METHODOLOGY TO ESTABLISH A PRODUCT CARBON FOOTPRINT

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Amendments to Doc167/11

Section	Change
	Editorial to align style with IHC associations
6	Update to references with latest data

Note: Technical changes from the previous edition are underlined

1 Introduction

EIGA 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, in some cases, to use this information to calculate their own product carbon footprint (for example, for carbon labelling of food products in UK).

In the future national regulations could require organisations to estimate the carbon footprint for the organisation or its products.

Currently, these requests have been answered using different calculations rules and scope. The production of industrial gases is a global business. Today, there is no clear method for calculating and reporting a product carbon footprint that is internationally harmonised.

This publication 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.

2 Scope and purpose

2.1 Scope

This publication presents the basis of a methodology for EIGA 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 precise questions raised by customers assessing their own carbon footprint;
- evaluate carbon footprints for alternative methods of delivering industrial gases;
- promote gas products that reduce the carbon footprint of customers applications; or
- provide a process to evaluate the impact on climate change up and down the supply chain and take actions to minimise this impact where appropriate.

2.2 Purpose

This publication proposes the methodology, sources of emission factors and the scope and borders to be considered and applied by EIGA 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).

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicate that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Best Available Techniques (BAT)

The most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole:

a) ‘techniques’ includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

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) ‘best’ means most effective in achieving a high general level of protection of the environment as a whole.

3.2.2 Carbon dioxide equivalent (CO2e)

Unit for comparing the radiative forcing of a greenhouse gas (GHG) to that of carbon dioxide, see ISO 14064-1 *Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* [1].[1] It is the amount of carbon dioxide by weight that is emitted into the atmosphere that would produce the same estimated radiative forcing 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 (for example for methane this is 21). Global warming potentials can be found in the Fifth Assessment Report of the Intergovernmental Panel on climate Change (IPCC) (though the values used in calculations should always be the latest available) [2].

3.2.3 Carbon equivalent units.

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

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2.4 Carbon footprint

The amount of greenhouse gas (GHG) emissions associated with an organisation, product or service when taking into consideration defined steps of its production, use and discharge, (steps selected from all possible steps from cradle to grave, see section 3.2.6). This is generally expressed as tonnes carbon dioxide equivalent per unit of product (for example per tonne of gas, per 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.

3.2.5 Product carbon footprint

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 (CH_4) and nitrous oxide (N_20), together with families of gases including hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) from PAS 2050 [3, 4].

3.2.6 Radiative Forcing

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 as defined at 1750 and are expressed in watts per square metre (W/m^2).

3.2.7 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 (for example raw material acquisition) though final disposal or end use by the end consumer. Figure 1 below illustrates cradle to grave system boundaries.

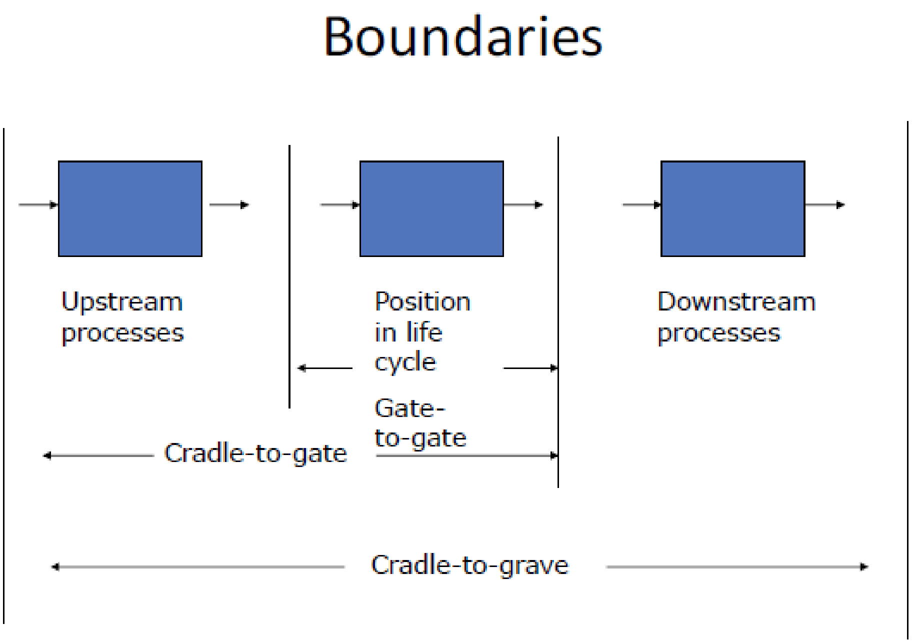


Figure 1 Cradle to grave system boundaries

4 Carbon footprint

4.1 Scope and boundary of carbon footprint

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

A product carbon footprint is measured in units of carbon dioxide for example kg CO2 equivalent (CO2e) per unit of product or tonnes 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 different possible scopes and system boundaries for calculation of carbon footprints.

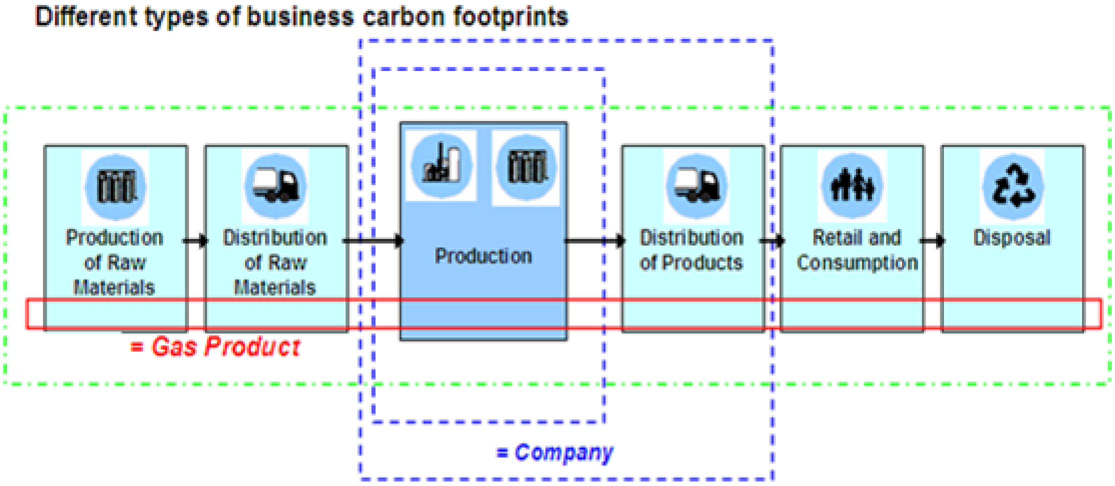


Figure 2 System boundaries for carbon footprint

Scope A (Blue line – Figure 2) is the organisation's carbon footprint, covering all activities under the operational control of the organisation, typically used for corporate reporting. More details on calculating the organisation's greenhouse gas emissions can be found in ISO 14064 and the World Resources Institute (WRI) GHG protocol [1, 5].

Scope B (Red line – Figure 2) is the product carbon footprint and the boundary covering carbon emissions related only to the activities undertaken for a specific product; this includes an evaluation / review of upstream emissions (raw material related) and downstream emissions (products use and disposal) which may not be within the operational control of the organisation. Appendix A provides a summary of scopes and assumptions for some typical gases supplied by industrial gas companies.

NOTE This publication 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, covering production and distribution and following the methodologies suggested in the references in Section 6.

Scope C (Green line – Figure 2) covers the carbon footprint of the whole organisation'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.

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.

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.

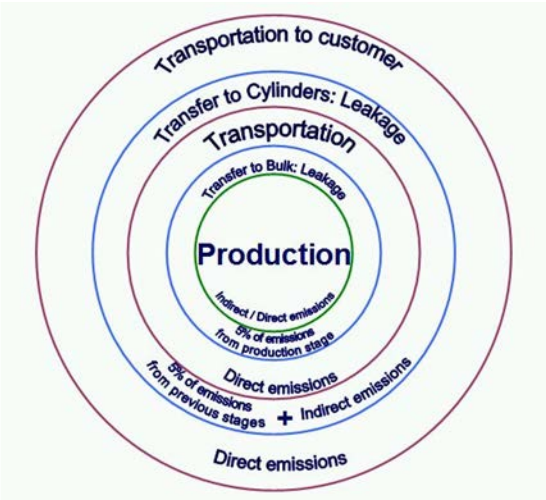


Figure 3 Steps for data collection

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 (CO2e) resulting from the product and its supply chain; and
  - 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; or
  - an efficiency indicator.

However, a carbon footprint uses information produced by all these methods.

5 Calculation methodology

For the purposes of calculation of a carbon footprint for the gases industry, EIGA has standardised 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 organisation itself (for example carbon dioxide emissions from employees commuting, office and building heating, or paper or office material / equipment usage). This is consistent with the business to business scope in the World Business Council for Sustainable Development (WBCSD) GHG protocol and PAS 2050 [4, 5].

The method used to assess the carbon footprint is based on commonly used techniques employed to evaluate an LCA (Life Cycle Analysis) for a product. Firstly, the boundaries are set, then definitions, assumptions and standard referenced 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 3.2.6), 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 life of the product?

Some of these questions are easy to answer, other 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.

A sensitivity analysis points to parameters and assumptions with a high impact. It is especially interesting to motivate the sources and choices made for these parameters.

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. Operation of the plant.
3. Distribution:
    - product transfer (i.e. gas leakage resulting from leaks during filling); and
    - product transportation to the customer.
4. Use and end of life of the product and of the plant.

Steps 2 and 3 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 4 is not generally under control of an industrial gases company and selection of scope depends on the products and their uses by the consumer.

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 EIGA members would usually state product footprints on a business to business (B2B) basis or gate to gate basis [1, 4, 6, 7]. This means that the calculation and scope for the carbon footprint stops once the product is delivered to the user. Therefore Step 4 (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 shall be taken in communicating the boundaries and scope of the carbon footprint calculations to the end user.

5.1.1 Raw material inputs and construction of the production plant

Whether the raw material carbon content is taken into account or not depends on the specific product. Reference to best available techniques (BAT) can 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 (for example for hydrogen production); or

- 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 which two or more products manufactured from the same process, for example 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 of 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 MWh per Nm^3) at a specific plant where actual inputs and outputs are known and may already be provided to the user.

   Specifically, EIGA recommends the following method of energy allocation for the products produced in an air separation plant in accordance with the energy benchmarks for nitrogen and oxygen in gaseous and liquid forms as presented in the EIGA PP 33*, Indirect CO2 emissions compensation: Benchmark proposal for Air Separation Plants* [8].

Presuming an air separation plant produces a quantity gaseous nitrogen (m_{gan}), liquid nitrogen (m_{lin}), gaseous oxygen (m_{gox}), and liquid oxygen (m_{lox}) whilst consuming e MWh of electricity, the energy consumption of each individual product stream in MWh shall be given by:

Gaseous nitrogen (GAN), $e_{gan} = e / e_{benchmark} \times m_{gan}$ x Benchmark specific electricity consumption;

Liquid nitrogen (LIN), $e_{lin} = e / e_{benchmark} \times m_{lin}$ x Benchmark specific electricity consumption;

Gaseous oxygen (GOX), $e_{gox} = e / e_{benchmark} \times m_{gox}$ x Benchmark specific electricity consumption;

Liquid oxygen (LOX), $e_{lox} = e / e_{benchmark} \times m_{lox}$ x Benchmark specific electricity consumption;

where, $e_{benchmark}$ is the electricity consumption of an equivalent 'benchmark' plant, given by $e_{benchmark} = m_{gan} \times 243 + m_{lin} \times 549 + m_{gan} \times 400 + m_{gan} \times 638$.

2. Revenue based allocation – This methodology may be most appropriate for a user of carbon footprint information that requires more generic information. It does not require plant specific footprint data and is only interested if an organisation 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 its 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 organisation 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 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, including transport emissions (see 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; and
- 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 filling 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 are 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 referenced 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; and
- speciality gases, for example arsine, chlorine and 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; and
- scope / boundary differences.

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

- methodology, for example PAS 2050 or ISO;
- products evaluated;
- boundaries and system scope (see 4.1);
- physical / business scope, for example regional business unit, region, site, etc;
- supply scope, for example bulk tanker, 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; and
    - emission factors employed and references.
- context for example kg CO_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 (see 5.1, step 4) shall always be considered in the scope in order to avoid possible misinterpretation by the user of the information, for example 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 (see 5.1, 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.

6 References

Unless otherwise stated the latest edition shall apply.

[1] ISO 14064-1, *Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*, www.iso.org.

[2] IPCC, *2014: Climate Change 2014: Synthesis Report*, https://www.ipcc.ch/report/ar5/syr/.

[3] Guide to PAS 2050:2011, *How to carbon footprint your products, identify hotspots and reduce emissions in your supply chain*, www.shop.bsigroup.com.

[4] PAS 2050:2011, *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*, www.shop.bsigroup.com.

[5] World Resources Institute (WRI) GHG protocols, *Product Life Cycle Accounting and Reporting Standard*, www.wri.org.

[6] ISO 14067, *Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification*, www.iso.org.

[7] Bilan Carbone® Entreprises et Collectivités, Guide des Facteurs D'Emissions (2010), http://23dd.fr/images/stories/Documents/PV/Ademe_Metro_Chapitre_2_Energie.pdf.

[8] EIGA PP 33, *Indirect CO2 emissions compensation: Benchmark proposal for Air Separation Plants*, www.eiga.eu.

[9] IEA statistics, International Energy Agency, https://www.iea.org/data-and-statistics.

[10] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: *Energy, Chapter 1: Introduction*, www.ipcc-nggip.iges.or.jp/public/2006gl.

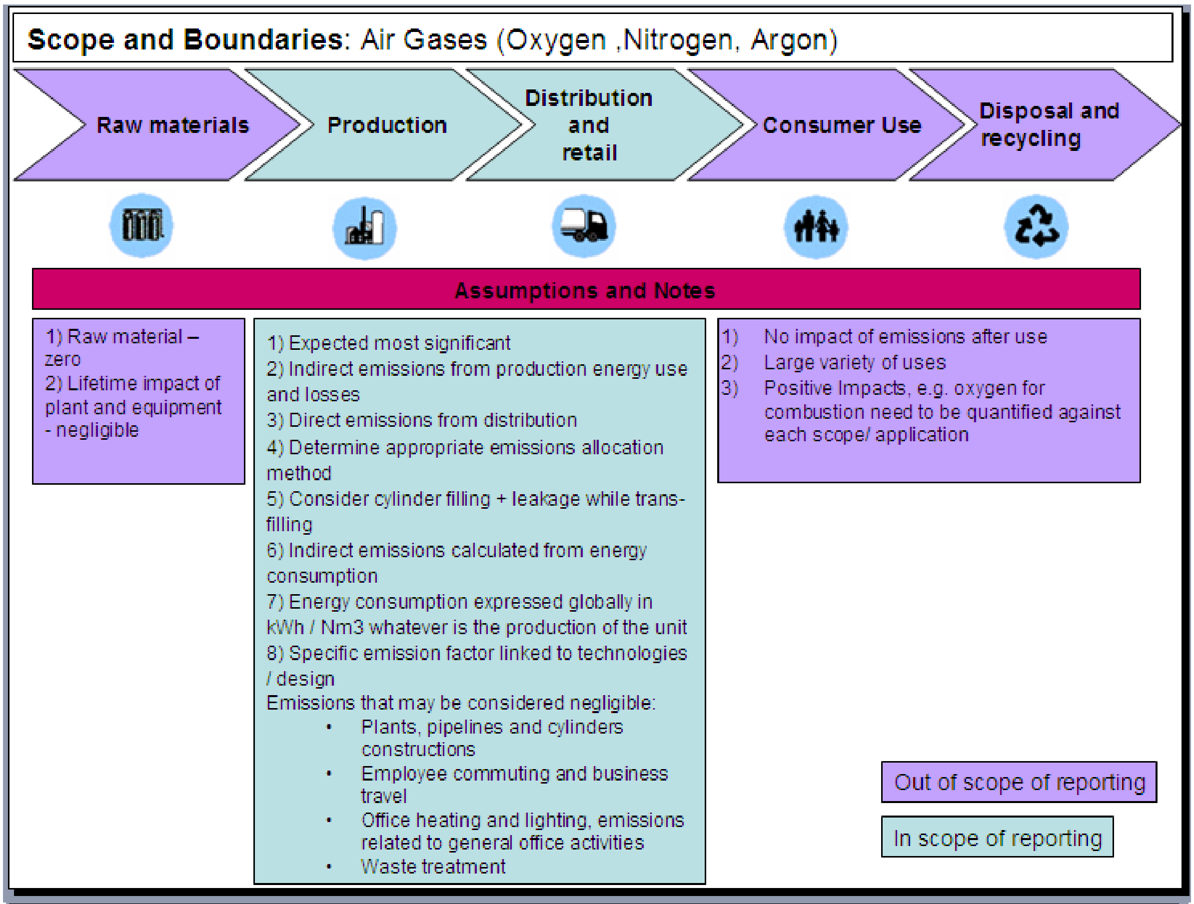
[11] 2007/589/EC, *Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council*, www.europa.eu.

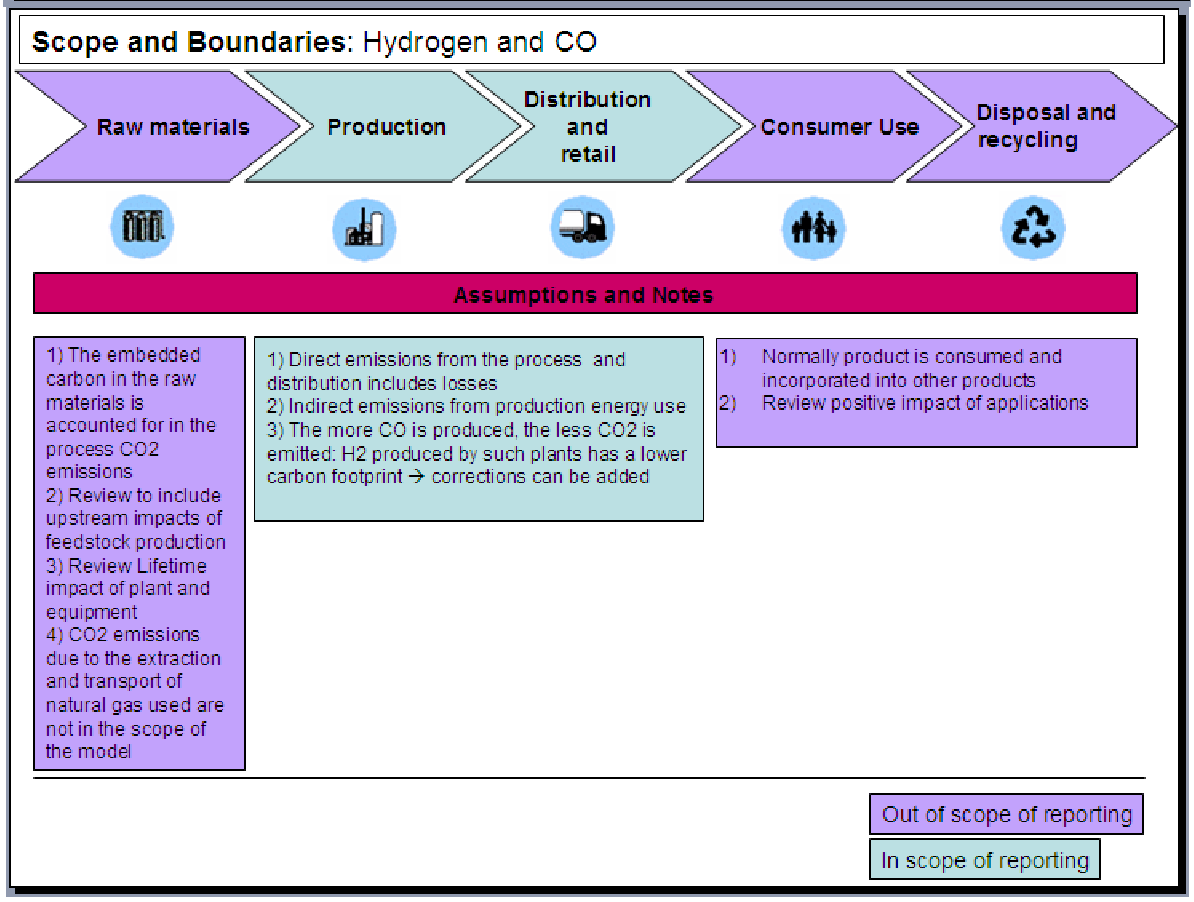
7 Additional references

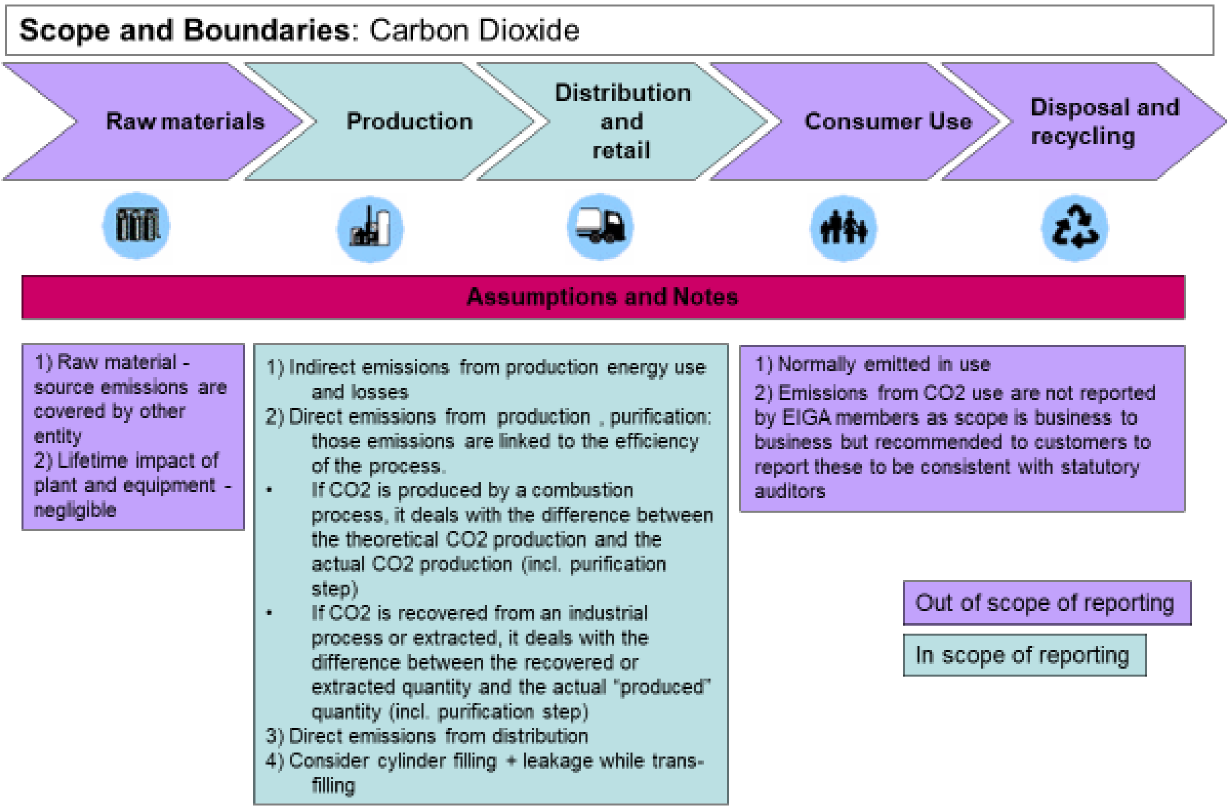
EN ISO14040, *Environmental management – Life cycle assessment – Principles and framework*, www.iso.org.

EN ISO 14044, *Environmental management – Life cycle assessment – Requirements and guidelines*, www.iso.org.

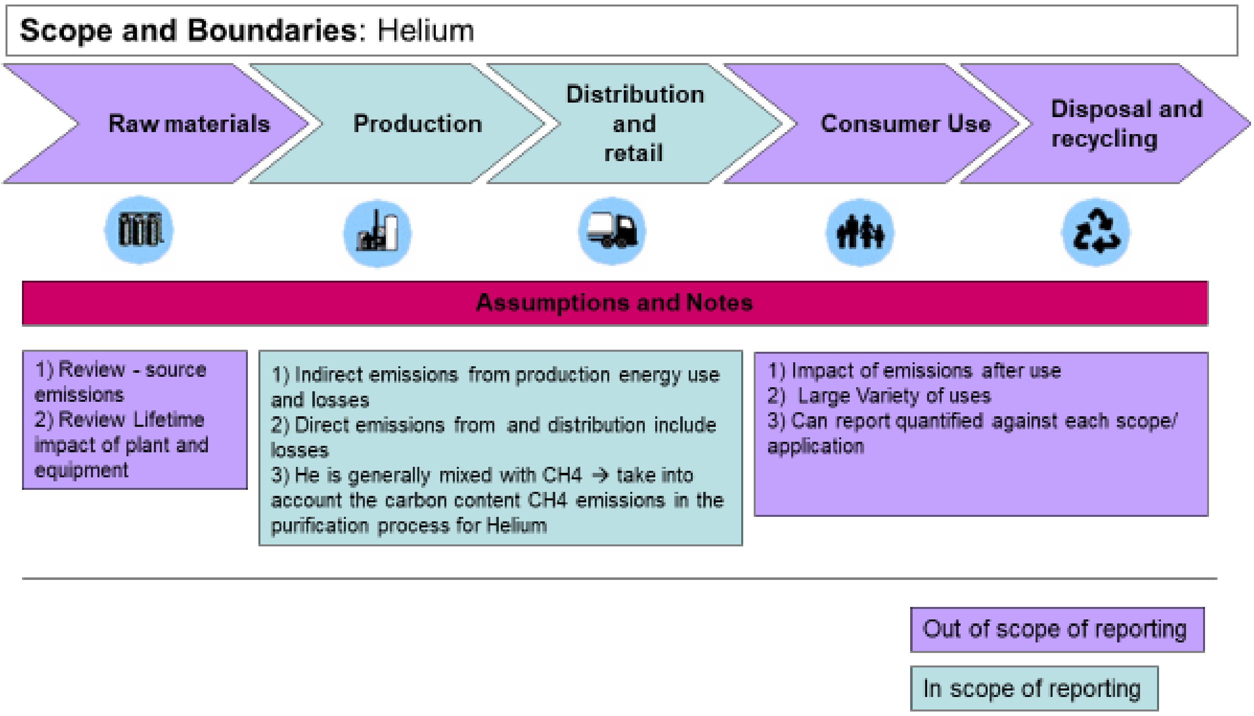
Appendix A - Examples

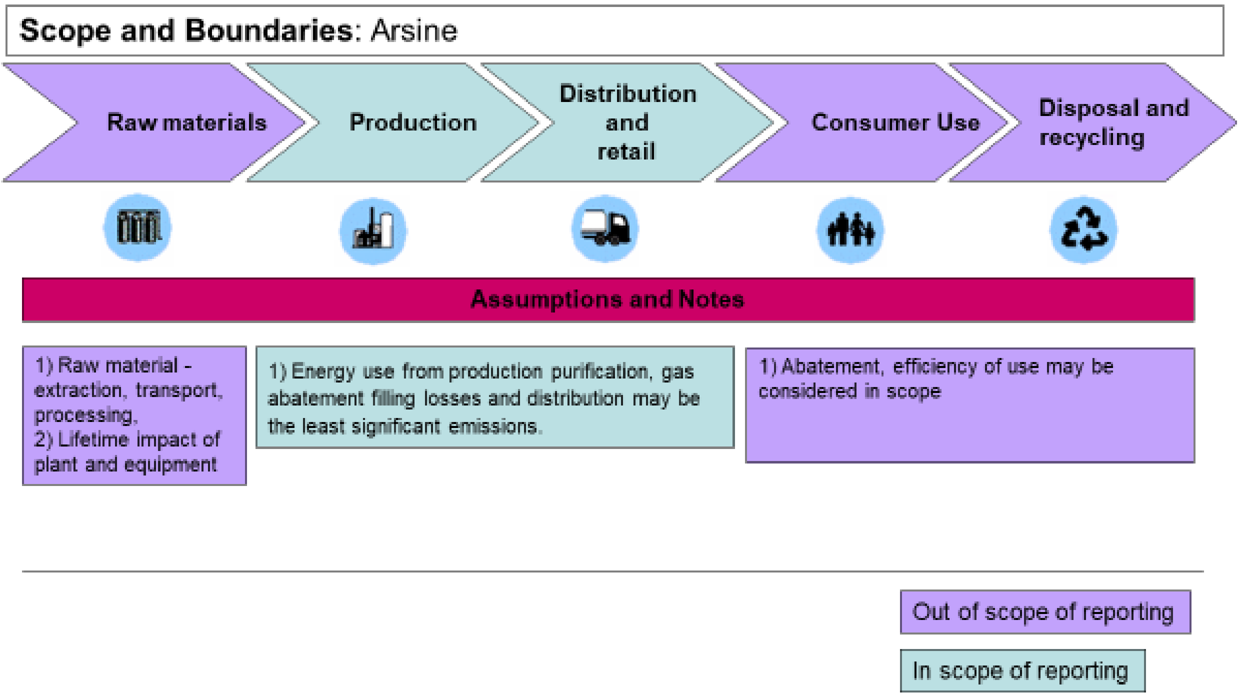


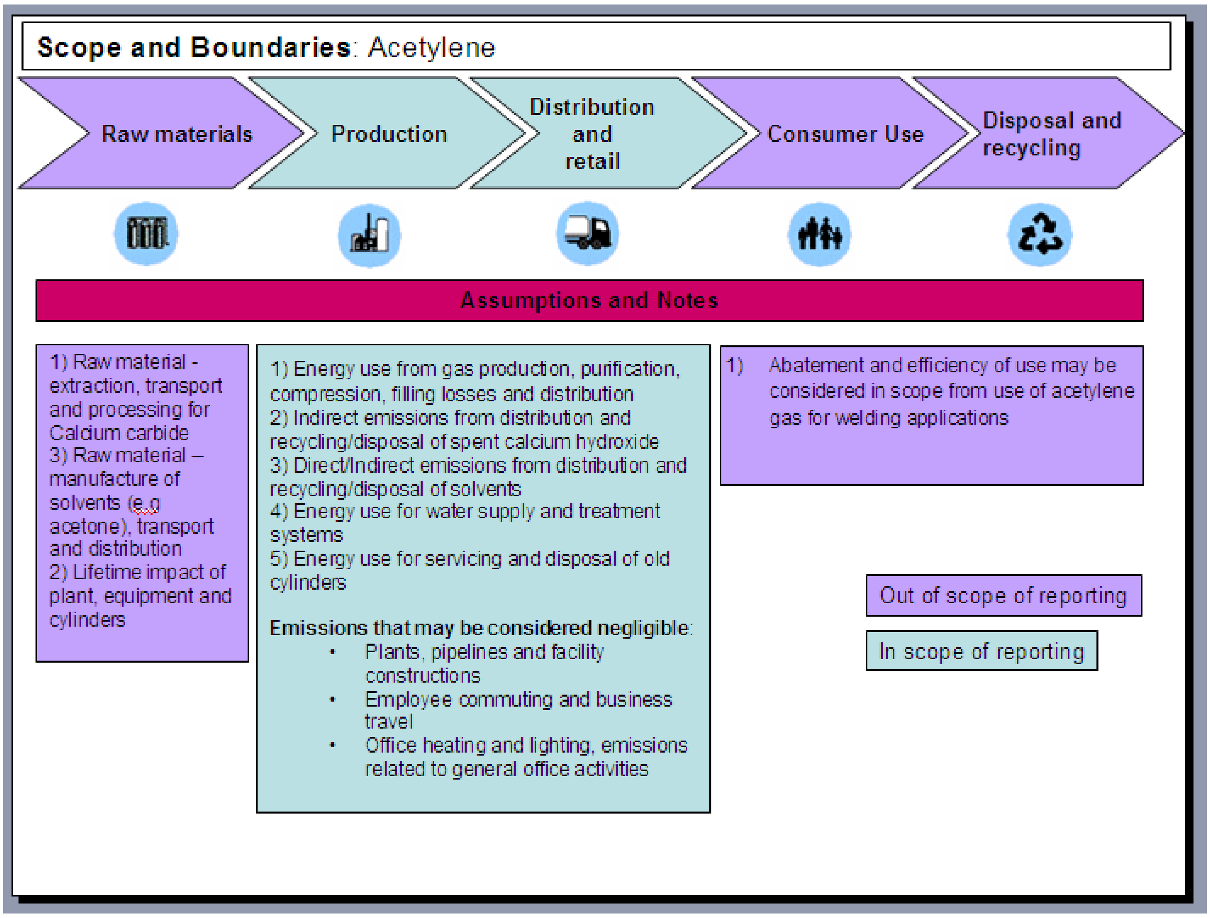




NOTE Emissions from carbon dioxide product use are not reported by EIGA members as scope is business to business.




Scope and Boundaries: Arsine
Raw materials
Production
Distribution and retail
Consumer Use
Disposal and recycling
Assumptions and Notes
1) Raw material - extraction, transport, processing,
2) Lifetime impact of plant and equipment
1) Energy use from production purification, gas abatement filling losses and distribution may be the least significant emissions.
1) Abatement, efficiency of use may be considered in scope
Out of scope of reporting
In scope of reporting


Scope and Boundaries: Acetylene
Raw materials
Production
Distribution and retail
Consumer Use
Disposal and recycling
Assumptions and Notes
1) Raw material - extraction, transport and processing for Calcium carbide
3) Raw material – manufacture of solvents (e.g acetone), transport and distribution
2) Lifetime impact of plant, equipment and cylinders
1) Energy use from gas production, purification, compression, filling losses and distribution
2) Indirect emissions from distribution and recycling/disposal of spent calcium hydroxide
3) Direct/Indirect emissions from distribution and recycling/disposal of solvents
4) Energy use for water supply and treatment systems
5) Energy use for servicing and disposal of old cylinders
Emissions that may be considered negligible:
• Plants, pipelines and facility constructions
• Employee commuting and business travel
• Office heating and lighting, emissions related to general office activities
1) Abatement and efficiency of use may be considered in scope from use of acetylene gas for welding applications
Out of scope of reporting
In scope of reporting

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" [9]).

Country	CO2 emissions per kWh from electricity and heat generation [kg/MWh]
Austria	183
Belgium	239
Czech Republic	534
Denmark	311
Finland	207
France	89
Germany	447
Greece	739
Hungary	326
Ireland	482
Italy	416
Luxembourg	282
Norway	10
Poland	652
Portugal	379
Romania	(no data)
Slovak Republic	337
Spain	337
Sweden	41
Switzerland	40
Turkey	484
United Kingdom	480
EU – 27 average	356
USA	531
Japan	435

Table 1 CO2 emissions per kWh from electricity and heat generation

Direct CO2 emissions from fuel combustion - For transportation emissions [9]:

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

Table 2 CO2 emissions from fuel combustion

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

Table 3 CO2 emissions linked to construction material

2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 1: Introduction, Table 1.4 [10]

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	
		A	B	C=A*B*44/12*1000	Lower	Upper
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.

2007/589/EC: Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, Table 4 [11]

Table 4

Fuel emission factors related to net calorific value (NCV) and net calorific values per mass of fuel

Fuel type description	Emission factor (tCO_2/TJ)	Net calorific value (TJ/Gg)
	2006 IPCC guidelines (except biomass)	2006 IPCC guidelines
Crude oil	73,3	42,3
Orimulsion	76,9	27,5
Natural gas liquids	64,1	44,2
Motor gasoline	69,2	44,3
Kerosene	71,8	43,8
Shale oil	73,3	38,1
Gas/diesel oil	74,0	43,0
Residual fuel oil	77,3	40,4
Liquefied petroleum gases	63,0	47,3
Ethane	61,6	46,4
Naphtha	73,3	44,5
Bitumen	80,6	40,2
Lubricants	73,3	40,2
Petroleum coke	97,5	32,5
Refinery feedstocks	73,3	43,0
Refinery gas	51,3	49,5
Paraffin waxes	73,3	40,2
White spirit and SBP	73,3	40,2
Other petroleum products	73,3	40,2
Anthracite	98,2	26,7
Coking coal	94,5	28,2
Other bituminous coal	94,5	25,8
Sub-bituminous coal	96,0	18,9
Lignite	101,1	11,9
Oil shale and tar sands	106,6	8,9

Fuel type description	Emission factor (tCO_2/TJ)	Net calorific value (TJ/Gg)
	2006 IPCC guidelines (except biomass)	2006 IPCC guidelines
Patent fuel	97,5	20,7
Coke oven coke and lignite coke	107,0	28,2
Gas coke	107,0	28,2
Coal tar	80,6	28,0
Gas works gas	44,7	38,7
Coke oven gas	44,7	38,7
Blast furnace gas	259,4	2,5
Oxygen steel furnace gas	171,8	7,1
Natural gas	56,1	48,0
Industrial wastes	142,9	n.a.
Waste oils	73,3	40,2
Peat	105,9	9,8
Wood/wood waste	0	15,6
Other primary solid biomass	0	11,6
Charcoal	0	29,5
Biogasoline	0	27,0
Biodiesels	0	27,0
Other liquid biofuels	0	27,4
Landfill gas	0	50,4
Sludge gas	0	50,4
Other biogas	0	50,4
	Other sources	Other sources
Waste tyres	85,0	n.a.
Carbon monoxide	155,2	10,1
Methane	54,9	50,0