AIGA

METHODOLOGY TO ESTABLISH A “PRODUCT CARBON FOOTPRINT”

AIGA 084/13

Asia Industrial Gases Association

3 HarbourFront Place, #09-04 HarbourFront Tower 2, Singapore 099254
Tel : +65 62760160 Fax : +65 62749379
Internet : http://www.asiaiga.org

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1 Introduction

AIGA members are receiving more and more requests for the "carbon footprint" of their products.

Increasingly customers want to use this information to evaluate the carbon footprint of products they buy and also, in some cases, to use this information to calculate their own "product carbon footprint." Examples: Japan TS Q0010 and Taiwan guideline specification for Product Carbon Footprint.

In the future, national regulations could require organizations to estimate the "carbon footprint" for the organization or its products.

Currently, answers are given using different calculation rules and scope definitions. The production of industrial gases is a global business. There is no consistent method for calculating and reporting a product carbon footprint that is internationally harmonized for industrial gases. Differences can cause customers, NGO's, or communities to potentially make inappropriate comparisons or conclusions.

This document has been developed taking these issues into account and seeks to define a common set of guidelines for the industrial gases industry for calculating and reporting of product carbon footprint.

Whilst this document has not been harmonized with other gas associations it is based on the European Industrial Gases Association (EIGA) document Doc. 167/11 'Methodology to establish Product Carbon Footprint' and AIGA thanks EIGA for permission to reproduce parts of Doc. 167 in this document.

2 Scope and Purpose

2.1 Scope

This document presents the basis of a common methodology for AIGA members to calculate a "product carbon footprint" that is applicable to industrial gases products, and guidelines on how to communicate this information to stakeholders.

A "carbon footprint" or "carbon content" for a product can be used to:

- Answer the questions raised by customers assessing their own carbon footprint
- Evaluate carbon footprints for alternative methods of delivering similar industrial gases
- Promote gas products or methodologies that reduce the carbon footprint of our customer's applications
- Provide a process to evaluate the potential climate impact up and down the supply chain and take actions to minimize this impact where appropriate.

2.2 Purpose

This document proposes a standardized methodology, sources of emission factors and the definition of scope and borders to be considered and applied by AIGA members when calculating a carbon footprint for products. These principles are based on and have been developed from currently established national and international standard methodologies (see section 5.4 and 5.5).

3 Definitions

3.1 Carbon footprint

Carbon footprint is defined as the amount of greenhouse gas (GHG) emissions associated with an organization, product or service and considering defined steps of its production, use and discharge, (steps selected from all possible steps from "cradle to grave" – see section 3.6). This is generally expressed as tons carbon dioxide equivalent per unit of product (e.g. per ton of gas Nm^3). The selection of an appropriate unit is important as it provides a unit of measurement to the consumer that reflects the quantity of product that is used by the end user.

3.2 Product carbon footprint

This is the total greenhouse gas emissions of a product across its life cycle, from raw materials through production (or service provision), distribution, consumer use and or disposal/recycling. It includes the emissions of greenhouse gases, including carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N20), together with families of gases including hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) from PAS 2050 (see References 1 ,2, 3).

3.3 Carbon dioxide equivalent (CO_2e)

This is a unit for comparing the radiative force of a GHG to that of carbon dioxide (ISO 14064-1 2006, see Reference 4). It is the amount of carbon dioxide by weight that would be emitted into the atmosphere that would produce the same estimated radiative force as a given weight of another radiatively active gas.

Carbon dioxide equivalents are calculated by multiplying the weight of the gas being measured by its estimated global warming potential (e.g. for methane this is 21). Global warming potentials can be found in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Table 2.14 (see Reference 5), though the values used in calculations should always be the latest available.

3.4 Radiative Forcing

Radiative forcing is a measure of the influence that a climatic factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In the report from the IPCC, radiative forcing values are for changes relative to pre-industrial conditions defined at 1750 and are expressed in watts per square meter (W/m2).

3.5 Carbon equivalent units

These are defined as carbon dioxide equivalents multiplied by the carbon content of carbon dioxide (i.e., 12/44).

3.6 Cradle to grave – system boundaries

The term “Cradle to Grave” is often used when describing the scope and boundaries for a full inventory that includes all GHG emissions from the complete life cycle of a product from the beginning of the life cycle (e.g. raw material acquisition) through final disposal or end use by the end consumer.

The term “Cradle to Gate” or “Gate to Gate” is used to describe when the scope is limited by some notional boundary such as not including raw material acquisition, or not including downstream customer processes. Often a change in product custody defines a Gate boundary.

Figure 1 below illustrates cradle to grave system boundaries.

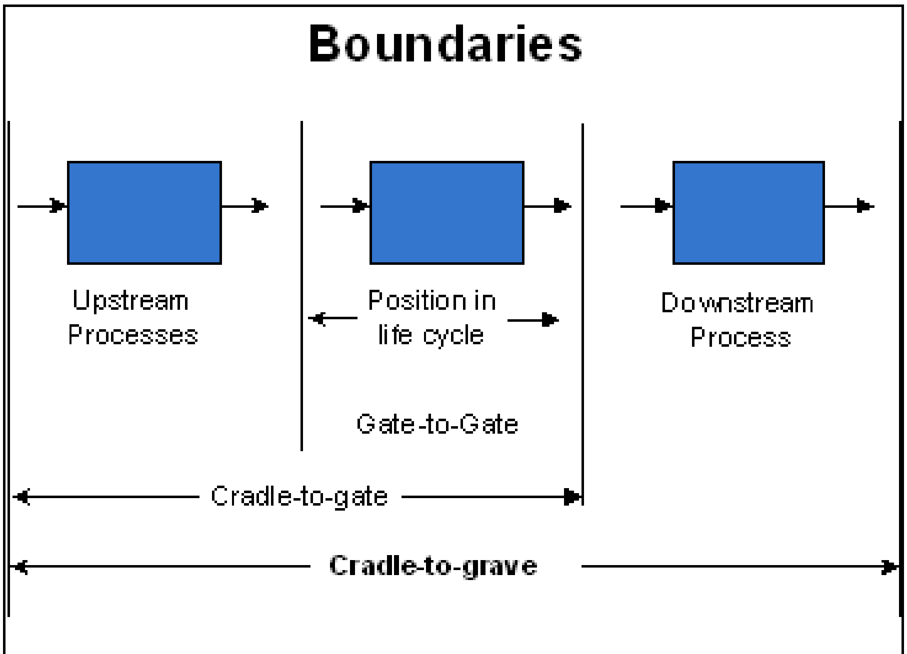

Figure 1 Cradle to grave system boundaries

3.7 Best Available Techniques (BAT)

"Best Available Techniques" means the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole:

(a) "Best" means most effective in achieving a high general level of protection of the environment as a whole.
(b) "Available Techniques" means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator.
(c) "Techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

4. Carbon footprints

4.1 Scope and boundary of carbon footprint

A **carbon footprint** is a term used to describe and a method used to measure, the amount of impact human activities have on the environment in terms of the amount of greenhouse (GHG) produced by a particular activity or entity. It can be used by organizations to communicate with stakeholders about their contribution to climate change.

A product carbon footprint is measured in unites of carbon dioxide (e.g. kg CO2 equivalent [CO2e] per unit of product or tons CO2e. The selection of an appropriate unit is important as it provides a unit of measurement to the consumer that reflects the quantity of product that is used by the end user.

Figure 2 below shows the different possible scopes and system boundaries for calculation of carbon footprints.

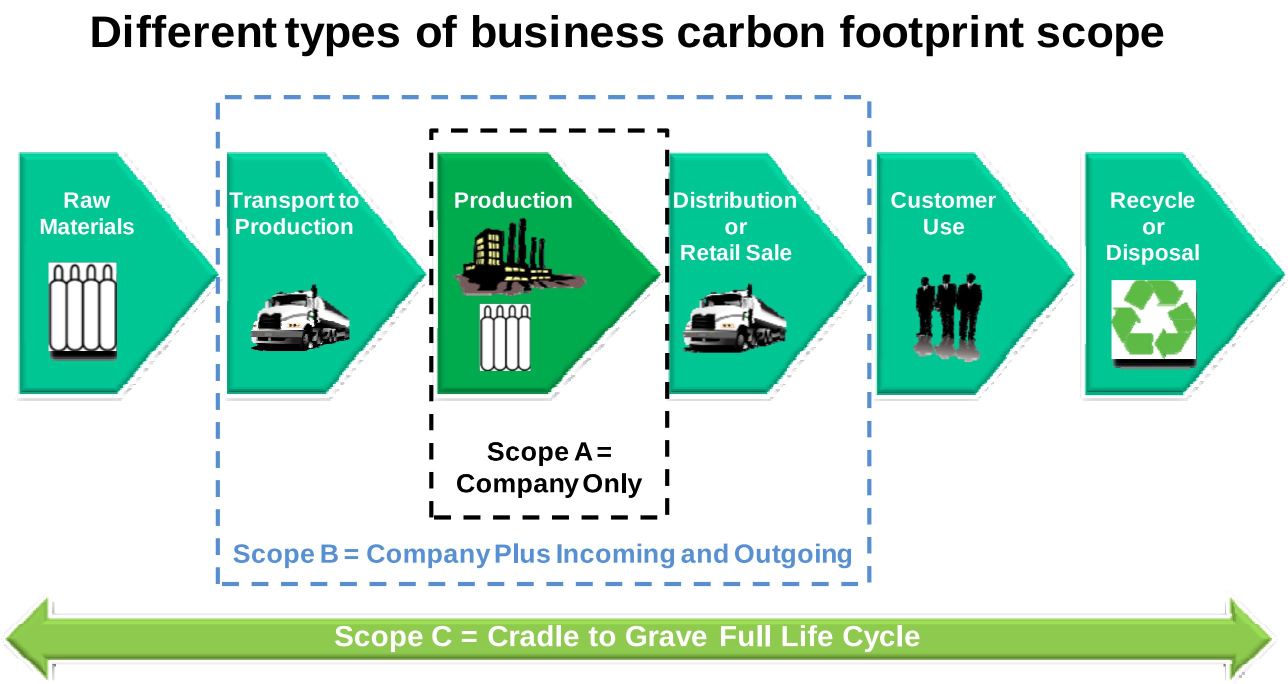

Figure 2 - System boundaries for carbon footprint

Scope A is the organization's carbon footprint, covering only activities under the direct operational control of the organization, typically used for site ISO14064 registration or corporate reporting. More details on calculating the organization's greenhouse gas emissions can be found in ISO 14064 and the World Resources Institute (WRI) GHG protocol (see Reference 1, 6).

Scope B is the larger organizational carbon footprint and the boundary covers carbon emissions related only to the activities undertaken for a "fence line to fence line", this includes an evaluation / review of upstream emissions (raw material transportation related) and downstream emissions (products distribution and disposal) which may not be within the full operational control of the organization. Appendix A provides examples of scopes and assumptions for some typical gases supplied by industrial gas companies.
Scope B can be described as including just one product, a representative product family or all products produced at the facility. Depending upon degree of control the gate boundary may include both incoming and outgoing or may include just one of these paths. The boundaries must be very clearly defined in the scope statement.

This document is primarily concerned with the methodology for calculating the product footprint of Scope B, with a business to business (B2B) scope for a single gas or family of gases, covering production and distribution and following the methodologies suggested in the references in section 5.0.

Scope C covers the carbon footprint of the whole organization's activities, upstream and downstream, and includes all raw material and product impacts. This is more comprehensive but requires extensive data across all products and activities.
Scope C can also be described as including just one product, a representative product family or all products produced across the product life cycle.

4.1.1 Data collection

Having determined the scope and boundaries for the carbon footprint, the next step is to collect the data to match the scope and boundary.

The following diagram figure 3, illustrates the different steps considered for data collection, the boundaries for the data required, assumptions and their associated emissions for the carbon footprint for a product supplied in a cylinder to a customer.

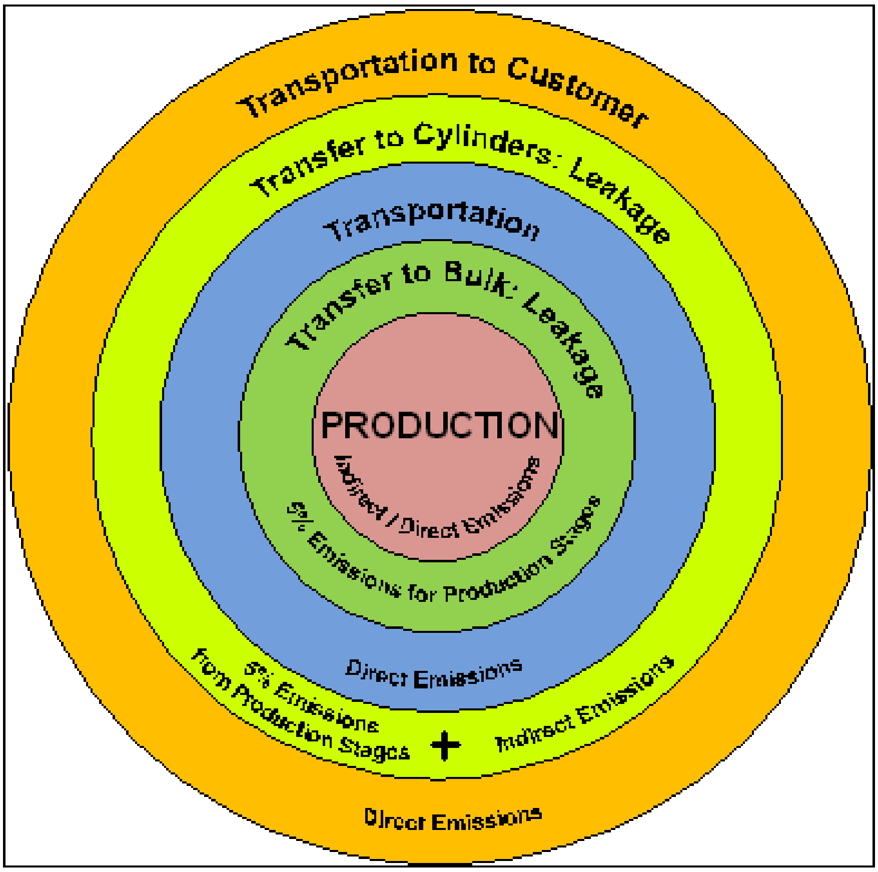

Figure 3 - Steps for data collection

4.2 Carbon footprint in practice

Comparing this approach to other methods of calculating ecological impacts, it should be noted that:

- Carbon footprint is
  - a measure of the carbon dioxide equivalent impact on the environment as a result of producing, processing and supplying the product.
  - a measure of the total amount of carbon dioxide and greenhouse gases (CO_2e) resulting from the product and its supply chain.
  - a measure that can capture carbon dioxide equivalent impact of all resource consumptions, including energy, water, waste, etc., depending on the scope.

- Carbon footprint is not
  - a complete or exhaustive Life Cycle Analysis.
  - an Ecological Footprint.
  - an efficiency indicator.

However it uses information produced by all these methods.

5 Calculation methodology

For the purposes of calculation of a carbon footprint for the gases industry, AIGA has standardized on an approach that will only focus on the production and distribution phases of specific products (Scope B from section 4.1) and will not take into account other greenhouse gas emissions from the organization itself (e.g. carbon dioxide emissions from employees' commuting; from offices and buildings heating; from paper or office material/equipment usage). This is consistent with the business to business (B2B scope in the World Business Council for Sustainable Development (WBCSD) GHG protocol and PAS 2050. (See References 1-4).

The method used to assess the carbon footprint is based on commonly used techniques employed to evaluate a LCA (Life Cycle Analysis) for a product. Firstly, the boundaries are set, then definitions, assumptions, and standard reference emission factors are collected and finally the calculations are documented in a traceable, reproducible format.

While considering the production of a product, for each step from cradle to grave (see 3.6), the carbon footprint methodology is asking several questions:

- What raw materials are used? What is their carbon content? How are they transported to the production site?
- How much electricity is used? How much energy is used? What kind of energy? What is their carbon content?
- Which direct carbon dioxide /GHG emissions are emitted during the production process?
- What is the effective yield of the production process?
- How is the final product transported to the customer?
- What happens at the end of the life of the product?

Some of these questions are easy to answer, others are not or may lead to complex calculation or data reporting without any significant impact on the total carbon footprint of the considered product. Sometimes, several answers are possible with a great influence on the final result.

To get comparable results from one company to another and from one product to another, it is therefore, of utmost importance to specify the selected steps and to define the calculation rules for each of them.

5.1 Main assumptions for calculation

Four main steps can be highlighted for each product:

1. Raw material inputs and construction of the production plant.
2. Transportation of ongoing raw materials to production plant.
3. Operation of the plant.
4. Distribution from plant.
    - product transfer (i.e. gas leakage resulting from leaks during filling);
    - product transportation to the customer (or discharge into a pipeline).
5. Use and end of life of the product or of the plant.

Steps 2, 3 and 4 are the ones typically under control of an industrial gases company. The influence of Step 1 on the final result depends on the product. Accurate carbon content for raw material may sometimes be difficult to obtain and therefore, simplified assumptions are sometimes needed. Appendix A provides a summary of assumptions for some typical gases supplied by industrial gas companies.

Step 5 is not generally under control of an industrial gases company and selection of scope depends on the products and their uses by the customer.

Industrial gases are mainly used in industrial applications, rather than consumer applications. Therefore, in accordance with the principles of PAS 2050 and EN ISO 14064 (References 1-4) AIGA members would usually state product footprints on a business to business (B2B) basis or gate to gate basis (References 7, 8, 9, 10). This means that the calculation and scope for the carbon footprint stops once the product is delivered to the user. Therefore, Step 5 “end of life and product use” is not usually included in the scope of calculation. See Appendix A for scope and assumptions.

In all cases, care must be taken in communicating the boundaries and scope of the carbon footprint calculations to the end user (section 5.4).

5.1.1 Raw material inputs and construction of the production plant

Depending on the specific product the raw material carbon content is taken into account or not depends on the specific product. Reference to best available techniques (BAT) could provide average values in determining carbon content of raw materials. Emissions associated with construction of plants, pipelines, and cylinders can be considered as negligible and should not typically be included in the calculation of the product carbon footprint for industrial gas products.

5.1.2 Operation of the plant

Direct emissions include:

- carbon dioxide emissions from fuel combustion in the process (e.g. for hydrogen production)
- other GHG process emissions.

Indirect emissions include emissions from the production of energy used in the process. The power consumption is obtained in one of two ways:

- either directly by the specific consumption of the site (typically for plants producing a single product), or
- by multiplying a specific power consumption per product which takes into account the different products produced by the plant by the production equivalent factor for each of the produced products

In circumstances in which two or more products manufactured from the same process e.g. air separation, it is important to allocate the respective amount of emission for each of the co-products from the same process. For air gases it may not always be possible to separate the production process inputs to relate to one product output and in these circumstances an allocation procedure may be necessary.

Allocation of power to co-products is ideally done according to the power required to produce each product. This is derived from the specific power along with the production volumes for each product as well as the energy source. Therefore, the carbon footprint will vary from one plant to another.

With respect to air gases, it is possible to allocate emissions based on two methods, the choice to which method is used is highly dependent upon end user requirements.

1) **Energy based allocation** – This methodology may be most appropriate for users that require data that aligns exactly with the single product they have been supplied with from a specific plant and/or the user requires the carbon footprint that is based on the actual production situation.

   In these instances it is most appropriate to allocate emissions for co-products based on methodology that takes account of the actual unit of power used to produce a unit of product (specific power MWhr per Nm3) at a specific plant where actual inputs and outputs are known and may already be provided to the user.

2) **Revenue based allocation** – This methodology may be most appropriate for a user of carbon footprint information that requires more generic information, does not require plant specific footprint data and is only interested if an organization can provide it with an average carbon footprint figure that has been calculated and communicated to all users.

The user may also be geographically widespread, with multiple suppliers from a variety of regions or countries, resulting in it not being pragmatic to calculate complex supply situations. In these instances it is most appropriate to report a country wide/region average footprint for all the plants supplying products to all users.

Where users have these requirements it is most appropriate to allocate emissions based on the volume and economic value of the co-products sold by an organization to all its users. This may also be appropriate if the user is short of time and resources and the specific use based allocation input data is difficult to obtain.

The disadvantage of revenue based allocation is that it may be influenced by changes in external financial factors not relevant to the environmental impact.

In both circumstances the allocation methodology should be declared and clearly communicated to the user. Both of these methods will still provide the same overall total emission, but will differ in that the relative weighting may be different for the mix of co-products.

A reasonable estimate of gas leakage/losses for air gas production is 5% of total production emissions and is taken into account for each product transfer (liquid to bulk, bulk to cylinder). This means 5% of the energy necessary to produce the product so far (including transport emissions (§5.1.3) if it deals with cylinder transfer) is lost. It means that leaks during transfer to cylinder take into account both energy used during this transfer and emissions during bulk transport. If a more accurate estimate of leakage or losses can be made, this should be used.

Indirect emissions from the production of energy used in the filling process are also taken into account.

Some emissions may be considered as negligible such as:

- Employee commuting and business travel
- Office heating and lighting, emissions related to general office activities;
- Waste treatment;
- Carbon dioxide emissions associated with producing and delivering water to the production site.

Where such emissions have been determined to be negligible, it may also be appropriate to provide evidence to document the justification that such emissions are deemed negligible.

As production of industrial gases is mainly local, emissions need to take into account country specific emissions factors for indirect carbon dioxide emissions from electricity production.

More detailed calculations can be done at the request of customers provided the assumptions are clearly stated.

5.1.3 Distribution

Carbon dioxide emissions from transportation include direct emissions from use of fuel during product transportation to the cylinder filing station, redistribution centres and/or customers, and product transfer (gas leakage and losses as a result of filling).

5.1.4 Use and end of life of the product and of the plant

At this stage impacts to be included are any significant product emissions from the customer application and use (where the product is itself a GHG), energy impacts from use of the products, and impacts from waste disposal if any. Normally the end of life emissions is included in the customer's scope of reporting.

In many cases, the use of industrial gases has a positive contribution to improving energy efficiency and reducing GHG and other emissions by the user. This can reduce the overall carbon footprint of the customer and can also be included in an estimation of the impact of the use phase.

5.2 Emission factors

Standard references emission factors should be used to convert units of energy and fuel into carbon dioxide equivalents. Typically, emission factors that have been specified by the local regulatory authority should be used where available. Where no emission factors are available, the emission factors in Appendix B may be used and referenced accordingly.

5.3 Example scopes and assumptions for gases

Examples of how this methodology can be applied to different industrial gas products are shown in Appendix A, with examples of key assumptions and guidance for scope and boundaries to guide users on what is and what is not typically included. The examples are:

- Acetylene
- Air gases (nitrogen, oxygen, argon)
- Carbon dioxide
- Helium
- Hydrogen and carbon monoxide
- Specialty gases, e.g. arsine, chlorine, ammonia

5.4 Communicating the carbon footprint

It should be noted that there may be significant difference in the carbon footprint for the same product, these differences may be based on the following factors:

- Emissions factors per country for electricity production, where countries with large carbon based electricity generation have significantly greater emissions factors than those based on other energy generation.
- Transport methods.
- Plant efficiency and plant loading.
- Allocation methods for co-products.
- Scope/boundary differences.

The following items shall be included when communicating or sharing a carbon footprint calculation:

- Methodology; e.g. PAS 2050, ISO etc.
- Products evaluated.
- Boundaries, and system scope (see section 4.1).
- Physical/business scope: e.g. regional business unit, region, site, etc.
- Supply/scope: e.g. bulk tankers, cylinders, dewars/portable cryogenic containers, etc.
- Resource scope
    - Energy consumption (electricity, natural gas, steam, other energy fuels);
    - Refrigerant consumption (R22, ammonia, etc.);
    - water consumption;
    - waste production;
    - transport fuel consumption;
    - emission factors employed and references.
- Context e.g. kgCO_2e per volume of product.

There may be instances where interested parties wish to understand and compare the relative carbon footprints of different products used for the same application. In such circumstances, the use phase (step 4) shall always be considered in the scope in order to avoid possible misinterpretation by the user of the information, e.g. not including significant product emissions in the use phase could lead to inequitable differences in the relative magnitude of respective environmental emissions associated with the same application or differences in the efficiency of using different products in the application.

Where use of industrial gases has a positive contribution to improving energy efficiency, reducing GHG and other emissions and can reduce the overall carbon footprint for the customer's activities and products, the use phase (step 4) shall always be considered in the scope. To avoid any misinterpretation by the user of the information, the type of contribution and benefit should be clearly communicated.

5.5 References

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7. EN ISO 14040, Environmental management – Life cycle assessment – Principles and framework
8. EN ISO14044, Environmental management – Life cycle assessment – Requirements and guidelines
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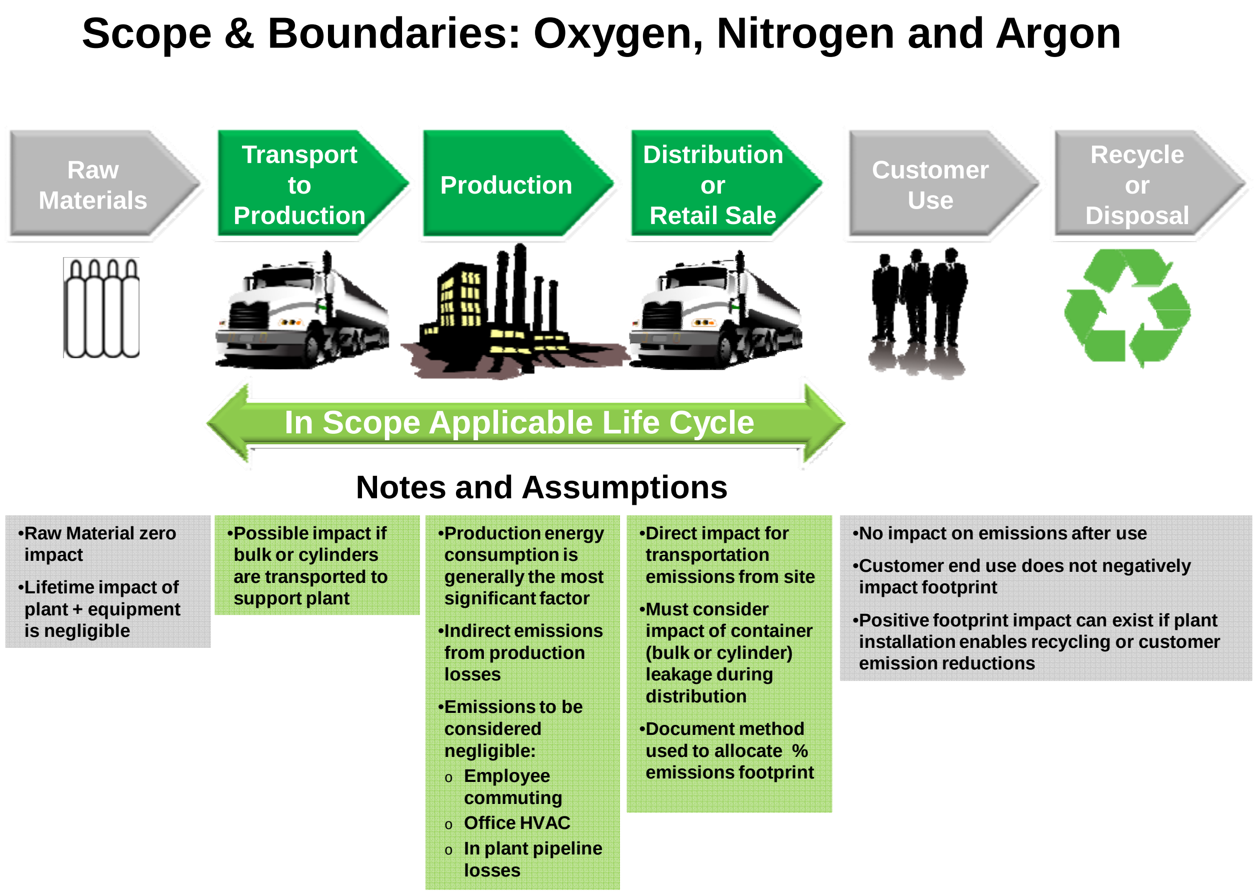
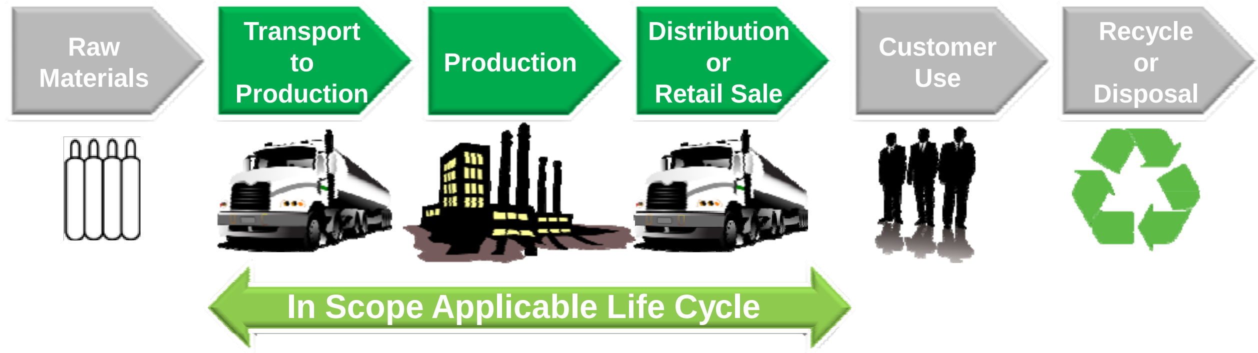
10. Draft ISO standard ISO/CD 14067-1 Carbon footprint of products – Part 1; Quantification
11. Bilan Carbone® Entreprises et Collectivités, Guide des Facteurs D'Emissions Version 5.0 Calcul des facteurs d'émissions et sources bibliographiques utilizes, 2007
12. International Energy Agency (IEA) CO2 Emissions From Fuel Combustion *Highlights (2011 Edition) http://www.iea.org/co2highlights/co2highlights.pdf*

Appendix A: Examples



Scope & Boundaries: Hydrogen, CO and CO_2

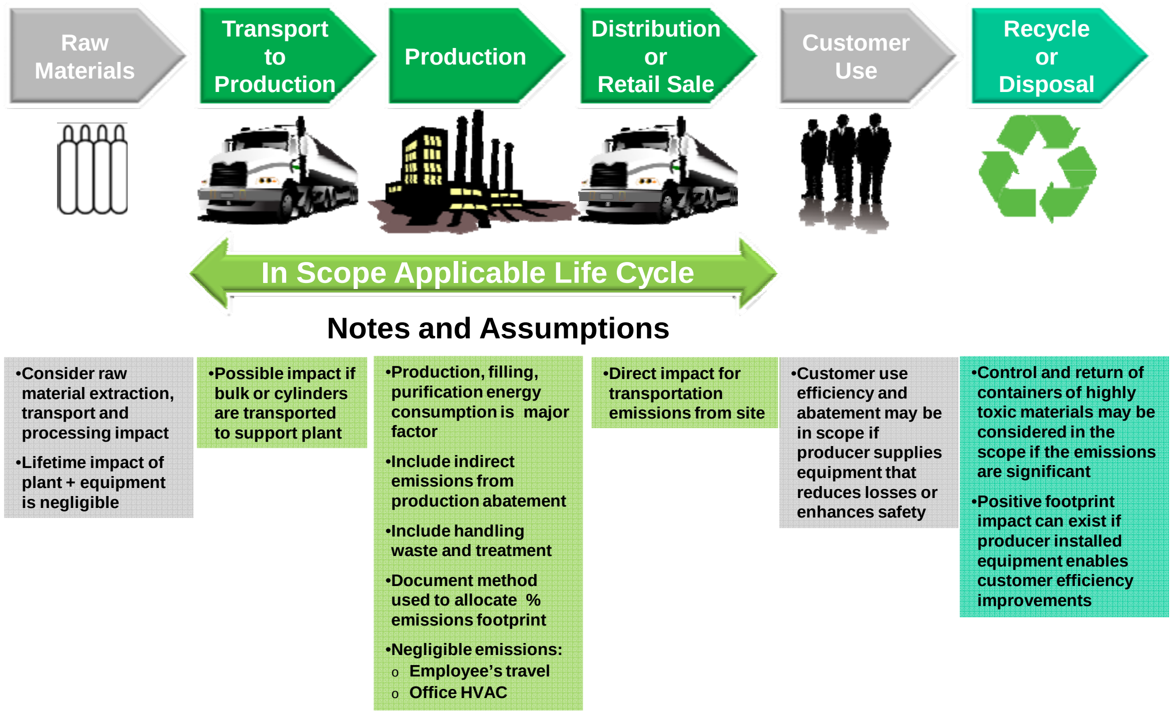


Notes and Assumptions

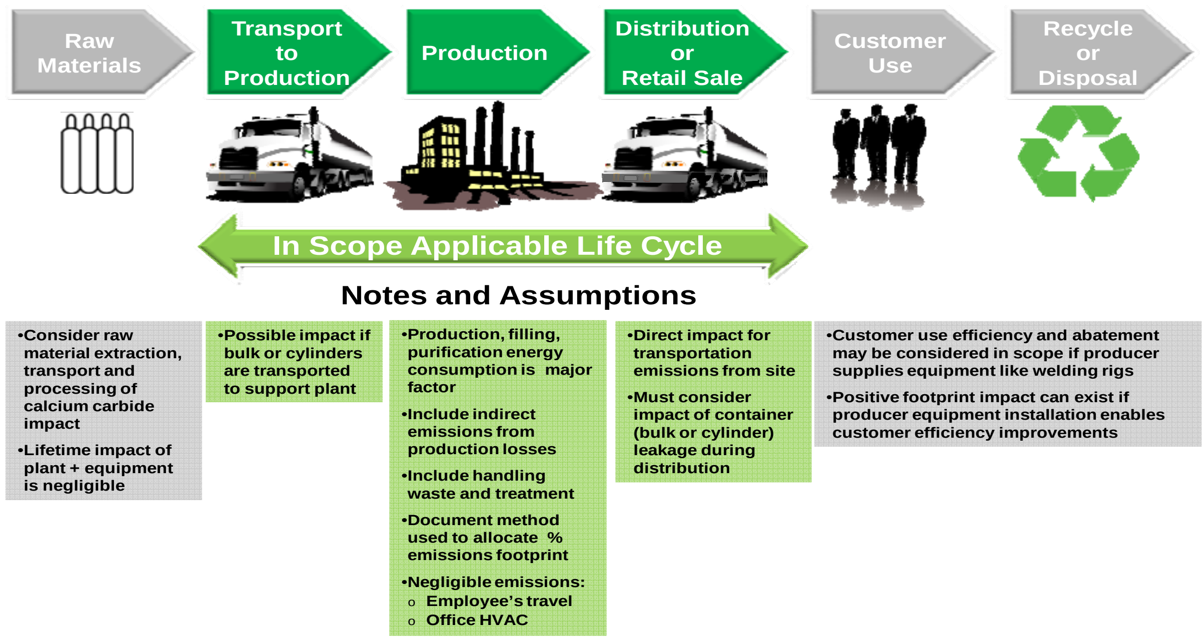
•Raw Material embedded Carbon is accounted for in Production and Distribution •Positive impact can exist if plant use enables supplier recycling or emission reduction •Lifetime impact of plant + equipment is negligible •CO_2 from natural gas extraction is out of scope	•Possible impact of transportation emissions for bulk or cylinders to support plant •Must consider impact of container (bulk, cylinder or pipeline) leakage during transport to site	•Production energy consumption is generally the most significant factor •Indirect emissions from production losses or CO/CO_2 ratio •Emissions to be considered negligible: o Employee commuting o Office HVAC o In plant pipeline losses	•Direct impact for transportation emissions from site •Must consider impact of container (bulk or cylinder) leakage during distribution •Document method used to allocate % emissions footprint	•Customer end use does not negatively impact footprint as supplier's product is usually consumed as part of customer's product •Positive footprint impact can exist if plant installation enables recycling or customer emission reductions

Note: Emissions from CO2 product use are not reported by AIGA members as scope is business to business.

Scope & Boundaries: Highly Toxics like Arsine or Phosphine



Scope & Boundaries: Acetylene



Appendix B: Emission factors for the calculations

Examples of emissions factors that can be used

Indirect carbon dioxide emissions from electricity production

The carbon dioxide Emission Factor (gCO2/kWh) of power for each country is the average of the last 3 available years for this information in the last available IEA yearly energy report (IEA Statistics – carbon dioxide emissions from fuel combustion – table "CO2 emissions per KWh from electricity and heat generation").

Country	CO2 emissions per kWh from electricity and heat generation [kg/MWh]
Bangladesh	575
Brunei Darussalam	738
Cambodia	1154
Chinese Taipei	647
India	950
Indonesia	757
DPR of Korea	483
Malaysia	638
Mongolia	546
Myanmar	249
Nepal	4
Pakistan	447
Philippines	471
Singapore	523
Sri Lanka	425
Thailand	530
Vietnam	409
Other Asia	274
Asia	745
People's Rep of China	748
Hong Kong, China	765

Direct CO2 emissions from fuel combustion - For transportation emissions [1]

Gross Weight	Fuel consumption per 100 km	g C equivalent per km
< 1,5 tonnes petrol / gasoline	8,4	62,1
< 1,5 tonnes diesel	7,2	58,6
3,5 tonnes	12,4	100,9
trucks - trailers	37,1	302,0

CO2 emissions linked to construction material [1]

Material	kg C equivalent per metric tonne
Steel - virgin	870
Steel - recycled	300
Aluminium – virgin	2890
Aluminium - recycled	670
Concrete	235
Wood	- 500

2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 1: Introduction, Table 1.4, page 1.23-1.24

TABLE 1.4
DEFAULT CO_2 EMISSION FACTORS FOR COMBUSTION [1]

Fuel type English description		Default carbon content (kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (kg/TJ) [2]		
				Default value [3]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Crude Oil		20.0	1	73 300	71 100	75 500
Orimulsion		21.0	1	77 000	69 300	85 400
Natural Gas Liquids		17.5	1	64 200	58 300	70 400
Gasoline	Motor Gasoline	18.9	1	69 300	67 500	73 000
	Aviation Gasoline	19.1	1	70 000	67 500	73 000
	Jet Gasoline	19.1	1	70 000	67 500	73 000
Jet Kerosene		19.5	1	71 500	69 700	74 400
Other Kerosene		19.6	1	71 900	70 800	73 700
Shale Oil		20.0	1	73 300	67 800	79 200
Gas/Diesel Oil		20.2	1	74 100	72 600	74 800
Residual Fuel Oil		21.1	1	77 400	75 500	78 800
Liquefied Petroleum Gases		17.2	1	63 100	61 600	65 600
Ethane		16.8	1	61 600	56 500	68 600
Naphtha		20.0	1	73 300	69 300	76 300
Bitumen		22.0	1	80 700	73 000	89 900
Lubricants		20.0	1	73 300	71 900	75 200
Petroleum Coke		26.6	1	97 500	82 900	115 000
Refinery Feedstocks		20.0	1	73 300	68 900	76 600
Other Oil	Refinery Gas	15.7	1	57 600	48 200	69 000
	Paraffin Waxes	20.0	1	73 300	72 200	74 400
	White Spirit & SBP	20.0	1	73 300	72 200	74 400
Other Petroleum Products		20.0	1	73 300	72 200	74 400
Anthracite		26.8	1	98 300	94 600	101 000
Coking Coal		25.8	1	94 600	87 300	101 000
Other Bituminous Coal		25.8	1	94 600	89 500	99 700
Sub-Bituminous Coal		26.2	1	96 100	92 800	100 000
Lignite		27.6	1	101 000	90 900	115 000
Oil Shale and Tar Sands		29.1	1	107 000	90 200	125 000
Brown Coal Briquettes		26.6	1	97 500	87 300	109 000
Patent Fuel		26.6	1	97 500	87 300	109 000
Coke	Coke oven coke and lignite Coke	29.2	1	107 000	95 700	119 000
	Gas Coke	29.2	1	107 000	95 700	119 000
Coal Tar		22.0	1	80 700	68 200	95 300
Derived Gases	Gas Works Gas	12.1	1	44 400	37 300	54 100
	Coke Oven Gas	12.1	1	44 400	37 300	54 100
	Blast Furnace Gas [4]	70.8	1	260 000	219 000	308 000
	Oxygen Steel Furnace Gas [5]	49.6	1	182 000	145 000	202 000

TABLE 1.4 (CONTINUED)
DEFAULT CO_2 EMISSION FACTORS FOR COMBUSTION [1]

Fuel type English description		Default carbon content (kg/GJ)	Default carbon oxidation Factor	Effective CO_2 emission factor (kg/TJ) [2]		
				Default value	95% confidence interval	
					Lower	Upper
		A	B	C=A*B*44/ 12*1000		
Natural Gas		15.3	1	56 100	54 300	58 300
Municipal Wastes (non-biomass fraction)		25.0	1	91 700	73 300	121 000
Industrial Wastes		39.0	1	143 000	110 000	183 000
Waste Oil		20.0	1	73 300	72 200	74 400
Peat		28.9	1	106 000	100 000	108 000
Solid Biofuels	Wood/Wood Waste	30.5	1	112 000	95 000	132 000
	Sulphite lyes (black liquor)[5]	26.0	1	95 300	80 700	110 000
	Other Primary Solid Biomass	27.3	1	100 000	84 700	117 000
	Charcoal	30.5	1	112 000	95 000	132 000
Liquid Biofuels	Biogasoline	19.3	1	70 800	59 800	84 300
	Biodiesels	19.3	1	70 800	59 800	84 300
	Other Liquid Biofuels	21.7	1	79 600	67 100	95 300
Gas biomass	Landfill Gas	14.9	1	54 600	46 200	66 000
	Sludge Gas	14.9	1	54 600	46 200	66 000
	Other Biogas	14.9	1	54 600	46 200	66 000
Other non-fossil fuels	Municipal Wastes (biomass fraction)	27.3	1	100 000	84 700	117 000

Notes:

[1] The lower and upper limits of the 95 percent confidence intervals, assuming lognormal distributions, fitted to a dataset, based on national inventory reports, IEA data and available national data. A more detailed description is given in section 1.5

[2] TJ = 1000GJ

[3] The emission factor values for BFG includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas.

[4] The emission factor values for OSF includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas

[5] Includes the biomass-derived CO_2 emitted from the black liquor combustion unit and the biomass-derived CO_2 emitted from the kraft mill lime kiln.