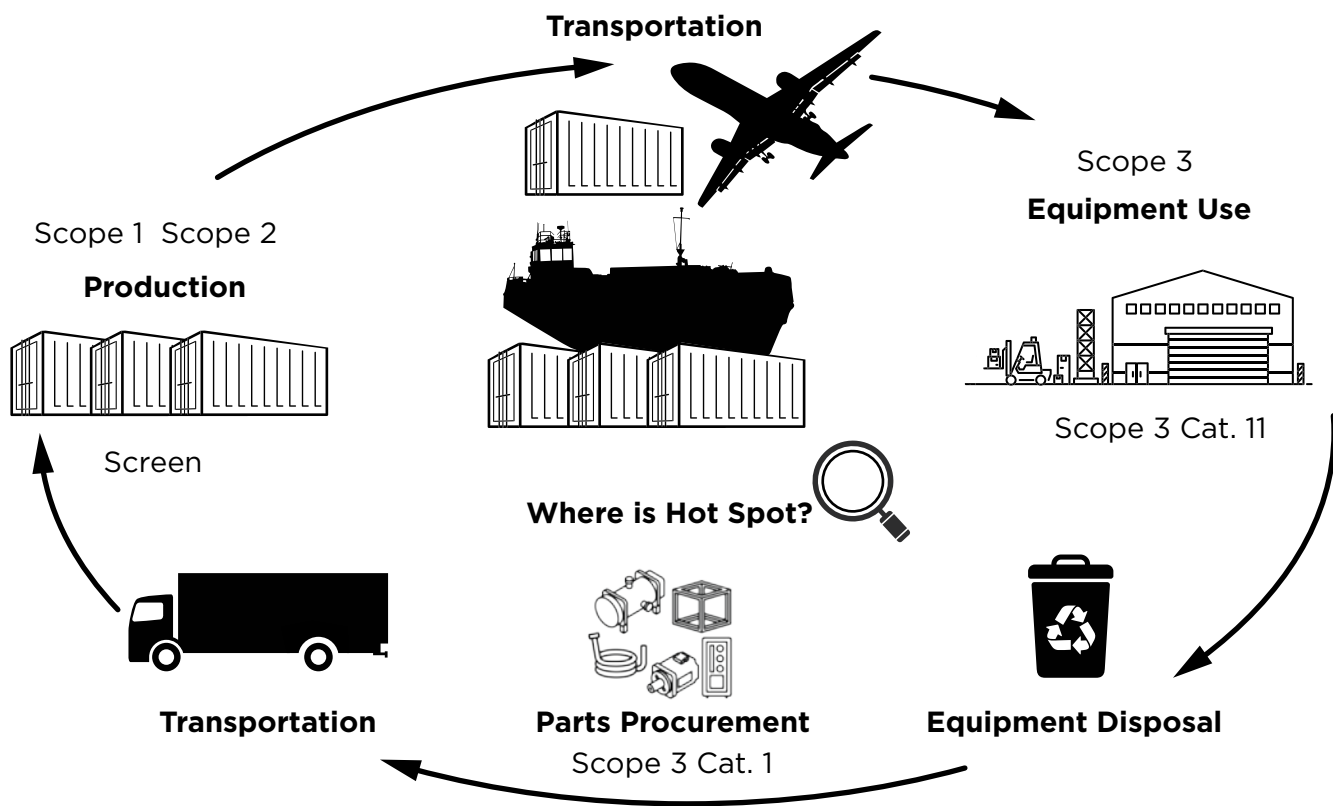


Figure 22 – LC-CO2 calculation actions

5.3.2 THE CONTEXT OF GHG ASSESSMENT

The GHG accounting process implemented involved three main steps (Table 1):

- **Step 1:** boundary setting through LC flow diagram and Equipment Use scenario selection;
- **Step 2:** LC-CO2 emissions were assessed using secondary data for computation;
- **Step 3:** analysis extension by collecting and incorporating primary data.

Primary data collection involved interviews with individual companies and industry groups. However, limitations were encountered (e.g., only one chemical solution manufacturer could provide primary data for some products, while industry associations showed limited action in visualizing and reducing emissions).

Table 16 – LCA calculation process

LCA calculation process		Methodology details
Create LC flow diagram/Set boundary		
Calculation of LC-CO2 (Secondary data calculation)	Parts Procurement	Scope 3 Cat. 1, based on custom and commercial parts actual data
	Production	Scope 1 & 2: energy data collected at production sites and calculated
	Transportation	Scope 3: Calculated based on equipment weight and overseas export distance scenario.
	Equipment Use	Scope 3 Cat. 11, based on Configuration 1 and Configuration 2 scenarios
Primary data collection/ replacement	Equipment Disposal	Scope 3, based on equipment weight
	Equipment Use * Chemicals	Scope 3 Cat. 11, involvement of chemicals manufacturers and industry associations

For calculation, it was assumed that the equipment would be in use for 15 years. Results from the analysis on the overall LC indicate that the majority of SU-3200's LC-CO2 emissions came from equipment use in both the Configuration 1 and 2 scenarios. Notably, utility usage and chemical

procurement (Table 2) were identified as hot spots, emphasizing the significance of reducing CO2 emissions during use. In particular, utility use is the most emitting subcategory for the Configuration 1 scenario, while this was chemical procurement in the case of Configuration 2.

Table 17 – Life cycle (LC) categories and subcategory for CO2 computation for case study

CO2 emissions in each life cycle		
LC category	LC subcategory	Scope
Parts procurement	Customer products	Scope 3 Category 1
Transportation (procurement)	Commercially available products	Scope 3 Category 1
	Transportation	Scope 3
Production	Factory	Scope 1 & Scope 2
Transportation (shipping)	Transportation	Scope 3
Equipment utilization	Utility procurement	Scope 3 Category 11
	Utility use	Scope 3 Category 11
	Heat load	Scope 3 Category 11
	Drainage disposal	Scope 3 Category 11
	Exhaust gas treatment	Scope 3 Category 11
	Chemical procurement	Scope 3 Category 11
Equipment disposal	All equipment	Scope 3

5.3.3 SCOPE 3 CATEGORY 1 GHG EMISSIONS ASSESSMENT METHODOLOGY

In order to assess GHG emissions due to parts procurement, the machine's parts were listed and grouped into three categories: 1) custom parts (25 types), 2) commercial parts (196 types), and 3) miscellaneous. (Note: the miscellaneous category was excluded from the assessment, since the weight-based ratio of parts belonging to this category was small, and therefore the impact on the overall emissions of the equipment was expected to be similarly small.)

The assessment was performed using IDEA v3.2 (i.e., Inventory Database for Environmental Analysis), which was developed by the Japanese National Institute of Advanced Industrial Science and Technology. IDEA v3.2's intensity combines a mix of "material" and "product" items (See Table 3).

Table 18 – Parts lists and groupings for the procurement phase for the case study

Parts procurement: Parts lists and groupings		
Criteria	“Material” intensity	“Product” intensity
Description of target products	Chemical and steel industry products	Plastic and metal processed products
Intensity unit	Mainly weight-based	By weight or by value
Advantages	Fine classification, suitable for material-specific environmental impact analysis	CO2 emissions during processing by component manufacturers are included
Disadvantages	CO2 emissions during processing by component manufacturers are not included	Coarse classification, not suitable for material-specific environmental impact analysis

For custom and commercial products, intensities were selected based on two rules:

- Product-based intensity shall be applied.
- Priority is given to weight-based intensity because it is easier to link to reduction actions and not subject to market fluctuations.

An exception was defined for fluororesin, recognizing its distinct environmental impact compared to general resins; the intensity per unit of material (= fluororesin) was applied to fluororesin-derived parts.

5.3.4 SCOPE 3 CATEGORY 1 GHG EMISSIONS ASSESSMENT RESULTS

Based on secondary data, the emissions from procurement parts for all equipment were estimated to be around 1.5 percent of the total LC emissions for both Configuration 1 and 2 products.

In the case of Configuration 1, the top seven emission sources accounted for about 50 percent of the total emissions from parts procurement (Figure 23). Similarly, the top eight emission sources account for about 50 percent of the emissions from parts procurement for the Configuration 2 scenario (Figure 24).

Config. 1 Parts Procurement-Pareto Chart of CO₂ Emission Calculation Results (t-CO₂)

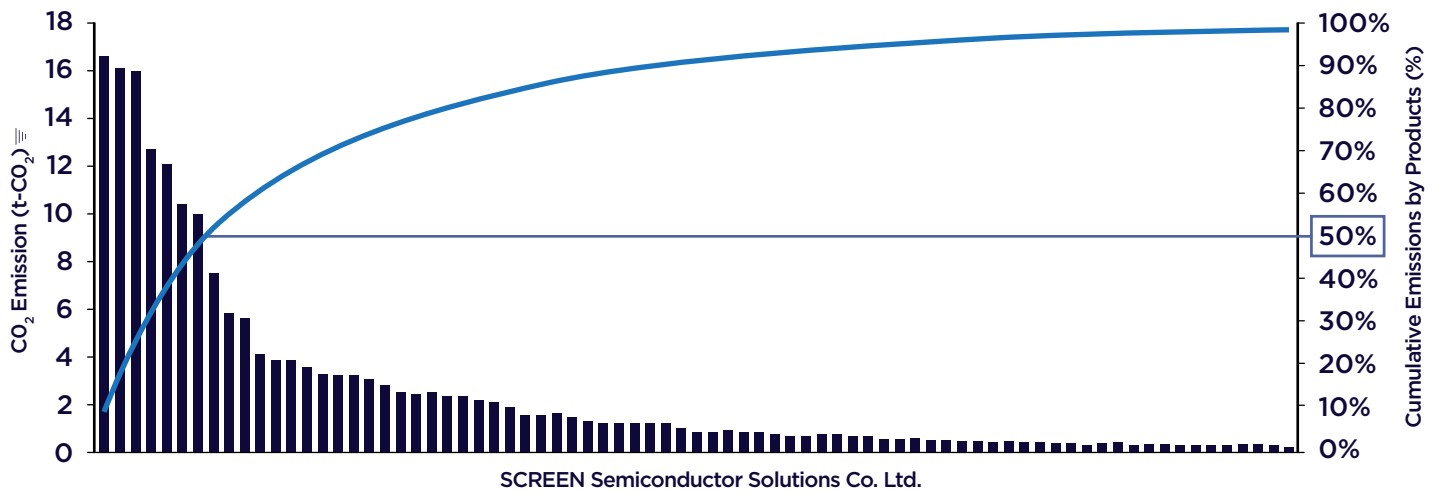


Figure 23 - Configuration 1 parts procurement: Pareto chart of CO₂ emissions calculation results (t-CO₂)

Config. 2 Parts Procurement-Pareto Chart of CO₂ Emission Calculation Results (t-CO₂)

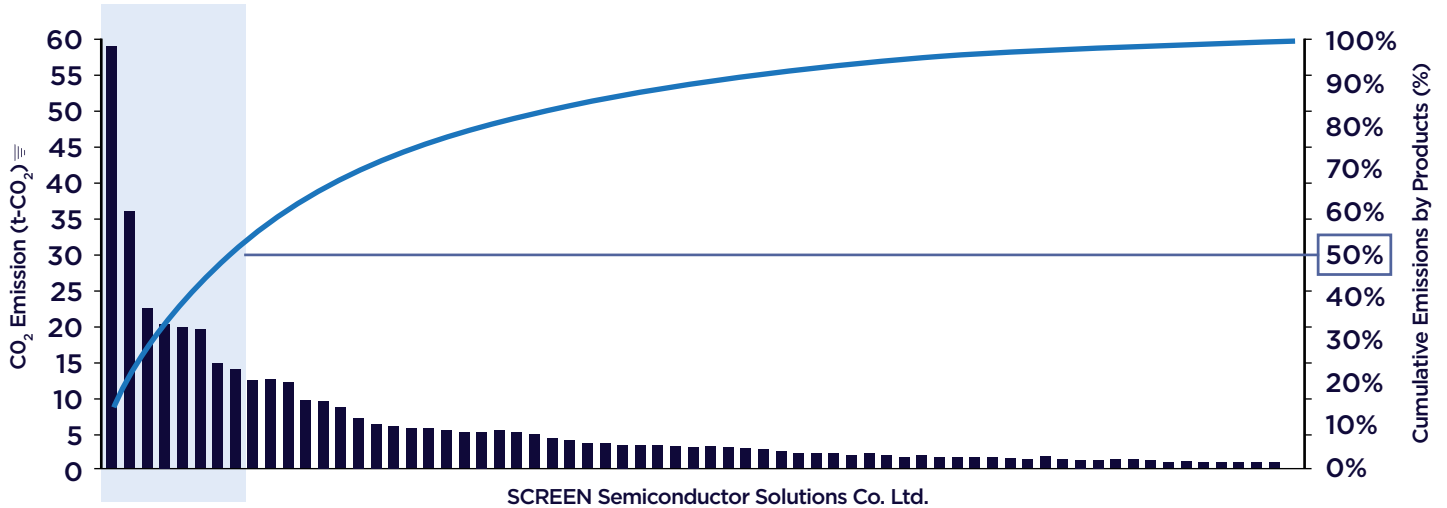


Figure 24 - Configuration 2 parts procurement: Pareto chart of CO₂ emissions calculation results (t-CO₂)

5.3.5 KEY TAKEAWAYS

We can summarize the key takeaways from this case study in three categories:

Highlights

- SCREEN completed initial LC calculation for Model SU-3200 single-wafer cleaning equipment.
- The majority of SU-3200 emissions are generated by equipment use.
- Emissions from parts procurement are less than 2 percent of the total product life cycle.
- Fluorine compounds (PFASs) are considered to have a high environmental impact; however, their impact in terms of GHG emissions is not so relevant.

Assumptions

- The estimated lifespan of the equipment is 15 years.
- The annual operating hours have been estimated based on SU-3200 use recommendations.
- The parts have been classified by material or type.
- IDEA v3.2 has been used as the inventory data set.

Challenges

- Need to obtain primary data for chemical solutions.
- There are more than 10,000 types of parts per equipment, and very few manufacturers calculate and provide primary data about single parts.
- Some equipment models are shipped as only a few units per year, and it would be inefficient to apply the same methodology for all the equipment.



6. GLOSSARY OF TERMS

Abbreviation	Term	Definition
ADEME	Agency for Ecological Transition	Procedure for steel production through furnace-basic oxygen furnace.
BoM	Bills of materials	Structured list identifying all materials and components required to construct a product, as well as the instructions for procuring and using the materials.
CF	Carbon Footprint	A measurement of the amount of carbon dioxide that activities produce.
CH ⁴	Methane	Colorless, odorless gas that occurs abundantly in nature and as a product of certain human activities.
CIR	Compound Inflation Rate	The compound inflation is the total increase in the price of a good or basket of goods over a term of many years.
CO ₂	Carbon dioxide	Most important GHG linked to global warming.
CO ₂ e	Carbon dioxide equivalent	Metric measure used to compare the emissions from various GHG on the basis of their global warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.
CVD	Chemical vapor deposition	Vacuum deposition method used to produce high-quality, high-performance, solid materials.
DEFRA	Department for Environment, Food, and Rural Affairs	Department for Environment, Food, and Rural Affairs of the UK.
DRI-EAF	Iron-electric arc furnace	Steel-making plant that melts iron sources such as scrap and direct-reduced iron (DRI) using electric energy.
EEIO	Environmentally extended input-output	Analysis used in environmental accounting as a tool that reflects production and consumption structures within one or several economies.
EIO-LCA	Economic input-output life cycle assessment	Assessment that involves the use of aggregate sector-level data to quantify the amount of environmental impact that can be directly attributed to each sector of the economy, and how much each sector purchases from other sectors in producing its output.
ERP	Enterprise resource planning	Integrated management of primary business processes, often in real time and mediated by software and technology.
GHG	Greenhouse gas	Any gas that has the property of absorbing infrared radiation.
GHGRP	Greenhouse Gas Reporting Program	The GHGRP is a program that requires reporting of GHG data and other relevant information from large GHG emission sources, fuel and industrial gas suppliers, and CO ₂ injection sites in the United States.

GLOSSARY OF TERMS

GWP	Global warming potential	A measure of how much infrared thermal radiation a GHG added to the atmosphere would absorb over a given time frame, as a multiple of the radiation that would be absorbed by the same mass of added carbon dioxide (CO ₂).
HFCs, CHF ₃ , CH ₃ F and CH ₂ F ₂	Hydrofluorocarbons	Manufactured organic compounds that contain fluorine and hydrogen atoms and are the most common type of organofluoride compounds.
IPCC	Intergovernmental Panel on Climate Change	Flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers.
LCI	Life cycle inventory	The methodology step that involves creating an inventory of input and output flows for a product system.
MEMS	Microelectromechanical systems	Tiny mechanical module that is driven by electricity.
METI	Ministry of Economy, Trade, and Industry	Ministry of Economy, Trade, and Industry (Japan).
MOE	Ministry of the Environment	Ministry of the Environment (Japan).
N ₂ O	Nitrous Oxide	Colorless, sweet-smelling gas that occurs naturally in the atmosphere and is a GHG.
NAICS	North American Industry Classification System	The North American Industry Classification System is the standard used by federal statistical agencies in classifying business establishments for the purposes of collecting, analyzing, and publishing statistical data related to the US business economy.
NF ₃	Nitrogen trifluoride	A synthetic inorganic chemical.
NFR	Nomenclature for Reporting	Acronym of Nomenclature for Reporting, which refers to the format for reporting of national data in accordance with the Convention on Long-Range Transboundary Air Pollution (CLRTAP), also remitted to the European Environment Agency (EEA).
PEEK	Polyether ether ketone	High-performance thermoplastic polymer.
PFCs, CF ₄ , C ₂ F ₆ , and C ₃ F ₈	Perfluorocarbons	Manufactured compounds containing just fluorine and carbon.
PV	Photovoltaic cells	Materials and devices that convert sunlight into electrical energy.
SBTs	Science-Based Targets	GHG gas reduction goals set by businesses and organizations.

GLOSSARY OF TERMS

SCC	Semiconductor Climate Consortium	It was formed in 2022 by SEMI, the industry association serving the global electronics manufacturing and design supply chain, and companies across the industry value chain to deal with the industry's carbon footprint.
SF ₆	Sulphur hexafluoride	Inorganic compound. It is a colorless, odorless, nonflammable, non-toxic gas.
TfS	Together for Sustainability	An industry-leading initiative driven by chemical procurement specialists.
UNFCCC	United Nations Framework Convention on Climate Change	Foundational treaty that has provided a basis for international climate negotiations since it was established, including landmark agreements such as the Kyoto Protocol (1997) and the Paris Agreement (2015).

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