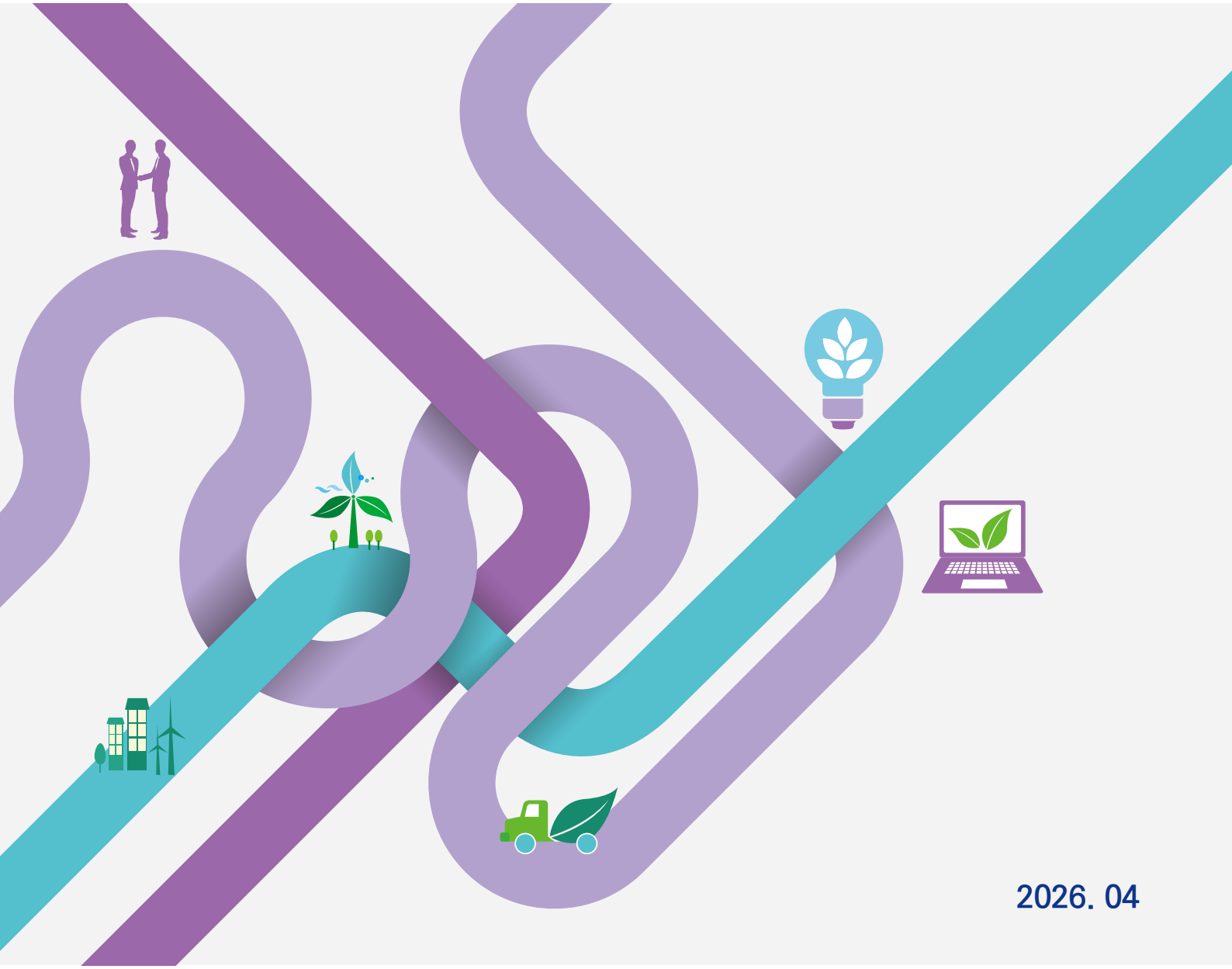
Calculation Guidance for Scope 3 Emissions in the Semiconductor Industry



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Ministry of Climate, Energy and Environment

KEITI Korea Environmental Industry & Technology Institute

Against the backdrop of prolonged low growth, major countries such as the United States (US) have implemented adjustments to ESG-related policies. Nevertheless, global corporations and investors continue to demand sustainability information, and many countries and regions, including the European Union (EU) and Japan, are steadily advancing the institutionalization of disclosure standards. As a result, the overall trajectory of sustainability, particularly in relation to environmental issues, is expected to remain valid in the long term.

Sustainability disclosures addressing environmental, social, and governance (ESG) factors increasingly emphasize climate-related information, particularly the calculation of greenhouse gas (GHG) emissions. These disclosure requirements often extend beyond the reporting entity's direct operations to include emissions across the entire value chain. While the US SEC recently excluded Scope 3 emissions from its initial climate disclosure proposal, both the European Sustainability Reporting Standard (ESRS) and the International Financial Reporting Standards (IFRS)'s Sustainability Disclosure Standard include Scope 3 emissions. This evolving landscape underscores the growing importance for Korean companies to be prepared for reporting Scope 3 emissions.

To support this effort, the Ministry of Environment launched a pilot series of documents entitled *"Calculation Guidance for Scope 3 Emissions"* in 2023. Among Korea's 15 major export industries, those facing the most urgent ESG and environmental regulatory challenges have been prioritized for guidance development. Following the publication of guidance for the rechargeable battery industry in 2023, the Ministry selected the semiconductor and display sectors as focus areas for 2024.

This guidance for the semiconductor sector was developed by the Scope 3 Emissions Calculation Working Group for the Semiconductor Industry, a collaboration among the Ministry of Environment, the Korea Environmental Industry & Technology Institute (KEITI), leading semiconductor manufacturers, and the Korea Semiconductor Industry Association (KSIA). The working group reviewed domestic and international environmental-regulatory trends, analyzed current methodologies used by participating companies to calculate Scope 3 emissions, and incorporated expert feedback to enhance the completeness of this guidance.

The calculation methodology in the guidance is based on two key components of the internationally recognized GHG Protocol: the *Corporate Value Chain (Scope 3) Accounting and Reporting Standard and the Technical Guidance for Calculating Scope 3 Emissions*. To enhance its practical applicability, the guidance provides specific examples of calculations for each emissions category as defined by the GHG Protocol. It also draws on the guideline for Scope 3 category 1 GHG assessment developed by the Semiconductor Climate Consortium (SCC), a global initiative led by semiconductor companies to address the sector's unique characteristics. While designed primarily for semiconductor companies, these examples can also benefit businesses in other industries engaged in emissions reporting.

Calculating Scope 3 emissions enables companies to identify greenhouse gases generated throughout their supply chains, set credible reduction targets, and ultimately progress toward carbon neutrality. We anticipate that this guidance will serve as a valuable tool in supporting companies' ongoing efforts to achieve their net-zero goals.

* This guidance is current as of March 2025.

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Significance of Scope 3 Emissions in the Semiconductor Industry

01 Overview of the Semiconductor Industry

Korea's semiconductor ecosystem spans the entire value chain—from upstream activities such as chemicals, materials, and environmental services, which supply essential inputs like polysilicon for wafer fabrication, to downstream sectors that integrate semiconductors into key components for mobile phones, PCs, and other electronic devices. Semiconductor manufacturers are categorized into distinct value chain segments based on their business models: integrated device manufacturers (IDMs), which comprehensively handle design, fabrication, assembly, testing, and sales; fabless firms, which focus exclusively on design; intellectual property (IP) providers that develop semiconductor design IP and license it to other companies; pure-play foundries, which specialize in manufacturing; and outsourced semiconductor assembly and test (OSAT) providers, which manage packaging and testing in the back-end process.

Globally, the semiconductor value chain reflects a stable division of labor: the US leads in design, Japan in materials and equipment, and Korea and Taiwan in manufacturing. As of 2023, Korea accounted for 13.2%[1] of global semiconductor production—including memory, system semiconductors, and optoelectronics—ranking second only to the US. Within Korea's semiconductor exports that year, system semiconductors represented 33.8% and memory semiconductors 29.2%,[2] underscoring the industry's reliance on these two segments. Government-led initiatives, such as tax incentives and the creation of mega-clusters, are expected to further strengthen Korea's competitiveness and drive sectoral growth.

Semiconductor manufacturing is a highly technical process involving numerous complex steps and advanced equipment. As a result, indirect greenhouse gas (GHG) emissions—primarily from electricity use—account for approximately 70 to 80%[3] of total emissions. Direct emissions also occur during production, particularly from the release of fluorinated gases (F-gases) used in etching. Furthermore, semiconductors are critical components in end-use applications such as PCs, smartphones, and data centers, all of which generate substantial GHG emissions throughout their operational lifecycles. Notably, data centers—filled with high-performance servers and networking equipment—operate continuously, consuming vast amounts of electricity and accounting for roughly 1%[4] of global electricity demand in 2022.

As demand increases for high-performance semiconductors capable of processing large volumes of data at high speeds, production volumes are expected to expand further. This trend makes it increasingly vital to manage GHG emissions across both upstream and downstream segments of the semiconductor value chain.

02 Supply Chain-Related Regulations

In the face of urgent climate challenges and the transition toward sustainability, the global economy is undergoing profound transformation. Achieving sustainable management requires companies to assume responsibility across their entire supply chains, rather than limiting efforts to their own operations. Additionally, supply chain disruptions triggered by US-China trade tensions and pandemic-related border closures have prompted major economies to adopt regulations designed to bolster economic security.

Prominent supply-chain measures include the EU's Corporate Sustainability Due Diligence Directive (CSDDD) and the Critical Raw Materials Act (CRMA) ([Reference 1]). These frameworks require companies to uphold environmental responsibilities not only in their own production processes but also across their supply chains by adopting transparent and sustainable practices. As a result, robust supply chain management has become integral to credible corporate carbon neutrality strategies. Korea's semiconductor industry also relies heavily on imported critical raw materials, including rare earth elements, fluorspar, and germanium, and involves a high concentration of imports. This dependence makes the sector particularly vulnerable to supply-chain regulations, making comprehensive oversight even more crucial than in other industries. Semiconductor manufacturers must therefore collaborate closely with suppliers to strengthen environmental responsibility across the supply chain and to systematically measure and manage Scope 3 GHG emissions. Both of these actions are essential to sustaining and enhancing global competitiveness.

Scope 3 emissions capture all carbon emissions generated across a company's value chain, with a significant portion originating in the supply chain. Accordingly, supply-chain regulations affect not only reporting companies but also their upstream and downstream partners. To address these challenges, many companies are actively engaging stakeholders to identify and mitigate climate-

1) Statistics Korea. (April 16, 2024). *Semiconductor Industry Trends Market Share*

2) Korea Institute for International Economic Policy. (February 28, 2024). *Analyzing South Korea's Semiconductor Industry: Trade Dynamics and Global Position*

3) Korea Semiconductor Industry Association. (2019). *GHG Emission Status and Reduction Measures in the Semiconductor Industry*

4) Korea Energy Economics Institute. (2024). *World Energy Market Insight No. 24-18: Global Electricity Supply and Demand Status in the First Half of 2024 (IEA)*

related risks throughout the value chain, including emissions accounting. In addition, they are providing training and support to suppliers to encourage green procurement practices.

[Reference 1]

Examples of supply chain regulations in the EU

Regulation	Scope	Key Obligations	Major Impacts
CSDDD	• (July 2028 ~) Companies with €900 million in net turnover and over 3,000 employees[1)] • (July 2029 ~) Companies with €450 million in net turnover and over 1,000 employees	• Report on due diligence measures for direct supply chains—including risk assessment, prevention, and mitigation measures—based on monitoring conducted every five years. • Adopt and implement a climate transition plan, updating it annually	• Companies with a high proportion of exports to the EU need to proactively prevent supply chain risks • Reviewing climate transition plans including supply chain emissions is necessary • Changes in raw material sourcing and recycling systems are needed
CRMA	• Companies involved in mining, processing, or recycling of 34 designated critical raw materials	• Conduct a supply chain risk assessment every two years and disclose raw material origins • Meet EU supply and recycling targets, requiring at least a certain percentage	

(Source: Compiled and edited based on information from corporate-sustainability-due-diligence-directive.com and the Critical Raw Materials Act section of the European Commission website.)

1) Although the laws for this group of companies were initially scheduled to take effect in July 2027, the EU adopted the "Stop-the-Clock" Directive on April 14, 2025, which postponed the obligations for this group from July 2027 to July 2028. The deadline for EU member states to transpose CSDDD into national law has also been delayed by one year to July 26, 2027

03 Global Sustainability Disclosure Standards and Initiatives

1. Overview of Global Disclosure Standards

As the need for mandatory ESG disclosure and standardization becomes increasingly prominent, corporate sustainability reporting standards are converging on the ESRS[5)] of the European Financial Reporting Advisory Group (EFRAG), the US SEC's climate disclosure requirements,[6)] and the IFRS's ISSB disclosure standards[7)] ([Reference 1]). Although requirements differ across these frameworks, they commonly mandate calculation and disclosure of a reporting entity's Scope 3 emissions based on materiality assessments. Notably, the US SEC's final rules exclude Scope 3 emissions from mandatory disclosures.

5) European Sustainability Reporting Standards (ESRS)

6) U.S. Securities and Exchange Commission (SEC), The Enhancement and Standardization of Climate-Related Disclosures for Investors

7) International Sustainability Standards Board (ISSB), *Sustainability Disclosure Standards.*

[Reference 1]

Overview of key global sustainability disclosure standards

Disclosure standards	EU ESRS[1)]	US SEC Regulation[2)]	IFRS ISSB
Overview	• Sustainability reporting standards detailing the requirements for entities, including EU Taxonomy disclosures • Consists of two general standards (ESRS 1, ESRS 2) and 10 topical standards (ESRS E1-E5, ESRS S1-S4, ESRS G1)	• Climate information disclosure is required for SEC-listed companies • Consists of general climate disclosures (Items 1500-1504 [metrics and targets] under Regulations S-K), GHG emissions disclosures (Items 1505-1506 under Regulations S-K), and disclosures on the impact on financial statements (Articles 14-01 and 14-02 under Regulations S-X)	• Global disclosure standards for information about sustainability • Consists of general principles for sustainability topics (S1) and climate-related disclosures (S2), with S2 further divided into cross-industry and industry-based disclosure requirements
Scope and Timeline	• (FY24, Wave 1) Listed enterprises with more than 1000 employees and either a net turnover above EUR 50 million or a balance sheet above EUR 25 million[3)] • (FY27, Wave 2) Unlisted enterprises with more than 1000 employees and either a net turnover above EUR 50 million or a balance sheet above EUR 25 million • (FY28, Wave 4) Large* EU subsidiaries or branches (net turnover above EUR 50 million) and non-EU parent companies with net turnover in the EU exceeding EUR 450 million.[4)] * A large company defined as meeting at least two of the criteria (assets above EUR 25 million, net turnover above EUR 50 million, or more than 250 employees) per Commission Delegated Directive (EU) 2023/2775 Article 1(4)).	• (FY25) Large Accelerated Filers (LAF)* • (FY26) Accelerated Filers (AF)** • (FY27) Non-Accelerated Filers (NAF) (including SRC, EGC)*** * Market capitalization of USD 700 million or more ** Market capitalization between USD 75 million and USD 700 million and annual revenue of USD 100 million or more *** The abbreviations for Small Reporting Company, and Emerging Growth Company	• Companies reporting general-purpose financial statements in participating countries • Adoption of the disclosure standards determined by each jurisdiction
Organi-zational Boundaries	• Follows the financial reporting boundaries, with additional consideration of operational control* • Includes both consolidated entities and non-consolidated entities under operational control for Scope 1 & 2 emissions reporting	• Align reporting with the financial statement boundaries* * Disclosing additional explanations if there are differences from the consolidated financial statements	• Report on a consolidated basis, including subsidiaries
Materiality criteria	• A multi-stakeholder perspective with environmental and social concerns, beyond a financial viewpoint • Double materiality	• Financial (investor) perspective	• Financial (investor) perspective

(Source: Compiled and edited based on [Draft] ESRS E1 Climate Change (2022), SEC Final Rule, IFRS S2 Climate-related Disclosures (2023), etc.)

1) As part of Omnibus measures and in response to concerns from stakeholders about complexity and a high number of data points, the European Commission formally instructed the European Financial Reporting Advisory Group (EFRAG) in March 2025 to revise the ESRS. EFRAG submitted its work plan in April 2025 and launched a public call for engagement, aiming to provide its final recommendations by November 30, 2025. On July 31, 2025, EFRAG published draft amendments for public consultation, proposing to: (1) substantially reduce the number of required data points by over 50%, (2) simplify the double materiality assessment process, and (3) reduce narrative disclosures and improve overall clarity and readability. The final revised standards are expected to be adopted by the Commission in mid-2026, in time for companies to use them for their 2027 financial year reporting.

2) In 2024, a lawsuit against the climate disclosure rule was consolidated in the U.S. Eighth Circuit court, and the SEC paused the rule's implementation pending a review of the legal challenges. Following a change in the U.S. administration, the SEC dropped its defense of the rule in courts. Since the court has declined SEC's request to decide the case, SEC is currently in a position where it needs to take a definitive action – reconsider or defend the rule – before the legal challenges move forward

3) The EU's adoption of the "Stop-the-Clock" Directive in April 2025 did not change the reporting timeline for Wave 1 entities. Nevertheless, these entities may apply certain phase-in reliefs for FY2025 and FY2026, including extended exemptions from selected ESRS disclosure requirements on specific sustainability topics.

4) The EU's adoption of the "Stop-the-Clock" Directive in April 2025 deferred the application dates by two years for Wave 2 and Wave 3 companies (Wave 2: from FY2025 to FY2027; Wave 3: from FY2026 to FY2028). In parallel, the Omnibus I proposal introduces a potential scope adjustment by excluding large undertakings with fewer than 1,000 employees. If this proposal is incorporated into the final legislative text, it would suggest that listed SMEs (i.e., undertakings under Wave 3) may no longer fall within scope.

2. GHG Emissions Reporting Requirements According to Global Disclosure Standards

1) ESRS

(Reporting entities and scope) Under the ESRS framework, the disclosure timelines for entities subject to sustainability reporting are aligned. According to the ESRS guidelines, reporting entities must report Scope 1 and Scope 2 emissions separately for all entities over which they exercise operational control. They must also disclose total Scope 3 emissions, along with emissions

from key categories identified through value chain analysis. Any exclusions of Scope 3 categories must be explicitly justified. The calculation of Scope 3 emissions follows the *GHG Protocol Accounting and Reporting Standard*.

According to the detailed guidelines, entities must report emissions on both financial and operational control bases. Specifically, companies are required to include 100% of Scope 1, Scope 2, and Scope 3 emissions from subsidiaries over which they have financial (accounting) control in the reporting entity's inventory. For other types of companies—such as joint ventures, associates, and non-consolidated subsidiaries—emissions should be calculated and reported based on whether operational control is exercised, clearly distinguishing these entities from wholly owned subsidiaries.

(Reporting boundary) Reporting entities are required to disclose, for the reporting period, the total GHG emissions for Scope 1, Scope 2, and Scope 3, the aggregated total GHG emissions across all Scopes; the proportion of emissions calculated using primary data; the calculation methodologies applied; and any calculation tools used, if applicable.

- **Scope 1** Total GHG emissions
- **Scope 2** Total location-based and market-based GHG emissions
- **Scope 3** Total GHG emissions by categories and justification for any exclusions

2) ISSB

(Reporting boundary) Entities reporting under ISSB are required to disclose GHG emissions, including Scope 3, unless otherwise determined by jurisdictional authorities. The adoption timeline and requirements are subject to each country's regulatory decisions. Entities must follow the GHG Protocol methodology (e.g., equity method and control approach) for both consolidated and non-consolidated entities.

(Reporting entities and scope) Reporting entities must disclose total GHG emissions for Scope 1, Scope 2, and Scope 3. For each Scope, they are required to provide detailed descriptions of calculation methodologies used and justification for any methodological changes during the reporting period. Detailed guidelines further require that Scope 3 disclosures be based on a Measurement Framework for Reliable Emission Calculation. This framework emphasizes the use of dependable measurement methods, input factors, and assumptions. Companies are advised to prioritize data sources according to defined criteria to ensure accuracy and reliability.

- **Scope 1** Total GHG emissions
- **Scope 2** Total location-based GHG emissions (market-based disclosures are required if contractual instruments exist)
- **Scope 3** Total GHG emissions by categories and justification for any exclusions

3) KSSB[8)]

(Reporting entities and scope) Entities reporting under KSSB must follow the GHG Protocol methodology (equity method and control approach) for both consolidated and non-consolidated entities. The obligations and timeline for mandatory disclosure are currently being finalized after stakeholder feedback was collected until August 31, 2024.

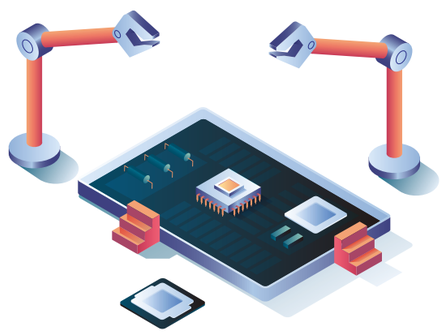
(Reporting boundary) Entities must disclose total GHG emissions for Scope 1, Scope 2, and Scope 3. Reports must specify measurement approaches used, input variables (such as emission factors), assumptions applied, and justifications for any changes in methodologies during the reporting period. In the meantime, the entity is encouraged to disclose the measurement approaches, input variables, and assumptions used in calculating Scope 3 emissions. The guidance assumes that reliable estimates can be derived using secondary data and industry averages.

- **Scope 1** Total GHG emissions
- **Scope 2** Total location-based GHG emissions
- **Scope 3** Total GHG emissions by categories (including the input variables and assumptions used in the calculation)

3. Industry-Specific Initiatives: SCC

The Semiconductor Climate Consortium (SCC) was established in 2022 to accelerate carbon emission reductions across the semiconductor industry. In January 2024, the SCC published a guideline outlining sector-specific processes and methodologies for calculating Scope 3 category 1 emissions. The guideline provides detailed instructions on defining inventory and category boundaries, quantifying greenhouse gas (GHG) emissions, selecting and classifying data types, and conducting data collection, estimation, and monitoring. To improve understanding of the sector's value chain, the guideline includes a semiconductor value chain map and introduces a prioritization approach based on the materiality of GHG emissions and financial expenditures. It also offers references to help companies calculate upstream emissions—such as lists of key raw materials and equipment commonly used in semiconductor manufacturing.

As of March 2025, the SCC has released "Scope 3 Category 11 GHG Assessment: Guideline for the Semiconductor Sector" and provides a standardized framework for companies in the industry to measure and report on emissions from the "use of sold products."



8) Exposure Draft of the Korean Sustainability Disclosure Standards (KSDS), developed by the Korea Sustainability Standards Board (KSSB) on April 30, 2024

II

Building a Scope 3 Greenhouse Gas Inventory

01 Significance of Scope 3

1. Defining Scope 3 Emissions

GHG emissions are broadly categorized into direct and indirect emissions, as well as Scope 1, Scope 2, and Scope 3, determined by the organizational and operational boundaries of the reporting entity. Direct GHG emissions come from sources owned or controlled by the reporting entity, while indirect GHG emissions result from the entity's activities but occur at sources not owned or controlled by the reporting entity. To ensure that GHG emissions are calculated and reported without double counting or omission, they are categorized into three Scopes: Scope 1 encompasses all direct emissions, while Scope 2 and Scope 3 include indirect emissions ([Reference 1]).

[Reference 1]

Definitions of Scope 1, Scope 2, and Scope 3

- **Scope 1 (direct emissions)**
  Direct GHG emissions originating from sources owned or controlled by the entity
  Examples: Emissions from combustion in entity-owned or controlled boilers, furnaces, or motor vehicles
- **Scope 2 (indirect emissions)**
  Indirect GHG emissions resulting from the generation of purchased electricity, steam, heating, or cooling consumed by the entity
  Examples: Emissions from the production of electricity, steam, or heat consumed by the entity in its operations
- **Scope 3 (indirect emissions)**
  All other indirect GHG emissions arising from the reporting entity's value chain that are not included in Scope 1 and 2, including both upstream and downstream emissions
  Examples: Emissions from the production of purchased goods and services; emissions associated with employee business travel and commuting; emissions from the transportation and distribution of purchased products

Scope 3 refers to all indirect GHG emissions from activities in the value chain that are outside the entity's ownership or direct control. In other words, Scope 3 encompasses indirect emissions that are not within Scope 1 and 2. These emissions may include those associated with the extraction and production of purchased goods, transportation-related activities (such as the transport of purchased materials, goods, and fuels, employee business travel and commuting, the transport of sold products, and waste transport), electricity-related activities not included in Scope 1 or Scope 2, and emissions from leased assets and franchised operations.

Scope 3 emissions are further classified into 15 detailed categories as defined by the GHG Protocol, which are broadly divided into upstream and downstream emissions (refer to "01. Significance of Scope 3" under "II. Building a Scope 3 Greenhouse Gas Inventory"). Upstream emissions refer to indirect GHG emissions resulting from the goods and services purchased or acquired by the reporting entity, covering emissions that occur until the point where the purchased goods are received. Downstream emissions, on the other hand, refer to indirect GHG emissions that occur during the distribution, storage, use, and disposal of sold goods and services. This category encompasses emissions that arise after control of the goods has been transferred from the reporting entity to other companies or consumers.

2. Classifying Scope 3 Categories

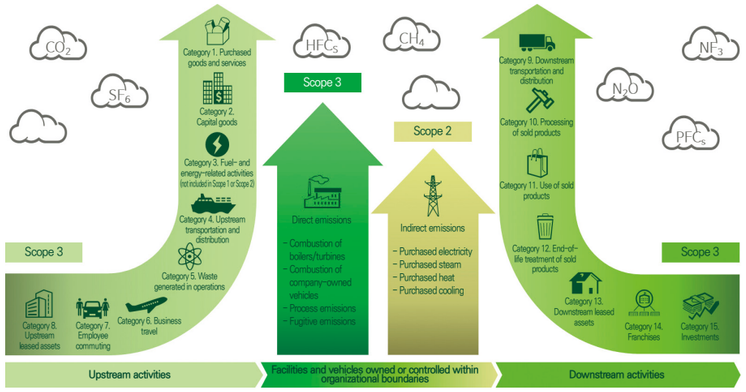
Scope 3 emissions encompass all indirect emissions, excluding Scope 1 and Scope 2 emissions, that occur within the value chain of the reporting entity. The reporting entity shall calculate Scope 3 emissions according to its established organizational and operational boundaries, including the following items:

- Report the aggregated GHG emissions (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3) from all Scope 3 activities within the organizational and operational boundaries.
- Exclude from Scope 3 any biological CO_2 emissions from the value chain (e.g., CO_2 emissions from biomass combustion) and GHG removals (e.g., biological carbon sequestration), which can be reported separately (e.g., in a corporate disclosure report).

The reporting entity should attempt to achieve completeness in GHG accounting. However, it may not be feasible to account for all Scope 3 emissions, and some categories may not be applicable in certain situations (e.g., when no leased assets or franchises are present). In such cases, the reporting entity should report "zero" emissions or "not applicable" for the relevant categories. Additionally, if certain data constraints or other limitations make it impossible to estimate emissions (e.g., difficulties in data collection), the corresponding Scope 3 activities can be excluded from reporting. However, any exclusions should be disclosed and justified, along with a plan to improve data collection and estimation in the future.

As a general principle, activities that are likely to contribute significantly to Scope 3 emissions shall not be excluded. The reporting entity's Scope 3 inventory shall accurately reflect its GHG emissions to meet the needs of both internal and external stakeholders.

Furthermore, the reporting entity shall define and categorize all relevant Scope 3 activities across the value chain. As shown in the figure below, the entity shall classify and report emissions under 15 categories based on the definition and characteristics of each Scope 3 category ([Reference 2]). The reporting entity must also ensure emissions are not double-counted. If a potential for double counting exists, the emissions from the relevant activity should be reported only once ([Reference 3]).



(Source: GHG Protocol *"Corporate Value Chain Accounting Reporting Standard"* p.31)

[Reference 2]

Description of Scope 3 categories

Category		Category description	Remarks
1	Purchased goods and services	• All upstream emissions from goods and services purchased by the reporting entity that are not already covered in categories 2–8. – Emissions from raw material extraction, manufacturing, assembly, processing, and waste treatment related to purchased goods and services (i.e., the supplier's own Scope 1 and 2 emissions). – Any changes in land use resulting from the production of these purchased goods and services. – Other upstream activities that happen before the acquisition of these goods or services by the reporting entity.	
2	Capital goods	• Emissions from raw material extraction, production, and transportation of capital goods purchased by the reporting entity. – Examples include equipment, machinery, buildings, facilities, and land used as capital goods.	* To avoid double-counting or omitting data in category 1 (purchased goods and services), entities should categorize capital goods consistently based on their characteristics (e.g., accounting standards).
3	Fuel- and energy-related activities (not included in Scope 1 or Scope 2)	• Emissions associated with the production of purchased fuels and energy consumed by the reporting entity during the reporting year that are not already accounted for in Scope 1 or Scope 2. Divided into four types: A. Upstream emissions of purchased fuels B. Upstream emissions of purchased electricity C. Transmission and distribution (T&D) losses D. Generation of purchased electricity that is sold to end users (reported by a utility company or energy retailer only)	
4	Upstream transportation and distribution	• Emissions from upstream transportation and distribution of vehicles not owned or controlled by the reporting entity (excluding fuels covered in category 3). – Emissions from the transportation and distribution of products purchased by the reporting entity that occur between a company's tier 1 suppliers and its own operations. – Transportation and distribution services purchased by the reporting entity, including both inbound logistics and outbound logistics (outbound logistics are considered upstream emissions since they are services purchased by the reporting entity).	
5	Waste generated in operations	• Emissions from waste disposal and treatment generated in facilities not owned or controlled by the reporting entity. – Emissions calculated by waste disposal methods, such as landfill, recycling, incineration, composting, waste-to-energy (WtE), and wastewater treatment. – The Scope 1 and Scope 2 emissions of waste management suppliers that occur during disposal or treatment.	* Emissions from waste treatment at facilities owned or controlled by the reporting entity are accounted for in Scope 1 and Scope 2.
6	Business travel	• Emissions from employee business travel in vehicles not owned or operated by the reporting entity. – Optional: Emissions from hotel stays during business travel. – The Scope 1 and Scope 2 emissions of transportation providers that occur while the vehicles are used.	* Emissions from employee business travel in vehicles owned by the reporting entity are accounted for in Scope 1 and Scope 2. * Emissions from leased vehicles are accounted for in category 8 (upstream leased assets). * Optional: Emissions from accommodation stays.
7	Employee commuting	• Emissions from employees commuting in vehicles not owned or operated by the reporting entity. – Optional: Emissions from teleworking. – The Scope 1 and Scope 2 emissions of employees and transportation providers that occur while the vehicles are used.	
8	Upstream leased assets	• Emissions from the operation of assets leased by the reporting entity (lessee) during the reporting year that are not included in the lessee's Scope 1 or Scope 2. – The Scope 1 and Scope 2 emissions of the lessors (e.g., vehicles, facilities) that occur during the reporting entity's operation of leased assets.	* Emissions from upstream leased assets not recognized as assets under the entity's accounting procedures, and thus not included in Scope 1 and Scope 2, should be reported.
9	Downstream transportation and distribution	• Emissions from the transportation and distribution of sold products in vehicles and facilities not owned or operated by the reporting entity. – Emissions from storage in warehouses, distribution centers, and retail facilities not owned or operated by the reporting entity, as well as transportation and distribution between the reporting entity and retailers, if not paid for by the reporting entity.	* Third-party outbound transportation and distribution services are accounted for in category 4 (upstream transportation and distribution).
10	Processing of sold products	• Downstream emissions from the processing of intermediate products sold by the reporting entity to downstream companies. – Emissions only from intermediate products that require further processing, transformation, or incorporation into other products before final use.	
11	Use of sold products	• Emissions from the end use of goods and services sold by the reporting entity. – The Scope 1 and Scope 2 emissions of end users that occur from the use of goods and services. – Emissions from the direct-use phase, categorized as 1) products that directly consume energy (fuel or electricity) and 2) products that contain or release GHGs during use – Optional: Emissions from the indirect-use phase of sold products.	* Entities may optionally include the indirect use-phase emissions of sold intermediate products based on the final product's lifecycle.
12	End-of-life treatment of sold products	• Downstream emissions from the waste disposal and treatment of products sold by the reporting entity at the end of their life in the reporting year. – Emissions calculated by waste disposal methods, such as landfill, recycling, incineration, composting, waste to energy (WtE), and wastewater treatment. – The Scope 1 and Scope 2 emissions of waste management companies that occur during disposal or treatment of sold products.	* Emissions from waste disposal and treatment at facilities owned and controlled by the reporting entity are accounted for in Scope 1 and Scope 2.

Category		Category description	Remarks
13	Downstream leased assets	• Emissions from the operation of assets owned by the reporting entity (lessor) and leased to other entities in the reporting year that are not included in the lessor's Scope 1 or Scope 2. – The Scope 1 and Scope 2 emissions of lessees that occur during the operation of leased assets.	* Emissions from downstream leased assets not recognized as assets under the entity's accounting procedures, and thus not included in Scope 1 or Scope 2, should be reported separately.
14	Franchises	• Emissions from the operation of franchises by the reporting entity (as franchisor). – The Scope 1 and Scope 2 emissions of franchisees that occur during the operation of franchises.	
15	Investments	• Emissions from the reporting entity's operation of investments. – Equity investments: The Scope 1 and Scope 2 emissions excluded by the reporting entity's Scope 1 and Scope 2, due to the organizational boundary setting, are accounted for proportional to the equity share. – Debt investments: These are applicable if the use of proceeds from debt investments held by the reporting entity, such as corporate bonds or convertible bonds, can be tracked. – Project finance: The Scope 1 and Scope 2 emissions from financed projects are included. The total projected lifetime emissions should be reported in the initial year that the project is financed.	* The scope of investment activities may vary depending on how the reporting entity defines its organizational boundaries.

(Source: GHG Protocol *"Corporate Value Chain Accounting Reporting Standard"* p.34–37)

[Reference 3]

The reporting entity shall calculate emissions according to the precise definitions of each Scope 3 category. Due to the variety of activity data collected and methodologies applied, several situations may give rise to double counting. Therefore, particular care must be taken. If double counting is possible between categories, the reporting entity must clearly explain in which category the GHG emissions have been reported. The following examples illustrate common cases where double counting may occur:

Example 1

Category 1 (purchased goods and services) and category 4 (upstream transportation and distribution)

If purchased goods and services are transported using vehicles owned by the supplier or through transportation services procured by the supplier, emissions from this transportation may be double-counted in both category 1 and category 4, depending on the methodology used. For example, if a hybrid method is used to calculate category 1 emissions—where the supplier's Scope 1 and 2 emissions already include transportation of purchased goods—then transportation emissions must be excluded from category 4. In such cases, the reporting entity must also clarify in which category these emissions have been reported.

Example 2

Category 1 (purchased goods and services) and category 15 (investments)

If the supplier providing purchased goods and services is a subsidiary of the reporting entity, its Scope 1 and 2 emissions may be double-counted in both category 1 and category 15, depending on the organizational boundary selected. In such cases, the reporting entity should report these emissions under only one category and clearly indicate where they are disclosed. Additionally, if the chosen boundary already includes the subsidiary's emissions within the reporting entity's Scope 1 and 2, those emissions must not also be included in both category 1 and category 15. Instead, the reporting entity must adjust the reporting location to avoid double counting.

02 Setting Organizational Boundaries

Business operations vary in their legal and organizational structures, and their reporting is typically structured for financial accounting purposes. For GHG emissions reporting, entities shall also define organizational boundaries. To accurately reflect their GHG inventory, it is essential for the reporting entity to select an approach for consolidating GHG emissions and then consistently apply the chosen approach. The method for setting organizational boundaries may be updated in the future as revisions to the GHG Protocol and the final version of KSSB are released.

To set organizational boundaries for GHG emissions reporting, the reporting entity may use one of the following three approaches:

- Equity share approach ····· ①
- Control approaches
  - Financial control approach ····· ②
  - Operational control approach ····· ③

Specifically, the reporting entity shall choose one of three organizational boundary approaches—the equity share approach, the financial control approach, or the operational control approach—and record and report their consolidated GHG data accordingly. The organizational boundary and resulting reported emissions may vary depending on the approach chosen. For entities with effective control over all operations, organizational boundaries may align across entities of the method used. For joint ventures and affiliates, however, organizational boundaries may differ depending on the approach applied.

The reporting entity shall clearly define its organizational boundaries in accordance with the selected approach and review the reporting scope (Scope 1, Scope 2, and Scope 3) for each asset type and emission source, ensuring that all reported emissions are free from double counting or omissions. Scope 1 includes direct GHG emissions from sources that are owned or controlled by the reporting entity. Scope 2 covers indirect GHG emissions from the generation of electricity, steam, and other energy sources that are purchased and consumed within the organizational boundary. Scope 3 comprises all other indirect emissions across the value chain not included in Scope 2. These include emissions generated across the value chain of operations within the entity's organizational boundaries, as well as emissions arising from leased assets, investments, and franchises that fall outside the organizational boundary but are partially or wholly owned or controlled by the entity.

For example, if a reporting company selects the financial control approach, emissions from partially or wholly owned assets are included in its Scope 1 and 2, and are correspondingly offset in Scope 3 category 1 (purchased goods

and services), which represents upstream emissions from products purchased or procured by the reporting entity during the reporting year. If a reporting company selects the equity share approach and disposes of sold products through an affiliate, the portion of the affiliate's Scope 1 and Scope 2 emissions corresponding to the reporting entity's equity share shall be included in the reporting entity's own Scope 1 and Scope 2 disclosures. Any emissions not included in Scope 1 or 2 must instead be reported under Scope 3 category 15 (Investments). However, when the reporting entity disposes of sold products (e.g., incineration, landfill) through an affiliate, the emissions arising from fuel and electricity use in that process are to be included in the reporting entity's Scope 1 and Scope 2, and therefore the emissions associated with end-of-life treatment of sold products during the reporting year are offset in Scope 3 category 12 (End-of-life treatment of sold products) ([Reference 1]). Additionally, depending on corporate structure and operations, some assets may be controlled by the reporting company but excluded from its organizational boundary and not allocated to any Scope 3 category. In such cases, emissions must be reported separately under "Other" Scope 3 activities.

[Reference 1]

Examples of emission reporting using different organizational boundary approach

Example 1

- **If a reporting entity sets its organizational boundary using the financial control approach and sources raw materials from a subsidiary engaged in raw material production:**
  - The reporting entity has financial control over the subsidiary. Therefore, 100% of the subsidiary's Scope 1 and Scope 2 emissions are included in the reporting entity's Scope 1 and Scope 2 emissions, as the subsidiary is part of the consolidated entity.
  - The emissions from fuel and electricity used by the subsidiary for raw material production are included in the reporting entity's Scope 1 and Scope 2 emissions. Therefore, to avoid double-counting, these emissions are offset against the reporting entity's Scope 3 category 1 data (purchased goods and services), which consist of upstream emissions from products purchased or acquired during the reporting year.

Example 2

- **If a reporting entity sets its organizational boundary using the equity share approach and disposes of sold products through an associate company (40% equity share):**
  - Under the equity share approach, a reporting entity, while not involved in the management of an associate, holds an ownership interest that entitles it to a share of the risks and benefits arising from the business. Accordingly, the reporting entity includes in its Scope 1 and Scope 2 reports the proportion of the associate's emissions corresponding to its equity share, while the remaining emissions not reflected in Scope 1 or Scope 2 are reported under Scope 3, Category 15 (Investments).
  - Emissions resulting from the use of fuel and electricity in the disposal (e.g., incineration or landfill) of sold products through an associate company are included in the reporting entity's Scope 1 and Scope 2. Therefore, to avoid double-counting, these emissions are offset against the reporting entity's Scope 3 category 12 data (end-of-life treatment of sold products), which consist of emissions arising from the disposal and treatment of products sold by the reporting entity during the reporting year.

1. Equity Share Approach

Under the equity share approach, an entity accounts for GHG emissions according to its equity share in the operation. The equity share reflects economic interest, which is the extent of rights the entity has to the risks and rewards associated with that operation. Typically, the economic risks and rewards align with the reporting entity's ownership percentage in the operation. However, if this is not the case, the equity share may be adjusted to reflect the actual percentage of economic rights derived from the operation. The equity share must reflect the percentage of economic interest, regardless of the status of legal ownership. This approach is consistent with the IFRS principles. Therefore, the personnel managing the GHG inventory may need to consult with their accounting or legal colleagues to confirm the appropriate equity share for each joint operation.

2. Control Approach

Under the control approach, an entity includes 100% of the GHG emissions from the operations it controls in its GHG emissions data. However, it does not account for GHG emissions from operations in which it has an ownership interest but no control. Control can be defined in either financial or operational terms. When using this approach, the reporting entity must choose between operational and financial control criteria.

1) Financial control approach

A reporting entity that follows the financial control approach is considered able to direct the financial and operational policies of the operations it controls, which allows it to gain economic benefits from its activities. Consequently, the economic substance of the relationship between the reporting entity and an operation takes precedence over their legal ownership status. Thus, financial control can exist even if the reporting entity holds less than a 50% interest in that operation ([Reference 2] and [Reference 3]).

[Reference 2]

IFRS S1 requires that the reporting entity for sustainability-related disclosures be the same as the entity used in financial statements.[9] Similarly, the Korean Sustainability Standards Board (KSSB), in its draft domestic sustainability disclosure standards, also stipulates that the scope of sustainability reporting must correspond to that of the financial reporting entity.[10]

A clear trend is emerging among global standards to recommend using the same consolidation criteria for financial and sustainability reporting, including GHG emissions. This alignment allows integrated management of financial and environmental performance. As a result, it is highly likely that organizational boundaries for GHG emissions will follow the financial control approach consistent with financial consolidation. If the boundary is set according to financial consolidation standards, the entity must calculate and report emissions for at least the consolidated group, in line with international accounting standards.

9) IFRS. (2023). IFRS Sustainability Disclosure Standards S1 (Paragraph 20).

10) KAI. (2024). Exposure Draft of the Korean Sustainability Disclosure Standards No. 1: General Requirements (Paragraph 20).

[Reference 3]

Industries required to use the financial control approach according to IFRS S2 industry-based guidance

The IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information) and S2 (Climate-related Disclosures) standards do not prescribe a specific approach for setting organizational boundaries. However, the industry-based guidance (IBG) for IFRS S2 requires using the financial control approach for reporting consolidated GHG emission data in certain industries when disclosing GHG emissions.

The industries for which the IBG requires the financial control approach are as follows:

No.	IFRS S2 annex	Sustainable Industry Classification System (SICS) industry
1	7 (EM-CO)	Coal operations
2	8 (EM-CM)	Construction materials
3	9 (EM-IS)	Iron & steel producers
4	10 (EM-MM)	Metals & mining
5	11 (EM-EP)	Oil & gas—exploration and production
6	12 (EM-MD)	Oil & gas—midstream
7	13 (EM-RM)	Oil & gas—refining and marketing
8	20 (FB-AG)	Agricultural products
9	22 (FB-FR)	Food retailers & distributors
10	23 (FB-MP)	Meat, poultry, & dairy
11	32 (IF-EU)	Electric utilities & power generators
12	38 (IF-WM)	Waste management
13	43 (RR-PP)	Pulp & paper products
14	47 (RT-CH)	Chemicals
15	48 (RT-CP)	Containers & packaging
16	57 (TC-SC)	Semiconductors
17	60 (TR-AF)	Air freight & logistics
18	61 (TR-AL)	Airlines
19	65 (TR-CL)	Cruise lines
20	66 (TR-MT)	Marine transportation
21	67 (TR-RA)	Rail transportation
22	68 (TR-RO)	Road transportation

(Source: Compiled and edited based on information from the Industry-based Guidance on Implementing IFRS S2 Volume 1-68.)

* For industries where GHG emissions are not a disclosure requirement, the IBG, like IFRS S2, does not mandate the use of any specific approach.

2) Operational control approach

A reporting entity is considered to have operational control over an activity if it has full authority to introduce and implement policies, either directly or through one of its subsidiaries. Specifically, if the reporting entity or any of its subsidiaries acts as the operator of a facility, it holds the authority to establish and enforce operational policies and, therefore, may adopt the operational control approach for GHG emissions reporting. Under this approach, the reporting entity accounts for and reports 100% of the GHG emissions from operations it controls. However, operational control does not necessarily imply full authority over all decisions. For example, major capital investments may require approval from all partners with joint financial control. That said, exceptions such as emission facilities located within entities included in the organizational boundary but not under operational control should be assessed based on the reporting entity's own judgment and internal criteria.

3. Consolidation at Multiple Levels

All levels of an organization shall follow the same consolidation policy to ensure consistent data when consolidating GHG emissions across the organization. The parent entity's management shall first decide on an approach for setting organizational boundaries (i.e., equity share, financial control, or operational control) and then develop a consolidation policy. The policy must be applied consistently across all sub-levels of the organization.

03 Collecting Activity Data by Emission Source

According to its established organizational boundaries, the reporting entity should identify which activities to include within Scope 3 and collect the data necessary to calculate total Scope 3 emissions. Collecting Scope 3 emissions data is likely to require broader engagement within the reporting entity compared to Scope 1 and Scope 2 emissions data. The entity may need to involve several internal departments, such as procurement, energy, manufacturing, marketing, research and development, product design, logistics, and accounting. Cooperation with external suppliers and partners may also be necessary.

Although the principle is to quantify emissions from all sources, it is rarely feasible to gather complete data. Accordingly, the entity should establish internal materiality criteria and use the best available data to ensure accuracy.

1. Materiality Criteria

1) Concept and definition of materiality criteria

Before establishing materiality criteria, a reporting entity must first identify all emissions within each category definition, based on the principle of completeness. The entity should then produce an initial estimate of Scope 3 emissions using basic or proxy data. After this estimation, the entity may establish materiality criteria that allow for the exclusion of minor emission sources, thereby improving the efficiency of internal management and prioritizing accurate data collection. When reporting emissions, the reporting entity may exercise discretion in disclosure based on these criteria. However, if certain emissions are excluded from reporting or estimated incompletely due to data limitations, they must disclose such exclusions transparently and provide a clear justification for them.

The GHG Protocol introduces two related concepts: the Materiality Threshold and the De Minimis Threshold. The Materiality Threshold is an external benchmark applied by verifiers to determine whether errors or omissions in the calculation materially affect the reported total. It functions as an external verification criterion. The De Minimis Threshold is an internal benchmark that allows a reporting entity to exclude small sources or groups of sources from the inventory, provided their emissions remain below the specified threshold.

The materiality threshold established by the reporting entity corresponds to the De Minimis Threshold concept presented in the GHG Protocol. The GHG Protocol notes that applying a De Minimis threshold may conflict with the principle of completeness in the Corporate Standard. Importantly, to apply a De Minimis threshold, emissions from a source must still be quantified to confirm they fall below the chosen limit.

Data type	Description
Materiality Threshold	A concept used by the verifier during the verification process to assess the potential impact and interrelation of calculation errors or omissions on the overall inventory report
De Minimis Threshold	A specified threshold below which emissions from a source are considered negligible relative to the entire inventory and may be excluded from reporting. (While this practice is allowed under the GHG Protocol, it is not compatible with the principle of completeness.)

(Source: GHG Protocol, *"US Public Sector Protocol," pp. 72, 100, 103, and "A Corporate Accounting and Reporting Standard (Revised Edition)"*, p.69–70. 100)

The GHG Protocol does not prescribe a quantitative benchmark for the De Minimis threshold, which is an internal materiality criterion set by a reporting entity when calculating emissions. However, it does provide guidance for the materiality threshold applied during verification. As a rule of thumb, an error or omission is considered material if it exceeds 5% of the total inventory for the portion of the organization being verified. Nevertheless, verifiers must also consider context. For example, a 2% error may still be deemed material if it prevents achievement of a corporate emissions-reduction target. Likewise, relatively small Scope 3 errors may be material if they involve regulatory compliance, create significant risk exposure, or are judged significant by investors.

2) Establishing materiality criteria

Although Scope 3 emissions are currently disclosed on a voluntary basis, reporting entities should establish an internal materiality threshold that meets the external materiality criterion suggested by the GHG Protocol – namely, that excluded emissions must not exceed 5% of total emissions – in preparation for the potential future mandate of emissions verification. When establishing these criteria, entities should consider both quantitative thresholds and qualitative criteria outlined by the GHG Protocol for assessing the relevance of Scope 3 activities, as well as guidance from other relevant ESG disclosure standards ([Reference 1]).

Criteria		Description
Quantitative criteria		Exclusion threshold of 5% of total Scope 3 emissions[11] (Note: The total emissions excluded in each category under the De Minimis threshold must not collectively exceed 5% of the company's total Scope 3 emissions.)
Qualitative criteria	Size	Activities that contribute significantly to the company's total anticipated Scope 3 emissions
	Influence	Activities associated with potential emissions reductions that could be undertaken or influenced by the company
	Risk	Activities that contribute to the company's risk exposure
	Stakeholders	Activities deemed critical by key stakeholders
	Outsourcing	Activities outsourced by the reporting company but typically performed in-house by other companies in the same sector
	Sector guidance	Activities identified as significant by sector-specific guidance, if available for the relevant industry
	Other	Activities that meet any additional criteria for determining relevance established by the company or its sector

(Source: GHG Protocol, *"Corporate Value Chain (Scope 3) Accounting and Reporting Standard"* p.61, 115)

[Reference 1]

Other ESG disclosure standards (SBTi/ SEC) applicable to establishing materiality assessment

The Science Based Targets initiative (SBTi) requires that Scope 1 and Scope 2 disclosures cover at least 95% of a company's total GHG inventory, including both reported and excluded emissions.[12] For Scope 3, no more than 5% of total emissions may be excluded. Similarly, the US Securities and Exchange Commission (SEC) finalized climate-related disclosure rules in March 2024. Under these rules, companies must disclose in financial statement notes the financial impact of severe weather or natural conditions if it exceeds specified thresholds.[13] A reporting entity may refer to these ESG disclosure standards and other initiatives that have established quantitative thresholds to inform the development of its internal materiality criteria.

Category	Description
SBTi	• Companies shall not exclude more than 5% of total combined Scope 1 and Scope 2 emissions from either the boundary of the GHG inventory or the target boundary. • Companies shall not exclude more than 5% of emissions from their total Scope 3 GHG inventory.
SEC	• Disclosure is required for capitalized costs and charges recognized on the balance sheet if their aggregate absolute value equals or exceeds 1% of the absolute value of stockholders' equity or deficit at the end of the fiscal year and exceeds USD 500,000. • Disclosure is required if the aggregate expenditures expensed and losses in the income statement equal or exceed 1% of the absolute value of pre-tax income or loss and exceed USD 100,000 for the fiscal year.

(Source: SBTi, *"SBTi Corporate near-term criteria" p.9 and SEC, "Final Rules"* 14-02(b) p.466-478, p.771-772)

11) The 5% figure is presented by the GHG Protocol as a rule of thumb, not a strictly defined threshold.

12) SBTi, (May 2024), *SBTi CORPORATE NEAR-TERM CRITERIA* (p.9)

13) SEC, (May 2024) *Final Rules* 14-02(b) (p.466-478, p.771-772)

3) Collecting data based on materiality criteria

After establishing materiality criteria, the reporting entity must collect the data necessary to calculate Scope 3 emissions. In this process, the entity should first identify high-priority activities based on the established materiality criteria and focus on obtaining more accurate data for those activities. If criteria are based on quantitative magnitude, activities should be ranked from highest to lowest emissions. For activities that represent a substantial share of emissions, the entity should strive to collect high-quality data. For activities contributing only a small share of emissions, however, it is acceptable to rely on secondary data or less precise sources in order to balance practicality and management efficiency. For further details on data collection methods, entities may refer to Sections 4 (Collecting Primary Data) and 5 (Collecting Secondary Data and Filling Data Gaps) in Part II of this guidance.

[Reference 2]

Category 1 data collection process based on materiality criteria

When calculating category 1 (purchased goods and services) emissions, the ideal approach is to collect accurate GHG emissions data for all purchased products and raw materials. However, practical constraints such as limited time and resources often prevent this. In such cases, companies may focus on collecting more detailed and accurate data for products and raw materials of greater material significance. The SCC emphasizes GHG emissions and financial expenditures as central to this process and outlines the following data collection procedure based on materiality criteria.

Category	Description
Step 1	Conduct an initial screening of GHG emissions using basic estimation methods or proxy data
Step 2	Prioritize data collection for products that account for at least 80% of total GHG emissions and/or spend within the category 1 boundary
Step 3	Include any products within the remaining 20% that individually account for more than 1% of total GHG emissions and/or total spend
Step 4	Optionally, select additional products for priority data collection where the reporting entity has a higher degree of influence over suppliers or where the products contribute to the entity's risk exposure

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.26)

[Reference 3]

Example of category 1 internal materiality criteria and data collection

A semiconductor foundry, Company A, conducts an initial screening of its Scope 3 emissions and estimates a total of 200,000 tCO_2eq. Of this, emissions from category 1 are estimated at 20,000 tCO_2eq. Among the materials purchased, the proportions of raw materials X, Y, and Z within category 1 emissions and total Scope 3 emissions are calculated as follows:

Category 1 raw material	Estimated emissions (tCO_2eq)	Share of category 1 emissions (%)	Share of total Scope 3 emission (%)
X	4,000	20	2.0
Y	15,000	75	7.5
Z	1,000	5	0.5

Following this initial estimate, Company A establishes the following internal materiality criteria for Scope 3 category 1 based on the guidelines developed by the SCC:

1) Products that collectively account for at least 80% of category 1 emissions
2) Among products purchased from the remaining 20%, any product that individually accounts for at least 1% of total category 1 emissions

Based on these criteria, Company A prioritizes data collection for raw materials Y, X, and Z, respectively. For raw material Y, the supplier provides emissions data for Scope 1, Scope 2, and Scope 3 (category 1). In the case of raw material X, the supplier only provides Scope 1 and Scope 2 emissions, with no data for Scope 3. To estimate the missing upstream emissions for raw material X, Company A attempts to identify the material's component composition and apply relevant upstream emission factors. However, since the supplier does not disclose the composition, Company A uses average component ratios from industry statistics to estimate emissions. Meanwhile, raw material Z is excluded from data collection in accordance with the materiality criteria, and its preliminary emission estimate is retained without further refinement. The recalculated emissions based on collected data shows some variation from the initial estimates, as follows:

Category 1 raw material	Calculated emissions (tCO_2eq)	Share of category 1 emissions (%)	Share of total Scope 3 emission (%)
X	1,500	6.5	0.7
Y	20,500	89.1	10.1
Z	1,000 (estimated)	4.4	0.5

Recognizing the limited accuracy of emissions estimated using industry-average data, Company A reviews raw material X's share of total emissions and finds that it accounted for only 6.5% of category 1 emissions and 0.7% of total Scope 3 emissions—both below its internal materiality thresholds. As a result, Company A excludes raw materials X and Z from category 1 reporting due to limited data availability and their immaterial contribution.

2. Quantification Methods and Data Types

Two main methods exist for quantifying GHG emissions. First, direct measurement involves monitoring or stoichiometric calculations, applying the formula ((emission data) × (GWP[14])). Second, calculation involves multiplying an activity data value by an emission factor and a GWP value ([Reference 4]), using the formula ((activity data) × (emission factor) × (GWP)). These two methods require different types of data. In practice, calculation is most commonly used method for quantifying Scope 3 emissions. For the calculation method, two types of data are required: activity data and emission factors.

14) Global warming potential (GWP) indicates the extent to which one unit of a specific GHG contributes to global warming while it remains in the atmosphere. It is used to compare and assess the relative warming effects of different GHGs.

[Reference 4]

Considerations when setting values for GWP

The reporting entity should convert GHG emissions data into the standardized metric of carbon dioxide equivalent (CO_2eq) based on the GWP for each GHG. The reporting entity should use the most recent GWP values published by the Intergovernmental Panel on Climate Change (IPCC). Although the reporting entity may choose GWP values appropriate for its specific circumstances, it is important to use such values consistently across inventories. Additionally, the reporting entity is required to disclose the source of the GWP values used to calculate the inventory. [Reference 4-1] lists the GWP values for the seven GHGs[15] as provided in the IPCC's second, fourth, fifth, and sixth assessment reports and approved for use under the GHG Protocol.

- The GHG Protocol requires using consistent 100-year GWP values from the IPCC across Scope 1, 2, and 3 inventories. Reports should use the most recent GWP values. To maintain consistency, a reporting entity that has already developed Scope 1 and Scope 2 GHG inventories[16] should use the same GWP values for Scope 3. However, entities that have not yet developed a corporate GHG inventory should use the most recent GWP values available.

[Reference 4-1]

GWP values for GHGs (partial list)

GHG		GWP			
		IPCC Second Assessment Report (SAR)	IPCC Fourth Assessment Report (AR4)	IPCC Fifth Assessment Report (AR5)	IPCC Sixth Assessment Report (AR6)
Carbon dioxide (CO_2)		1	1	1	1
Methane (CH_4)		21	25	28	27.9
Nitrous oxide (N2O)		310	298	265	273
Hydrofluorocarbons (HFCs)	HFC-23	11,700	14,800	12,400	14,600
	HFC-32	650	675	677	771
	HFC-41	150	-	116	135
	HFC-43-10mee	1,300	1,640	1,650	1,600
	HFC-125	2,800	3,500	3,170	3,740
	HFC-134	1,000	-	1,120	1,260
	HFC-134a	1,300	1,430	1,300	1,530
	HFC-143	300	-	328	364
	HFC-143a	3,800	4,470	4,800	5,810
	HFC-152a	140	124	138	164
	HFC-227ea	2,900	3,220	3,350	3,600
	HFC-236fa	6,300	9,810	8,060	8,690
	HFC-245ca	560	-	716	787

15) Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

16) The Korean Act on the Allocation and Trading of Greenhouse-Gas Emission Permits adopted its GWP values from the IPCC's SAR.

GHG		GWP			
		IPCC Second Assessment Report (SAR)	IPCC Fourth Assessment Report (AR4)	IPCC Fifth Assessment Report (AR5)	IPCC Sixth Assessment Report (AR6)
Perfluorocarbons (PFCs)	PFC-14	6,500	7,390	6,630	7,380
	PFC-116	9,200	12,200	16,100	12,400
	PFC-218	7,000	8,830	8,900	9,290
	PFC-31-10	7,000	8,860	9,200	10,000
	PFC-c318	8,700	10,300	9,540	10,200
	PFC-41-12	7,500	9,160	8,550	9,220
	PFC-51-14	7,400	9,300	7,910	8,620
Sulfur hexafluoride (SF_6)		23,900	22,800	23,500	25,200
Nitrogen trifluoride (NF_3)			17,200	16,100	17,400

(Source: GHG Protocol *"IPCC Global Warming Potential Values"*)

1) Activity data

Reporting entities collect and use activity data for calculating Scope 3 emissions, which can be broadly categorized into primary data and secondary data ([Reference 5]).

Primary data refer to data provided by suppliers or other value chain partners that are directly related to the reporting entity's specific activities. These data may consist primarily of key activity data or emissions data that are closely related to the activities of these suppliers or partners.

Secondary data serve as supplemental data and include industry-average data (e.g., from published databases, government statistics, literature studies, and industry associations), financial data, proxy data, and other generic data. In some cases, the reporting entity may use specific data from one activity to estimate emissions from another activity in the value chain. This type of data, which serves as a proxy rather than being directly related to actual emissions, is defined as secondary data because it is not relevant to the activity for which the emissions are calculated.

[Reference 5

Examples of primary and secondary data by Scope 3 category

Category		Primary data	Secondary data
1	Purchased goods and services	Product-level cradle-to-gate GHG data from suppliers, calculated using site-specific data	Industry-average emission factors per material consumed from lifecycle inventory databases
2	Capital goods	Product-level cradle-to-gate GHG data from suppliers, calculated using site-specific data	Industry-average emission factors per material consumed from lifecycle inventory databases
3	Fuel- and energy-related activities (not included in Scope 1 or Scope 2)	Entity-specific data on upstream emissions (e.g., extraction of fuels)	National average data on upstream emissions (e.g., from a lifecycle inventory database)
4	Upstream transportation and distribution	Activity-specific energy use or emissions data from third-party transportation and distribution suppliers	Estimated distance traveled based on industry-average data
5	Waste generated in operations	Site-specific emissions data from waste management companies	Estimated metric tons of waste generated based on industry-average data
6	Business travel	Activity-specific data from transportation suppliers (e.g., airlines)	Estimated distance traveled based on industry-average data
7	Employee commuting	Specific distance traveled and mode of transport data collected from employees	Estimated distance traveled based on industry-average data
8	Upstream leased assets	Site-specific energy use data collected by utility bills or meters	Estimated emissions based on industry-average data, such as energy use per square meter by building type
9	Downstream transportation and distribution	Activity-specific energy use or emissions data from third-party transportation and distribution partners	Estimated distance traveled based on industry-average data
10	Processing of sold products	Site-specific energy use or emissions from downstream value-chain partners	Estimated distance traveled based on industry-average data
11	Use of sold products	Specific data collected from consumers	Estimated energy used based on national average statistics on product use
12	End-of-life treatment of sold products	Specific data collected from waste management providers on emissions rates or energy use	Estimated disposal rates or energy use based on national average statistics
13	Downstream leased assets	Site-specific energy use data collected by utility bills or meters	Estimated emissions based on industry-average data such as energy use per square meter by building type
14	Franchises	Site-specific energy use data collected by utility bills or meters	Estimated emissions based on industry-average data such as energy use per square meter by building type
15	Investments	Site-specific energy use or emissions data from investee companies	Estimated emissions based on industry-average data

(Source: GHG Protocol *"Corporate Value Chain Accounting Reporting Standard"* p.72-73)

2) Emission factors

When calculating Scope 3 emissions, the reporting entity should select appropriate emission factors based on its reporting activities and the characteristics of the aggregated data for each category. If it is not feasible to use internally developed emission factors, such as site-specific factors, the reporting entity may refer to reputable third-party emission factor databases to select emission factors that best reflect its specific characteristics for inventory calculation and reporting. Emission factors are structured according to the unit of activity data. Examples of commonly used emission factor units include the following:

- $kgCO_2$ emitted per kg, L, or m^3 of fuel consumed
- $kgCO_2$ emitted per kWh of electricity consumed
- $kgCO_2$ emitted per kg of material consumed
- tCO_2 emitted per km traveled
- $kgCO_2$ emitted per hour of operation
- $kgCO_2$ emitted per kg of product sold
- $kgCO_2$ emitted per USD or KRW of currency spent
- gCH_4 emitted per kg of waste generated
- gN_2O emitted per m^2 of area

(1) Third-party emission factor resources

Reporting entities may consult third-party resources while collecting GHG inventory data related to its product lifecycles and value chain (Scope 3). However, before using information from such databases to calculate actual emissions, the reporting entity should consider the principles of relevance, completeness, consistency, transparency, and accuracy. It should then evaluate and select the highest quality data within the context of its business goals.

Examples of third-party databases[17] include the Life Cycle Inventory Database (LCI DB) and emission factor databases based on the Environmentally-Extended Input-Output (EEIO) model. The reporting entity should evaluate the characteristics of their collected data and select the most appropriate emission factor database. The LCI DB[18] collects input/output data for entire product systems (from raw material extraction to disposal) per functional unit. An EEIO model combines economic transactions between industries with environmental data, enabling emission factor databases to allocate national GHG emissions across product categories. Emission factor databases based on EEIO models[19] provide spend-based emission factors, which can be used when applying cost-based methodologies to calculate emissions across Scope 3 categories.

17) All third-party resources provided as examples take CO_2 and GHGs into account.

18) LCI DBs do not usually include the use and end-of-life stages for most raw materials; therefore, the system boundaries for each emission factor should be checked.

19) EEIO models are built on historical statistical data and may not reflect the latest economic structures, technological advancements, or adequately account for national or regional differences. Reporting entities should understand these limitations and use EEIO-based factors as one of several indirect estimation methods, applying them only where appropriate to their specific circumstances.

Resource name	Country	Relevant organizations	Free/Paid	Overview and characteristics	Link
ADEME Base Carbone	France	ADEME (Environment and Energy Management Agency)	Free	• The French Environment and Energy Management Agency provides spend-based emission factors necessary for calculating GHG emissions and overall carbon accounting. • The data are available in Excel CSV format and can be used after converting its encoding.	https://data.ademe.fr/datasets/base-carboner
Carbon Minds	Germany	Carbon Minds	Paid	• Carbon Minds is a data analytics company specializes in environmental sustainability in the chemical industry, offering solutions to reduce impacts using LCA data. • It provides an LCA-based database that covers more than 1,300 chemicals and plastics.	https://www.carbon-minds.com/products/data/carbon-footprint-and-lca-data/
Comprehensive Environmental Data Archive (CEDA)	US	Watershed	Paid	• The CEDA supplies data derived from the US input-output tables, alongside a range of statistical sources. • It is highly regarded for its reliability, having undergone multiple validations and consistency analyses. • However, a separate license and consultation with the support team are required to use the emission factors.	https://watershed.com/solutions/ceda
DoD Database	US	DoD (Department of Defense)	Free	• Developed by the US Department of Defense in 2016, DoD Database provides an LCI dataset classified according to the North American Industry Classification System (NAICS). • The website offers sustainability assessment guidelines based on LCA and provides downloadable spend-based upstream and downstream emission factors.	https://www.denix.osd.mil/esohacq/
Ecoinvent Database	Switzerland	Ecoinvent Association	Paid	• The Ecoinvent Database covers various countries and industries, is widely used in Europe and the US, and is highly regarded for its reliability, having undergone review by multiple experts. • The data are available in website access and as Excel and EcoSpold v2 XML files.	https://ecoinvent.org/the-ecoinvent-database/
EMEP/EEA	EU	EEA (European Environment Agency)	Free	• EMEP/EEA covers air emission factors from the EMEP/EEA air pollutant emission inventory guidebook 2023 for sector-specific inventories, including energy, industrial processes, and agriculture. • The emission factor data are available from the website and as Excel files.	https://www.eea.europa.eu/publications/emep-eea-guidebook-2023
Emissions Intensity Database	Japan	Ministry of the Environment, Government of Japan	Free	• The Ministry of the Environment, Japan, provides a database that allows users to select emission factors corresponding to each Scope 3 category for calculating supply chain emissions. • The Emissions Intensity Database is utilized by companies, governments, and research institutions to make environmental decisions and develop sustainable economic and environmental policies based on environmental assessment and carbon footprint data.	https://ghg-santeikohyo.env.go.jp/calc
EXIOBASE Database	Netherlands	PRé Sustainability	Paid	• The EXIOBASE Database is available through SimaPro, a paid LCA software developed by PRé Sustainability, a Dutch consulting company • It covers environmental supply and use/input-output data for 43 countries, 160 industry sectors, and 200 product categories.	https://simapro.com/products/exiobase-database/
GHG Emission Factors Hub, provided via Scope 3 Inventory Guidance	US	Environmental Protection Agency	Free	• The US government, recognizing the significance of Scope 3 emissions quantification, has developed and provided a comprehensive supply-chain emission factor spreadsheet that encompasses all goods and services categories within the US economy. • The emission factors for US goods and services are based on the US Environmentally Extended Input-Output model.	https://www.epa.gov/climateleadership/ghg-emission-factors-hub

Resource name	Country	Relevant organizations	Free/Paid	Overview and characteristics	Link
Inventory Database for Environmental Analysis (IDEA)	Japan	AIST (National Institute of Advanced Industrial Science and Technology); JEMAI (Japan Environmental Management Association for Industry)	Free	• IDEA has been developed with the goal of achieving high comprehensiveness, completeness, representativeness, and transparency. • It includes data related to all products in non-manufacturing, manufacturing, electric power, urban gas, and water supply and sewage sectors. However, in the processing sector, it is somewhat less comprehensive for certain items.	https://riss.aist.go.jp/idealab/
Sphera LCA for Experts (LCA FE)	US[20]	Sphera	Paid	• LCA FE covers a wide range of industries. Users can select the industries they need and install the software accordingly. • However, additional programming work would be required to use the emission factors.	https://lcadatabase.sphera.com/
Supply Chain Greenhouse Gas Emission Factors	UK	Department for Energy Security and Net Zero; Department for Business, Energy, and Industrial Strategy	Free	• Supply Chain Greenhouse Gas Emission Factors are annual spreadsheets, based on the UK input-output tables, provide various GHG emissions data, including upstream emissions for products consumed in the UK. • They support corporations that disclose environmental impact information required by investors and shareholders.	https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
The Australian National Life Cycle Inventory Database	Australia	Australian Life Cycle Assessment Society	Free	• The Australian Life Cycle Inventory Database covers various industries in Australia, providing authoritative, comprehensive, and transparent environmental information on a wide range of products and services within the country. • The data are available as Excel files and SimaProDB snapshots.	https://auslci.com.au/index.php/Home
US Life Cycle Inventory Database	US	National Renewable Energy Laboratory	Free	• The US Life Cycle Inventory Database covers a wide range of sectors in the US, with data on frequently used materials, products, and processes. • It is available in website access and as JSON-LD files.	https://www.nrel.gov/lci/
LCI Database	Korea	Korea Environmental Industry & Technology Institute (KEITI)	Free	• The LCI Database, which covers various industries in Korea, is based on the Korean Life Cycle Inventory (LCI) Databases developed in accordance with ISO-14044 procedures. It is used for environmental impact assessments of products. • The data are available in website access and as Excel and PDF files.	https://ecosq.or.kr/websquare.do#w2xPath=/ui/cer/ic/oh/ICOH110M01.xml&valVl=tabs3&menuSn=20018000&tabId2=3
Environmental Product Declaration Assessment Factors	Korea	KEITI	Free	• Environmental Product Declaration Assessment Factors provides values that quantify environmental impacts per unit of raw material and energy production, transportation methods, and waste treatment methods. It covers categories such as resource footprint, carbon footprint, and ozone layer impact.	https://ecosq.or.kr/websquare.do#w2xPath=/ui/cer/ic/oh/ICOH110M01.xml&valVl=tabs3&menuSn=20018000&tabId2=3
National GHG Emission and Removal Factors	Korea	Ministry of Environment, Republic of Korea	Free	• National GHG Emission and Removal Factors contains emission factors for national GHG inventories. It is used to quantify GHG emissions or removals per unit of national activity for emission sources and sinks.	https://www.gir.go.kr/home/index.do?menuId=36

20) Germany's PE International initially developed the GaBi Database, which was later acquired by Sphera.

(2) Methods for using Korean emission factor databases

In Korea, three key national emission factor databases are used: the National Life Cycle Inventory (LCI) Database, Environmental Product Declaration Evaluation Factors, and National GHG Emission and Removal Factors. To improve the accuracy of emissions calculations based on domestic activity data, reporting entities should use emission factors that correspond to the same geographic location as their business activities (e.g., Korea). However, before using these databases, reporting entities should consider the principles of relevance, completeness, consistency, transparency, and accuracy, just as they would when selecting third-party databases. The selection of high-quality data aligned with business goals and context should be prioritized.

① National Life Cycle Inventory (LCI) database

Overview

The National LCI Database (LCI DB) is a dataset that catalogs the inputs and outputs of a product system throughout its life cycle – from raw material extraction, production, and transportation, distribution to use and disposal – per functional unit. This resource offers fundamental information for conducting lifecycle assessments (LCAs) of products. It includes lists of energy and mineral resources extracted from the environment, as well as air emissions, waterborne effluents, and waste outputs to the environment. When calculating a product's carbon footprint, which quantifies the impact of GHG emissions such as carbon dioxide on global climate change, air emissions data from the LCI DB are utilized. Given its relevance, the reporting entity can use the national LCI DB to determine Scope 3 emissions by ensuring alignment with their business activities in terms of system boundaries and processes.

Example of utilization

To calculate emissions for the incineration of general waste under category 5 (waste generated in operations) using the LCI DB, the following method may be applied:

Calculation methodology	Waste-type-specific	Σ ((Amount of waste generated) × (Emission factor by waste type and disposal method))
Activity data	Amount of general waste generated	2,000 (kg/month)
Emission factor*	Emission factor for general waste incineration**	= Σ ((Emission factor per kg from the LCI Database of each GHG) × (GWP of each GHG***)) = (120.79 ×1) + (0.085259 ×27.9) + (0.00080584 ×273) = 123.3887204 ($kgCO_2eq/kg$)
Emissions from general waste incineration	= 2,000 (kg/month) ×123.3887204 ($kgCO_2eq/kg$) = 246,777.4408 ($kgCO_2eq$/month)	

* The emission factor was derived from the LCI DB entry for general waste incineration. See additional explanation below (See the method in [Annex 1.2]).

** Among the seven greenhouse gases, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are three that are emitted during the incineration of general waste.

*** The GWP values used in this example are based on the most recent values provided in the IPCC's AR6.

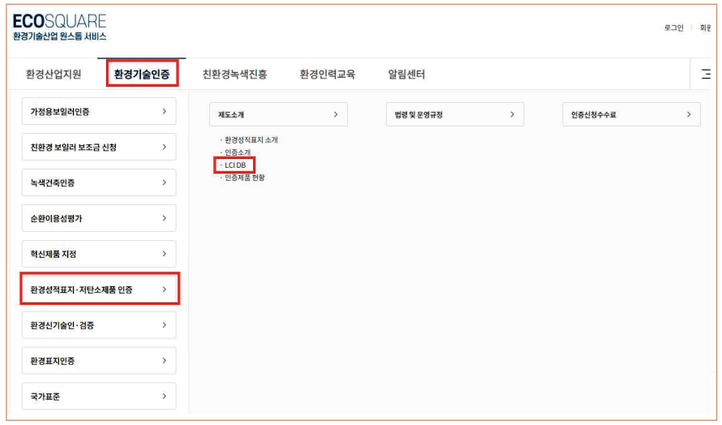
If the reporting entity can obtain activity data on general waste incineration, it can calculate the relevant emissions under category 5 using the methodology for disposal method–based calculation specified in the GHG Protocol. The necessary emission factors, categorized by waste type and disposal method, can be derived from the LCI DB for general waste incineration.

Additional explanation: Method for deriving emission factors

When calculating Scope 3 emissions using the LCI DB, the first step is to convert its inputs and outputs data into emission factors for the specific GHGs being measured. The following steps (Step 1 through Step 5) may be used in this process:

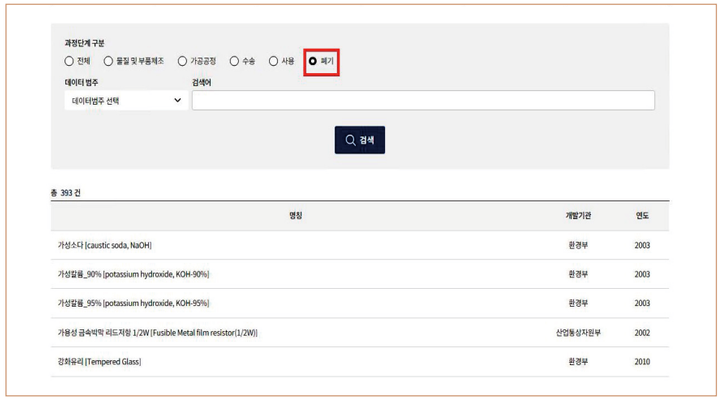
Step 1

Access KEITI's Environmental Technology Industry One-Stop Service, EcoSquare (www.ecosq.or.kr) and select "환경기술인증" (Environmental Technology Certification) from the main menu options ➠ From the dropdown menu, select "환경성적표지·저탄소제품 인증" (Environmental Product Declaration · Low Carbon Product Certification) ➠ Navigate to the "제도소개" (System Introduction) section ➠ From the dropdown menu, select "LCI DB," and then choose "National LCI DB."



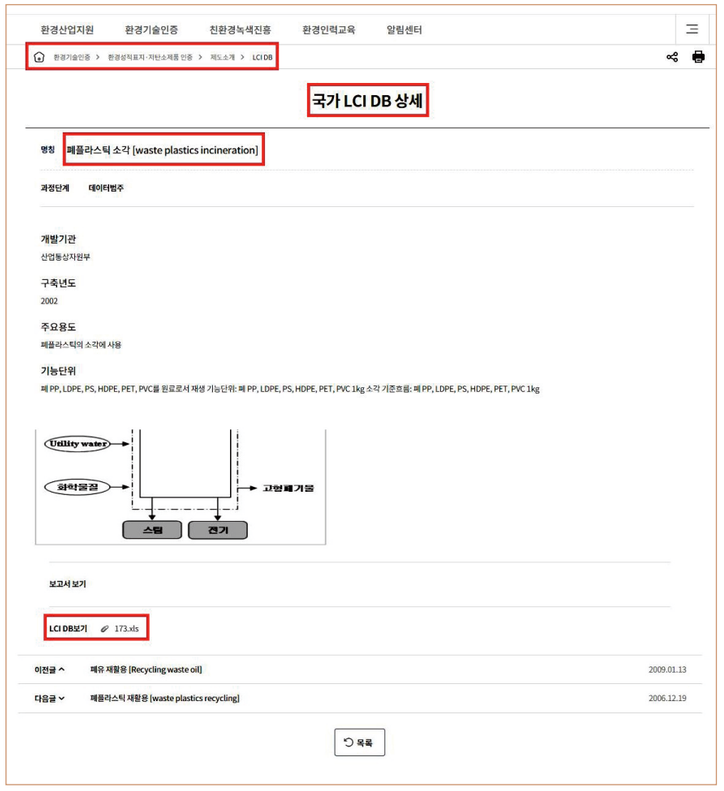
Step 2

From the National LCI DB, locate the relevant life cycle stage and data category for the item subject to emission calculation. Then access the corresponding entry in the LCI DB (example in the image below: 폐기 (Disposal) ➠ 폐플라스틱 소각 [Waste plastic incineration]).



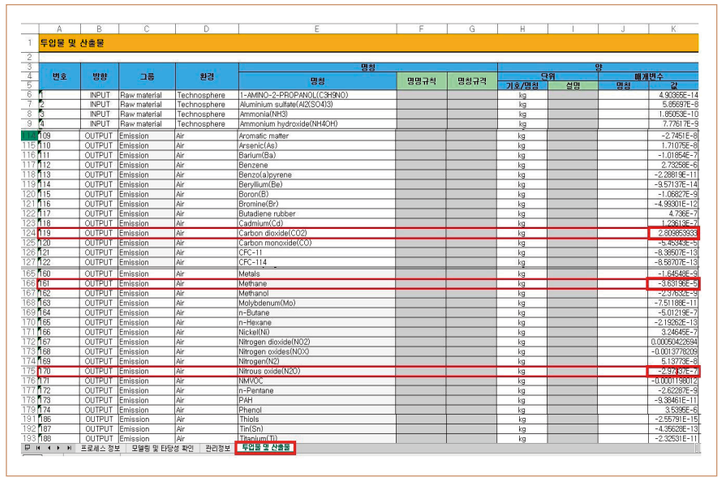
Step 3

On the detailed page for the selected item, select the Excel file option in the "LCI DB 보기" (LCI DB view) section to download the file.



Step 4

In the “투입물 및 산출물” (Inputs and Outputs) sheet of the LCI DB Excel file, focus on the rows where column B shows OUTPUT, column C shows Emission, and column D shows Air. Then, identify the seven major emission values for GHGs in column K
(Note: values may only be available for some of the seven GHGs.)



투입물 및 산출물

번호	방향	그룹	환경	명칭	명칭규격	명칭규격	단위		양	
				명칭			기호/명칭	설명	배계변수 명칭	값
0										
1		INPUT	Raw material	Technosphere	1-AMINO-2-PROPANOL(C3H9NO)			kg		4.9035E-14
2		INPUT	Raw material	Technosphere	Aluminium sulfate(Al2SO4)3)			kg		5.9993E-9
3		INPUT	Raw material	Technosphere	Ammonia(NH3)			kg		1.8503E-10
4		INPUT	Raw material	Technosphere	Ammonium hydroxide(NH4OH)			kg		7.7761E-9
109		OUTPUT	Emission	Air	Aromatic matter			kg		-2.7451E-8
110		OUTPUT	Emission	Air	Arsenic(As)			kg		1.7107E-8
111		OUTPUT	Emission	Air	Barium(Ba)			kg		-1.0185E-7
112		OUTPUT	Emission	Air	Benzene			kg		2.7325E-8
113		OUTPUT	Emission	Air	Benzo(a)pyrene			kg		-2.2881E-11
114		OUTPUT	Emission	Air	Beryllium(Be)			kg		-9.5713E-14
115		OUTPUT	Emission	Air	Boron(B)			kg		-1.0882E-9
116		OUTPUT	Emission	Air	Bromine(Br)			kg		-4.9830E-12
117		OUTPUT	Emission	Air	Butadiene rubber			kg		4.79E-7
118		OUTPUT	Emission	Air	Cadmium(Cd)			kg		1.2581E-7
119		OUTPUT	Emission	Air	Carbon dioxide(CO2)			kg		2.8585393
120		OUTPUT	Emission	Air	Carbon monoxide(CO)			kg		-5.4524E-5
121		OUTPUT	Emission	Air	CFC-11			kg		-8.3850E-13
122		OUTPUT	Emission	Air	CFC-114			kg		-8.5870E-13
160		OUTPUT	Emission	Air	Metals			kg		-1.6454E-8
161		OUTPUT	Emission	Air	Methane			kg		-3.6319E-5
162		OUTPUT	Emission	Air	Methanol			kg		-2.3785E-9
163		OUTPUT	Emission	Air	Molybdenum(Mo)			kg		-7.5118E-11
164		OUTPUT	Emission	Air	n-Butane			kg		-5.0121E-7
165		OUTPUT	Emission	Air	n-Hexane			kg		-2.1926E-13
166		OUTPUT	Emission	Air	Nickel(Ni)			kg		3.2464E-7
167		OUTPUT	Emission	Air	Nitrogen dioxide(NO2)			kg		0.0005042694
168		OUTPUT	Emission	Air	Nitrogen oxides(NOX)			kg		-0.0013778208
169		OUTPUT	Emission	Air	Nitrogen(N2)			kg		5.1377E-8
170		OUTPUT	Emission	Air	Nitrous oxide(N2O)			kg		-2.973E-7
171		OUTPUT	Emission	Air	NMVOC			kg		-0.0001189012
172		OUTPUT	Emission	Air	n-Pentane			kg		-2.6228E-9
173		OUTPUT	Emission	Air	PAH			kg		-3.3946E-11
174		OUTPUT	Emission	Air	Phenol			kg		3.5395E-6
191		OUTPUT	Emission	Air	Thiols			kg		-2.5579E-15
192		OUTPUT	Emission	Air	Tin(Sn)			kg		-4.9628E-13
193		OUTPUT	Emission	Air	Titanium(Ti)			kg		-2.3253E-11

프로세스 정보 | 모델링 및 타당성 확인 | 관리정보 | 투입물 및 산출물

Step 5

For each identified GHG, multiply its emission value by its GWP value. Then, sum these results to calculate the overall GHG emission factor for waste plastic incineration.

Example Calculation method for the gate-to-grave emission factor for waste plastic incineration

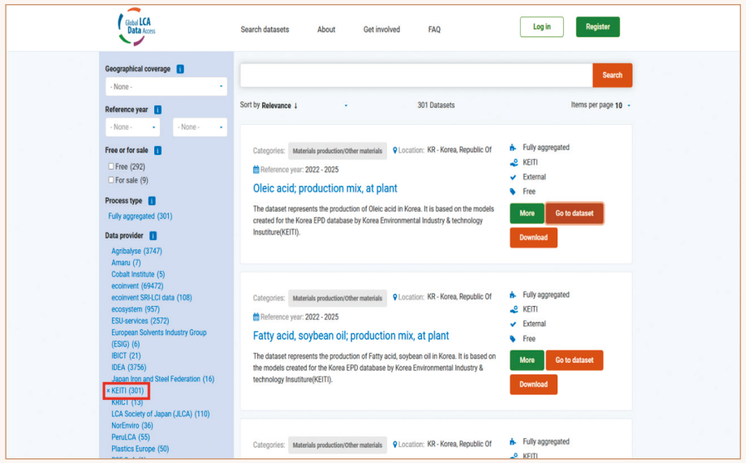
GHG	GWP	Air emission in LCI DB (kg)	Emission factor ($kgCO_2eq/kg$)
CO_2	1	2.809853933	2.809853933
CH_4	27.9	-3.63196E-05	-0.001013316
N_2O	273	-2.97337E-07	-8.11731E-05
Total			2.808759444

- By multiplying the GWP value corresponding to each GHG by the air emission value in the LCI DB, the gate-to-grave emission factor for waste plastic incineration can be calculated to be approximately 2.81 $kgCO_2eq/kg$. In other words, (2.8080953033X1)+(-3.63196E-05X27.9)+(-2.97337E-07X273)=2.808690437≒2.81
- The GWP values used in this example are based on the most recent values provided in the IPCC's AR6.

※ [Reference 5]

Developed and revised national LCI DB

National LCI databases developed or revised since 2022 are registered on the Global LCA Data Access Network (GLAD), an international LCI platform operated by the United Nations Environment Programme (UNEP). GLAD hosts approximately 100,000 LCI datasets from various countries and private organizations. As of December 2024, KEITI had uploaded 301 emission factors, most of which are freely accessible.



② Utilization of environmental product declaration assessment factors

Overview

The Environmental Product Declaration (EPD) system aims to improve environmental performance by disclosing the quantified environmental impacts of products and services throughout their life cycle—covering raw material extraction, manufacturing, transportation, use, and end-of-life disposal. To support its application, the program provides LCI-based assessment factors. The EPD program also certifies products and services that complete full life cycle assessments (LCAs) and disclose their environmental results. Although voluntary, this scheme encourages proactive participation.

The EPD assessment factors quantify the environmental impact per unit of raw material according to its energy production, transportation methods, and waste treatment methods.[21] These factors are categorized into various environmental impact metrics, such as resource footprint, carbon footprint, and ozone layer impact. The carbon footprint metric quantifies the impact when GHGs, such as carbon dioxide, are released into the atmosphere and contribute to global climate change.[22] Therefore, after its suitability is assessed, this metric can be utilized by the reporting entity to calculate Scope 3 emissions.

21) Korea Environmental Industry & Technology Institute, *“Environmental Product Declaration Assessment Factors,”* https://ecosq.or.kr/websquare.do#w2xPath=/ui/cer/ic/oh/ICOH110M01.xml&valVl=tabs3&menuSn=20018500 (accessed on November 11, 2024).

22) Ministry of Environment, *“Public Notice on Comprehensive Revision of the Environmental Product Declaration Guidelines,”* 2021.03.30, https://me.go.kr/home/web/policy_data/read.do?pagerOffset=0&maxPageItems=10&maxIndexPages=10&searchKey=&searchValue=&menuId=10260&orgCd=&condition.code=A1&condition.deleteYn=N&seq=7688 (accessed on September 22, 2023).

Example of utilization

To calculate emissions from the incineration of general waste under category 5 (waste generated in operations) using carbon footprint information from the EPD assessment factors, the following method may be used.

Calculation methodology	Waste-type-specific	Σ ((Amount of waste generated) × (Emission factor by waste type and disposal method))
Activity data	Amount of general waste generated	5,000 (kg/month)
Emission factor	Carbon footprint for general waste incineration	1.18168730881208 ($kgCO_2eq/kg$)
Emissions from general waste incineration	= 5,000 (kg/month) ×1.18168730881208 ($kgCO_2eq/kg$) = 5,908.4365440604 ($kgCO_2eq$/month)	

If the reporting entity can obtain activity data on general waste incineration, it can calculate emissions under category 5 using the methodology for waste-type-specific calculation specified in the GHG Protocol. The necessary emission factors, categorized by waste type and disposal method, can be derived from the carbon footprint assessment factors in the EPD for general waste incineration.

Additional explanation: considerations for application

EPD assessment factors are quantitative values representing the environmental impact per unit of raw materials, energy production, transportation methods, and waste treatment methods, based on the national LCI DB. Differences in results may occur depending on the categorization and characterization methods used. Therefore, when a reporting entity intends to use carbon footprint information from the EPD assessment factors for calculating Scope 3 emissions, it should first verify the original source (i.e., the LCI DB) and determine its suitability for use.

- Carbon footprint information from the EPD assessment factors includes gases beyond the seven GHGs covered by the Kyoto Protocol (e.g., carbon monoxide [CO], chlorofluorocarbons [CFCs]). Therefore, when using the carbon footprint as an emission factor to calculate emissions, the reporting entity should consider the possibility of discrepancies compared to the actual emissions.
- Reporting entities that intend to measure only the seven GHGs can derive emission factors directly from the LCI DB and use them to calculate Scope 3 emissions. However, before deciding to use this information, they should determine whether the processes and system boundaries of the LCI DB are appropriate for their specific circumstances.

③ Utilization of national GHG emission and removal factors

Overview

The national GHG emission and removal factors are designed to quantify the GHG emissions or removals per unit of activity at the national level for compiling national GHG inventories.[23] Since these factors are used to calculate GHG emissions and removals by governments, businesses, and other entities, they can be applied for Scope 3 emissions calculation, provided that the reporting entity evaluates the suitability of these factors based on its emission activities and the available activity data.

Example of utilization

To calculate emissions under category 7 (employee commuting) for employees commuting in compact passenger vehicles powered by liquefied petroleum gas (LPG), the following method can be applied using the national GHG emission factors.

Calculation methodology	Distance basis	Σ ((Travel distance per transport mode [km]) × (Emission factor for the transport mode))	
Activity data	Survey-based commuting data	• Fuel and vehicle types: LPG, compact car • Average speed: 60 km/h • Average round-trip commuting distance per employee per day under these conditions: 20 km	
Emissions	Emission for the given fuel type, vehicle type, and range of speed	CO_2 emissions	= 989.9413 × (speed [km/h]) ^ (−0.5937) = 87.0805264423241 [gCO_2/km]
		CH_4 emissions	= 0.0114 × (speed [km/h]) ^ (−0.7073) = 0.000629822935753512 (gCH_4/km) = 0.013226281650823 8 (gCO_2eq/km)
		N_2O emissions	= −0.0001 + 0.0217/(speed [km/h]) = 0.000261666666666667 (gN_2O/km) = 0.0811166666666668 (gCO_2eq/km)
		Total	= 87.1748693906416 (gCO_2eq/km)
Emissions from commuting for one employee under these conditions	= 20 [km/day] × 87.1748693906416 [gCO_2eq/km] = 1,743.49738781283 [gCO_2eq/day]		

- The emission factors were derived from the national GHG emission and removal factors approved in 2021 for the road transport sector. While it is most accurate to calculate the emission factors by dividing them into ranges of speed below and above 65.4 km/h, the calculation can still be performed using this average speed over the total distance if only those data are available. However, this approach may result in reduced accuracy to some extent.
- Note: For the range of speed below 65.4 km/h, the emission factor formulas for compact cars using LPG, as specified in the road transport section of the 2021 approved national GHG emission and removal factors (y: emissions [g/km], x: speed [km/h]), are as follows:
  - CO_2 emission factor: $y = 989.9413 \times (x^{(-0.5937)})$
  - CH_4 emission factor: $y = 0.0114 \times (x^{(-0.7073)})$
  - N_2O emission factor: $y = -0.0001 + 0.0217/x$

Additional explanation: considerations for application

If the reporting entity can obtain activity data on employee commuting, including fuel type, vehicle type, travel distance, and travel speed, it can

23) Greenhouse Gas Inventory and Research Center of Korea, *"Development and Verification Guidelines of the National Greenhouse Gas Emission and Removal Factors (2020),"* (2020.12), p.4.

calculate emissions under category 7 (employee commuting) using the distance-based calculation methodology specified in the GHG Protocol. The necessary emission factors for the transport mode can be derived using the emission factor formulas from the national GHG emission and removal factors.

If exact activity data matching the national GHG emission factors is unavailable, similar activity data may be used; however, this may result in less accurate emissions calculations.

For the "road transport" category in the national GHG emission and removal factors, the emission factor formulas vary depending on vehicle type, fuel type, travel speed, and travel distance within specific speed intervals. Therefore, detailed activity data is necessary for determining the most accurate emission factor. If obtaining detailed activity data on travel distance by speed interval and average speed proves challenging, an alternative approach is to use average travel distance and average speed. This option is less accurate but still provides a reasonable estimate.

3. Selecting Data

The quality of the Scope 3 inventory depends on the quality of the data used to calculate GHG emissions. Reporting entities should collect data of sufficient quality ([Reference 6]) to ensure that the inventory appropriately reflects the entity's GHG emissions, aligns with its business objectives, and meets the decision-making needs of both internal and external users.

In general, a reporting entity should collect high-quality primary data for high-priority activities. To most effectively track performance, the reporting entity should use primary data collected from suppliers and other value chain partners particularly for Scope 3 activities where GHG reductions are targeted. However, in some cases, primary data may be unavailable or of insufficient quality. In such cases, secondary data may be considered of higher quality than the primary data available for a given activity.

Data selection may also align with the entity's business goals. If a primary goal of the reporting entity is to set GHG reduction targets, track performance from specific operations within the value chain, or engage with suppliers, the entity should collect primary data. Instead, the entity should collect and use secondary data if its primary goal is to understand the relative magnitude of various Scope 3 activities, identify hot spots, and prioritize efforts in primary data collection ([Reference 7]). The reporting entity is required to compile a description of the types and sources of data used to calculate emissions (including activity data, emission factors, and GWP values), and the percentage of emissions calculated using data obtained from suppliers or other value chain partners.

[Reference 6]

Guidance for collecting data of sufficient quality

- **Appropriately reflects the GHG emissions of the reporting entity**
- **Meets the decision-making needs of internal and external users of the reporting entity**
- **Supports the business goals for managing the GHG inventory of the reporting entity** (refer to section 7.3 of the GHG Protocol Scope 3 Standard))

[Reference 7]

Examples for collecting secondary data

- **Activities not prioritized based on initial estimation methods or other criteria**
- **Activities for which primary data are not available** (e.g., when a value chain partner is unable to provide data)
- **Activities for which secondary data are of higher quality than primary data** (e.g., when a value chain partner is unable to provide data of sufficient quality)

1) Data quality indicators and evaluation

The GHG Protocol describes indicators of data quality in terms of how representative the data are (with respect to technology, time, and geography) and how well the data are measured (completeness and reliability) ([Reference 8]). The reporting entity should select the data that are the most representative in terms of technology, time period, and geographic scope; most complete; and most reliable. It should also determine the most useful method for evaluating and applying indicators of data quality. To ensure transparency and avoid misinterpretation of data, the reporting entity is required to compile a description of the quality of its reported emissions data.

Alternatively, the reporting entity may choose to adopt a qualitative approach to assess the quality indicators of its direct emissions data, activity data, and emission factors ([Reference 9]). However, quality metrics might conflict. For example, if a reporting entity must choose between data with high temporal representativeness but low geographical representativeness and data with low temporal representativeness but high geographical representativeness, the reporting entity may select the data based on its own discretion.

[Reference 8]

Data quality indicators

Indicator	Description
Technological representativeness	The degree to which the dataset reflects the actual technologies used
Temporal representativeness	The degree to which the dataset reflects the actual timespan (e.g., year) or duration of the activity
Geographical representativeness	The degree to which the dataset reflects the actual geographic location of the activity (e.g., country or site)
Completeness	The degree to which the data are statistically representative of the relevant activity (e.g., the percentage of locations for which data are available and used, and the extent to which the data cover seasonal and other normal fluctuations)
Reliability	The degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable

(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.)

[Reference 9]

Example of criteria for evaluating indicators of data quality

Score	Technological representativeness	Temporal representativeness	Geographical representativeness	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 yet distinct technology	Data with less than 6 years of difference	Data from a similar area	Data from more than 50% of sites for an adequate time period to even out normal fluctuations	Verified data based partly 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% of sites for an adequate time period to even out normal fluctuations, or more than 50% of sites but for a shorter time period	Non-verified data based partly on assumptions or a qualified estimate (e.g., by a sector expert)
Poor	Data where the technology is unknown	Data with more than 10 years of difference or of unknown age	Data from an unknown area	Data from less than 50% of sites for a shorter time period or representativeness is unknown	Non-qualified estimate

(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.)

4. Collecting Primary Data

Primary activity data may be obtained through various methods, such as meter readings, purchase records, utility bills, direct monitoring, and other approaches for collecting the necessary data from specific activities in the entity's value chain. This includes data provided by suppliers or other value chain partners regarding specific activities within the reporting entity's value chain.

Where possible, the reporting entity should collect energy or emissions data from suppliers and other value chain partners to obtain site-specific data for high-priority Scope 3 activities. To facilitate this, the reporting entity should identify the relevant suppliers to request GHG data. These suppliers may include contract manufacturers, raw material and parts suppliers, capital equipment suppliers, fuel suppliers, third-party logistics providers, waste management companies, and other entities that provide goods or services to the reporting entity.

The reporting entity should engage first with relevant tier 1 suppliers—that is, companies with which the reporting entity has purchase orders for goods or services (e.g., raw materials, parts, or components). Tier 1 suppliers have contractual obligations with the reporting entity and can receive the necessary support and cooperation to request GHG inventory data. Additionally, where relevant, the reporting entity may seek GHG emissions data from tier 2 suppliers (N-tier suppliers). Tier 2 suppliers are those with which tier 1 suppliers have purchase orders for goods or services. If the data are not collected from specific suppliers or are incomplete ([Reference 10]), secondary data may be used to calculate emissions for the activities involved. To achieve this goal, the reporting entity may develop its own policy to establish criteria for selecting relevant suppliers for primary data collection.

The reporting entity is required to declare the percentage of emissions calculated using data obtained from suppliers or other value chain partners. However, not all relevant suppliers will be able to provide GHG inventory data. In such cases, the reporting entity should encourage these suppliers to develop GHG inventories in the future, and it may work towards increasing supplier participation in public GHG emissions reporting.

[Reference 10]

Challenges and guidance for collecting primary data from value chain partners

Challenges	Guidance
Large number of suppliers	• Prioritize key suppliers based on spending and/or anticipated emissions impact • Target suppliers with which the reporting entity has a high degree of influence (e.g., contract manufacturers or suppliers where the reporting entity accounts for a significant share of the supplier's total sales)
Lack of supplier familiarity with GHG inventories and accounting practices	• Target suppliers with prior experience in developing GHG inventories • Identify the correct subject-matter expert in the supplier's organization • Explain the business value of investing in GHG accounting and management • Request data that suppliers have already collected, such as energy-use data, and prioritize requesting activity data rather than emissions data to minimize errors • Provide clear instructions and guidance with the data request • Provide training, support, and follow-up
Lack of supplier capacity and resources for tracking data	• Make the data request as straightforward as possible • Use a simple, user-friendly, standardized data template or questionnaire • Provide a clear list of the data required and where to find them (e.g., utility bills) • Use an automated online data collection system to streamline data entry • Consider using a third-party database to collect data • Leverage resources from suppliers' trade associations • Coordinate the GHG data request with other requests • Follow up with suppliers
Lack of transparency regarding the quality of supplier data	• Request documentation on the methodology and data sources used, as well as inclusions, exclusions, assumptions, and any other relevant information • Minimize errors by requesting activity data (e.g., kWh electricity used, kg of fuels used) and calculating the GHG emissions separately • Consider engaging third-party assurance
Confidentiality of suppliers	• Protect suppliers' confidential and proprietary information (e.g., through nondisclosure agreements or firewalls) • To avoid requiring confidential details, request third-party assurance of supplier data instead of direct submission of detailed activity data
Language barriers	• Translate the questionnaire and communications into local languages

(Source: GHG Protocol, *"Corporate Value Chain Accounting Reporting Standard"* p.82)

5. Collecting Secondary Data and Filling Data Gaps

When using secondary data, a reporting entity should prioritize internationally recognized databases, government-provided data, or data reviewed by experts. The reporting entity should also engage in an iterative process of collecting data, assessing data quality, and improving the level of quality. When selecting data sources, the reporting entity should first assess their data quality by applying the relevant indicators. Once it has collected the data, it should use the same data quality assessment approach to review the quality of the inventory.

In the initial years of Scope 3 data collection, a reporting entity may need to rely on relatively low-quality data due to limited availability. However, over time, entities should prioritize improving the overall quality of their inventory by replacing lower-quality data with higher-quality data. Furthermore, entities that report relatively high emissions must compile a description of data quality when reporting Scope 3 emissions to ensure transparency and avoid potential misinterpretation.

04 GHG Emissions Accounting and Methodologies for Application

1. GHG Emissions Accounting

When accounting for Scope 3 emissions, the reporting entity is required to adhere to standard calculation methods and follow the five GHG Protocol principles (relevance, completeness, consistency, transparency, and accuracy) to ensure verification of the Scope 3 inventory ([Reference 1]).

[Reference 1]

The five principles of GHG emissions accounting

Principle	Guidance
Relevance	• Ensure that the GHG inventory appropriately reflects the GHG emissions of the entity and serves the decision-making needs of users—both internal and external to the entity.
Completeness	• Account for and report on all GHG emission sources and activities within the inventory boundary. • If the entity is unable to account for and report all GHG emission sources and activities (e.g., due to data limitations or other constraints), all exclusions shall be documented and justified.
Consistency	• Use consistent calculation methods to enable users to monitor and track GHG emissions trends. • However, when consistency is compromised (e.g., inclusion of previously excluded activities, other changes affecting emission estimates and data), these changes must be transparently documented and justified, and the base year emissions may need to be recalculated.
Transparency	• Disclose all relevant information about the construction of the GHG inventory in a clear, factual, neutral, and understandable manner, including procedures, assumptions, applied calculation methods and data sources with appropriate references, and limitations. • Information should be disclosed based on clear documentation (i.e., an audit trail) and should be recorded, compiled, and analyzed in a way that enables internal reviewers and external assurance providers to attest to its credibility. Specific exclusions shall be clearly identified and justified.
Accuracy	• Ensure systematic alignment, to the extent possible, between the quantification of GHG emissions and actual emissions. (Ensure that the reported emissions are neither overestimated nor underestimated, compared to the actual emissions.) • Reduce uncertainties as far as practicable, and ensure the data are sufficiently accurate to meet decision-making needs.

(Source: GHG Protocol *"A Corporate Accounting and Reporting Standard"* Chapter 1 GHG Accounting and Reporting Principles, p.8-9)

In practice, the reporting entity may encounter trade-offs among these five principles when compiling a Scope 3 inventory. For example, an entity may use relatively less accurate data to achieve a more complete Scope 3 inventory, which could compromise overall accuracy. Conversely, achieving the most accurate Scope 3 inventory may require excluding activities with less accurate data, and this approach may result in an inventory that is less complete overall.

Therefore, the reporting entity should balance trade-offs among these principles relative to its specific business goals. Though trade-offs between accuracy and completeness may exist, the entity should strive to improve both the accuracy and completeness of the reported emissions data over time

through efforts that enhance overall data quality, thereby minimizing these trade-offs.

The reporting entity should calculate emissions for each Scope 3 category in accordance with these five principles. The calculation methods and emission factors applicable to each category can be found in Chapter II (Building a Scope 3 Greenhouse Gas Inventory), 03. Collecting Activity Data by Emission Source—Section 2: Quantification Methods and Data Types, to which the entity may refer when calculating its inventories for reporting purposes.

2. Methodologies for Application

When applying category-specific calculation methods, the reporting entity may use commonly applicable methodologies to calculate more accurate emissions for each category. Representative methodologies include allocation and sampling techniques. Allocation refers to the process of partitioning GHG emissions from a single facility or other system (e.g., activity, vehicle, production line, or business unit) among its various outputs or targets. Meanwhile, in statistics and data analysis, sampling refers to the selection and application of specific data values from the dataset.

1) Allocation

When a reporting entity uses primary data from suppliers or other value chain partners to calculate Scope 3 emissions, it may apply the allocation method to estimate emissions. Similarly, when the reporting entity provides primary data to its customers, those customers can also use the allocation method to estimate their own Scope 3 emissions.

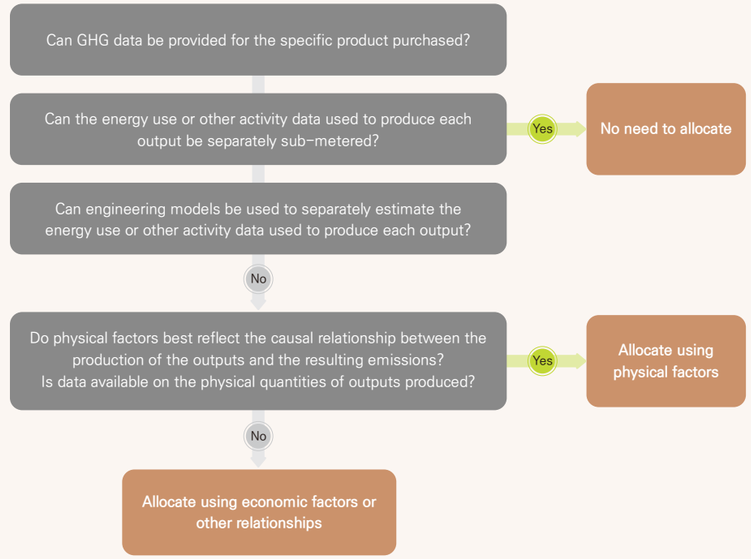
Allocation is necessary when:
- A single facility or other type of system produces multiple outputs
- Emissions are quantified only for the facility or system as a whole
  - Emissions from the facility or other systems need to be allocated to (or divided among) the various outputs

Allocation is not necessary when:
- A facility or other type of system produces only one output
- Emissions from producing each output are separately quantified
  - (In most cases) secondary data are used to calculate Scope 3 emissions

When a reporting entity chooses to apply the allocation method, it should use a consistent allocation factor for allocating emissions across the entire facility or system. The total of the allocated emissions for each output should match the overall emissions from the system. However, allocation adds uncertainty to the emissions estimates and may be especially inaccurate when an activity or facility produces a wide variety of products that differ significantly in their GHG contribution. Therefore, the reporting entity should avoid or minimize allocation if possible when using primary data to calculate Scope 3 emissions ([Reference 2]).

[Reference 2]

Decision tree for selecting the allocation approach



(Source: GHG Protocol *"Corporate Value Chain Accounting Reporting Standard"* p.89)

Once the reporting entity has determined that allocation is necessary based on the decision tree above, it must then select an appropriate allocation method—such as using physical or economic factors. Since different allocation methods can lead to significantly different emission estimates, the entity should choose the approach that most accurately reflects the causal relationship between the production of the outputs and the resulting emissions ([Reference 3]).

- Physical allocation
  Allocating emissions based on the physical relationships between various inputs, outputs, and emissions
- Economic allocation
  Allocating emissions based on the economic value of each output or product
- Other methods
  Allocating emissions based on industry- or company-specific practices

[Reference 3]

Examples and guidelines for category-specific allocation data

	Allocation factor	Details	Example allocation formula
Physical allocation			
1	**Mass**	Mass of co-products	Allocated facility emissions = $\frac{\text{Mass of products purchased}}{\text{Total mass of products produced}}$ × Total emissions
2	**Volume**	Volume of co-products	Allocated facility emissions = $\frac{\text{Volume of products purchased}}{\text{Total volume of products produced}}$ × Total emissions
3	**Energy**	Energy content of heat and electricity co-products	Allocated facility emissions = $\frac{\text{Energy content of products purchased}}{\text{Total energy content of products produced}}$ × Total emissions
4	**Chemicals**	Chemical composition of chemical co-products	Allocated facility emissions = $\frac{\text{Chemical content of products purchased}}{\text{Total chemical content of products produced}}$ × Total emissions
5	**Number of units**	Number of units shipped	Allocated facility emissions = $\frac{\text{Number of units purchased}}{\text{Total mass of products produced}}$ × Total emissions
6	**Other factors**	Factors such as protein content in food products or space occupied by co-products	
Economic allocation			
7	**Market value**	Market value of co-products	llocated facility emissions = $\frac{\text{Market value of products purchased}}{\text{Total market value of products produced}}$ × Total emissions
Other methods			
8	**Other factors**	Other formulas specific to an industry or company, as established by that industry or company	

(Source: GHG Protocol *"Corporate Value Chain Accounting Reporting Standard"* p.91)

Examples and guidance for determining appropriate allocation methods by category are provided below ([Reference 4]).

[Reference 4]

Allocation examples and guidance by Scope 3 category

	Category	Examples of allocation data	Guidance
1	**Purchased goods and services**	Site-specific energy use or emissions data from suppliers	Physical or economic allocation
2	**Capital goods**	Site-specific energy use or emissions data from capital goods suppliers	Physical or economic allocation
3	**Fuel- and energy-related activities (not included in Scope 1 or Scope 2)**	Entity-specific data on upstream emissions (e.g., extraction of fuels) and actual power purchase data for purchased power	Physical allocation (energy)
4	**Upstream transportation and distribution**	Activity-specific energy use or emissions data from third-party transportation and distribution suppliers (for shared vehicles), and physical allocation for shared facilities (based on volume or area)	Physical allocation for shared vehicles (mass or volume)
5	**Waste generated in operations**	Site-specific emissions data from waste management companies	Physical or economic allocation
6	**Business travel**	Activity-specific emissions data from transportation suppliers (e.g., airlines)	Physical allocation for shared vehicles (area)
7	**Employee commuting**	Specific distance traveled and mode of transport, using data collected from employees	Physical allocation for shared vehicles (area)
8	**Upstream leased assets**	Site-specific energy use data collected by utility bills or meters	Physical allocation for shared facilities (area or volume)
9	**Downstream transportation and distribution**	Activity-specific energy use or emissions data from third-party transportation and distribution partners (for shared vehicles), and physical allocation for shared facilities (volume or area)	Physical allocation for shared vehicles (mass or volume)
10	**Processing of sold products**	Site-specific energy use or emissions from downstream value chain partners	Physical or economic allocation
11	**Use of sold products**	Specific data collected from consumers	Physical allocation, where applicable
12	**End-of-life treatment of sold products**	Specific data collected from waste management providers on emissions rates or energy use	Physical allocation, where applicable
13	**Downstream leased assets**	Site-specific energy use data collected by utility bills or meters	Physical allocation for shared facilities (area or volume)
14	**Franchises**	Site-specific energy use data collected by utility bills or meters	Physical allocation for shared facilities (area or volume)
15	**Investments**	Site-specific energy use or emissions data	Economic allocation based on the entity's proportional share of equity or debt in the investee company

(Source: GHG Protocol *"Corporate Value Chain Accounting Reporting Standard"* p.92-93)

2) Sampling

If a reporting entity needs to collect a large quantity of data for a particular Scope 3 category but finds it impractical or impossible to collect the data from each individual activity, it may use appropriate sampling techniques. This allows the entity to extrapolate data from a representative sample of activities within the category. Activities can also be grouped into similar categories to facilitate data collection and emission estimation.

When sampling and grouping may be necessary:

- Calculating emissions by grouping buildings by type or floor area, or vehicles by type
- Calculating emissions associated with employee commuting (category 7) by extrapolating data from a representative sample of employees
- For entities with multiple distribution channels, calculating emissions associated with transportation and distribution (categories 4 and 9)

A reporting entity chooses to use sampling, and selects a specific method, with the goal of optimizing the trade-off between cost of measurement and accurately representing all emission sources. The reporting entity may use a sampling method ([Reference 5]) that aligns with its business goals and is appropriate for each specific emissions activity.

[Reference 5]

Sampling methods

Sampling method	Description
Simple random sampling	• Simple random sampling creates a representative view of the entire dataset with an appropriate sample size. • It is relatively straightforward to construct the sample; however, if the total number of activities is too large, the process may become cumbersome.
Systematic sampling	• Systematic sampling involves randomly selecting the first item to sample and then selecting subsequent activities at regular intervals to achieve the desired sample size. • It is simple to implement and guarantees even sampling without clustering; however, if the dataset has a periodic pattern, sampling bias could occur.
Stratified sampling	• Stratified sampling initially groups the dataset's activities into categories with similar characteristics, followed by random sampling within these groups. • It may improve precision due to less variability within groups, reducing the necessary sample size and saving time and money; however, identifying appropriate variables and forming relevant groups may be difficult and complex.

(Source: GHG Protocol *"Technical Guidance for Calculating Scope 3 Emissions"* Appendix A. Sampling, p.154-155)

Determining sample size is fundamental to all sampling activities ([Reference 6]). When determining the sample size for estimating emissions, the reporting entity should consider multiple factors simultaneously from various perspectives, including the significance of GHG emissions from the source, the size of the population, the variability of the emission sources, and the necessary degree of precision.

[Reference 6]

Determining sample size

Determination method	Description
Using the sample size of a similar inventory	• The reporting entity may refer to similar inventories for guidance on appropriate sample size and sampling techniques; however, when using this approach, entities should justify the similarity and appropriateness for comparison.
Using online calculators	• Online calculators offer a quick and easy way to assess sample size. • Available online calculator websites include: http://www.research-advisors.com/tools/SampleSize.htm (Provides a downloadable spreadsheet to calculate the necessary sample size with customizable sampling criteria.) www.surveysystem.com/sscalc.htm (Provides an interactive online calculator with fixed options for confidence level.)
Using published tables	• Many published tables provide the necessary sample size for specific criteria, such as precision, confidence levels, and variability for a given population size. (Reporting entities should refer to standard statistics texts or search online to find tables that match their specific sampling criteria.)
Using formulas	• Formulas for calculating sample size are available in all standard statistics and sampling textbooks. Reporting entities may refer to these established formulas, which are accessible both in standard textbooks and online, to ensure greater assurance for their choice of sample size.

(Source: GHG Protocol *"Technical Guidance for Calculating Scope 3 Emissions"* Appendix A. Sampling, p.156)

When a normal distribution is assumed during the sampling process, increasing the sample size is likely to reduce sampling error. However, it is important to recognize that all measurements contain some level of uncertainty. The reporting entity should estimate the uncertainty[24] for the parts of the assessment that are significant to its organization.

An estimate of uncertainty should include both precision from random error and bias from systematic error. A commonly accepted standard level of confidence regarding uncertainty is a 95% confidence level. For example, if the uncertainty level is ±5% for an emissions estimate of 100 tons CO_2eq, the true value is likely to lie between 95 and 105 tons with 95% confidence.

Variability refers to the degree of difference among activities within a dataset. A more heterogeneous (more variable) dataset will require a larger sample size. Generally, the maximum level of variability is 50%, and a conservative estimate of variability is often represented by 0.5 in many cases.

24) This concept involves evaluating how accurate a particular measurement or assessment is and understanding the degree of uncertainty involved.

05 Assurance and Reporting

1. Assurance

Assurance refers to the level of confidence that the inventory is complete, accurate, consistent, transparent, relevant, and free from material misstatements. Assuring Scope 3 inventory results can provide a variety of benefits, including:

- Increased senior management confidence in the reported information on which to base reduction targets and related decisions
- Enhanced internal accounting and reporting practices (e.g., data collection, calculation, and internal reporting systems), as well as support for learning and knowledge transfer
- Improved efficiency in subsequent inventory update processes
- Greater stakeholder confidence in the reported information

Thoroughly documenting the assurance process is a crucial step in preparing for assurance. Three key parties are involved in the assurance process:

- The reporting entity seeking assurance
- Stakeholders using the inventory report
- The assurance provider(s)
  - Assurance is classified into two types: first-party assurance (internal providers) and third-party assurance (external providers)
  - The type of assurance is classified by the level of independence maintained by the assurance providers from the reporting entity's inventory process ([Reference 1])

[Reference 1]

Types of assurance

Type of assurance	Description	Independence mechanism
First-party assurance	Person(s) from within the reporting entity, but independent of the GHG inventory process conduct internal assurance	Different lines of reporting within the reporting entity
Third-party assurance	Person(s) from an organization independent of the Scope 3 inventory process conduct third-party assurance	Different business entity from the reporting entity

(Source: GHG Protocol *"Product Life Cycle Accounting Reporting Standard"*, p.93)

Both first-party and third-party assurance providers should follow similar procedures and processes, including:

- Planning and scoping (e.g., identifying risks and material misstatements)
- Identifying emission sources included in the Scope 3 inventory
- Performing the assurance process (e.g., gathering evidence, performing analytics)
- Evaluating results
- Determining and reporting conclusions

For external stakeholders, third-party assurance is likely to increase the credibility of the GHG inventory. Inherently, assurance provided by a third party offers a higher degree of objectivity and independence. However, first-party assurance can also provide confidence in the reliability of the inventory report and serve as a valuable learning experience for the reporting entity prior to commissioning third-party assurance. In such cases, a reporting entity undergoing first-party assurance should report how potential conflicts of interest were avoided during the assurance process.

When conducting the assurance process, the reporting entity should choose between limited or reasonable assurance, based on the components of the audit (e.g., assertions, subject matter, criteria, evidence, standards, and opinions) ([Reference 2]). The level of assurance indicates the degree of confidence stakeholders can have over the information in the inventory report. Additionally, the level of assurance requested by the reporting entity will determine the rigor of the assurance process and the volume of evidence required. The highest level of assurance that can be provided is reasonable assurance. However, since it is practically impossible to test 100% of all inputs to a GHG inventory, it is important to note that "absolute assurance" cannot be provided.

[Reference 2]

Offering limited or reasonable assurance opinions

Assurance opinion	Nature of opinion	Example wording
Limited assurance	Negative opinion	"Based on our review, we are not aware of any material modifications that should be made to the entity's assertion that their Scope 3 inventory is in conformance with the requirements of the *GHG Protocol Scope 3 Standard*."
Reasonable assurance	Positive opinion	"In our opinion, the reporting entity's assertion of their Scope 3 emissions by category, as reported in the inventory report, is fairly stated, in all material respects, and is in conformance with the *GHG Protocol Scope 3 Standard*."

(Source: GHG Protocol *"Product Life Cycle Accounting Reporting Standard"*, p.96)

2. Reporting

The reporting entity shall present information based on the principles of relevance, accuracy, completeness, consistency, and transparency through a credible GHG emissions report. The report should be based on the best available data and transparently disclose any limitations.

1) Required information

The GHG Protocol specifies that reporting entities shall publicly disclose the following information:

- Scope 1 and Scope 2 emissions reports in conformance with the GHG Protocol Corporate Standard
- Total Scope 3 emissions reported separately by Scope 3 category
- For each Scope 3 category, total emissions of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3) reported in metric tons of CO_2-equivalent, excluding biogenic CO_2 emissions and independent of any GHG trades, such as purchases, sales, or transfers of offsets or allowances
- A list of Scope 3 categories and activities included in the inventory
- A list of Scope 3 categories or activities excluded from the inventory with justification of their exclusion
- Once a base year has been established: the year chosen as the scope 3 base year; the rationale for choosing the base year; the base year emissions recalculation policy; scope 3 emissions by category in the base year, consistent with the base year emissions recalculation policy; and appropriate context for any significant emissions changes that triggered base year emissions recalculations
- For each Scope 3 category, any biogenic CO_2 emissions reported separately
- For each Scope 3 category, a description of the types and sources of data, including activity data, emission factors and GWP values, used to calculate emissions, and a description of the data quality of reported emissions data
- For each Scope 3 category, a description of the methodologies, allocation methods, and assumptions used to calculate Scope 3 emissions
- For each Scope 3 category, the percentage of emissions calculated using data obtained from suppliers or other value chain partners

2) Optional information

Reporting entities should incorporate into their GHG emissions report, when applicable, the following additional points:

- Emissions data further subdivided where this adds relevance and transparency (e.g., by business unit, facility, country, source type, or activity type)
- Emissions data further disaggregated within Scope 3 categories where this adds relevance and transparency (e.g., reporting by different types of purchased materials within category 1, or different types of sold products within category 11)
- Emissions from Scope 3 activities not included in the list of Scope 3 categories (e.g., transportation of attendees to events), reported separately (e.g., in an "other" Scope 3 category)
- Emissions of GHGs reported in metric tons of each individual gas
- Emissions of any GHGs other than CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3 whose 100-year GWP values have been identified by the IPCC, to the extent they are emitted in the entity's value chain (e.g., CFCs, HCFCs, NOx, etc.), and a list of any additional GHGs included in the inventory
- Historic Scope 3 emissions (i.e., those that have previously occurred), reported separately from future Scope 3 emissions expected to occur as a result of the reporting entity's activities in the reporting year (e.g., from waste generated in operations, the use of sold products, or the end-of-life treatment of sold products)
- Qualitative information about emission sources that have not been quantified
- Information on any GHG sequestration or removals, reported separately from Scope 1, Scope 2, and Scope 3 emissions
- Information on project-based GHG reductions calculated using the project method (e.g., using the GHG Protocol for Project Accounting), reported separately from Scope 1, Scope 2, and Scope 3 emissions
- Information on avoided emissions (e.g., from the use of sold products), reported separately from Scope 1, Scope 2, and Scope 3 emissions
- Quantitative assessments of data quality
- Information on inventory uncertainty (e.g., information on the causes and magnitude of uncertainties in emission estimates) and an outline of policies in place to improve inventory quality
- The type of assurance performed (first or third party), the relevant competencies of the assurance provider(s), and the opinion issued by the assurance provider
- Relevant performance indicators and intensity ratios
- Information on the entity's GHG management and reduction activities, including Scope 3 reduction targets, supplier engagement strategies, product GHG reduction initiatives, etc.
- Information on supplier/partner engagement and performance
- Information on product performance
- A description of performance measured against internal and external benchmarks
- Information on purchases of GHG reduction instruments, such as emissions allowances and offsets, from outside the inventory boundary
- Information on reductions at sources within the inventory boundary that have been sold or transferred as offsets to a third party
- Information on any contractual provisions addressing GHG-related risks or obligations
- Information on the causes of emissions changes that did not trigger a Scope 3 base-year emissions recalculation
- GHG emissions data for all years between the Scope 3 base year and the reporting year (including details of and reasons for recalculations, if appropriate)
- Additional explanations that provide context for interpreting the data

III

Calculation Methodology by Category

Overview

This section systematically addresses the 15 categories of Scope 3 emissions, following the structure of the GHG Protocol. It includes category definitions, calculation methodologies, and practical calculation examples.

The main components are organized as follows:

- Category definitions: Key emission sources and calculation boundaries for each of the 15 categories
- Calculation methodologies: Available calculation methods (formulas and explanations) and decision trees
- Calculation examples: Case-specific examples illustrating data application and methodology use

To reflect the characteristics of the semiconductor industry, feedback was collected through interviews and written consultations with key stakeholders. This process identified significant practical challenges, particularly in calculating upstream emissions for categories 1 and 2, as well as downstream emissions for categories 10, 11, and 12.

As of March 2025, the GHG Protocol has not yet fully addressed these practical issues, and updates remain in progress. Recognizing these limitations, this guidance is intended to provide semiconductor industry stakeholders with tailored reference materials and calculation examples to support more accurate and comprehensive Scope 3 emissions accounting. In addition to this guidance, reporting entities may refer to the Scope 3 category 1 GHG assessment guideline developed by the Semiconductor Climate Consortium (SCC) to enhance the accuracy and consistency of their emission inventories. Future updates to SCC's category-specific guidance will also serve as valuable resources for Scope 3 calculations. (As of June 2025, guidance for Scope 3 Category 11 has been published[25]).

Classification	Key categories	Key improvements and additions in this guidance
Upstream	Category 1 (purchased goods and services) Category 2 (capital goods)	• Comprehensive value chain map for the industry and lists of major raw materials and equipment • Supplement upstream emission estimates for completeness by providing examples of matching with third-party emission factor database
Downstream	Category 10 (processing of sold products) Category 11 (use of sold products) Category 12 (end-of-life treatment of sold products)	• Allocation methods for downstream processing, use, and disposal emissions based on the GHG Protocol • Develop calculation methods for intermediate product use and disposal emissions

Accordingly, stakeholders in the semiconductor industry are encouraged to use this guidance as a reference and to adapt its application based on their organizational context and data availability.

25) https://www.semi.org/en/blogs/technology-and-trends/semiconductor-climate-consortium-working-group-progress-and-carbon-disclosure-project-opportunities

01 Category 1 (Purchased Goods and Services)

1. Definition

Category 1 includes the cradle-to-gate emissions ([Reference 2]) of purchased or acquired goods and services ([Reference 1]) by the reporting entity in the reporting year. It encompasses emissions from all upstream activities not included in other upstream categories, from category 2 (capital goods) to category 8 (upstream leased assets). In other words, it covers all emissions that occur throughout the life cycle of the goods purchased by the reporting entity until they reach the point of receipt.

[Referenc 1]

Examples of entity purchases

- **Production-related procurement (direct procurement):**
  - 1) Raw materials
  - 2) Intermediate goods
    - Purchased for processing, transformation, or inclusion in other products
    - Examples: materials, components, parts
  - 3) Final goods
    - Purchased for resale
    - Only for retail and distribution companies
  - 4) Capital goods (included in category 2)
    - Used by entities to manufacture products, provide services, and sell, store, and deliver products
    - Examples: plants, assets, equipment
- **Non-production-related procurement (indirect procurement):**
  - 1) Operations resource management
    - Products used in work environments, such as offices
    - Examples: office supplies, office furniture, computers, IT support, consulting services, cleaning and landscaping services
  - 2) Maintenance, repairs, and operations
    - Products used in manufacturing settings
    - Examples: spare parts, replacement parts

[Reference 2]

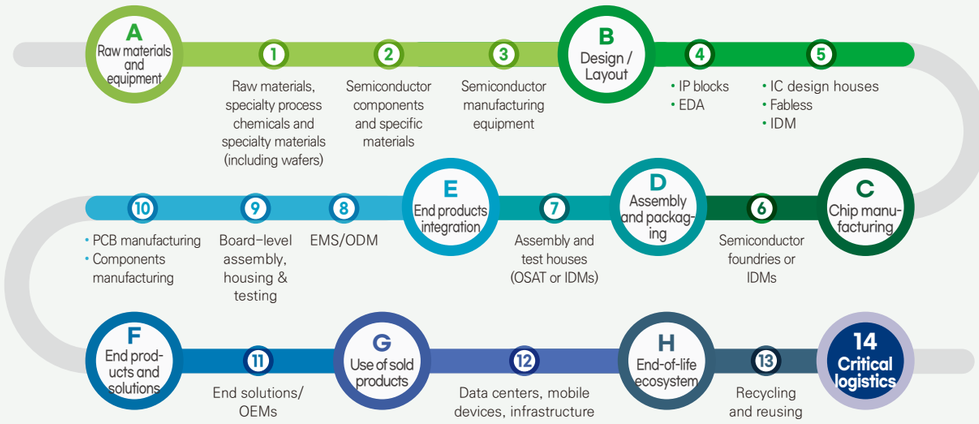
Examples of products' upstream (cradle-to-gate) emission activities

- **Extraction of raw materials**
- **Manufacturing, production, and processing**
- **Electricity consumed during upstream activities**
- **Disposal or treatment of waste generated by upstream activities and land use**
- **Transportation of materials and products between suppliers**
- **Other activities performed prior to the product's acquisition by the reporting entity**

[Reference 3]

Value chain map of the semiconductor industry

When calculating emissions for categories 1 and 2, a reporting entity must account for cradle-to-gate emissions across all upstream activities. This includes emissions from first-tier, second-tier, third-tier, and even more distant suppliers. By using the semiconductor industry value chain map, the reporting entity should identify its specific business operations and associated upstream emission sources to ensure complete and accurate Scope 3 calculations. (Note: The use of sold products (G) and end-of-life ecosystem (H) pertains to downstream activities and therefore does not affect Scope 3 category 1 emissions.) The figure below illustrates the semiconductor value chain map provided by the SCC, which can be used as a reference when calculating category 1 emissions.



(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.10).

[Reference 4]

Examples of semiconductor-specific value chains for goods & services

The tables below provide examples of goods and services across the semiconductor industry value chain. These examples, derived from consultations with SCC member companies, are intended to support reporting entities in estimating emissions for categories 1 and 2. In some cases, ambiguity may arise regarding whether a purchased product should be classified as a capital good (reported under category 2) or as a purchased good or service (reported under category 1). In such situations, companies should rely on their internal financial accounting procedures to determine the appropriate classification.

① Raw materials and equipment

Category	Examples
Chemicals and gases	Wet chemicals, acids, bases, solvents, resist strippers, developers, etchants, cleaning, surface modifiers, bulk gases, fluorine, chlorine, bromine, Xe, SiF6, CH_4, oxygen, nitrogen, hydrogen, hafnium, ozone, reactive gases such as ammonia (NH3), CF4, SF_6, Cl2, inert gases such as argon, carrier gases such as nitrogen and helium, precursor gases such as silane (SiH4), dichlorosilane (SiH2Cl2), tungsten hexafluoride (WF6), 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 additives, PVDF, PFA, PTFE, PEEK
Equipment	Lithography equipment, packaging, etching tools, ATP tools (OSAT/IDM), handlers & holders, deposition tools, 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, condensers, air handlers (including evaporator coil and blower), thermal expansion valves, interconnects and connectors, spare parts, photomasks, reticules, blanks, dicers, mold compounds, encapsulants (epoxies), ceramic impregnators, power generation, inverters
Services	Maintenance and repair, transportation, shipping

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.56-59)

② Design

Category	Examples
Equipment	EDA tools (IC design & simulation environment, PCB design) and IC design tools (Cadence Spectre, Synopsis)
Services	Cloud platform, IT services, logistics
Digital, other components	MCUs, CPUs, memory, logic, amplifiers
MEMS* & sensors	Pressure, temperature, acceleration, microphones, gyroscopes, magnetometers, gas sensors
IP cores & process design kit	ARM, imagination

* MEMS: Micro-Electromechanical System

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.56-59)

③ Chip manufacturing

Category	Examples
Chemicals and gases	Wet chemicals, acids, bases, solvents, resist strippers, developers, etchants, cleaning, surface modifiers, bulk gases, fluorine, chlorine, bromine, Xe, SiF6, CH_4, oxygen, nitrogen, hydrogen, hafnium, ozone, reactive gases such as ammonia (NH3), CF4, SF_6, 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)
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, additives, PVDF, PFA, PTFE, PEEK
Equipment	Lithography equipment, etching tools, ATP tools, handlers & holders, deposition tools
Components	Photomasks, reticules, blanks, probers, probe cards, spare parts
Maintenance and repair	Maintenance and repair, IT services, transportation, shipping

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.56-59)

④ Assembly and packaging

Category	Examples
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 Spectre, 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

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.56-59)

⑤ End-product integration

Category	Examples
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, microphones, gyroscopes, magnetometers, gas sensors
IP cores & process design kit	ARM, imagination
Services	Maintenance and repair, EMS, cloud platform, IT services, transportation, and shipping

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.56-59)

⑥ End products and solutions

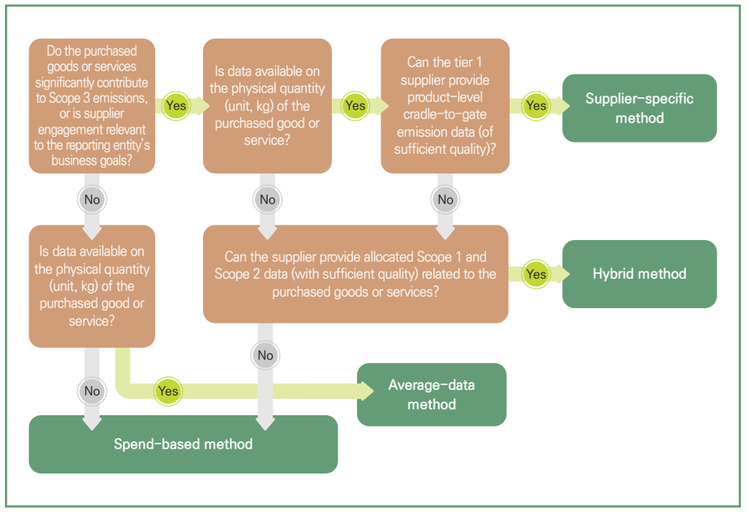
Category	Examples
Metals and alloys	Al, aluminum-silicon, Al-Cu, Cu, gold, silver, platinum, tungsten, chromium, nickel, stainless steel, lithium, cobalt
Equipment	Electrical modules & systems, HVAC systems
Components	Interconnects and connectors, spare parts, power generation, inverters, air conditioner, 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

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.56-59)

2. Calculation Methodology

Four methods can be used to calculate emissions from category 1 (purchased goods and services): the supplier-specific, hybrid, average-data, and spend-based methods. The most appropriate method depends on the level of data available to the reporting entity (e.g., data with sufficient quality). They may be determined as shown in the following diagram ([Reference 5]).

1) Decision tree



[Reference 5]

Determining the calculation method based on the level of collected data

The supplier-specific and hybrid methods can yield more precise results for individual suppliers than the average-data and spend-based methods. However, these methods may not accurately reflect product-specific contributions to the reporting entity's Scope 3 emissions, and the collected data from a reporting entity's actual suppliers may be less accurate than industry-average data for certain products. Therefore, the reporting entity should clarify the specificity and accuracy of the data and select the appropriate calculation method for reporting emission values in category 1. Given the high complexity of the semiconductor value chain, collecting supplier-specific data can be particularly challenging. Nevertheless, reporting entities are strongly encouraged to continuously collect such data to improve the accuracy of emissions estimates. This ongoing process also strengthens supplier engagement and helps identify practical opportunities to reduce emissions across the supply chain.

[Reference 6]

Data hierarchy classification based on the degree of primary data specificity

When collecting data from suppliers or other value chain partners, a reporting entity should strive to obtain data as specific to the purchased product as possible. The level of specificity, however, may vary depending on the Scope and diversity of a supplier's product portfolio. For suppliers producing relatively homogeneous products, data aggregated at the business-unit or corporate level may be sufficient. In contrast, for suppliers with a more diverse product range, more detailed data at the product, production line, or facility level should be sought. The SCC's hierarchy of primary data specificity below provides a useful reference for assessing the quality of supplier data.

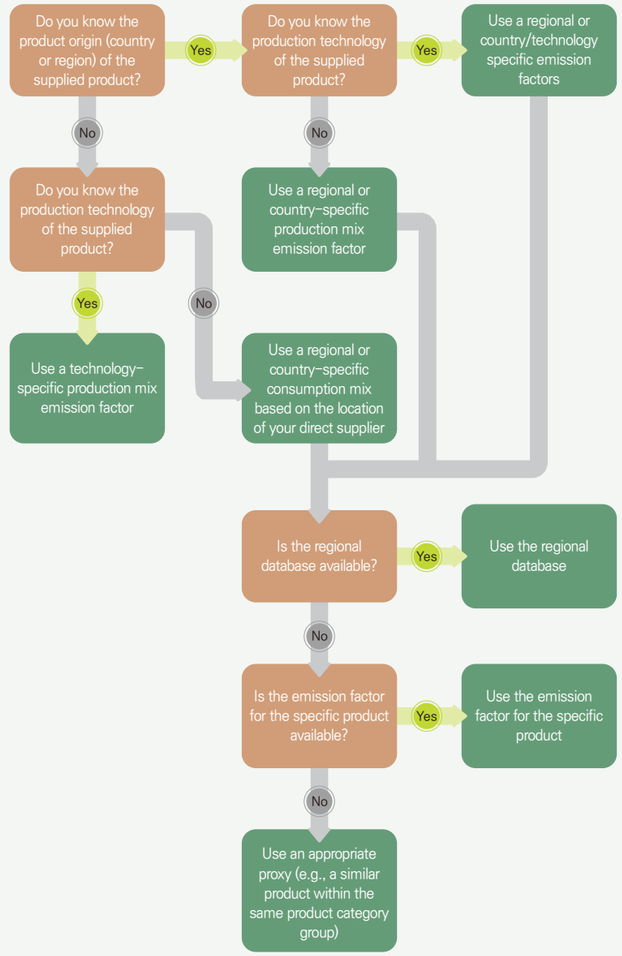
Data type	Description
Product-level data	Cradle-to-gate GHG emissions and/or activity data for the product of interest
Activity-process or production line-level data	GHG emissions and/or activity data for the activities, processes, or production lines that produce the product of interest
Facility-level 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

(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.33)

[Reference 7]

Decision tree for selecting emission factors

When selecting emission factors, reporting entities should prioritize sources from internationally recognized databases or those that have undergone rigorous peer review. Emission factors should be representative of both the product's country of origin and the technology applied in its production. The decision tree below, provided by the SCC, serves as a helpful reference for determining appropriate emission factors.



(Source: SCC, *"Scope 3 Category 1 GHG Assessment"* p.33)

2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Supplier-specific method	Σ((quantity of goods purchased) × (supplier-specific product emission factor))	Collect product-level cradle-to-gate emission factors for the purchased goods and services from suppliers.
b	Hybrid method[26]	Σ(Scope 1 and 2 emissions of tier 1 supplier relating to the reporting company's purchased good or service) + Σ{(mass of waste from tier 1 supplier relating to the purchased good or service) × (waste emission factor)} + Σ{(units of the reporting company's purchased goods and services) × (emission factor of the good or service excluding Scope 1 and 2 emissions and waste emissions generated by supplier)}	If data available from suppliers is limited, secondary and primary data is combined to calculate emissions.
c	Average-data method	Σ((mass or unit of purchased good or service) × (emission factor of purchased good or service per unit of mass or reference unit))	Collect data on the mass of goods and services (e.g., kg or other relevant units), and multiply by a secondary emission factor (e.g., average emissions per unit of goods or services) to estimate the emissions of the goods and services. ※ The emission factor for a product may represent the upstream GHG emissions (e.g., raw material extraction, processing, transportation, etc.) per unit mass ($kgCO_2$-eq/kg), as determined by the reporting company's life cycle assessment (LCA).
d	Spend-based method	Σ((cost of purchased good or service) × (emission factor of purchased good or service per unit of economic value))	Collect data on the economic value of purchased goods and services, and multiply by the relevant secondary emission factor (e.g., average emissions per monetary value of the goods).

[Reference 8]

Example of matching key raw materials in the semiconductor industry to LCI database

For calculating GHG emissions for categories 1 and 2 in the semiconductor industry, obtaining supplier-specific emissions data enables most accurate results. However, if supplier data are unavailable, companies may estimate emissions using the average-data method—typically by applying product life cycle emission factors. In Korea, a common practice is to use Environmental Product Declaration (EPD) assessment factors[27] from the national LCI database.

SCC		EPD assessment factors				
Category	Example materials	Main category	Subcategory	Raw material/ energy	Unit	Carbon Footprint ($kgCO_2eq$)
Chemicals and gases	Oxygen	Raw material and energy production	Basic chemical substance	Oxygen	kg	0.125997435
	Nitrogen	Raw material and energy production	Basic chemical substance	Nitrogen	kg	0.1517021

26) This guidance addresses only the second hybrid method described in the GHG Protocol's Scope 3 calculation guidance, which is intended for situations where supplier-specific data are limited to Scope 1, Scope 2, and waste emissions. Hybrid methods that require more comprehensive primary data from suppliers—such as full emission activities including Scope 1 and 2 emissions, relevant purchased raw materials, transportation, and product disposal—are beyond the Scope of this guidance.

27) https://ecosq.or.kr/websquare.do#w2xPath=/ui/cer/ic/oh/ICOH110M01.xml&valVl=tabs3&menuSn=20018500

SCC		EPD assessment factors				
Category	Example materials	Main category	Subcategory	Raw material/ energy	Unit	Carbon Footprint ($kgCO_2eq$)
Chemicals and gases	Hydrogen	Raw material and energy production	Basic chemical substance	Hydrogen	kg	0.709
	Ammonia (NH3)	Chemical reaction process	Ammonia production	Ammonia	Kg C	3.67
	SF_6	Chemical reaction process	HFCs, PFCs, SF_6 production	SF_6 production	kg SF_6	47.8
	Argon	Raw material and energy production	Basic chemical substance	Argon	kg	0.072359376
Wafers	Silicon carbide	Chemical reaction process	Carbide production and use	Silicon carbide production	kg cokes	2.3
		Chemical reaction process	Carbide production and use	Silicon carbide production	kg petrol cokes	0.2142
		Chemical reaction process	Carbide production and use	Silicon carbide production	kg carbide	0.2436
	Glass	Raw material and energy production	Construction materials	Tempered glass	kg	1.05343479
		Raw material and energy production	Construction materials	Glass wafer	kg	0.189737865
		Raw material and energy production	Construction materials	Flat glass	kg	0.789049506
Metals and alloys	Aluminum*	Raw material and energy production	Metal	Aluminum foil	kg	2.393932339
		Raw material and energy production	Metal	Aluminum plate	kg	1.956641706
		Raw material and energy production	Metal	Aluminum billet (A6061, A6063)	kg	0.833981727
		Raw material and energy production	Metal	Recycled aluminum ingot	kg	0.484981239
		Raw material and energy production	Metal	Recycled aluminum chips	kg	0.072855305
		Raw material and energy production	Metal	Chemically treated aluminum foil	kg	2.438023245
	Copper	Raw material and energy production	Metal	Copper	kg	4.569875381
Plastics	HDPE	Raw material and energy production	Plastic	High-density polyethylene	kg	2.02649893
		Raw material and energy production	Plastic	High-density polyethylene film	kg	2.801602
Equipment	Electric modules and systems	Raw material and energy production	Electrical components	Rigid printed circuit board	kg	29.60561241
		Raw material and energy production	Electrical components	Flexible printed circuit board	kg	36.2524031

* Because the carbon footprint of aluminum can vary significantly depending on the proportion of recycled feedstock used, supplier-provided data should be prioritized whenever possible.

(Source: SCC, Scope 3 Category 1 GHG Assessment, p. 56–59; KEITI, EPD Assessment Factors)

3. Calculation Examples by Methodology[28)]

a. Supplier-specific method

- Company A, a semiconductor foundry, sources key raw materials—wafers X, Y, and Z—from suppliers B, C, and D, respectively. Using its internal IT system, Company A can determine the quantities of each purchased product. Company A also collects product-specific emission factors from the supplier for the purchased products.

Purchased item	Quantity purchased (kg)	Supplier	Supplier-specific emission factor ($kgCO_2eq/kg$)
X	500,000	Supplier B	1.35
Y	800,000	Supplier C	1.80
Z	700,000	Supplier D	0.75

- Using the supplier-specific method, the total emissions of the goods purchased by Company A are calculated as follows:

Σ(quantities of good purchased (kg) × supplier-specific emission factor of purchased good or service ($kgCO_2eq/kg$))

= (Emissions from purchased good X) + (Emissions from purchased good Y) + (Emissions from purchased good Z)
= (500,000 × 1.35) + (800,000 × 1.80) + (700,000 × 0.75)
= 2,640,000 $kgCO_2eq$

b. Hybrid method

- Company A, a semiconductor chip manufacturer, purchases raw materials X, Y, and Z from three suppliers for use in semiconductor chip production.
- Company A collects information on Scope 1 and 2 emissions, as well as Scope 3 category 1 emissions, for each raw material from each supplier. Because the Scope 1 and 2 emissions reported by each supplier are only available at the business unit level, Company A explores allocation methods to estimate the emissions attributable to each raw material. Since each supplier produces products with homogeneous material content, Company A chooses a mass-based physical allocation approach. This involves collecting data on each supplier's total production and the quantities purchased by Company A. The activity data are as follows:

Raw material	Company A's quantity purchased (kg)	Supplier's total produced (kg)
X	150	1,000
Y	200	2,000
Z	500	3,000

- After analyzing the primary data provided by each supplier, Company A requested upstream emission factors for each raw material to fill missing information. The company confirmed that the Scope 3 category 1 emissions reported by suppliers of raw materials X and Y included waste treatment, disposal, transportation, distribution, and other upstream activities. The activity data and emission factors collected are summarized below:

28) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

Raw material	Primary data		Upstream emission factor	
	Scope 1, 2 emissions ($kgCO_2eq$)	Scope 3 Cat 1 emissions ($kgCO_2eq$)	Required data	Emission factor ($kg/kgCO_2eq$)
X	200	Not available	Upstream emission factor covering Tier 1 and lower-tier suppliers for raw material X	1.5
Y	500	100 (only 1st-tier supplier included)	Upstream emission factor covering Tier 2 and lower-tier suppliers for raw material Y	1.2
Z	700	500 (all upstream emissions)	Not applicable	

- Using the hybrid method, the total emissions of the goods purchased by Company A are calculated as follows:

① Emissions from purchased raw material X
(Emissions from primary data for raw material X) + (Emissions from the upstream emission factor for raw material X)
= (Scope 1, 2, and 3 emissions of the relevant business unit of the supplier of raw material X ($kgCO_2eq$)) × (Company A's quantity of raw material X purchased (kg)/ Supplier's total raw material X produced (kg)) + (Upstream emission factor for raw material X ($kg/kgCO_2eq$) × Company A's quantity of raw material X purchased (kg))
= (200 × (150/1,000)) + (1.5 × 150)
= 255 $kgCO_2eq$

② Emissions from purchased raw material Y
(Emissions from primary data for raw material Y) + (Emissions from the upstream emission factor for raw material Y)
= (Scope 1, 2, and 3 emissions of the relevant business unit of the supplier of raw material Y ($kgCO_2eq$) × Company A's quantity of raw material Y purchased (kg)/ Supplier's total raw material Y produced (kg)) + (Upstream emission factor for raw material Y ($kg/kgCO_2eq$) ×
Company A's quantity of raw material Y purchased (kg))
= ((500 + 100) × (200/2,000)) + (1.2 × 200)
= (600 ×0.1) + 240
= 300 $kgCO_2eq$

③ Emissions from purchased raw material Z
(Emissions from primary data for raw material Z)
= (Scope 1, 2, and 3 emissions of the relevant business unit of the supplier of raw material Z ($kgCO_2eq$)) × (Company A's quantity of raw material Z purchased / Supplier's total raw material Z produced (kg))
= {(700 + 500) × (500/3,000)}
= 1,200 × 0.167
= 200.4 $kgCO_2eq$

④ Sum of the above values
= (Emissions from purchased raw material X) + (Emissions from purchased raw material Y) + (Emissions from purchased raw material Z)
= 255 + 300 + 200.4
= 755.4 $kgCO_2eq$

c. Average-data method

- Company A, a semiconductor foundry, purchases chemicals and gases required for its production from multiple suppliers.
- Company A identifies the quantities purchased from each supplier through its internal procurement system, categorizes them by purchased item, and investigates upstream emission factors for each chemical and gas using a paid database as follows:

Purchased item	Quantity purchased (kg)	Emission factor ($kgCO_2eq/kg$)
Oxygen	300,000	0.126
Nitrogen	200,000	0.152
Ammonia	100,000	3.670
Argon	500,000	0.072

- Using the average-data method, the total emissions of the goods purchased by Company A are calculated as follows:

Σ((quantities of goods purchased (kg)) × (emission factor per purchased product ($kgCO_2eq/kg$)))

= (300,000 × 0.126) + (200,000 × 0.152) + (100,000 × 3.670) + (500,000 × 0.072)
= 471,200 $kgCO_2eq$

d. Spend-based method

- Company A, a semiconductor wafer manufacturer, purchases raw materials required for its production from multiple suppliers.
- Company A identifies the purchase cost from each supplier through its internal procurement system, categorizes the costs by purchased item, and investigates emission factors for each item using a paid LCI database as follows:

Purchased item	Purchase cost (USD)	Emission factor ($kgCO_2eq$/USD)
Silicon	50,000	1.2
Silicon-germanium (SiGe)	20,000	1.5
Glass	75,000	0.4

- Using the spend-based method, the total emissions of the goods purchased by Company A are calculated as follows:

Σ((Purchase cost (USD)) × (emission factor per purchased product ($kgCO_2eq$/USD)))

= (50,000 × 1.2) + (20,000 × 1.5) + (75,000 × 0.4)
= 120,000$kgCO_2eq$

4. Matters to Be Considered Upon Application

(Calculation complement) If the reporting entity cannot acquire primary data-based upstream emissions from its nth suppliers, it should complement the final emission calculation by using secondary data to apply the average-data or spend-based methods.

(Definition distinction) Emissions from capital goods should be reported as part of category 2 (capital goods) rather than category 1 (purchased goods and services). Capital goods are final goods that are not immediately consumed or further processed by the reporting entity and, instead, are used in their current form by the reporting entity to manufacture products, provide services, or sell, store, and deliver products. Intermediate goods are production inputs that require further processing, transformation, or inclusion in other goods or services before use by the end customer, in which case they should be analyzed as part of category 1. Due to the inherent characteristics of semiconductors, which contain metallic materials such as copper, tin, and gold, end-of-life semiconductor chips may be recycled or repaired to extract raw materials for resale. When purchasing products that contain recycled materials, the emissions associated with the original extraction of raw materials, subsequent production, and transportation related to the original manufacture of the end-of-life products must not be included in Scope 3 category 1 emissions.

(Category distinction) Fluorinated GHGs (F-gases), which are widely used in the semiconductor industry, have a high GWP and can have significant environmental impacts when released. Depending on the stage of the value chain in which the reporting entity operates, F-gas emissions should be reported under Scope 1 (e.g., for semiconductor manufacturers) or under Scope 3, category 1 (e.g., for electronics manufacturers using semiconductor chips).

02 Category 2 (Capital Goods)

1. Definition

Category 2 includes all upstream (cradle-to-gate) emissions from the production of capital goods purchased or acquired by the reporting entity in the reporting year. Capital goods refer to long-lived final products used by the company to manufacture products, provide services, or sell, store, and deliver products. In financial accounting, capital goods are treated as fixed assets (property, plant, and equipment). Examples of capital goods include equipment, machinery, buildings, facilities, and vehicles. However, emissions from the use of capital goods by the reporting entity, which are not upstream emissions, are accounted for under Scope 1 or Scope 2, not Scope 3.

2. Calculation Methodology

The calculation methodology is identical for category 1 (purchased goods and services) and category 2 (capital goods). Detailed guidance on calculating emissions in category 2 can be found in section 2. Calculation Methodology regarding category 1.

3. Calculation Examples by Methodology

The calculation examples for each methodology are identical for category 1 (purchased goods and services) and category 2 (capital goods). Detailed guidance on calculating emissions in category 2 can be found in the guidance in section 3. Calculation Examples by Methodology regarding category 1.

4. Matters to Be Considered Upon Application

(Definition distinction) In some cases, it may be ambiguous whether certain purchased goods fall under capital goods (reported in category 2) or purchased goods or services (reported in category 1). The reporting entity should follow its own financial accounting procedures to determine whether to consider these goods as capital goods or as purchased goods or services. It should avoid double-counting emissions under both categories 1 and 2.

(Additional reporting) The reporting entity should clarify that the emissions from capital goods may fluctuate from year to year. Unlike in financial accounting, where assets typically depreciate over their lifetime, Scope 3 requires that emissions from the production of capital goods be reported in the year of acquisition, without depreciation, discounting, or allocation over future periods. If major capital investments occur irregularly (e.g., once every few years), the reporting entity should acknowledge that the emissions from capital goods may be highly volatile from year to year and explain relevant matters.

03 Category 3 (Fuel- and Energy-Related Activities Not Included in Scope 1 or Scope 2)

1. Definition

Category 3 includes emissions related to the production of fuels and energy that are purchased and consumed by the reporting entity in the reporting year and that are not included in Scope 1 or Scope 2. Depending on the entity's activities, they are categorized into four types: upstream emissions of purchased fuels, upstream emissions of purchased electricity, transmission and distribution (T&D) losses, and the generation of purchased electricity that is sold to end users. The emissions from all activities pertinent to the reporting entity are summed to calculate its Scope 3 emissions in category 3 (fuel- and energy-related activities not included in Scope 1 or Scope 2).

- Among fuel- and energy-related emission activities, the category includes the following four types:

1) Upstream emissions of purchased fuels (activity A)
   - Emissions from extraction, production, and transportation of fuels consumed by the reporting entity
   - Applicable to the end users of fuels (e.g., mining of coal, refining of gasoline, transmission and distribution of natural gas, or production of biofuels)

2) Upstream emissions of purchased electricity (activity B)
   - Emissions from the extraction, production, and transportation of fuels consumed to generate electricity, steam, heating, and cooling that are consumed by the reporting entity
   - Applicable to the end users of electricity, steam, heating, and cooling (e.g., mining of coal, refining of fuels, or extraction of natural gas)

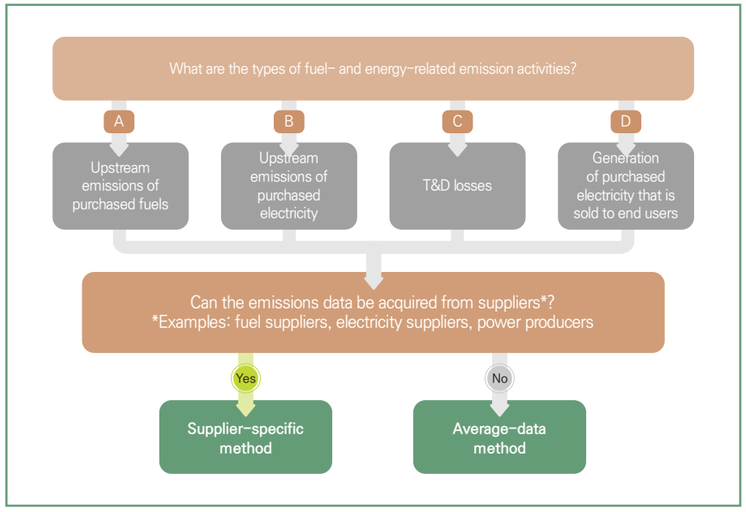
3) T&D losses (activity C)
   - Emissions from the generation (upstream activities and combustion) of electricity, steam, heating, and cooling lost in T&D systems and reported by end users
   - Applicable to the end users of electricity, steam, heating, and cooling

4) Generation of purchased electricity that is sold to end users (activity D)
   - Emissions from the production (upstream activities and combustion) of electricity, steam, heating, and cooling that are purchased by the reporting entity and sold to end users, and reported by utility companies or energy retailers
   - Applicable to activities especially relevant for utility companies that purchase wholesale electricity supplied by independent power producers for resale to their customers

2. Calculation Methodology

Two methods can be used to calculate the emissions from category 3 (fuel- and energy-related activities not included in Scope 1 or Scope 2): the supplier-specific and average-data methods. The applicable method might vary depending on the level of data available to the reporting entity. The method may be determined as shown in the following diagram. Within each methodology, the calculation formulas vary for each activity type (A, B, C, and D). The method may be determined as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification	Calculation formula	Description		
Activity A	Σ((fuel consumed) × (upstream fuel emission factor)) (upstream emission factor = (life-cycle emission factor) − (fuel-combustion emission factor))	a	Supplier-specific method	Collect upstream data from fuel suppliers regarding the fuels consumed by the reporting entity to estimate emissions. (Since emissions from fuel combustion fall under Scope 1, the life-cycle emission factors excluding them are applied.)
		b	Average-data method	Apply secondary emission factors (e.g., industry-average data) for upstream emissions per unit of the reporting entity's fuel consumption to estimate emissions.
Activity B	Σ((electricity, steam, heating, or cooling consumed) × (upstream electricity, steam, heating, or cooling emission factor)) (upstream emission factor = (life-cycle emission factor) − ((fuel combustion + T&D) emission factor))	a	Supplier-specific method	Collect upstream data from electricity suppliers regarding the electricity consumed by the reporting entity to estimate emissions. (T&D losses should be excluded from the upstream emission factor only if they have already been included in the life-cycle emission factor. Additionally, because emissions from fuel combustion fall under Scope 2, life-cycle emission factors excluding them are applied.)
		b	Average-data method	Apply secondary emission factors (e.g., industry average) for upstream emissions per unit of the reporting entity's electricity consumption to estimate emissions.
Activity C	Σ((electricity, steam, heating, or cooling consumed) × ((life-cycle emission factor for electricity, steam, heating, or cooling) × (T&D loss rate) (includes fuel combustion emissions)	a	Supplier-specific method	Collect T&D loss rate data from electricity suppliers for the reporting entity's grid consumption to estimate emissions. (Utility companies that own T&D systems report these as Scope 1 and Scope 2 emissions.)
		b	Average-data method	Apply the average T&D loss rate (e.g., national, regional, or global average) to estimate emissions.
Activity D	Σ((electricity, steam, heating, or cooling purchased for resale) × (electricity, steam, heating, or cooling emission factor))	a	Supplier-specific method	Collect GHG emissions data from power producers that have generated the purchased electricity to estimate emissions.
		b	Average-data method	Apply the average grid emission rate to estimate emissions.

3. Calculation Examples by Methodology[29)]

a. Supplier-specific method & b. Average-data method (activities A–D)

- Company A, a semiconductor foundry, operates corporations in four countries
- Company A purchases electricity and, in select regions, district heating to support its operations
- Company A collects primary data on all electricity purchased through its energy tracking system. It uses the average-data method to collect the emission factors for the extraction, production, and transportation of fuels consumed to generate electricity and heating, for the combustion of electricity and heating, and for its T&D losses. Here, the upstream emission factor is the life-cycle emission factor that excludes fuel combustion and T&D emission factors. The primary data and emission factors are as follows:

Country	Primary data		Average data			
	Electricity purchased (kWh)	District heating purchased (kWh)	Upstream factor of purchased electricity ($kgCO_2eq/kWh$)	Electricity/ heating combustion emission factor ($kgCO_2eq/kWh$)	T&D loss rate (%)	Upstream factor of purchased heating ($kgCO_2eq/kWh$)
China	4,000,000	70,000	0.11	0.9 (electricity) 0.3 (heating)	7 (electricity) 4 (heating)	0.04
Taiwan	300,000	50,000	0.12	0.5 (electricity) 0.1 (heating)	8 (electricity) 5 (heating)	0.05
USA	100,000	N/A	0.07	0.4 (electricity)	5 (electricity)	N/A
Germany	200,000	N/A	0.08	0.6 (electricity)	2 (electricity)	N/A

- Based on the collected data, the total emissions from fuel- and energy-related activities that are not included in Company A's Scope 1 or Scope 2 for the reporting year are calculated as shown below. In this calculation, upstream emissions for electricity and heating are already captured in activities A and B. Therefore, when calculating emissions for activity C, only the combustion emission factors are applied—not the full life-cycle emission factors.

29) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

① **Upstream emissions from purchased electricity (activity A)**

Σ(purchased electricity per country (kWh) × upstream emission factor of electricity purchased per country ($kgCO_2eq/kWh$))
(4,000,000 × 0.11) + (300,000 × 0.12) + (100,000 × 0.07) + (200,000 × 0.08)
= 499,000 $kgCO_2eq$

② **Life-cycle emissions from T&D losses of electricity/heating (activity C)**

Σ(purchased electricity or heating per country (kWh)) × upstream emission factor of electricity or heating purchased per country ($kgCO_2eq$/ kWh) × T&D loss rate (%))
(4,000,000 × 0.9 × 0.07) + (70,000 × 0.3 × 0.04) + (300,000 × 0.5 × 0.08) +
(50,000 × 0.1 × 0.05) + (100,000 × 0.4 × 0.05) + (200,000 × 0.6 × 0.02)
= 269,490 $kgCO_2eq$

③ **Upstream emissions from purchased heating (activity B)**

Σ(purchased heating per country (kWh) × upstream emission factor of heating purchased per country ($kgCO_2eq/kWh$))
(70,000 × 0.04) + (50,000 × 0.05)
= 5,300 $kgCO_2eq$

④ **Sum of the above values**

= (upstream emissions from purchased electricity) + (Life-cycle emissions from T&D losses of electricity and heating) + (upstream emission factor from purchased heating)
= 499,000 + 269,490 + 5,300
= 773,790 $kgCO_2eq$

4. Matters to Be Considered Upon Application

(Category distinction) The reporting entity should select transparent, disaggregated emission factors that allow separate accounting of emissions from electricity generation in Scope 2 and non-generation activities related to electricity in Scope 3.

(Data collection) To avoid double-counting emissions, the reporting entity should review whether T&D losses are already accounted for in the electricity-related emission factors it might use. The process endpoints regarding electricity-related emission factors may vary depending on the calculation entity's location and jurisdiction (e.g., overseas operations). For example, in Korea, the LCI DB defines the technical scope of electricity generation as a cradle-to-gate process—that is, from the acquisition of raw materials to product manufacturing. Therefore, the reporting entity should check the definitions of relevant emission factors to ensure accuracy.

(Reporting considerations) The reporting entity should disclose which Scope 2 methodology (market-based or location-based) it applied when calculating emissions related to fuel and energy production. Using market-based Scope 2 results to calculate category 3 emissions may reflect upstream emissions associated with renewable energy generation. In contrast, if category 3 emissions are based on location-based Scope 2 results, upstream emissions from the grid mix (e.g., natural gas, coal, etc.) should be included [30)]

30) This information is specified in Appendix B, *"Accounting for Energy-Related Emissions Throughout the Value Chain,"* of the GHG Protocol's Scope 2 guidance. Further detailed clarification will be needed following the planned revision of the Scope 2 guidance, scheduled for release in 2026.

04 Category 4 (Upstream Transportation and Distribution)

1. Definition

Category 4 includes emissions from transportation and distribution of products purchased or acquired by the reporting entity in the reporting year. It refers to transportation activities that use vehicles and facilities owned or operated by the reporting entity, as well as third-party transportation and distribution services purchased by the reporting entity ([Reference 1]). It includes Scope 1 and Scope 2 emissions from third-party transportation and distribution service providers.

[Reference 1]

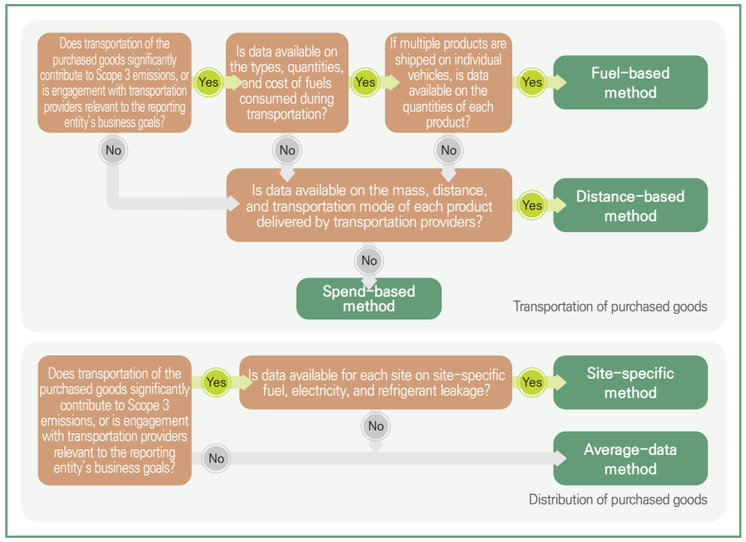
Examples of emissions from upstream transportation and distribution activities

- **Transportation and distribution between tier 1 suppliers and their own operations**
  (e.g., air, rail, road, or marine transport)
- **Third-party transportation and distribution among the reporting entity's own facilities**
  (e.g., air, rail, road, or marine transport)
- **Storage of purchased products in warehouses, distribution centers, and retail facilities**
  Logistically, transportation and distribution activities to sell the reporting entity's products generate downstream emissions, but they should be classified as upstream transportation and distribution emission activities if the reporting entity has purchased them

2. Calculation Methodology

Category 4 (upstream transportation and distribution) emissions are categorized into upstream transportation and upstream distribution and calculated separately based on the reporting entity's activities. Three methods (fuel-based, distance-based, and spend-based) may be used to calculate emissions from upstream transportation, while two methods (supplier-specific and average-data) may be used to calculate emissions from upstream distribution. The most appropriate method depends on the level of data available to the reporting entity, as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification			Calculation formula	Description
Transportation	a	Fuel-based method	Σ((quantity of fuel consumed) × (fuel emission factor)) + Σ((quantity of electricity consumed) × (electrical grid emission factor)) + Σ((quantity of refrigerant leakage) × (refrigerant emission factor)) (optional) + Σ((quantity of fuel consumed from unladen vehicle) × (emission factor for fuel)) ((quantity of fuel consumed from unladen vehicle) = (average efficiency of unladen vehicle) × (total distance traveled of unladen vehicle))	Determine the amount of fuel consumed (i.e., Scope 1 and Scope 2 emissions of transportation providers) and apply the fuel type's appropriate emission factor to calculate emissions. Additional energy consumption and fugitive emissions are also considered. The reporting entity may optionally include emissions from unladen backhaul. However, if the vehicle is not dedicated solely to transporting products purchased by the reporting entity, the reporting entity's emissions may be estimated by extrapolating only a portion of the total emissions using a reasonable method. If fuel data is not available, they may be supplemented by fuel expenditures or distance traveled ([Reference 2]).
	b	Distance-based method	Σ((mass of goods purchased) × (distance traveled by vehicle type in transport legs) × (emission factor of transport mode or vehicle type))	Determine the mass, distance, transport modes, and vehicle types, and apply the appropriate emission factor for the transport mode or vehicle type (the reporting entity's average fuel consumption, average utilization rate, average size, mass, or volume of products and vehicles, and their associated GHG emissions) to calculate emissions ([Reference 3]).
	c	Spend-based method	Σ((amount spent on transportation by type) × (EEIO emission factors per unit of economic value))	Determine the amount spent for each transport mode or vehicle type and apply the relevant EEIO emission factors to calculate emissions.
Distribution	d	Site-specific method	Σ((quantity of fuel consumed) × (fuel emission factor)) + Σ((quantity of electricity consumed) × (electrical grid emission factor)) + Σ((quantity of refrigerant leakage) × (refrigerant emission factor)) (Emissions are allocated based on the volume that the reporting entity's products occupy within storage facilities, and then the allocations across all storage facilities are summed.)	Collect fuel and energy data for each storage facility (e.g., warehouses, distribution centers) according to their specific distribution activities, and apply the appropriate emission factor to calculate emissions. However, if some storage facilities are not dedicated solely to storing the reporting entity's products, the reporting entity's emissions may be estimated by extrapolating only a portion of the total emissions using a reasonable method.
	e	Average-data method	Σ((volume of stored products) × (average number of days stored) × (emission factor for storage facility))	Estimate activity-specific emissions based on the average data (e.g., average emissions per warehousing capacity) for each distribution activity.

[Reference 2]

Fuel data estimation methods when fuel data is not available

- If fuel data is not available but the reporting entity wants to calculate emissions using the fuel-based method, the final emission calculation may be supplemented using the following formulas
- Calculating the quantity of fuel consumed from fuel expenditure: sum by fuel type, Σ(total fuel expenditure (e.g., KRW) / average fuel price (e.g., KRW/liter))
- Calculating the quantity of fuel consumed from distance traveled: sum by transport legs, Σ(total distance traveled (e.g., km) × fuel efficiency of the vehicle (e.g., liter/km)

[Reference 3]

Emission factors in the distance-based method

- For the distance-based method, the emission factors are typically indicated as gram or kilogram of CO_2eq per ton-km or TEU-km of products transported
- Ton-km: a measurement unit representing 1 ton of products traveling one kilometer
- TEU[31]-km: a measurement unit representing one 20-foot container of products traveling 1 kilometer

3. Calculation Examples by Methodology[32]

a. Fuel-based method (transportation)

- Company A, a semiconductor testing company, receives semiconductor packages produced by foundry companies B, C, and D. During this process, plating solutions are transported through a freight transportation service provider
- To calculate emissions from the upstream transportation of the manufactured semiconductor packages, for each production entity, Company A collects the following activity data and emission factors for the fuel consumed, as well as refrigerant leakage during the transportation of plating solution from the freight transportation service provider

Entity	Quantity of fuel consumed (liter, kWh for electric vehicles, or mass of refrigerant leakage (kg))	Fuel/ refrigerant type	Emission factor ($kgCO_2eq$/liter for fuels, $kgCO_2eq$/kWh for electricity, $kgCO_2eq$/kg for refrigerants)
B	5,000	Electric vehicle	0.5
C	60,000	Diesel	3
	100	Refrigerant R22	1,800[33]
D	70,000	Gasoline	2

- Using the fuel-based method, the emissions from the transportation of the semiconductor packages to Company A, engaged in back-end processing, are calculated as follows:

31) Twenty-foot equivalent unit: A unit based on the size of a 20-foot standard container that is used to compare capacity between transport modes.

32) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

33) For refrigerants, emission factors are estimated by applying GWPs to express emissions in CO_2 equivalents ($kgCO_2eq$/kg).

① Sum across fuel types:

Σ(quantity of fuel consumed (liters) × emission factor for the fuel ($kgCO_2eq$/liter))
=(quantity of diesel consumed × emission factor for diesel) + (quantity of gasoline consumed × emission factor for gasoline)
=(60,000 × 3) + (70,000 × 2)
= 320,000 $kgCO_2eq$

② Sum across electrical grid regions:

Σ(quantity of electricity consumed (kWh) × emission factor for the electrical grid ($kgCO_2eq$/kWh))
= 5,000 × 0.5
= 2,500 $kgCO_2eq$

③ Sum across refrigerant and air-conditioning types:

Σ(quantity of refrigerant leakage (kg) × GWP for the refrigerants ($kgCO_2eq$/kg))
= 100 × 1,800
= 180,000 $kgCO_2eq$

④ Sum of the above values

= (emissions from fuel consumed (diesel and gasoline)) + (emissions from electricity consumed by electric vehicles) + (emissions from refrigerant leakage)
= 320,000 + 2,500 + 180,000
= 502,500 $kgCO_2eq$

b. Distance-based method (transportation)

- Company A, a fabless semiconductor company, purchases wafers from its suppliers B, C, and D for outsourced manufacturing after completing semiconductor design
- Company A calculates the total distance traveled for the transportation of the basic goods and collects information on the vehicle type from its suppliers. In addition, Company A collects relevant emission factors from its life-cycle database. The activity data and emissions factors collected are as follows:

Supplier	Mass of products transported (tons)	Distance traveled (km)	Transport mode or vehicle type	Emission factor ($kgCO_2eq$/ton-km)
B	5	3,000	Rail	0.04
C	10	12,000	Air	1.3
D	8	8,000	Ship (container vessel)	0.01
E	7	2,000	Truck	0.2

- Using the distance-based method, the emissions from the upstream transportation of the wafers supplied to Company A are calculated as follows:

① Emissions from road transport

Σ(mass of purchased goods (tons) × distance traveled in road transport (km) × emission factor for road transport ($kgCO_2eq$/ton-km))
= (5 × 3,000 × 0.04) + (7 × 2,000 × 0.2)
= 3,400$kgCO_2eq$

② Emissions from air transport

Σ(mass of purchased goods (tons) × distance traveled in air transport (km) × emission factor for air transport ($kgCO_2eq$/ton-km))
= 10 × 12,000 × 1.3
= 156,000$kgCO_2eq$

③ Emissions from marine transport

Σ(mass of purchased goods (tons) × (distance traveled in marine transport (km) × emission factor for marine transport ($kgCO_2eq$/ton-km))
= 8 × 8,000 × 0.01
= 640$kgCO_2eq$

④ Sum of the above values

= (emissions from road transport) + (emissions from air transport) + (emissions from marine transport)
= 3,400 + 156,000 + 640
= 160,040$kgCO_2eq$

c. Spend-based method (transportation)

- Company A, a wafer manufacturer, procures polysilicon, a key raw material, from its suppliers B, C, and D
- To calculate emissions from the upstream transportation, Company A collects information from its internal financial accounting system on the total amount spent on raw material transportation and the types of vehicles used by its suppliers. In addition, Company A collects relevant emission factors through the relevant EEIO databases. The activity data and emission factors collected are as follows:

Supplier	Expenditure (USD)	Transport mode or vehicle type	EEIO emission factor ($kgCO_2eq$/USD)
B	10,000	Rail	0.7
C	20,000	Truck	0.9
	30,000	Air	3.1
D	25,000	Ship (container vessel)	2.4

- Using the spend-based method, the emissions from the upstream transportation by wafer manufacturing company A are calculated as follows:

① Emissions from road transport

Σ(amount spent on road transport leg (USD) × EEIO emission factor of transport mode or vehicle type ($kgCO_2eq$/USD))
= (10,000 × 0.7) + (20,000 × 0.9)
= 25,000 $kgCO_2eq$

② Emissions from air transport

Σ(amount spent on air transport leg (USD) × EEIO emission factor of transport mode or vehicle type ($kgCO_2eq$/USD))
= 30,000 × 3.1
= 93,000 $kgCO_2eq$

③ Emissions from marine transport

Σ(amount spent on marine transport leg (USD) × EEIO emission factor of transport mode or vehicle type ($kgCO_2eq/USD$))
= 23,000 × 2.4
= 55,200 $kgCO_2eq$

④ Sum of the above values

= (emissions from road transport) + (emissions from air transport) + (emissions from marine transport)
= 25,000 + 93,000 + 60,000
= 178,000 $kgCO_2eq$

d. Site-specific method (distribution)

- Company A, a PCB manufacturer for semiconductor components, places its products in two distribution centers located in Taiwan and China, where its production plants are based. The products are stored there for a short period (two months) before being distributed to customers with whom Company A has pre-arranged supply contracts.
- Company A collects data from its distribution center suppliers on fuel and electricity consumption for the reporting year, as well as the total capacity (e.g., volume) of the distribution facilities used to store its products. In addition, Company A collects emission factors from relevant databases. The activity data and emissions factors collected are as follows:

Distribution center	Electricity consumed (kWh/year)	Electricity emission factor ($kgCO_2eq/kWh$)	Natural gas consumed (kg)	Natural gas emission factor ($kgCO_2eq/kg$)	Total volume of Company A's goods in storage (m^3)	Total volume of goods stored in distribution centers (m^3)
X	15,000	0.5	800	0.25	100	1,000
Y	10,000	0.7	400	0.3	200	800

- Using the site-specific method, the emissions from the upstream distribution of PCB manufacturer A are calculated as follows:

① Emissions from distribution center X

((fuel consumed (kg) × fuel emission factor ($kgCO_2eq/kg$)) + (electricity consumed (kWh) × electricity emission factor ($kgCO_2eq/kWh$))) × (total volume of Company A's products in storage (m^3) / total volume of products stored in distribution centers (m^3)) × 2 month/12 months
= ((15,000×0.5) + (800×0.25)) × (100/1,000) × (2/12)
= 128.33 $kgCO_2eq$

② Emissions from distribution center Y (calculated using the same formula as in ①)

= {(10,000 × 0.7) + (400 × 0.3)} × (200/800) × (2/12)
= 296.67 $kgCO_2eq$

③ Sum of the above values

= (emissions from distribution center X) + (emissions from distribution center Y)
= 128.33 + 296.67
= 425 $kgCO_2eq$

e. Average-data method (distribution)

- Company A, a semiconductor foundry, stores its products in two distribution centers under short-term leases and ships them to assembly and packaging companies
- Company A collects data on the total capacity (e.g., volume) of the distribution centers from their lease contracts and average storage days of goods from its internal system. In addition, Company A collects the average emission factors on the warehousing capacity of the distribution centers from research papers. The activity data and emissions factors collected are as follows:

Distribution centers	Total volume of stored goods (m^3)	Average days stored (days)	Emission factors of distribution centers ($kgCO_2eq/m^3/day$)
X	10,000	3	0.01
Y	6,000	5	0.02

- Using the average-data method, the emissions from the upstream distribution of semiconductor foundry A are calculated as follows:

Emissions from upstream distribution

Σ(volume of stored goods (m^3) × number of days stored (days) × emission factor of distribution facility ($kgCO_2eq/m^3/day$))
= (10,000 × 3 × 0.01) + (6,000 × 5 × 0.02)
= 300 + 600
= 900 $kgCO_2eq$

4. Matters to Be Considered Upon Application

(Definition distinction) The reporting entity should calculate emissions for certain transportation and distribution activities by clearly separating them into upstream (category 4) and downstream (category 9) activities. All inbound and outbound transportation and distribution[34] services purchased by the reporting entity are upstream activities, whereas outbound transportation and distribution services not purchased by the reporting entity are downstream activities. Therefore, the reporting entity should establish accurate definitions of upstream and downstream transportation and distribution activities and manage the relevant data internally.

34) Since the service was purchased to support outbound logistics, it is classified and calculated as upstream even though it is an outbound transportation and distribution activity.

05 Category 5 (Waste Generated in Operations)

1. Definition

Category 5 includes emissions from the third-party disposal and treatment of waste that is generated in the operations owned or controlled by the reporting company in the reporting year ([Reference 1]). It includes all future emissions that are expected to occur due to waste generated in the reporting year. These can be derived from Scope 1 and Scope 2 emissions of third-party waste treatment providers not owned or operated by the reporting entity.

[Reference 1]

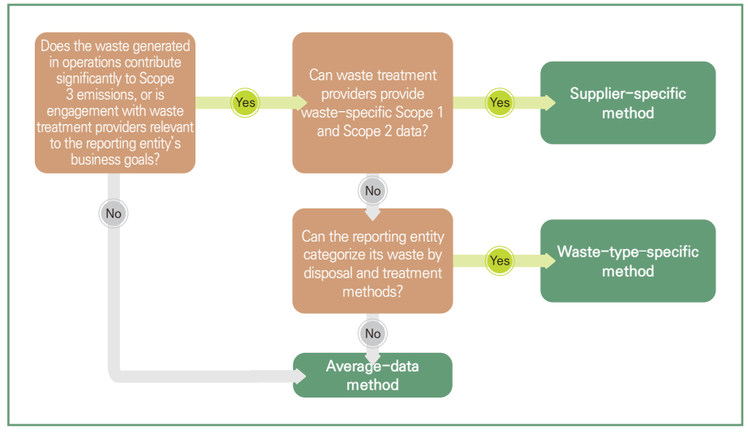
Examples of waste disposal and treatment activities

- Landfill
- Recovery for recycling
- Incineration
- Composting
- WtE to generate electricity
- (Optional) Emissions from the transportation of waste

2. Calculation Methodology

Three methods can be used to calculate emissions from category 5 (waste generated in operations): the supplier-specific, waste-type-specific, and average-data methods. The applicable method might vary depending on the level of data available to the reporting entity, as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Supplier-specific method	Σ((Scope 1 emissions from a waste treatment provider for waste allocated to the reporting entity) + (Scope 2 emissions from a waste treatment provider for waste allocated to the reporting entity))	Collect Scope 1 and Scope 2 emission data of the waste treatment provider for waste allocated to the reporting entity, and sum the emissions from all waste treatment methods of the reporting entity.
B	Waste-type-specific method	Σ((mass of waste generated) × (emission factor for waste type and treatment method))	Estimate emissions by categorizing among waste types and waste disposal methods and applying waste type-specific and waste treatment-specific emission factor. Emissions from the transportation of waste may be included in the emission factors.
c	Average-data method	Σ((total mass of waste) × (proportion of waste by treatment method (%)) × (emission factor by treatment method))	Estimate emissions based on the mass of waste generated, the treatment proportion of waste by each treatment method, and the average emission factor.

3. Calculation Examples by Methodology[35)]

a. Supplier-specific method

- Company A, a semiconductor foundry, operates production plants in both Korea and China. Waste generated at each plant is disposed of by waste treatment providers B and C, respectively
- These waste treatment providers measure the GHG emissions associated with the services they provide to all their clients. Company A collects Scope 1 and Scope 2 emissions from providers B and C for waste allocated to Company A in the reporting year. The collected emission data are as follows:

Entity	Location	Allocated Scope 1 emissions ($kgCO_2eq$)	Allocated Scope 2 emissions ($kgCO_2eq$)
B	Korea	13,000	2,500
C	China	8,000	1,500
D	Vietnam	11,500	3,000

- Using the supplier-specific method, the total emissions from waste generated by Company A's operations in the reporting year are calculated as follows:

Waste emissions using supplier-specific method

Σ(Scope 1 emissions from waste treatment providers for waste allocated to the reporting entity ($kgCO_2eq$) + Scope 2 emissions from waste treatment providers for waste allocated to the reporting entity ($kgCO_2eq$))
= (13,000 + 2,500) + (8,000 + 1,500) + (11,500 + 3,000)
= 39,500 $kgCO_2eq$

35) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

b. Waste-type-specific method

- Company A, a wafer manufacturer, generates a large volume of wastewater and byproducts during wafer manufacturing processes, such as cutting and cleaning. Through its own waste management system, it investigates the types of waste, the mass of waste generated by type, waste treatment methods, and emission factors for each treatment method as follows:

Waste type	Waste generated (tons)	Waste treatment method	Emission factor by waste type and treatment method ($kgCO_2eq/ton$)
Wastewater	8,000	Recycling	1.5
Plastics	1,000	Landfill	13
Scraps	3,000	Recycling	6
	5,000	Landfill	12.5

- Using the waste-type-specific method, the total emissions from waste generated by semiconductor foundry A's operations in the reporting year are calculated as follows:

Waste emissions using waste-type-specific method
Σ(mass of waste generated (ton or m^3) × emission factor by waste type and treatment method ($kgCO_2eq/ton$ or m^3))

= (8,000 × 1.5) +(1,000 × 13) +(3,000 ×6) + (5,000 × 12.5)
= 105,500 $kgCO_2eq$

c. Average-data method

- Company A, a transistor manufacturer, generates a large amount of waste during the transistor manufacturing process. It investigates the average waste types and average treatment proportions by type from a national public data system, as well as emission factors by waste treatment method from a national inventory, as follows.

Total waste generated (tons)	Waste treatment method	Proportion (%)	Emission factor by treatment method ($kgCO_2eq/ton$)
500	Recycling of non-ferrous metal waste	15	18
	Landfilling of scrap metal	75	12
	Incineration of waste glass	10	40

- Using the average-data method, the total emissions from waste generated by Company A's operations during the reporting year are calculated as follows:

Waste emissions using average-data method
Σ(total mass of waste (tons) × proportion of waste by treatment method (%) × emission factor by treatment method ($kgCO_2eq/ton$))

= (500 × 0.15 × 18) + (500 × 0.75 × 12) + (500 × 0.1 × 40)
= 7,850 $kgCO_2eq$

4. Matters to Be Considered Upon Application

(Reporting boundary) With demand for semiconductors expanding across diverse applications, production volumes are rising, leading to a proportional increase in manufacturing waste. Semiconductor fabrication processes, including wafer cutting, generate substantial wastewater and polishing by-products. Because these by-products often contain valuable metals such as cobalt and nickel, many companies are actively developing methods to recover and recycle them. As this trend continues, waste disposal—through both in-house facilities and external contractors—is expected to increase. When reporting emissions, entities must clearly classify waste managed internally versus waste handled by external treatment providers. This distinction must align with the selected organizational boundary approach to prevent double counting or omissions in reporting. In other words, the reporting entity's Scope 3 emissions should only include Scope 1 and Scope 2 emissions from the disposal and treatment of waste at facilities owned or operated by third parties, and include emissions from disposal at facilities owned or controlled by the reporting entity under Scope 1 or Scope 2, respectively.

(Data collection) Emissions generated during the recycling process are attributed to the purchase of recycled-content materials and therefore fall under category 1 or 2. Consequently, only emissions from the collection and transport of end-of-life materials should be included in category 5, while emissions from the recycling process itself should be excluded. However, some emission factors provided by third-party waste treatment providers may already include recycling-related emissions. In such cases, a reporting entity applying the waste-type-specific method or average-data method must either select emission factors that exclude recycling process emissions or adjust the total to deduct them. Furthermore, avoided emissions associated with recycling should not be included in, or deducted from, the Scope 3 inventory, but may instead be reported separately. To ensure transparency, the reporting entity should disclose the methodology, data sources, system boundaries, time period, and any assumptions applied when calculating avoided emissions.

06 Category 6 (Business Travel)

1. Definition

Category 6 includes emissions from the movement of employees for the reporting entity's business-related activities (hereinafter referred to as "business travel") in vehicles (e.g., airplanes, trains, buses, or automobiles) that are owned or operated by third parties ([Reference 1]). This category includes Scope 1 and Scope 2 emissions from companies that provide transportation for business travel (e.g., airlines or national railroads). However, it excludes emissions from business travel that uses vehicles owned or operated by the reporting entity.

[Reference 1]

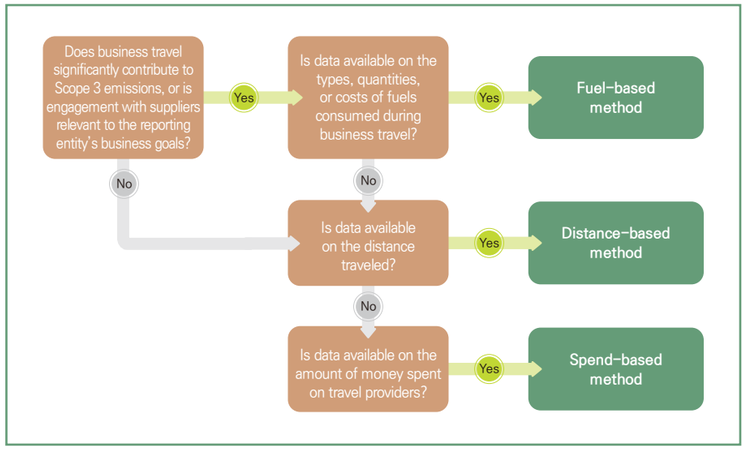
Examples of business travel emissions

- **Air travel**
- **Rail travel**
- **Bus travel**
- **Automobile travel** (e.g., business travel in rental cars or employee-owned vehicles)
- **(Optional) Business travelers' hotel stays**

2. Calculation Methodology

Three methods can be used to calculate emissions from category 6 (business travel): the fuel-based, distance-based, and spend-based methods. The most appropriate method depends on the level of data available to the reporting entity, as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Fuel-based method	Σ((quantity of fuel consumed) × (fuel emission factor)) + Σ((quantity of electricity consumed) × (electrical grid emission factor)) + Σ((quantity of refrigerant leakage) × (refrigerant emission factor))	Determine the quantities of fuels consumed during business travel and apply the appropriate emission factor for each fuel. This means the Scope 1 and Scope 2 emissions of the transportation providers. If fuel data is not available, the quantities of fuel consumed can be estimated from the fuel expenditures or distance traveled ([Reference 2]).
b	Distance-based method	Σ((distance traveled by vehicle type) × (vehicle-specific emission factor))	Determine the distance and vehicle type, and apply the appropriate emission factor for the vehicle. Calculate emissions based on the distance traveled and the transport mode.
c	Spend-based method	Σ((amount spent on transportation by type) × (EEIO emission factors per unit of economic value))	Determine the amount spent for each transport mode or vehicle type, and apply the relevant EEIO emission factors. Calculate emissions based on the type of business travel or the amount spent on each type of transportation.

[Reference 2]

Fuel data estimation methods when fuel data is not available

- If fuel data is not available but the reporting entity wants to calculate emissions using the fuel-based method, the final emission calculation can be supplemented using the following formulas
- Calculating the quantity of fuel consumed from fuel expenditure: sum by fuel type, Σ(total fuel expenditure (e.g., USD) / average fuel price (e.g., USD/liter))
- **Calculating the quantity of fuel consumed from the distance traveled: sum by transport legs,** Σ(total distance traveled (e.g., km) × fuel efficiency of the vehicle (e.g., liter/km)

3. Calculation Examples by Methodology[36)]

a. Fuel-based method

The calculation methodology is identical to that for category 4 (upstream transportation and distribution). For guidance on calculating emissions using the fuel-based method, please refer to the instructions in section 4.3.a (fuel-based method) regarding category 4.

b. Distance-based method

- Company A, a semiconductor manufacturer, sends representatives to domestic and international forums and seminars to analyze global semiconductor market trends and engage in technology exchange
- Company A collects activity data on travel distances and the type of transportation for each site visit using its internal business travel system. As a result, the following information was obtained:

36) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

Travel destination		Transport mode	Number of travelers (persons)	Travel distance (round trip, km)	Emission factor by transport mode ($kmCO_2eq$/person·vehicle-km)
Korea	Busan	KTX (Korea train express)	3	850	0.06
	Seoul	Taxi (Gasoline)	3	30	0.35
China	Shanghai	Airplane	2	1,650	0.15
USA	New York	Airplane	5	22,500	0.15
Türkiye	Istanbul	Airplane	5	17,000	0.15

- Using the distance-based method, the total emissions from Company A's domestic and international business travel to attend forums and seminars in the reporting year are calculated as follows:

① Emissions from road travel

Σ(distance traveled by vehicle type (vehicle-km) × vehicle-specific emission factor ($kgCO_2eq$/person·vehicle-km) × number of travelers)
= (travel using KTX to Busan) + (travel using taxi to Seoul)
= (850 × 0.06 x 3) + (30 × 0.35 x 3)
= 184.5 $kgCO_2eq$

② Emissions from air travel (calculated using the same formula as in ①)

= (travel using airplanes to Shanghai / New York / Istanbul)
= (1,650 × 0.15 × 2) + (22,500× 0.15 x 5) + (17,000 × 0.15 × 5)
= 30,120 $kgCO_2eq$

③ Sum of the above values

= (Emissions from road travel) + (Emissions from air travel)
= 184.5 + 30,120
= 30,304.5$kgCO_2eq$

c. Spend-based method

The calculation methodology is the same as for category 4 (upstream transportation and distribution), but some activity data capture the amount spent by type and mode of business travel. For guidance on calculating emissions using the spend-based method, see the guidance in section 4.3.c (spend-based method) regarding category 4 (upstream transportation and distribution).

4. Matters to Be Considered Upon Application

(Data collection) Depending on the destination of the business travel, transport emission factors may vary, and the transport mode may have a significant impact on emissions. Therefore, when using the distance-based method, the reporting entity should collect detailed activity data, including the actual countries visited and the transport mode, and reflect it in the final calculation to improve accuracy.

07 Category 7 (Employee Commuting)

1. Definition

Category 7 includes emissions from the commuting activities of employees between their homes and workplaces using transportation not owned or operated by the reporting entity ([Reference 1]). It includes Scope 1 and Scope 2 emissions from employees ([Reference 2]) and third-party transportation providers.

[Reference 1]

Examples of commuting emissions

- **Automobile travel**
- **Rail travel**
- **Other modes of transportation** (e.g., subway, bicycle, walking)
- **Bus travel**
- **Air travel**
- **(Optional) telecommuting of employees**

[Reference 2]

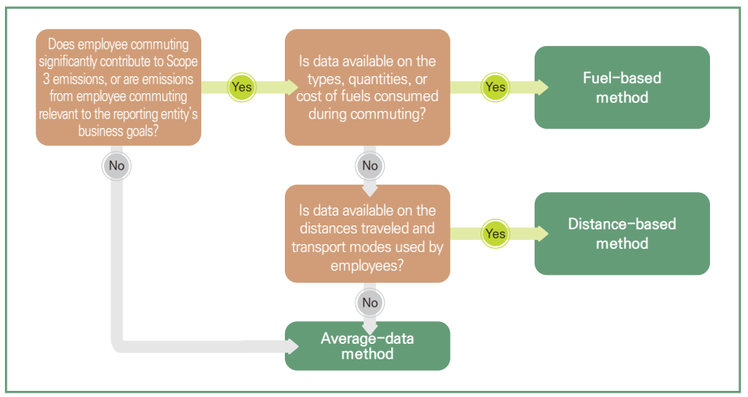
Scope of employees

- Employees of businesses and facilities owned, operated, or leased by the reporting entity
- **(Optional) Employees of other related entities of the reporting entity** (e.g., franchises or outsourced entities)
- **(Optional) Other individuals who are not employees of the reporting entity, such as consultants and contract workers, but who commute to facilities owned or operated by the reporting entity**

2. Calculation Methodology

Three methods can be used to calculate emissions from category 7 (employee commuting): the fuel-based, distance-based, and average-data methods. The most appropriate method depends on the level of data available to the reporting entity, as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Fuel-based method	Σ((quantity of fuel consumed) × (fuel emission factor)) + Σ((quantity of electricity consumed) × (electrical grid emission factor)) + Σ((quantity of refrigerant leakage) × (refrigerant emission factor))	Determine the quantities of fuels consumed while employees commute and apply the appropriate emission factor for the fuel. For public transportation, if the vehicle is not dedicated solely to transporting the reporting entity's employees, the reporting entity's emissions can be estimated by reflecting only a portion of the total emissions of public transportation using a reasonable method.
b	Distance-based method	Σ((distance traveled by vehicle type) × (vehicle-specific emission factor))	Collect data on commuting patterns (e.g., distance traveled and types of vehicles used) from the entity's employees, and apply the appropriate emission factor for the transport mode. If it is difficult to collect commuting data from all employees, appropriate sample techniques can be used to estimate patterns.
c	Average-data method	Σ((number of employees by transport mode) × (roundtrip commuting distance) × (commuting days per year) × (emission factor of transport mode))	Estimate emissions from employee commuting based on average data regarding employee commuting.

3. Calculation Examples by Methodology[37)]

a. Fuel-based method

The calculation methodology is identical to that for category 4 (upstream transportation and distribution). For guidance on calculating emissions using the fuel-based method, please refer to the instructions in section 4.3.a (fuel-based method) regarding category 4. However, when using the fuel-based method is used to calculate emissions from public transportation commuting, emissions from public transportation should be allocated to the employees.

b. Distance-based method

- Company A, a fabless semiconductor company, conducts a survey of approximately 280 employees at its research center to quantify emissions associated with employee commuting. Based on the survey results, employees' residential locations are classified into four zones. The commuting travel modes for each zone are identified and summarized as follows:

Residential zone	Average working days (days)	Average distance from the research center (km)	Transport mode	Number of employees (persons)	Emission factor by transport mode ($kgCO_2eq$/person·vehicle-km)
Zone A	220	3	Walking / bicycle	8	0
			Bus	10	0.089
Zone B		7	Bus	20	0.089
			Subway	32	0.156
			Automobile	18	0.508
Zone C		15	Bus	35	0.089
			Subway	25	0.156
			Automobile	40	0.508
Zone D		30	Bus	25	0.089
			Subway	22	0.156
			Automobile	45	0.508

37) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

- Using the distance-based method, the total emissions from employees commuting to Company A's research center in the reporting year are calculated as follows:

① Commuting emissions from residential zone A

Σ(average one-way distance from the research center (km) × 2 × average working days (day) × Emission factor by transport mode ($kgCO_2eq$/vehicle-km) × Number of employees by mode)
= (Commuting by walking/bicycle) + (Commuting by bus)
= (3 × 2 × 220 × 0 × 8) + (3 × 2 × 220 × 0.089 × 10)
= 1,174.8 $kgCO_2eq$

② Commuting emissions from residential zone B (calculated using the same formula as in ①)

= (Commuting by bus) + (Commuting by subway) + (Commuting by automobile)
= (7 × 2 × 220 × 0.089 × 20) + (7 × 2 × 220 × 0.156 × 32) + (7 × 2 × 220 × 0.508 × 18)
= 49,021.28 $kgCO_2eq$

③ Commuting emissions from residential zone C (calculated using the same formula as in ①)

= (Commuting by bus) + (Commuting by subway) + (Commuting by automobile)
= (15 × 2 × 220 × 0.089 × 35) + (15 × 2 × 220 × 0.156 × 25) + (15 × 2 × 220 × 0.508 × 40)
= 180,411 $kgCO_2eq$

④ Commuting emissions from residential zone D (calculated using the same formula as in ①)

= (Commuting by bus) + (Commuting by subway) + (Commuting by automobile)
= (30 × 2 × 220 × 0.089 × 25) + (30 × 2 × 220 × 0.156 × 22) + (30 × 2 × 220 × 0.508 × 45)
= 376,424.4 $kgCO_2eq$

⑤ Sum of the above values

= 1,174.8 + 49,021.28 + 180,411 + 376,424.4
= 607,031.48 $kgCO_2eq$

[Reference 3]

Examples of data to be collected through employee surveys

- Distance traveled daily by employees or location of residence and office
- Daily frequency of use for different modes of transport (e.g., subway, automobile, bus, train, bicycle)
- The number of commuting days per week and working days per year
- (For multinational companies) Residence and working regions of employees, since transport emission factors may vary depending on regional locations
- Whether there is a significant car-pooling scheme in operation, the proportion of employees using the scheme and the average occupancy per vehicle
- If applicable, the amount of energy used from teleworking (e.g., kWh of gas, electricity consumed)

c. Average-data method

- Company A, a semiconductor foundry, operates production plants in Korea, Taiwan, and China, and a local sales subsidiary in Germany, employing approximately 350 Korean and local employees. To calculate emissions from employee commuting at its production and sales subsidiary, Company A collects national statistics on commuting modes and average one-way commuting distances by country. Across all locations, the annual number of working days is assumed to be 220.

Country	Number of employees (persons)	Transport mode	Percentage of employees commuting by transport mode (%)	Average commuting distance (one way, km)	Emission factor ($kgCO_2eq$/vehicle-km)
Korea	200	Subway	60	15	0.1
		Automobile	15	10	0.3
		Walking	5	2	0.0
		Bus	20	15	0.1
Taiwan	80	Subway	35	20	0.1
		Automobile	15	10	0.3
		Walking	25	1	0.0
		Bus	25	12	0.1
China	100	Subway	30	20	0.1
		Automobile	10	10	0.3
		Walking	20	1	0.0
		Bus	40	15	0.1
Germany	40	Subway	70	15	0.1
		Automobile	5	7	0.3
		Walking	15	2	0.0
		Bus	10	13	0.1

- Using the average-data method, the total emissions from employee commuting at Company A's Korea and overseas subsidiaries in the reporting year are calculated as follows:

① Emissions from employee commuting at the production plant in Korea

Σ{(total number of employees) × ((proportion of employees using mode of transport (%)) × (one-way commuting distance (km)) × 2 × (emission factor of transport mode ($kgCO_2eq$/vehicle-km) × (working days per year)

= (subway) + (automobile) + (walking) + (bus)

(130 x 0.6 × 15 × 2 × 0.1 × 220) + (130 × 0.15 × 10 × 2 × 0.3 × 220) + (130 × 0.05 × 2 × 2 × 0.0 × 220) + (130 × 0.2 × 15 × 2 × 0.1 × 220)

= 94,380 $kgCO_2eq$

② Emissions from employee commuting at the production plant in Taiwan (calculated using the same formula as in ①)

= (80 × 0.35 × 20 × 2 × 0.1 × 220) + (80 × 0.15 × 10 × 2 × 0.3 × 220) + (80 × 0.25 × 1 × 2 × 0.0 × 220) + (80 × 0.25 × 12 × 2 × 0.1 × 220)

= 51,040 $kgCO_2eq$

③ Emissions from employee commuting at the production plant in China (calculated using the same formula as in ①)

= (100 × 0.30 × 20 × 2 × 0.1 × 220) + (100 × 0.10 × 10 × 2 × 0.3 × 220) + (100 × 0.20 × 1 × 2 × 0.0 × 220) + (100 × 0.40 × 15 × 2 × 0.1 × 220)

= 62,480 $kgCO_2eq$

④ Emissions from employee commuting at the sales subsidiary located in Germany (calculated using the same formula as in ①)

= (40 × 0.70 × 15 × 2 × 0.1 × 220) + (40 × 0.05 × 7 × 2 × 0.3 × 220) + (40 × 0.15 × 2 × 2 × 0.0 × 220) + (40 × 0.10 × 13 × 2 × 0.1 × 220)

= 22,616$kgCO_2eq$

⑤ Sum of the above values

= 94,380 + 51,040 + 62,480 + 22,616

= 230,516 $kgCO_2eq$

4. Matters to Be Considered Upon Application

(Data collection) When the reporting entity optionally calculates emissions from employee telecommuting, it should first establish baseline[38] emission levels and only consider only the additional emissions specifically attributable to telecommuting (e.g., energy consumed for air conditioning to create a comfortable environment). Emissions from telecommuting are calculated by multiplying the energy consumption by the emission factor for the energy source used.

(Category distinction) For commuting-related emissions from commuter buses provided by the reporting entity, emissions should be reported separately for buses owned and operated by the reporting entity and for those owned and operated by third parties. If the buses are owned by the reporting entity, the emissions are reported in Scope 1 and Scope 2 because the reporting entity uses purchased fuels and electricity directly to operate the buses. If the buses are owned by a third party, the third party's Scope 1 and Scope 2 emissions from operating commuter buses dedicated solely to the reporting entity's commuting activities are reported in the reporting entity's Scope 3 category 7 (employee commuting).

38) A baseline is a hypothetical scenario of GHG emissions that would have occurred in the absence of GHG projects or reduction activities. For category 7 (employee commuting), examples of baseline emissions include energy consumption from operating computers and monitors.

08 Category 8 (Upstream Leased Assets)

1. Definition

Category 8 includes emissions from the operation of assets that are leased from other entities by the reporting entity in the reporting year and not included in the reporting entity's Scope 1 or Scope 2 inventories ([Reference 1]). This category only applies to reporting entities that operate leased assets. The calculation of emissions from leased assets may vary depending on the type of lease and the consolidation approach (i.e., equity share, financial control, or operational control) used to define the reporting entity's organizational boundaries.

[Reference 1]

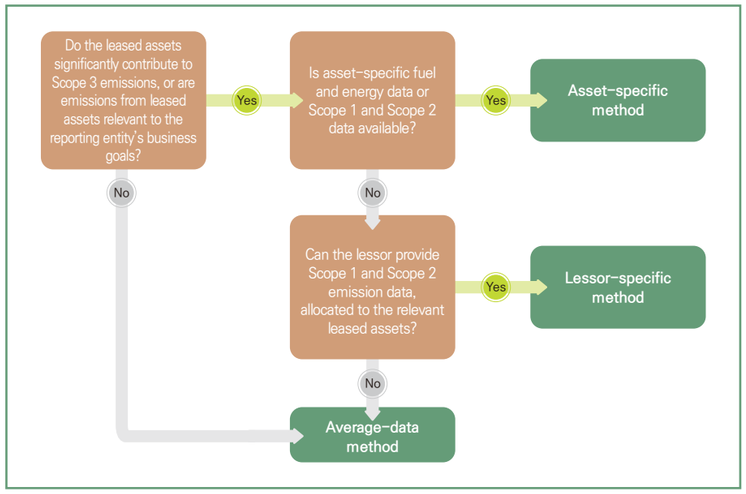
Examples of upstream leased asset emissions

- **Lessors' Scope 1 and Scope 2 emissions (e.g., emissions from energy consumption, emissions from transportation and distribution) during the operation of assets (e.g., vehicles, facilities) leased by the reporting entity and not included in the reporting entity's Scope 1 or Scope 2**
- **(Optional) Life-cycle emissions related to the manufacturing or construction of the leased assets**

2. Calculation Methodology

Three methods can be used to calculate emissions from category 8 (upstream leased assets): the asset-specific, lessor-specific, and average-data methods. The most appropriate method depends on the level of data available to the reporting entity, as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Asset-specific method	(Σ((quantity of fuel consumed) × (fuel-specific emission factor)) + Σ((quantity of refrigerant leakage) × (refrigerant emission factor)) + (process emissions)) + (Σ((quantity of electricity, steam, heating, or cooling consumed) × (emission factor for electricity, steam, heating, or cooling))	Collect asset-specific fuel and energy data, or Scope 1 and Scope 2 emission data, from individual leased assets, and sum the emissions from all leased assets of the reporting entity. If the reporting entity leases assets for which the lessee does not measure energy consumption separately, the energy consumption can be estimated from the building's gross floor area and total energy consumption ([Reference 2]).
b	Lessor-specific method	Σ((Scope 1 emissions of lessor) + (Scope 2 emissions of lessor)) × ((area and volume of the leased asset) ÷ (total area and volume of lessor's assets)) (i.e., (formula a) × (the reporting entity's occupancy rate))	Collect Scope 1 and Scope 2 emissions from the lessor and estimate emissions from the relevant leased asset by reflecting only a portion of the total emissions using a reasonable method ([Reference 2]).
c	Average-data method	Σ((gross floor area per building type) × (average emission factor per building type)) or Σ((number of leased assets) × (average emissions per leased asset type))	If purchase records, utility bills, and meter measurements regarding actual fuel or energy consumption are not available, emissions from each leased asset or groups of leased assets are estimated based on average statistics and secondary data (e.g., average emissions per asset type or square area), and emissions are summed from all leased assets of the reporting entity.

[Reference 2]

Estimation of the energy consumption of the reporting entity's leased assets if the lessor does not measure energy consumption separately per asset

If the lessor does not separately measure the energy consumption of each asset, the reporting entity may estimate the energy use of its leased assets by allocating a portion of the building's total energy consumption based on the ratio of the lessee's leased floor area to the building's total floor area, while also taking into account the building's occupancy rate. Accordingly, the energy consumption of the reporting entity's leased asset can be estimated using the following formula:

(energy consumption of leased assets) = (reporting entity's leased asset area (m^2) / building's gross floor area (m^2)) × (building's occupancy rate (%)) × (total energy consumption of the building (kWh))

3. Calculation Examples by Methodology[39)]

a. Asset-specific method

- Company A, a fabless semiconductor company, leases two floors of Building X and one floor of Building Y from lessor B. Building X is a 20-story building with a gross floor area of 120,000 m^2 and an occupancy rate of 85%, while Building Y is a 10-story building with 60,000 m^2 of gross floor area and a 70% occupancy rate.
- Company A collects data from the lessor on the total electricity and natural gas consumption of Buildings X and Y for the reporting year. The activity data and emission factors used for calculation are as follows:

39) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

Leased building	Area leased (m^2)	Electricity consumed (kWh)	Electricity emission factor ($kgCO_2eq/kWh$)	Natural gas consumed (kg)	Natural gas emission factor ($kgCO_2eq/kg$)
X	12,000	20,000	0.4	3,000	1.5
Y	6,000	10,000	0.4	1,800	1.5

- Using the asset-specific method, the total emissions from leased assets of Company A in the reporting year are calculated as follows:

① Emissions from electricity and natural gas allocated to Company A in Building X

{(reporting entity's area (m^2) / building's gross floor area (m^2)) × building's occupancy rate (%)} × {(building's total electricity consumed (kWh)) × electricity emission factor ($kgCO_2eq/kWh$)) + (building's total natural gas consumed (kg) × natural gas emission factor ($kgCO_2eq/kg$))}
= {(12,000 / 120,000) × 0.85} × {(20,000 × 0.4) + (3,000 × 1.5)}
= (0.1 × 0.85) × (8,000 + 4,500)
= 0.085 × 12,500
= 1,062.5 $kgCO_2eq$

② Emissions from electricity and natural gas allocated to Company A in Building Y (calculated using the same formula as in ①)

= {(6,000 / 60,000) × 0.7} × {(10,000 × 0.4) + (1,800 × 1.5)}
= (0.1 × 0.85) × (8,000 + 4,500)
= 0.07 × 6,700
= 469 $kgCO_2eq$

③ Sum of the above values

(Emissions from electricity and natural gas allocated to Company A in Building X) + (Emissions from electricity and natural gas allocated to Company A in Building Y)
= 1,062.5 + 469
= 1,531.5 $kgCO_2eq$

b. Lessor-specific method

- Company A, a wafer manufacturer, leases warehouse space for short-term wafer storage in Japan prior to export
- The space leased by Company A is 150 m^2, and the building's gross floor area is 20,000 m^2. Company A collects the total emissions data from lessor B for the entire building

Total building area (m^2)	Area leased (m^2)	Lessor's Scope 1 emissions ($kgCO_2eq$)	Lessor's Scope 2 emissions ($kgCO_2eq$)
2,000	150	7,500	3,000

- Using the lessor-specific method, the total emissions from Company A's leased assets in the reporting year are calculated as follows:

Leased asset emissions using lessor-specific method

Σ((Scope 1 emissions of lessor ($kgCO_2eq$) + Scope 2 emissions of lessor ($kgCO_2eq$)) × (area and volume of the leased asset (m^2) / total area and volume of the lessor's assets (m^2))
= (7,500 + 3,000) × (150/2,000)
= 787.5 $kgCO_2eq$

c. Average-data method

- Company A, a fabless semiconductor company, temporarily dispatches employees to its production contractor B in the US to inspect and validate semiconductor chips and leases a small office space for the duration
- Since Company A is unable to obtain activity data from the lessor to calculate electricity consumption and emissions for the leased space, it recognizes that the emission factor used might not be accurate. Accordingly, Company A refers to the average emission factor for office buildings, which is 83 $kgCO_2eq/m^2$ according to data from external academic sources (emission factors provided by Japan's Ministry of the Environment)
- Using the average-data method, the total emissions from leased assets of Company A in the reporting year are calculated as follows:

Leased asset emissions using average-data method

Σ(gross floor area per building type (m^2) × average emission factor per building type ($kgCO_2eq/m^2$))
= 1,500 × 83
= 124,500 $kgCO_2eq$

4. Matters to Be Considered Upon Application

(Category and definition distinction) To ensure the completeness of its disclosures and avoid double counting or omissions, the reporting entity should assess upstream leased assets that are not included in Scope 1 or Scope 2, based on its asset accounting system. Leased assets recognized as assets are reported in Scope 1 or Scope 2, regardless of the approach used for setting the reporting entity's organizational boundaries (i.e., equity share, financial control, or operational control). Leased assets not recognized as assets (e.g., short-term leases, leases of small capital assets) are reported in Scope 3 category 8 (upstream leased assets) if the equity share or financial control approach is used to set the organizational boundary, and in Scope 1 or Scope 2 if the operational control approach is used.

09 Category 9 (Downstream Transportation and Distribution)

1. Definition

Category 9 includes emissions from the transportation and distribution of sold products in vehicles and facilities not owned or operated by the reporting entity in the reporting year ([Reference 1]). It includes emissions only from the transportation and distribution of products after the point of sale. A reporting entity that sells intermediate products should report emissions from the products' transportation and distribution between the point of sale and either its end customers or its business customers, if the intermediate products' end use is known or may reasonably be estimated.

[Reference 1]

Examples of downstream transportation and distribution emissions

- **Storage of products for sale in warehouses, distribution centers, and retail facilities not owned or operated by the reporting entity**
- **Transportation and distribution between the reporting entity and retailers where the reporting entity does not pay for transportation**
  (e.g., air, rail, road, or marine transportation)
- **Transportation and distribution between retailers and customers**
  (e.g., air, rail, road, or marine transportation)

Although transportation and distribution activities for the sake of selling the reporting entity's products would usually generate downstream transportation and distribution emissions, the emissions should be classified as upstream transportation and distribution emissions if the reporting entity has purchased the products

2. Calculation Methodology

The calculation methodology is identical for category 4 (upstream transportation and distribution) and category 9 (downstream transportation and distribution). Detailed guidance on calculating emissions in category 9 can be found in the guidance in sections 4.2 and 4.3 regarding category 4.

3. Calculation Examples by Methodology

The calculation examples by methodology are identical for category 4 (upstream transportation and distribution) and category 9 (downstream transportation and distribution). Detailed guidance on calculating emissions in category 9 can be found in the guidance in section 4.3 regarding category 4.

4. Matters to Be Considered Upon Application

(Definition distinction) All inbound transportation and distribution and outbound transportation and distribution services purchased by the reporting entity are part of upstream activities (category 4) since the services are purchased for shipping logistics. However, outbound transportation and distribution services not purchased by the reporting entity fall under downstream activities (category 9). Therefore, the reporting entity should establish accurate definitions of upstream and downstream transportation and distribution activities and manage the relevant data internally when calculating emissions to ensure the completeness of its report.

10 Category 10 (Processing of Sold Products)

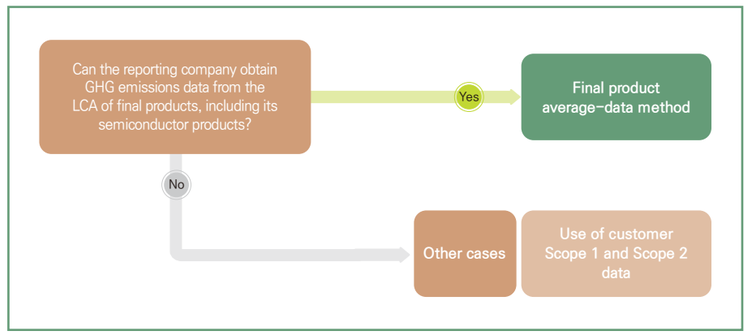
1. Description

Category 10 includes emissions from the processing of sold intermediate products by third parties (e.g., manufacturers) subsequent to sale by the reporting entity and before their use by end customers. Intermediate products are products that require further processing, transformation, or inclusion in other products before use. Even if the end use of the intermediate products is unknown, their emissions should be reported if they may reasonably be estimated.

2. Calculation Methodology

To calculate emissions under category 10 (processing of sold products), companies may apply the average-data method for final products. In practice, however, using the GHG Protocol's recommended site-specific method for intermediate products is often challenging, as tracking downstream energy consumption associated with their processing can be difficult. As an alternative, the reporting entity may estimate emissions by multiplying its customer's average LCA data with the quantity of intermediate products sold and then applying an appropriate physical or economic allocation. The applicable approach may vary depending on the level and quality of data available to the reporting entity, as illustrated in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification	Calculation formula	Description
Final Product – Average-data Method	Σ {(quantity of intermediate products sold) × (emission factor for processing of final products)} × (allocation factor of intermediate product)	The reporting entity allocates a portion of the GHG emissions from downstream processing, based on LCA results disclosed by customer companies, in proportion to the mass or value of intermediate products sold. Emission factors for the processing of final products should be derived from product-specific LCA data for the processing stages. ※ For further guidance on allocation, see subsection "1) Allocation" under "2. Methodologies for Application" in Chapter 4, "GHG Emissions Accounting and Methodologies for Application," Section II, "Building a Scope 3 Greenhouse Gas Inventory," of this guide

3. Calculation Examples by Methodology[40)]

a. Final product average-data method

- Company A, a semiconductor packaging company, sells semiconductor chips to electronics manufacturers X and Y. Company A obtains data on average processing-stage emissions from the LCA disclosures of customers X and Y. For customer X, Company A obtains the average weight of the final product, while for customer Y, it identifies the total purchase amount. Based on the fact that customers X and Y produce only laptops and smartphones, respectively, Company A uses its internal research data to determine the typical number of semiconductor chips embedded in laptops and smartphones. The data collected are as follows:

Customer	Semiconductor chips sold by Company A (units)	Avg. processing-stage emissions of final product ($kgCO_2eq$/unit)	Weight of Company A's semiconductor (kg/unit)	Avg. weight of final product of customer X (kg/unit)	Number of semiconductors per final product
X	150,000	230	0.14kg	1.6kg	10

Customer	Semiconductor chips sold by Company A |(units)	Avg. processing-stage emissions of final product ($kgCO_2eq$/unit)	Sales by Company A to customer Y (KRW 100M)	Total purchases by customer Y (KRW 100M)	Number of semiconductors per final product
Y	300,000	5	230,000	5,750,000	20

- Using the final product average-data method, the total processing emissions of the intermediate products sold by Company A are calculated as follows:

① Processing emissions from intermediate products sold to customer X

Σ{(mass of sold intermediate product (units) / semiconductors embedded per final product (units)) × emission factor for processing of final products ($kgCO_2eq$/unit))} x (weight ratio of intermediate product to final product)
= (150,000/10) × 230 × (0.14/1.6)
= 301,875 $kgCO_2eq$

40) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

② Processing emissions from intermediate products sold to customer Y

Σ {(mass of sold intermediate product (units) / semiconductors embedded per final product (units)) × (emission factor for processing of final products ($kgCO_2eq$/unit))} x (sales ratio of intermediate product)
= (300,000/20) × 5 × (230,000/5,750,000)
= 3,000 $kgCO_2eq$

③ Sum of the above values

(Processing emissions from intermediate products sold to customer X) +
(Processing emissions from intermediate products sold to customer Y)
= 301,875 + 3,000
= 304,875 $kgCO_2eq$

※ [Reference 1]

Alternative method
Use of customer's Scope 1 and 2 emissions

- It is recommended to prioritize the use of LCA-based processing emission factors by product category when calculating emissions under category 10. Although an increasing number of companies disclose product-specific environmental impact data, many still lack fully developed LCA processes. As a result, the average-data method for final products described in this guidance may not always be applicable. In such cases, estimating processing emissions using Scope 1 and Scope 2 emissions data disclosed by customer companies can serve as a practical alternative.
- However, allocating a customer's total Scope 1 and 2 emissions to the intermediate products sold by the reporting entity may capture emissions that are not directly related to the processing or production of the relevant final products. For this reason, the use of customer Scope 1 and 2 data should be treated strictly as substitute data, and reporting entities are advised to apply a conservative approach when using this method.

Σ (customer's Scope 1 and 2 emissions / customer annual revenue ($kgCO_2eq$/KRW)) × (sales to customer by the reporting entity (KRW))

If product-specific LCA-based processing emission factors are not available, an alternative approach is to divide the customer's Scope 1 and 2 emissions by their annual revenue to determine an emission factor per unit of revenue ($kgCO_2eq$/KRW). This factor can then be multiplied by the revenue earned from sales to that customer by the reporting entity

4. Matters to Be Considered Upon Application

(Allocation method) The GHG Protocol recommends both physical and economic allocation methods when allocating emissions for category 10 (processing of sold products) involving intermediate products. (See [Reference 4], subsection "1) Allocation" under "2. Methodologies for Application" in Chapter 4, "GHG Emissions Accounting and Methodologies for Application," Section II, "Building a Scope 3 Greenhouse Gas Inventory," of this guide.)

(Data collection) According to the GHG Protocol, upstream emissions from the fuel and electricity consumed during downstream processing of final products should be included. Therefore, the reporting entity should, whenever possible, confirm whether the customer's LCA-based processing emissions already incorporate upstream energy use, or whether they are limited to Scope 1 and Scope 2 emissions from direct manufacturing processes.

11 Category 11 (Use of Sold Products)

1. Definition

This category includes emissions from the use by end users (e.g., business customers, individual customers) of goods and services sold by the reporting entity in the reporting year. It includes the Scope 1 and Scope 2 emissions of end use. Use-phase emissions are classified into direct use-phase emissions from products that consume energy directly and indirect use-phase emissions from products that consume energy indirectly ([Reference 1]). Category 11 includes all emissions that are expected to occur in the future from products sold in the reporting year. The reporting entity may optionally report the indirect use-phase emissions of its sold products, and it is encouraged to report such emissions if they are expected to be significant.

If the reporting entity sells intermediate products, it can report emissions if these may reasonably be estimated, even though the end use of the intermediate products is unknown. Calculating use-phase emissions of sold products requires product design specifications and assumptions about how the end users may use these products, and the reporting entity should report both its calculation methods and its assumptions.

[Reference 1]

Examples of the use-phase emissions of sold products

- Direct emissions from products that directly consume energy (fuels or electricity) during use
- Direct emissions from fuels and feedstocks (e.g., petroleum, natural gas, coal, biofuels, crude oil)
- Direct emissions from products that form or emit GHGs during use (e.g., CO_2, CH_4, N_2O, refrigeration and air-conditioning equipment, industrial gases, fire extinguishers, fertilizers)
- (Optional) Indirect emissions from sold products (including intermediate products) that indirectly consume energy (fuels or electricity) during use over their expected lifetime
- (Optional) Emissions from the maintenance of sold products

2. Calculation Methodology

Two methods can be used to calculate emissions under category 11 (use of sold products): the fuel- or electricity-based method for intermediate products, and the average-data method for final products. The most appropriate method depends on the level of data available to the reporting entity. The method can be determined as shown in the following diagram.

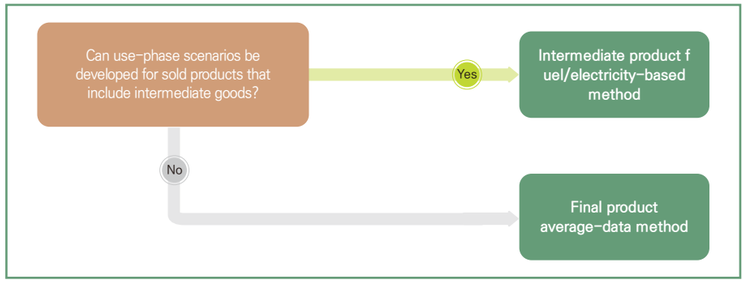
[Reference 2]

SCC Category 11 guideline

Following the release of its category 1 (purchased goods and services) guideline, the SCC published category 11 (use of sold products) guideline in June 2025.[41] Reporting entities can refer to this guidance and the SCC guidelines when calculating emissions for this category.

41) https://www.semi.org/en/blogs/technology-and-trends/semiconductor-climate-consortium-working-group-progress-and-carbon-disclosure-project-opportunities

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Intermediate product fuel/electricity-based method	Σ{(total lifetime expected uses of final product) × (annual usage days of final product) × (daily usage hours of final product)} × (quantity of intermediate products sold) × (fuel/electricity consumption of intermediate product per hour) × (fuel/electricity emission factor)}	Estimate the use-phase emissions by applying the fuel/electricity consumption of the intermediate product within the use scenario of the reporting company's final product. ※ The use scenario for the final product may be derived from secondary data. ※ Measured and tested values of hourly fuel/electricity consumption for the intermediate product provide more accurate estimates. If unavailable, allocation methods based on the final product may be considered.
b	Final product average-data method	Σ{(quantity of intermediate products sold) × (use-phase emission factor of final product) × (total lifetime expected uses of final product) × (allocation factor of intermediate product)} ※ If the final product use-phase emission factor already includes lifetime emissions, care should be taken to avoid double-counting	Identify final products produced using the sold intermediate products and estimate emissions using the LCA-based use-phase emissions of the final product. The reporting entity allocates a portion of the final product's use-phase emissions to itself based on the share represented by the intermediate product. ※ For further guidance on allocation, see subsection "1) Allocation" under "2. Methodologies for Application" in Chapter 4, "GHG Emissions Accounting and Methodologies for Application," Section II, "Building a Scope 3 Greenhouse Gas Inventory," of this guide

[Reference 3]

Variables for use scenarios based on the EPD

- If the intermediate product fuel- or electricity-based method is adopted, it is recommended that the reporting entity utilizes internally developed R&D-based use scenarios to produce more accurate estimates. Alternatively, secondary data, such as industry statistics, may be used.
- This guidance selects five representative semiconductor product categories from the environmental product declaration (EPD) guidelines, as shown in the table below. These use scenario variables may serve as reference data in Scope 3 emissions calculations. However, the reporting entity must disclose the specific use scenario applied in a transparent manner.

Product category	Use scenario	Days used per year	Expected lifetime
PC	Off mode 55%, sleep mode 5%, idle mode 40% daily	365 days	4 years
Laptop	Off mode 60%, sleep mode 10%, idle mode 30% daily	365 days	4 years
Smartphone	Daily use assuming full battery drain and recharge	365 charges	3 years
Tablet PC	Daily use assuming full battery drain and recharge	365 charges	3 years
Television	4 hours in active mode, 20 hours in standby mode daily	365 days	7 years

(Source: Ministry of Environment (2024), EPD guidelines [Annex 4], [Annex 5])

3. Calculation Examples by Methodology[42)]

Intermediate product fuel/electricity-based method (1) – When intermediate product energy use can be identified

- Company A, a semiconductor foundry, sells semiconductor package products X and Y, each designed for different end-use applications
- Company A measures the hourly electricity consumption of products X and Y through in-house testing. Based on the use scenarios provided in the EPD guidelines, it determines the expected lifetime and annual operating days of the final products (smartphones and PCs) in which the sold intermediate products are applied. Using statistical data, Company A also collects information on the average daily operating hours of these final products. The activity data and emission factors are as follows:

Package product	End-use application of final product	Intermediate products sold (units)	Electricity consumed by intermediate products per hour (kWh)	Electricity emission factor ($kgCO_2eq/kWh$)
X	Mobile	5,000	0.11	0.09
Y	PC	3,000	0.13	0.09

Final product	Expected lifetime (years)	Days used per year (days)	Hours used per day (hours)
Smart phone	3	365	5
PC	4	365	5

- Using the intermediate product fuel/electricity-based method, the total use-phase emissions from the semiconductor packages sold by Company A are calculated as follows:

① Use-phase emissions from intermediate products used in X

Σ{(total lifetime expected uses of final product (years)) × (annual usage days of final product)} × (daily usage hours of final product) × (quantity of intermediate products sold) x (fuel/electricity consumption of intermediate product per hour (kWh)) × (fuel/electricity emission factor ($kgCO_2eq/kWh$))}
= 3 × 365 × 5 × 5,000 × 0.11 × 0.09
= 271,012.5 $kgCO_2eq$

② Use-phase emissions from intermediate products used in Y (calculated using the same formula as in ①)

= 4 × 365 × 5 × 3,000 × 0.13 × 0.09
= 256,230$kgCO_2eq$

③ Sum of the above values

= (Use-phase emissions from intermediate products used in X) + (Use-phase emissions from intermediate products used in Y)
= 271,012.5 + 256,230
= 527,242.5$kgCO_2eq$

42) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

b. Intermediate product fuel/electricity-based method (2) – When intermediate product energy use cannot be identified

- Company A, a semiconductor packaging company, produces 300,000 computer-use semiconductor packages in the reporting year, which are supplied to customer B for use in PCs. Company A initially intends to calculate category 11 emissions by applying the electricity consumption of the semiconductor package to the use scenarios of final products provided in the EPD guidelines. However, Company A encountered limitations in obtaining electricity consumption data for each operational mode of the computer under typical daily use scenarios
- As a result, Company A decided to allocate the electricity consumption of the final product (i.e., the computer) based on the weight ratio of the semiconductor package. The average weight of the semiconductor package sold by Company A is 0.2 kg per unit, while the average weight of the PCs produced by customer B is 1.2 kg per unit. (It is confirmed that each computer contains one semiconductor package.) Additionally, mode-specific daily electricity consumption of the final product is estimated using secondary data obtained through industry research

Product	Expected lifetime (years)	Days used per year (days)	Daily use scenario (hours)		Electricity consumed (kWh)
PC	4	365	Off mode	13.2 hours (55%)	0.001
			Sleep mode	1.2 hours (5%)	0.003
			Idle mode	9.6 hours (40%)	0.06

- Using the intermediate product fuel/electricity-based method, the total use-phase emissions from the semiconductor packages sold by Company A are calculated as follows:

① Electricity consumption emissions from the final product (PC):

(total lifetime expected uses of final product (years)) x (annual usage days of final product) × Σ{(daily usage hours by mode under the daily use scenario of the final product) x (hourly electricity consumption of the final product by mode (kWh/hour))} × (electricity emission factor ($kgCO_2eq/kWh$)
= 4 × 365 × {(13.2 x 0.001) + (1.2 x 0.003) + (9.6 × 0.06)} × 0.4781
= 413.789 $kgCO_2eq$

② Allocated emissions for the intermediate product (semiconductor package)

= ① × (0.2/1.2)
= 69.103 $kgCO_2eq$

③ Total use-phase emissions from all intermediate products sold

= ② x 300,000
= 20,730,870 $kgCO_2eq$ (= 20,730.8 tCO_2eq)

c. Final product average-data method

- Company A, a semiconductor packaging and testing company, sells semiconductor package products to customers B and C, which are electronics manufacturers. Using its internal research data, Company A identifies the electricity consumption of its semiconductor packages and, from the publicly disclosed data of customers B and C, obtains information on the use-phase LCA emissions and electricity consumption of the final products over their expected lifetime. It is also confirmed through customers B and C that each final product contains one semiconductor package from Company A

Customer	Semiconductor packages sold by Company A (units)	Electricity consumption of Company A's semiconductor packages (kWh)	Life cycle emissions of final product ($kgCO_2eq$/unit)	Electricity consumption of final product (kWh)
B	50,000	1.5	32	16.5
C	100,000	0.5	12.5	8

- Using the final product average-data method, the use-phase emissions from the semiconductor packages sold by Company A are calculated as follows:[43]

① Use-phase emissions from intermediate products sold to customer B

Σ{(quantity of intermediate products sold (units)) × (Use-phase emission factor of final product ($kgCO_2eq$/unit))} x (Electricity consumption ratio of intermediate product[43]
※ Since the final product's use-phase emission factor already accounts for lifetime emissions, no further multiplication by lifetime usage is required
= 50,000 × 32 × (1.5 /16.5)
= 145,454.5 $kgCO_2eq$

② Use-phase emissions from intermediate products sold to customer C (calculated using the same formula as in ①)

= 100,000 × 12.5 × (0.5 /8)
= 78,125 $kgCO_2eq$

③ Sum of the above values

= (Use-phase emissions from intermediate products sold to customer B) + (Use-phase emissions from intermediate products sold to customer C)
= 145,454.5 + 78,125
= 223,579.5$kgCO_2eq$

4. Matters to Be Considered Upon Application

(Allocation method) The GHG Protocol recommends both physical and economic allocation methods when allocating emissions for category 11 (use of sold products) involving intermediate products. (See [Reference 4], subsection "1) Allocation" under "2. Methodologies for Application" in Chapter 4, "GHG Emissions Accounting and Methodologies for Application," Section II, "Building a Scope 3 Greenhouse Gas Inventory," of this guide.)

43) The energy allocation method, one of the allocation approaches provided in the GHG Protocol, was applied.

12 Category 12 (End-of-Life Treatment of Sold Products)

1. Definition

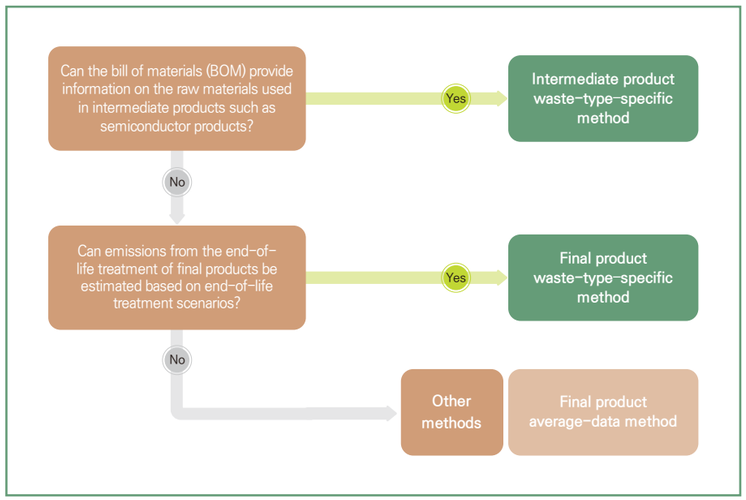
This category includes emissions from the waste disposal and treatment of products sold by the reporting entity in the reporting year at the end of their life. It includes disposal emissions expected to occur in the future from all products sold in the reporting year.

Calculating emissions from the end-of-life treatment of sold products requires assumptions about how end users dispose of and treat the products. The reporting entity should report both its calculation methods and its assumptions. If the reporting entity sells intermediate products, it should report emissions from the disposal of the intermediate products, not their related final products.

2. Calculation Methodology

Three calculation methodologies can be applied to estimate category 12 (end-of-life treatment of sold products) emissions from intermediate products, such as those used in the production of various semiconductor final products. The methodologies consist of the intermediate product waste-type-specific method, the final product waste-type-specific method, and the final product average-data method. The appropriate methodology should be selected based on the level and quality of data available to the reporting entity, as illustrated in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Intermediate product waste-type-specific method	Σ{(weight of each raw material in the intermediate product) × (quantity of intermediate products sold) × Σ ((% of each waste treatment method by raw material) × (emission factor of waste treatment method))}	Identify the raw materials of the intermediate products sold by the reporting entity using the BOM, determine the waste treatment method for each raw material, and apply the relevant emission factor to estimate emissions.
b	Final product waste-type-specific method	Σ {(weight of intermediate product) × (quantity of intermediate products sold) × Σ((% of final product-specific waste treatment method) × (emission factor of waste treatment method))}	Identify final products manufactured using the reporting entity's intermediate products, then calculate the reporting entity's share of end-of-life emissions by applying the proportion of final product-specific waste treatment methods and the share of intermediate products used in each final product. (The reporting entity should establish end-of-life treatment scenarios for estimating the proportions of each final product's waste-type-specific method, utilizing recycling categories and waste treatment proportions based on the classification of final products. See [Reference 1] and [Reference 2]).

[Reference 1]

Final product waste-type-specific method – development of end-of-life treatment scenario using secondary data

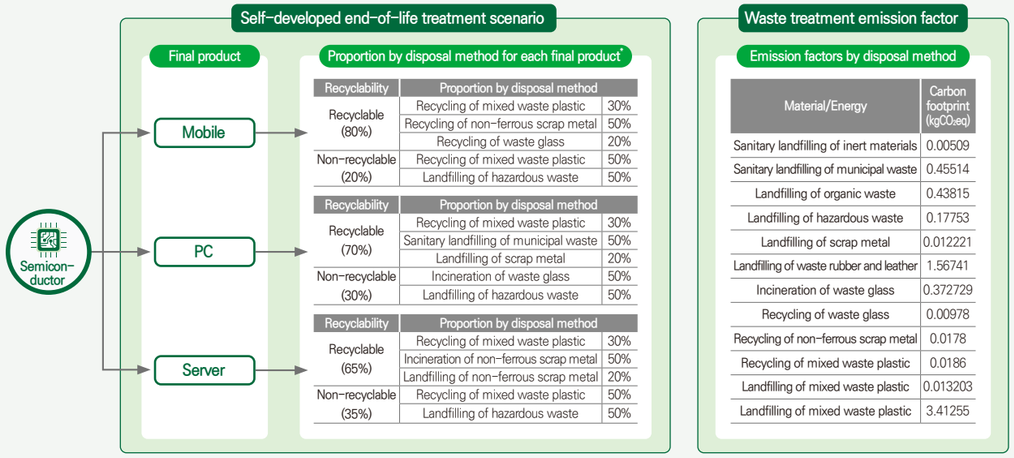
If the reporting entity is unable to identify raw material data through the BOM, it may instead estimate its share of disposal-stage emissions from the final products that incorporate its intermediate products. Because manufacturers of intermediate products typically have limited access to detailed information about final products, they may establish end-of-life treatment scenarios using secondary data sources, such as industry statistics and academic literature.

Procedure and references for end-of-life treatment scenario development		
1	Classification of final products	The reporting entity may refer to the major product groups of its customer companies that purchase its products, as well as secondary data such as statistical sources and research papers.
2	Recycling rates by final product	If the final product group falls under Article 2 of the *Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles* – namely, machines or apparatuses that generate, transfer, transmit, or measure electric current or electromagnetic fields (including components and accessories) – the reporting entity may establish its own scenario in compliance with the Enforcement Rule of the Act specified in Annex 1, Methods and Criteria for Recycling by Product Group (Article 5).
3	Proportion by disposal method	If the proportion of disposal method is unknown, the reporting entity may refer to the national waste generation and treatment statistics published annually by the Ministry of Environment.
4	Application of emission factors by disposal method	Emission factors by disposal method in the EPD within the National LCI DB provided by the KEITI can be used.
5	Derivation of final product specific-waste treatment emission factors	The reporting entity can derive final product specific-waste treatment emission factors based on its developed scenarios or on data collected from industry statistics and academic references.

[Reference 2]

Example of a self-developed end-of-life treatment scenarios based on final-product waste-type-specific method

Given the wide range of end-use applications for semiconductors—from smartphones, PCs, and servers to other consumer electronics—the reporting entity should define final product categories that encompass its major product groups and develop internal disposal scenarios for each category. It may then identify the final products in which its intermediate products are used, establish end-of-life treatment scenarios with assumed disposal method proportion for each category, and estimate disposal-phase emissions using the relevant emission factors.



* The figures showing recycling classifications and proportion by disposal methods for each final product are provided for illustration purposes only. Emission factors for each waste treatment method are derived from those provided in the EPD.

3. Calculation Examples by Methodology[44)]

a. Intermediate product waste-type-specific method

- Company A, a semiconductor foundry, produces 100,000 units of memory semiconductors in the reporting year, each weighing 80 g. Based on its BOM, Company A collected data on the raw materials used to manufacture the semiconductors and, using internally developed research data, established its own scenario for the proportion of waste treatment methods by component, as shown below
- The emission factors for each waste disposal method are derived from EPD assessment factor data provided by the KEITI

Compo-nent	Weight (kg)	Recyclability		Waste treatment method		Waste treatment emission factor ($kgCO_2eq/kg$)
		Type	Proportion (%)	Type	Proportion (%)	
X	0.01	Recyclable	30	Recycling of mixed waste plastic	100	0.0186
		Non-recyclable	70	Incineration of waste glass	50	0.3728
				Landfilling of scrap metal	50	0.0122
Y	0.03	Non-recyclable	100	Landfilling of scrap metal	100	0.0122
Z	0.04	Non-recyclable	100	Landfilling of organic waste	100	3.4126

44) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

- Using the intermediate product waste-type-specific method, the waste treatment emissions from the wafers produced by Company A are calculated as follows:

① Waste treatment emissions from component X

Weight of component X (kg) × quantity of intermediate products sold (units) × Σ {(proportion of waste treatment method for component X (%)) × (emission factor of waste treatment method ($kgCO_2eq/kg$))}
= (0.01 × 100,000 × {(0.3 ×1.0 ×0.0186) + (0.7 ×0.5 × 0.3728) + (0.7 ×0.5 × 0.0122)}
= 1,000 × (0.00558 + 0.13048 + 0.00427)
= 140.33 $kgCO_2eq$

② Waste treatment emissions from component Y (calculated using the same formula as in ①)

= (0.03 × 100,000) × (1.0 ×1.0 × 0.0122)
= 3,000 × 0.0122
= 36.6 $kgCO_2eq$

③ Waste treatment emissions from component Z (calculated using the same formula as in ①)

= (0.04 × 100,000 × (1.0 ×1.0 × 0.4382)
= 4,000 × 0.4382
= 1,752.8 $kgCO_2eq$

④ Sum of the above values

= (Waste treatment emissions from component X) + (Waste treatment emissions from component Y) + (Waste treatment emissions from component Z)
= 140.33 + 36.6 + 1,752.8
= 1,929.73$kgCO_2eq$

b. Final product waste-type-specific method

- Company A, a semiconductor foundry subcontractor for customer B, an electronics manufacturer, produces 500,000 units annually of semiconductor X for tablets (50 g each) and 1,000,000 units annually of semiconductor Y for smartphones (30 g each), upon B's requests
- Company A confirms with customer B that one unit of its semiconductor is embedded in each final product and obtains the average weight of B's tablets and smartphones from B's publicly disclosed material
- Using various statistical and academic publications, Company A investigates waste treatment methods for smartphones and PCs and develops its own end-of-life treatment scenarios, as shown below

Final product	Weight of Company A's semi-conductor (g)	Semicon-ductor sold by Company A (units)	Avg. weight of final product (g)	Recyclability		Waste treatment method		Waste treatment emission factor ($kgCO_2eq/kg$)
				Type	Proportion (%)	Type	Proportion (%)	
X	50	500,000	400	Recyclable	80	Recycling of mixed waste plastic	100	0.0186
				Non-recyclable	20	Landfilling of mixed waste plastic	20	0.0132
						Incineration of mixed waste plastic	80	3.4126
Y	30	1,000,000	200	Recyclable	70	Recycling of mixed waste plastic	100	0.0186
				Non-recyclable	30	Landfilling of mixed waste plastic	40	0.0132
						Incineration of mixed waste plastic	60	3.4126

- Using the final product waste-type-specific method, the end-of-life waste treatment emissions for Company A's semiconductors are calculated by allocating the emissions from the final products in which the semiconductors are embedded, as follows:

① Intermediate product emissions allocated from the end-of-life waste treatment emissions of final product X

{(weight of intermediate product (kg) × quantity of intermediate product sold(unit)) × Σ{(proportion of final product-specific waste treatment method (%)) × (emission factor of waste treatment method ($kgCO_2eq/kg$))} × mass-based allocation factor
= (0.05 ×500,000) × {(0.8 ×1.0 ×0.0186) + (0.2 ×0.2 × 0.0132) + (0.2 ×0.8 × 3.4126)} × (0.05/0.4)
= 25,000 × (0.01488 + 0.00053 + 0.54602) × 0.125
= 1,754.45 $kgCO_2eq$

② ntermediate product emissions allocated from the end-of-life waste treatment emissions of final product Y ((calculated using the same formula as in ①))

= (0.03 ×1,000,000) × {(0.7 ×1.0 ×0.0186) + (0.3 ×0.4 × 0.0132) + (0.3 ×0.6 × 3.4126)} × (0.03/0.2)
= 30,000 × (0.01302 + 0.00158 + 0.61427) × 0.15
= 2,829.92 $kgCO_2eq$

③ Sum of the above values

= (Intermediate product emissions allocated from the end-of-life waste treatment emissions of final product X) + (Intermediate product emissions allocated from the end-of-life waste treatment emissions of final product Y)
= 1,754.45 + 2,829.92
= 4,584.37 $kgCO_2eq$

[Reference 3]

Alternative methodology
Application of the final product average-data method

When calculating category 12 emissions, it is recommended to prioritize the intermediate product waste-type-specific method or the final product waste-type-specific method. However, if sufficient data is not available to apply these methodologies, an alternative approach can be adopted. In such cases, the final product average-data method enables the reporting entity to estimate its share of end-of-life emissions by using LCA-reported waste treatment emissions disclosed by companies that manufacture and sell the final products incorporating its intermediate products.

Σ((quantity of intermediate products sold) × (final product-specific waste treatment emission factor))

* Final product-specific waste treatment emission factor = (end-of-life emissions from the LCA of each final product) × (allocation factor for intermediate product)

4. Matters to Be Considered Upon Application

(Allocation method) The GHG Protocol recommends using both physical and economic allocation methods when allocating emissions for category 12 (end-of-life treatment of sold products) involving intermediate products. (See [Reference 4], subsection "1) Allocation" under "2. Methodologies for Application" in Chapter 4, "GHG Emissions Accounting and Methodologies for Application," Section II, "Building a Scope 3 Greenhouse Gas Inventory," of this guide.)

13 Category 13 (Downstream Leased Assets)

1. Definition

Category 13 includes emissions from the operation of assets that are owned by the reporting entity, leased to other entities in the reporting year that are not already included in Scope 1 and Scope 2 inventories ([Reference 1]). This category only applies to reporting entities that own leased assets and receive payments from lessees. The calculation of emissions from leased assets may vary depending on the type of lease and the consolidation approach (i.e., equity share, financial control, or operational control) used to define the reporting entity's organizational boundaries.

[Reference 1]

Examples of downstream leased asset emissions

- **Lessees' Scope 1 and Scope 2 emissions** (e.g., emissions from energy consumption) **during the operation of assets that are owned by the reporting entity and leased to other entities**
- **(Optional) Life-cycle emissions related to the manufacturing or construction of the leased assets**

2. Calculation Methodology

The calculation methodology is identical for category 8 (upstream leased assets) and category 13 (downstream leased assets). Detailed guidance on calculating emissions in category 13 can be found in the guidance in section 8.2 regarding category 8.

3. Calculation Examples by Methodology

The calculation examples by methodology are identical for category 8 (upstream leased assets) and category 13 (downstream leased assets). Detailed guidance on calculating emissions in category 13 can be found in the guidance in section 8.3 regarding category 8.

4. Matters to Be Considered Upon Application

(Category and definition distinction) To avoid double counting or omissions and to ensure the completeness of its disclosures, the reporting entity should review downstream leased assets not included in Scope 1 or Scope 2 based on its asset accounting system. In addition, if there is no meaningful distinction between products sold to customers (category 11) and products leased to

customers (category 13), the reporting entity may account for products leased to customers and sold products in the same way and report them in category 11 (use of sold products). In this case, while ensuring that emissions are not double-counted, the reporting entity may calculate emissions by accounting for the total expected lifetime emissions of all relevant products leased to other entities in the reporting year.

14 Category 14 (Franchises)

1. Definition

Category 14 includes emissions from the reporting entity's operation of franchises in the reporting year that are not part of its Scope 1 and Scope 2 inventories ([Reference 1]). This category is applicable to reporting entities that operate franchises as franchisors that grant licenses to other entities to sell or distribute its goods or services in return for payments, such as royalties for the use of trademarks. The category includes the franchises' Scope 1 and Scope 2 emissions. Reporting entities that operate franchises under license as franchisees should include emissions from operations under their control according to the consolidation approach in this category, if they have not included those emissions in their Scope 1 and Scope 2 inventories.

[Reference 1]

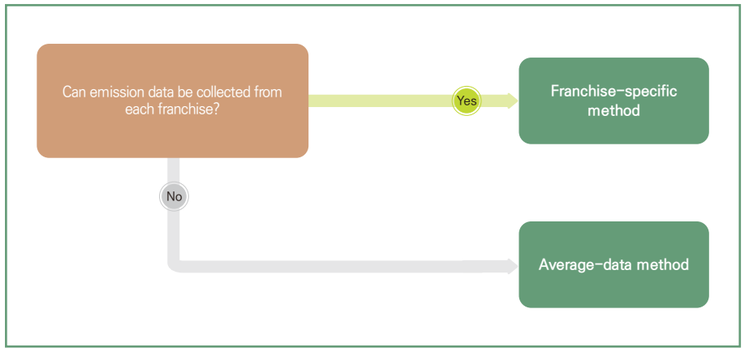
Examples of franchise emissions

- **Scope 1 and Scope 2 emissions of franchises**
- **(Optional) Scope 3 emissions if purchases of a franchise's goods or services would result in significant upstream emissions**

2. Calculation Methodology

Two methods can be used to calculate emissions from category 14 (franchises): the franchise-specific and average-data methods. The most appropriate method depends on the level of data available to the reporting entity. The method can be determined as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification		Calculation formula	Description
a	Franchise-specific method	Σ (franchise's Scope 1 and Scope 2 emissions)	Collect Scope 1 and Scope 2 emission data from individual franchises and sum the emissions for all franchises of the reporting entity. If a franchise does not measure its emissions separately, emissions can be estimated from the franchise's total floor area and its asset-specific fuel and energy consumption. Additionally, if the number of franchises is large and collecting franchise-specific data is difficult, emissions can be calculated through appropriate sampling.
b	Average-data method	Σ((building-specific total floor area) × (building-specific average emission factor))	Estimate emissions for a franchise or a group of franchises based on average statistics (e.g., average emissions per franchise type or square area), and sum the emissions for all franchises in the reporting entity.

15 Category 15 (Investments)

1. Definition

Category 15 includes emissions that are associated with the reporting entity's investments in the reporting year, not already included in Scope 1 and Scope 2 inventories. The reporting entity's emissions are estimated from an investee's total Scope 1 and Scope 2 emissions and are proportional to the reporting entity's investment equity. If the investee's Scope 3 emissions are significant or otherwise relevant compared to other emission sources, they may be included when estimating the reporting entity's emissions.

The investment activities included in this category may vary depending on the reporting entity's organizational boundaries. According to the four categories of financial investments and services (equity, debt, project finance, managed investments, and client services), activities are divided into those for which GHG accounting is required and those for which it is optional. If accounting for GHGs is required, it is reported in this category. Cases with required and optional accounting for GHGs depending on the investment type are as follows.

- **(Required)** Cases of investments with required accounting of GHGs based on the investment type:

1) Equity investments
   - If emissions from equity investments are not included in the reporting entity's Scope 1 and Scope 2 inventories because the reporting entity does not have control over the investee company, then Scope 1 and Scope 2 (and Scope 3 if significant) emissions of equity investments in the reporting year are accounted for in Scope 3 category 15 (investments), in proportion to the equity owned by the reporting entity
   - Equity investments in subsidiaries where the reporting entity has financial control, associate companies where the reporting entity has significant influence but no financial control, and joint ventures where partners have joint financial control

2) Debt investments and project finance
   - Scope 1 and Scope 2 emissions from relevant projects in the reporting year are accounted for in Scope 3 category 15 (investments), in proportion to the reporting entity's total investment cost. Emissions expected to occur over a project's lifetime are reported in the project's initial year of funding
   - Debt investments include corporate debt instruments (e.g., convertible bonds prior to conversion, bonds) or commercial loans, where the use of the proceeds is known. They are included in corporate debt holdings held in the reporting entity's portfolio
   - Project finance includes the long-term financing of projects by the reporting entity as either an equity investor (sponsor) or debt investor (financier)

- **(Optional)** Cases for investments with optional accounting of GHGs, based on the types of investments (report these in the reporting entity's Scope 3 category 15):

1) Debt investments
   - General debt-holding for corporate purposes (e.g., loans, bonds) in the reporting entity's portfolio, for which the use of proceeds is not specified

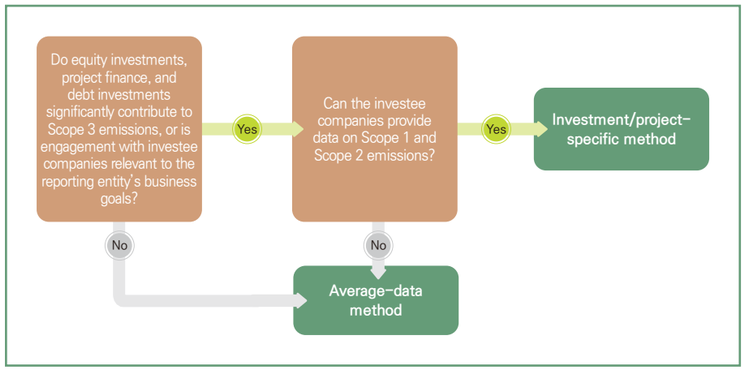
2) Managed investments and client services
   - Investments and services managed by the reporting entity on behalf of clients using the clients' capital
   - Investments and asset management services, such as stocks and bonds on behalf of clients, and financial advisory services for clients seeking assistance with mergers

3) Other investments or financial services
   - Other financial services (e.g., pension funds, retirement accounts, insurance contracts) not included among the above-mentioned four types of financial investments and services (equity investments, debt investments, project finance, and managed investments and client services)

2. Calculation Methodology

Two methods can be used to calculate emissions from category 15 (investments): the investment/project-specific and average-data methods. The most appropriate method depends on the level of data available to the reporting entity. The method can be determined as shown in the following diagram.

1) Decision tree



2) Calculation formulas and descriptions

Classification			Calculation formula	Description
Equity investments	a	Investment/project-specific method	Σ((investee company's Scope 1 and Scope 2 emissions) × (share of equity))	Collect Scope 1 and Scope 2 emissions from the investee company. The reporting entity's emissions are estimated from only a portion of the investee company's total Scope 1 and Scope 2 emissions, in proportion to the reporting entity's investment equity.
	b	Average-data method	Σ((investee company's total revenue) × emission factor for investee company's sector) × share of equity))	Estimate the investee company's Scope 1 and Scope 2 emissions based on its sales data and EEIO data in the relevant sector. The reporting entity's emissions are estimated from only a portion of the investee company's total Scope 1 and Scope 2 emissions, in proportion to the reporting entity's investment equity. ※ In the future, once emission factors for domestic industrial sectors are developed, they could serve as an alternative to EEIO data.
Project finance and debt investments	a	Investment/project-specific method	Σ((investee company's Scope 1 and Scope 2 emissions from the relevant project) × (share of equity))	Collect Scope 1 and Scope 2 emissions from the investee company. The reporting entity's emissions are estimated from only a portion of the investee company's total Scope 1 and Scope 2 emissions, in proportion to the reporting entity's investment equity regarding the relevant project.
	b	Average-data method	Σ((construction cost or project revenue in the reporting year) × (emission factor of relevant sector) × (investment share of total project costs))	Estimate investee company's Scope 1 and Scope 2 emissions based on EEIO data. The reporting entity's emissions are estimated from only a portion of the investee company's total Scope 1 and Scope 2 emissions, in proportion to the reporting entity's investment equity regarding the total project capital.

3. Calculation Examples by Methodology[45)]

a. Investment/project-specific method

(1) Equity investments

- Company A, an integrated device manufacturer (IDM), has equity investments in three associate companies, X, Y, and Z. Company A uses the operational control approach to define its organizational boundaries. Since it does not have operational control over the three associate companies, Company A should report the associate companies' Scope 1 and Scope 2 emissions in Scope 3 category 15, in proportion to its equity share
- Company A collects the GHG emissions of each associate company from their GHG inventory reports and obtains equity information related to the investments from the electronic disclosure system

Investment	Investment type	Investee company's Scope 1 and Scope 2 emissions in the reporting year (tCO_2eq)	Reporting entity's share of equity (%)
1	Equity investments in associate company X	200,000	30
2	Equity investments in associate company Y	750,000	45
3	Equity investments in associate company Z	900,000	25

- Using the investment-specific method, the total emissions from Company A's equity investments are calculated as follows:

Emissions from equity investments using investment-specific method

Σ((investee company's Scope 1 and Scope 2 emissions (tCO_2eq)) × (share of equity (%))
= (120,000 × 0.3) + (750,000 × 0.45) + (900,000 × 0.25)
= 60,000 + 337,500 + 225,000
= 622,500 tCO_2eq

(2) Project finance and debt investments

- Company A, a semiconductor foundry, has debt investments in several projects aimed at developing an industrial complex within a semiconductor cluster. Company A collects Scope 1 and Scope 2 emissions from its investee companies. The collected data are as follows:

Investee company	Investee company's Scope 1 and Scope 2 emissions (tCO_2eq)	Debt investment value (USD)	Total project costs (USD)	Reporting entity's share of equity (%)
1	100,000	1,000,000	8,000,000	10.00
2	50,000	3,000,000	60,000,000	7.00
3	140,000	5,000,000	12,000,000	5.00

- Using the project-specific method, the total emissions from Company A's project finance and debt investments (where the use of the proceeds is known) are calculated as follows:

Emissions from project finance and debt investments using project-specific method

Σ((investee company's Scope 1 and Scope 2 emissions from the relevant project (tCO_2eq) × (share of equity (%))
= (100,000 × 0.1) + (50,000 × 0.07) + (140,000 × 0.05)
= 10,000 + 3,500 + 7,000
= 20,500 tCO_2eq

b. Average-data method

(1) Equity investments

- Company A, an IDM, has a portfolio of equity investments in a considerable number of companies located across various regions. However, since most of its investee companies have not completed their GHG inventories, Company A cannot collect their Scope 1 and Scope 2 emissions. Therefore, Company A wants to group its investments according to the investee companies' economic sectors and estimate emissions based on economic average values
- Using the EEIO database, Company A collects EEIO emission factors corresponding to each investee group's economic sector. Additionally, it collects the following information on the proportion of investments from an internal financial system and the investee companies' business reports

45) All activity data and emission factors are for illustrative purposes only and do not represent actual data.

Investee company	Investee company's total revenue (USD)	Reporting entity's share of equity (%)	Investee company sector	Investee company's revenue in the sector (%)	Sector's Scope 1 and Scope 2 emission factor ($kgCO_2eq$/USD)
1	2,000,000	5	Wafer supply	100	0.17
2	5,000,000	8.5	Chip design R&D	100	0.22
3	3,500,000	10	Collection of waste semiconductor	30	2.0
			Disposal of waste semiconductor	70	1.5

- Using the average-data method, the total emissions from Company A's equity investments are calculated as follows:

Emissions from equity investments using average-data method

Σ {(investee company's total revenue (USD) × investee company's revenue in sector (%) × emission factor for investee company's sector ($kgCO_2eq$/USD revenue)) × share of equity (%)}
= {(2,000,000 × 1.0 × 0.17) × 0.05} + {(5,000,000 × 1.0 × 0.22) × 0.085} + {((3,500,000 × 0.3 × 2) + (3,500,000 × 0.7 × 1.5)) × 0.10}
= 17,000 + 93,500 + 577,500
= 688,000 $kgCO_2eq$

(2) Project finance and debt investments

- Company A, a fabless semiconductor company, has debt investments in several public facilities and infrastructure companies for a project to develop a semiconductor cluster. Company A conducts its initial calculation of Scope 3 emissions in the reporting year, and due to time and resource constraints, it plans to cooperate with its investee companies starting the following year
- Company A collects the following data from its internal data management system

Project type	Project phase	Construction cost or project revenue in the reporting year (USD million)	Relevant EEIO sector	EEIO emission factor (Scope 1 and Scope 2 only) (tCO_2eq/USD million)	Reporting entity's share of equity (%)
Semiconductor chip manufacturing facility	Construction	30	Semiconductor manufacturing	230	20
Water supply facility	Construction	8	Non-residential commercial and medical structures	350	5
Road construction	Construction	10	Non-residential structures	280	12
Renewable energy power plant	Construction	15	Power generation and supply	500	7

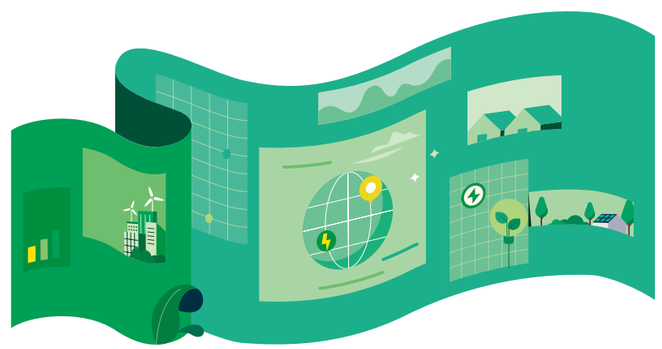
- Using the average-data method, the total emissions from Company A's project finance and debt investments (where the use of the proceeds is known) are calculated as follows:

Emissions from project finance and debt investments using average-data method

Σ {construction cost or project revenue in the reporting year (USD million) × emission factor of relevant sector (tCO_2eq/USD million) × share of total project costs (%)}
= {(30 × 230) × 0.20} + {(8 × 350) × 0.05} + {(10 × 280) × 0.12} + {(15 × 500) × 0.07}
= 1,380 + 140 + 336 + 525
= 2,381 tCO_2eq

4. Matters to Be Considered Upon Application

(Category distinction) GHG emissions from investment activities may fall under Scope 1, 2, or 3, depending on how the reporting entity defines its organizational boundaries. This underscores the importance of ensuring that emissions are neither double counted nor omitted. That is, the reporting entity should review investments not included in Scope 1 or Scope 2 based on its asset accounting system to ensure the completeness of its disclosures. Additionally, if any entities are excluded from reporting based on a materiality assessment, the reporting entity should provide clear reasons.



List of Abbreviations

AIST/JEMAI	National Institute of Advanced Industrial Science and Technology/ Japan Environmental Management Association for Industry
CO_2eq	Carbon Dioxide Equivalent
CRMA	Critical Raw Materials Act
CSDDD	The Corporate Sustainability Due Diligence Directive
DB	Database
EEIO	Environmentally-Extended Input Output
EFRAG	European Financial Reporting Advisory Group
EMEP/EEA	European Monitoring and Evaluation Programme/ European Environment Agency
EOL	End-of-Life
EPA	Environmental Protection Agency
ESG	Environmental, Social, Governance
ESRS	European Sustainability Reporting Standards
EU	European Union
GHG	Greenhouse Gas
GIR	Greenhouse gas inventory & research center
GWP	Global Warming Potential
IBG	Industry-Based Guidance
IFRS	International Financial Reporting Standards
ILCD	International Reference Life Cycle Data
IPCC	Intergovernmental Panel on Climate Change
ISSB	International Sustainability Standards Board
JSON-LD	JavaScript Object Notation for Linked Data
KEITI	Korea Environmental Industry and Technology Institute
KRW	Korean Won
KSSB	Korea Sustainability Standards Board
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LPG	Liquefied Petroleum Gas
MOE	Ministry of Environment
PF	Project Finance
R&D	Research and Development
SBTi	Science-based Target Initiative
SCC	Semiconductor Climate Consortium
SEC	Securities and Exchange Commission
T&D	Transmission and Distribution
TCFD	Task Force on Climate-Related Financial Disclosures
TEU	Twenty-Foot Equivalent Unit
US	United States
WtE	Waste-to-Energy

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