# Aerospace Industry Tool for Calculating Scope 3 Greenhouse Gas Emissions of Purchased Goods & Services and Capital Goods: Methodology

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This document is released for purpose of supporting voluntary accounting and reporting of greenhouse gas (GHG) emissions associated with purchased goods and services and capital goods across the aerospace industry.

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# Version History

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# 1 Glossary

| Acronym | Definition |
|---|---|
| **ADEME** | Agence de l'Environnement et de la Maîtrise de l'Energie |
| **A&D** | Aerospace and Defense |
| **CG** | Capital Goods |
| **CtG** | Cradle-to-Gate |
| **DoD** | US Department of Defense |
| **EIO-LCA** | Economic Input-Output Life Cycle Assessment |
| **EEIO** | Environmentally Extended Input Output |
| **EF** | Emission Factor |
| **GHG** | Greenhouse Gases |
| **GHGP** | GHG Protocol |
| **GtG** | Gate-to-Gate |
| **$kgCO_2e$** | Kilograms of $CO_2$-equivalent |
| **k$** | 1000 US dollars |
| **k€** | 1000 euros |
| **LCA** | Life-Cycle Analysis |
| **NAICS** | North American Industry Classification System |
| **PG&S** | Purchased Goods & Services |
| **$tCO_2e$** | (metric) tons of $CO_2$-equivalent |
| **USEEIO** | United-States Environmentally Extended Input-Output model |

# 2 Executive Summary

As described in “GHG Reporting Guidance for the Aerospace Industry, A Supplement to the GHG Protocol Corporate (Scope 1 and 2) and Value Chain (Scope 3) Accounting and Reporting Standards”, the International Aerospace Environmental Group (IAEG) identified that both “Purchase of Goods and Services” (PG&S) and “Capital Goods” (CG) categories are potentially relevant as Scope 3 categories. As for other potentially relevant categories, IAEG decided to develop relevant methodology and guidance materials to allow the aerospace companies to report greenhouse gas (GHG) emissions for these categories.

The methodology document is meant to complement the user guide by providing additional supporting information. The document highlights the context and purpose of the work as well as the criteria used to build the tool and to select the databases. It also elaborates on the proxies used for each subcategory of products and helps the user get a sense of the results’ level of uncertainty. In sum, it will help users who wish to improve their understanding of the reasoning behind the methodology or who might have additional questions.

This document also includes all relevant information for updating the tool and maintain the methodology up to date as newly information becomes available.

# 3 Acknowledgements

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IAEG Work Group 3 - Greenhouse Gas Management and Reporting

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This methodology is the property of IAEG.

# 4 Context and purpose

## 4.1 Introduction

Corporate disclosure of Greenhouse Gas (GHG) emissions has garnered increasing momentum over the years due to a convergence of regulatory requirements, public pressure, and investor concerns over the impact of climate change-related risks on corporate performance. With most publicly listed companies already disclosing Scopes 1 and 2 emissions on a regular basis, attention is turning towards Scope 3 emissions disclosure.

There are multiple reasons to justify this shift. Scope 3 emissions often represent the largest part of a company's carbon footprint and can account for up to 90%[1] of its total emissions. Organizations are exposed to a multitude of carbon constraints and risks along their entire value chain, each potentially impacting long-term returns.

Recent studies provided hard evidence to support the idea that Scope 3 emissions may turn out to be a more powerful indicator of a company's resilience and preparedness than Scopes 1 and 2 emissions. As a result, investors' focus is shifting to ensuring that relevant Scope 3 emissions information becomes available. Furthermore, France's mandatory disclosure requirements for significant Scope 3 categories is seen as a sign that regulations are also evolving on this issue. Companies calculating and disclosing their Scope 3 emissions will send a clear signal that they are ahead of the issue and wish to demonstrate transparency.

IAEG Work Group (WG3) has the mandate to address the issue of GHG accounting and reporting by aerospace companies. Its objective is to promote these practices and bring consistency across the industry. The first deliverable from this group is the GHG Reporting Guidance for the Aerospace Industry – A Supplement to the GHG Protocol Corporate Accounting and Reporting Standard[2]. This guidance provides a common framework of guidelines, methodologies, vocabulary, and relevant recommendations for GHG accounting and reporting to promote consistent, complete, and accurate reporting across the aerospace industry. It also identifies relevant Scope 3 categories for the aerospace sector.

In the aerospace and defense industry, both "Purchase of Goods and Services" and "Capital Goods" categories are among the most material Scope 3 categories. The actual document describes the methodology developed for assessing GHG emissions associated with PG&S and CG. An Excel tool and a user guide to facilitate the implementation of calculations are provided separately.

## 4.2 Main objectives of the methodology

The aim of the methodology development process was to find the best balance between the following key elements:

- Reliable emission factors and, if possible, regional differentiation;
- Fully applicable to the aerospace sector;
- As robust as possible;
- As simple as possible;
- As accurate as possible;

- Compatible with the technical capabilities of IAEG members;
- As transparent as possible;
- Based on recognized standards;
- Free of intellectual property rights.

A thorough review of design recommendations performed in Phase 2 led to the identification of the requirements presented in Table 1.

**Table 1 - Requirements used in the conception of the methodology**

| # | Topic | Requirement for phase 3 |
|---|---|---|
| **1** | Emission factors | 1.1 Use publicly available Emission Factors (EF), whenever available (with the option to use EcoInvent EF as a last resort) |
| | | 1.2 Priority given to public EF originating from key areas such as the EU and the US. When easily available, integrate EF from China, India, Brazil, Mexico, Japan. |
| | | 1.3 Enable the use of supplier specific LCA data if available, under restrictions (see Chapter 10 for more details) |
| | | 1.4 Provide steps and requirements for integrating new EF |
| **2** | Resources | 2.1 Enable users to estimate the order of magnitude through simple calculations requiring less than a week of work. |
| | | 2.2 The initial accounting should require less than a week using the spend-based approach and up to a few months using the mass-based approach. |
| **3** | Accuracy vs. simplicity | 3.1 Maintain coherence across all three approaches. |
| | | 3.2. Favor simplicity over accuracy. Strive to provide a good order of magnitude as a starting point and provide options to increase accuracy for those who wish to and are able to do so. |
| | | 3.3 Sectorial Aerospace & Defense (A&D) agreed purchasing categories reflecting the spend-based categories. |
| | | 3.4 A mass-based approach as auditable as possible. |
| **4** | Standards | 4.1 Absence of conflict with ISO14064-1[3] and the GHG Protocol[4,5]. See Appendix 3: Compliance to international standards for details. |

| | | |
|---|---|---|
| **5** | General approach | 5.1 Define the spend-based approach as the default option to help newcomers get started with scope 3 accounting. Provide detailed guidelines on how to obtain and categorize datasets for PG&S. |
| | | 5.2 Satisfy the needs of all members of the IAEG community using a multi-level approach. |
| | | 5.3 Define an approximate level of accuracy for each approach. |
| | | 5.4 Provide mass-based datasets those who seek more accurate results. |
| | | 5.5 Present the pros and cons of each approach, focusing on ease of use, accuracy, time, and resources. |

# 5 Emissions factor sources

## 5.1 Emission factor databases selection

The following criteria were used to select the EF databases:

- Whenever possible, use **public sources**;
- Whenever possible, use **cradle-to-gate EF**;
- Databases **updated** within the last 5 years;
- **Geographical scope**: US, Europe, Japan, Brazil, or China;
- **Environmentally Extended Input-Output** (EEIO) tables for spend-based approach.

Publicly available EF: An important database criterion for IAEG was the free access to the EF to ensure that no copyright limitation would constrain the use of its tool in years to come. The main drawbacks, however, are a lower number of suitable databases as well as older EF being accessible.

Cradle-to-gate EF: Cradle-to-gate EF encompass all the emissions from raw material extraction to the delivery of the material/part/system. Using such factors increases accuracy and robustness and reduces the risk for incomplete factors. The main challenge is that these EF tend to be disseminated in the literature and are not always public.

Up-to-date EF: The most recent EF were selected to account for up-to-date industrial processes, realistic electricity emission factors, and to limit corrections due to inflation.

Geographical standpoint: EF may vary by location due to a multitude of factors such as the predominant energy sources of a given country. To increase accuracy, the tool proposes, when possible, EF at world level and/or at country level. Unfortunately, no factors were found to cover Japan, Brazil, or China specifically.

EEIO tables: These databases allow for simple and quick access to sets of spend-based EF for numerous economic sectors and subsectors. Their accuracy is relatively low because the EF are aggregated.

None of the identified database could meet all the criteria mentioned in Table 1. In the public field, only seven databases seemed to match the cradle-to-gate criterion. Their age or geographical scopes were heterogeneous. Among the seven, only five appeared suitable for the methodology:

- Carnegie Mellon;
- DoD;
- USEEIO;
- Base Impacts;
- Base Carbone.

Other database candidates were considered:

- Ecoinvent: it is not a public database. It could potentially be used as a last resort option to complete the methodology database if some EF are missing;
- Exiobase: a good geographical coverage but pure LCA database, with EF to be reconstructed;
- WIOD: similar to Exiobase;

- ELCD3: not available anymore.

Additional EF for certain materials (i.e., for certain metals) were taken from other public sources and integrated in the methodology. They were used to improve the accuracy and the robustness of the tool using more recent and specific factors.

## 5.2 Sources used in the methodology

Since no single database meets all criteria for every category, several databases were used, as presented in Table 2:

**Table 2: Summary of the databases used in the methodology**

| Database or Source | Type of EF | Geography | Last update | Source |
|---|---|---|---|---|
| **DoD** | Spend-based | USA | 2014 | DoD Sustainability Assessment Guidance - Appendix I Scoring Factors |
| **EIO-LCA** | Spend-based | USA | 2007 | Carnegie-Mellon University |
| **USEEIO** | Spend-based | USA | 2017 | US EPA |
| **Base IMPACTS ®** | Mass-based | Europe / World | 2018 | ADEME |
| **Base Carbone ®** | Spend-based and mass-based | France / Europe | 2019 | ADEME |

More details on these sources can be found in Appendix 2: Description of the main databases.

# 6 Approaches

## 6.1 Spend-Based Approach

The inputs needed to use this approach are annual spend data for the relevant sub-category. This information is combined with spend-based EF which embedded in the tool. The spend-based approach granularity is relatively low.

For all categories, emissions are estimated using the equation below:

**Subcategory Emissions ($tCO_2e$) =**
Subcategory expenses (k$ or k€) × Subcategory EF ($kgCO_2e$/k$ or k€) / 1000

## 6.2 Hybrid-Based Approach

The hybrid-based approach is a combination of mass-based approach and spend-based approach. It therefore applies in the case when the material mass breakdown is partially known. Therefore it still allows the estimation of emissions from products for which some material breakdown is missing.

When the material breakdown is known, the following equation is used:

**Subcategory emissions ($tCO_2e$) =**

$$\sum_i \sum_j Units\ of\ products\ \boldsymbol{i}\ bought \times Mass\ of\ material\ \boldsymbol{j}\ in\ product\ \boldsymbol{i} \times material\ \boldsymbol{j}\ EF\ /\ 1000$$

For other products with unknown material breakdown, the same equation as the spend-based approach one is used.

**Subcategory emissions ($tCO_2e$) =**
Subcategory expenses (k$ or k€) × Subcategory EF ($kgCO_2e$/k$ or k€) / 1000

The hybrid approach proposes provides a higher number of subcategories and therefore it provides a higher resolution than in the spend based approach.

## 6.3 Mass-Based Approach

The mass-based approach uses a mass-based EF for most of the purchased products, hence providing the most granular and accurate reporting of all approaches. For products with a known mass breakdown, the following equation is used:

**Subcategory emissions ($tCO_2e$) =**

$$\sum_i \sum_j Quantity\ of\ products\ \boldsymbol{i}\ bought \times Mass\ of\ material\ \boldsymbol{j}\ in\ product\ \boldsymbol{i} \times material\ j\ EF\ /\ 1000$$

Emissions from other purchased products for which a known material mass breakdown is not available are estimated based on total mass or number of units purchased:

**Emissions from subcategory A ($tCO_2e$) =**
Purchases on subcategory A (kg) * EF for subcategory A ($kgCO_2e/kg$) / 1000

**<u>OR</u>**

**Emissions from subcategory A ($tCO_2e$) =**
Purchases on subcategory A (units) * EF for subcategory A ($kgCO_2e/unit$) / 1000

In this approach, spend-based EF are used for all services. For goods, a spend-based approach is allowed only if a very specific spend-based EF is identified. In both cases, the following equation is applicable:

**Emissions from subcategory A ($tCO_2e$) =**
Expenses on subcategory A (k$) * EF for subcategory A ($kgCO_2e/k\$$) / 1000

# 7 List of subcategories and emissions factors

## 7.1 General considerations

The purpose of this section is to detail the nomenclature for all purchases covered by the methodology. Indeed, the different types of purchases are classified in 3 levels: group, category and subcategory.

Each product subcategory is associated to a product proxy selected from one of the databases. The matching proxy's description can be found under the column "EF Proxy" and the corresponding database under the column "database."

Most EF used in the spend-based approach originate from either the Carnegie-Mellon[8], the DoD[7] or the USEEIO database[9]. In the mass-based approach, most EF were taken from ADEME Base Impacts[11].

The classification is based upon North American Industry Classification System (NAICS) standard which classifies business activities and gathers them according to the similarity of the processes used to produce goods or services.

## 7.2 Assembly and structural components group

This group includes all assembly and structural components, whether metallic or non-metallic (i.e., fuselage, wing, landing gear, breaks, nacelles, engine housing, stabilizers, etc.).

This group is composed of 2 categories:

- Metallic assembly and structural components;
- Non-metallic assembly and structural components.

### 7.2.1 Metallic assembly and structural components category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Metal-based structural product, unknown material and/or mass | Metal Structural Products | Carnegie Mellon | 584,00 | kgCO2e / kUSD |
| Aluminium, extrusion profile - Casting | Aluminium extrusion profile + Casting (low impact) | Base Impacts | 3,80 | kgCO2e / kg |
| Aluminium, extrusion profile - Cold rolling | Aluminium extrusion profile + Cold rolling (low impact metal) | Base Impacts | 2,58 | kgCO2e / kg |
| Aluminium, extrusion profile - Hot rolling | Aluminium extrusion profile + Hot rolling (low impact metal) | Base Impacts | 2,61 | kgCO2e / kg |
| Aluminium, extrusion profile - Metal drilling | Aluminium extrusion profile + Metal drilling (low impact metal) | Base Impacts | 2,53 | kgCO2e / kg |
| Aluminium, extrusion profile - Metal sheet stamping | Aluminium extrusion profile + Metal sheet stamping (20% loss) | Base Impacts | 2,60 | kgCO2e / kg |
| Aluminium, extrusion profile - Unspecified process | Processed Aluminium extrusion profile | Base Impacts | 3,80 | kgCO2e / kg |
| Aluminium, sheet - Casting | Aluminium sheet + Casting (low impact) | Base Impacts | 4,90 | kgCO2e / kg |
| Aluminium, sheet - Cold rolling | Aluminium sheet + Cold rolling (low impact metal) | Base Impacts | 3,44 | kgCO2e / kg |
| Aluminium, sheet - Hot rolling | Aluminium sheet + Hot rolling (low impact metal) | Base Impacts | 3,51 | kgCO2e / kg |
| Aluminium, sheet - Metal drilling | Aluminium sheet + Metal drilling (low impact metal) | Base Impacts | 3,36 | kgCO2e / kg |
| Aluminium, sheet - Metal sheet stamping | Aluminium sheet + Metal sheet stamping (20% loss) | Base Impacts | 3,57 | kgCO2e / kg |
| Aluminium, sheet - Unspecified process | Processed Aluminium sheet | Base Impacts | 4,90 | kgCO2e / kg |
| Brass - Casting | Brass (CuZn20) + Casting (low impact) | Base Impacts | 1,34 | kgCO2e / kg |
| Brass - Cold rolling | Brass (CuZn20) + Cold rolling (low impact metal) | Base Impacts | 0,67 | kgCO2e / kg |
| Brass - Hot rolling | Brass (CuZn20) + Hot rolling (low impact metal) | Base Impacts | 0,62 | kgCO2e / kg |
| Brass - Metal drilling | Brass (CuZn20) + Metal drilling (low impact metal) | Base Impacts | 0,69 | kgCO2e / kg |
| Brass - Metal sheet stamping | Brass (CuZn20) + Metal sheet stamping (20% loss) | Base Impacts | 0,46 | kgCO2e / kg |
| Brass - Unspecified process | Processed Brass (CuZn20) | Base Impacts | 1,34 | kgCO2e / kg |
| Copper - Casting | Copper mix (99,999% from electrolysis) + Casting (low impact) | Base Impacts | 5,84 | kgCO2e / kg |
| Copper - Cold rolling | Copper mix (99,999% from electrolysis) + Cold rolling (low impact metal) | Base Impacts | 4,18 | kgCO2e / kg |
| Copper - Hot rolling | Copper mix (99,999% from electrolysis) + Hot rolling (low impact metal) | Base Impacts | 4,27 | kgCO2e / kg |
| Copper - Metal drilling | Copper mix (99,999% from electrolysis) + Metal drilling (low impact metal) | Base Impacts | 4,07 | kgCO2e / kg |
| Copper - Metal sheet stamping | Copper mix (99,999% from electrolysis) + Metal sheet stamping (20% loss) | Base Impacts | 4,40 | kgCO2e / kg |
| Copper - Unspecified process | Processed Copper mix (99,999% from electrolysis) | Base Impacts | 5,84 | kgCO2e / kg |
| Lead - Casting | Lead + Casting (low impact) | Base Impacts | 2,78 | kgCO2e / kg |
| Lead - Cold rolling | Lead + Cold rolling (low impact metal) | Base Impacts | 1,79 | kgCO2e / kg |
| Lead - Hot rolling | Lead + Hot rolling (low impact metal) | Base Impacts | 1,79 | kgCO2e / kg |

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Lead - Metal drilling | Lead + Metal drilling (low impact metal) | Base Impacts | 1,77 | kgCO2e / kg |
| Lead - Metal sheet stamping | Lead + Metal sheet stamping (20% loss) | Base Impacts | 1,72 | kgCO2e / kg |
| Lead - Unspecified process | Processed Lead | Base Impacts | 2,78 | kgCO2e / kg |
| Nickel - Casting | Monel (nickel alloy) + Casting (high impact) | Base Impacts | 19,11 | kgCO2e / kg |
| Nickel - Cold rolling | Monel (nickel alloy) + Cold rolling (high impact metal) | Base Impacts | 11,71 | kgCO2e / kg |
| Nickel - Hot rolling | Monel (nickel alloy) + Hot rolling (high impact metal) | Base Impacts | 12,08 | kgCO2e / kg |
| Nickel - Metal drilling | Monel (nickel alloy) + Metal drilling (high impact metal) | Base Impacts | 16,66 | kgCO2e / kg |
| Nickel - Metal sheet stamping | Monel (nickel alloy) + Metal sheet stamping (20% loss) | Base Impacts | 13,67 | kgCO2e / kg |
| Nickel - Unspecified process | Processed Monel (nickel alloy) | Base Impacts | 19,11 | kgCO2e / kg |
| Stainless Steel - Steel part turning | Stainless Steel + Steel part turning (5% loss), GLO | Base Impacts | 0,09 | kgCO2e / kg |
| Stainless Steel - Steel sheet scouring (deburring) | Stainless Steel + Steel sheet scouring (deburring), GLO | Base Impacts | 0,04 | kgCO2e / kg |
| Stainless Steel - Unspecified process | Processed Stainless Steel | Base Impacts | 0,18 | kgCO2e / kg |
| Steel - Steel part turning | Steel + Steel part turning (5% loss), GLO | Base Impacts | 1,65 | kgCO2e / kg |
| Steel - Steel sheet scouring (deburring) | Steel + Steel sheet scouring (deburring), GLO | Base Impacts | 1,34 | kgCO2e / kg |
| Steel - Galvanisation steel sheet | Steel + Galvanisation steel sheet, GLO | Base Impacts | 1,70 | kgCO2e / kg |
| Steel - Unspecified process | Processed Steel | Base Impacts | 1,70 | kgCO2e / kg |
| Titanium - Casting | Titanium + Casting (high impact) | Base Impacts | 26,65 | kgCO2e / kg |
| Titanium - Cold rolling | Titanium + Cold rolling (high impact metal) | Base Impacts | 16,84 | kgCO2e / kg |
| Titanium - Hot rolling | Titanium + Hot rolling (high impact metal) | Base Impacts | 17,31 | kgCO2e / kg |
| Titanium - Metal drilling | Titanium + Metal drilling (high impact metal) | Base Impacts | 24,20 | kgCO2e / kg |
| Titanium - Metal sheet stamping | Titanium + Metal sheet stamping (20% loss) | Base Impacts | 19,83 | kgCO2e / kg |
| Titanium - Unspecified process | Processed Titanium | Base Impacts | 26,65 | kgCO2e / kg |
| Zinc - Casting | Zamak zinc alloy (ZnAlMgCu) + Casting (high impact) | Base Impacts | 7,11 | kgCO2e / kg |
| Zinc - Cold rolling | Zamak zinc alloy (ZnAlMgCu) + Cold rolling (high impact metal) | Base Impacts | 3,55 | kgCO2e / kg |
| Zinc - Hot rolling | Zamak zinc alloy (ZnAlMgCu) + Hot rolling (high impact metal) | Base Impacts | 3,75 | kgCO2e / kg |
| Zinc - Metal drilling | Zamak zinc alloy (ZnAlMgCu) + Metal drilling (high impact metal) | Base Impacts | 4,66 | kgCO2e / kg |
| Zinc - Metal sheet stamping | Zamak zinc alloy (ZnAlMgCu) + Metal sheet stamping (20% loss) | Base Impacts | 3,87 | kgCO2e / kg |
| Zinc - Unspecified process | Processed Zamak zinc alloy (ZnAlMgCu) | Base Impacts | 7,11 | kgCO2e / kg |

### 7.2.2 Non-metallic assembly and structural components category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Composite-based structural product, unknown material and/or mass | Carbon fiber (CF, from PAN, high strengths, long fibers ) + Thermocompression | Base Impacts & Infosys | 495,06 | kgCO2e / kUSD |
| Other non metal-based assembly and structural components for aircraft | Other Aircraft Parts | Carnegie Mellon | 243,00 | kgCO2e / kUSD |
| Other non metal-based assembly and structural components for spacecraft and missiles | Guided Missiles And Space Vehicles | Carnegie Mellon | 111,00 | kgCO2e / kUSD |
| Carbon fiber, high strengths, long fibers - Pultrusion | Carbon fiber (CF, from PAN, high strengths, long fibers ) + Pultrusion | Base Impacts | 41,11 | kgCO2e / kg |
| Carbon fiber, high strengths, long fibers - Thermocompression | Carbon fiber (CF, from PAN, high strengths, long fibers ) + Thermocompression | Base Impacts | 42,08 | kgCO2e / kg |
| Carbon fiber, high strengths, long fibers - Unspecified process | Processed Carbon fiber (CF, from PAN, high strengths, long fibers ) | Base Impacts | 42,08 | kgCO2e / kg |
| Carbon Fiber, short fibers - Pultrusion | Carbon Fiber (CF, from PAN, short fibers) + Pultrusion | Base Impacts | 18,72 | kgCO2e / kg |
| Carbon Fiber, short fibers - Thermocompression | Carbon Fiber (CF, from PAN, short fibers) + Thermocompression | Base Impacts | 19,69 | kgCO2e / kg |
| Carbon Fiber, short fibers - Unspecified process | Processed Carbon Fiber (CF, from PAN, short fibers) | Base Impacts | 19,69 | kgCO2e / kg |
| Glass fibers, high strength - Pultrusion | Glass fibers (high strength) + Pultrusion | Base Impacts | 2,78 | kgCO2e / kg |
| Glass fibers, high strength - Thermocompression | Glass fibers (high strength) + Thermocompression | Base Impacts | 3,75 | kgCO2e / kg |
| Glass fibers, high strength - Unspecified process | Processed Glass fibers (high strength) | Base Impacts | 3,75 | kgCO2e / kg |
| Glass fibers, low strength - Pultrusion | Glass fibers (low strength) + Pultrusion | Base Impacts | 3,56 | kgCO2e / kg |
| Glass fibers, low strength - Thermocompression | Glass fibers (low strength) + Thermocompression | Base Impacts | 4,53 | kgCO2e / kg |
| Glass fibers, low strength - Unspecified process | Processed Glass fibers (low strength) | Base Impacts | 4,53 | kgCO2e / kg |

### 7.2.3 Examples of products covered in the category "Aircraft parts other than engines"

The following example demonstrates how different types of products relating to the aerospace industry may be grouped under a NAICS nomenclature.

This category originally entitled ***Other Aircraft Parts*** in the USEEIO database was renamed ***Aircraft parts other than engines*** so that IAEG members better understand it.

| NAICS number | Definition |
|---|---|
| **336413** | This U.S. industry comprises establishments primarily engaged in (1) manufacturing aircraft parts or auxiliary equipment (except engines and aircraft fluid power subassemblies) and/or (2) developing and making prototypes of aircraft parts and auxiliary equipment. Auxiliary equipment includes such items as crop dusting apparatus, armament racks, inflight refueling equipment, and external fuel tanks. |

**Here are some examples of products included in this subcategory:**

- Aircraft assemblies, subassemblies, and parts (except engines) manufacturing
- Aircraft auxiliary parts (e.g., crop dusting, external fuel tanks, inflight refueling equipment) manufacturing
- Aircraft brakes manufacturing
- Aircraft control surface assemblies manufacturing
- Aircraft fuselage wing tail and similar assemblies manufacturing
- Aircraft propellers and parts manufacturing
- Aircraft wheels manufacturing
- Airframe assemblies (except for guided missiles) manufacturing
- Developing and producing prototypes for aircraft parts (except engines) and auxiliary equipment
- Joints, universal, aircraft, manufacturing
- Targets, trailer type, aircraft, manufacturing
- Tow targets, aircraft, manufacturing
- Universal joints, aircraft, manufacturing

## 7.3 Manufactured components and materials group

This group includes all product-related components that are nonstructural such as casting and forging, fan blades, carbon brake pads, cargo equipment (hoisting, tools for cargo activities, etc.) cabin and seats, entertainment equipment and galleys, carpets, propulsion system in space equipment, solar panels, etc.

This group is divided into 3 categories:

- Metallic manufactured components;
- Non-metallic manufactured components;
- Electrical and electronic equipment.

### 7.3.1 Metallic manufactured components category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Air conditioning and industrial refrigeration equipment, unknown material and mass | Air conditioning, refrigeration, and warm air heating equipment manufacturing (333415) | DoD | 310,69 | kgCO2e / kUSD |
| Aircraft engines, engine parts and other propulsion systems, unknown material and mass | Aircraft Engines And Parts | Carnegie Mellon | 205,00 | kgCO2e / kUSD |
| Aluminium-based manufactured products, unknown mass | Aluminum product manufacturing from purchased aluminum (33131B) | DoD | 1441,10 | kgCO2e / kUSD |
| Copper-based manufactured products, unknown mass | Copper rolling, drawing, extruding and alloying (331420) | DoD | 583,51 | kgCO2e / kUSD |
| Hardware, unknown material and mass | Hardware manufacturing (332500) | DoD | 471,39 | kgCO2e / kUSD |
| Metal pipes and fittings, unknown material and mass | Fabricated pipe and pipe fitting manufacturing (332996) | DoD | 662,42 | kgCO2e / kUSD |
| Metal-based manufactured components for aircraft (other than engines), unknown material and mass | Other Aircraft Parts | Carnegie Mellon | 243,00 | kgCO2e / kUSD |
| Metal-based propulsion units and parts for space vehicles and guided missiles, unknown material and mass | Propulsion Units And Parts For Space Vehicles And Guided Missiles | Carnegie Mellon | 174,00 | kgCO2e / kUSD |
| Other non-ferrous metal-based manufactured products, unspecified material and mass | Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying (331490) | DoD | 1649,50 | kgCO2e / kUSD |
| Steel-based manufactured components, unknown mass | Steel product manufacturing from purchased steel (331200) | DoD | 1021,20 | kgCO2e / kUSD |
| Aluminium, extrusion profile - Casting | Aluminium extrusion profile + Casting (low impact) | Base Impacts | 3,80 | kgCO2e / kg |
| Aluminium, extrusion profile - Cold rolling | Aluminium extrusion profile + Cold rolling (low impact metal) | Base Impacts | 2,58 | kgCO2e / kg |
| Aluminium, extrusion profile - Hot rolling | Aluminium extrusion profile + Hot rolling (low impact metal) | Base Impacts | 2,61 | kgCO2e / kg |
| Aluminium, extrusion profile - Metal drilling | Aluminium extrusion profile + Metal drilling (low impact metal) | Base Impacts | 2,53 | kgCO2e / kg |
| Aluminium, extrusion profile - Metal sheet stamping | Aluminium extrusion profile + Metal sheet stamping (20% loss) | Base Impacts | 2,60 | kgCO2e / kg |
| Aluminium, extrusion profile - Unspecified process | Processed Aluminium extrusion profile | Base Impacts | 3,80 | kgCO2e / kg |
| Aluminium, sheet - Casting | Aluminium sheet + Casting (low impact) | Base Impacts | 4,90 | kgCO2e / kg |
| Aluminium, sheet - Cold rolling | Aluminium sheet + Cold rolling (low impact metal) | Base Impacts | 3,44 | kgCO2e / kg |
| Aluminium, sheet - Hot rolling | Aluminium sheet + Hot rolling (low impact metal) | Base Impacts | 3,51 | kgCO2e / kg |
| Aluminium, sheet - Metal drilling | Aluminium sheet + Metal drilling (low impact metal) | Base Impacts | 3,36 | kgCO2e / kg |
| Aluminium, sheet - Metal sheet stamping | Aluminium sheet + Metal sheet stamping (20% loss) | Base Impacts | 3,57 | kgCO2e / kg |
| Aluminium, sheet - Unspecified process | Processed Aluminium sheet | Base Impacts | 4,90 | kgCO2e / kg |
| Brass - Casting | Brass (CuZn20) + Casting (low impact) | Base Impacts | 1,34 | kgCO2e / kg |
| Brass - Cold rolling | Brass (CuZn20) + Cold rolling (low impact metal) | Base Impacts | 0,67 | kgCO2e / kg |
| Brass - Hot rolling | Brass (CuZn20) + Hot rolling (low impact metal) | Base Impacts | 0,62 | kgCO2e / kg |
| Brass - Metal drilling | Brass (CuZn20) + Metal drilling (low impact metal) | Base Impacts | 0,69 | kgCO2e / kg |
| Brass - Metal sheet stamping | Brass (CuZn20) + Metal sheet stamping (20% loss) | Base Impacts | 0,46 | kgCO2e / kg |
| Brass - Unspecified process | Processed Brass (CuZn20) | Base Impacts | 1,34 | kgCO2e / kg |
| Copper - Casting | Copper mix (99,999% from electrolysis) + Casting (low impact) | Base Impacts | 5,84 | kgCO2e / kg |
| Copper - Cold rolling | Copper mix (99,999% from electrolysis) + Cold rolling (low impact metal) | Base Impacts | 4,18 | kgCO2e / kg |

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Copper - Hot rolling | Copper mix (99,999% from electrolysis) + Hot rolling (low impact metal) | Base Impacts | 4,27 | kgCO2e / kg |
| Copper - Metal drilling | Copper mix (99,999% from electrolysis) + Metal drilling (low impact metal) | Base Impacts | 4,07 | kgCO2e / kg |
| Copper - Metal sheet stamping | Copper mix (99,999% from electrolysis) + Metal sheet stamping (20% loss) | Base Impacts | 4,40 | kgCO2e / kg |
| Copper - Unspecified process | Processed Copper mix (99,999% from electrolysis) | Base Impacts | 5,84 | kgCO2e / kg |
| Lead - Casting | Lead + Casting (low impact) | Base Impacts | 2,78 | kgCO2e / kg |
| Lead - Cold rolling | Lead + Cold rolling (low impact metal) | Base Impacts | 1,79 | kgCO2e / kg |
| Lead - Hot rolling | Lead + Hot rolling (low impact metal) | Base Impacts | 1,79 | kgCO2e / kg |
| Lead - Metal drilling | Lead + Metal drilling (low impact metal) | Base Impacts | 1,77 | kgCO2e / kg |
| Lead - Metal sheet stamping | Lead + Metal sheet stamping (20% loss) | Base Impacts | 1,72 | kgCO2e / kg |
| Lead - Unspecified process | Processed Lead | Base Impacts | 2,78 | kgCO2e / kg |
| Nickel - Casting | Monel (nickel alloy) + Casting (high impact) | Base Impacts | 19,11 | kgCO2e / kg |
| Nickel - Cold rolling | Monel (nickel alloy) + Cold rolling (high impact metal) | Base Impacts | 11,71 | kgCO2e / kg |
| Nickel - Hot rolling | Monel (nickel alloy) + Hot rolling (high impact metal) | Base Impacts | 12,08 | kgCO2e / kg |
| Nickel - Metal drilling | Monel (nickel alloy) + Metal drilling (high impact metal) | Base Impacts | 16,66 | kgCO2e / kg |
| Nickel - Metal sheet stamping | Monel (nickel alloy) + Metal sheet stamping (20% loss) | Base Impacts | 13,67 | kgCO2e / kg |
| Nickel - Unspecified process | Processed Monel (nickel alloy) | Base Impacts | 19,11 | kgCO2e / kg |
| Stainless Steel - Steel part turning | Stainless Steel + Steel part turning (5% loss), GLO | Base Impacts | 0,09 | kgCO2e / kg |
| Stainless Steel - Steel sheet scouring (deburring) | Stainless Steel + Steel sheet scouring (deburring), GLO | Base Impacts | 0,04 | kgCO2e / kg |
| Stainless Steel - Unspecified process | Processed Stainless Steel | Base Impacts | 0,18 | kgCO2e / kg |
| Steel - Steel part turning | Steel + Steel part turning (5% loss), GLO | Base Impacts | 1,65 | kgCO2e / kg |
| Steel - Steel sheet scouring (deburring) | Steel + Steel sheet scouring (deburring), GLO | Base Impacts | 1,34 | kgCO2e / kg |
| Steel - Galvanisation steel sheet | Steel + Galvanisation steel sheet, GLO | Base Impacts | 1,70 | kgCO2e / kg |
| Steel - Unspecified process | Processed Steel | Base Impacts | 1,70 | kgCO2e / kg |
| Titanium - Casting | Titanium + Casting (high impact) | Base Impacts | 26,65 | kgCO2e / kg |
| Titanium - Cold rolling | Titanium + Cold rolling (high impact metal) | Base Impacts | 16,84 | kgCO2e / kg |
| Titanium - Hot rolling | Titanium + Hot rolling (high impact metal) | Base Impacts | 17,31 | kgCO2e / kg |
| Titanium - Metal drilling | Titanium + Metal drilling (high impact metal) | Base Impacts | 24,20 | kgCO2e / kg |
| Titanium - Metal sheet stamping | Titanium + Metal sheet stamping (20% loss) | Base Impacts | 19,83 | kgCO2e / kg |
| Titanium - Unspecified process | Processed Titanium | Base Impacts | 26,65 | kgCO2e / kg |
| Zinc - Casting | Zamak zinc alloy (ZnAlMgCu) + Casting (high impact) | Base Impacts | 7,11 | kgCO2e / kg |
| Zinc - Cold rolling | Zamak zinc alloy (ZnAlMgCu) + Cold rolling (high impact metal) | Base Impacts | 3,55 | kgCO2e / kg |
| Zinc - Hot rolling | Zamak zinc alloy (ZnAlMgCu) + Hot rolling (high impact metal) | Base Impacts | 3,75 | kgCO2e / kg |
| Zinc - Metal drilling | Zamak zinc alloy (ZnAlMgCu) + Metal drilling (high impact metal) | Base Impacts | 4,66 | kgCO2e / kg |
| Zinc - Metal sheet stamping | Zamak zinc alloy (ZnAlMgCu) + Metal sheet stamping (20% loss) | Base Impacts | 3,87 | kgCO2e / kg |
| Zinc - Unspecified process | Processed Zamak zinc alloy (ZnAlMgCu) | Base Impacts | 7,11 | kgCO2e / kg |

### 7.3.2 Non-metallic manufactured components category

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Composite-based manufactured products, unknown mass | Carbon fiber (CF, from PAN, high strengths, long fibers ) + Thermocompression | Base Impacts & Infosys | 495,06 | kgCO2e / kUSD |
| Glass-based manufactured products, unknown mass | Glass And Glass Products | Carnegie Mellon | 932,00 | kgCO2e / kUSD |
| Non metal-based aircraft engines, engine parts and other propulsion systems, unknown material and mass | Aircraft Engines And Parts | Carnegie Mellon | 205,00 | kgCO2e / kUSD |
| Non metal-based manufactured components for aircraft (other than engines), unknown material and mass | Other Aircraft Parts | Carnegie Mellon | 243,00 | kgCO2e / kUSD |
| Non metal-based propulsion units and parts for space vehicles or missiles, unknown material and mass | Propulsion Units And Parts For Space Vehicles And Guided Missiles | Carnegie Mellon | 174,00 | kgCO2e / kUSD |
| Plastic-based manufactured products, unknown mass | Other Plastic Products | Carnegie Mellon | 649,00 | kgCO2e / kUSD |
| Acrylonitrile-butadiene-styrene (ABS), any process | Processed Acrylonitrile-butadiene-styrene granulate (ABS), RER | Base Impacts | 5,74 | kgCO2e / kg |
| Carbon fiber, high strengths, long fibers - Pultrusion | Carbon fiber (CF, from PAN, high strengths, long fibers ) + Pultrusion | Base Impacts | 41,11 | kgCO2e / kg |
| Carbon fiber, high strengths, long fibers - Thermocompression | Carbon fiber (CF, from PAN, high strengths, long fibers ) + Thermocompression | Base Impacts | 42,08 | kgCO2e / kg |
| Carbon fiber, high strengths, long fibers - Unspecified process | Processed Carbon fiber (CF, from PAN, high strengths, long fibers ) | Base Impacts | 42,08 | kgCO2e / kg |
| Carbon Fiber, short fibers - Pultrusion | Carbon Fiber (CF, from PAN, short fibers) + Pultrusion | Base Impacts | 18,72 | kgCO2e / kg |
| Carbon Fiber, short fibers - Thermocompression | Carbon Fiber (CF, from PAN, short fibers) + Thermocompression | Base Impacts | 19,69 | kgCO2e / kg |
| Carbon Fiber, short fibers - Unspecified process | Processed Carbon Fiber (CF, from PAN, short fibers) | Base Impacts | 19,69 | kgCO2e / kg |
| Glass fibers, high strength - Pultrusion | Glass fibers (high strength) + Pultrusion | Base Impacts | 2,78 | kgCO2e / kg |
| Glass fibers, high strength - Thermocompression | Glass fibers (high strength) + Thermocompression | Base Impacts | 3,75 | kgCO2e / kg |
| Glass fibers, high strength - Unspecified process | Processed Glass fibers (high strength) | Base Impacts | 3,75 | kgCO2e / kg |
| Glass fibers, low strength - Pultrusion | Glass fibers (low strength) + Pultrusion | Base Impacts | 3,56 | kgCO2e / kg |
| Glass fibers, low strength - Thermocompression | Glass fibers (low strength) + Thermocompression | Base Impacts | 4,53 | kgCO2e / kg |
| Glass fibers, low strength - Unspecified process | Processed Glass fibers (low strength) | Base Impacts | 4,53 | kgCO2e / kg |
| Nylon, any process | Processed Nylon 6 granulate (PA 6), RER | Base Impacts | 11,26 | kgCO2e / kg |
| Phenolic resin, any process | Processed Phenolic resin (45% concentration) | Base Impacts | 2,93 | kgCO2e / kg |
| Polycarbonate (PC), any process | Processed Polycarbonate granulate (PC), EU-25 | Base Impacts | 5,65 | kgCO2e / kg |
| Polyethylene high density (PE-HD), any process | Processed Polyethylene high density granulate (PE-HD), RER | Base Impacts | 3,83 | kgCO2e / kg |
| Polyethylene low density (PE-LD), any process | Processed Polyethylene low density granulate (PE-LD), RER | Base Impacts | 4,01 | kgCO2e / kg |

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Polyethylene terephthalate (PET), any process | Processed Polyethylene terephthalate granulate (PET, amorph), RER | Base Impacts | 5,21 | kgCO2e / kg |
| Polymethylmethacrylate-ball (PMMA), any process | Processed Polymethylmethacrylate-ball (PMMA), RER | Base Impacts | 9,06 | kgCO2e / kg |
| Polyoxymethylene (POM), any process | Processed Polyoxymethylene granulate (POM), RER | Base Impacts | 5,65 | kgCO2e / kg |
| Polypropylene (PP), any process | Processed Polypropylene granulate (PP), RER | Base Impacts | 3,88 | kgCO2e / kg |
| Polystyrene (PS), any process | Processed Polystyrene granulate (PS), RER | Base Impacts | 5,42 | kgCO2e / kg |
| Polyvinylchloride (PVC), any process | Processed Polyvinylchloride granulate (Emulsion, E-PVC), RER | Base Impacts | 5,19 | kgCO2e / kg |
| Recycled polyethylene high density (PE-HD), any process | Processed Production of recycled HDPE granules from collected and sorted HDPE packaging waste | Base Impacts | 2,05 | kgCO2e / kg |
| Recycled polyethylene low density (PE-LD), any process | Processed Production of recycled LDPE granules from collected and sorted agricultural plastic film waste | Base Impacts | 1,98 | kgCO2e / kg |
| Recycled polyethylene terephthalate (PET), any process | Processed Production of recycled PET granules from collected and sorted PET packaging waste | Base Impacts | 2,13 | kgCO2e / kg |
| Recycled polypropylene (PP), any process | Processed Production of recycled PP granules from collected and sorted PP waste | Base Impacts | 1,99 | kgCO2e / kg |
| Recycled polypropylene (PP), any process | Processed Production of recycled PP granules from collected and sorted PP waste | Base Impacts | 1,99 | kgCO2e / kg |
| Recycled polyvinylchloride (PVC), any process | Processed Production of recycled PVC from collected and sorted PVC waste | Base Impacts | 1,96 | kgCO2e / kg |

### 7.3.3 Electrical and electronic equipment category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Audio and video equipment, unknown quantity | Audio and video equipment manufacturing (334300) | DoD | 294,28 | kgCO2e / kUSD |
| Batteries for electricity storage | Primary battery manufacturing (335912) | DoD | 658,51 | kgCO2e / kUSD |
| Communication or energy wires and cables, unknown quantity | Communication And Energy Wire And Cable | Carnegie Mellon | 499,00 | kgCO2e / kUSD |
| Electronic components (computers, servers) | Electronic computer manufacturing (334111) | DoD | 259,99 | kgCO2e / kUSD |
| Electronic components (printed circuits, screens, crystal assemblies, etc.) | Other electronic component manufacturing (33441A) | DoD | 359,46 | kgCO2e / kUSD |
| Other communications equipment manufacturing | Other communications equipment manufacturing (334290) | DoD | 351,52 | kgCO2e / kUSD |
| Other electronic equipment | Other electronic component manufacturing (33441A) | DoD | 359,46 | kgCO2e / kUSD |
| Other industrial electric components | All other miscellaneous electrical equipment and component manufacturing (335999) | DoD | 324,13 | kgCO2e / kUSD |
| Other industrial electric components | All other miscellaneous electrical equipment and component manufacturing (335999) | DoD | 324,13 | kgCO2e / kUSD |
| Printed circuits, unknown quantity | Printed circuit assembly (electronic assembly) manufacturing (334418) | DoD | 374,80 | kgCO2e / kUSD |
| Search, detection, and navigation instruments (sensors, etc.) | Search, detection, and navigation instruments manufacturing (334511) | DoD | 191,69 | kgCO2e / kUSD |
| Time-measuring and controlling devices | Watch, clock, and other measuring and controlling device manufacturing (33451A) | DoD | 252,24 | kgCO2e / kUSD |
| Wireless communication equipment | Broadcast and wireless communications equipment (334220) | DoD | 182,89 | kgCO2e / kUSD |
| Electrical cable | Electrical cable | Base Impacts | 0,16 | kgCO2e / m |
| Liquid crystal display panel | Liquid crystal display panel | Base Impacts | 134,43 | kgCO2e / Item |
| Printed circuit board | Printed circuit board assembly | Base Impacts | 606,12 | kgCO2e / m2 |

### 7.3.4 Examples of products covered in the category "Aircraft engines, engine parts and other propulsion systems"

The following example demonstrates how different types of products relating to the aerospace industry may be grouped under a NAICS nomenclature.

This category originally entitled ***Aircraft Engine and Engine Parts*** in the USEEIO database was renamed ***Aircraft engines, engine parts and other propulsion systems*** so that IAEG members better understand it.

| NAICS number | Definition |
|---|---|
| **336412** | This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing aircraft engines and engine parts; (2) developing and making prototypes of aircraft engines and engine parts; (3) aircraft propulsion system conversion (i.e., major modifications to systems); and (4) aircraft propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft propulsion system to original design specifications). |

Here are some examples of products included in this subcategory:

- Aircraft engine and engine parts (except carburetors, pistons, piston rings, valves) manufacturing
- Aircraft engine overhauling
- Aircraft engine rebuilding
- Aircraft turbines manufacturing
- Developing and producing prototypes for aircraft engines and engine parts
- Engines and engine parts, aircraft (except carburetors, pistons, piston rings, valves), manufacturing
- Gas turbines, aircraft, manufacturing
- Gasoline engine parts (except carburetors, pistons, piston rings, valves), aircraft, manufacturing
- Gasoline engines, aircraft, manufacturing
- Internal combustion engines, aircraft, manufacturing
- Jet propulsion and internal combustion engines and parts, aircraft, manufacturing
- Rocket engines, aircraft, manufacturing

Note: some EF can be found in different Groups (Assembly and structural components, Manufactured components, and materials) because they can cover similar products. This is particularly true at the spend-based approach (because categories / subcategories are very aggregate and then generic).

## 7.4 Raw materials group

This group includes all raw materials and is composed of 3 categories:

- Metallic raw materials;
- Non-metallic raw materials;
- Gases and chemicals.

### 7.4.1 Metallic raw materials category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Aluminum and aluminum alloys, unknown mass | Secondary smelting and alloying of aluminum (331314) | DoD | 1413,00 | kgCO2e / kUSD |
| Copper, unknown mass | Primary smelting and refining of copper (331411) | DoD | 638,04 | kgCO2e / kUSD |
| Iron, steel and ferro-alloys, unknown mass | Iron and steel mills and ferroalloy manufacturing (331110) | DoD | 2031,90 | kgCO2e / kUSD |
| Metals, unknown material and mass | Métaux (aluminium, cuivre, acier, etc.) | Base Carbone | 1700,00 | kgCO2e / k€ |
| Other non-ferrous metals, unknown mass | Primary smelting and refining of nonferrous metal (except copper and aluminum) (331419) | DoD | 554,21 | kgCO2e / kUSD |
| Aluminium, extrusion profile | Aluminium extrusion profile | Base Impacts | 2,39 | kgCO2e / kg |
| Aluminium, sheet | Aluminium sheet | Base Impacts | 3,19 | kgCO2e / kg |
| Aluminum, unspecified | Aluminium - production of aluminium | Metal LCAs | 22,40 | kgCO2e / kg |
| Copper | Copper mix (99,999% from electrolysis) | Base Impacts | 3,88 | kgCO2e / kg |
| Ferroalloy | Ferroalloy production | Base Carbone | 2,21 | kgCO2e / kg |
| Ferronickel | Ferronickel - production of ferronickel | Metal LCAs | 8,53 | kgCO2e / kg |
| Iron | Iron production | Base Carbone | 2,21 | kgCO2e / kg |
| Lead | Lead | Base Impacts | 1,65 | kgCO2e / kg |
| Magnesium | Magnesium - production of magnesium | Metal LCAs | 42,00 | kgCO2e / kg |
| Monel (nickel alloy) | Monel (nickel alloy) | Base Impacts | 11,61 | kgCO2e / kg |
| Nickel, unspecified | Nickel - production of class 1 nickel | Metal LCAs | 7,64 | kgCO2e / kg |
| Stainless steel, coil, cold rolled (0% recycling) | Stainless steel, coil, cold rolled (304) for clothing (0% recycling) | Base Impacts | 7,27 | kgCO2e / kg |
| Stainless steel, coil, cold rolled (100% recycling) | Stainless steel, coil, cold rolled (304) for furniture (100% recycling) | Base Impacts | 3,75 | kgCO2e / kg |
| Stainless steel, coil, cold rolled (50% recycling) | Stainless steel, coil, cold rolled (304) for EEE (50% recycling) | Base Impacts | 4,38 | kgCO2e / kg |
| Steel, cold rolled (0% of recycling) | Steel, coil, cold rolled for clothing (0% of recycling) | Base Impacts | 2,42 | kgCO2e / kg |
| Steel, cold rolled (50% of recycling) | Steel, coil, cold rolled for EEE (50% of recycling) | Base Impacts | 1,66 | kgCO2e / kg |
| Steel, electrolytic chrome-coated (ECCS) (50% recycling) | Steel, coil, electrolytic chrome-coated (ECCS) for EEE (50% recycling) | Base Impacts | 1,91 | kgCO2e / kg |
| Steel, finished cold rolled (0% recycling) | Steel, coil, finished cold rolled (0% recycling) for clothing | Base Impacts | 2,49 | kgCO2e / kg |
| Steel, finished cold rolled (50% recycling) | Steel, coil, finished cold rolled (50% recycling) for EEE | Base Impacts | 1,74 | kgCO2e / kg |
| Steel, hot dip galvanized (50% recycling) | Steel, coil, hot dip galvanized for EEE (50% recycling) | Base Impacts | 1,94 | kgCO2e / kg |
| Steel, hot dip galvanized (50% recycling) | Steel, coil, hot dip galvanized for EEE (50% recycling) | Base Impacts | 1,94 | kgCO2e / kg |
| Steel, organic coated (50% recycling) | Steel, coil, organic coated for EEE (50% recycling) | Base Impacts | 2,16 | kgCO2e / kg |
| Steel, tinplated (39.3% of recycling) | Steel, coil, tinplated for industrial packaging (39.3% of recycling) | Base Impacts | 2,06 | kgCO2e / kg |
| Steel, tinplated (54% of recycling) | Steel, coil, tinplated for any packaging (54% of recycling) | Base Impacts | 1,84 | kgCO2e / kg |
| Steel, tinplated (66.7% of recycling) | Steel, coil, tinplated for household packaging (66.7% of recycling) | Base Impacts | 1,65 | kgCO2e / kg |
| Steel, unspecified | Steel - production of steel | Metal LCAs | 2,30 | kgCO2e / kg |
| Steel, wire rod (50% recycling) | Steel, wire rod for EEE (50% recycling) | Base Impacts | 1,82 | kgCO2e / kg |

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Titanium, FFC electrowinning process | Titanium - FFC electrowinning process | Metal LCAs | 31,00 | kgCO2e / kg |
| Titanium, kroll process | Titanium - kroll process | Metal LCAs | 35,70 | kgCO2e / kg |
| Titanium, plasma powder process | Titanium - plasma powder process | Metal LCAs | 33,20 | kgCO2e / kg |
| Titanium, unspecified | Titanium | Base Impacts | 16,74 | kgCO2e / kg |
| Zinc, concentrate | Zinc concentrate - production of zinc concentrate | Metal LCAs | 0,43 | kgCO2e / kg |
| Zinc, special high-grade (SHG) | Zinc SHG - production of special high-grade zinc | Metal LCAs | 2,66 | kgCO2e / kg |
| Zinc, unspecified | Zinc concentrate - production of zinc concentrate | Metal LCAs | 0,43 | kgCO2e / kg |
| Zinc, Zamak | Zamak zinc alloy (ZnAlMgCu) | Base Impacts | 3,44 | kgCO2e / kg |

### 7.4.2 Non-metallic raw materials category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Clay and ceramic | Clay And Ceramic Products | Carnegie Mellon | 780,00 | kgCO2e / kUSD |
| Fabrics for seat, unknown mass and material | Vehicle seating and interior trim (upholstery) | USSEIO | 486,00 | kgCO2e / kUSD |
| Foams, unknown material and mass | Urethane And Other Foam Products | Carnegie Mellon | 816,00 | kgCO2e / kUSD |
| Glass, unspecified or unknown mass | Glass And Glass Products | Carnegie Mellon | 932,00 | kgCO2e / kUSD |
| Other non-metallic mineral | Miscellaneous nonmetallic mineral products (327999) | DoD | 1172,00 | kgCO2e / kUSD |
| Plastic - bags, films, and sheets - unknown mass | Plastic Bags, Films, And Sheets | Carnegie Mellon | 741,00 | kgCO2e / kUSD |
| Plastic - laminated plates - unknown mass | Laminated Plastic Plates And Shapes | Carnegie Mellon | 605,00 | kgCO2e / kUSD |
| Plastic - pipes and fittings - unknown mass | Plastic Pipe, Fittings, And Sausage Casings | Carnegie Mellon | 674,00 | kgCO2e / kUSD |
| Plastic - unknown material and mass | Other Plastic Products | Carnegie Mellon | 649,00 | kgCO2e / kUSD |
| Plastics, unspecified | Plastics | Carnegie Mellon | 1120,00 | kgCO2e / kUSD |
| Polystyrene foam, unknown mass | Polystyrene Foam Products | Carnegie Mellon | 772,00 | kgCO2e / kUSD |
| Rubber or plastic belts and hoses, unknown mass | Rubber And Plastic Belts And Hoses | Carnegie Mellon | 473,00 | kgCO2e / kUSD |
| Rubber products - unknown material and/or mass | Other Rubber Products | Carnegie Mellon | 557,00 | kgCO2e / kUSD |
| Synthetic Rubber and fibers | Synthetic Rubber And Artificial And Synthetic Fibers | Carnegie Mellon | 1070,00 | kgCO2e / kUSD |
| Carbon fiber, high strengths, long fibers | Carbon fiber (CF, from PAN, high strengths, long fibers ) | Base Impacts | 40,42 | kgCO2e / kg |
| Carbon fiber, short fibers | Carbon Fiber (CF, from PAN, short fibers) | Base Impacts | 18,25 | kgCO2e / kg |
| Fabrics for seat, unknown material | Polyurethane foam of 1.5 mm thick (40 g/m3), 58% polyamide/42% elastane fabric (75 g/m²) | Base Impacts | 1,00 | kgCO2e / kg |
| Foam, polystyrene foam | EPS-Foam (expanded polystyrene foam (PS 12)), RER | Base Impacts | 2,93 | kgCO2e / kg |
| Foam, polyurethane flexible foam (PU) | Polyurethane flexible foam (PU), RER | Base Impacts | 4,71 | kgCO2e / kg |
| Foam, polyurethane rigid foam (PU) | Polyurethane rigid foam (PU), RER | Base Impacts | 4,20 | kgCO2e / kg |
| Foam, urea formaldehyde foam | Urea formaldehyde resin in- situ foam | Base Impacts | 3,03 | kgCO2e / kg |
| Glass fibers, high strength | Glass fibers (high strength) | Base Impacts | 2,46 | kgCO2e / kg |
| Glass fibers, low strength | Glass fibers (low strength) | Base Impacts | 3,24 | kgCO2e / kg |
| Glass, chrystal/Lead glass | Chrystal/ Lead glass, RER | Base Impacts | 1,90 | kgCO2e / kg |
| Glass, container glass | Container glass, RER | Base Impacts | 0,81 | kgCO2e / kg |
| Glass, curved glass | Curved glass, RER | Base Impacts | 2,39 | kgCO2e / kg |
| Glass, flat glass average | Flat glass average | Base Impacts | 1,60 | kgCO2e / kg |
| Glass, float flat glass | Float flat glass, RER | Base Impacts | 1,26 | kgCO2e / kg |
| Glass, laminated safety glass | Laminated safety glass, RER | Base Impacts | 3,42 | kgCO2e / kg |
| Glass, patterned glass | Patterned glass, RER | Base Impacts | 1,16 | kgCO2e / kg |

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Glass, toughened glass (ESG) | Toughened glass (ESG) (thickness 1 mm; denstiy 2.5 kg/m2), RER | Base Impacts | 1,82 | kgCO2e / kg |
| Plastic, HDPE pipe | HDPE pipe, extruded, RER | Base Impacts | 1,72 | kgCO2e / kg |
| Plastic, HDPE, processed by injection moulding | HDPE, processed by injection moulding, RER | Base Impacts | 2,65 | kgCO2e / kg |
| Plastic, packaging film, LDPE | Packaging film, LDPE | Base Impacts | 2,59 | kgCO2e / kg |
| Plastic, packaging film, PE | Packaging film, PE | Base Impacts | 2,59 | kgCO2e / kg |
| Plastic, packaging film, PE-EVOH | Packaging film, PE-EVOH | Base Impacts | 2,58 | kgCO2e / kg |
| Plastic, packaging film, PET | Packaging film, PET | Base Impacts | 3,31 | kgCO2e / kg |
| Plastic, packaging film, PP | Packaging film, PP | Base Impacts | 2,45 | kgCO2e / kg |
| Plastic, PET, processed by injection stretch blow moulding | PET, processed by injection stretch blow moulding, RER | Base Impacts | 3,98 | kgCO2e / kg |
| Plastic, PEX pipe | PEX pipe, extruded, RER | Base Impacts | 2,29 | kgCO2e / kg |
| Plastic, plastic film, PA | Plastic film, PA | Base Impacts | 8,63 | kgCO2e / kg |
| Plastic, PP pipe | PP pipe, extruded, RER | Base Impacts | 2,07 | kgCO2e / kg |
| Plastic, PP, processed by injection moulding | PP, processed by injection moulding, RER | Base Impacts | 2,24 | kgCO2e / kg |
| Plastic, PVC film | PVC film, calendered, RER | Base Impacts | 2,92 | kgCO2e / kg |
| Plastic, PVC pipe | PVC pipe, extruded, RER | Base Impacts | 2,53 | kgCO2e / kg |
| Plastic, PVC, processed by injection moulding | PVC, processed by injection moulding, RER | Base Impacts | 2,92 | kgCO2e / kg |
| Plastic, thermoforming film, PA-PE | Thermoforming film, PA-PE | Base Impacts | 5,61 | kgCO2e / kg |
| Rubber, epoxy resin | Epoxy resin, RER | Base Impacts | 8,25 | kgCO2e / kg |
| Rubber, Isobutylene Isoprene Rubber (IIR) | Butyl rubber - Isobutylene Isoprene Rubber (IIR) by emulsion polymerization , RER | Base Impacts | 3,37 | kgCO2e / kg |
| Rubber, Nitrile-Butadiene-Rubber (NBR) | Nitrile-Butadiene-Rubber (NBR), RER | Base Impacts | 5,38 | kgCO2e / kg |
| Rubber, phenolic resin | Phenolic resin (45% concentration) | Base Impacts | 1,66 | kgCO2e / kg |
| Rubber, polyester resin unsaturated (UP) | Polyester Resin unsaturated (UP), RER | Base Impacts | 3,01 | kgCO2e / kg |
| Rubber, polyvinylchloride resin (B-PVC) | Polyvinylchloride resin (B-PVC), RER | Base Impacts | 1,58 | kgCO2e / kg |
| Rubber, polyvinylpolypyrolidore (PVPP) | Polyvinylpolypyrolidore (PVPP) | Base Impacts | 1,99 | kgCO2e / kg |
| Rubber, styrene-Butadiene Rubber (SBR) | Styrene-Butadiene Rubber (SBR) Mix, RER | Base Impacts | 3,53 | kgCO2e / kg |
| Rubber, styreneacrylonitrile (SAN) | Styreneacrylonitrile (SAN), RER | Base Impacts | 3,47 | kgCO2e / kg |
| Ruber, Polybutadiene rubber | Polybutadiene rubber, RER | Base Impacts | 4,35 | kgCO2e / kg |

### 7.4.3 Gases and chemicals category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Basic inorganic chemicals | Other Basic Inorganic Chemicals | Carnegie Mellon | 1310,00 | kgCO2e / kUSD |
| Basic organic chemicals | Other Basic Organic Chemicals | Carnegie Mellon | 1290,00 | kgCO2e / kUSD |
| Chemicals, unspecifieed | Produits chimiques | Base Carbone | 1600,00 | kgCO2e / k€ |
| Paint and coating | Paint and coating manufacturing (325510) | DoD | 518,54 | kgCO2e / kUSD |

## 7.5 Services group

This group includes all services and is composed of the following categories:

- Professional services and consulting;
- Financial services;
- Insurance;
- Travel services;
- Telecom services and IT support;
- Materials handling;
- Research, development and testing services;
- Repair and overhaul;
- Miscellaneous.

### 7.5.1 Professional services and consulting category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Advertising, public relations, and related services | Advertising, public relations, and related services (541800) | DoD | 127,52 | kgCO2e / kUSD |
| Business support services | Business support services (561400) | DoD | 158,61 | kgCO2e / kUSD |
| Environmental and other technical consulting services | Environmental and other technical consulting services (5416A0) | DoD | 148,76 | kgCO2e / kUSD |
| Facilities support services | Facilities support services (561200) | DoD | 293,25 | kgCO2e / kUSD |
| Marketing research and other professional, scientific, and technical services | Marketing research and all other miscellaneous professional, scientific, and technical services (5419A0) | DoD | 163,11 | kgCO2e / kUSD |
| Office administrative services | Office administrative services (561100) | DoD | 114,80 | kgCO2e / kUSD |
| Other professional services | Services (imprimerie, publicité, architecture et ingénierie, maintenance multi-technique des bâtiments, etc.) | Base Carbone | 170,00 | kgCO2e / k€ |
| Professional services (printing, advertising, architecture and engineering, multi-technical maintenance of buildings, etc.) | Services (imprimerie, publicité, architecture et ingénierie, maintenance multi-technique des bâtiments, etc.) | Base Carbone | 170,00 | kgCO2e / k€ |

### 7.5.2 Financial services and insurance category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Financial services, insurance and consulting | Accounting, tax preparation, bookkeeping, and payroll services (541200) | DoD | 97,78 | kgCO2e / kUSD |

### 7.5.3 Travel services category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Travel services | Travel arrangement and reservation services (561500) | DoD | 186,36 | kgCO2e / kUSD |

### 7.5.4 Telecom services and IT support category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Cloud services | Storage and process of data with a distant server, through a wired network | TSP & Carbone 4 | 301,00 | kgCO2e / Tb |
| Telecom services and IT support | Télécommunications | Base Carbone | 170,00 | kgCO2e / k€ |

### 7.5.5 Materials handling category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Materials handling | Réparation et installation de machines et d'équipements | Base Carbone | 390,00 | kgCO2e / k€ |

### 7.5.6 Research, development and testing services category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Research, development and testing services | Recherche et développement | Base Carbone | 250,00 | kgCO2e / k€ |

### 7.5.7 Repair and overhaul category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Nonresidential Building Repair And Maintanence | Nonresidential Building Repair And Maintanence | Carnegie Mellon | 385,00 | kgCO2e / kUSD |
| Repair, overhaul of machines and equipments | Réparation et installation de machines et d'équipements | Base Carbone | 390,00 | kgCO2e / k€ |

### 7.5.8 Miscellaneous category breakdown

| Subcategory | Proxy EF | Database | Ref. value | Ref. EF unit |
|---|---|---|---|---|
| Accommodation and catering | Hébergement et restauration | Base Carbone | 320,00 | kgCO2e / k€ |
| Construction | Construction | Base Carbone | 360,00 | kgCO2e / k€ |
| Other services | Services (imprimerie, publicité, architecture et ingénierie, maintenance multi-technique des bâtiments, etc.) | Base Carbone | 170,00 | kgCO2e / k€ |

## 7.6 Capital goods group

Capital goods are final products that have an extended life and are used by the company to manufacture a product, provide a service, or sell, store, and deliver merchandise. In financial accounting, capital goods are treated as fixed assets or as plant, property, and equipment (PP&E). Examples of capital goods include equipment, machinery, buildings, facilities, and vehicles.

This group is composed of the following categories:

- Buildings and industrial plants;
- Industrial equipment;
- Fleet;
- Telecom equipment and IT hardware.

### 7.6.1 Buildings and industrial plants category breakdown

| Subcategory | Proxy EF | Proxy EF | Value | EF unit |
|---|---|---|---|---|
| Commercial buildings | Commercial structures, including farm structures (2332A0) | DoD | 338,45 | kgCO2e / kUSD |
| Infrastructures | Utilities Buildings And Infrastructure | Carnegie Mellon | 243,00 | kgCO2e / kUSD |
| Manufacturing Buildings | Manufacturing Buildings | Carnegie Mellon | 229,00 | kgCO2e / kUSD |
| Other non-residential buildings | Other nonresidential structures (2332B0) | DoD | 319,85 | kgCO2e / kUSD |
| Renewable energy plant - Geothermal plant, unknown installed capacity | Deep geothermal plant - per invested k€ | Ecoinvent & Carbone 4 | 4300,00 | kgCO2e / k€ |
| Renewable energy plant - Solar PV plant, unknown installed capacity | Solar PV plant - open ground, multi-Si, 570 kW, France | Ecoinvent & Carbone 4 | 4400,00 | kgCO2e / k€ |
| Industrial building, concrete | Bâtiment industriel - structure en béton | Base Carbone | 825,00 | kgCO2e / m2 |
| Industrial building, metal | Bâtiment industriel - structure métallique | Base Carbone | 275,00 | kgCO2e / m2 |
| Office building | Bâtiments de bureaux | Base Carbone | 650,00 | kgCO2e / m2 |
| Renewable energy plant - Biomass plant | Biomass plant - manufacturing country unknown | IPCC AR5 | 19222000,00 | kgCO2e / MW |
| Renewable energy plant - Geothermal plant | Geothermal plant -manufacturing country unknown | IPCC AR5 | 8813000,00 | kgCO2e / MW |
| Renewable energy plant - Solar PV plant | Solar PV plant - manufacturing country unknown | IPCC AR5 | 1266000,00 | kgCO2e / MW |

### 7.6.2 Industrial equipment category breakdown

| Subcategory | Proxy EF | Proxy EF | Value | EF unit |
|---|---|---|---|---|
| Air conditioning and industrial refrigeration equipment, unknown mass | Air Conditioning, Refrigeration, And Warm Air Heating Equipment | Carnegie Mellon | 657,00 | kgCO2e / kUSD |
| Heating equipment other than warm air furnaces, unknown mass | Heating Equipment Other Than Warm Air Furnaces | Carnegie Mellon | 399,00 | kgCO2e / kUSD |
| Industrial process furnaces and ovens, unknown mass | Industrial Process Furnaces And Ovens | Carnegie Mellon | 338,00 | kgCO2e / kUSD |
| Internal Combustion Engines, unknown mass | Other Engine Equipment | Carnegie Mellon | 447,00 | kgCO2e / kUSD |
| Machines and industrial equipment, unspecified and unknown mass | Machines et équipements | Base Carbone | 700,00 | kgCO2e / k€ |
| Material handling equipment, unknown mass | Material Handling Equipment | Carnegie Mellon | 377,00 | kgCO2e / kUSD |
| Metalworking machines, unknown mass | Cutting And Machine Tool Accessory, Rolling Mill, And Other Metalworking Machines | Carnegie Mellon | 347,00 | kgCO2e / kUSD |
| Other machines and industrial equipment, unknown mass | Machines et équipements | Base Carbone | 700,00 | kgCO2e / k€ |
| Plasticworking machines, unknown mass | Plastics And Rubber Industry Machinery | Carnegie Mellon | 327,00 | kgCO2e / kUSD |
| Machines and industrial equipment | Machines - fabrication | Base Carbone | 5,50 | kgCO2e / kg |

### 7.6.3 Fleet category breakdown

| Subcategory | Proxy EF | Proxy EF | Value | EF unit |
|---|---|---|---|---|
| Heavy-duty vehicles and mobile machinery (SB) | Heavy Duty Trucks | Carnegie Mellon | 403,00 | kgCO2e / kUSD |
| Light-duty vehicles and mobile machinery (SB) | Automobiles | Carnegie Mellon | 376,00 | kgCO2e / kUSD |
| Aircrafts and jets | Aircraft | Carnegie Mellon | 204,00 | kgCO2e / kUSD |
| Heavy-duty vehicles and mobile machinery | Véhicules - fabrication | Base Carbone | 5500,00 | kgCO2e / tonne |
| Light-duty vehicles and mobile machinery | Véhicules - fabrication | Base Carbone | 5500,00 | kgCO2e / tonne |

### 7.6.4 Telecom equipment and IT hardware category breakdown

| Subcategory | Proxy EF | Proxy EF | Value | EF unit |
|---|---|---|---|---|
| IT hardware, unknown quantity | Produits informatiques, électroniques et optiques | Base Carbone | 400,00 | kgCO2e / k€ |
| Desktop | Ordinateur - fixe - Bureautique | Base Carbone | 169,00 | kgCO2e / item |
| Desktop, high performance | Ordinateur - fixe - haute performance | Base Carbone | 296,00 | kgCO2e / item |
| Hard drive | Baies de disques | Base Carbone | 15,50 | kgCO2e / item |
| IT server | Serveurs informatiques | Base Carbone | 600,00 | kgCO2e / item |
| Laptop | Ordinateur - portable | Base Carbone | 156,00 | kgCO2e / item |
| Printer, laser | Imprimante - laser | Base Carbone | 197,00 | kgCO2e / item |
| Printer, multi-function | Imprimante - multi-fonction | Base Carbone | 87,90 | kgCO2e / item |
| Smartphone, < 5 inchs | Smartphone - de plus de 5,5 pouces | Base Carbone | 39,10 | kgCO2e / item |
| Smartphone, > 5 inchs | Smartphone - de 5 pouces | Base Carbone | 32,80 | kgCO2e / item |
| Tablet, classic | Tablette - classique - 9 à 11 pouces | Base Carbone | 63,20 | kgCO2e / item |
| Video projector | Vidéo projecteur | Base Carbone | 94,00 | kgCO2e / item |

# 8 Methodology specific features

## 8.1 General comments on the accuracy

Scope 3 emissions calculations usually have a high level of uncertainty, sometimes as high as 50%. The high level of uncertainty is mainly due to the following two factors:

- **Activity data**: This type of data is usually the result of approximations or aggregation of sectoral data. They serve as an alternative to more costly and precise information.
- **Emission factors:** While both spend-based and mass-based factors have relatively high levels of uncertainty, spend-based EF have higher levels of uncertainty. This is mainly due to the fact that these EF are estimates that do not take in account considerations such as country of production and the type of industrial processes used.

The levels of uncertainty of EF within a sector can vary widely from one source to another. These uncertainties are rarely assessed in detail and there is little information on the disparity within a sector. Consequently, this methodology does not quantify the uncertainties associated to PG&S/CG emissions. Focus is directed to providing a breakdown of GHG emissions between spend-based and mass-based factors, which provides an indication of the result's uncertainty.

In addition, the use of public EF as proxies for specific products brings a fair number of uncertainties. Although likely more representative of sector specificities (product price, type of materials used, etc.), supplier specific EF were not included in the methodology for practical reasons.

Over time, calculations are expected to become more accurate for all users as IAEG members add A&D specific EF. The adoption of this tool will allow users to select the level of accuracy that best corresponds to their available resources while retaining methodological consistency.

## 8.2 Influence of location and release dates on EF level of certainty

The level of confidence for a factor is derived from a combination between:

- the age of the EF;
- the specificity of its geographical data.

Figure 1 and Figure 2 indicate the level of certainty based on geographical coverage and on the age of the EF.

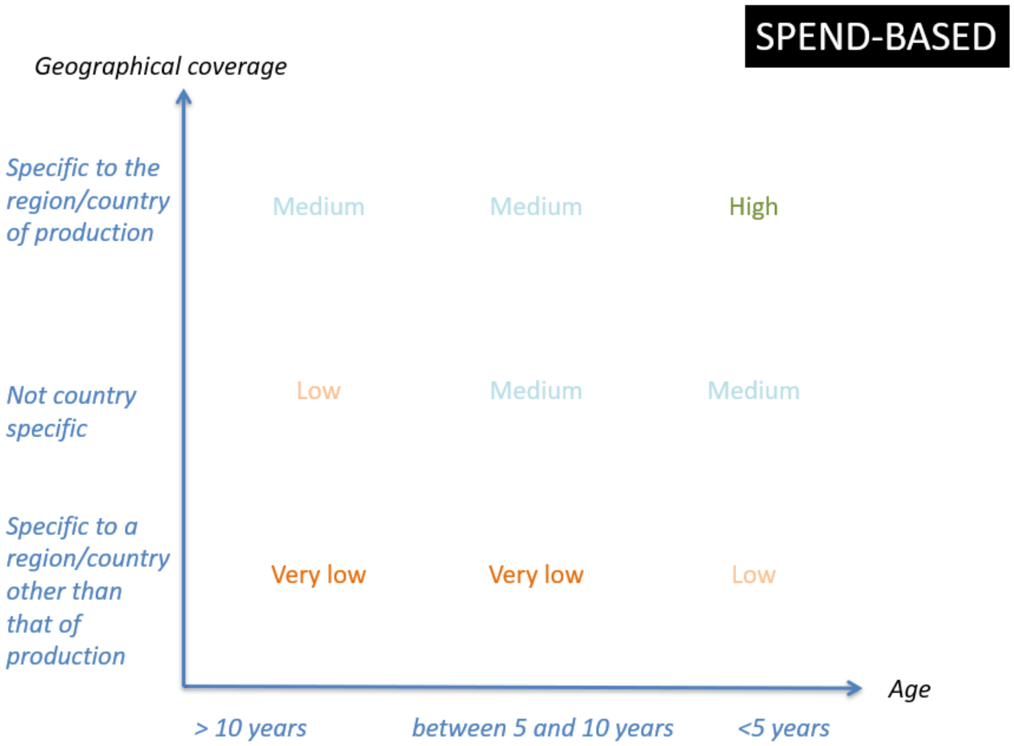


**Figure 1 - Level of certainty for different levels of geographical specificity and age for spend-based factors**

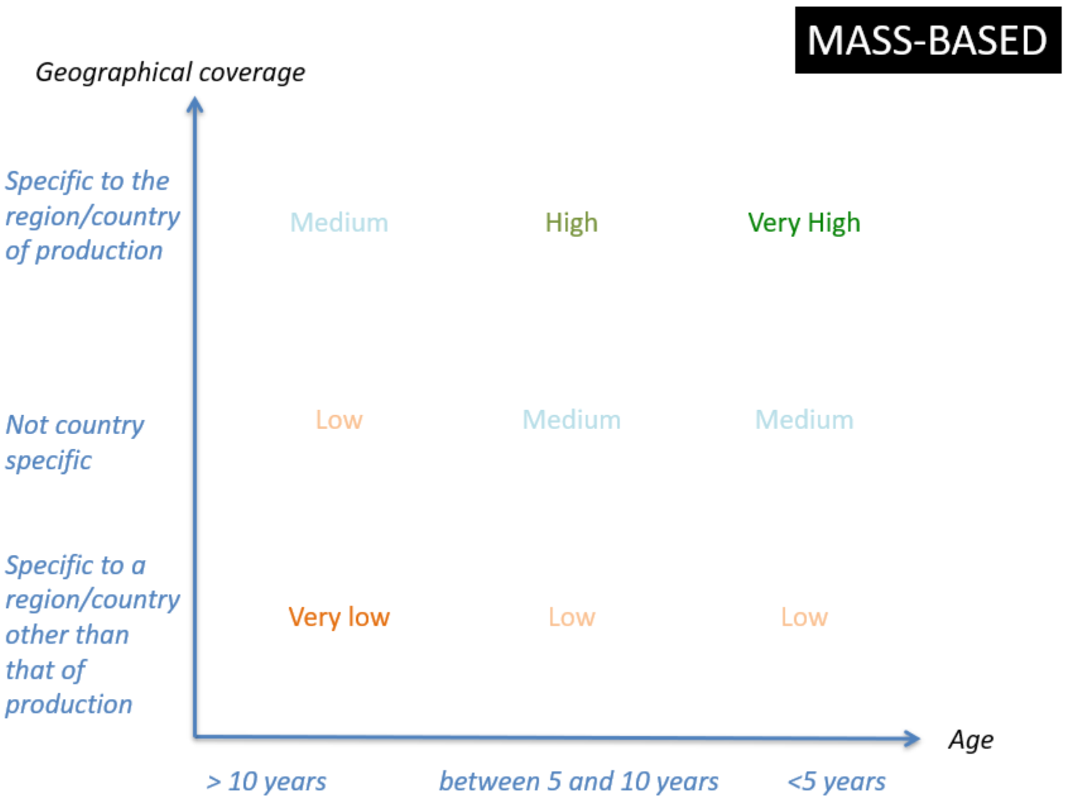

**Figure 2 -Level of certainty for different levels of geographical specificity and age for massed-based factors**

## 8.3 EF validity periods

Although the methodology aims for EF released within five years of the reporting date, the methodology does include older EF since some of the public databases use older yet useful comprehensive data. Such consideration is accounted for in an EF's confidence level and the procedure allows for the application of data in the absence of better alternatives. Therefore, the methodology does not prescribe a mandatory validity period for the EF but recommends the use of the most recent reliable EF available.

## 8.4 Spend based approach specific features

### 8.4.1 Consideration for inflation

The EF values in the spend-based approach are given in $kgCO_2$/k$ and $kgCO_2$/k€. A drawback of this type of data is the yearly variability associated to economic factors such as inflation. Using a series of American and European inflation rates allows for more reliable results.

A correction functionality located in the "conversion" tab mitigates the variability associated to inflation. Data for a few past years is already incorporated and additional fields are left blank to integrate future yearly inflation rates. See Chapter 9.1 for more information on how to integrate annual inflation data to the tool.

The following example demonstrates how the inflation rate is applied to correct spend-based EF.

Considering that the inflation rate is 2% between year N and year N+1, then:

$$EF_{(\text{year } N+1)} = EF_{(\text{year } N)}/(1+2\%)$$

### 8.4.2 Consideration for exchange rate

Most EF are obtained from a limited number of geographical locations and expressed in the corresponding currencies. To make them applicable in other geographies and currencies, the use of an exchange rate functionality is integrated in the tool.

Users can collect currency exchange data through public website such as IRS, OFX, or using other reputable sources.

The following example demonstrates how the exchange rate is taken into consideration. As an example, in 2018, US$1 was worth, on average, €0.848. Therefore, for the year 2018, if the reporting company expenses are in €, EF shall be converted as follows:

EF (in €) = EF (in US$) x 0.848

### 8.4.3 Accuracy

The considerable reliance on EEIO EF also brings uncertainty to the users' assessments. The values are based on averages within a category, they do not distinguish between products within a sector, assume linear proportionality between economic activity and environmental burden, usually do not distinguish between domestically produced goods and imports, and are very sensitive to price fluctuation. The reliance on these values also makes it impossible to bring specific adjustment or refinements in the emissions calculations, such as for differentiating between different types of materials.

#### 8.4.4 Other effects of currency

The reliance on currency has significant effects on the accuracy of spend-based factors. Any element that will affect purchasing prices will affect the accuracy of the EF. Among these elements are:

- year-on-year price variability due to market price variations;
- supplier discounts policies.

It is not possible to adjust spend-based calculations to remove these variabilities. Hence, consideration of these limitations is required when selecting the appropriate quantification approach. Users seeking a higher level of accuracy should consider the hybrid-based approach and mass-based approach for their higher level of certainty.

# 9 Maintaining the database

## 9.1 Adding the annual average inflation rate

The EF values for the spend-based approach are given in $kgCO_2e$/k$ and $kgCO_2e$/k€. The tool contains already past inflation rates for converting the EF to the current reporting date. In case the average inflation rate is not displayed in the "conversion" tab for the reporting year, the user must collect inflation data using the OECD Inflation tool or using other reputable sources.

> OECD inflation tool: to collect yearly inflation rate data, the user can use the inflation indicator chart on OECD's website. In the 'Time' Panel, in the middle-right section of the page, select the **yearly** option. The user can collect the appropriate data by hovering its mouse over the charts for different countries.

Once the yearly inflation rate is known, open the "conversion" tab and enter the appropriate information in the blank field of the "inflation rate" table.

## 9.2 Adding the currency exchange rate

Final results will likely depend on spend-based EF using both euros and USD. It is therefore important to update the currency exchange rate between these currencies to reflect the latest monetary tendencies.

The users must first collect inflation data using the OECD Inflation tool or using other reputable sources.

- IRS: Known as the United States' Internal Revenue Service, the institution provides an annual average exchange rate with many national and international currencies.
- OFX: An entity that provides conversions between major currencies. It can also offer specific data depending on the frequency and reporting period.

To integrate the data in the tool, ensure that the year reporting year is entered in the "import data" tab. Open the "conversion" tab and enter the appropriate information in the blank fields of the "currency rate" section.

## 9.3 Adding supplier specific emission factors

Specific EF provided by members of the aerospace industry may be added to the tool when appropriate and available. The tool is editable and can be modified to add EF by following a specific process: please contact IAEG WG3 for more information.

The IAEG member proposing the EF shall explain the calculation methodology, which will either respect the GHGP standard[4,6], the ISO14064-1 norm, or any recognized national referential (particular attention should be given to the choice of the inventory boundaries). GHG footprint analysis limited to scopes 1 and 2 is not appropriate for a cradle to gate EF.

## 9.4 Adding new raw materials

New raw materials can be integrated in the database to make the method richer and closer to an IAEG member's purchase inventory.

To do this, the IAEG member should request that IAEG WG3 account for the new raw material and provide the associated mass-based EF. Should the EF be unknown to IAEG WG3, the supplier of the new raw material will be responsible for providing either the corresponding EF with the right level of confidence or to carry out documentary research to find information and propose a robust EF.

## 9.5 Recommendations for future updates

Future updates of the methodology could target the following two topics:

- the emission factors;
- Integration of user feedback and calculation principles.

### 9.5.1 Emission factors update

The EF updates should follow the data source's (DoD, Base Impact, etc.) updates. IAEG should monitor these sources' updates on a yearly basis and, if needed, decide the opportune timing for the internal database update. During this yearly review of database updates, IAEG should also keep a look out for new public databases that may complement or replace data in the tool. A new version of the tool with updated EF tables should be communicated to members in accordance with annual reporting timelines in mind.

### 9.5.2 Integration of user feedback and update of calculation principles

Feedback should be collected from tool users over time to identify opportunities to adjust certain methodological features. Except for a major change requiring rapid action, the necessary changes can be addressed on an annual basis.

Moreover, calculation principles such as product categorization, specific rules, inflation adjustments, etc. should be addressed at the same frequency.

# 10 Frequently Asked Questions (FAQs)

This section answers a few questions that commonly arise when dealing with the accounting of GHG emissions for PG&S and CG.

***Is the buy-to-fly ratio considered by the methodology for transformed raw materials?***

The methodology does not take into consideration any buy-to-fly[i] ratio. In cases where specific EF are provided by product suppliers, they should respect GHGP's specific requirements regarding consideration of waste and recycled material as discussed in Appendix 3: Compliance to international standards to properly account for the potential buy-to-fly ratio.

**What to expect when undergoing a change in approach?**

While spend-based EF are convenient and provide a basis for calculating scope 3 emissions, mass-based EF will help users identify more accurately their company's emissions. Hence, it is expected that users will, over time, progress from the spend-based approach to the mass-based approach. The overall reported results might differ significantly on the years when such changes occur due to the sudden increase in EF specificity. This might occur if the company consumes a large quantity of a material for which the more specific mass-based EF differs considerably from the more general spend-based EF.  Should a company identify PG&S as a major source of GHG emissions, it is encouraged to use the mass-based approach due to its higher accuracy.

**Which EF to select if there are two EF for a single sub-category?**

The rules below were used during the development phase of the methodology and is applicable in this context. When more than one factor is available for a given item, the user should determine the relevant action through the following steps:

1. If the EF are associated to different geographical locations, the user should enter the appropriate amount of material (in currency or mass) from each of these different locations.
2. If the EF target the same geographical location and are very similar, priority should be given to the EF with the latest release date.
3. If the EF target the same geographical location and have a discrepancy greater than 30% then the most reliable[ii] database must be selected.

Ideally, only the most recent EF should be considered in the IAEG methodology (typically less than 5 years old). However, older public databases are used because they provide useful EF in a few cases.

**Can the emissions of capital goods be amortized over several reporting years?**

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[i] For composite and metallic materials, between the upstream of the value chain (production of the raw material) and the delivery of finished parts to an OEM or a manufacturer, many "losses" of material are accumulated: the "buy-to-fly" ratio explicates the amount of material included in a finished product (purchased and installed by a manufacturer on an A/C for example) compared to the total amount of material used to manufacture this product along the value chain.

[ii] This judgment is made by the authors of the methodology.

As directed in the GHG Protocol, the emissions from the production of capital goods must be entirely accounted for in the year of acquisition.

# 11 Appendices

## 11.1 Appendix 1: the process leading to the creation of this document

The present document is the result of a collaborative work completed over three key phases.

### 11.1.1 Phase 1

The first phase is described in Figure 3.

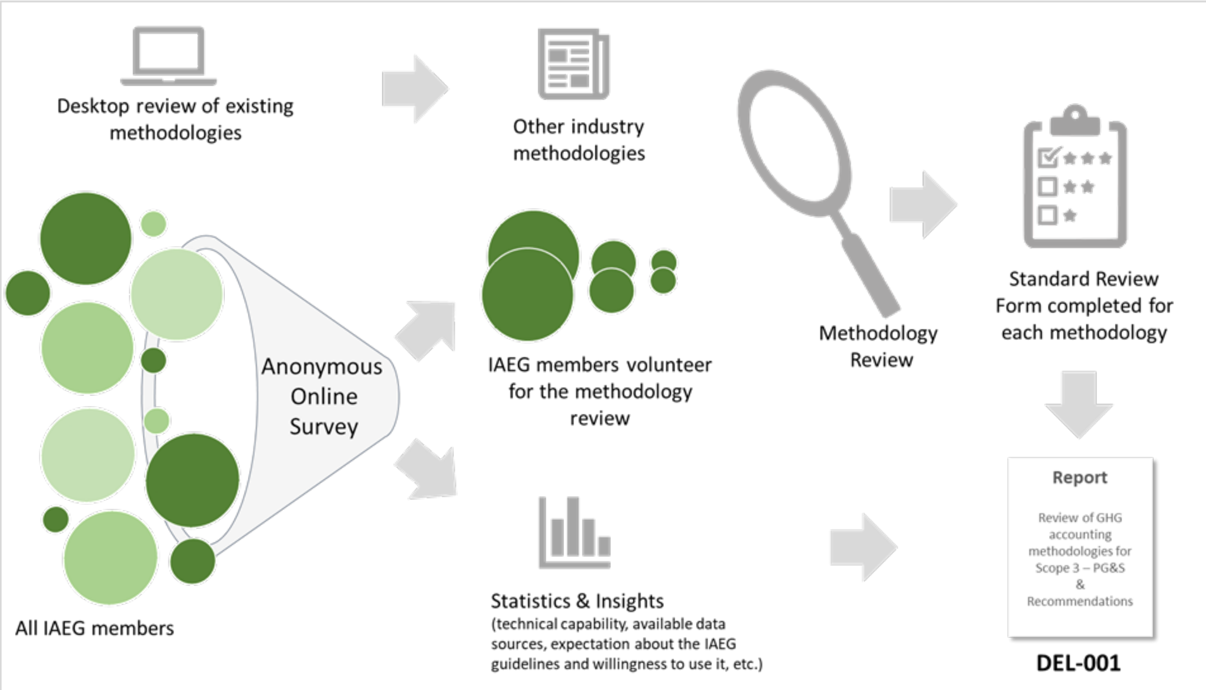


**Figure 3 - Overview of the steps taken in Phase 1 of the project**

Phase 1 consisted of 4 main steps:

1. Online survey conducted among voluntary IAEG members;
2. Interviews with a selection of IAEG members having previously worked on PG&S emissions assessment;
3. Desktop review of non-IAEG methodologies comprising a specific section on PG&S and/or CG;
4. Interviews with selected non-A&D companies.

A multi-criteria analysis grid was specifically developed to better characterize the different approaches observed, to identify their strengths and weaknesses, and to compare them to IAEG members' main expectations. This approach allowed to:

- Perform a review of the different tactics and practices that IAEG members and other industries use to address Scope 3 PG&S and CG;
- Assess the level of technical capabilities and expectations of IAEG members with regards to Scope 3 PG&S and CG;
- Draft recommendations of methodology requirements & parameters.

#### 11.1.2 Phase 2

A second phase was devoted to establishing final requirements for the methodology.

#### 11.1.3 Phase 3

Phase 3 integrated the results from Phase 1 and Phase 2 to develop the user guide and the methodology, to clarify the categorizations and approaches, and to assemble the required emissions factor.

The user guide and this document – the methodology - are the main deliverable for phase 3 and are complemented by a simple tool for users to perform the calculations.

### 11.2 Appendix 2: Description of the main databases

#### 11.2.1 DoD database

The US Department of Defense developed in 2016 a guidance for Sustainability Analysis[7]. It presents a standardized framework for conducting a Sustainability Analysis, an assessment of life cycle costs and impacts for weapons systems, equipment, or platforms. The Sustainability Analysis combines life cycle cost (LCC) estimation and life cycle assessment (LCA).

This led to the development of a rich database categorized according to the North American Industry Classification System (NAICS) nomenclature. However, most of the factors are limited to a Gate-to-Gate scope.

A supplemental guideline was created to provide a streamlined lifecycle assessment example and demonstrate how to use the data[8].

#### 11.2.2 Carnegie Mellon database

The Economic Input-Output Life Cycle Assessment (EIO-LCA) method developed by Carnegie-Mellon[9] estimates the materials and energy resources required for, and the environmental emissions resulting from, activities in our economy. It is used to perform life cycle assessments and evaluate the environmental impacts of a product or process over its entire life cycle. The method uses information about industry transactions - purchase of materials by one firm from other firms - and each firm's direct environmental emissions to estimate the total emissions in the supply chain.

The EIO-LCA method was theorized and developed by economist Wassily Leontief in the 1970s based on his earlier input-output work from the 1930s and for which he received the Nobel Prize in Economics. Researchers at the Green Design Institute of Carnegie Mellon University operationalized Leontief's method in the mid-1990s, once sufficient computing power had become available enough to perform the large-scale matrix manipulations required in real time.

The EIO-LCA database was last updated in 2007, making it quite old with regards to the accuracy required by IAEG.

#### 11.2.3 Description of the USEEIO database

USEEIO[10] is a new, environmentally extended input-output model designed in the United States for assessing organization-wide impacts, identifying purchasing hot spots, analyzing environmental impacts of policies, performing streamlined life cycle assessments, and conducting other sustainable materials management applications.

It has built a life cycle model for 385 US goods and services by melding data on economic transactions between 389 industry sectors and environmental data for these sectors covering land, water, energy and mineral usage, emissions of greenhouse gases, nutrients and toxins, and air pollution criteria. In comparison with existing US input-output models, USEEIO is more recent - most data referring to year 2013; more extensive in its coverage of resources and emissions; more deliberate and detailed in its interpretation and combination of data sources; and includes formal data quality evaluation and description.

All USEEIO files are publicly available, adding a level of transparency to the EEIO models.

The dataset and its method provide useful lifecycle data per dollar (2013 USD) for a multitude of goods and services. The financial basis for the price corresponds to the producer's price. The dataset is categorized in matrices using goods and services' original names to distinguish them from the sector names provided by the Bureau of Economic Analysis (BEA). The BEA's sector names are included in the tool for guidance.

#### 11.2.4 ADEME Base IMPACTS database

Base IMPACTS® [11] is the official, generic inventory database for the French government's environmental labeling program for consumer products.

The scope of Base IMPACTS ® respects the following principles:

- It applies to all products currently available on the market, irrespective of how they are distributed.
- It applies to the environmental communication at the purchase or acquisition location.
- It deals with the environmental impacts generated throughout the product lifecycle. It does not cover other sustainable development-related issues.

Base IMPACTS ® has multiple objectives:

- The objective of the environmental communication is to give consumers practical information concerning the environmental impacts of a product throughout its life cycle as a choice criterion when deciding on a purchase.
- This communication shall be readily understandable for consumers and operationally usable for businesses.
- The environmental communication must allow comparison of products belonging to the same category and, when relevant, between product categories. Relevance for the consumer will be assessed when defining the nomenclature of the product categories.
- The communication shall respect the principles and guidelines of this guide so that the information is comparable, on the one hand, within the same purchase or acquisition location

of a product, and on the other hand, with different purchase or acquisition locations of a product.

- The aim of this good practice guide is to harmonize the environmental communication practices. Implementation of the environmental communication, irrespective of product category, shall be done at an acceptable cost, affordable to any type of business regardless of its size and type of activity (especially for microenterprise and SMEs), and based on accessible scientific knowledge.

Sectoral information is available[12] for electronics, plastics, metals, chemicals, etc.

#### 11.2.5 ADEME Base Carbone database

Base Carbone ® [13] is a French public database of emission factors needed to carry out carbon accounting assessments. It is administered by ADEME (body under the tutelage of the French Ministry for the Ecological and Solidarity Transition), but its governance is headed by several stakeholders and its enrichment is open. Its orientations and the data it contains are validated by a governance committee gathering various public and private actors.

The data of Base Carbone ® are freely available to all. Moreover, it is unique in that it allows third parties to add their own data. These data are evaluated on their quality and transparency by Base Carbone ®'s staff and incorporated in the database when validated. Finally, a forum allows users to ask questions about the data or to challenge them.

As of August 2019, more than 2,600 emission factors were available, including spend-based EF for the purchase of goods[14] and the purchase of services[15].

Finally, transparency is one of the keystones of Base Carbone ®.

The database provides documentation detailing the assumptions and references behind each EF.

## 11.3 Appendix 3: Compliance to international standards

Table 3 summarizes the basic principles of GHG Protocol[4], ISO14064-1, and ISO/TR 14069[16] requirements and explains how the methodology complies with these requirements.

**Table 3: Compliance of the methodology with key ISO 14064-1, ISO 14069, and GHG Protocol requirements**

| Source | Requirement | This methodology |
|---|---|---|
| **GHG Protocol** | "Extraction, production, and transportation of goods and services purchased or acquired by the reporting company in the reporting year, not otherwise included in Categories 2 – 8" Minimum boundary: "all upstream (cradle-to-gate) emissions of PG&S)" (p. 34) | Transportation-related emissions between the Tier 1 supplier and the company's gate are accounted for in the other category #4 "Upstream transportation and distribution". Upstream, transport-related emissions should be included in the EF. |
| **GHG Protocol** | "This category [purchased goods and services] includes emissions from all purchased goods and services not otherwise included in the other categories of upstream scope 3 emissions (i.e., category 2 through category 8). Specific categories of upstream emissions are separately reported in category 2 through category 8 to enhance the transparency and consistency of scope 3 reports." (p. 38) | All expenses related to energy, transportation of people (either through business travel or employee commuting), and transportation of goods are excluded from the current methodology, as they were already addressed by IAEG. |
| **GHG Protocol** | "A company's purchases can be divided into two types: Production-related procurement & Non-production-related procurement" (p. 38) | Supported by the methodology. |
| **GHG Protocol** | "Capital goods are final goods that are not immediately consumed or further processed by the company but are used in their current form by the company […]. Scope 3 emissions from capital goods are reported in category 2 (Capital Goods), rather than category 1 (PG&S)." (p. 39) | Supported by the methodology. |

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| **GHG Protocol** | "For purposes of accounting for scope 3 emissions, companies should not depreciate, discount, or amortize the emissions from the production of capital goods over time. Instead companies should account for the total cradle-to-gate emissions of purchased capital goods in the year of acquisition, the same way the company accounts for emissions from other purchased products in category 1." (p. 39) | The methodology respects this prescription from GHG Protocol. |
| **GHG Protocol** | "To avoid double counting of emissions from recycling processes by the same company, companies should account for upstream emissions from recycling processes in category 1 and category 2 when the company purchases goods or materials with recycled content. » (p. 46) | The aerospace industry uses minimal amounts of recycled content for safety reasons; this specific issue is thus not considered in the methodology. Should a company wish to add a specific EF for a given material, they shall respect this GHG Protocol requirement in their calculation. |
| **GHG Protocol** | ***Examples of primary data*** *[for « Purchased Goods and Services]*<br>• Product-level cradle-to-gate GHG data from suppliers calculated using site-specific data<br>• Site-specific energy use or emissions data from suppliers »<br>***Examples of secondary data***<br>• Industry average emission factors per material consumed from life cycle inventory databases » (p. 72) | The current tool is based on the use of secondary data from public sources for convenience, but it encourages the use of primary data from suppliers, under specific conditions. |
| **GHG Protocol** | "Waste may be generated from production processes included in category 1 (Purchased Goods and Services) […]. If a facility produces waste during production, no emissions from the facility should be allocated to the waste. All emissions from the facility should instead be allocated among the facility's other outputs. If waste becomes useful and marketable for use in another system, it is no longer considered waste and should be treated like other types of outputs. » (p. 90) | This recommendation applies only to suppliers willing to provide specific EF for their products manufactured from raw materials. In such a case, the supplier will pay attention to this GHG Protocol requirement addressing allocation.<br><br>See Chapter 10 for more details. |

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|---|---|---|
| **ISO14064-1** | « Examples of emission sources and sinks: Emissions from purchased goods and associated with the fabrication of the product. As this could encompass a wide range of products, further subcategorization may be defined by the intended user. For example, subcategorization may distinguish products by type of materials (steel, plastic, glass, electronic, etc.) or by function in the value chain (production-related product versus non-production-related product). This subcategory includes emissions associated with the production of energy purchased (i.e., upstream emissions associated with oil and electricity production) that are not otherwise included in the category for indirect GHG emissions from energy » (p. 23) | The present methodology proposes a subcategorization in line with this requirement (raw materials, product or non-product related, etc.).<br><br>Upstream emissions associated with oil products or electricity production are not accounted for in the "Purchased goods and services" category, but in the "Fuel- and energy-related activities" category, to remain in line with the GHG Protocol. |
| **ISO14064-1** | "Indirect GHG emissions from services used by the organization occur from sources located outside the organizational boundaries. Those emissions might cover a very wide range of services and associated processes. Emissions should be calculated in a "cradle to supplier output gate" approach.<br>Subcategorization may be used by the intended user to differentiate and quantify emissions linked to different types of services used by an organization as described in the examples below :<br>a) Emissions from the disposal of solid and liquid waste<br>b) Emissions from the use of assets are generated through equipment leased by the reporting organization in the reporting year<br>c) Emissions from the use of services that are not described in the above subcategories include consulting, cleaning, maintenance, mail delivery, bank services, etc." (p. 23) | The methodology only considers the emissions derived from Purchased Goods & Services and Capital Goods (as defined by the Technical Guide for Calculating Scope 3 Emissions[17]). |

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|---|---|---|
| **ISO/TR 14069** | "Purchased products include upstream franchises. A franchisee (i.e., an organization that operates franchises and pays fees to a franchisor) reports the franchisor's activity in this category, including all activities of the franchisor (i.e. an organization that grants licenses to other organizations to sell or distribute its goods or services, in return for payments, such as royalties for the use of trademarks and other services). The franchisor is asked to specify how it has allocated the GHG emissions of its services. » (p. 35) | The aerospace and defense industry does not typically operate under a franchise model. Therefore, this requirement is not considered in this methodology. |
| **ISO/TR 14069** | "Organizations often have incomplete records, of purchased goods. This is why the organization should clearly describe which purchased goods and services are taken into account and neglected and how this can affect the total GHG emissions. The possible ways to select a certain percentage of the purchased goods or services to be taken into account are the following:<br>embedded GHG emissions of the purchased product;<br>monetary value of purchased amount; weight of purchased amount. » (p. 35) | The methodology described here aims at the clear definition of which purchased goods and services are to be taken into account (refer to Chapter 7 for more details).<br>The choice was made to cover all PG&S that could be material to an aerospace company.<br>Within the categories prescribed by the methodology, the reporting company may decide to neglect the emissions of some goods or services. If so, it will have to justify the exclusion by respecting the requirements set in ISO/TR 14069. |

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