2022 Carbon Emissions Management Guidelines

for Small-and Medium-sized Enterprises

Ministry of SMEs and Startups

ASEM SMEs Eco Innovation Center

2022

Carbon Emissions Management Guidelines for SMEs

[Foreword]

This guidebook provides the background, terminology, how to build greenhouse gas inventory, and how to achieve the carbon neutrality target to help small- and medium-sized enterprises (SMEs) understand carbon neutrality, calculate greenhouse gas emissions, and both set and achieve targets, with detailed explanations.

This guidebook was developed based on the global greenhouse gas calculation guideline and international initiatives, and it is recommended to use relevant country-specific regulations and guidelines by applying to specific countries and type of business.

[Purpose and Structure of Carbon Emissions Management Guidelines]

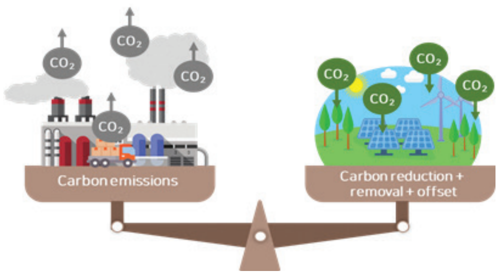
- As the international community's awareness in responding to the climate crisis is rapidly increases, countries pay much more attention to carbon neutrality, the same can be said for corporations.
- In order to keep the average temperature, rise of the earth below 2 degrees Celsius, and to implement the Paris Agreement commitments to limit the increase to under 1.5 degrees Celsius, each nation's response to carbon neutrality has been rapidly developed. Under these circumstances, measures at the corporate level are thus urgently called for.

● Explanation of Terminology

What is Carbon Neutrality? It refers to a state in which net emissions become "0" (zero) by offsetting the amount of greenhouse gas (hereafter "GHG") absorption from the amount of GHG emitted, released, or leaked into the atmosphere. In other words, it is an idea in which actual emissions become zero through absorption (forests) and removal of the remaining GHG after minimizing GHG emissions. This is the reason why carbon neutrality is called net-zero.

: : Net emissions = 0 kg

: : Carbon neutralization = Carbon zero = Net-zero ▶ All the same meaning



※ Figure Source: https://about.att.com/ (reformation)

- Accordingly, 「Carbon Emission Management Guidelines for SMEs」 was developed in 2021 so that SMEs that experience difficulties in responding to carbon neutrality can voluntarily set targets for GHG carbon neutrality.
  - Unlike conglomerates, SMEs have practical difficulties such as costs and manpower required for GHG management. In consideration of this reality, the scope and method that can be practically performed are presented here.
  - Based on the 2006 IPCC guidelines for national GHG inventory, GHG Protocol, and international carbon neutrality initiatives for SMEs such as SME Climate Hub, SBTi, the emission calculation scope and methodologies applicable to Korean SMEs are explained
  - It is not limited to calculating GHG emissions, but also covering the method of setting reduction targets and GHG reduction measures in the field of products and services.
- Most companies in ASEAN countries are SMEs, and the issue of carbon neutrality of SMEs in ASEAN countries is important not only to minimize economic losses due to climate change, but also to consider for countries' carbon neutrality.
  - A 2°C increase in temperature was predicted to reduce the GDP of ASEAN countries by 4% and potentially up to 37% (Swiss Re Institute, 2021).
  - SMEs, the backbone of the Asian economy, account for an average of 97% of all businesses in ASEAN countries, 69% of employment and 41% of GDP in the ASEAN region (ADB, 2020).
- In addition, as global companies move to become carbon neutral, not only GHG emission management within companies, but also there is increased demand for SMEs along the global supply chain to respond in detail to carbon neutrality, such as a focus on the GHG emissions that companies produce and carbon footprint of their products.
  - The number of companies participating in the CDP (Carbon Disclosure Project) supply chain increased by about 2.4 times from 115 in 2018 to 280 in 2022, and about 11,000 suppliers are disclosing information.
  - About 84% of 1,834 companies that set reduction targets for the SBTi (Science Based Target initiative) declared that they would also reduce Scope 3 as well.
- In order to promote carbon neutrality implementation within SMEs in ASEAN countries, 「2022 Carbon Emission Management Guidelines for SMEs」 has been expanded and developed for SMEs entering (or planning to enter) ASEAN countries. These guidelines were designed with the following objectives in mind.
  - To explain the calculation of emissions by using IPCC guidelines, GHG Protocol, global emission factors presented by IEA, etc.
  - To respond to the requirements of the global supply chain, GHG emission that occur outside the boundaries of business sites are organized into Scope 3, and definitions, category classification, calculation methods, and examples are covered.
  - To present examples of carbon certification systems in ASEAN countries and carbon neutrality declarations for each company to which other companies can refer to.
- In line with these guidelines, we hope that SMEs will be able to quantify their GHG emissions and set reduction targets, so that they can adapt to the transition toward a carbon neutrality society in the future.

● The Relationship between GHG Emissions Reduction in Products and Services and Carbon Neutrality

Even though it is important to contribute to carbon neutrality by reducing the GHG emissions of individual companies, it is more important to approach from the perspective of minimizing the environmental impact in the entire production process. This ranges from raw material collection to production, transportation, consumption, and disposal in order to reduce GHG emissions in society as a whole.

In addition, as stakeholders' awareness on how the products and services produced by companies affect the environment increases, there is also an increasing demand to quantify the resources used in the entire production process and pollutants emitted and disclose the information to all.

To respond to these changes of the times, these guidelines suggest ways to quantify the GHG reduction effect due to the use of low-carbon, eco-friendly products throughout the entire product production process. Therefore, SMEs can use them to secure competitiveness for low-carbon, eco-friendly products in a carbon neutral society.

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ASEM SMEs Eco-Innovation Center (ASEIC) is an organization for international cooperation established in 2011 to promote cooperation for sustainable growth of SMEs in Europe and Asia.

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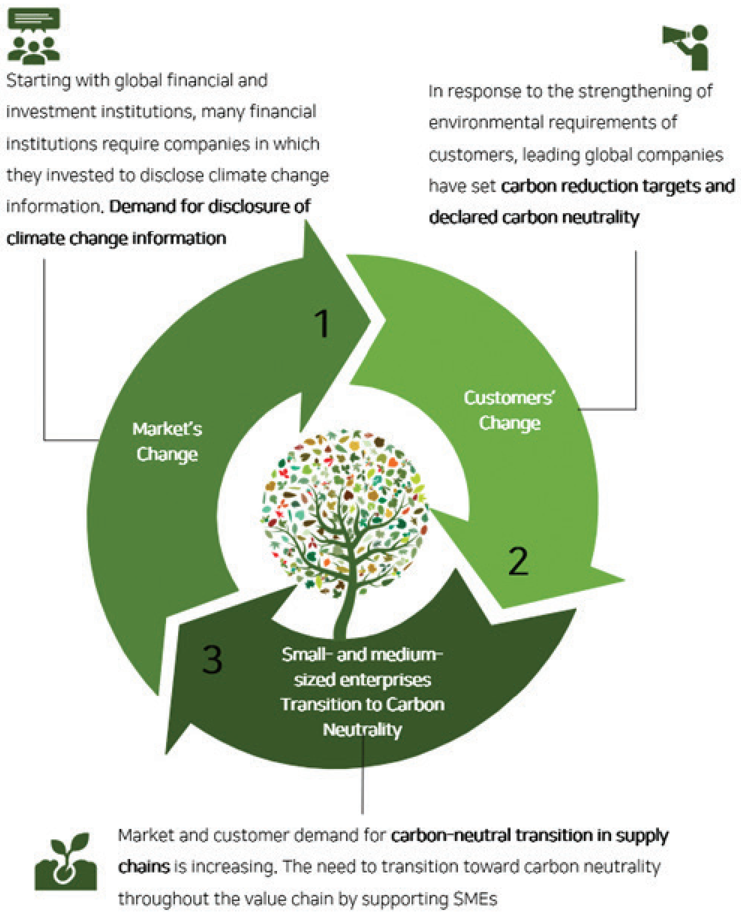
[I] Carbon Neutrality and SMEs

[1] Why do SMEs need to shift to carbon neutrality?

■ As the international community actively moves toward reducing carbon emission, the government, financial institutions, and private companies declare carbon neutrality and come up with action plans. In particular, major international companies demand carbon neutrality to SMEs in their supply chain as one of the implementation measures to achieve carbon neutrality. Accordingly, SMEs need to understand carbon neutrality and prepare a coping strategy in order to respond to requirements of upper-level supply chain and secure competitiveness.

- Major domestic and international companies declared carbon neutrality in response to the demands of customers and investors.
- Major companies strengthened cooperation through active supply chain management to achieve carbon neutrality.
- Demand for disclosure of climate change information through financial institutions' engagement with firms in which they have invested increased.

[Figure 1] SMEs' need to shift toward carbon neutrality



■ For reasons such as strengthening regulations in each country for carbon neutrality and reinforced environmental requirements of financial institutions and customers, leading international companies recognize carbon neutrality as an important corporate issue. Most notably, export-oriented companies are inevitably affected by these changes and actively participate in the overall response to the climate crisis.

[Table 1] Carbon neutrality declaration by Korean companies

Category	Industry	Company Name
Financial institutions	BNK Financial Group Inc., Hana Financial Group, Woori Financial Group	
Government offices	Korea Agro-Fisheries & Food Trade Corporation	
Private-sector manufacturers	Chemical	Kolon Industries, INC., LG Chem
	Household goods	Amore Pacific Corporation
	Auto industry	Hyundai Mobis Co.,Ltd.
	Tire industry	Hankook Tire & Technology Co., Ltd., Kumho Tire Co., Inc.
	Technology/Equipment	Ace Technologies Co.,Ltd., LG Innotek
	Textile and apparel	Shinwon Corporation
	Telecommunications	SK Networks Co., Ltd.
	Tobacco	KT&G Corporation

※ Source: SBTi Carbon Neutral Declaration Companies List (2022)

[Table 2] Carbon neutrality declaration by ASEAN companies

Country	Industry	Company Name
Malaysia	Architecture and construction	Gamuda Berhad, Malaysian Resources Corporation Berhad, Minconsult Sdn. Bhd, Sunway Berhad
	Agriculture and food	MSM Malaysia Holdings Berhad, FGV Holdings Berhad
	Real estate and investment	Sunway REIT
	Banking and securities	FGV Holdings Berhad, CIMB
	Telecommunications	Axiata Group Berhad
Vietnam	Textile and apparel	Alliance One Apparel Co.,Ltd, Jia Hsin Co., Ltd, TCE Jeans Co., Ltd, TCE Vina Denim Joint Stock Company, Viet Nam Samho Company Limited
	Steel finishing material	Hanacans Joint Stock Company
Singapore	Architecture and construction	Meinhardt Group International Limited
	Real estate and investment	Frasers Centrepoint Trust
	Lodging	Capella Hotel Group Pte. Ltd.
	Banking and securities	DBS Bank
	Steel finishes	Tung Mung International Pte. Ltd.
	Telecommunications	Singapore Telecommunications Limited (Singtel)
	Sewage treatment plants	Moya Holdings Asia Limited

Country	Industry	Company Name
Indonesia	Architecture and construction	PT United Tractors Tbk
	Oil and gas	PT Aneka Tambang Tbk (ANTAM), PT Bumi Resources Tbk, PT Indesso Aroma
	Textile and apparel	PT Kahatex, PT Prima Sejati Sejahtera
	Telecommunications	PT Alpha Indo Nusa
	Can manufacturing	PT United Can
Cambodia	Textile and apparel	Trax Apparel (Cambodia) Co., Ltd.
Thailand	Rubber	Von BunditCo., Ltd
	Agriculture and food	Charoen Pokphand Foods Public Company Limited, NR Instant Produce Co.,Ltd, Thai Union Group Public Company Limited
	Food retail	Home Product Center Public Company Limited
	Oil and gas	PTT Public Co. Ltd.
	Textile and apparel	Thong Thai Textile Co., Ltd.
	Banking	SCB X Public Company Limited
	Telecommunications	True Corporation Public Company Limited
Philippines	Tcommunications	Globe Telecom, Inc.

※ Source: List of Climate Action 100 carbon neutrality declaration companies (2022)
SBTi list of companies declaring carbon neutrality (2022)

■ Numerous international companies, including Apple, have documented this in their supplier code of conduct to obtain GHG information on their supply chains, and accordingly, large companies increasingly demand GHG information from SMEs.

[Table 3] Demands for disclosure of GHG information in the supply chain of major conglomerates (Example)

Apple Supplier Code of Conduct	Hyndai Supplier Code of Conduct
Apple Supplier Code of Conduct **Greenhouse Gas Emissions Management** Supplier shall identify, manage, reduce, and responsibly control Greenhouse Gas (GHG) emissions from its operations. Supplier shall regularly quantify, set targets, monitor progress, and reduce its emissions of Greenhouse Gases through conservation, use of clean energy, or other measures.	**3. Environment** **B. Energy Consumption and Greenhouse Gas Emissions** ① Suppliers should develop programs to measure energy consumption and greenhouse gas emissions. ② Suppliers should strive to reduce energy consumption and greenhouse gas emissions.
KT Environmental Management Guidelines	**Richemont Supplier Code of Conduct**
V Supplier Environmental Guidelines **3. Evaluation of Environmental Outcomes** (Minimum) requirements for suppliers: Suppliers should collect data on environmental outcomes. As of 2014, it became obligatory to collect data on energy usage, emissions of GHG, emissions of GHG, and water usage of suppliers.	**4.3 ENERGY USAGE AND GREENHOUSE GAS (GHG) EMISSIONS** Suppliers shall monitor their energy consumption and take actions to reduce greenhouse gas emissions and combat climate change.

※ Source: Each company's partner code of conduct and sustainable business report, etc.

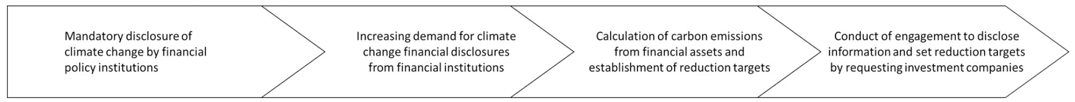
[Table 4] Demands for disclosure of GHG information in SMEs by major conglomerates (Example)

Company A, a textile materials company	Company C, a cosmetic OEM company	
• Nike demanded to calculate GHG emissions	• Major cosmetic brands such as Lancome, L'Oreal and Johnson & Johnson demanded to calculate GHG emissions	
1. Carbon Footprint (kg CO2e/kg) of materials delivered to Nike • Inclusive of all upstream material/ingredient carbon footprints (e.g., polystyrene, polybutadiene, isocyanate, polyol etc.) • Biogenic carbon shall be listed separately for biobased materials as per LCA Guidance • Manufacturing energy consumption (megajoule, or MJ) • Other energy (e.g., transportation and packaging)	CDP SUPPLY CHAIN MEMBER ↑ L'ORÉAL GROUPE ESTĒE LAUDER Johnson&Johnson Information demand ↓↑ Information demand C사	CDP Supply chain: • CDP program, a global GHG information disclosure initiative • Companies joining the CDP supply chain must also report GHG emissions of their supply chain. • Calculate the company's own GHG emissions and supply chain emissions and submit the information to the CDP • After calculating GHG emissions, emission information is submitted to customers.

※ Source: Nike LCA Guide for Material Vendors

■ Lastly, due to the strengthening of regulations such as mandatory climate change disclosure by international organizations and financial supervisory agencies, the demands of financial institutions to calculate carbon emissions and set GHG emissions reduction targets are on the rise. Accordingly, financial institutions demand the disclosure of climate change information from companies in which they have invested to calculate financial asset emissions and achieve carbon neutrality

[Figure 2] Demand for carbon neutrality by financial institutions

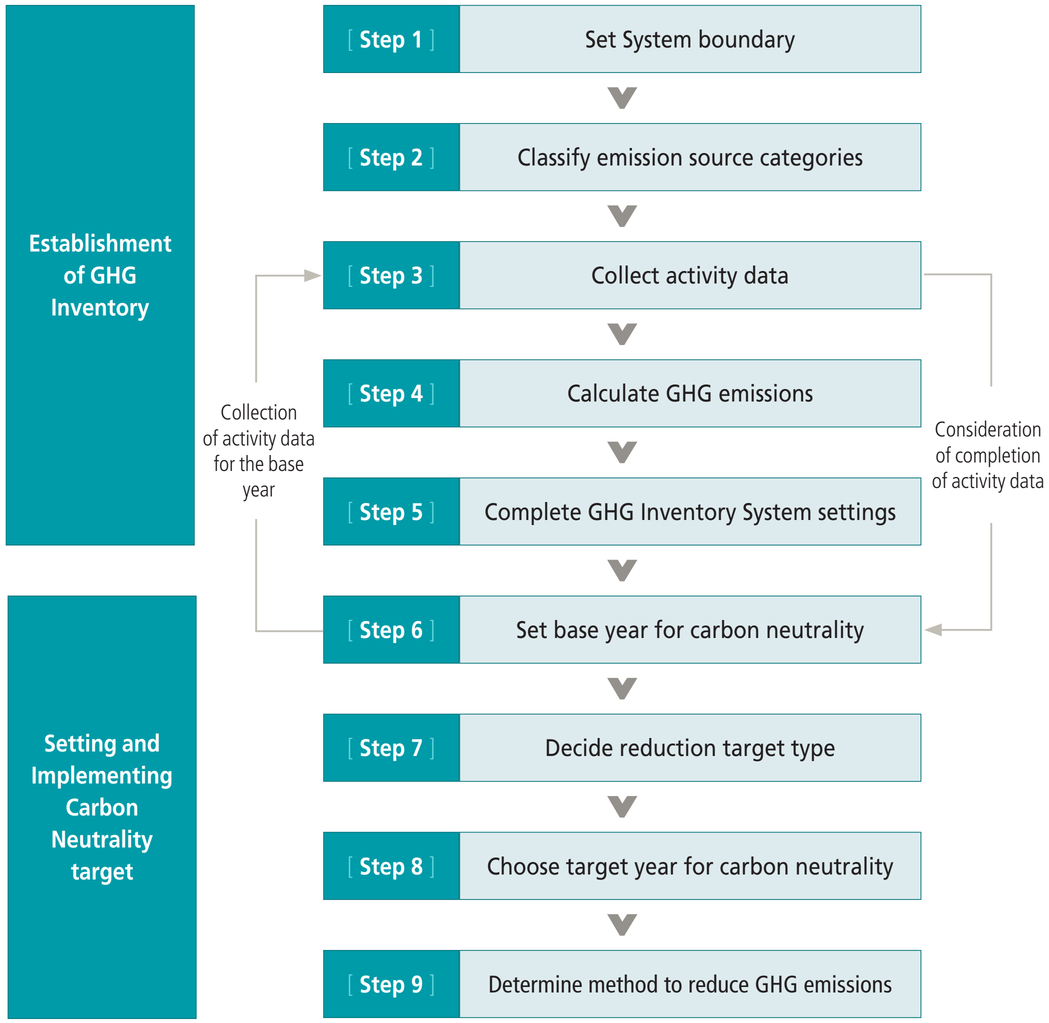


[2] Establishment of carbon neutrality target and its implementation procedure

■ In consideration of the circumstances of SMEs, these guidelines provide the most basic "organizational boundary setting method," "How to calculate GHG emissions based on fuel and electricity consumption," and "method for setting reduction targets" among the elements of a company's GHG quantification.

- In order to establish and implement a carbon neutrality target, SMEs must first build a GHG inventory. As shown in [Figure 3] below, after building the GHG inventory step by step, interim and final targets are established, and the reduction means and methods for each year to achieve the targets are specified.

[Figure 3] Steps for GHG quantification and carbon neutrality target setting



[II] Establishment of Greenhouse Gas Inventory

[1] Purpose of establishing GHG inventory and its procedure

■ **(Purpose)** Building a GHG inventory is the first step to do before responding to carbon neutrality. The purpose of this is to analyze the characteristics of the GHG inventory and ascertain the reduction potential by identifying the sources of GHG emission and calculating the GHG emissions within the organizational boundaries set by the company.

[Figure 4] Detailed process of building GHG inventory

Explanation of Terminology

:: What is a GHG inventory?

This is a list of GHG emissions by company or organization and refers to a series of GHG management systems that identify, record, manage, calculate, and report all GHG emissions emitted from business activities.

[2] How to build a GHG inventory

2 - 1 Setting system boundaries

■ The system boundary refers to the virtual boundary that manages direct and indirect emissions in order to identify the source and amount of GHG emissions of a company.

• The system boundary is again divided into "organizational boundary" and "operational boundary." After setting the "organizational boundary" first, the "operating boundary" can be set.

2-1-1. Setting an organizational boundary

■ The organizational boundary is the most important step in calculating GHG emissions by clearly stipulating which organizations within a company are included in the scope of the GHG inventory setting.

• As companies have many different forms and structures and often flexibly change the organizational system in response to the business environment for more effective business operations, it is necessary to define in advance which areas to include in the calculation range when estimating GHG emissions.

■ Organizational boundaries of a company can be established through the equity share approach or the control approach. One should be careful, however, that organizational boundaries should be established through a consistent approach when estimating multi-year GHG emissions over time.

Explanation of Terminology

1. What is the equity share approach?

This refers to a way in which a company calculates GHG emissions according to the stake allocation (investment ratio) of the target place of business. If emission facilities and buildings (dormitories and factories) have stakes (ownership ratio) outside the scope of the place of business, those facilities and buildings can be included in the organizational boundary.

2. What is the control approach?

This is a method that calculates 100% of GHG emissions from the place of business under the control of a company. It can be broadly divided into operational control and financial control.

• Operational control: A company or its subsidiaries have operational control when they have all right to introduce and enforce operational policies.

• Financial control: A company or its subsidiaries have financial control when they lead financial and operational policies for economic benefits in their business activities.

How to set organizational boundaries by sector

1. Setting organizational boundaries for the place of business

Business sites owned or directly operated by a company are included within the organizational boundary. If the company has an operational stake allocated to it, only the stake it owns is included within the organizational boundary.

EX **If Company A owns an 80% stake in Site B, 80% of the total GHG emissions from Site B are included within the organizational boundary.**

2. Setting organizational boundaries for transportation modes (vehicles)

Vehicles owned or operated by a company under its control are included within the organizational boundary. If there are vehicles operated by a company that runs a freight truck transportation business under contract with another company, it is excluded from the organizational boundary if it does not have direct control (unless operations and operating costs are managed directly).

3. Setting the organizational boundary for convenience facilities (dormitories, corporate housing, etc.)

Amenities that are substantially owned by a company and provided to its employees may be included within the organizational boundary. Other than dormitories directly run by the company, apartments and studio buildings that employees pay maintenance fees are excluded from the organizational boundary.

2-1-2. Setting an operating boundary

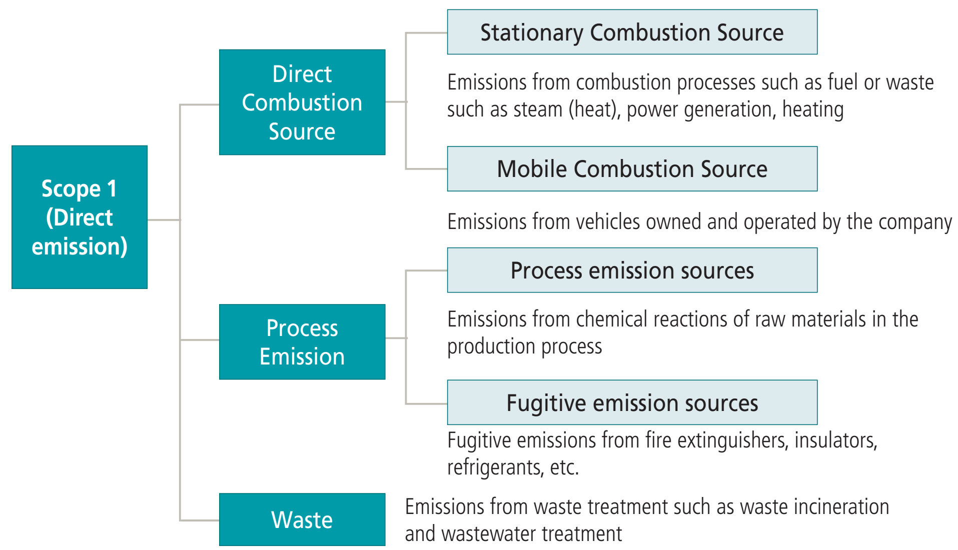
- Once the organizational boundaries are established, the emission facilities, fuels and raw materials used within the organizational boundary are identified to find out the sources of GHG emission and operating boundaries that clearly separate direct and indirect emissions have to be set. These operating boundaries are divided into Scope 1, 2, and 3.
- Companies must first prepare a list of emission sources that are expected to generate GHG emissions and then list them by examining facilities according to each emission source.
  - Scope 1 emission sources are divided into stationary combustion, mobile combustion, process emissions and fugitive emissions and only the first three Scope 1 emission sources excluding fugitive emissions are covered in these guidelines.
  - Scope 2 emission sources can be classified into emissions from the use of external electricity and those from the use of external heat (steam).
  - Scope 3 emission sources can be classified into 15 categories according to the "Corporate Value Chain (Scope 3) Accounting and Report Standard" of the GHG Protocol. Scope 3 categories and GHG emissions calculation formulas will be discussed in Chapter 4 and these guidelines will explain the method using the tool for Scope 1 and 2 emissions calculations only.

Explanation of Terminology

: : Scope 1 (direct emissions)

It refers to emission from sources owned or controlled by business operators and GHG emission resulting from direct combustion of fuels, such as stationary and mobile combustion sources.

[Figure 5] Schematic diagram classifying Scope 1 emission sources



: : Scope 2 (indirect emission)

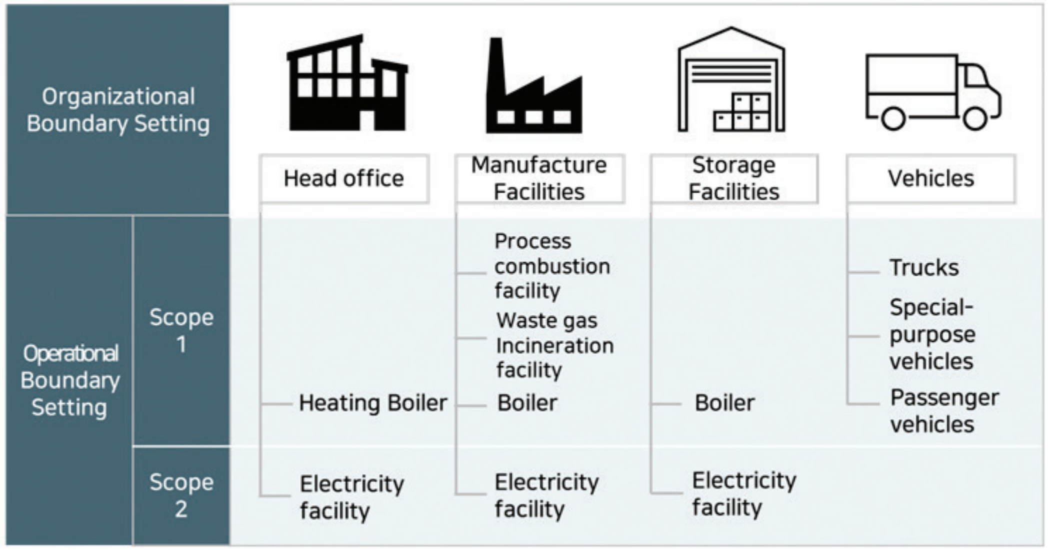
It is GHG emission generated as a result of the business operator's activities but are indirectly generated when electricity or steam necessary for running the business is used as emission from sources owned or controlled by other organizations.

[Figure 6] Schematic diagram classifying Scope 2 emission sources

:: Scope 3 (other indirect emission)

Scope 3 is indirect emission sources other than those included in Scope 2, referring to emissions that occur outside the boundaries of the business site (organizational boundaries). GHG emissions at boundaries such as employee commuting and business travel, franchises, purchased goods and services or processing of sold products are included in Scope 3

[Figure 7] Company A's system boundary setting (Example)

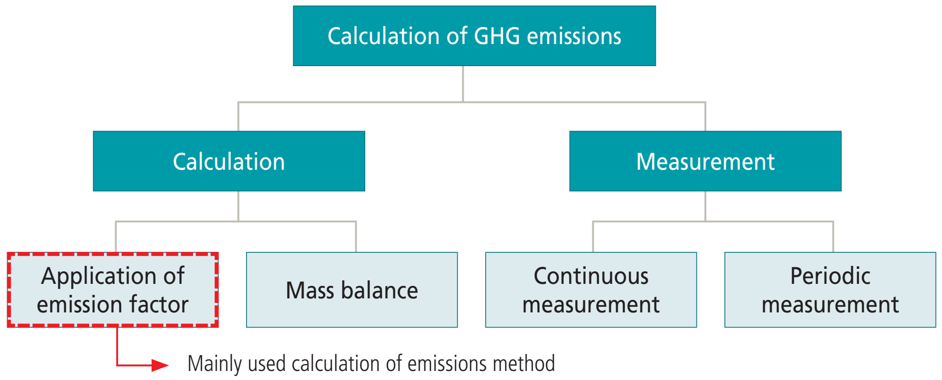


2-2 Classification of emission source categories

■ We explained above that it is necessary to make a list by emission source when setting the operating boundary. In this chapter, we will define what emission sources should be considered when setting operational boundaries and explain which emission calculation method should be used for each emission source before estimating emissions.

* [Reference] Calculation of GHG emissions

When calculating GHG emissions, companies may apply a method of calculating or measuring emissions according to the calculation tier (Tier 1 to 3) for GHG emission facilities. The higher the calculation tier, the higher the reliability and accuracy of GHG emissions, but the lower the accessibility, so calculation methods are mainly used.



Explanation of Terminology

:: The classification system of calculation tier

- Tier 1: Basic methodology for calculating emissions using activity data, and IPCC emission factor (including basic oxidation coefficients, calorific value, etc.)
- Tier 2: Methodology for calculating emissions using parameter values developed through testing and analysis for certain parts of the country's unique emission factor and calorific value
- Tier 3: Calculation of emissions methodology in which the operator develops emission factor by analyzing a significant portion of the emission factor of the workplace, emission facility, and reduction technology unit or utilizes the parameter values provided by the supplier

※ Source: Korean 「Guidelines for Reporting and Certification of Emissions in the GHG Emissions Trading Scheme」 [attached table 5] Minimum application criteria for calculation tier by emission factor and facility size

2-2-1. Classification by Scope 1 emission type

A. Stationary combustion

■ Stationary combustion is GHG emission from the intentional combustion of fuel and it is generated from combustion facilities (boilers, etc.) that use fuels such as fossil fuels for producing heat.

■ The main emission sources corresponding to these stationary combustion facilities are as follows:

- Thermal power generators (hydro turbine, steam turbine, gas turbine, etc.)
- Cogeneration facilities
- Internal combustion engines for power generation (internal combustion power generation, gas turbine power generation, etc.)
- General boiler facilities (cylindrical, water tube, cast iron boiler, etc.)
- Process combustion facilities (drying, heating, melting/smelting facilities, annealing furnaces, other furnaces, etc.)
- Facilities using solid fuels (cement kilns, thermal power plants, cogeneration facilities, boiler facilities, etc.)

■ Among the GHGs, the target substances generated from stationary combustion facilities are as follows:

Category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Occurrence	○	○	○			

B. Mobile combustion

■ Mobile combustion refers to GHG emissions generated by the combustion of fuel in an internal combustion engine for transportation and an internal combustion engine for transportation is equipment that produces power or electricity for self-consumption in vehicles such as automobiles, trains, ships and aircraft.

■ The main emission sources corresponding to these mobile combustion facilities are as follows:

- Aircraft (domestic passenger/freight, others)
- Automobiles (passenger cars, vans, trucks, special-purpose vehicles)
- Two-wheeled vehicles (motorcycles)
- Non-road engines and others (construction machines, agricultural machines, forklifts, etc.)
- Railroad cars (high-speed cars, electric locomotives, electric cars, diesel locomotives, diesel cars, special railroad cars, etc.)
- Vessels (passenger ships, cargo ships, fishing boats, other vessels, etc.)

■ Among the GHGs, target substances generated from mobile combustion facilities are as follows:

Category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Occurrence	○	○	○			

Calculation of stationary/mobile combustion emissions

:: GHG emissions = fuel consumption × calorific value (corresponding fuel) × emission factor (corresponding fuel) × Global Warming Potential (GWP)

* For the emission factor and calorific value for each fuel in stationary/mobile combustion facilities, refer to the "SMEs GHG Emission Calculation Tool" provided in the guidelines.

Explanation of Terminology

:: Calorific value

The amount of heat generated by the complete combustion of a certain unit of fuel

:: Emission factor

It refers to a factor indicating the amount of GHG emissions generated per unit activity data, such as unit fuel consumption, unit item production, unit raw material usage, unit waste incineration or treatment volume of the relevant gas-emitting facility.

:: Oxidation factor

The oxidation factor is a parameter[1] for the CO_2 oxidation rate[2]. In these guidelines, considering the size of most SMEs, the oxidation factor is applied equally as " 1."

:: Global Warming Potential (GWP)

It refers to a number that converts the effect of each GHG on global warming based on the contribution of CO_2 to global warming and indicates a conversion factor required to convert and report all greenhouse gases into CO_2 when building a GHG inventory.

※ Source: Korean 「Guidelines for Reporting and Certification of Emissions in the GHG Emissions Trading Scheme」

(1) A variable that indicates a correlation between two or more variables
(2) Ratio of the amount of oxidized substance per unit substance

C. Process emission

- Process emission refer to GHG generated by physiochemical reactions of raw materials used in the production process. Process emission vary by business type and process, and GHG emissions are calculated by applying emission factors that reflect these characteristics.
- Emission facilities by major process are as follows:
  - Cement production process: Kiln
  - Lime production process: Kiln
  - Other carbonate-using processes: Kiln and melting/smelting facilities among "porcelain/ceramic product manufacturing facilities," chemical recovery facilities and flue gas desulfurization facilities among "pulp/paper and paper product manufacturing facilities"
  - Glass manufacturing process: Melting/smelting facilities
  - Carbide production process: Calcium carbide manufacturing facility, silicon carbide manufacturing facility
  - Soda ash production process: Natural soda ash production process, ammonia soda ash production facilities (Solvay process)
  - Ferroalloy production process: Bessemer furnace, electric furnace
  - Zinc production process: Roasting furnace, melting/smelting furnace, electrolytic furnace, other smelting processes (TSL, etc.)
  - Lead production process: Roasting furnace, melting/smelting furnace, other smelting processes (TSL, etc.)
  - Other emission facilities such as hydrogen production process and petrochemical production process
- Since GHG are generated in process emission facilities due to chemical reactions during the process, GHG emissions generated differs depending on the process. The Emissions Calculation Tool* provided in these guidelines includes the emissions calculation function for CO_2 and CH_4 for some process emission sources that are relatively easy to quantify in SMEs.

  * In consideration of the convenience of estimating emissions for SMEs, the process emission factors for some processes are reflected in the emissions calculation tool so that process emission can be calculated. But refer to the "2006 IPCC Guidelines for National GHG Inventories" for a more accurate calculation of emissions.

Calculation of process emissions

:: GHG emissions = production volume × process emission factor × Global Warming Potential (GWP)

D. Waste

- The waste sector can be divided into GHG emissions generated by direct incineration of waste and GHG emissions generated by anaerobic reactions during wastewater treatment.
  - In the case of direct incineration of waste, it is also applicable to "A. stationary combustion" described in 2-2-1 above. Since most of the fuel consumption and waste incineration are managed separately, the waste incineration sector is described separately in these guidelines from the "stationary combustion" category.
  - In the case of GHG emissions generated from the wastewater treatment process, it also applies to "C. process emission" described in 2-2-1 above. Since activity data such as "production and raw materials usage" and "wastewater treatment volume" are managed separately, the wastewater treatment sector is described separately from the "process discharge" category in these guidelines.
- The main discharge facilities in the waste sector are as follows:
  - Waste incineration facilities (waste gas incineration facilities, municipal waste/Industry waste incinerators, etc.)
  - Wastewater treatment facilities (anaerobic treatment, etc.)

Calculation of emissions in the waste sector

:: Global Warming Potential (GWP)

GHG emissions = waste incineration volume × emission factor (corresponding waste) × oxidation factor x Global Warming Potential (GWP)

:: In the case of emissions from wastewater treatment

GHG emissions = {(influent COD concentration × influent flow rate) - (effluent COD concentration × effluent flow rate) - (sludge output COD concentration × sludge output amount)} × emission factor × 10^(-6)) - CH_4 recovery amount × Global Warming Potential (GWP)

* Due to the circumstances of SMEs, it is almost impossible to calculate GHG emissions from wastewater treatment, so these guidelines focus on emissions from waste incineration.

- Among the GHGs, the target substances generated by waste incineration and wastewater treatment are as follows:

Category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Waste incineration	○	○	○			
Wastewater treatment		○				

* In the case of solid/liquid waste incineration, the CH_4 and N_2O emission factors can be calculated depending on the type of waste incineration technology. Considering the convenience of calculating emissions for SMEs, the emissions calculation tool is implemented so that only CO_2 emissions can be calculated.

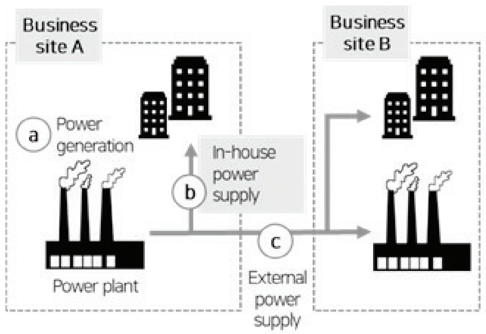
2-2-2. Classification by Scope 2 emission type

A. Indirect emission (use of electricity)

- Indirect emission (use of electricity) refers to GHG emission from the use of electricity by business activities and facilities owned and operated by the company. The consumption of electricity supplied from the outside is generally measured by the place of business, but in the case of emission facilities equipped with a watt-hour meter, the electricity consumption data can be managed separately for each emission facility. In this case, the sum of electricity consumption by each emission facility must match the total electricity consumption of the place of business.
  - The amount of indirect GHG emission (use of electricity) is excluded in the case where power generators exist within the boundaries of the company and generate and use electricity on their own.
  - This is because the above-described stationary combustion facilities include power generators, so emissions have already been calculated as Scope 1 (direct emission). If GHG emissions are calculated based on self-generated and used power consumption, its calculation may address double counting with Scope 1 emissions.

Precautions by calculating electricity emissions

The calculation method for each case when business site A is owned by Company A and business site B is owned by Company B is as follows:



Category	Emissions Calculation
ⓐ Generating electricity from a power generation facility located within Business Site A	→ Calculation of Scope 1 emissions in Business Site A
ⓑ Internally supplying electricity generated in Business Site A	→ Excluded from the calculation of Scope 2 emissions in Business Site A
ⓒ Supplying electricity generated in Business Site A to Business Site B	→ Calculation of Scope 2 emissions in Business Site B

※ Source: Korean「Guidelines for Reporting and Certification of Emissions in the GHG Emissions Trading Scheme」

B. Indirect emission (use of heat/steam)

- Indirect emission (use of heat/steam) refer to GHG emission generated by receiving heat (steam) from external cogeneration and waste incineration facilities and using it in facilities owned and operated by the company. The scope of calculation of indirect emission due to the use of externally supplied heat (steam) is determined for each business site, and steam consumption can be managed by each facility if a separate steam flow meter is attached to each emission facility. In this case, the sum of steam consumption by each emission facility must match the total steam consumption of the place of business
- In addition, if the heat (steam) produced within the organizational boundary is used on its own, it is excluded from the Scope 2 emissions calculation due to the issue of double counting.

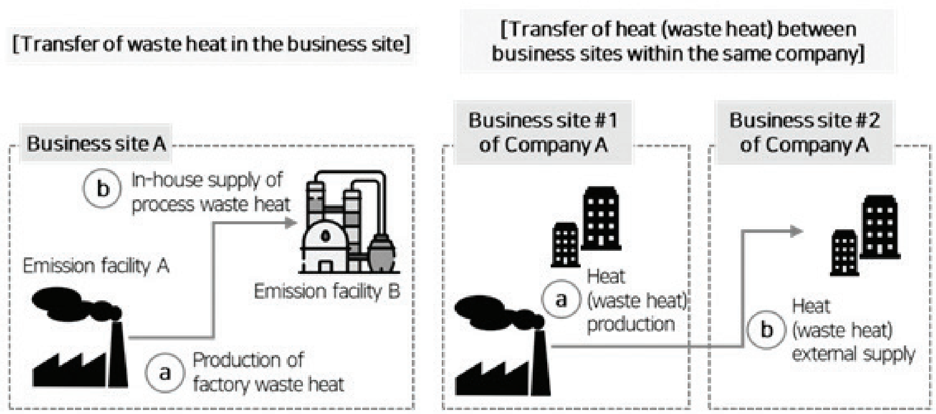
Flowchart of calculation of GHG emissions using heat (steam)

Emission factors provided by heat (steam) supplier → No → Heat (steam) supplier provided evidence → No → Calculate emissions using the U.S. Environmental Protection Agency (EPA) heat (steam) emission factor

Emission factors provided by heat (steam) supplier → Yes → Calculate emissions using provided emission factors

Heat (steam) supplier provided evidence → Yes → Calculate emissions by developing an emission factor based on the provided evidence

Cases of exclusion from Scope 2 emissions calculation



※ Source: Korean「Guidelines for Reporting and Certification of Emissions in the GHG Emissions Trading Scheme」

2-3 Collection of activity data by emission source

- Collecting relevant activity data should be carried out first to estimate GHG emissions. Although the method of collecting and recording activity data may be different depending on the condition of the company, it is necessary to manage the activity data according to certain criteria in order to accurately calculate GHG emissions.
  - In the case of managing activity data based on measured values, fuel consumption can be recorded and managed by creating a daily operating log for facilities installed with fuel meters.
  - In the case of managing activity data based on purchase volume, activity data is recorded and managed based on fuel consumption volume indicated on receipts issued by fuel suppliers.
- If the unit of fuel consumption volume is incorrect, errors may occur in the calculation of emissions. Therefore, it is important to record and manage data with caution when collecting activity data.

2-3-1. Collection of activity data for stationary/mobile combustion

- In stationary combustion, fuels such as fuel gas, diesel, LNG, LPG, or waste gas, sludge and waste plastics, etc., are burned in emission facilities such as boilers and incinerators to emit GHG such as carbon dioxide, methane, and nitrous oxide. Depending on the type of fuel, activity data can be classified into solid, liquid and gaseous fuels. In the case where a fuel meter is in place, the fuel consumption level can be checked through the meter, but in the case of facilities that do not have a separate meter installed, the volume of usage must be calculated through fuel purchase, etc.
  - Gas fuel (m^3): Gas fuels include LNG and LPG that are usually managed in cubic meters, but portable liquid petroleum gas (LPG), which is not stored in tank trucks, is considered propane and its emissions can be calculated in the unit of kilograms. Therefore, it is important to record and manage fuel consumption by paying close attention to the unit indicated on the receipt issued by the supplier.

Method of revising activity data for LPG (Propane) in Korea

LPG (Propane) generally collects and manages activity data in volume (m^3) units, but when calculating GHG emissions, since the unit of calorific value is in weight (kg), it is converted into units of weight using the standard vaporization rate and regulator pressure correction factor by region.

: : LPG (propane) consumption (kg) = LPG (propane) consumption (m^3) ÷ standard vaporization rate by region (m^3/kg) × regulator pressure correction factor

: : Regional standard vaporization rate and regulator correction factor

As shown below, standard vaporization rate and regulator correction factor by region can be checked on the Korea Gas Safety Corporation website.

Applicable area	Standard vaporization rate	Regulator pressure (kPa)	Regulator correction factor	Vaporization rate
Seoul, Incheon Metropolitan City, Gyeonggi-do, Chungcheongbuk-do, Gangwon-do Yeongseo region (Regions other than Gangwon-do Yeongdong region)	0.4810	2.8 6.0 10.0 15.0 20.0 25.0	1.0000 1.0302 1.0679 1.1150 1.1621 1.2093	0.4810 0.4669 0.4504 0.4314 0.4139 0.3978
Daejeon Metropolitan City, Daegu Metropolitan City, Chungcheongnam-do, Jeollabuk-do, Gangwon-do Yeongdong region (Gangneung-si, Donghae-si, Samcheok-si, Sokcho-si, Goseong-gun, Yangyang-gun), Gyeongsangbuk-do Yeongseo region (Region other than Gyeongsangbuk-do Yeongdong region)	0.4837	2.8 6.0 10.0 15.0 20.0 25.0	1.0000 1.0302 1.0679 1.1150 1.1621 1.2093	0.4837 0.4695 0.4529 0.4338 0.4162 0.4000
Busan Metropolitan City, Gwangju Metropolitan City, Ulsan Metropolitan City, Jeollanam-do, Gyeongsangbuk-do Yeongdong Region (Pohang-si, Yeongdeok-gun, Ulleung-gun, Uljin-gun), Gyeongsangnam-do	0.4864	2.8 6.0 10.0 15.0 20.0 25.0	1.0000 1.0302 1.0679 1.1150 1.1621 1.2093	0.4864 0.4721 0.4555 0.4362 0.4186 0.4022
Jeju Island	0.4913	2.8 6.0 10.0 15.0 20.0 25.0	1.0000 1.0302 1.0679 1.1150 1.1621 1.2093	0.4913 0.4769 0.4601 0.4406 0.4228 0.4063

※ Source: Emissions Trading Scheme 2nd Planning Period GHG Emissions Conformity Assessment and Certification Guidelines (Jan. 2020), Korean Ministry of Environment GHG Emissions Monitoring Plan Verification Manual and Detailed Verification Guidelines (Jul. 2015), Korean National Institute of Environmental Research

- Solid fuel (kg): Solid fuels include anthracite and coal and since they are purchased in units of grams from the supplier, they can be converted into and managed in kilogram or ton units. In the case of calculating back the consumption of solid fuels based on purchase and inventory, it is calculated by referring to related records such as daily logs.
- Liquid fuel (ℓ): Liquid fuels include gasoline, diesel, bunker-C oil and kerosene and the unit of activity data is managed in terms of ℓ

■ In the case of mobile combustion, there is a direct calculation method based on the amount of use and inventory of the fuel storage tank for transportation and an indirect calculation method that calculates by multiplying the travel distance by driving fuel efficiency of the transportation mode. In the case of the former, it is necessary to collect activity data on the amount of fuel purchased and the amount of fuel in inventory (residual amount) to calculate the fuel consumption. In the latter case, it is necessary to manage the total distance traveled and fuel efficiency data for each transportation mode. As with stationary combustion, solid fuel is expressed in kg, liquid fuel in l and gaseous fuel in units of m^3.

- Formula using storage tank usage and inventory
  Fuel consumption (ℓ) = monthly (annual) total fuel purchase (ℓ) + monthly (annual) initial fuel reserve (ℓ) - end of month (year) fuel reserve (ℓ)
- Formula for calculating fuel consumption based on distance traveled
  Fuel consumption (ℓ) = ∑ (total distance traveled by transportation mode (km) ÷ fuel efficiency (km/ ℓ)
- Formula for calculating fuel consumption using the purchase cost of fuel by mode of transportation (fuel receipt, etc.) and the purchase unit price for each fuel
  Fuel consumption (ℓ) = ∑ (purchase cost of fuel by mobile combustion emission source by fuel ($) ÷ unit purchase price by mobile combustion emission source by fuel ($/ ℓ))

Method of converting units in case the amount of fuel use is managed by fuel receipt or mileage

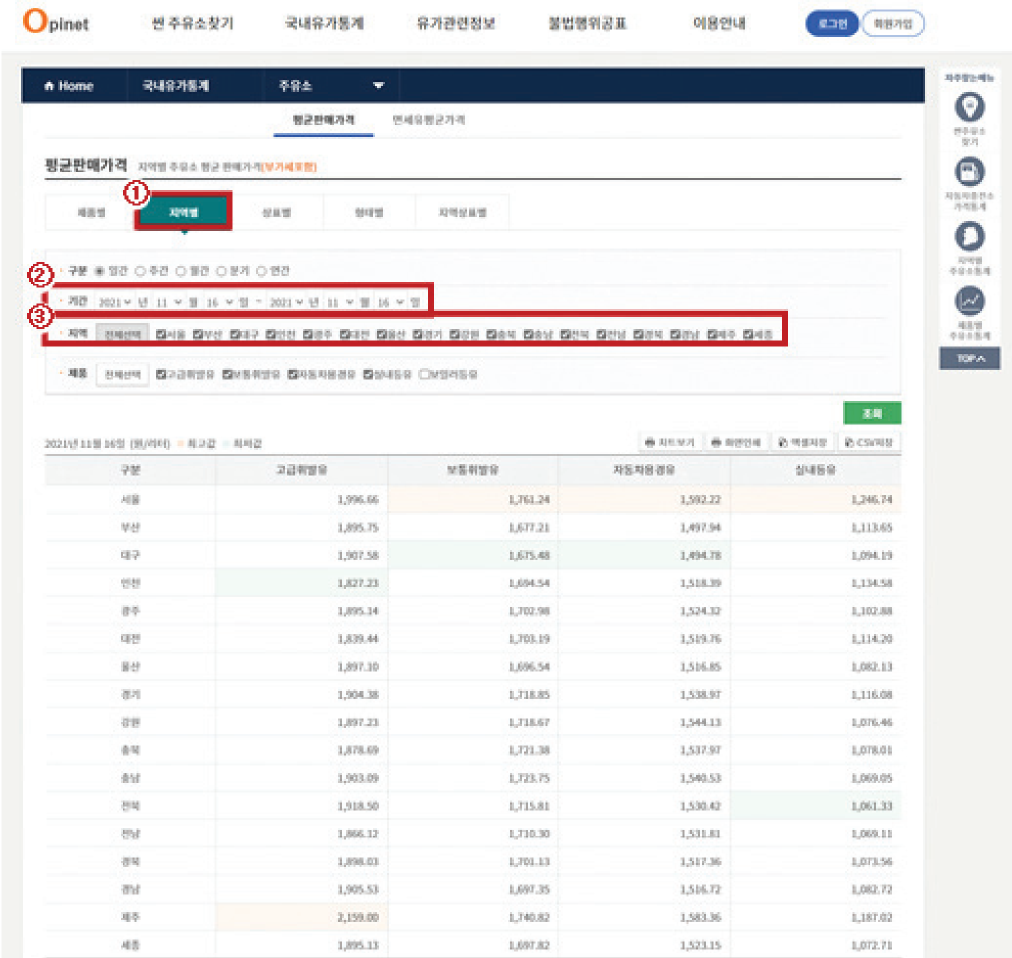
If a Korean company manages it through receipts, Korea National Oil Corporation (Opinet) can convert KRW (amount) units into l or kℓ units. The method to convert KRW (amount) unit to l or kℓ is as follows..

Step 1 | Access the Korea National Oil Corporation (Opinet) website (http://www.opinet.co.kr/)

Step 2 | Click "Domestic Oil Price Statistics" located at the top of the homepage; the following screen will appear. In the menu that appears, click "Gas Station" → "Average Selling Price" in this order.

Step 3 | On the Gas Station Average Selling Price page, the unit price information in "KRW/l" by product, region, brand, and type can be checked. Convert the unit of activity data by checking the date, region, product, etc. based on the gas receipt. If the mobile combustion activity data is managed by mileage, it is possible to convert the activity data unit based on the mileage and fuel efficiency of the mobile combustion facility.

* Note: For LPG, the unit price information of "KRW/m^3" depending on the charging station, sales office, and collective supply can be checked.



Method of converting activity data according to mobile combustion base data

: : In the case of calculating mobile combustion facility activity data based on fuel receipt (1)

When calculating monthly activity data for vehicles owned by Company A, the fuel consumption volume can be calculated as follows:

Date	Region	Fuel	Amount (KRW)
Oct. 3, 2021	Seoul	Diesel	35,200
Oct. 16, 2021	Seoul	Diesel	16,000
⋮	⋮	⋮	⋮
Total fuel amount in October			74,600

▶

- The amount of diesel sales in Seoul in October 2021 checked: 1,591 (KRW/ ℓ)
- Fuel consumption in October 2021 (ℓ)
  = 74,600 (total gas purchase amount in October) ÷ 1,591 (October average diesel price) = 46.89 ℓ

: : In the case of calculating mobile combustion facility activity data based on fuel receipt (2)

When calculating annual activity data for vehicles owned by Company B, the fuel consumption volume can be calculated as follows:

Date	Region	Fuel	Unit purchase price (KRW/ ℓ)	Amount (KRW)
January	Seoul	Diesel	1,350	2,500,000
May	Seoul	Diesel	1,300	1,300,000
October	Seoul	Diesel	1,450	560,000

▶

- Annual fuel consumption (ℓ)
  = (Jan. fuel amount ÷ Jan. diesel unit purchase price) + (May fuel amount ÷ May diesel unit purchase price) + (Oct. fuel amount ÷ Oct. diesel unit purchase price) = (2,500,000 ÷ 1,350) + (1,300,000 ÷ 1,300) + (560,000 ÷ 1,450) = 3,238.06 ℓ

: : In the case of calculating mobile combustion facility activity data based on travel distance (1)

When calculating monthly activity data for two vehicles with identical fuel efficiency owned by Company C, the fuel consumption volume can be calculated as follows:

Date	Travel distance (km)	Fuel	Fuel efficiency (km/ ℓ)
May 9, 2021	46.7	Diesel	10
May 10, 2021	62	Diesel	10
May 14, 2021	22	Diesel	10
May 28, 2021	36.5	Diesel	10

▶

- Conversion of activity data according to distance traveled and fuel efficiency
- Fuel consumption in May 2021 (ℓ)
  = (May 9 travel distance + May 10 travel distance + May 14 travel distance + May 28 travel distance) ÷ fuel efficiency = (46.7 + 62 + 22 + 36.5) ÷ 10 = 16.72 ℓ

: : In the case of calculating mobile combustion facility activity data based on travel distance (2)

When calculating annual activity data for three vehicles (2 gasoline cars and 1 diesel car) owned by Company D, the fuel consumption volume can be calculated as follows:

Category	Annual travel distance (km)	Certified fuel efficiency (km/l)
Gasoline vehicle A	3,500	12
Diesel vehicle B	7,000	9
Diesel vehicle C	6,300	10

- Gasoline consumption (ℓ) = vehicle A annual travel distance ÷ certified fuel efficiency = 3,500 ÷ 12 = 291.67 ℓ
- Diesel consumption (ℓ) = (vehicle B annual travel distance ÷ certified fuel efficiency) + (vehicle C annual travel distance ÷ certified fuel efficiency) = (7,000 ÷ 9) + (6,300 ÷ 10) = 1,407.78 ℓ

2-3-2. Collection of process emission activity data

■ Compiling Scope 1 process emissions requires the collection of process data.

- Production volume and raw material usage differ in the form in which data is recorded depending on the control method in each business site, but it can be in general monitored with tax invoices, sales receipts and production logs. Most production and raw materials usage activity data are managed in terms of product and raw materials weight (ton).

- The "SMEs GHG Emissions Calculation Tool" provided in these guidelines reflects process emission calculation formulas for the production of lime, glass, carbide, soda ash, ferroalloy, zinc, lead and carbonate.
- For an accurate calculation, it is necessary to know the waste glass content for glass production and the carbonate content for carbonate usage.

2-3-3. Collection of indirect emission (electricity) and indirect emission (heat/steam) activity data

■ Electricity usage can be recorded and managed through the electricity bill.

- If purchased power or part of power generated by self-generated facilities is resold to other operators, the resold power is deducted from total volume, and it is applied as purchased power consumption.

■ For heat (steam) usage, if a legally mandated meter is installed, the meter reading is checked and in the case of a facility without a meter, the supplier can record and manage activity data through tax invoices, purchase receipts and steam supply contracts.

- If purchased heat/steam or part of heat/steam generated by self-generated facilities is resold to other operators, the resold heat/steam is deducted from total volume, and it is applied as purchased heat/steam consumption and managed in terms of ton units.

2-3-4. Collection of activity data in the waste sector

■ In the case of waste incineration, it is necessary to collect the amount of waste that are put into the incinerator. Incinerated waste is classified into three states and the unit of activity data is managed in units of weight (kg or ton).

- Solid waste (kg): Includes most incineration wastes such as municipal waste, waste wood, waste plastic and other industrial waste
- Liquid waste (kg): Liquid waste (waste oil, waste organic solvent, etc.) originating from fossil fuels
- Gas waste (kg): By-product gas, waste gas, and biogas generated in the process are included.

■ In the case of wastewater treatment, not only the amount of wastewater to be treated, but also the measured COD concentration (mg/L) of influent and effluent wastewater and sludge output flow rate (m^3) of the influent/effluent wastewater, the amount of sludge discharged (m^3) and the amount of CH_4 recovery (m^3), etc., are needed to collect activity data.

- As it is difficult to collect all of these activity data due to the circumstances of SMEs, these guidelines will focus on calculating emissions using activity data in the waste incineration sector.

How to record and manage activity data

Documents/forms for recording and managing activity data follow its own form depending on each company. For companies that do not have their own form, please refer to the table below to prepare an activity data management form.

[Table 5] Activity data management form (Example)

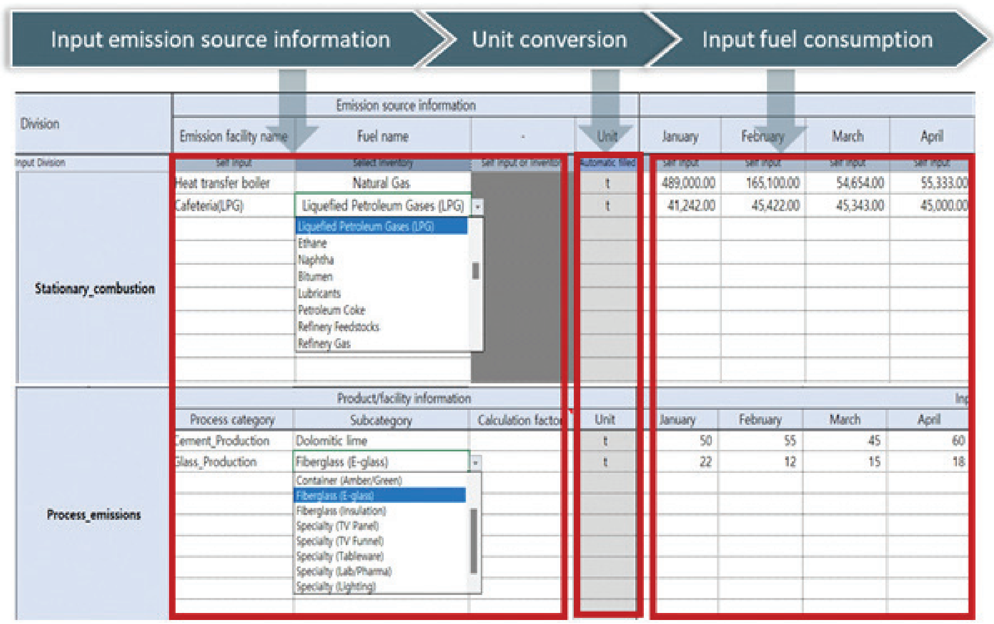
Year	2021	Month	March
Type of fuel in use	Steam	Usage/Unit	142 GJ
Person in charge/Dept.	Kim Gong-jang/Environment Safety Team	Activity source data	Heat (steam) bill
Name of emission facility	Heat (steam)-using facility		
Collection interval for activity data (Monitoring cycle)	Once a month		
How to monitor activity data	Checks on monthly heat (steam) usage on the heating (steam) bill		
Instrument calibration management	Legally mandated meter (calibration managed by the supplier)		
How to manage activity data	Electronic media/paper-based documents		
Remarks	Stored for 5 years after calculating emissions		

Companies collect monthly bills for activity data, tax invoices, and purchase receipts, record annual fuel consumption and production in a certain format and calculate GHG emissions.

※ Source: Guidelines for Establishing Voluntary GHG Inventory for SMEs (2015), Korean Ministry of Environment

2-4 Calculation of GHG emissions

[Figure 8] GHG Emission Calculation Tool



■ As the final stage of building the inventory, collected activity data must be converted into GHG emissions using the Emissions Calculation Tool. To use the Emissions Calculation Tool, information on emission sources by scope (emission facility name, fuel name, consumption) is required for each scope classified above.

■ The SMEs GHG Emissions Calculation Tool consists of a total of four sheets and the information available for each sheet is as follows:

- Comprehensive information sheet: Input business site information and check on total GHG emissions

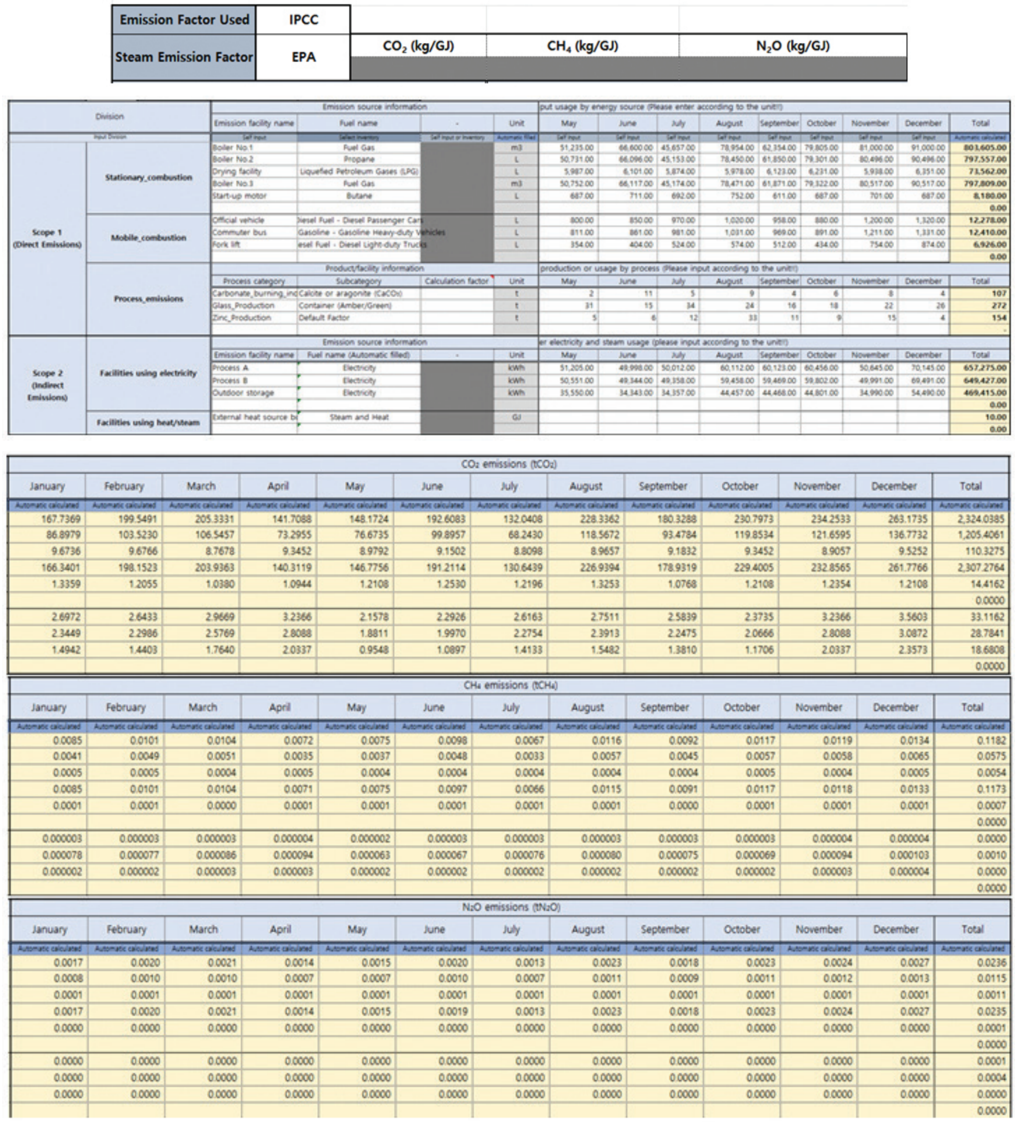
(1) Company basic information

Company name	OOO factory
Business site (Country)	Vietnam
Types of industry	Manufacturing Industries
Name	OOO
Department	Environment team
Job title	Manager
Phone No.	000-0000-0000
E-mail	OOOOO@hanmail.net
Base year sales (USD)	2,000,000,000

(2) Total greenhouse gas emissions in the base year (unit: tCO_2eq)

Scope 1	Stationary combustion	9,148
	Mobile combustion	81
	Process emissions	149
	Waste incineration	412,362
	Subtotal	**421,740**
Scope 2	Facilities using electricity	1,158
	Facilities using heat/steam	853
	Subtotal	**2,011**
Total (tCO_2eq)		**423,751**
(Reference) GHG intensity based on sales (tCO_2eq/USD)		569.42

- Base year activity data input sheet: Selection of the emission factor to be applied and input the collected monthly activity data for each emission source



• Base year emissions output (detail) sheet: Check on the automatically calculated emissions based on the monthly activity data input

Division		Emission source information				GHG emissions (tCO₂eq)												
		Emission facility name	Fuel	-	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Total
Scope 1 (Direct emissions)	Stationary combustion	Boiler No.1	Fuel Gas		m3	168.4278	200.3710	206.1788	142.2924	148.7827	193.4015	132.5846	229.2767	181.0715	231.7479	235.2181	264.2574	2,333.6104
		Boiler No.2	Propane		L	87.2338	103.9231	106.9576	73.5788	76.9698	100.2818	68.5068	119.0255	93.8397	120.3166	122.1297	137.3018	1,210.0651
		Drying facility	Liquefied Petroleum Gases (LPG)		L	9.7117	9.7147	8.8023	9.3820	9.0146	9.1862	8.8445	9.0010	9.2194	9.3820	8.9408	9.5627	110.7619
		Boiler No.3	Fuel Gas		m3	167.0252	198.9684	204.7762	140.8898	147.3801	191.9990	131.1820	227.8741	179.6689	230.3453	233.8155	262.8548	2,316.7792
		Start-up motor	Butane		L	1.3409	1.2100	1.0419	1.0985	1.2153	1.2577	1.2241	1.3303	1.0808	1.2153	1.2401	1.2153	14.4703
																		0.0000
	Mobile combustion	Official vehicle	Diesel Fuel - Diesel Passenger Car		L	2.6989	2.6449	2.9687	3.2386	2.1591	2.2940	2.6179	2.7528	2.5855	2.3750	3.2386	3.5625	33.1365
		Commuter bus	Gasoline - Gasoline Heavy-duty V		L	2.3555	2.3089	2.5885	2.8215	1.8895	2.0060	2.2856	2.4021	2.2576	2.0759	2.8215	3.1010	28.9135
		Fork lift	iesel Fuel - Diesel Light-duty Truck		L	1.4953	1.4413	1.7652	2.0351	0.9555	1.0904	1.4143	1.5492	1.3819	1.1714	2.0351	2.3589	18.6934
																		0.0000
	Process_emissions	Product/facility information				GHG emissions (tCO₂eq)												
		Process category	Subcategory	Calculation factor	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Total
		Carbonate_burning_i	Calcite or aragonite ($CaCO_3$)		t	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Glass_Production	Container (Amber/Green)		t	6.3000	4.2000	2.3100	5.2500	6.5100	3.1500	7.1400	5.0400	3.3600	3.7800	4.6200	5.4600	57.1200
		Zinc_Production	Default factor		t	18.9200	17.2000	22.3600	43.0000	8.6000	10.3200	20.6400	56.7600	18.9200	15.4800	25.8000	6.8800	264.8800
																		0.0000
Scope 2 (Indirect Emissions)	Facilities using electricity	Emission source information				GHG emissions (tCO₂eq)												
		Emission facility name	Fuel	-	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Total
		Process A	Electricity		kWh	29.6635	35.4127	41.8595	26.4326	33.3813	32.5945	32.6036	39.1880	39.1951	39.4122	33.0163	45.7286	428.4879
		Process B	Electricity		kWh	29.2371	34.9864	41.4332	26.0062	32.9550	32.1681	32.1773	38.7616	38.7688	38.9859	32.5899	45.3023	423.3717
		Outdoor storage	Electricity		kWh	19.4577	25.2070	31.6538	16.2268	23.1756	22.3887	22.3979	28.9822	28.9894	29.2065	22.8105	35.5229	306.0190
																		0.0000
	Facilities using heat/steam	External heat source I	Steam and Heat		GJ	0.7004												0.7004
																		0.0000

• Reference sheet: Check on the calorific value and emission factor that are the basis for calculating the emission-by-emission source

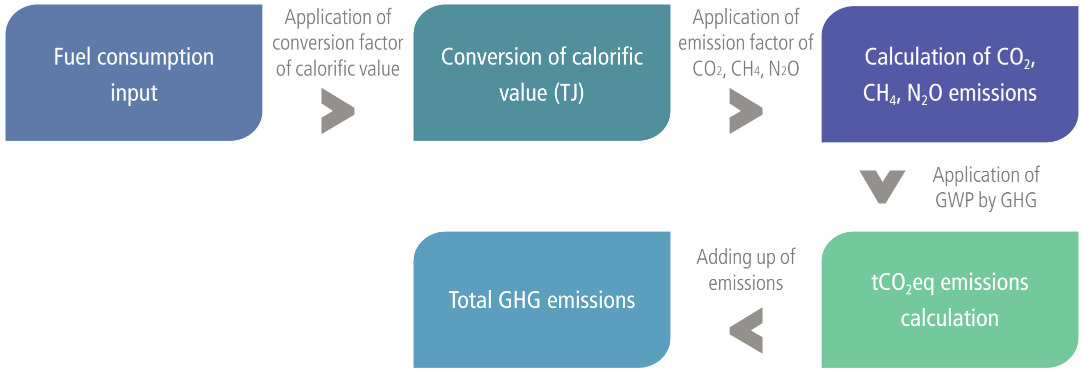
EPA net calorific value and emission factor by fuel

Fuel	Fuel unit	Previous unit	Gross calorific value (MMBtu/short ton, MMBtu/scf, MMBtu/gallon)	Gross calorific value (MMBtu/ton, MMBtu/m^3, MMBtu/L)	CO_2 Factor ($kgCO_2$/MMBtu)	CH_4 Factor (gCH_4/MMBtu)	N_2O Factor (gN_2O/MMBtu)	비고
Anthracite Coal	t	short ton	25.09	27.656526	103.69	11	1.6	Unit conversion: 1short ton=907.2kg 1ton=1,000kg 1 ton=(1000/907.2) short ton
Bituminous Coal	t	short ton	24.93	27.480159	93.28	11	1.6	
Sub-bituminous Coal	t	short ton	17.25	19.014550	97.17	11	1.6	
Lignite Coal	t	short ton	14.21	15.663580	97.72	11	1.6	
Mixed (Commercial Sector)	t	short ton	21.39	23.578042	94.27	11	1.6	
Mixed (Electric Power Sector)	t	short ton	19.73	21.748236	95.52	11	1.6	
Mixed (Industrial Coking)	t	short ton	26.28	28.968254	93.9	11	1.6	
Mixed (Industrial Sector)	t	short ton	22.35	24.636243	94.67	11	1.6	
Coal Coke	t	short ton	24.8	27.336861	113.67	11	1.6	
Municipal Solid Waste	t	short ton	9.95	10.967813	90.7	32	4.2	
Petroleum Coke (Solid)	t	short ton	30	33.068783	102.41	32	4.2	
Plastics	t	short ton	38	41.887125	75	32	4.2	
Tires	t	short ton	28	30.864198	85.97	32	4.2	
Agricultural Byproducts	t	short ton	8.25	9.093915		32	4.2	
Peat	t	short ton	8	8.818342		32	4.2	
Solid Byproducts	t	short ton	10.39	11.452822		32	4.2	
Wood and Wood Residuals	t	short ton	17.48	19.268078		7.2	3.6	
Natural Gas	m^3	scf	0.001026	0.036233	53.06	1	0.1	Unit conversion: 1m3=35.315 scf
Blast Furnace Gas	m^3	scf	0.000092	0.003249	274.32	0.022	0.1	
Coke Oven Gas	m^3	scf	0.000599	0.021154	46.85	0.48	0.1	
Fuel Gas	m^3	scf	0.001388	0.049017	59	3	0.6	
Propane Gas	m^3	scf	0.002516	0.088853	61.46	3	0.6	
Landfill Gas	m^3	scf	0.000485	0.017128		3.2	0.63	
Other Biomass Gases	m^3	scf	0.000655	0.023131		3.2	0.63	
Asphalt and Road Oil	L	gallon	0.158	0.041739	75.36	3	0.6	Unit conversion: 1L=0.264172gallon
Aviation Gasoline	L	gallon	0.12	0.031701	69.25	3	0.6	
Butane	L	gallon	0.103	0.027210	64.77	3	0.6	
Butylene	L	gallon	0.105	0.027738	68.72	3	0.6	
Crude Oil	L	gallon	0.138	0.036456	74.54	3	0.6	
Distillate Fuel Oil No. 1	L	gallon	0.139	0.036720	73.25	3	0.6	
Distillate Fuel Oil No. 2	L	gallon	0.138	0.036456	73.96	3	0.6	

※ Source : EPA "Emission Factors for Greenhouse Gas Inventories", Stationary Combustion Emission Factors

Flowchart of GHG emissions calculation within GHG emissions calculation tool

• The emissions calculation tool estimates the emissions in the following steps:



2-4-1. Calculation of emissions from fuel combustion

■ When fuels such as oil and gas are combusted in stationary or mobile combustion facilities to emit GHG, the emissions are calculated according to the following procedure:

1) Select the emission factor
- Since the IPCC emission factor and the US EPA emission factor are applied in the GHG Emissions Calculation Tool, select one of them and apply it.

2) Total annual (monthly) purchases, stocks or usage by emission source are compiled.
- The total units can be kg, ℓ, m³, etc. If the unit set by default in the Emissions Calculation Tool is different from the unit of the collected activity data, it needs to be converted into the unit displayed in the Emissions Calculation Tool.
- The total unit of activity data based on IPCC emission factor is t, and the total unit of activity data based on EPA emission factor is t, m³, and ℓ.

3) The fuel consumption collected by emission source is divided and entered for each facility in the Emissions Calculation Tool.
- Confirmation by emission source: All activity data need to be entered in the relevant emission source by stationary or mobile combustion.

Step	Content	Emissions calculation tool input
[Step 1]	Select emission factor	(Select one on the list)
[Step 2]	Enter the name of the emission facility	(Manual data entry)
[Step 3]	Select the type of fuel used in the facility	(Select one on the list)
[Step 4]	Check on fuel unit	Automatic selection
(When necessary)	Conversion of fuel consumption units	-
[Step 5]	Input monthly fuel consumption	(Manual data entry)

How to record and manage activity data

:: How to convert LNG from caloric units to volume units

Company A manages LNG, which is the fuel used for boiler facilities, in calorific value (MJ) indicated on the bill. In this case, since the unit of LNG in the GHG emissions calculation tool is set to volume (m³), it is necessary to convert from calorific value (MJ) to volume (m³) unit before entering activity data into the calculation tool. Companies can convert the calorific value of LNG used divided by the total calorific value in accordance with "(Korean) the Enforcement Rules of the Energy Act" to convert into volume units as shown below:

- LNG consumption of boiler a in January (MJ): 45,231
- LNG consumption of boiler a in January (m³) = 45,231MJ (calorific value) ÷ 43.1MJ/m³ (total calorific value) = 1,049 m³

＊ Reference] (Korean) the Enforcement Rules of the Energy Act [attached table] Energy conversion standards:
City gas (LNG) 1Nm³ = 43.1MJ (total calorific value) = 38.9MJ (net calorific value)
1J = 1,000kJ = 1,000,000MJ

:: How to convert LPG (propane) from volume units to weight units

Company B manages the LPG boilers in use with the gas meter measurement values based on the volumetric transaction method. In this case, conversion into weight (kg), which is the unit of LPG (propane) value, is required in the GHG Calculation Tool. Companies can use LPG consumption (measured by the meter), regional standard vaporization rate, and regulator pressure correction factor to convert unit as follows:

- Company B status

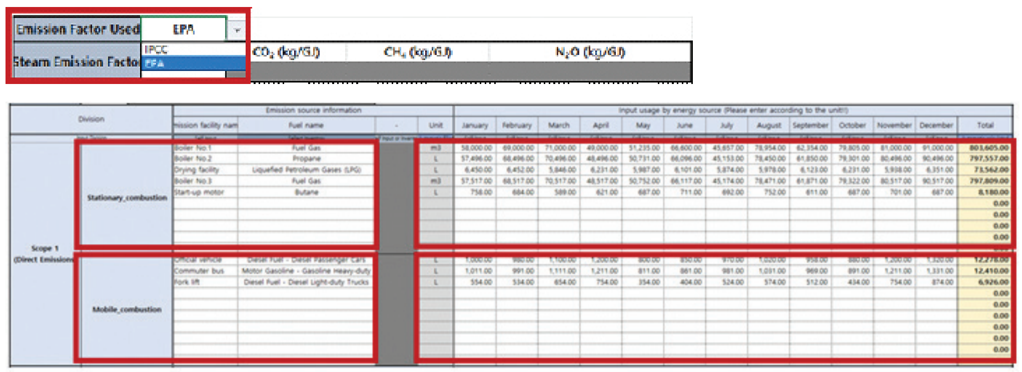
Region	Regulator pressure	Activity data	Net calorific value
Seoul	2.8 kpa	1,500 Nm³	46.3 TJ/Gg

- Fuel consumption of LPG boiler (kg) = LPG consumption (m³) ÷ standard vaporization rate by region (m³/kg) × regulator pressure correction factor = 1,500 ÷ 0.4810 × 1.000 = 3,119 kg

[Reference] Standard vaporization rate and regulator correction factor of Seoul and Metropolitan Area in Korea

Applicable area	standard vaporization rate	Regulator pressure (kPa)	Regulator correction factor	Vaporization rate
Seoul, Incheon Metropolitan City, Gyeonggi-do, Chungcheongbuk-do, Gangwon-do Yeongseo region (Regions other than Gangwon-do Yeongdong region)	0.4810	2.8 6.0 10.0 15.0 20.0 25.0	1.0000 1.0302 1.0679 1.1150 1.1621 1.2093	0.4810 0.4669 0.4504 0.4314 0.4139 0.3978

[Figure 9] Input activity data of stationary/mobile combustion activity data in the GHG Emissions Calculation Tool (Example)



2-4-2. Calculation of emissions from process emission

■ When carbon dioxide is used in the process or when a substance equivalent to a GHG is emitted during a physiochemical process for production, the emissions are calculated according to the following procedure:

1) The annual (monthly) production according to the applicable process at the business site is compiled
  - Production of lime
  - Use of carbonate in other processes
  - Production of glass
  - Production of carbide:
  - Production of soda ash
  - Production of ferroalloy
  - Production of zinc
  - Production of lead

2) The amount of production, usage, etc. collected through process emission is divided and entered for each process in the Emissions Calculation Tool.
  - Caution must be taken that other processes that use carbonates and glass production processes require additional information to calculate emissions.

Step	Content	Emissions calculation tool input
[Step 1]	Select process	(Select one on the list)
[Step 2]	Selection of raw materials/products produced and used in the process	(Select one on the list)
[Step 3]	Check on fuel unit	Automatic selection
Given process	Other processes using carbonates: Input carbonate content Glass production process: Enter glass cullet (waste glass) utilization ratio	(Manual data entry)
[Step 4]	Input monthly production volume	(Manual data entry)

[Figure 10] Input of activity data for process emission in the GHG Emissions Calculation Tool (Example)

Division		Emission facility name	Fuel name	-	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Total
Scope 1 (Direct Emissions)	Process_emissions	Carbonate_burning	Calcite or aragonite (CaCO3)		t	20	15	19	4	2	11	5	9	4	6	8	4	107
		Glass_Production	Container (Amber/Green)		t	30	20	11	25	31	15	34	24	16	18	22	26	272
		Zinc_Production	Default Factor		t	11	10	13	25	5	6	12	33	11	9	15	4	154

2-4-3. Calculation of emissions from waste incineration

■ It is similar to the procedure for calculating fuel emissions in a stationary combustion facility and calculates the amount of waste gas and emissions from industrial waste incinerated in a waste incinerator.

1) The incinerator's waste input is compiled.
  - The total unit uses the weight (ton), which is the default unit set in the Emissions Calculation Tool, and if it is different, it needs to be converted into the unit displayed in the Emissions Calculation Tool.

2) The amount of waste incinerated is divided and entered for each facility in the Emissions Calculation Tool.
  - Confirmation of emission source classification: all activity data values must be entered in the "Waste Incineration" field

Step	Content	Emissions calculation tool input
[Step 1]	Enter incinerator name.	(Manual data entry)
[Step 2]	Select a state of waste to be incinerated.	(Select one on the list)
[Step 3]	Select waste to be incinerated classification	(Select one on the list)
(part)	Select incineration waste sub-category	(Select one on the list)
[Step 4]	Input monthly incineration volume	(Manual data entry)

[Figure 11] Input the amount of waste incinerated in the GHG emissions Calculation Tool (Example)

Division		Waste	Emission facility name	Fuel name	-	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Total
Scope 1 (Direct Emissions)	Waste incineration	Solid	Incinerator No. 1	Industrial_waste	Other	t	4,500.00	6,800.00	9,055.00	3,587.00	6,488.00	6,581.00	4,568.00	9,332.00	5,465.00	1,324.00	2,354.00	9,453.00	69,707.00
			Incinerator No. 2	Municipal_solid_waste	Plastics	t	2,142.00	3,213.00	5,468.00	3,245.00	2,901.00	2,994.00	3,456.00	5,945.00	1,878.00	2,465.00	3,157.00	4,854.00	41,718.00
			Wastewater inciner	Sludge	Sludge	t	305.00	351.00	396.00	352.00	345.00	347.00	307.00	406.00	325.00	303.00	324.00	404.00	4,165.00
																			0.00
																			0.00
																			0.00
		Liquid	Waste Oil Combustion Furnace				3,053.00	3,513.00	3,964.00	3,519.00	3,450.00	3,469.00	3,066.00	4,059.00	3,246.00	3,032.00	3,238.00	4,043.00	41,652.00
			Municipal waste incinerator				2,998.00	3,458.00	3,909.00	3,395.00	3,414.00	3,011.00	4,044.00	3,191.00	2,977.00	3,183.00	3,988.00	2,875.00	40,443.00
		Gas	RTO				1,221.00	1,405.00	1,585.00	1,408.00	1,380.00	1,388.00	1,226.00	1,624.00	1,298.00	1,213.00	1,295.00	1,617.00	16,660.00
			Biomass boiler				244.00	281.00	317.00	282.00	276.00	278.00	245.00	325.00	260.00	243.00	259.00	323.00	3,333.00

* In the case of gaseous waste, regardless of the classification of industrial waste or municipal waste, the emission factor varies depending on the detailed classification of gaseous waste, so it is not necessary to fill out the "Waste Category" column.

2-4-4. Calculation of emissions from externally supplied electricity

■ GHGs may be generated from facilities owned by the company and the electricity used in business activities. GHG emissions from purchased electricity are a major source of emission with a high proportion in the place of business and are an important factor in achieving the reduction target. Emissions calculation for this indirect emission (electricity) is possible according to the following procedure:

1) Annual (monthly) electricity usage is compiled through bills issued by suppliers or the reading of meters installed at business sites.

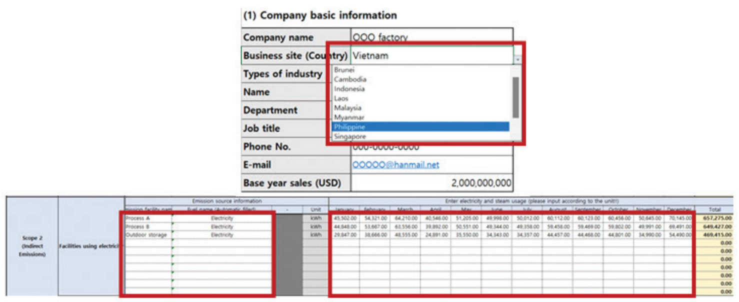
2) The electricity usage data collected at the business site are entered into the Emissions Calculation Tool. If the data on the total power consumption of the business site can be checked, the total indirect emission (electricity) amount of the business site can be estimated without entering data for each facility.
- In the GHG Emissions Calculation Tool, the country-specific electricity emission factors published by the IEA are applied.

Step	Content	Emissions calculation tool input
[Step 1]	Select the country of business location (first sheet)	(Select one on the list)
[Step 2]	Enter the name of the emission facility	(Manual data entry)
[Step 3]	Check on unit	Automatic selection
(When necessary)	Conversion of electricity consumption units	-
[Step 4]	Input monthly electricity consumption	(Manual data entry)

Calculation of indirect emissions (electricity)

: : GHG emissions = electricity usage × electricity emission factor provided by country × Global Warming Potential (GWP)

[Figure 12] Input electricity consumption in the GHG emissions Calculation Tool (Example)



2-4-5. Calculation of emissions from externally supplied heat/steam

■ If GHG emissions are emitted from facilities that operate equipment by purchasing heat (steam) from external operators, the amount of indirect emission (heat/steam) can be calculated according to the following procedure:

1) Annual (monthly) heat/steam usage is compiled from vendor-issued receipts, contracts or premises-installed meters.

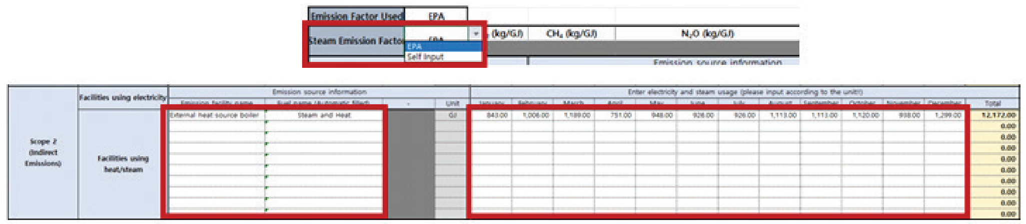
2) The heat/steam usage collected in business sites is entered into the Emissions Calculation Tool. If the data on the total heat/steam consumption of the business site can be checked, the total indirect emission (heat/steam) amount of the business site can be estimated without entering data for each facility.
- The emission factor applied by the GHG emissions calculation tool applies the U.S. EPA steam emission factor according to the GHG Protocol.
- If steam emission factors are provided by the supplier, it is preferred to use these emission factors to calculate emissions.

Step	Content	Emissions calculation tool input
[Step 1]	Enter the name of the emission facility	(Manual data entry)
(When necessary)	Enter the supplied steam emission factor	(Manual data entry)
[Step 2]	Check on unit	Automatic selection
(When necessary)	Conversion of units (1cal = 4.1868J)	-
[Step 3]	Input monthly fuel consumption	(Manual data entry)

Calculation of indirect emissions (heating/steam)

: : GHG emissions = heat (steam) production volume × heat (steam) emission factor provided by the supplier × Global Warming Potential (GWP)

[Figure 13] Input heat (steam) consumption data in the GHG Emissions Calculation Tool (Example)



2-5 Completion of inventory setting

■ Once the GHG inventory has been completed, it is necessary to record annual emissions in a certain format to facilitate management of the data obtained through the calculation of emissions. To record GHG emissions data, the format appropriate to each company can be adopted.

How to record and manage GHG emissions data

If the GHG Emissions Calculation Tool is used to calculate the GHG emissions for each business site, all business sites within the organizational boundary are to be collected and managed. Each company needs to adopt its own form. If there is no such form, the table below can be used as an example to prepare one. In general, the scope classification and the name of the emission facility are written so that it is easy to track the emissions and it is organized by year so that the emissions trend can be identified.

[Table 6] Form to manage GHG emissions (Example)

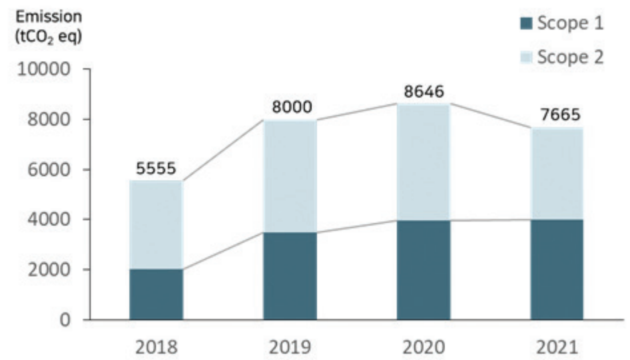
Category	Name of emission facility		2019 emissions (tCO_2eq)	2020 emissions (tCO_2eq)	2021 emissions (tCO_2eq)
Scope 1	Stationary Combustion	Boiler #1	1,755(25.3%)	1,594(23.1%)	2,000(28.2%)
		Boiler #2	2,947(42.5%)	2,663(38.7%)	2,545(35.9%)
		Drying facility	1,743(25.1%)	1,554(22.6%)	1,663(23.5%)
	Mobile Combustion	Official vehicles	27(0.4%)	10(0.1%)	33%(0.5%)
		Forklifts	28(0.4%)	55(0.8%)	64(0.9%)
	Process Emissions	Production of zinc	80(1.1%)	66(1%)	50(0.7%)
		Production of glass	265(3.8%)	886(12.9%)	668(9.4%)
		Production of lime	95(1.4%)	58(0.8%)	65(0.9%)
	Subtotal		6,912	6,886	7,088
Scope 2	Electricity usage	Office A	2,082(42.8%)	1,955(36.3%)	2,265(42.2%)
		Office B	2,057(42.3%)	2,551(47.3%)	2,331(43.7%)
	Steam usage	External boiler	726(14.9%)	886(16.4%)	744(13.9%)
	Subtotal		4,865	5,392	5,340
Total emissions			11,777	12,278	12,428

If a company conducts an emissions analysis through data collected by year, it can be usefully applied to set carbon neutrality target and establish GHG reduction targets.

■ Before setting targets, an emissions analysis using annual GHG emissions data needs to be performed. Through the annual emissions change analysis, one can learn the information necessary for overall target setting, such as identifying the causes of changes in emissions, finding out the emission sources that account for most, and setting reduction estimates and reduction strategies.

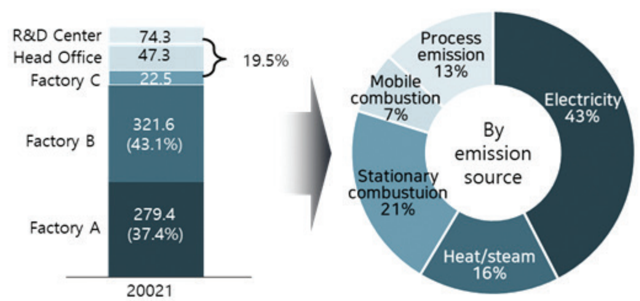
How to analyze GHG emissions

:: Trend analysis on annual emissions



- Estimated cause of increase in emissions in 2019
  - Full-scale operation of Business Site A's factory
  - Beginning of CFC and HCFC calculation (not available due to elapse of the data document retention period before 2018)
- Estimated cause of decrease in emissions in 2021
  - Suspension of operation of the pilot line at Business Site A

:: Trend analysis on specific year's emissions



- Factory A: Large amount of electricity/steam consumption in the zinc production process
- Factory B: Use of electricity for production facilities with a large amount of refrigerant leakage
- Factory C: High power consumption of production facilities
- Head Office: High electricity consumption
- R&D center: High electricity consumption

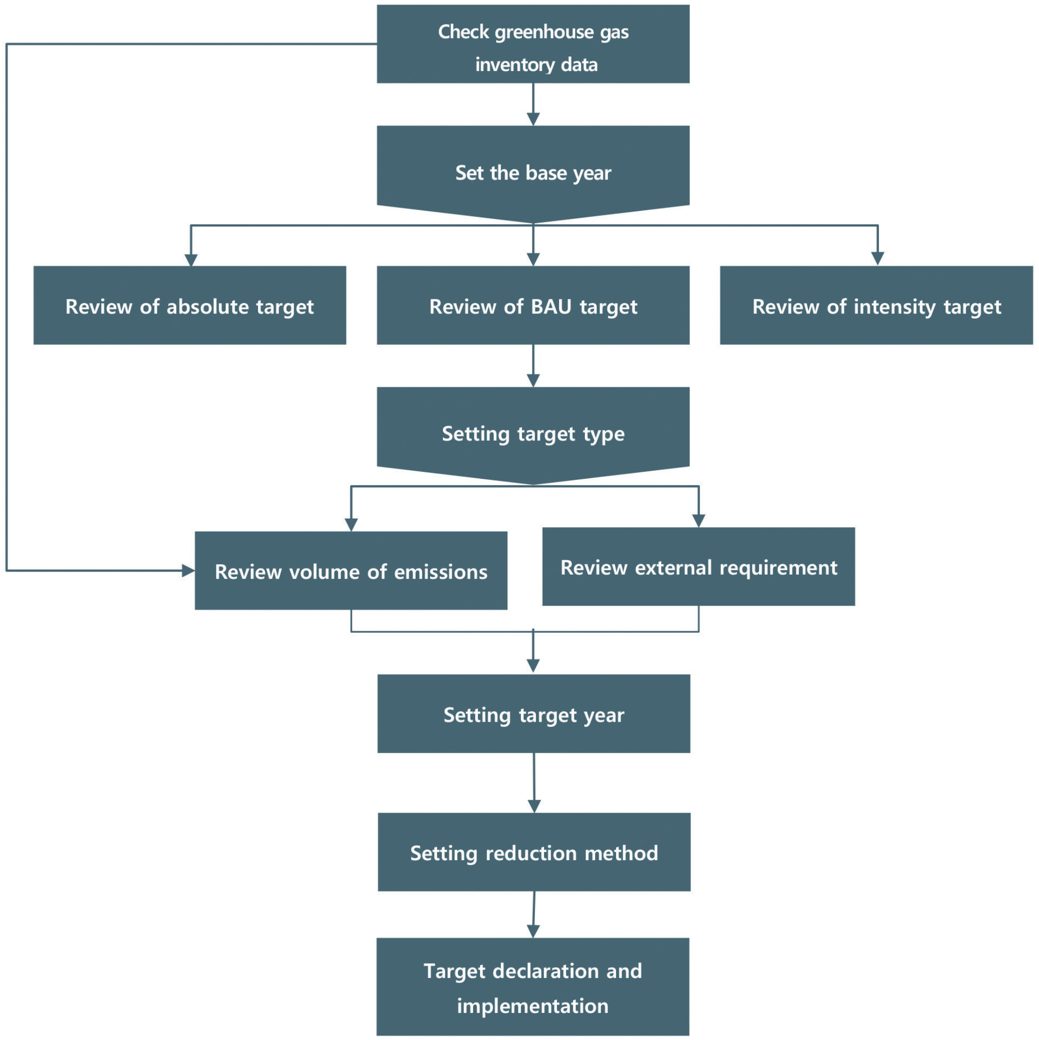
Analysis of GHG emissions can be carried out in various ways according to needs. Emissions analysis is not only performed to obtain information necessary for setting targets, but also used for emissions data management, such as checking errors of emission data by data collection and estimating expected emissions due to changes in emission sources, so it is essential to improve the accuracy of the data.

[III] Setting Greenhouse Gas Emissions Reduction Targets

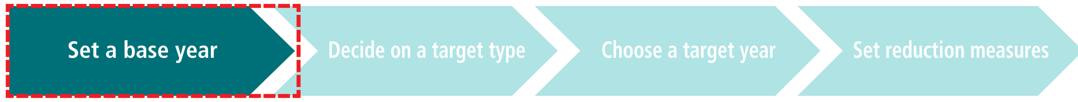
[1] Purpose and procedure of setting GHG emissions reduction targets

■ (Purpose) Setting GHG reduction targets is the final step in a company's carbon neutrality strategy. Based on the previously established GHG inventory, the goal is to set GHG emissions, target intensity and level, and to ascertain emissions reduction methods so that companies can establish reasonable targets and realistically implement them.

[Figure 14] Process of setting carbon neutrality target



[2] How to set GHG emissions reduction targets



2 - 1 Set a base year

■ If a company intends to establish a carbon neutrality target, it is important to set an appropriate base year to track and manage GHG emission performance during the target period systematically and consistently.

Explanation of Terminology

:: Base year

Refers to the specific year used when setting the GHG emissions reduction target, and the concept is used when setting the target by applying the absolute reduction target

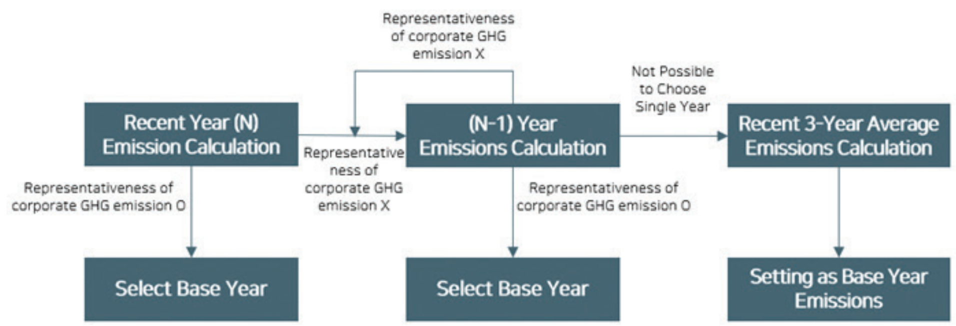
■ In these guidelines, we recommend each company set the base year by referring to SBTi, GHG Protocol, etc. in consideration of the following:

1) It is recommended that operators select at least the year 2015 to reflect the company's GHG emission status.

2) It is recommended to **select the most recent year** for which all reliable and verifiable data for estimating Scope 1 and 2 emissions within organizational boundaries exists as the base year.

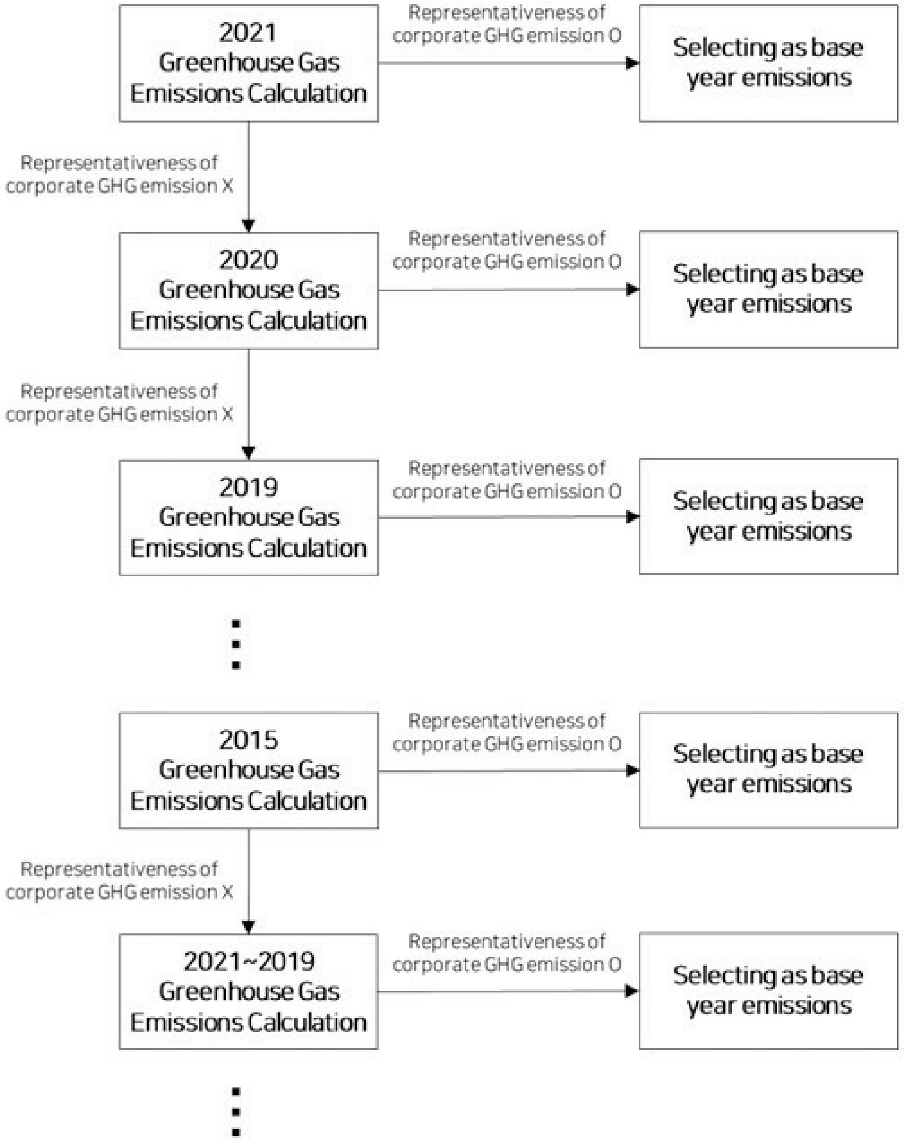
3) It is recommended to set the base year as a year that can **represent the general GHG emissions trend of the business operator.** If it is **difficult to select a representative year,** the operator uses the **average of the GHG emissions for the last three consecutive years** as the base year's emissions.

[Figure 15] Setting process of base year



Example of how to set a base year

This year, if Company A wants to set the base year for establishing the GHG emissions reduction target by 2030 in the absolute emissions method, emissions of the base year can be reviewed in the following order:



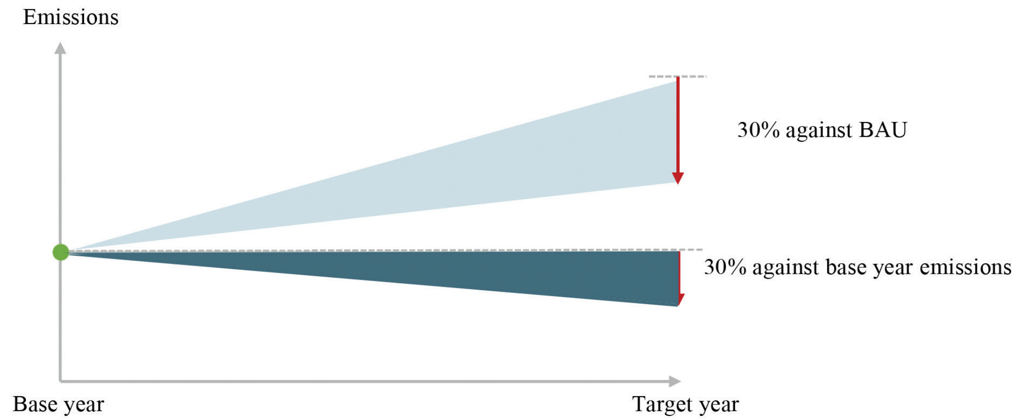
2-2 Decide on a target type

- If the base year has been set in consideration of the possibility of verifying emissions, the trend of emissions, the most recent year, etc., a target type must be selected before setting the target year.

- There are three main types of targets when it comes to calculating, and they can be classified into absolute quantity, emission forecast (BAU) and intensity.

  - Absolute target: This is the method of setting the reduction of GHG emissions compared to the base year, and the most preferred method due to its transparent and reliable implementation.
  - Emission forecast (BAU; business-as-usual): This indicates the projected future GHG emissions if no special actions are taken to reduce it and is mainly adopted by developing countries.
  - Intensity target: This is a method of setting a target to reduce GHG emissions by dividing GHG emissions through economic outputs (production, energy consumption, etc.)

[Figure 16] Comparison of GHG emissions reduction target types (against BAU vs. against base year)



- In these guidelines, we recommend that each company adopts the internationally preferred and reliable "absolute target" method instead of "BAU," which is highly variable depending on business growth and fluctuations.

Set a base year > Decide on a target type > **Choose a target year** > Set reduction measures

2-3 Choose a target year for carbon neutrality

■ After setting the target type, the target year needs to be set, which represents the endpoint of the reduction path. The target year can be divided into the final target of achieving carbon neutrality and the interim target, which is a point on the reduction path. Each company can set targets on its own or consider external circumstances, such as global initiatives.

- Company's voluntary targets: Based on the calculated emissions data, GHG emissions reduction is estimated depending company's budget and technological capability and a target that suits its situation based on the forecast result.

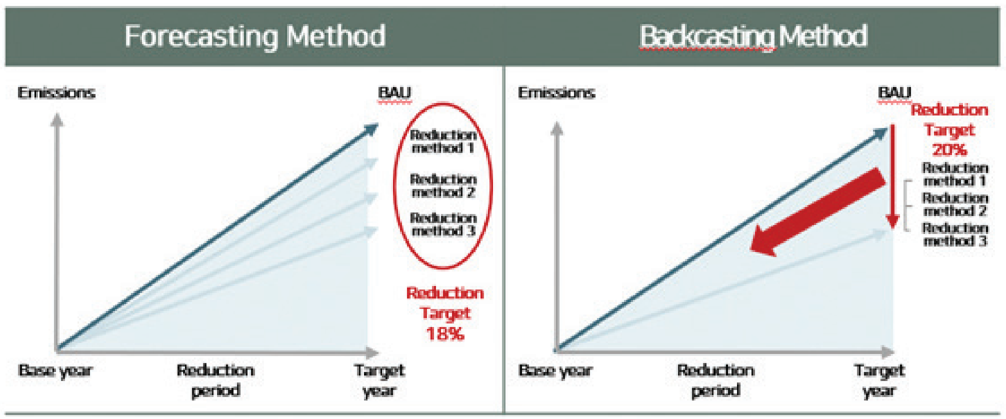
How to set voluntary targets: Forecasting & Backcasting

The GHG reduction target can be set by selecting the method suitable for the situation of the company among the forecasting and backcasting methods.

- Forecasting method: This is a method to set a reduction target by forecasting the GHG emissions BAU for the target year, identifying feasible reduction measures and then synthesizing the amount of GHG that can be reduced.

- Backcasting method: Given that the GHG emissions reduction target is set by external circumstances such as customer's demand, it is a method to set the reduction target first and then determine the reduction methods and intensity needed to achieve the target.

By creating multiple scenarios in this way, the most likely scenario to reduce GHG emissions can be selected considering the impact and the reduction intensity of each scenario. In addition, flexibility to select different scenarios according to the changing internal and external circumstances in the process of achieving the target is secured.



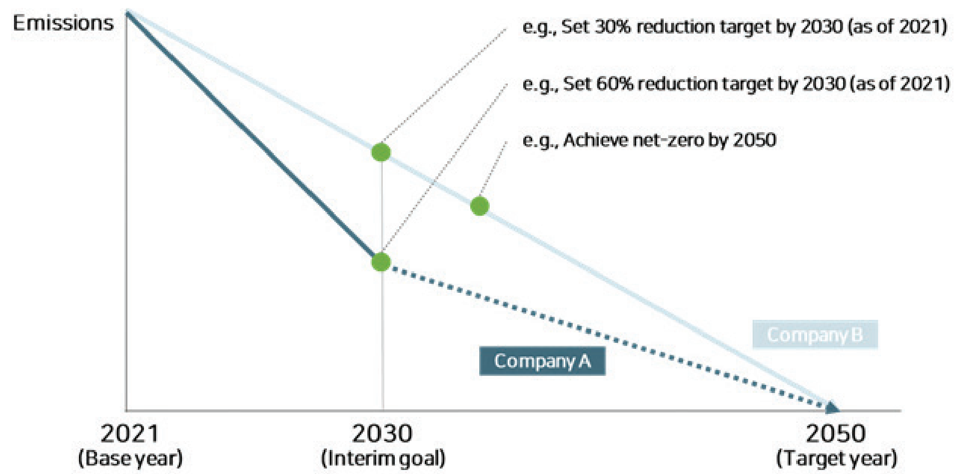
- Global initiative targets: SBTi and SME Climate Hub are global initiatives that can be referenced in setting SMEs' carbon neutrality target.

[Table 7] Guide on global initiative carbon neutrality target setting

Category	SBTi	SME Climate Hub
Base year	Most recent year's emissions	Emissions within 2 years from the year of submission
Target year	5-10 years	2030
Target intensity	At least 1.5°C or lower At least of 2°C *Only Scope 3 among short-term targets	Reduce emissions by 50% by 2030 Achieve carbon neutrality by 2050
Scope target	[Mandatory] Scope 1+2 [Recommended] Scope 1+2+3 *Scope 3 targets are included if the proportion of Scope 3 is 40% or more	[Mandatory] Scope 1+2+3 (business travel) [Recommended] Scope 1+2+3

How to set reduction targets

If one draws a reduction path endpoints of the base year and target year as both ends, short-term, mid-term and long-term targets for each year can be set.



Set a base year → Decide on a target type → Choose a target year → **Set reduction measures**

2-4 Set reduction measures

■ To achieve the GHG emissions reduction target, it is necessary to first understand the characteristics of the GHG emission of the places of business. Through identifying the GHG emissions of each activity, reduction priorities are set and specific reduction measures are determined.

2-4 -1. Creating a GHG reduction portfolio

A. Analysis on multi-GHG emission sources

■ Opportunities to reduce GHG emission are identified by considering GHG emissions and characteristics by major GHG emission sources such as fuel sources, waste heat of heat boiler, operating conditions, exhaust gas, etc.

[Figure 17] Emissions by emission source within organizational boundaries (Example)

Emission source	Emissions by facility (tCO_2eq)				
Scope 1	700	150	0	50	0
Scope 2	850			200	50

B. Discover opportunities to reduce internal and external GHG emissions

■ After identifying opportunities to reduce GHG emissions, discover which internal and external opportunities exist at the places of business, such as fuel conversion, adjustment of operating conditions, the introduction of high-efficiency facilities, and development of new and renewable energy sources.

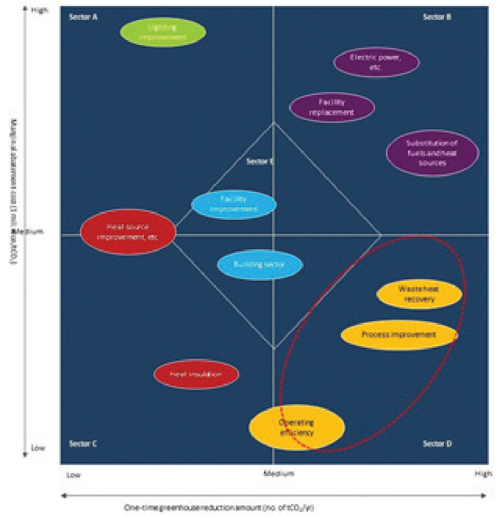
[Table 8] Analysis on opportunities to reduce GHG (Example)

Category	Improvement possibility	Current situation	Content	Possibility for GHG reduction
Fuel conversion	Medium	Good	• Convert bunker C oil into LNG	High
Methane boiler	High	Middle	• Methane generated from wastewater treatment plants is used as a heat source.	Medium
Eco-friendly vehicles	Low	Bad	• Use of EVs or hybrid vehicles	Low
Green buildings	Low	Middle	• Introduction of carbon neutral buildings	Low
Introduction of waste heat collection system	High	Bad	• Raw material pre-heating using waste heat	Low
Solar panels	N/A	N/A	• Installation of solar power system on the roof of the places of business	High

C. Calculation of marginal abatement cost (MAC) and expected savings from reduction options

■ The marginal abatement cost and expected savings for the opportunities of GHG emissions reduction are compared and analyzed.

[Figure 18] MAC analysis by GHG emissions reduction option (Example)



* [Reference]

The U.S. Department of Energy's Advanced Manufacturing Office provides software called "MEASUR" to improve industrial system efficiencies in the manufacturing sector and identify potential savings opportunities. With the system, energy and GHG savings can be quantified by comparing the performance of facilities before and after installation of equipment such as pumps, air compressor, process heat and wastewater.

- Software download (https://ornl-amo.github.io/) → Execution and language selection → Facility selection → Enter current facility information → Add scenario and enter information on the facility to invest for comparison → Compare results (energy, CO_2 savings, etc.)

[Figure 19] Expected energy savings from facility replacement (Example)

	Baseline	Scenario 1	Scenario 2
Percent Savings (%)	— —	61.0%	22.0%
Pump efficiency (%)	29.5	78.6	29.5
Motor rated power (hp)	300	300	300
Motor shaft power (hp)	152.3	57.2	120.1
Pump shaft power (hp)	152.3	57.2	120.1
Motor efficiency (%)	94.7	92	95.4
Motor power factor (%)	75.6	45.2	69.1
Percent Loaded (%)	51	19	40
Drive efficiency (%)	100	100	100
Motor current (amps)	199	129	171
Motor power (kW)	120	46.4	94
Annual CO2 Emissions (tonne CO_2)	**0.0**	—	—
Annual CO2 Emissions Savings (tonne CO_2)	—	—	—
Annual Energy (MWh)	**1,051**	**406**	**823**
Annual Energy Savings (MWh)	—	**645**	**228**
Annual Cost ($)	**69,379**	**26,804**	**54,315**
Annual Savings ($)	—	**42,575**	**15,064**
Implementation Cost	—	—	—
Payback Period (months)	—	0	0

※ Source: https://ornl-amo.github.io/

Explanation of Terminology

: : What is the marginal abatement cost (MAC)?

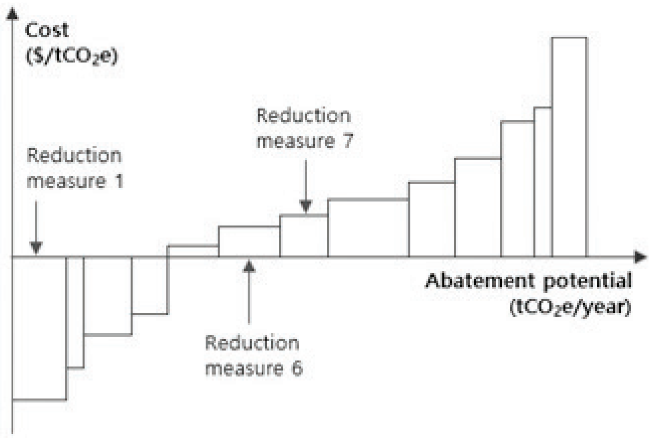
It refers to the operating and investment cost to reduce 1 ton of GHG when making technical changes to the system or converting fuel for the purpose of reducing GHG.

$$\text{MAC} = \frac{\triangle \text{Cost difference (\$) of before (A) and after (B) technical change}}{\triangle \text{ GHG emissions difference (tCO}_2\text{eq) of before (A') and after (B') technical change}} = \frac{B - A}{A' - B'}$$

※ Source: KEMRI, Electric Economic Review (No. 13, 2019)

Marginal abatement cost curve

The marginal abatement cost curve (MAC curve) is a visualization of the potential GHG emissions reduction and effectiveness of abatement measures. The vertical axis of the graph means the marginal reduction cost, and the horizontal axis indicates GHG emissions that is reduced annually, which allows one to compare GHG emissions that can be reduced up to a cost threshold.



※ Source: Ministry for the Environment, New Zealand Government

As various reduction measures are listed and visualized in the order of lowest marginal abatement cost for easy investment decision making, the marginal abatement cost curve can be helpful in identifying suitable measures for companies.

D. Determining priorities for GHG emissions reduction opportunities

- Priorities are set for GHG emissions reduction opportunities through emissions calculation results, facility characteristics, investment costs and scenario analysis.
- The following aspects can be considered when determining the priority of GHG emissions reduction opportunities.
  - Which facilities emit the most GHG emissions?
  - What is the costliest scenario?
  - Which scenarios are immediately applicable to your business?

[Table 9] Priorities for each GHG reduction option (Example)

Reduction method	Reduction volume (tCO_2/yr)	Investment Cost (100 mil.)	Promotion time	Effectiveness	Priority
Replacement of boiler tube header	1,600	1.9	Short term	Medium	1
Replacement of air pre-heater heating elements	650	1.6	Short term	Low	4
Improving turbine efficiency by enhancing circulating water system performance	1,500	2.1	Medium term	Medium	2
Installation of turbine inlet steam pipe debris removal device	1,800	5.8	Medium term	Medium	5
Reduced power consumption through fly ash control operations	500	-	Medium term	Low	3
Reduced power consumption through desulfurization facility	400	-	Medium term	Low	3
Reduced power consumption by installing a variable speed pump device	2,000	4.9	Medium term	Medium	6
Improving the efficiency of internal combustion power generator	5,000	700	Long term	High	Postponed

E. Creating a GHG reduction portfolio

- An optimal reduction portfolio is designed for companies in consideration of the priority of GHG emissions reduction opportunities.
  - Existing facility improvement plans and new annual facility introduction plans are prepared.

Annual facility improvement plan improvement plan by year

Once the order of introduction of reduction measures has been decided, one can manage the schedule by creating an annual facility improvement plan

	Means of reduction	2022년		2023년		2024년	
		The first half	The second half	The first half	The second half	The first half	The second half
1	**Replacement of No. O boiler tube header**						
	- Facility investigation and comparative analysis	→					
	- Facility selection and installation	→	→				
	- Pilot operations and stabilization		→				
2	**Improving turbine efficiency by enhancing circulating water system performance**						
	- System analysis and modelling progress			→			
	- Introduction and stabilization				→		
3	**Reduced power consumption in No. O, O and O through fly ash control operations**						
	- Case studies			→	→		
	- Quantitative analysis through trial run				→	→	
	- Derivation of optimal solutions and stabilization					→	→

2-4-2. GHG emissions reduction plans for Scope 1 emissions

■ Improving operational efficiency

- Improving operational efficiency and GHG emissions reduction effect through process improvement, etc.
  e.g., improving boiler operation, maintaining proper steam generation pressure, adjusting boiler air ratio and controlling combustion, blocking outside air inflow through furnace pressure control, etc.

■ Use of waste heat

- Reducing GHG emissions by recovering and reusing waste heat generated from boilers, etc.
  e.g., installation of boiler air pre-heater, boiler exhaust gas waste heat recovery, heat transfer boiler waste heat recovery, cooling water heat recovery, waste heat boiler, etc.

■ Replacement with high-efficiency facilities

- Replacing obsolete facilities, investing in facilities with a large GHG reduction effect

  e.g., high-temperature condensate pump, oxygen-enriched combustion system, regenerative burner system, regeneration thermal oxidizer (RTO), electric induction furnace, etc.

※ Source: EG-TIPS Energy and GHG Comprehensive Information Platform (http://tips.energy.or.kr/main/main.do)
Carbon Trust (http://www.carbontrust.com)

2-4-3. GHG emissions reduction plans for Scope 2 emissions

■ Power efficiency boost and consumption reduction

- Introduction of facilities that use electricity such as lightings and air-conditioning systems to improve energy efficiency and reduce energy consumption
  e.g., introduction of smart LED lighting systems, etc. (lightings), replacement of air conditioners, etc. (HVAC), introduction of power saving devices (inverters, etc.)

■ Use of renewable energy

- Power generation: Install renewable energy power generation sources such as solar power panels by directly utilizing idle land plots in business sites
  e.g., GHG emissions reduction by installing solar panels on the building rooftop, parking lots, walls, etc.

- Purchase: Reduction of GHG emissions through the purchase of renewable energy.

Scheme	Content
Power purchase agreement (PPA)	Signing a contract to purchase electricity directly from a renewable energy generator
Green pricing	Pays higher prices (with separate fees) for electricity generated by renewable energy
Purchase of certificates	Purchased renewable energy supply certificates from a power generator

■ Utilization of internal heat sources and discovery of external waste heat sources

- Conversion of steam(heat) supply to internal facilities (reduction of external steam purchases) or utilization of external waste heat e.g., in-house steam generation using in-house boiler waste heat, incineration heat supplied from an external waste incineration operator, etc.

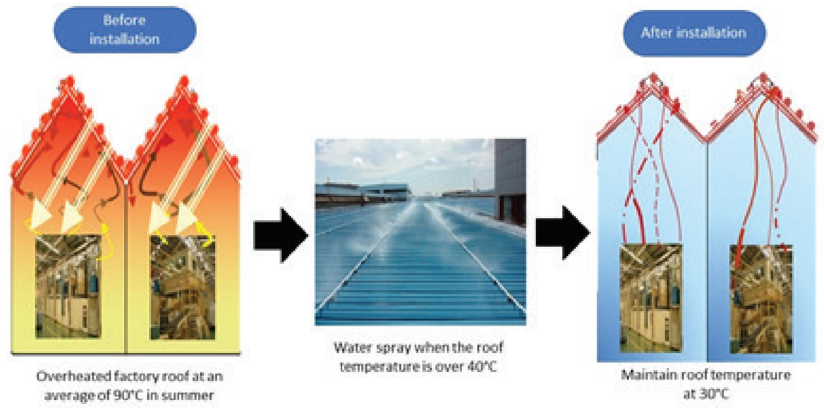
※ Source: U.S. EPA (http://www.epa.gov/climateleadership), RE100 (http://www.there100.org)
SME Climate Hub (http://smeclimatehub.org/uk/#steps)

Scope 2 emissions reduction: Installation of factory cooling sprinkler system

Manufacturing plants have difficulties in cooling system due to factory dust and open doors. Especially in summer, high cooling and maintenance costs are required for high temperature inside the factory and the need for air circulation.

Company W, a sprinkler manufacturer, installed a factory cooling sprinkler on the roof of its building, so that when the roof temperature is high, rainwater is sprayed through a sensor in the form of mist to create an indoor cooling effect and energy savings.

[Figure 20] Company W's sprinkler cooling system



: : Calculation of GHG emissions reduction through installation of factory cooling sprinkler system

- A sprinkler system was installed on the total roof area of 24,000m^2
- The average temperature in summer is 31.7°C and the average indoor temperature dropped by 11°C from 41.4°C to 30.4°C after installation.

Average indoor temperature before replacement	Average indoor temperature after replacement	Average power consumption before replacement	Average power consumption after replacement	Monthly power savings
41.4°C	30.4°C	52,775kWh	27,200kWh	25,575kWh

- Based on the Korean carbon emission factor of electric power, it is equivalent to about 11.76 tons of GHG emissions reduction effect.

Monthly Power savings	Korean Carbon emission factor (As of that point of time)	The amount of GHG reduction
25,575kWh	0.459tCO_2eq/MWh	11.74 tCO_2

※ Source: W Company website

[IV] Scope 3 Management

[1] Categories of Scope 3

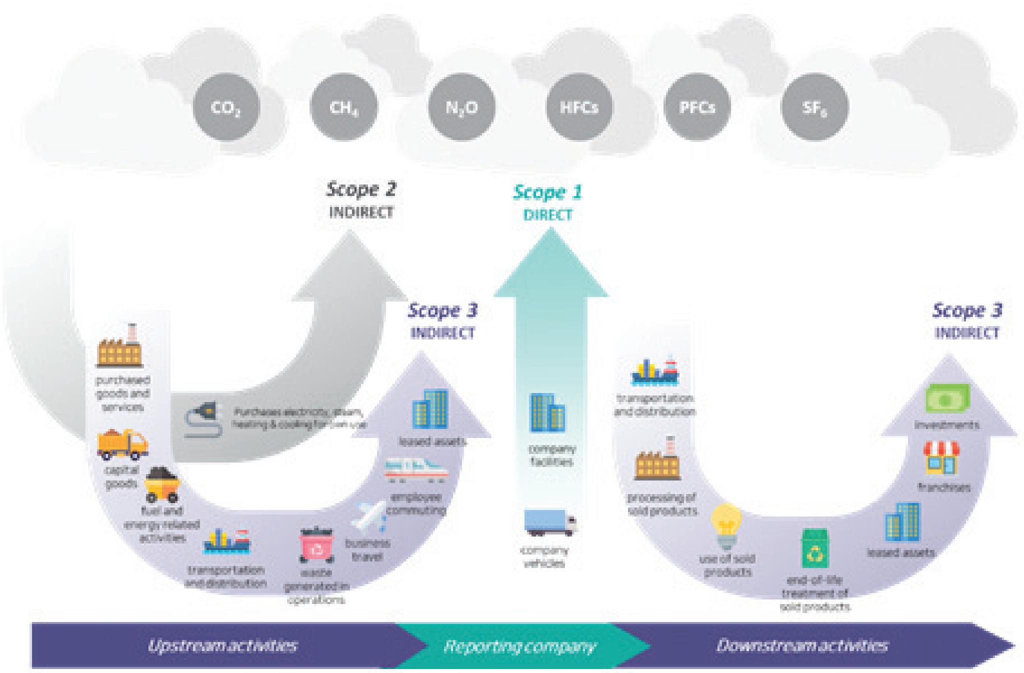
■ The demand for information disclosure on carbon neutrality has increased at rapid pace. Recently, the international community's interest on corporate carbon neutrality has been moved from Scope 1 and 2 to Scope 3.

- Of the 3,865 companies that joined the SBTi, 1,834 set targets based on scientific scenarios, and of these, about 1,500 companies (about 84%) set reduction targets that encompass Scope 3. The scope of a company's carbon neutrality is expands from the inside to the outside of the organizational boundaries, and it seems that SMEs need to be prepared for this change. In this chapter, we look at the definition of Scope 3, an explanation of each category and relevant calculation method of GHG emissons.

■ Scope 3 refers to GHG emission that are indirectly caused by business activities outside the organizational boundaries for which the company reports. Although the scope of Scope 3 is very comprehensive and the boundaries are not yet clear, it is generally used as 15 categories defined by the GHG Protocol and is largely divided into upstream in corporate production activities and downstream in product consumption and disposal stages.

- Upstream activities are supplier-oriented items that can occur and manage relatively at the corporate level, such as the production of raw materials and cooperation with suppliers. These include business travel, employee commuting, waste generated in operations, and purchased goods and services.
- Downstream activities include the life cycle of a product, from distribution to storage, consumption, and disposal. These usually depend on the consumer's usage cycle, habits, etc.

[Figure 21] Classification of GHG emission categories



※ Source : GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard

[Table 10] 15 categories of Scope 3

Area	Category	Content
Upstream	1. Purchased goods and services	GHG emissions generated by suppliers for producing goods and services when purchasing goods/services
	2. Capital goods (investment and purchasing)	GHG emissions generated by the production of those capital goods when purchasing capital goods* *capital goods: means of production used for the production/sale/storage/transportation of goods/services other than land
	3. Fuel- and energy-related activities	GHG emissions from energy-related activities not included in Scope 1 and 2
	4. Upstream transportation and distribution	GHG emissions from transportation and distribution related to the purchase of products and services
	5. Waste generated in operations	GHG emissions from the process of consigning third-party disposal (landfill, incineration, recycling, etc.) of wastes generated at the place of business owned or operated by the company
	6. Business travel	GHG emissions from business trips of members using transportation modes owned or operated by a third party
	7. Employee commuting	GHG emissions from the transportation modes that employees use when commuting
	8. Upstream leased assets	GHG emissions from the operation of properties leased from other companies
Downstream	9. Downstream transportation and distribution	GHG emissions from the transportation and distribution of sold products and services
	10. Processing of sold products	GHG emissions generated during product processing of third-party companies who purchased the products sold (calculated only when intermediate goods/components are sold)
	11. Use of sold products	GHG emissions from the use of sold products/services
	12. End-of-life treatment of sold products	GHG emissions from the disposal of products sold
	13. Downstream leased assets	GHG gas emissions from the operation of properties leased to other companies among owned properties
	14. Franchises	Scope 1 and 2 emissions from franchisees (Calculated only when the company engages in franchise business)
	15. Investments	Scope 1 and 2 emissions from invested companies

Source : GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard (Reformation)

[2] Outline of collecting activity data and calculating GHG emissions

■ While the scope of the Scope 3 classification system is still unclear and diverse, a step-by-step and gradual approach is required for estimating GHG emissions for Scope 3. Instead of estimating the total emissions of upstream and downstream activities right away, it is important to first identify the activities that the company's business needs the most or is easily to be easy to estimate.

- After reviewing what activity data can be collected within a company based on 15 categories, it is necessary to set up a calculation method suitable for the situation of the places of business to calculate the possible GHG emissions by category.
- In the guidelines, we will briefly review activity data and calculation methods for each category, and also look at examples of some activities that are relatively easy to collect activity data and have simple calculation methods.

2-1 Upstream activities

[Table 11] Scope 3 upstream activity data

Area	Category	Activity data
Upstream	1. Purchased goods and services	• GHG emissions from the entire life cycle of a supplier's goods • Energy use or GHG emissions by places of goods suppliers
	2. Capital goods (investment and purchasing)	• GHG emissions from the entire product life cycle of a supplier measured and calculated for each place • Energy use or GHG emissions by places of capital goods suppliers
	3. Fuel- and energy-related activities	• GHG emissions by category for upstream emissions (e.g., fuel extraction) • Energy loss rate during transportation and distribution by grid • Power purchased by company and emission rate by generator for purchased power
	4. Upstream transportation and distribution	• Energy use or GHG emissions by activity of other distributors/transporters • Actual travel distance • Product emission factor
	5. Waste generated in operations	• GHG emissions by site measured by waste management companies • Company's specific metric ton waste emissions • Company-specific emission factor
	6. Business travel	• Transportation modes and distance used in business travel • Emission factor by transportation modes
	7. Employee commuting	• Types of transportation modes and distance of employees between their homes and work sites
	8. Upstream leased assets	• Energy usage collected from electricity bills or meter readings from assets leased from other businesses

※ Source : GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard (Reformation

2-1-1. Purchased goods and services

■ This category includes life cycle GHG emissions generated when companies purchase goods and services in the reporting year. Purchased goods can be divided into production-related ones (e.g., raw materials, parts, components, etc.) and non-production-related ones (e.g., office furniture, office supplies, IT supply chains, etc.).

- Calculation methods include supplier-specific method, hybrid method, average-data method, and spend-based method

Methods and examples of calculating emissions for purchased goods and services

: : Formula for calculating emissions based on supplier-specific method

GHG emissions = total amount of goods and services purchased (kg) x emission factor (kgCO_2eq/kg)

EX | Company A is a construction contractor, and the materials required for construction were managed through an in-house system and data on the total amount purchased for each material was collected.

Product name	Supplier	Purchased amount (kg)	Emission factor (kgCO_2eq/kg)
Cement	Supplier C	200,000	0.15
Lime	Supplier D	600,000	0.10
Paint	Supplier E	200,000	0.10
Wood	Supplier F	100,000	0.25

GHG emissions of goods purchased by Company A

= (200,000 × 0.15) + (600,000 × 0.1) + (200,000 × 0.1) + (100,000 × 0.25) = 135,000 kgCO_2eq

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-1-2. Capital goods (investment and purchasing)

■ Capital goods are ones used in the manufacture, storage, transportation, and provision of services in the place of business. Examples of capital goods include processing equipment, machinery, buildings, facilities, and vehicles.

- As in Category 1 (purchased goods and services), calculation methods include supplier-specific method, hybrid method, average data method, and spend-based method.

2–1–3. Fuel– and energy–related activities

■ Fuel and energy-related activities in Scope 3 refer to emissions excluding GHG emissions generated from energy activities related to Scope 1 and 2 (fuel consumption or electricity use) among all energy activities.

- For example, upstream emissions mainly come from of purchased fossil fuels, upstream emissions of purchased electricity, emissions resulting from losses during transportation and distribution of fossil fuels and electricity.

Methods of calculating emissions for fuel- and energy-related activities

:: Formula for calculating upstream emissions of purchased fossil fuels

GHG emissions = fuel consumption (kWh) x upstream fuel emission factor ($kgCO_2eq/kWh$)

* Upstream fuel emission factor = life cycle emission factor – fuel emission factor

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-1-4. Upstream transportation and distribution

■ It refers to generated GHG emissions from products and services that are transported and distributed by using transportation modes owned or operated by a third party. Examples include air transport, railroad transport, road transport, sea transport and storage of products in warehouses and distribution centers.

- There are fuel-based methods, distance-based methods, and spend-based method. If information on the weight, distance, and transportation modes of each shipment delivered by the carrier can be ascertained, the emissions can be calculated using the distance-based calculation method.

Methods and examples of calculating emissions for upstream transportation and distribution

:: Formula for calculating emissions based on the distance-based method

GHG emissions = mass (ton) of purchased product x distance traveled (km) x emission factor by transportation modes ($kgCO_2eq$/ton-km)

EX | Company B is an Italian chair manufacturing plant and receives materials from Companies X, Y, and Z. Accordingly, Company B has collected data on the type of vehicle, distance, and weight.

Supplier	Mass of purchased products (ton)	Distance traveled (km)	Transportation modes	Emission factor ($kgCO_2eq$/ton-km)
X	2	2,000	Truck (load > 3.5-7.5 t)	0.2
Y	1	3,000	Air transport (long-distance flight)	1.0
Z	6	4,000	Shipping (container 2,000-2,999 TEU)	0.05

GHG emissions of goods purchased by Company A

= (2 x 2,000 x 0.2) + (1 x 3,000 x 1.0) + (6 x 4,000 x 0.05) = 5,000 $kgCO_2eq$

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-1-5. Waste generated in operation

■ It refers to GHG emissions generated in the process of consigning waste from the place of business to a third-party contractor. However, if waste treatment is directly carried out in the place of business, it must be calculated by including it in Scope 1 and 2.

- There are the supplier-specific method, waste-type-specific method, and average-data method. If the waste treatment company can provide waste-related Scope 1 and 2 data, the supplier-specific method is adopted. Otherwise, the waste-type-specific method or average-data method must be applied.

Methods and examples of calculating GHG emissions for waste generated in operation

:: Formula for calculating GHG emissions based on the supplier-specific method

GHG emissions = Scope 1 and 2 emissions from waste treatment companies

:: Formula for calculating GHG emissions based on the waste-type-specific method

GHG emissions = waste amount (ton or m^3) x emission factor ($kgCO_2eq$/ton or m^3)

EX | Company C is a manufacturer of plastic components and has produced large amounts of solid waste and wastewater. Company A collected data according to the treatment method for each waste type.

Waste type	Waste volume	Treatment method	Emission factor
Plastic	2,000 ton	Landfill	40 $kgCO_2eq$/ton
Plastic	3,000 ton	Waste incineration and heat recovery	2 $kgCO_2eq$/ton
Plastic	4,000 ton	Recycling	10 $kgCO_2eq$/ton
Wastewater	5,000 m^3	Wastewater treatment	0.5 $kgCO_2eq/m^3$

GHG emissions from waste generated by Company C

= (2,000 x 40) + (3,000 x 2) + (4,000 x 10) + (5,000 x 0.5) = 128,500 $kgCO_2eq$

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-1-6. Business travel

- It refers to GHG emissions generated from business travel of employees using transportation modes not owned or operated by the company. Examples of transportation modes include air, railroad, bus, and automobile (rental car), and may optionally include emissions from accommodation.
  - There are the fuel-based method, distance-based method, and spend-based method. The distance-based method calculates emissions according to the transportation modes used and the distance traveled during business travel. The required activity data are the destination of the business travel, the distance traveled by transportation modes, and the number of passengers.

Methods and examples of calculating emissions for business travel

:: Formula for calculating GHG emissions based on the distance-based method

GHG emissions = travel distance (transportation modes-km or passenger-km) x emission factor by transportation modes (kgCO_2eq/transportation modes-km or passenger-km)

EX | Company D is a financial services company that sends a group of experts to Britain and Australia every year. Activity data for each group are collected from employee questionnaires and travel and transport companies, assuming each member traveled at the same amount of budget.

Vehicle movement						
No.	The number of employees in group	Vehicle type	No. of passengers for each vehicle	Location	Distance (km)	Emission factor (kgCO_2eq/transportation modes-km)
1	10	Hybrid	2	Britain	50	1
2	20	Gasoline	2	Australia	200	2

To calculate the emission factor, three types of flight types are defined: Short-haul flights have a higher emission factor due to the large impact of landing/take-off cycles on emissions, while long-haul flights have slightly higher emissions compared to mid-range flights due to the additional weight of fuel. Depending on the country, specific criteria for flight types exist, and the following criteria are exemplary:

- Short-haul: flights less than 3 hours in length
- Mid-haul: flights 3-6 hours in length
- Long-haul: flights longer than 6.5 hours

Air flight				
No.	No. of employees in group	Flight type	Distance (km)	Emission factor (kgCO_2eq/passenger-km)
1	10	Long-haul	20,000	5
2	20	Short-haul	10,000	6

GHG emissions from business travel of Company D members

= emissions from road travel + emissions from air travel = ((10/2 x 50 x 1) + (20/2 x 200 x 2)) + ((10 x 20,000 x 5) + (20 x 10,000 x 6)) = 4,250 + 2,200,000 = 2,204,250 kgCO_2eq

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-1-7. Employee commuting

- It refers to GHG emissions generated by the transportation modes that employees use by commuting. This category may include automobiles, buses, trains, and aircraft and involves the use of transportation modes owned or operated by third parties. Emissions from working from home can also be optionally included.
  - There are the fuel-based method, distance-based method, and average-data method. The distance-based method calculates emissions according to the transportation modes and distance traveled during commuting and data include distance traveled and transportation modes.

Methods and examples of calculating emissions for employee commuting

:: Formula for calculating emissions based on the distance-based method

GHG emissions = total GHG emissions by distance traveled by employees in each transportation modes= (daily one-way commuting distance (vehicle-km or passenger-km) x 2 x annual commuting days) x fuel emission factor (kgCO_2eq/transportation modes-km or kgCO_2eq/passenger-km)

EX | Company E is a small advertising agency with 3 employees working for 48 weeks in a year. A commuting profile was created, and each employee's questionnaires are collected and organized as follows:

Employees	No. of times to commute with train (No. in a week)	One-way train ride distance (km)	Train emission factor (kgCO_2eq/ passenger-km)	No. of amount of commute with vehicle	One-way vehicle ride distance (km)	Vehicle emission factor (kgCO_2eq/ transportation modes-km)
M	5	10	0.1	0	-	0.2
N	4	10		1	15	
O	0	-		5	20	

GHG emissions from commuting of Company D members

= emissions from train mode + emissions from vehicle mode = {((10 x 2 x 5 x 48) + (10 x 2 x 4 x 48)) x 0.1} + {((15 x 2 x 1 x 48)) + (20 x 2 x 5 x 48)) x 0.2} = (8,640 x 0.1) + (11,040 x 0.2) = 3,072 kgCO_2eq

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-1-8. Upstream leased asset

- It refers to Scope 1 and 2 GHG emissions generated during the operation process of leased assets from other companies and is not calculated when there are no leased assets.
  - Calculation methods include the asset-specific method, a lessor-specific method, and an average data method. Depending on whether Scope 1 or 2 activity data can be obtained for each asset or lessor, the calculation method for each asset or lessor can be applied.

Methods of calculating emissions for upstream leased assets

:: Formula for calculating GHG emissions based on the lessor-specific method

GHG emissions = Scope 1 and 2 emissions of lessor assets ($kgCO_2eq$) x physical scope of leased assets (area, volume, quantity, etc.) / total physical scope of lessor assets (area, volume, quantity, etc.)

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-2 Downstream activities

[Table 12] Scope 3 downstream activity data

Area	Category	Activity data
Down stream	9. Downstream transportation and distribution	• Energy use or GHG emissions by transportation and distribution activity of distributors • Travel distance by activity • Emission factor by company
	10. Processing of sold products	• Site-specific energy use or GHG emissions by downstream value chain partners
	11. Use of sold products	• Quantity of products/services sold (e.g., ton, gallon, etc.)
	12. End-of-life treatment of sold products	• Product waste collected from consumers • Energy use or GHG emissions collected from waste management companies
	13. Downstream leased assets	• Energy use collected by electricity bills or meters from assets leased to other companies
	14. Franchises	• Energy use collected by the franchisee's electricity bill or meter
	15. Investments	• Energy use or GHG emissions of invested companies

※ Source: GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard (Reformation)

2-2-1. Downstream transportation and distribution

■ It refers to the GHG emissions generated during transportation, distribution and storage of products and services at the time they are sold. Category 4 includes products shipped from suppliers.

• Calculation methods include the fuel-based method, distance-based method, and spend-based method, which is the same as Category 4 (upstream transportation and distribution), so an additional explanation is omitted.

2-2-2. Processing of sold products

■ It refers to the GHG emissions generated during product processing by third-party companies who purchased products sold and it is applicable to companies selling intermediate goods and components.

• Calculation methods include the site-specific method and average-data method. It is necessary to check whether the third party can provide the amount of energy or emissions associated with the intermediate goods processing process.

2-2-3. Use of sold products

■ It refers to GHG emissions from the use of products sold/services rendered. It includes Scope 1 and 2 emissions from the end consumer's point of view and is divided into a direct use stage that must be calculated and an indirect use stage that is calculated only when necessary.

• The direct use stage includes emissions from direct consumption of energy (fuel, electricity) during use, emissions from fuels and feedstocks and GHG emission directly generated during use.

• Examples of the indirect use stage include GHG emissions generated during the washing and drying of clothes and the cooking and refrigeration of food.

Methods and example for calculating emissions for use of sold products

:: Formula for calculating emissions based on direct use stage

GHG emissions = sum across fuels consumed from use of products + sum across electricity consumed from use of products + sum across refrigerant leakage from use of products =Total lifetime expected uses of product x quantity sold x fuel consumed per use (e.g., kWh) x fuel emission factor (e.g., $kgCO_2eq$/kWh) + total lifetime expected uses of product x the quantity sold x electricity consumed per use (kWh) x electricity emission factor + total lifetime expected uses of product x quantity sold x refrigerant leakage per use (kg) x Global Warming Potential ($kgCO_2eq$/kg) of refrigerant

EX | Company F is a home appliance manufacturer and has collected product sales volume, service life, power consumption per use and emission factor of electricity.

Product name	Total use over lifetime	No. of items sold (unit)	Electricity consumption per use (kWh)	Electricity emission factor ($kgCO_2eq$/kWh)
X100 (washing machine)	1,000	11,500	1.3	0.5
Y123 (iron)	2,000	20,000	0.2	

GHG emissions from Company F's product use stage

= X100 (washing machine) GHG emissions + Y123 (iron) GHG emissions = (1,000 x 11,500 x 1.3 x 0.5) + (2,000 x 20,000 x 0.2 x 0.5) = 7,475,000 + 4,000,000 = 11,475,000 $kgCO_2eq$

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-2-4. End-of-life treatment of sold products

- It refers to GHG emissions from the disposal of products sold in the reporting year. The disposal method of Category 12 is the same as that of Category 5 (waste generated in operations). However, companies that sell intermediate goods and components should use data from intermediate goods or components, not the amount of waste and lifecycle of the final product.

Methods and example of calculation emissions for end-of-life treatment of sold products

:: Formula for calculating emissions of end-of-life treatment of sold products

GHG emissions = Total mass of products and packaging sold from the point of sale to the end of life (kg) x the percentage of disposal by waste treatment method (%) x emission factor according to treatment method ($kgCO_2eq/kg$)

EX | Company G is a business that sells paper that cannot be recycled because it has been coated for special purpose. This year, it sold 10 tons of products and conducted a survey on consumers whose results are summarized as follows:

Disposal amount of products sold (kg)	Treatment method	Ratio (%)	Emission factor ($kgCO_2eq/kg$)
10,000	Landfill	90	0.3
	Incineration	10	1.0
	Recycling	0	0.0

GHG emissions from disposal of Company G's products
= (10,000 x 0.9 x 0.3) + (10,000 x 0.1 x 1) + (10,000 x 0 x 0) = 3,700 $kgCO_2e$

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-2-5. Downstream leased assets

- It refers to the GHG emissions generated during the operation of assets leased to other companies among owned assets and is not calculated if there are no leased assets.

Methods of calculating emissions for downstream leased assets

:: Formula for calculating emissions of downstream leased assets

GHG emissions = Scope 1 and 2 emissions of lessee ($kgCO_2eq$) x physical scope of leased assets (area, volume, etc.) / total physical range of lessee assets (area, volume, etc.)

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-2-6. Franchises

- It refers to Scope 1 and 2 GHG emissions generated by franchisees and is not calculated if there are no franchisees. Franchisees are required to report periodic Scope 1 and 2 emissions and may optionally include Scope 3.
  - Calculation methods include the franchise-specific method and average-data method. For estimating for each franchise, GHG emissions of Scope 1 and 2 need to be added together.

2-2-7. Investment

- Scope 1 and 2 emissions from invested companies are applied to all areas of investment for profit generation and non-profit investment and the same calculation method is used.
  - If an invested company can provide Scopes 1 and 2 data, it is calculated based on the equity-specific calculation method.

Methods of calculating emissions for investments

:: Formula for calculating emissions based on the investment-specific method

GHG emissions = Scope 1 and 2 emissions of invested companies x share of equity (%)

※ Source: GHG Protocol - Technical Guidance for Calculating Scope 3 Emissions

2-3 Major method of GHG emissions reduction in Scope 3

■ In addition to estimating Scope 3 emissions, GHG emissions reduction can be achived by using reduction method for each category.

[Table 13] Reduction method of Scope 3 upstream emission

Area	Category	Examples of reduction method
Upstream	1. Purchased goods and services	• Replace high-emission raw materials with low-emission ones • Implement of procurement/purchase policies for low-emission raw materials • Encourage tier 1 suppliers to engage their tier 1 suppliers (the suppliers' suppliers) and disclose GHG emissions reporting
	2. Capital goods (investment and purchasing)	• Replace high-emission capital goods with low-emission ones
	3. Fuel- and energy-related activities	• Energy saving • Change of energy source (e.g., shift to low-emission raw materials/energy) • Use of renewable energy
	4. Upstream transportation and distribution	• Reduce the distance between supplier and customer • Local material use • Efficiency improvement of transportation and distribution • Replace high-emission transportation modes (e.g., air transportation) with low-emission ones (e.g., sea transportation) • Shift to low-emission fuel sources
	5. Waste generated in operations	• Reduce the amount of waste generated during operation • Waste recycling • Implementation of low-emission waste treatment methods
	6. Business travel	• Reduce business travel (e.g., shift to video conferencing) • Recommend more efficient travel • Recommend low-emission transportation (e.g., railroad instead of airplane)
	7. Employee commuting	• Reduce commuting distances (e.g., by locating offices/facility near city centers and public transport hubs) • Provide incentives for public transport, bicycles, car-sharing, etc. • Implementation of telecommuting/telecommuting system • Reduce the number of working days per week (e.g., 4 days x 10 hours instead of 5 x 8 hours)
	8. Upstream leased assets	• Increase operational energy efficiency • Shift to low-emission fuel sources

※ Source: GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard (Reformation)

[Table 14] Reduction method of Scope 3 downstream emission

Area	Category	Examples of reduction methods
Upstream	9. Downstream transportation and distribution	• Reduce the distance between supplier and customer • Improve efficiency in the transportation modes and distribution • Replace high-emission transportation modes (e.g., air transportation) with low-emission transportation modes (e.g., sea transportation) • Shift to low-emission fuel sources
	10. Processing of sold products	• Improve process efficiency • Product redesign to reduce processing requirement • Use of low-emission energy sources
	11. Use of sold products	• Develop of new low-or zero-emitting products • Improve the energy efficiency of energy-intensive products • Change in user guidelines for efficient use of the product
	12. End-of-life treatment of sold products	• Implement of recycling plan for products sold • Prepare packing plan for GHG reduction
	13. Downstream leased assets	• Increase operational energy efficiency • Shift to low-emission fuel sources
	14. Franchises	• Increase operational energy efficiency • Shift to low-emission fuel sources
	15. Investments	• Invest in low-emission technology and projects

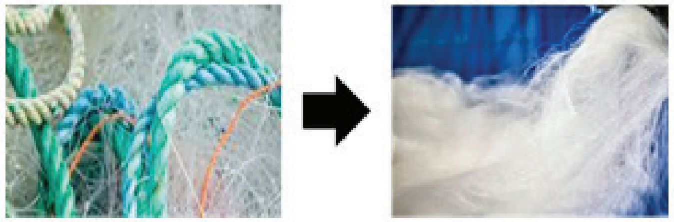
※ Source : GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard (Reformation)

Upstream - Category 1 (Purchased goods and services) emission reduction case study

Nylon is a popular material used by more than 60% of textile companies, produced from petroleum extract, it generates a lot of GHG in the manufacturing process. By using a recycled nylon which is made of nylon socks and waste clothes, it is possible to reduce GHG emission.

Company S, a brand specializing in fashion and household goods, has used recycled fabrics which reduced GHG emission at the oil extraction stage.

[Figure 22] Recycled nylon manufacturing process



: : Calculation of GHG Reduction through Recycled Nylon

Category	Total GHG reduction amount	GHG reduction rate
Recycle nylon	5.7 tonCO_2eq/ton nylon	52%

※ Source: Company S (https://www.simons.com/en/vision/recycled-fibres—v0008)

Upstream - Category 1 (Purchased goods and services) emission reduction cases study

Cement is a powder made by baking limestone, clay, and gypsum, which is widely used as a bonding material in construction and civil engineering. During the process of cement production, when limestone is burned, large GHG emissions are generated with high temperature of 1,450℃.

Using recycled cement manufactured by combining waste concrete and building waste (bricks, iron oxide, calcium silicate board) instead of cement, it enables to reduce use of limestone, GHG emissions, and ultimately facilitates to recycle construction waste.

: : Calculation of the amount of GHG Reduction through Recycled Cement Production

By comparing the difference between the GHG emissions from the production of 1 ton of commercial cement and recycled cement, the GHG emissions reduced about 60 to 720 kg per ton of recycled cement

CO_2 emissions of conventional cement production	CO_2 emissions of recycle cement production	Total CO_2 emissions reduction amount
0.725 tCO_2/ton cement	0.005-0.665 tCO_2/ton cement	0.06-0.72 tCO_2/ton cement

※ Source: CO_2 emission reduction by reuse of building material waste in the Japanese cement industry (2014)

[V] Ways to Reduce Greenhouse Gas in Products and Services

[1] Need to reduce GHG emissions in products and services

1 - 1 Reduction of GHG emissions and establishment of an eco-friendly supply chain in products and services

■ Chapters 2 to 4 dealt with the calculation of GHG emissions (Scope 1 and 2), establishment of emissions reduction targets, and Scope 3. Chapter 5 goes beyond the "production" stage and deals with measures to reduce GHG and best practices in the fields of products and services.

- While quantifying GHG emissions in places of business site is the main purpose of diagnosing the emission level of SMEs and setting emissions reduction targets, reducing GHG emissions in products and services is the main objective to gain a competitive edge in the "low-carbon and eco-friendly supply chain" market.

■ What is the relationship between the reduction of GHG emissions in products and services in SMEs and the "domination on the low-carbon and eco-friendly supply chain market"?

- In global GHG-related initiatives, companies that have joined initiatives and disclose information are required to not only "reduce GHG emissions" but also "build a low-carbon, eco-friendly supply chain." Global companies and domestic conglomerates that are receiving these demands have the burden not only to reduce GHG emissions from their manufacturing plants, but also to secure products such as raw materials and intermediate goods used for production from the "low-carbon and eco-friendly supply chain."
- In this case, if products and services produced by SMEs have GHG reduction effect and can describe it to the upper-level supply chain (customers), it is possible to gain a competitive edge in the supply chain market from the upper-level supply chain that is looking for a "low-carbon and eco-friendly supply chain."

Supply chain opportunities for SMEs through GHG reduction in products and services

[Table 15] Supply chain opportunities due to GHG reduction in places of business and products and services

Category	Calculation and reduction of emissions in places of business	GHG reduction in products and services
Demands imposed on upper-level supply chain	- Demand for estimating Scope 3 emissions	- Demand for establishing a low-carbon, eco-friendly supply chain
Opportunities for SMEs	- Contribute to reducing GHG intensity* and Scope 3 reduction in upper-level supply chains through calculation and reduction of GHG emissions"	- Enhancing opportunities to participate in low-carbon supply chains by estimating the GHG reduction effect of products and services
Core value	- Participation in supply chain carbon neutrality & ESG management	

* Reference: GHG intensity

It refers to the value obtained by dividing GHG emissions by the economic activity index. When dividing emissions by sales, revenue, it becomes "unit of sales" and when dividing by product output, it becomes "unit of production."
For example, assuming that the total GHG emissions of the places of business for one year are 1,000 tCO_2eq, the annual sales are 10 billion dollars and the goods produced at the places of business are 10,000 tons, the unit of sales is 100 tCO_2eq/billion dollars, and the unit of production is 1,000 ÷ 10,000 = 0.1 tCO_2eq/ton

1 - 2 Global carbon certification system for products and services

■ So, how can we evaluate that the products and services produced by companies are eco-friendly and help reduce GHG emissions? That depends on whether the product or service has obtained eco-friendly certification. The most common environmental certification systems include the environmental labeling, energy efficiency-related schemes and exist in various forms operated by government agencies or non-profit organizations.

- Among them, the carbon labeling system is a scheme that quantifies GHG emissions generated throughout the product life cycle and mark on the product and this scheme is also commonly referred to as carbon footprint. Recently, the carbon neutrality certification scheme for GHG emissions generated in the entire process of a product or a company is also widely in use, not just quantifying GHG emissions of a product.

[Table 16] Global environment and carbon certification schemes

Scheme name	Institution/Country	Content
The international EPD system	IVL Swedish Environmental Research Institute (non-profit research institutes) / Sweden	• Provides transparent, validated, comparable information with a voluntary declaration on environmental impacts including climate change impacts in the entire process of products and services
Environmental Product Declaration	UL solution (non-profit organization) / United States	• By taking into the entire process of the product, various attributes (energy efficiency, recycled material content, hazardous substance content, package eco-friendliness, etc.) are comprehensively evaluated and certified as an eco-friendly product, including the impact on climate change
Reducing CO_2	Carbon Trust (non-profit organization) / United Kingdom	• Certifies reduction of carbon footprint of products and indicates the reduction ratio
Reducing CO_2 Packaging		• Certifies reduction of carbon footprint of packaging and indicates the reduction ratio
Carbon Neutral		• Certifies carbon neutrality of products based on PAS2060
Carbon Neutral Packing		• Certifies carbon neutrality according to PAS2060 for packaging
Lower CO_2		• Certifies to be below the benchmark of the product family's carbon footprint
CO_2 Measured		• Measures and marks a product's carbon footprint
Carbon Free Certified label	The Carbon Fund (non-profit organization) / United States	• Certifies a product's carbon neutrality • All emissions must be offset by estimating a carbon footprint based on PAS2050, ISO14024, 14025, 14040, 14067, and GHG protocol
Carbon Neutral	Carbon Neutral (non-profit organization) / United States	• Certifies a product's carbon neutrality • Calculation of carbon footprint based on the GHG Protocol to offset emissions or purchase emission credits for insufficient amount and certify

※ Source: International EPD(https ://www.environdec.com/home)
UL solution (https://www.ul.com)
Carbon Trust(http ://www.carbontrust.com)
The Carbon Fund (http://www.carbonfund.org)
Climate Neutral (http://climateneutral.org)

[Table 17] Carbon certification schemes in ASEAN countries

Scheme name	Institution/Country	Certification standards and length of time
Sirim Product Carbon Footprint Certification Scheme	Sirim QAS International (Government agency / Malaysia)	• Measures and indicates the carbon footprint of a product within the scope of the places of business based on ISO14067
Carbon Footprint of Products	Thailand Greenhouse Gas Management Organization (Government agency) / Thailand	• Measures and indicates the carbon footprint of a product based on ISO14067
Carbon Footprint Reduction		• Certification of 2% reduction in the carbon footprint compared to the base year or that the carbon footprint is below the benchmark for the product family
Carbon Reduction Label	Thailand Environment Institute (non-profit organization) / Thailand	• Certifies a product's carbon reduction 1. Considers only the production process, when the carbon emissions in the last 12 months are 10% lower than that in 2002. 2. In cases where fuel, carbon, and waste met all requirements - Fossil fuel cannot be used, but fuel or electricity generated from biomass or industrial waste is used. - Carbon credit purchases = less than 5% of total emissions - No carbon emissions from waste in production plants 3. In case of applying new carbon reduction technology

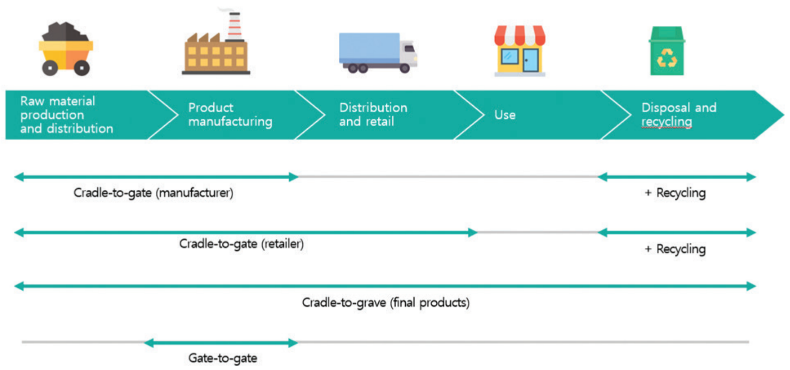
※ Source: SIRIM-QAS International Sdn. Bhd (http://www.sirim-qas.com.my)
Carbon Footprint Label, Thailand (http://www.thaicarbonlabel.tgo.or.th)
Thailand Environment Institute (http://www.tei.or.th)

Explanation of Terminology

:: Product Life Cycle

It is a series of processes that represent the entire life cycle of a product, from the collection and processing of raw materials to the production of materials and components, assembling, transporting, selling, consuming the products, and disposing of the used products. For example, finished products such as automobiles include the entire process and in the case of materials and parts, there is no use stage, so it includes the process from collecting raw materials to processing and manufacturing materials and parts.

[Figure 23] The whole range of product life cycle



※ Source: Carbon Trust

Explanation of Terminology

:: ISO14000 Series

Among the "ISO 14000 series," the international standards for environmental management systems established by the International Organization for Standardization's (ISO) technical committee (TC 207), there are environmental quality management standards such as environmental management system (ISO 14001), environmental audit (ISO 14010), environmental label (ISO 14020), environmental performance evaluation (ISO 14030), and life cycle assessment (ISO 14040).

Type	Explanation
ISO14024	**Environmental Labels and Declaration –Type 1 Environmental Labeling: Principles and Procedures (third-party accredited body certification)** Principles and procedures for developing a Type 1 environmental labeling program, including selection of product categories, product environmental criteria, and product functional characteristics, and assessing and demonstrating compliance
ISO14025	**Environmental Labels and Declarations –Type 3 Environmental Declarations: Principles and Procedures (comparable quantitative information between products)** Type 3 environmental declaration program and principles and procedures of Type 3 environmental declaration development
ISO14040	**Environmental Management – LCA (Life Cycle Assessment): Principles and Framework** Explains the principles and system of the whole process evaluation, definition of goals, and scope, etc.
ISO14067	**Greenhouse Gases – Carbon footprint of products: Requirements and guidelines for quantification** Sets forth the principles and requirements for quantifying and reporting a product's carbon footprint

:: PAS 2050 and 2060

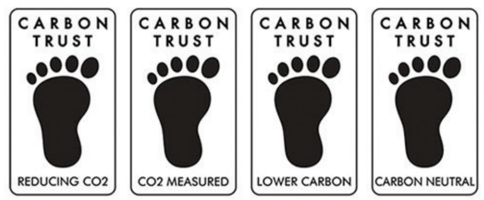
PAS 2050 is a manual for measuring GHG emission throughout the life cycle of products and services created by BSI British Standards. PAS 2060 is a manual for demonstrating the carbon neutrality of products and services.

※ Source: ISO website (https://www.iso.org) / BSI blog (http://bsiblog.co.kr

Carbon Trust

The Carbon Trust is an eco-friendly certification body established by the British government in 2001 as part of the carbon reduction measures to respond to climate change and is currently operated as an independent non-profit organization. Its certification consists of a total of seven categories (carbon measurement, carbon reduction, carbon reduction packaging, carbon neutrality, carbon neutral package, low carbon, and 100% renewable energy) according to product types and standards.

[Figure 24] Carbon trust certified label



[Figure 25] Example of Carbon Trust certified label

Food company Q's refrigerated ground meat
300 g carbon footprint 0.16 kgCO_2

※ Source: Carbon Trust(http://www.carbontrust.com) / Company Q (http://www.quorn.co.uk

[2] GHG emissions reduction factors in products and services by stage

2-1 Setting the range of analysis

■ Let us look at how products and services produced by SMEs help reduce GHG emissions at any stage in the entire life cycle of products in the upper-level supply chain. The entire process of a product is divided into five stages: "raw material production and distribution stage," "product manufacturing stage," "distribution and storage stage," "use stage," and "disposal and recycling stage."

- This chapter describes the reduction factors and best practices of SMEs according to the five stages of the product life cycle as described in the Product Life Cycle Accounting and Reporting Standard of the GHG Protocol.

Range of analysis	Definition and Examples
Raw material production and distribution	The stage from the source of raw materials to the production site, including processing of raw materials - (Reduction factor) use of alternative raw materials, etc.
Product manufacturing	Product and service manufacturing stage - (Reduction factor) replacement of GHG used as cleaning agents and refrigerant gas, replacement with high-efficiency facilities, etc.
Distribution and storage	Transport and storage of products and services - (Reduction factor) replacement of transportation modes to eco-friendly vehicles, etc.
Use	Stage to use products and services produced - (Reduction factor) energy (electricity, etc.)-saving effect, etc.
Disposal and recycling	Stage to dispose of product and services - (Reduction factor) recycling and re-use, energy recovery, etc.

2-2 Analyzing GHG reduction factors by stage

2-2-1. GHG emissions reduction factors in the raw material production and distribution stage

■ When an upper-level supply chain company purchases raw materials for production, processing or transporting raw materials from supplier (SMEs) is outside the organizational boundaries of the company, thus it is not included in the targets for setting inventory as described in Chapter 2. Once the scope is expanded beyond organizational boundaries, however, GHG emissions are also emitted at the time of raw material processing.

- For example, the product manufacturing stage in paper production starts with "pulp input," where both "natural pulp" made from wood and "recycled pulp" made from wastepaper are used.
- In the case of using natural pulp, GHG emissions are generated from the use of fuel and electricity during the "collection, cutting, and processing of wood," which is the raw material production and distribution stage.
- In this case, if "recycled pulp" made from wastepaper is used as a raw material instead of "natural pulp" during paper production, the "wood harvesting, cutting, and processing process" is eliminated and the GHG emissions from the "raw material production and distribution stage" will be reduced.

■ As mentioned above, the GHG emissions reduction factor in the case of using alternative raw materials is mainly the case of replacing "natural raw materials" with "recycled ones."

Reduction factors through using the raw material substitutes during the raw material production and distribution stage

:: Distinction of GHG emissions reduction factors between the use of natural raw materials and the use of recycled materials

Category		Recycled raw materials	Natural raw materials
Raw materials to make the same amount of pulp		1 ton of wastepaper	20 thirty-years-old trees
GHG emission sources	Collection of raw materials	-	Lumber harvesting (equipment)
	Raw materials processing	-	Wood chip processing
	Raw materials transportation	Wastepaper transportation	Wood chip transportation

※ Source: Recycling of Wastepaper as Countermeasure of Climate Change (Journal of Korea TAPPI, 2017)

2-2-2. GHG emissions reduction factors in the product manufacturing stage

■ In the product manufacturing stage, the largest amount of GHG emissions comes from the use of fuel and electricity used in the business site, so products and services are needed as a factor to realize "reduction of fuel and electricity consumption and efficiency enhancement" discussed in Chapter 3.

■ In addition, if there are GHG that are "used" in the manufacturing process, alternative substances can be used to reduce GHG. GHG such as HFCs, PFCs, and SF_6 are mainly used in the process of using refrigerant gas, insulation fillers, processing of non-ferrous metals and semiconductor cleaning. Manufacturing products using alternative substances has the effect of reducing GHG emissions

- Substances such as HFCs, PFCs, and SF_6 have high GWP values as described in Chapter 2, so even a small reduction in usage can have a large effect on reducing GHG emissions.

Reduction factors through substitution of GHG used in the product manufacturing stage

:: Emissions can be reduced by substituting refrigerant by manufacturing refrigerating/freezing substances that directly contain GHG

Uses	Existing refrigerant		Alternative refrigerant		Reduction effect compared to existing refrigerant emissions
	Substance name	GWP	Substance name	GWP	
Car air-conditioning	R134a	1,300	R1234yf	4	99.7%
Cooling system	R410a	1,924	R1233zd	4	99.8%

※ Source: EU Climate Action website(https://climate.ec.europa.eu/eu-action_en)

(Reference) Global Warming Potential (GWP) by global warming substances

Greenhouse Gase	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
GWP	1	28	265	4 ~ 12,400	6,630 ~ 11,100	23,500

※ Source: IPCC 5th Assessment Report

2-2-3. GHG emissions reduction factors in the distribution and storage stage

■ After the manufacturing of product, GHG emissions are also emitted during the transportation stage where the products are delivered to supplier or customer from the manufacturing site. Upper-level supply chains may consider introducing products and services to reduce GHG emission at the distribution and storage stage.

- If a product is delivered to a customer using an eco-friendly vehicle rather than a conventional-fuel vehicle, it is advantageous in terms of reducing GHG as well as cutting transportation costs.

Reduction factors at the distribution and storage stage

:: Difference in GHG emissions when the product is transported using conventional vehicles and eco-friendly vehicles for the same distance

Category	Conventional-fuel vehicle A	Electric vehicle B
Distance traveled from the manufacturing site	100 km of land transport	100 km of land transport
Fuel consumption	Diesel 10 liters	Electric power 16,300 Wh
GHG emissions ($kgCO_2eq$)	27	10.6

※ Source: Estimation using the GHG emissions calculation tool for SMEs (based on EPA Emission factor & IEA's electric power emission factor)

2-2-4. GHG emissions reduction factors in the use stage

■ GHG emission at the use stage are mostly generated by "energy-using products" such as vehicles, smartphones, home appliances, and lighting fixtures that we commonly use. That's because GHG emissions are emitted as much as energy consumed by customers when using purchased products.

- To reduce GHG emissions at the use stage, purchasing products and services (components) that can reduce energy consumption compared to similar product family must be considered.

GHG emissions reduction factors through improving the product's power efficiency in the use stage

Category	Power consumption	Usage scenarios*		Annual power consumption
		1 time of use	Daily frequency of use	
Company A's hand dryer	1,000W	10 seconds/ time	500 times	1,000 W x 10 s/time x 1 hr/3,600 s x 500 times/day x 365 days = 506.944 kWh
Same product group average	2,000W			2,000 W x 10 s/time x 1 hr/3,600 s x 500 times/day x 365 days = 1,013.889 kWh

※ Based on the guidelines of the Korean Environmental Product Declaration

Since the annual power consumption of product A produced by SMEs is half compared to the same type of products, the annual GHG emissions reduction effect can be approximately doubled compared to the same type of products.

2-2-5. GHG emissions reduction factors in the disposal and recycling stage

■ Reducing GHG emissions at the disposal and recycling stage does not simply mean reducing or recycling waste within the organizational boundaries of SMEs. It rather refers to the reduction of GHG emissions generated in the process of disposing of products after using of products

- It can be determined that the easier to reuse and recycle or longer to use of a product compared to the same product, the higher the GHG emissions effect. It is key to providing products and services that can extend the life of a product produced by the upper-level supply chain.

Reduction factor through improving the product's lifecycle in the disposal and recycling stage

Category	Product durability	Annual sales	Waste generation time	How to dispose of waste	Incineration emission factor*	Annual GHG emissions
Company A's rubber products	8 years	100 ton	100 tons after 8 years, 12.5 tons per year	Incineration	3.14 tCO_2eq/ton	39.3 tons
Same product group average	5 years		100 tons after 5 years, 20 tons per yea			62.8 tons

※ Based on the emission factor of the Korean Environmental Product Declaration

[3] Best practices for reducing GHG emissions in the fields of products and services

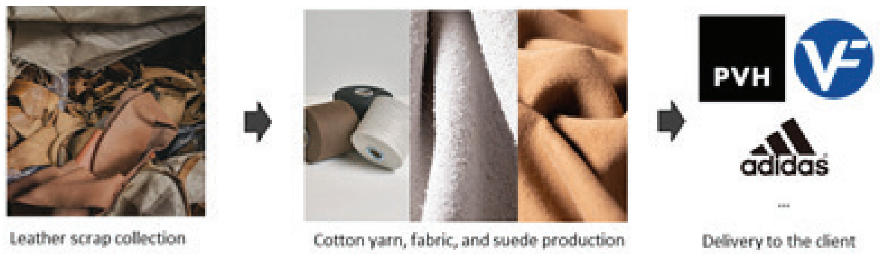
3-1 Case of reducing GHG emissions in the raw material production and distribution stage

■ The raw material production and distribution stage generally encompasses all pre-manufacturing activities to produce a product, from the extraction of raw materials to the production of raw materials. Companies can explore and implement measures to reduce GHG at each stage to enhance their competitiveness.

Case of GHG emissions reduction in the raw material production and distribution stage: Use of recycled raw materials

A by-product is produced when natural leather is processed to produce leather products. Fabric manufacturer ATKO Planning produces recycled fabrics using waste leather only, a by-product of this kind.

[Figure 26] ATKO Planning's use of recycled raw materials



:: Calculation of the amount of GHG reduction due to the use of recycled leather

Category	Livestock rearing	Primary transportation	Leather processing	Secondary transportation
When natural leather in used	○	○ (farm to slaughterhouse)	○ (extraction of natural leather)	○ (slaughterhouse → manufacturing plant)
When waste leather in used	×	×	×	○ (waste leather source → manufacturing plant)

• When waste leather is used instead of natural leather in the upper-level supply chain, it has the effect of reducing GHG emissions generated in the stages of "livestock rearing," "primary transportation," and "leather processing" compared to the case of using natural leather.

• According to the European standard guidelines on the carbon footprint of leather, the GHG emissions per 1 m^2 of leather are as follows:
- GHG emissions from livestock rearing required for leather: 93 $kgCO_2eq/m^2$
- GHG emissions from primary transportation from the animal farm: 0.6 $kgCO_2eq/m^2$
- GHG emissions from leather processing: 2.5 $kgCO_2eq/m$
⇨ When using natural leather, 96.1 $kgCO_2eq/m^2$ of GHG is generated in the raw material production and distribution stage.

※ Source: Leather Carbon Footprint, Review of European Standard EN16887:2017

• Since ATKO Planning uses 100% of waste leather in the production stage, companies that purchase and use its fabrics can reduce GHG by about 96.1 kg per 1 m^2 of leather in the "raw material production and distribution stage" according to the formula above.

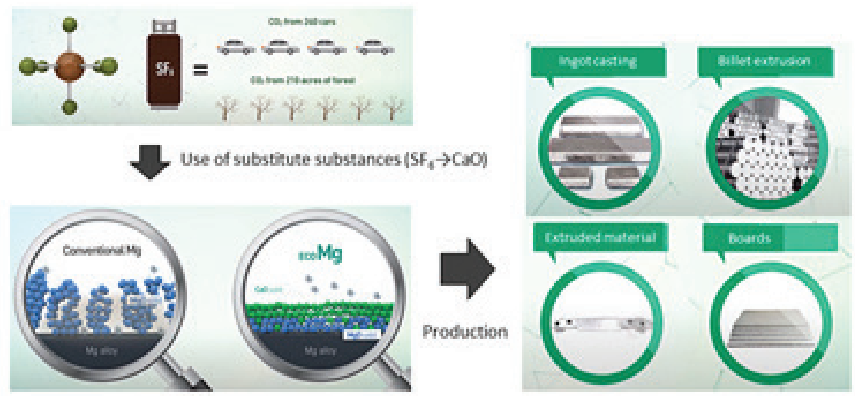
3-2 Case of reducing GHG emissions in the product manufacturing stage

■ The product manufacturing stage includes all activities in the manufacturing process, such as assembling and packaging products. Manufacturing companies can explore reduction measures within the scope of conventional emissions reduction activities such as energy efficiency improvement and fuel replacement, but they can expand and identify GHG emissions reduction measures such as the use of process substitutes.

Case of GHG emissions reduction in the product manufacturing stage: Use of substitutes in the process

By producing magnesium (Mg) alloys, "shielding gas" is used to prevent magnesium from being ignited. In this case, sulfur hexafluoride (SF_6) is usually used as the shielding gas. This process releases SF_6 gas into the atmosphere, which has a greenhouse effect 23,500 times higher than that of the same amount of CO_2.
Nice LMS uses Eco-Mg technology to reduce GHG emissions by using calcium oxide instead of SF_6 in the magnesium alloy manufacturing process.

[Figure 27] Use of process substitutes by Nice LMS



:: Calculation of GHG emissions reduction due to substitution to hexafluoride gas (SF_6)

• GHG emissions reduction by Nice LMS's process improvement is shown in the table below.

Category	Existing process	Application of Eco-Mg technology
Mg alloy production process	47.1 $kgCO_2eq$	0
Melting and casting process	0.13 $kgCO_2eq$	0
Extrusion process	2.20 $kgCO_2eq$	0
Total	49.43 $kgCO_2eq$	0

• As seen above, the magnesium alloy produced by Nice LMS has an effect of reducing GHG emissions by 49.43 kg per 1 kg of product.

※ Source: KITECH – Developing Eco-Mg production-based technology to reduce environmental load and energy (2015)

3-3 Case of reducing GHG emissions in the distribution and storage stage

■ The distribution and storage stage includes all activities of distribution and storage processes from the completion of production to consumption. Companies can reduce GHG through reduction measures such as substitution of transportation modes and fuels.

Case of GHG emissions reduction in distribution and storage stage: Substitution of transportation modes

!K7 Music is a multinational music company based in Berlin, London and New York that provides global marketing, sales, and distribution services. As it sells music albums all over the world, it requires intercontinental transport.

Intercontinental transportation is usually operated through air freight and sea shipping. Although air freight can be faster than sea shipping, sea shipping has the advantage of being able to handle various types of goods in bulk and reducing GHG emissions.

!K7 Music reduced GHG emissions by converting its air freight network, which distributes products from warehouses in Austria to over 15,000 locations, into sea shipping.

[Figure 28] Substitution of means of transportation for products

Air freight

Sea shipping

:: Calculation of GHG emissions reduction through product distribution and transportation network shift

• It was possible to calculate the effect of reducing GHG of about 38-45 tons per year through the shift of distribution and transportation networks.

Year of application	No. of locations	The amount of GHG reduction
2019	15,737	38 tCO_2
2020	18,426	45 tCO_2

※ Sources: !K Music (https://k7.com/)

3-4 Case of reducing GHG emissions in the use stage

■ Through the supply of high-efficiency energy products and services, SMEs can enable customers who purchase SMEs' products to reduce energy at the use stage, and consequently reduce GHG emissions.

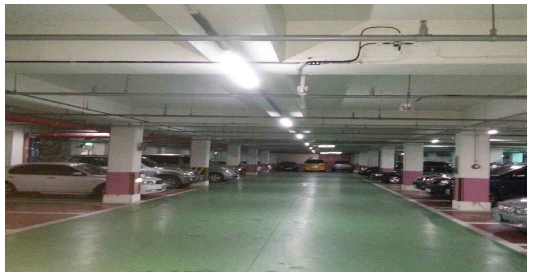
Cases of GHG reduction in the use stage: LED lighting replacement and use of dimmer

In the case of underground parking lots, they should always be illuminated regardless of the amount of sunlight outside. With conventional fluorescent lighting, however, there is a limitation in that it is always turned on at the same brightness for 24 hours regardless of whether a vehicle or a person is present.

Company I, an SME specializing in lighting fixtures, produces and supplies dimming LEDs that emit less GHG compared to fluorescent lightings. In fact, the energy efficiency of the target building has been improved by by replacing the fluorescent lightings installed in the company's underground parking lots with dimming LED lightings that can be controlled through a sensor.

Existing fluorescent lights before LED dimmer installation

Fluorescent lights after LED dimmer installation



:: Calculation of the amount of GHG reduction through LED dimmer installation

• In the case of fluorescent lights, which are conventional lighting fixtures, the average power consumption is 31.13 W.

• In the case of replaced LED dimmer, the maximum brightness is up to 20 W. By no activity, up to 4 W dimming through sensor detection is possible.

• As a result of measuring the amount of dimming LED power for one month, the average power per light was 7.34 W

• The number of existing lights before replacement was 496, and that after replacement was 491.

• Due to the nature of the underground parking lot that must be in operation 24 hours a day, the annual operating hours are 8,760 hours.

• With this information, the annual power savings are calculated as follows:

Average power consumption per light before replacement	Average power consumption per light after replacement	No. of lights before replacement	No. of lights after replacement	Annual operating time	Annual power savings
31.13 W	7.34 W	496	491	8,760 hrs	103,688.1 kWh

• Based on the Korea's electricity carbon emission factor, about 47.7 tons of GHG reduction effect can be achieved.

Annual total power savings	Carbon emission factor (as of the given time)	GHG reduction
103.7 MWh	0.4598t CO_2eq/MWh	47.7t CO_2

※ Source: Korea Energy Agency's Statistical Analysis Office – Energy Savings Calculation Report (2015)

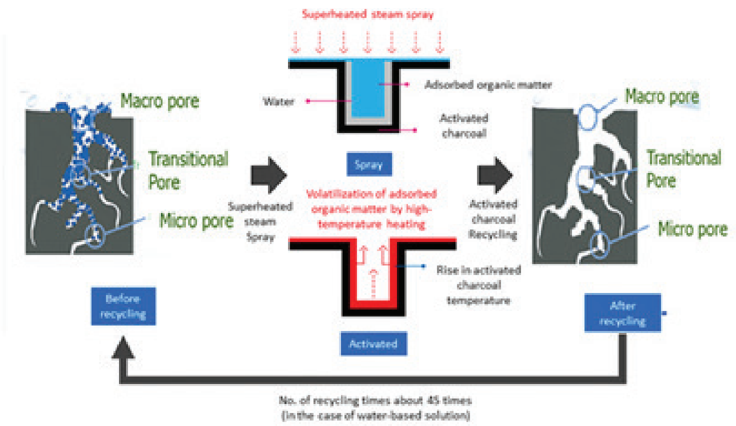
3-5 Case of reducing GHG emissions in the disposal and recycling stage

- The disposal and recycling stage includes all activities that occur in the process of disposal of end-of-life products. Depending on the nature of the product, processes such as disposal and recycling stage vary and also by-products and energy are generated during the processing. The GHG emissions reduction performance can be calculated after factors that can contribute to GHG emissions reduction are identified.

Case of GHG reduction in the disposal and recycling stage: Product recycling

Activated charcoal is widely used to adsorb and remove water pollutants or harmful gases generated in the manufacturing process. In general, when the harmful substances adsorbed to the activated charcoal become saturated, the activated charcoal is replaced, or the hazardous substances are removed by high-temperature heat treatment before reuse. However, there is a disadvantage that the adsorption capacity of activated charcoal declines after heat treatment. Wintec Glovis, an eco-friendly activated charcoal equipment manufacturer, applies the activated charcoal recycling source technology using superheated steam to manufacture activated charcoal recycling equipment that can maintain high adsorption capacity even after being recycled several times. Companies that used to apply once and discard activated charcoal introduced the Wintech Glovis activated charcoal recycling equipment. They also contribute to carbon emission reduction by extending the replacement period for activated charcoal and reducing waste generated in the manufacturing process.

[Figure 29] Wintec Glovis' activated charcoal recycling source technology



:: Calculation of the amount of GHG emissions reduction due to increased replacement cycle of activated charcoal

- By comparing the difference between the GHG emissions when producing 1 ton of activated charcoal and those used for the recycling of activated charcoal, it is possible to calculate the GHG reduction effect due to the recycling of activated charcoal.

CO_2 reduction by recycling of activated charcoal ①*	CO_2 emissions due to electricity consumption ②	CO_2 emissions due to generation of superheated steam ③	Total CO_2 emissions reduced ①-(②+③)
1.05 tCO_2/ton activated charcoal	0.426 tCO_2/ton activated charcoal	0.348 tCO_2/ton activated charcoal	0.276 tCO_2/ton activated charcoal

※ Based on the emission factor of the Korean Environmental Product Declaration

- According to the formula above, it was possible to estimate the GHG reduction effect of about 276 kg per 1 ton of activated charcoal recycling.

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