Climate Governance: Implementing public policies to calculate and reduce organisations carbon footprint

**LIFE Clim'Foot**
**Project No.: LIFE14 GIC/FR/000475**

# Deliverable A2.2:
# Methodology for constituting the National Databases

## ACTION A.2.1. Definition of the methodology for constituting the National DataBase

## Leader: ENEA

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## Glossary

**Biogenic carbon** carbon that is contained in biomass.

**calculation** (quantitative): is an act of obtaining the value of a given property through mathematical operations or models involving already known data related to the desired property.

**Data Quality Rating (DQR):** Semi-quantitative assessment of the quality criteria of a dataset based on (to be completed)

**Direct GHG emissions**: Emissions from sources that are owned or controlled by the reporting company

**Emissions**: The release of GHG into the atmosphere

**Emission factor**: A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g. tonnes of fuel consumed, tonnes of product produced) and absolute GHG emissions

**Estimation** (quantitative and/or qualitative): is an act of obtaining the value of a given entity, not involving measured or otherwise known quantities related to the desired quantity. However, more generally, "estimation" may also indicate any method of obtaining the quantitative and/or qualitative expression for a given entity not solely based on direct measurements.

**measurement** (quantitative): is an act of determination of the magnitude of a quantity by comparison with a standard unit for that quantity.

**Fugitive emissions**: Emissions that are not physically controlled but result from the intentional or unintentional releases of GHGs. They commonly arise from the production, processing transmission storage and use of fuels and other chemicals, often through joints, seals, packing, gaskets, etc

**Indirect emissions**: Emissions that are a consequence of the operations of the reporting company, but occur at sources owned or controlled by another company

**Intergovernmental Panel on Climate Change**: International body of climate change scientists. The role of the IPCC is to assess the scientific, technical and socio-economic information relevant to the understanding of the risk of human-induced climate change (www.ipcc.ch)

**Inventory**: A quantified list of an organization's GHG emissions and sources

**Kyoto Protocol**: A protocol to the United Nations Framework Convention on Climate Change (UNFCCC). Once entered into force it will require countries listed in its Annex B (developed nations) to meet reduction targets of GHG emissions relative to their 1990 levels during the period of 2008–12

**Land Use Change**: change in the purpose for which land is used by humans (e.g. between crop land, grass land, forest land, wetland, industrial land). Refers to emissions or sequestration of carbon associated with changes in land management practices.

**Life Cycle Inventory (LCI) dataset**: A document or file with life cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life cycle inventory . A LCI could be a unit process dataset, Unit process dataset – partially aggregated or an aggregated dataset. (to be adapted to the case of only carbon-related data).

**Mobile combustion**: Burning of fuels by transportation devices such as cars, trucks, trains, airplanes, ships etc

**Reporting**: Presenting data to internal management and external users such as regulators, shareholders, the general public or specific stakeholder groups

**Scope**: Defines the operational boundaries in relation to indirect and direct GHG emissions

**Stationary combustion**: Burning of fuels to generate electricity, steam, heat, or power in stationary equipment such as boilers, furnaces etc

# 1 Aim of the document

The aim of Deliverable A2.2 is to define the methodology for constituting the National Databases of Country-specific Emission Factors (EF). A common methodology is necessary for achieving consistency in the EF creation, sharing data within the project and for further replications of the project results.

The National Databases will then be the basis for constituting the Clim'Foot database, and can be used to calculate the Carbon Footprints of Organizations (CFO).

After the introduction, the document provides a description of the reference context, the definition of the database content and the criteria for data collection. A focus on the Energy Sector is included, and a proposal for a data quality management plan is discussed.

The chapter 3 on the reference context includes an overview of the methodological references for the definition of the methodology to constitute EF National databases, with a focus on developing CFO and related methodological issues.

The chapter 4 on the database content defines the information that should be implemented in the databases, identifies the reference greenhouse gases and the classification structure for datasets implementation, including some suggestions concerning a structure of dataset suitable to evolve from a single impact database (GHG) to a broaden environmental footprint database, i.e. including several impact indicators. The main sectors identified for the National Databases are also reported.

The chapter 5 on data collection gives an overview of the main sources of data to constitute a National Database, with some examples on the development of datasets from different sources of data such as Life Cycle Inventory (LCI) and National Inventory Reports (NIR)

The chapter 6 on Energy Sector and 7 on Transport are examples of how to constitute several datasets from different data sources . This is a tutorial that can be replicated for all the other Sectors included in the National Databases.

Finally, the chapter 8 on the Data quality management plan gives recommendations on data quality management, data quality control and verification of data.

## 2 Introduction

The increasing of global average temperature for about 0.85$^0$ C in the last 20 years is due to human activities, mainly burning fossil fuels, cutting down rainforests and farming livestock.
An increase of 2°C compared to the temperature in pre-industrial times is considered by scientists as the threshold beyond which the likelihood/risk of dangerous and possibly catastrophic events is very high. For this reason at the Paris Climate Conference (COP21) in December 2015, 195 countries agreed on a global action plan to limit global warming to well below 2°C above pre-industrial levels. The national climate action plans presented in Paris are not enough to reach this target, but show the trend that is necessary to follow. The EU countries have already started to deal with this problem. In particular, together with Iceland they endorsed the Kyoto protocol (1998) and were committed to cut the greenhouse gas emissions with a 20% reduction target compared to 1990 by 2020.
This reduction is shared in the following way:

1. The EU is responsible for emissions in sectors covered by the emission trading system (ETS);
2. Each country is responsible for its national emissions in the sectors outside the ETS[1].

The EU[2] has identified among the ETSs sectors the main producers of the GHG emissions as follows:

- **Carbon dioxide ($CO_2$) from**
  - Power and heat generation
  - Energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals
  - Commercial aviation
- **Nitrous oxide ($N_2O$)** from production of nitric, adipic, glyoxal and glyoxlic acids
- **Perfluorocarbons (PFCs)** from aluminium production

The EU ETS covers about 45% of total greenhouse gas emissions and concerns organizations' direct emissions. The organizations that are out of the ETS system could apply this framework for the mitigation of their GHG emissions but, according to a study published by ADEME (2010), about the 70% of their carbon footprint is constituted by indirect emissions. So direct emissions are not the main levers for reducing their contribution to global warming, but a broader approach, encompassing also indirect emissions (carbon footprint-CF) should be adopted. However, to develop policies and involve private and public organizations in reducing their carbon footprint, it is necessary to provide reliable data, tools and methodologies. Besides the environmental advantages due to the mitigation actions that can be introduced, the application of the CFO provides the organisations with the opportunity to reduce management costs, to optimize resources, to build stronger relationships within their supply chain, to innovate and to improve their management system.
The LIFE Clim'Foot project (*Climate Governance: Implementing Public Policies to Calculate and Reduce Organisations' Carbon Footprint*), which is coordinated by ADEME and involves five EU countries and seven partners (www.climfoot-project.eu/), aims to fill this gap and to propose tools and policies for the reduction of CFO. The main goals of the project are:

- to launch a dynamic European network for carbon accounting;

[1] (http://ec.europa.eu/clima/policies/strategies/progress/kyoto_2/index_en.htm
[2] http://ec.europa.eu/clima/policies/ets/index_en.htm

- to develop a complete tool box for calculating and reducing the carbon footprint of organisations including the development of five national databases on Emission Factors[3] (EF) for the calculation of CFO for each country involved in the project and of training materials and sessions for end-users.

ENEA, with the collaboration of Ecoinnovazione srl[4], is developing a common structure of the national databases and is setting the rules for the definition of the Country-specific EFs. The creation of EF National databases, including free country-specific and reliable data, is necessary to support the implementation of CFO in public and private organizations.

Moreover this is considered as a way to increase the awareness of the enterprises towards the application of life cycle methods, such as Life Cycle Assessment (LCA), which is the most complete and advanced method having a full set of impact categories. Indeed, CFO can be seen as an "entry level" of life cycle approaches, combining simplicity and connection with an urgent and well-known environmental problem, the climate change.

[3] A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g. tonnes of fuel consumed, tonnes of products) and absolute GHG emission (GHG, 2004)

[4] www.ecoinnovazione.it

# 3 Reference context

## 3.1 Methodology Reference

The following references have been considered for the methodology definition of Clim'Foot National Databases:

- **Standards for carbon footprint for product and organization**
  - GHG Protocol[5] Corporate Accounting and Reporting Standard - The Corporate Standard provides instruction on how a company should perform a GHG inventory; it covers scopes 1 and 2 (see also the Scope 2 Guidance.)
  - GHG Protocol Corporate Value Chain (Scope 3) Standard - This standard provides instruction on how a company should perform a scope 3 GHG inventory, which includes emissions throughout a company's value chain.
  - GHG Protocol Product Life Cycle Standard the Product Life Cycle Standard instructs users on accounting for the emissions of a product's full life cycle; users can learn to focus efforts on the greatest GHG reduction opportunities in order to develop more sustainable products.
  - ISO 14064:2006 Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals
  - ISO/TR 14069:2013 Greenhouse gases Quantification and reporting of greenhouse gas emissions for organizations -- Guidance for the application of ISO 14064-1.
  - ISO/TS 14067:2013 Carbon footprint of products - Requirements and guidelines for quantification and communication
  - ISO/TS 14072_2014 Environmental management – Life cycle assessment – Requirements and guidelines for organisational life cycle assessment.
  - PAS 2050:2011 assessment of the life cycle greenhouse gas emissions of goods and services
- **Standards for LCA at product level**
  - ISO 14040:2006 - Environmental management -- Life cycle assessment -- Principles and framework
  - ISO 14044:2006 -Environmental management -- Life cycle assessment -- Requirements and guidelines
- **EU Commission Recommendation (2013/179/EU) on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations**
  - Product Environmental Footprint (PEF) Guide, Annex II,
  - Organization Environmental Footprint (OEF) Guide, Annex III
- **IPCC**
  - 2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES
  - Climate Change 2013, The Physical Science Basis Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 2013

In the project **the main reference for the methodology to develop the national databases is the IPPCs, that define the methodology to calculate GHG emission factors for the sector of energy, waste, agriculture, industrial process and product use**.

[5] The Greenhouse Gas Protocol (GHG Protocol), developed by World Resources Institute (WRI) and World Business Council on Sustainable Development (WBCSD), is an international accounting tool for government and businesses to understand, quantify, and manage greenhouse gas emissions (http://www.ghgprotocol.org/). It offers multiple online learning solutions on the different GHG accounting standards.

## 3.2 Notes on Carbon Footprint of Organizations

The aim of Clim'Foot Database of Country specific EF is to guarantee the correct calculation of carbon footprint in European Organizations. Indeed specific and reliable data is considered a fundamental element to support them in the identification of improvement options and in the reduction of direct and indirect GHG emissions.
The reference documents for the Calculation of CFO are GHG protocols for Organizations and ISO 14064. Both documents define what an Organization should do to identify, measure and communicate the GHG emissions produced (directly and indirectly) from all the activities across the organization, including energy used in buildings, industrial processes and company vehicles (commonly referred to a year).

The approach to calculate the CF is similar in both documents. The Standard ISO, like all the standards, provides the reference framework for calculating the CFO, without going into the detail of its implementation. On the other hand, the GHG protocol is more descriptive and contains motivational reasons for GHG reporting. (Dawson and McGray, 2004).
They consider two types of organization boundaries:

- Control: the organization accounts for all quantified GHG emissions and/or removals from facilities over which it has financial or operational control.
- Equity share approach: The organization accounts for its portion of GHG emissions and removals from respective facilities (ISO 14064).

The GHG protocols and ISO propose the classification of three types of emissions:

1. ***Direct GHG emissions***: Emissions from greenhouse gas sources owned or controlled by the company.
2. ***Energy indirect GHG emissions***: Emissions from the production of purchased energy used by the company (electricity, heat or steam).
3. ***Other indirect GHG emission***: e.g.: emissions from business travel by employees, transport of products and materials, waste generated by the organization but managed by another organization.

The GHG Protocol documents define these emissions as ***Scope 1, Scope 2*** and ***Scope 3,*** respectively. The same nomenclature is adopted in this technical report.

Figure 1 reports the scheme of types of emission, their classification in the different sources and the kinds of emissions accounted for in the reports on Categories Corporate Accounting and Reporting Standard on Corporate Value Chain (Scope 3).

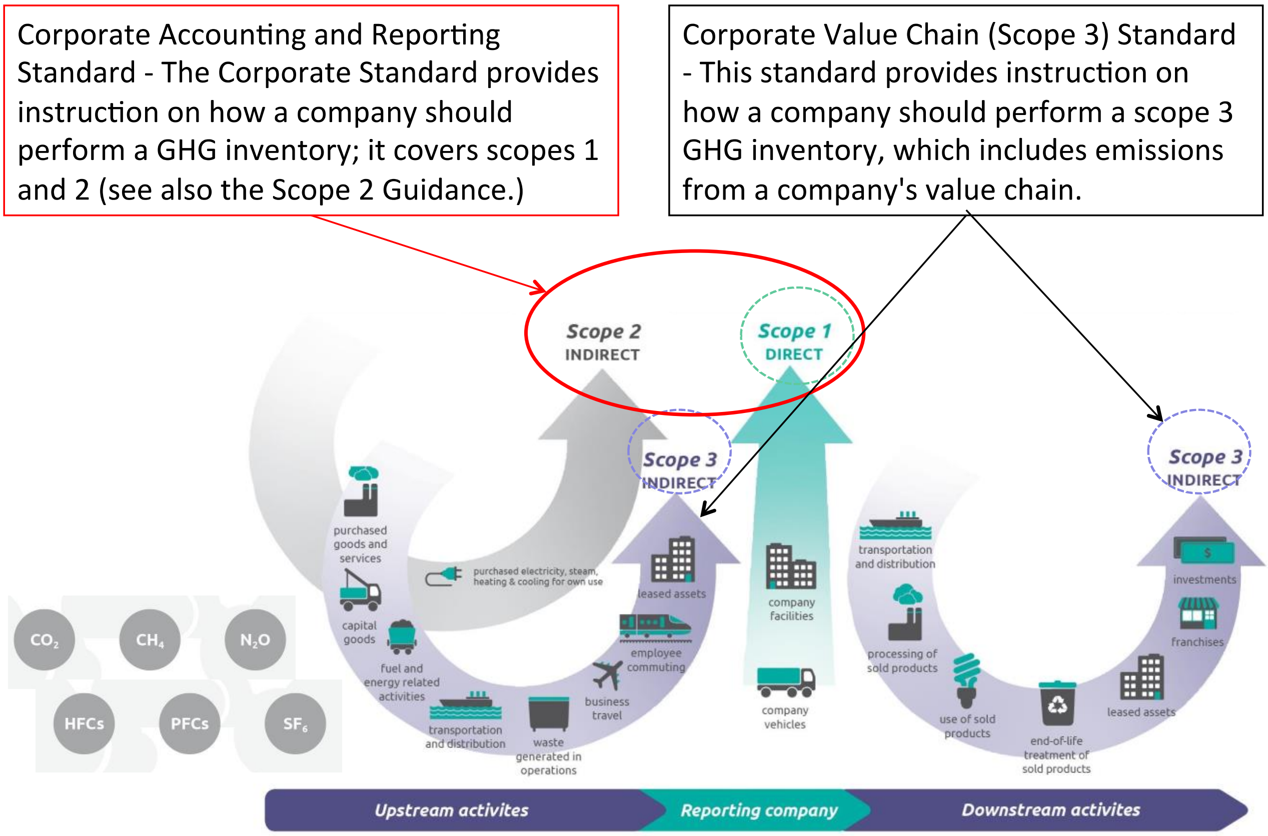



**Figure 1 Classification of GHG emission to calculate CF in GHG protocol (2013)**

For the CFO the Organization that collects data must highlight the difference of the direct and indirect emissions. The emissions reported in Scope 1 are:

- Combustion of fuels and/or Wastes
- Process and Fugitive emissions from:
    - Air conditioning and cooling
    - Agriculture
    - Industrial process
    - Wastes
- LULUCF[6] (Land use, Land Use Change and Forestry)

In Scope 2 the Organization collects the emissions from the production of the purchased energy used by the company (electricity, heat or steam) and does not include the transmission and distribution losses that are accounted for in Scope 3. By definition, scope 3 emissions occur from sources owned or controlled by other entities in the value chain (e.g., materials suppliers, third-party logistics providers, waste management suppliers, travel suppliers, lessees and lessors, franchisees, retailers, employees, and customers) (GHG, 2011).

Scope 3 includes:

- Emissions from activities in the value chain of the entities included in the company's organizational boundary
- Emissions from leased assets, investments, and franchises that are excluded from the company's organizational boundary but that the company partially or wholly owns or controls. (GHG, 2011)

[6] The LULUCF covers greenhouse gas (GHG) emissions into the atmosphere and removal of carbon from the atmosphere resulting from our use of soils, trees, plants, biomass and timber.

These kinds of accounting shall be considered in the construction of database.

## 3.1 Methodological Issues

In the construction of National Databases some methodological issues on Carbon Footprint should be highlighted. The way they are faced is different in the methodological references considered. In particular for each issue the deliverable reports the approach proposed by the GHG product Standard, the PAS 2050 and the PEF-OEF documents.
Recommendations are given below about the approach suggested for Clim'Foot.

### *3.1.1 Land Use, Land Use Change and Forestry (LULUCF) Land Use Change*

The **Land Use, Land Use Change and Forestry (LULUCF)** activities cover removal (sinks) as well as emissions of greenhouse gases. Emissions from this source occur for $CO_2$, $N_2O$ and $CH_4$ from clearing of forests and vegetation, flooding of land and from application of fertilizers and lime.
Land Use Change refers to emissions or sequestration of carbon associated with changes in land management practices by humans (e.g. between crop land, grass land, forest land, wetland, industrial land).

The GHG Protocol Product Standard includes land use change within the inventory results and requires separate reporting for transparency. It provides guidance for estimating direct land use change using average statistical data but also allows for the worst case scenario to be assumed and to calculate land use change emissions. Moreover reporting indirect land use change is not a requirement, but it can be accounted for separately.

The PAS 2050 includes land use change within the assessment and requires recording the type and timing of land use change. It does not require the use of worst case scenarios where previous land-use is unknown, allowing for average statistical data to determine direct land use change impacts. PAS 2050 provides some default values for land converted to cropland but reverts to IPCC for other types of land use change. Indirect land use change is not included.
In PEF-OEF carbon exchanges from deforestation, road construction or other soil activity are covered with the land use and land transformation indicators. Moreover it suggests following the PAS 2050 to model the direct land use change for horticultural product.

These emissions are always accounted for separately.
**In the national databases the LULUCF should be implemented for the national contest, taking data from IPPC2006** (Volume 4 Agriculture, Foresty and Other land Use), **National Inventory, and national statistical data**.

### *3.1.2 Biogenic Carbon*

Biogenic Carbon is carbon contained in biomass.

PAS 2050 requires biogenic emissions and removals to be included in the assessment, and excludes biogenic carbon for food and feed. This is on the grounds that they are short cycle products so the emissions & removals are likely to cancel each other out (and avoids the need to include CO2emissions from animal digestion). Note that for PAS2050, $CO_2$ from air converted to non-biomass carbonates is calculated as biogenic carbon.

GHG Protocol requires biogenic emissions and removals to be included in the assessment. It includes biogenic carbon in the inventory for all products and requires separate reporting for additional transparency.
PEF-OEF defines two options for modelling the biogenic carbon:

- Option 1: modelling all biogenic carbon uptakes and releases. This allows carbon tracking and assures that all flows are included. It may require complex modelling for a zero impact in the end.
- Option2 simplified modelling of only those flows that influence the climate change impact results (namely biogenic methane emissions and not modelling biogenic dioxide uptakes and emissions).

**In the national databases these emissions are accounted separately as well as the $CH_4$ biogenic**.

# 4 Database Contents

This section defines the information that should be implemented in the National Databases and identifies the reference greenhouse gases and the classification structure for datasets implementation, including some suggestions concerning a structure of dataset suitable to evolve from a single impact database (GHG) to a broaden footprint database. The main sectors identified for National Databases as well as the structure of the methodological report for each sector are also reported.

## 4.1 Gases included

The Clim'Foot DB includes the greenhouse gases covered by the Kyoto Protocol

- **Fossil Carbon dioxide** ($CO_2$)
- **Biogenic Carbon dioxide** ($CO_2$)
- **Methane** ($CH_4$)
- **Biogenic methane** ($CH_4$)
- **Nitrous oxide** ($N_2O$)
- **Hydrofluorocarbons** (HFCs)
- **Perfluorocarbons** (PFCs)
- **Sulphur hexafluoride** ($SF_6$)
- **Nitrogen trifluoride ($NF_3$)**

Nitrogen trifluoride ($NF_3$)[7] as been recently added to the requirements of Scope 3 Standard and Product Standard.

The emitted gases are reported as kg $CO_{2eq}$ using the characterization factors of IPCC 2013 reported in Table 1

The Biogenic Carbon dioxide ($CO_2$) is always accounted separately

**Table 1 Characterization factors from IPPC 2013**

| Gases- common name | Chemical formula | Characterization Factor in CO2eq |
|---|---|---|
| Fossil Carbon dioxide ($CO_2$) | $CO_2$ | 1 |
| Biogenic Carbon dioxide ($CO_2$) | $CO_2$ | - |
| Methane | $CH_4$ | 30 |
| Biogenic methane | $CH_4$ | 28 |
| Nitrous oxide | $N_2O$ | 265 |
| Hydrochlorofluorocabons[8] | CHFs | - |
| Perfluorocarbons[9] | PFCs | - |
| Sulphur hexafluoride | $SF_6$ | 23500 |
| **Nitrogen trifluoride** | **$NF_3$** | 16100 |

## 4.2 Classification

A hierarchical classification of processes is proposed, considering three levels:

[7] Nitrogen trifluoride is used in the plasma etching of silicon wafers. Today nitrogen trifluoride is predominantly employed in the cleaning of the chambers in the high-volume production of liquid-crystal displays and silicon-based thin-film solar cells. Nitrogen trifluoride is also used in hydrogen fluoride and deuterium fluoride lasers, which are types of chemical lasers.

[8] See Annex1for the complete list.

[9] See Annex 1 for the complete list

– Level 1 (main category),
– Level 2 (first subcategory)
– Level 3 (second subcategory)

The Table 2 shows the classification proposed by ADEME

**Table 2 Category organization**

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| Fuel | Fossil | Solid |
| | | Liquid |
| | | Gas |
| | Organic | Solid |
| | | Liquid |
| | | Gas |
| Process and fugitive | Cooling and refrigerant | cooling |
| | | refrigerant |
| | Industrial | Decarbonisation |
| | | Other |
| | Agriculture | Soil |
| | Waste | Solid |
| | | liquid |
| LULUCF | LUC | |
| | Forestry | |
| Electricity | Average grid | |
| | Type of production | Fossil/nuclear |
| | | renewable |
| Heating/cooling grid | heating network | |
| | Cooling network | |
| Transport | Freight | Air |
| | | Road |
| | | Rail |
| | | Sea/Rivers |
| | People | Air |
| | | Road |
| | | Rail |
| | | Sea/Rivers |
| Products and process | Agriculture | Vegetable |
| | | Meat |
| | | Liquid |
| | Agro industy | Vegetable base |
| | | Meat base |
| | | Mixed base |
| | | Liquid |
| | Plastics&chemical products | Plastics |
| | | Chemicals |
| | Metals | Steel |
| | | Aluminium |
| | | Other |
| | Machine and equipment | Electric and electronics |

| | | |
|---|---|---|
| | | IT and office equipments |
| | | Others |
| | Minerals and non metals | Cements, lime and plaster |
| | | Asphalt concrete for roads |
| | | Granulat/pierre de carrière |
| | | Glass |
| | Wood | |
| | Paper and carton | |
| | Buildings and Construction | Buildings |
| | | Road |
| | Other | |
| Services | | |

The Table with the list of 150 European EF is reported in the Annex 5.

## 4.3 Data set

Each data set of EF represents a unit process of human activity that exchanges GHG emission with the environment. **The activity can be referred to process/good/service and** it is important to determine the **reference flow** of each activity, i.e. the measure of the **process/good/service** output taken into account for each dataset.

**A data set has to describe and quantify this activity in terms of emission factor. Indeed each data set should be composed by four main parts (see**

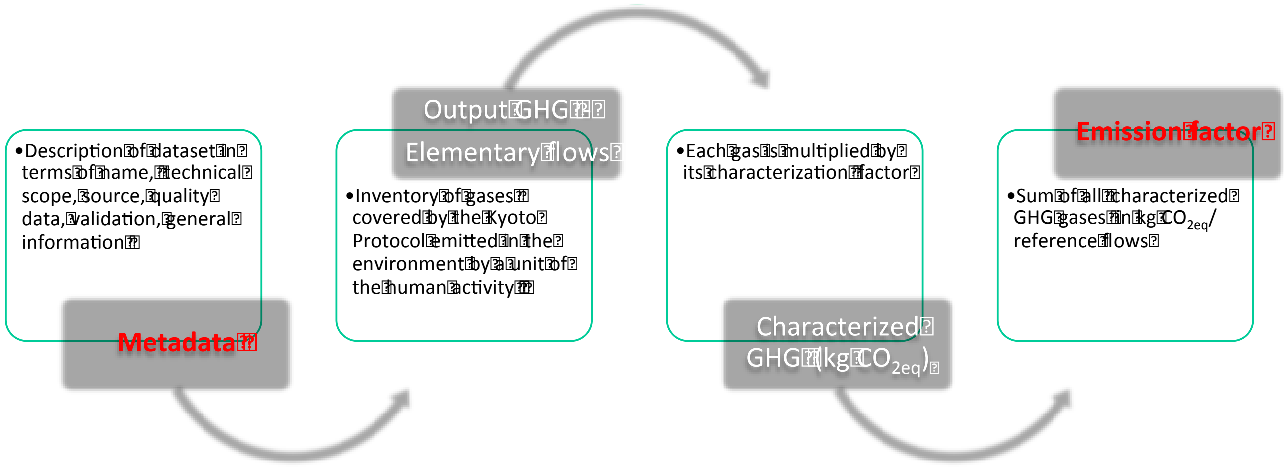



Figure 2 ):

- **metadata**: they provide a description of the data set with the aim to guaranty clear information to support the end user in the choice of dataset for the Carbon footprint calculation;
- **elementary flows:** all the GHG gases emitted in the environment by the human activity described in the data set with the quantity related to the amount of activity considered;

– **charactererized GHG** in $CO_{2eq}$: all GHG emitted gases are multiplied by their characterization emission factor as reported in Annex 1 **emission factor:** this is obtained by adding all different emissions of the human activity described in the data set expressed in $CO_{2eq}$ (mass unit of $CO_{2eq}$/ amount of activity – i.e. $kgCO_{2eq}$/1kg $CH_4$ production). The Biogenic Carbon dioxide ($CO_2$) is always accounted separately.

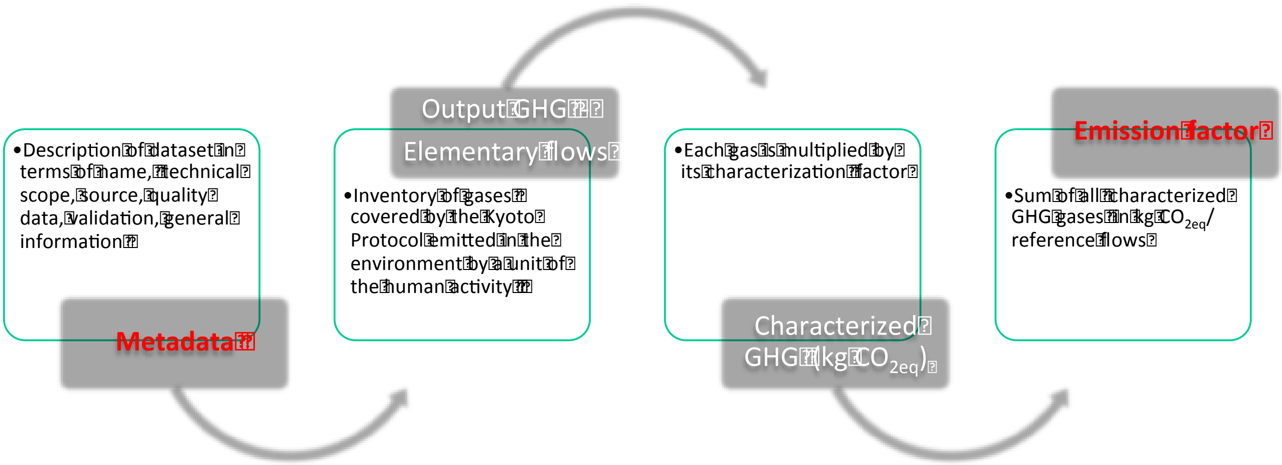



**Figure 2 The data set scheme, in Red mandatory part to be displayed. The other information can be reported if available.**

### *4.3.1 Metadata - Data description*

Data documentation provides a description of the data set with the aim to guarantee clear information to support the end user in the choice of dataset for the Carbon footprint calculation. Moreover the documentation intends to support a transparent reporting, interpretation and review of data collection, data calculation, data quality and data reporting, as well as facilitating data exchange.

The ISO 14048 provides the requirements and structure for a data documentation format, which consists of three parts:

– **Process description** describes the unit process. It includes the name, function, technical scope.
– **Modelling and validation** describes the modelling of a process as well as the validation of the resulting model. It includes allocation procedure and all the methodological choices made, e.g. which principles to use and what assumptions and exclusions to make. The relevance and the general quality of the data are based on these choices. Therefore, this documentation is valuable for a data user when interpreting the relevance and quality of the data for a specific goal and scope definition.
– **the administrative information** describes properties of the documentation of a process that is not directly related to the model, but to the administration of its documentation.

The Table 3 shows the kind of metadata that should be collected for the national databases. In red the mandatory fields are highlighted.

**Table 3 data description**

| General Information | | |
|---|---|---|

| Information | Description of content | typology |
| --- | --- | --- |
| Process name (***)(*) | This is a descriptive name for the activity e.g. Lamp Assembly Line. The process names must be unique and consistent across the project. | *Guidance to define how to set the name - max characters 100 => check text to better research on the website – separation between tags with " ,* |
| Synonym (***) | Use this field to record any other names by which the process is known by (eg a name which differs from the one assigned by the Environment Agency but which is more familiar to you). | *Guidance to define how to set the name - max characters 100 => check* |
| ClimFOOT ID | This number will be composed by two capital letters that define the Nation IT, FR, HR, GR, HU and five number example **IT00001** | text |
| Copyright | **Clim'Foot project** (except data already protected by copyright: in this case it has to be declared) | text |
| Data collector's organisation | This is the name of the partner's organisation. | |
| Source | Reference of data source | *text* |
| Creation date | The date of completion of this version of the dataset. | *format : day/month/year* |
| Modification Date | The date of modification of this version of the dataset | *format : day/month/year* |
| **Activity Description** | | |
| Unit (*) | Example: mass (kg, g, ecc); volume (m^3, l, ...) energy (kwh, Mwh, J, ...) | |
| Technical Description (***)(*) | A short description of the process (or combination of unit processes), and/or lists of unit processes with definition of system boundary | |
| Technological representativeness –TeR (*) | Technical data quality level to assess representatives of the technology used. (See chapter 8 and Table 38) | |
| Uncertainty | See chapter 8 and Table 38 | |
| Year(s) of validity (*) | Years of validity for data set | |
| Time representativeness –TiR (*) | Time data quality level to assess representatives of the technology used. (See chapter 8 and Table 38 ) | |
| Geographic Reference (***) (*) | The geographical area. | |
| Geographical representativeness –GeR (*) | Geographical data quality level to assess representatives of the | |

| | | |
|---|---|---|
| | technology used. (See chapter 8 and Table 38 ) | |
| Data Quality Statement (***)(*) | Use this box to add any other information which might indicate weaknesses in data quality or difficulties in use or interpretation of the data. | |
| **Data Acquisition** | | |
| Source and Reliability | It relates to the source of the information used to create the dataset, according to documentation, flows and meta information, and to the way in which the information has been elaborated. The elaboration of the data shall be documented adopting the following classification:<br>– Verified measurement<br>– Unverified measurement or verified calculation<br>– Unverified calculation<br>– Documented estimate<br>– 5 Undocumented estimate | |
| **Information sources** | | |
| Validation | Valid/Archived | text |
| Validation note | | text |
| General information (***)(*) | ISO: In addition to the overall documentation of the activity some general information may be supplied regarding for instance, advice on how to use the activity, recommendations on the applicability of the activity, known limitations Reference data source, etc. | text |

**Note:**
**The data set amount has to always referred to 1. It is possible change the unit**

(***) This information should be translated in English and in National languages,
(*) This information is mandatory.[10]

In the project each data set generated should be provided with a data documentation as shown in the example below. This format is appropriate to evolve from a single impact database (GHG) to a broaden environmental footprint database.

**Example**
In the example *beverage carton - generic - 1000.0 m² (Area)* process retrieved by ELCD database is considered. This process is reported as screenshot from the ELCD database in Annex 2 .

**The information reported in the data documentation is reported in the metadata shows in**

Table 4
The amount considered in the Clim'Foot dataset is reported to be the beverage carton - generic - **1** $m^2$ (Area).

**Table 4 Metadata of beverage carton - generic - 1 m2 (Area)**

| **General Information** | |
|---|---|
| *Information* | *Description of content* |
| **Process name (***)(*)** | Beverage carton converting (EU-27) |
| **Synonym** (***) | |
| ID Number | |
| Copyright | ELCD database |
| Data collector's organisation | Converting of Beverage Cartons |
| Source | ELCD database |
| Creation date | |
| Modification Date | |
| **Activity Description** | |
| **Amount** | **1** |
| Unit (*) | $m^2$ |
| Technical Description (***)(*) | converting mix, at plant. The manufacture of transport packaging materials, such as typically cardboard or shrink foil required for delivery to the filler is excluded in the LCI dataset presented here.<br>This parameterised data set is a gate-to gate data set that lists the inputs and outputs directly connected to the converting of LDPE granulate, liquid packaging board and aluminium foil to beverage carton.<br>This technology could be different from the average technology underlying this dataset in case of a particular site or in a regional context with a particular legal framework. For guidance a typical one litre aseptic carton for milk might for example comprise 78.5% board, 16.5% PE and 5% aluminum foil; while a typical one litre chilled carton could be 82.5% liquid packaging board and 17.5% LDPE. |
| Technological representativeness –TeR (*) | Good |
| Uncertainty | Not documented |
| Year(s) of validity (*) | 2014 |
| Time representativeness –TiR (*) | Very good |
| Geographic Reference (***) (*) | Europe |
| Geographical representativeness – GeR (*) | Good |
| Data Quality Statement (***)(*) | This data set is intended for the use by LCA practitioners" |
| **Data Acquisition** | |

| | |
|---|---|
| Source and Reliability<br>- R | |
| **Information sources** | |
| Validation | |
| Validation note | |
| General information (***)(*) | The original ELCD II dataset has been modified to fulfill Clim'Foot scope (single criteria-carbon) |

### 4.3.1 Elementary flows

The elementary flows considered in the Clim'Foot EF databases are the greenhouse gases covered by the Kyoto Protocol.
These are gases emitted in the environment and considered as output.
We can classify these elementary flows as:

**Output/Emissions / Emissions to air /**

This type of classification permits that additional flows are implemented, either as emissions or as input from nature. Indeed this format is appropriate for the transferability of this database in case the project will develop a data set for a broader environmental footprint.
Each gas is reported in the dataset in the quantity related to the functional unit in terms of kg. Table 5 reports the list of all GHG elementary flows covered in Clim'Foot DB, with their reference unit.

**Table 5: elementary flows considered in Clim'Foot database**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | CH4 (fossil) | kg | | |
| Output | Emissions | Emissions to air | CH4 (biogenic) | kg | | |
| Output | Emissions | Emissions to air | CO2 (biomass) | kg | | |
| Output | Emissions | Emissions to air | CO2 (fossil) | kg | | |
| Output | Emissions | Emissions to air | N2O | kg | | |
| Output | Emissions | Emissions to air | HFC-23 | kg | | |
| Output | Emissions | Emissions to air | HFC-32 | kg | | |
| Output | Emissions | Emissions to air | HFC-41 | kg | | |
| Output | Emissions | Emissions to air | HFC-125 | kg | | |
| Output | Emissions | Emissions to air | HFC-134 | kg | | |
| Output | Emissions | Emissions to air | HFC-134a | kg | | |
| Output | Emissions | Emissions to air | HFC-143 | kg | | |
| Output | Emissions | Emissions to air | HFC-143a | kg | | |
| Output | Emissions | Emissions to air | HFC-152 | kg | | |
| Output | Emissions | Emissions to air | HFC-152a | kg | | |
| Output | Emissions | Emissions to air | HFC-161 | kg | | |
| Output | Emissions | Emissions to air | HFC-227ca | kg | | |
| Output | Emissions | Emissions to air | HFC-227ea | kg | | |
| Output | Emissions | Emissions to air | HFC-236cb | kg | | |
| Output | Emissions | Emissions to air | HFC-236ea | kg | | |
| Output | Emissions | Emissions to air | HFC-236fa | kg | | |
| Output | Emissions | Emissions to air | HFC-245ca | kg | | |
| Output | Emissions | Emissions to air | HFC-245cb | kg | | |
| Output | Emissions | Emissions to air | HFC-245ea | kg | | |
| Output | Emissions | Emissions to air | HFC-245eb | kg | | |
| Output | Emissions | Emissions to air | HFC-245fa | kg | | |

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | HFC-263fb | kg | | |
| Output | Emissions | Emissions to air | HFC-272ca | kg | | |
| Output | Emissions | Emissions to air | HFC-329p | kg | | |
| Output | Emissions | Emissions to air | HFC-365mf | kg | | |
| Output | Emissions | Emissions to air | HFC-43-10 | kg | | |
| Output | Emissions | Emissions to air | HFC-1132a | kg | | |
| Output | Emissions | Emissions to air | HFC-1141 | kg | | |
| Output | Emissions | Emissions to air | (Z)-HFC-1225ye | kg | | |
| Output | Emissions | Emissions to air | (E)-HFC-1225ye | kg | | |
| Output | Emissions | Emissions to air | (Z)-HFC-1234ze | kg | | |
| Output | Emissions | Emissions to air | HFC-1234yf | kg | | |
| Output | Emissions | Emissions to air | (E)-HFC-1234ze | kg | | |
| Output | Emissions | Emissions to air | (Z)-HFC-1-1336 | kg | | |
| Output | Emissions | Emissions to air | HFC-1234zF | kg | | |
| Output | Emissions | Emissions to air | HFC-1345zFc | kg | | |
| Output | Emissions | Emissions to air | 3,3,4,4,5,5,6,6,6-Nonafluorohex-1-ene C4 | kg | | |
| Output | Emissions | Emissions to air | 3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluoroo-1-ene | kg | | |
| Output | Emissions | Emissions to air | 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-Heptadecafluorodec-1-ene | kg | | |
| Output | Emissions | Emissions to air | PFC-14 | kg | | |
| Output | Emissions | Emissions to air | PFC-116 | kg | | |
| Output | Emissions | Emissions to air | PFC-c21 | kg | | |
| Output | Emissions | Emissions to air | PFC-218 | kg | | |
| Output | Emissions | Emissions to air | PFC-318 | kg | | |
| Output | Emissions | Emissions to air | PFC-31-10 | kg | | |
| Output | Emissions | Emissions to air | Perfluorocyclopentene | kg | | |
| Output | Emissions | Emissions to air | PFC-41-12 | kg | | |
| Output | Emissions | Emissions to air | PFC-51-14 | kg | | |
| Output | Emissions | Emissions to air | PFC-61-16 | kg | | |
| Output | Emissions | Emissions to air | PFC-71-18 | kg | | |
| Output | Emissions | Emissions to air | PFC-91-18 | kg | | |
| Output | Emissions | Emissions to air | Perfluorodecalin (cis) Z | kg | | |
| Output | Emissions | Emissions to air | Perfluorodecalin (trans) | kg | | |
| Output | Emissions | Emissions to air | PFC-1114 | kg | | |
| Output | Emissions | Emissions to air | PFC-1216 | kg | | |
| Output | Emissions | Emissions to air | Perfluorobuta-1,3-diene | kg | | |
| Output | Emissions | Emissions to air | Perfluorobut-1-ene | kg | | |
| Output | Emissions | Emissions to air | Perfluorobut-2-ene | kg | | |
| Output | Emissions | Emissions to air | SF6 | kg | | |
| Output | Emissions | Emissions to air | NF3 | kg | | |

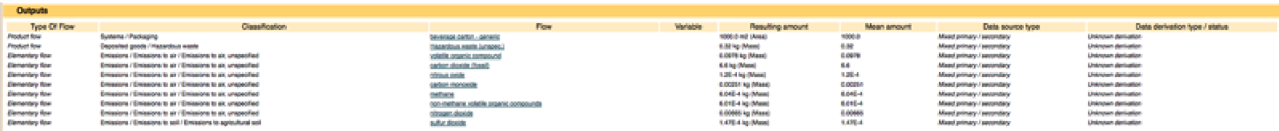
This table is just illustrative, as not all activities have all these emissions. Moreover only some emissions are often known and can be reported in the data set.

**Example**

**In the example beverage carton - generic – 1000 m² (Area) process retrieved from ELCD database is considered. This process includes only the emissions shown in**

Figure 3

**Figure 3 the output of beverage carton - generic – 1000 m2 (Area) process collected by ELCD**



| Outputs | | | | | | | |
|---|---|---|---|---|---|---|---|
| Type Of Flow | Classification | Flow | Variable | Resulting amount | Mean amount | Data source type | Data derivation type / status |
| Product flow | Systems / Packaging | beverage carton - generic | | 1000.0 m2 (Area) | 1000.0 | Mixed primary / secondary | Unknown derivation |
| Product flow | Deposited goods / Hazardous waste | hazardous waste (unspec.) | | 0.32 kg (Mass) | 0.32 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | volatile organic compound | | 0.0078 kg (Mass) | 0.0078 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | carbon dioxide (fossil) | | 6.6 kg (Mass) | 6.6 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | nitrous oxide | | 1.2E-4 kg (Mass) | 1.2E-4 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | carbon monoxide | | 0.00251 kg (Mass) | 0.00251 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | methane | | 6.04E-4 kg (Mass) | 6.04E-4 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | non-methane volatile organic compounds | | 8.01E-4 kg (Mass) | 8.01E-4 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to air / Emissions to air, unspecified | nitrogen dioxide | | 0.00665 kg (Mass) | 0.00665 | Mixed primary / secondary | Unknown derivation |
| Elementary flow | Emissions / Emissions to soil / Emissions to agricultural soil | sulfur dioxide | | 1.47E-4 kg (Mass) | 1.47E-4 | Mixed primary / secondary | Unknown derivation |

All these data have to be divided for 1000, as reported in Table 6 because the data set is referred to 1 m$^{2}$.

**Table 6 GHG emissions of the process beverage carton - generic**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | CH4 (fossil) | kg | 6.04E-07 | |
| Output | Emissions | Emissions to air | CO2 (fossil) | kg | 6.60E-03 | |
| Output | Emissions | Emissions to air | N2O | kg | 6.65E-06 | |

### *4.3.2 Characterization flows in $CO_{2eq}$*

All GHG emitted gases are multiplied by their emission factor in order to express all gases in the same measurement unit.

The characterization factors are reported in and Annex 1

**Example**

**In the example beverage carton - generic - 1 m² (Area) processes retrieved from the ELCD each emission is reported in kgCO2eq as shown**

Table 7

**Table 7 GHG gases reported in CO2eq for the process beverage carton - generic**

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| CH4 (fossil) | kg | 6.04E-07 | 30 | kgCO2 eq | 1.81E-05 | |
| CO2 (fossil) | kg | 6.60E-03 | 1 | kgCO2 eq | 6.60E-03 | |
| N2O | kg | 6.65E-06 | 265 | kgCO2 eq | 1.76E-03 | |

### *4.3.3 Emission factors*

The emission factor is the sum of emissions of $CO_{2eq}$ of the human activity described in the Dataset expressed as mass unit of $CO_{2eq}$/reference flows – i.e. kg $CO_{2eq}$/1kg $CH_4$ production. Sometime the available data report only the emission factor in terms of $CO_{2eq}$ or as Global Warming Potential in $CO_{2eq}$. In this case the emissions in terms of elementary flows cannot be defined. Moreover the characterization factors used to calculate these values could be different from the characterization factors used in Clim'Foot project, e.g. they could be referred to previous IPCC versions. These aspects can decrease the consistency of the database.

NOTE:
This is an important aspect that should be reported in the metadata in the general information with the statement Emission Factor was collected directly in terms of kg $CO_{2eq}$. Information on reference characterisation factors should be given if available. If not, another statement should be added to 'general information.

**Example**
In the example beverage carton - generic - 1 $m^2$ (Area) process collected by ELCD the emissions reported in $kgCO_{2eq}$ are summed

| | | |
|---|---|---|
| $CH_4$ (fossil) | $kgCO_{2\,eq}$ | 1.81E-05+ |
| $CO_2$ (fossil) | $kgCO_{2\,eq}$ | 6.60E-03+ |
| $N_2O$ | $kgCO_{2\,eq}$ | 1.76E-03= |
| Total | $kgCO_{2\,eq}$ | 8.38E-03 |

***the Emission factors is***
8.38E-03 ***kgCO₂eq/ beverage carton - generic - m²***

## 4.4 Sectors

In the EU countries the main sectors responsible for the GHG emission are (See Figure 4 ):

- energy (fuel combustion and fugitive emissions from fuels)
- transport;
- industrial processes and product use;
- agriculture;
- waste management.

The 'Fuel combustion and fugitive emissions from fuels (without transport)' contributes about the 57 % of the total emissions in 2013. Fuel combustion for transport (including international aviation) is the second most important source sector (about 22 % in 2013) and it has increased its contribution significantly since 1990. Agriculture contribute the 9,6 % of EU-28 total greenhouse gas emissions. Industrial processes and product use contribute another 7,8 %. The management of waste contributes the 3.3 % and has significantly decreased its share since 1990.

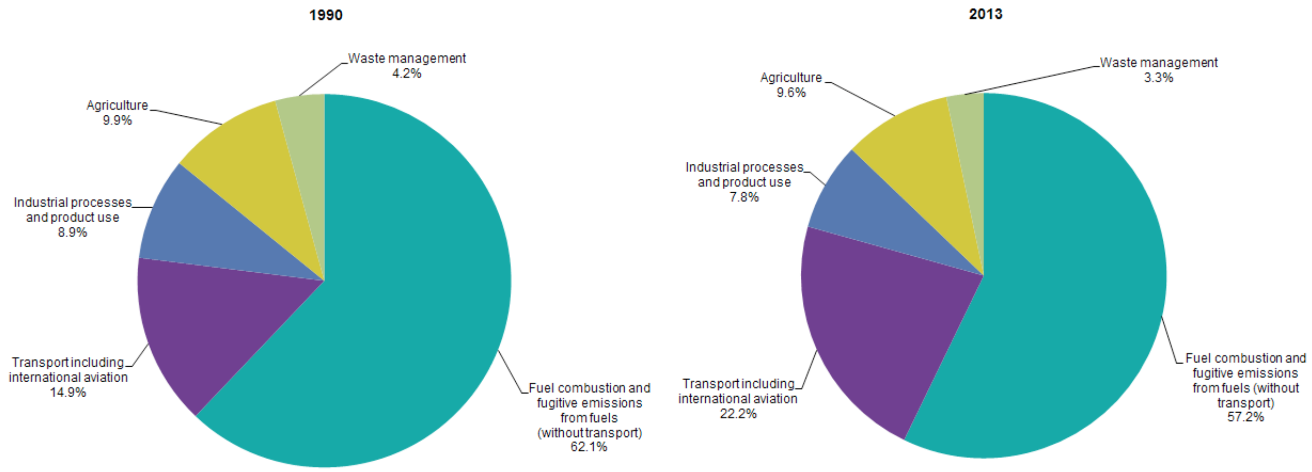



**Figure 4 Greenhouse gas emissions, analysis by source sector, EU-28, 1990 and 2013 (Eurostat)**

The countries involved in the Clim'foot project confirm this European trend of emissions. These sectors can be identified as "key categories" in terms of their contribution to the absolute level of national emissions and removals.

Moreover the GHG protocol provides an overview of direct and indirect GHG emission sources organized by scopes and industry sectors that may be used as an initial guide to identify major GHG emission sources. These sectors are

- Energy
- Metals
- Chemicals
- Minerals
- Waste
- Pulp and paper
- Semiconductor productions

The Clim'Foot database covers the key European categories and follows the recommendations of the GHG protocols to add details to the sector industrial processes and product use, which will include Metals, Chemicals, Minerals, Pulp and paper, Semiconductor productions, Refrigerants, and the emissions related to land use, land use change and forestry (LULUCF).

Therefore Clim'Foot Databases of emission factors will consider these categories:

- energy (fuel combustion and fugitive emissions from fuels)
- transport;
- industrial processes and product use;
    - Metals
    - Chemicals
    - Minerals
    - Pulp and paper
    - Semiconductor productions
    - Refrigerants
- agriculture;
- waste management

– land use, land use change and forestry (LULUCF).

**Note:**
Energy, transport and LUCUF are mandatory, because are used in the scope 1 and 2 to develop the CFO.
For all other sectors of interest, their inclusion in DB is related to the availability of data.

Each partner shall develop a document, where they describe how the emission factors have been calculate for the sector,. This document should be included in their National databases, with the aim of presenting data to external users such as regulators, the general public or specific stakeholder groups. The aim is to document, in a transparent way, all the calculations done for developing the emission factors, and to ease the revision and future updates of the data.
Tthe following information shall be included, in order of priority:

1. Sector description
2. Methodological choices
3. Method to calculation of GHG emissions
4. Description about quality data and uncertainty analysis
5. Data source

**Good best practise on this it is the "methodology paper for emission factors" (DEFRA, 2015)**

# 5 Data collection

In the ClimFoot DB the data can be collected from several sources:

- existing LCI databases;
- existing EF databases;
- LCA study of sector associations;
- literature data and Environmental Product Declarations (EPD);
- country-specific datasets from existing data or specific studies.

In the next sections, examples of data sources are provided, structured along the classification in scopes of the CFO.

## 5.1 Data source scope 1

The data source to collect data for the emission included in the Scope 1 are listed in order of priority:

1. National Inventory and Statistics Agencies
2. National Sectorial experts, stakeholder organisations or other national experts
3. IPCC Emission Factor Database
4. International experts
5. International organisations publishing statistics e.g., United Nations, Eurostat or the International Energy Agency, OECD and the IMF (which maintains international activity as well as economic data).

Table 8 Data sources for Scope 1

| Scope 1 | Sector | Source |
|---|---|---|
| Stationary Combustion | Fuels | National Inventory; National Statistics Agencies; IPCC Emission Factor Database default value |
| | Wastes Incinerator | National Inventory; National Statistics Agencies; IPCC Emission Factor Database default value |
| Mobile combustion | Transport | National Inventory; National Statistics Agencies; IPCC Emission Factor Database default value |
| Process and Fugitive emissions | Air conditioning and cooling | National Inventory; National Statistics Agencies |
| | Agriculture | National Inventory; National Statistics Agencies |
| | Industrial process | National Inventory; National Statistics Agencies |
| | Wastes | National Inventory; National Statistics Agencies |
| LULUCF | | National Inventory; IPPC guideline; GHG protocol |

## 5.2 Data sources for scope 2 and Scope 3

In the ClimFoot DB the data for the for scope 2 and 3 could be collected from several sources:

- **Existing LCI database**, for example:
    - ELCD (European reference Life Cycle Database)

- other nodes of the Life Cycle Data Network[11] (e.g., Plastic Europe, Italian National LCI Database, Chinese Core Life Cycled database, Association of European Producers of Steel for Packaging, Agri-footprint, CYCLECO, thinkstep)
- Agribalyse
- Agri-footprint database
- Okobau.dat
- Ecoinvent
- Thinkstep AG

– **Existing GHG and Emission Factors database**, for example:
  - Greenhouse Gas Conversion Factor Repository –DEFRA
  - Inventory of Carbon & Energy (ICE)

– **LCA study of sector associations**, for example:
  - European Aluminium Industry,
  - Copper Alliance
  - Worldsteel
  - Plastics Europe
  - Fefco - European Federation of Corrugated Board Manufacturers
  - Fertilizers Europe
  - CDI -Cobalt Development Institute
  - API-American Petroleum Industry

– **Environmental Product Declaration EPD studies**

– **Literature data**

- **Country specific dataset** from existing National Statistics Agencies
  - Sectorial experts, stakeholder organisations
  - Other national experts
  - IPCC Emission Factor Database

– **Specific studies**
  - Data could be collected by specific studies developed by the Clim'Foot partners. In this case they should develop the study in agreement with the ISO 14040 or ISO 14064 standards.

This is not an exhaustive list, but it mainly includes data from an European context. At a Global level it is possible find other data sources.

### 5.2.1 *LCI databases*

LCI databases can be available for free (e.g., ELCD, GHG database on feed crops) or for fee payment (e.g., Ecoinvent, Thinkstep AG). Moreover some LCI databases are strictly linked to specific LCA software, for example Agri-footprint is implemented only in SimaPro software (its implementation into the Life Cycle data Network is ongoing).
The free LCI databases were investigated with the aim to collect data for the project. A brief presentation of these databases, taken from the internet web site of each database, is reported.

***ELCD database***

The ELCD (European reference Life Cycle Database) comprises Life Cycle Inventory (LCI) data from front-running EU-level business associations and other sources for key materials, energy carriers, transport, and waste management. The respective data sets are officially provided and approved by the named industry associations.
The focus is to freely provide background data that are required in a high percentage of LCAs in a European market context. Coherence and quality are facilitated through compliance with

[11] The detailed list of database nodes and datasets is available at http://lcdn.jrc.ec.europa.eu/ILCDRegistry/pages/home.xhtml

the entry-level requirements of the Life Cycle Data Network (LCDN), as well as through endorsement by the organisations that provide the data.
Each data set is well documented with complete data description. The database was proposed by JRC.
http://eplca.jrc.ec.europa.eu/ELCD3/index.xhtml

***GHG database on feed-crops***

The GHG database on feed-crops is a global database of emissions, emission intensities and life cycle inventory for 5 main crops: maize, wheat, barley, soybean and cassava. It can be used by a wide range of users including the livestock industry, researchers, governments and others in need of data for analysis, awareness raising, planning, etc. Users will find the database an easy-to-use tool that provides downloadable information on emissions and emission intensities for the 5 main crops disaggregated by production system, agro-ecological zone, country and region. It is an initiative of the Animal Production and Health Division, produced in collaboration with the Livestock Environmental Assessment and Performance (LEAP) Partnership.
http://www.fao.org/partnerships/leap/database/ghg-crops/en/

***Life Cycle Data Network***

It was launched in Brussels on 6th February 2014 by the Vladimir Sucha, Director General of DG JRC, and Alan Seatter, Deputy Director General of DG Environment. Through entry-level requirements, the Network allows for flexibility while facilitating the availability of coherent and quality assured life cycle data from different organisations. The Network is a non-centralised web-based infrastructure that ensures life cycle data can be easily accessed via searches, filtering, and sorting. The datasets in the Network come globally from any data developer/owner, e.g. industry, national LCA projects, research groups, and consultants. Among these, a node is represented by the Italian National Database, set up as demonstrative database.
http://eplca.jrc.ec.europa.eu/LCDN/pages/newnodes.xhtml

***Agribalyse***

AGRIBALYSE® is a programme for the data collection on agricultural processes developed by ADEME, in collaboration with several stakeholders of the agricultural sector. The database has allowed the implementation of Life Cycle Inventories for the main French agricultural products in agreement with a methodology consistent and shared among the supply chain actors.
http://www.ademe.fr/expertises/produire-autrement/production-agricole/passer-a-laction/dossier/levaluation-environnementale-agriculture/loutil-agribalyse-agribalyse-program

***Okobau.dat***

Ökobau.dat is a German database for construction materials and building services provided by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).
It has been developed, within the framework of the on-going BMUB-sponsored research initiative "Zukunft Bau", by PE International AG, KIT-Institute for Applied Computer Science, and Online Now! GmbH, in collaboration with the German building materials industry.
All Ökobau.dat datasets are made available by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). A version for openLCA and SimaPro was created by GreenDelta, including a translation to English. In this case the Emission factor is expressed as Global Warming Potential.
http://www.oekobaudat.de/en.html
http://www.openlca.org/documents/14826/604800df-ae52-47b6-9bf1-2283d27d1e4e

### 5.2.2 Existing GHG and Emission Factors database

***Greenhouse Gas Conversion Factor Repository***

The UK Department for Environment Food & Rural Affairs has developed a Greenhouse Gas Conversion Factor Repository.

This online tool provides the values that should be used for such conversions, a step by step guidance on how to use the factors and allows users to tailor the volume and types of greenhouse gas (GHG) values they use during their reporting process.

http://www.ukconversionfactorscarbonsmart.co.uk/

***Inventory of Carbon & Energy (ICE)***

The Inventory of Carbon & Energy (ICE) Version 2.0 was developed by Sustainable. Energy Research Team (SERT), Department of Mechanical Engineering, University of Bath, UK.

ICE has been used to assess the energy and carbon impact of constructing new buildings in both the domestic and non-domestic building sectors. An ICE Housing Model is currently being developed, it will enable the embodied energy and carbon impact of a specific domestic building to be modelled and benchmarked against the status quo.

www.bath.ac.uk/mech-eng/sert/embodied

### 5.2.3 LCA study of sector associations

In this paragraph some examples of sector associations' studies on environmental or carbon footprint are given.

***European Aluminium Industry***

European Aluminium Industry produces "Environmental Profile Report April2013-Data" for the year 2010.

The document reports Life Cycle Inventory data for aluminium production and transformation processes in Europe. The data are well documented and representative of European countries and are referred to year 2010.

The emission factor is express in term of Global warming potential for the primary aluminium production; sheet production; aluminium foil production aluminium extrusion; aluminium recycling from scraps remelting; aluminium recycling

http://skemman.is/stream/get/1946/18519/44183/1/AMK_Cradle-to-gate_LCA_of_Nor%C3%B0ur%C3%A1l_primary_aluminium.pdf

***European copper Institute***

European copper Institute participate in the European Commission's Product Environmental Footprint Initiative.

They produce "The environmental profile of copper products. A 'cradle-to-gate' life-cycle - assessment for copper tube, sheet and wire produced in Europe, but the years or reference is not reported.

http://copperalliance.eu/about-copper/life-cycle-centre/life-cycle-assessment

These data are reported in the ELCD too. The data of emission factors are reported in terms of Global Warming Potential.

***World Steel Association***

They have launched a project "$CO_2$ emissions data collection". The aim of this project is to collect and report $CO_2$ emissions data on a site-by-site basis to give overall emission intensity for the production of steel at that site, irrespective of the final products that are being made.

The project is on going

https://www.worldsteel.org/steel-by-topic/climate-change/data-collection.html

***Plastic Europe***

They produced representative datasets on several kind of plastics. They have been included in various commercial life cycle databases as well as in the publicly available European Life Cycle Database (ELCD) and as a node in the Life Cycle Data Network.
In the web site the methodology used to calculate the dataset is available for download.,.
http://www.plasticseurope.org/plastics-sustainability-14017/life-cycle-thinking-1746/eco-profiles-programme.aspx

***Fefco - European Federation of Corrugated Board Manufacturers***
FEFCO and CEPI Containerboard (CCB) have been collecting and publishing data from the European paper and corrugated board industry for corrugated board life cycle studies for the past 20 years. The data is updated every three years.
The last report is the European Database for Corrugated Board Life Cycle Studies, the reference years is 2012 and the data for calculation of emission factors are reported in emission of $CO_2$ (fossil and biomass) into air
http://www.fefco.org/sites/default/files/documents/LCA%20report%202012_0.pdf

***Fertilizers Europe***
Fertilizers Europe developed a "Carbon Footprint Calculator for fertilizer products" v2.0
This Carbon Footprint Calculator can be used as a stand-alone module to calculate the GHG generated during the production of fertilizers. By selecting basic assumptions and filling in own values related to raw materials, transportation, energy, plant specifications and product specific data, the user calculates the total carbon footprint, expressed as 'ton CO2-equivalents / ton product'. This estimate includes both direct and indirect emissions.
A detailed description of the Carbon Footprint Calculator for fertilizer products is accessible after registration.
The Carbon Footprint Calculator for fertilizer products- module has been verified by a third party (Det Norske Veritas, DNV).
Only members of Fertilizers Europe or companies/public authorities authorised by Fertilizers Europe will have access to the calculator.
http://www.fertilizerseurope.com/index.php?id=137

***CDI -Cobalt Development Institute***
The Cobalt Development Institute promotes a Multi-metallic LCA Initiatives, and has also been working together with other metal commodity associations to align approaches to LCI and LCA studies. This includes the participation in a recent multi-metallic LCA initiative, headed by the International Copper Association, which has led to the development of a new multi-metallic LCI-LCA Guidance document.
The work is on going
http://www.thecdi.com/sustainability-and-lca

***API American Petroleum Institute***
The API American Petroleum Institute published a - COMPENDIUM OF GREENHOUSE GAS EMISSIONS METHODOLOGIES FOR THE OIL AND GAS INDUSTRY , 2004 http://www.wrapair.org/ClimateChange/GHGProtocol/docs/2004-02_API_COMPENDIUM_of_GHG_Emission_Methodologies_from_O&G.pdf
The report presents a description of the oil and gas industry and its segments to give some perspective on the potential sources of greenhouse gas (GHG) emissions. The key sectors considered are

- Exploration, Production, and Gas Processing;
- Transportation and Distribution;
- Refining; and

- Retail and Marketing.

For these sectors direct emissions from stationary and mobile combustion are reported. Moreover the emission of $CH_4$ and $N_2O$ are reported for the different technologies.

In addition, the emission factors for purchasing electric power are reported for type of plant production. The data are well explained but are referred to US production and to 2004

### 5.2.4 Environmental Product Declaration (EPD)

Another valuable source of data for the national contest are the documents from the Environmental Product Declaration (EPD) system.

An EPD® is a verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of a product/service.

The International EPD® System is a global programme for environmental declarations based on ISO 14025 and EN 15804. The database currently contains more than 500 EPDs registered by 150 companies in 27 countries.

For each product an LCA study is carried out, which is however not made available. The available information is included in the EPD document, in terms of potential environmental impacts of the product analysed, and among them, the global warming potential impact is always reported.

http://www.environdec.com/it/

### 5.2.5 Literature data

***Literature reviews***

In other cases it is possible to obtain data from literature on LCA and Carbon Footprint studies. These are specific cases but sometime it is possible to find interesting reviews of some issues as the Bessou C. , F. Ferchaud, B.Gabrielle, B. Mary, Biofuels, 2011 article proposed by greenhouse gases and climate change. A review, Agron. Sustain. Dev., INRA, EDP Sciences, 2010 DOI: 10.1051/agro/2009039, vol 31, pag. 1–79

***Livestock food chain***

FAO developed sector specific guidelines and methods for the life cycle assessment of GHG emissions from livestock food chains.

- Environmental performance of animal feeds supply chains
- Greenhouse gas emissions and fossil energy demand from poultry supply chains
- Greenhouse gas emissions and fossil energy demand from small ruminant supply chains

http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_production_-_animals#Livestock_numbers

***Well-to-wheels***

The well-to-wheels analyses by JEC pursues the objectives of estimating:

- greenhouse gas emissions,
- energy efficiency, and
- industrial costs

of all automotive fuels and power-trains options significant for Europe after 2010.

The study evolves by periodic updates incorporating process improvements reported by the relevant stakeholders, e.g. vehicle manufacturers, Original Equipment Manufacturers (OEMs), fuel, refining, biofuels and power producers as well as regulators.

http://iet.jrc.ec.europa.eu/about-jec/jec-well-wheels-analyses-wtw

### 5.2.6 Country specific dataset

***Existing data***

For the production of this national data the Clim'Foot partners could use existing data as:

- National Statistics Agencies
- Sectorial experts, stakeholder organisations
- Other national experts
- IPCC Emission Factor Database
- Other international experts
- International organisations publishing statistics e.g., United Nations, Eurostat or the International Energy Agency, OECD and the IMF (which maintains international activity as well as economic data)
- Reference libraries (National Libraries) Scientific and technical articles in environmental books, journals and reports.
- Universities
- Web search for organisations & specialists
- National Inventory Reports from Parties to the United Nations Framework Convention on Climate Change

***Data from LCA/carbon footprint studies***

Sometime data can be collected by specific studies developed by the Clim'Foot partners.
In this case they should develop the study in agreement with the ISO 14040 and ISO 14064 standards or GHG protocol
Each study should have a report that includes:

- Introduction
- Goal and scope definition
    - Description of system
    - Description of the reference data
    - Intended audience of the report
    - Scope of the study
    - Function of the system
    - Functional Unit
    - System boundaries
    - Method to calculation of GWP emissions
    - Allocation procedures
    - Cut of criteria
    - Data requirements
    - Assumptions
    - Type and format of the report required for the study.
- Inventory
    - Data collection procedures
    - Sensitivity analysis
    - Uncertainty analysis

## 5.3 Examples of how to calculate EF from different sources

This paragraph presents some examples on how to calculate EF for the dataset construction from different sources, according to the different data sources.

### *5.3.1 EF for scope 1: National Inventory Report (NIR)*

The NIRs are very useful and reliable National data sources. Indeed the countries that ratified the Kyoto Protocol must prepare a National Action Plan to reduce greenhouse gas emissions. In order to implement this Plan each country must perform a National Inventory. The IPCC 2006

Guidelines for National Greenhouse Gas Inventories (IPCC 2006 Guidelines) provide internationally agreed methodologies for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases.
The sectors covered by the NIR are:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture, Forestry and Other Land Use (AFOLU)
- Waste
- Other (e.g., indirect emissions from nitrogen deposition from non-agriculture sources).

For each sector, a general overview and the methodology description are reported. Moreover, individual categories (e.g., transport) and sub-categories (e.g., cars) are included, and for each of them a brief description and national statistical data including the relative GHG emissions is reported. The emissions data are often reported for several years from 1990 until last update.
The National NIR can be collected at the following web site:
http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php
For the calculation of the emission factor, using the NIR, an average of the last 5 years should be considered if available and representative. Moreover the standard deviation has to be calculated as well, in order to examine the influence on the total results.
The average is

$$M_a = \frac{1}{n}\sum_{i=1}^{n} x_i$$ equation 1

$M_a$ is the average
$x_i$ is the sample i
n is the max number of sample considered
The standard Deviation is

$$\sigma_X = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N}},$$

equation 2

$\bar{s}_x$ is the standard deviation.
$\bar{x}$ is the average
N is the max number of sample considered
Moreover the information to collect metadata should be collected by a sector overview and the categories and subcategories description.

***Example***
In the deliverable an example on data collection from NIR is reported for a composting process in Italy, a biological treatment of solid waste.
Biological treatment of solid waste is a key category for $N_2O$ emissions. Moreover $CH_4$ and $N_2O$ emissions from compost production have been reported in NIR (see
Figure 5). The amount of waste treated in composting and digestion plants has shown a great increase from 1990 to 2013 (from 283,879 Mg to7,408,485 Mg for composting and from 79,440 Mg to 2,410,470 Mg for anaerobic digestion).

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Activity data** | | | | | | | | |
| Amount of waste to composting process (Mg) | 283,879 | 657,215 | 2,834,309 | 5,550,888 | 7,030,808 | 7,163,543 | 7,150,442 | 7,408,485 |
| Amount of waste to anaerobic digestion (Mg) | 79,440 | 127,433 | 467,803 | 1,407,203 | 1,976,357 | 2,123,466 | 2,293,812 | 2,410,470 |
| **$CH_4$** | | | | | | | | |
| Compost production (Gg) | 0.008 | 0.019 | 0.083 | 0.163 | 0.206 | 0.210 | 0.210 | 0.217 |
| Anaerobic digestion (Gg) | 0.079 | 0.127 | 0.468 | 1.407 | 1.976 | 2.123 | 2.294 | 2.410 |
| **$N_2O$** | | | | | | | | |
| Compost production (Gg) | 0.014 | 0.033 | 0.144 | 0.282 | 0.357 | 0.364 | 0.363 | 0.376 |
| **NMVOC** | | | | | | | | |
| Compost production (Gg) | 0.057 | 0.131 | 0.567 | 1.110 | 1.406 | 1.433 | 1.430 | 1.482 |

**Figure 5 Amount and emissions factors for biological treatments in Italy (NIR-2015)**

With this information two emission factors can be developed, one for the composting process and one for the anaerobic digestion. Here the example on composting process is reported.

***Metadata***

**Table 9 Metadata on 1kg of biological treatment by composting process**

| **General Information** | |
|---|---|
| Information | Description of content |
| **Process name (***)(*)** | Composting process (IT) |
| **Synonym** (***) | |
| ID Number | |
| Copyright | **Clim'Foot project** |
| Data collector's organisation | ENEA |
| Source | Italian National Inventory Report (2015) |
| Creation date | 2015 |
| Modification Date | |
| **Activity Description** | |
| **Amount** | 1 |
| **Unit (*)** | kg |
| **Technical Description** (***)(*) | Average technology among: plants that treat a selected waste (food, market, garden waste, sewage sludge and other organic waste, mainly from the agro-food industry); and mechanical biological treatment plants, where the unselected waste is treated to produce compost, refuse derived fuel (RDF), and a waste with selected characteristics suitable for landfilling or incinerating systems. It is assumed that 100% of the input waste to the composting plants from selected waste is treated as compost, while in mechanical-biological treatment plants 30% of the input waste is treated as compost on the basis of |

| | |
|---|---|
| | national studies and references (NIR-2015). The system boundary is gate to gate. |
| Technological representativeness –TeR (*) | good |
| Uncertainty | |
| **Year(s) of validity (*)** | 2018 |
| Time representativeness –TiR (*) | Very good |
| Geographic Reference (***) (*) | |
| Geographical representativeness – GeR (*) | Very good |
| **Data Quality Statement** (***)(*) | The uncertainty in $CH_4$ emissions from biological treatment of waste is estimated to be about 100% in annual emissions, 20% and 100% concerning activity data and emission factors respectively (NIR-2015). |
| **Data Acquisition** | |
| Source and Reliability | Information on input waste to composting plants are published yearly by ISPRA since 1996. Amount of waste to composting process 7,408,485 Mg |
| **Information sources** | |
| Validation | |
| Validation note | |
| **General information** (***)(*) | The data set reports only the $CH_4$ and $N_2O$ emissions |

***Elementary Flows***

From the data reported in
Figure 5 calculation of kg of GHG per kg of waste is performed by diving emission data with amount of waste data (Table 10)

**Table 10 GHG emission per kg of compost waste**

| Emissions | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ for kg of compost | kg/kg | 2.82E-05 | 2.89E-05 | 2.93E-05 | 2.94E-05 | 2.93E-05 | 2.93E-05 | 2.94E-05 | 2.93E-05 |
| $N_2O$ for kg of compost | kg/kg | 4.3E-05 | 5.02E-05 | 5,.8E-05 | 5.08E-05 | 5.08E-05 | 5.08E-05 | 5.08E-05 | 5.08E-05 |

From this data the average of the the last 5 years and the correlated deviation standard is calculated with the Equation 1 and 2.

**Table 11 Average and standard deviation of GHG emission per kg of compost waste**

| Emission | Average | Standard deviation (st) |
|---|---|---|
| $CH_4$ for kg of compost | 2.93E-05 | 3.28E-08 |
| $N_2O$ for kg of compost | 5.08E-05 | 1.12E-08 |

**Table 12 elementary flows per kg of compost waste**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | CH4 (biogenic) | kg | 2.93E-05 | St 3.28E-08 |
| Output | Emissions | Emissions to air | N2O | kg | 5.08E-05 | St 2.25E-08 |

***Characterization factors***

**Table 13 GHG gases reported in CO2eq for the process of kg compost waste**

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| $CH_4$ (biogenic) | kg | 6.04E-04 | 28 | kgCO2 eq | 8.21E-04 | |
| $N_2O$ | kg | 6.65E-03 | 265 | kgCO2 eq | 1.35E-02 | |

***Emission factor***

In the example the emissions for composting of 1kg of waste reported in kgCO2eq ( Table 13) are summed.

| | | |
|---|---|---|
| $CH_4$ (biogenic) | $kgCO_2$ eq | 8.21E-04+ |
| $N_2O$ | $kgCO_2$ eq | 1.35E-02= |
| Total | $kgCO_2$ eq | 1.43E-02 |

the Emission factors is
1.43E-02 kgCO2eq/ kg of compost waste

### *5.3.2 EF for scope 2 and 3: Life Cycle Inventory (LCI),*

The LCI databases have data sets on processes and materials. Each data set is composed by data in input and output.
This data can be defined in terms of processes or elementary flows[12].
The list of elementary flow includes resources from nature as inputs and emission to air, water and soil as outputs. In addition these datasets are described in terms of metadata i.e. data on activity, geographical, technological a temporal representativeness, data on modelling,validation and administrative information.
This kind of data sources are often well documented and can be easily used to define Emission factors dataset.
An example of data collection from LCI database defined as Elementary flows was reported in 4.3 Data set on “average carton - generic - 1000 $m^2$ (Area)” process collected by ELCD database.
Here below an example is reported of data collection from LCI database defined in term of processes, which reports the emission of the process as Global Warming Potential.

**Example**

Process Data set: Gypsum plaster (CaSO4 alpha semihydrate) (en) from ***Okobau.dat***
http://www.oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=2ab1085e-c4f9-43e0-aad8-9a7c4c8154c6&stock=OBD_MULTILANG_06_2015&lang=en

[12] elementary flow: material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation (ISO 14044)

## *Metadata*

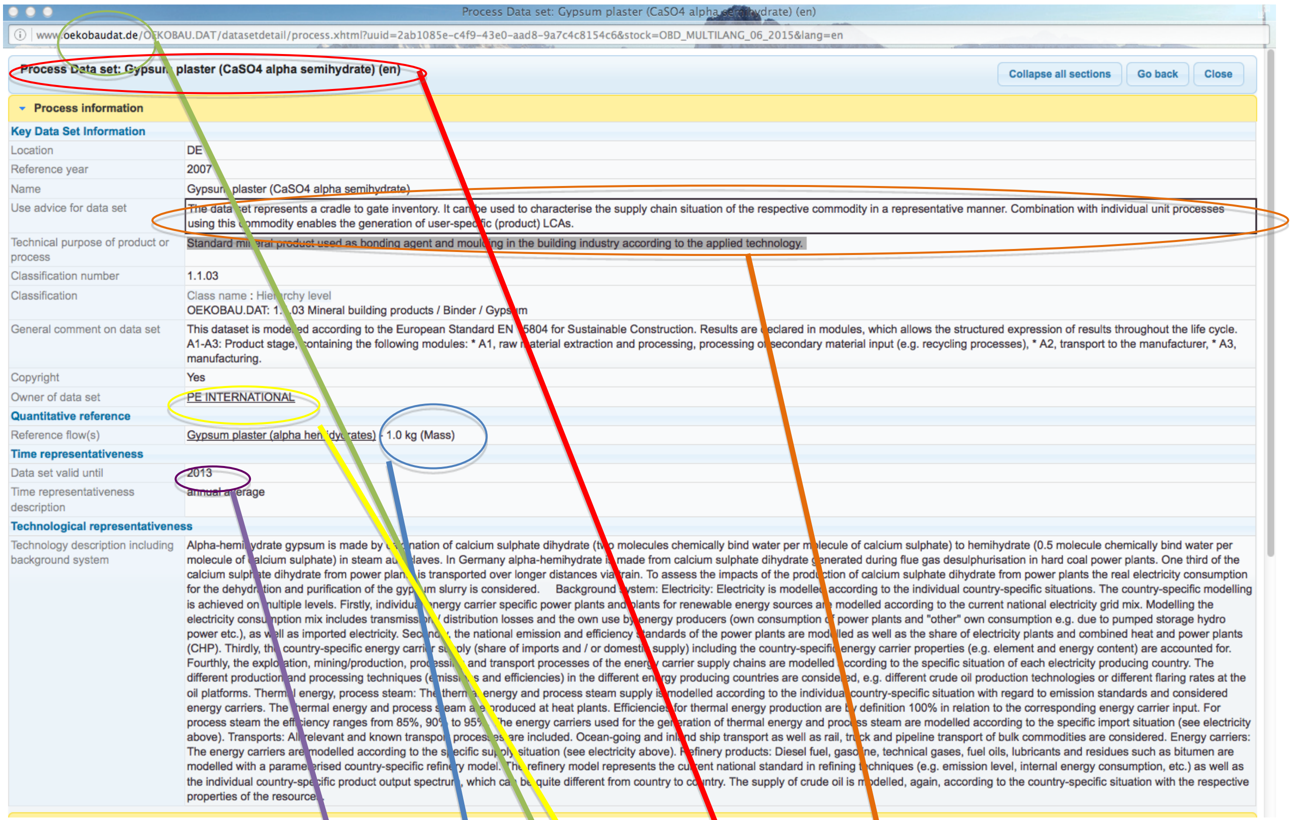



**Figure 6 Clipboard of xml file of OEKOBAU.DAT**

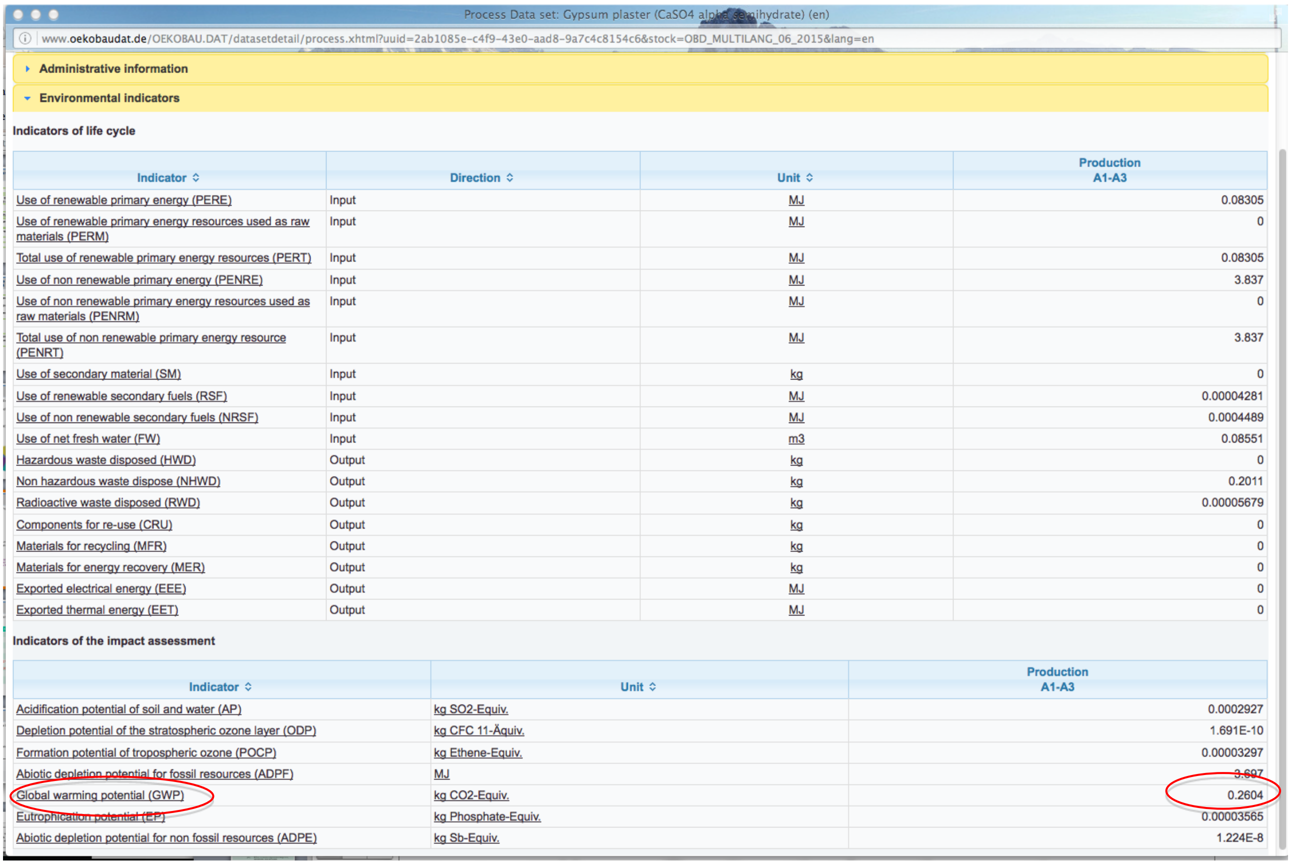
**Table 14 the metadata of Gypsum plaster (CaSO4 alpha semihydrate) by OEKOBAU.DAT**

| **General Information** | |
|---|---|
| Information | Description of content |
| **Process name (***)(*)** | Gypsum plaster (CaSO4 alpha semihydrate) (en) |
| **Synonym** (***) | |
| ID Number | |
| Copyright | OEKOBAU.DAT |
| Data collector's organisation | PE International |
| Source | |
| Creation date | 01/01/2007 |
| Modification Date | |
| **Activity Description** | |
| **Amount** | 1 this amount should be reported to 1 |
| **Unit (*)** | kg |
| **Technical Description** (***)(*) | The data set represents a cradle to gate inventory. Standard mineral product used as bonding agent and moulding in the building industry according to the applied technology. |
| Technological representativeness –TeR (*) | good |
| Uncertainty | Not documented |
| **Year(s) of validity (*)** | 2013 |

| | |
|---|---|
| Time representativeness –TiR (*) | Germany |
| Geographic Reference (***) (*) | good |
| Geographical representativeness – GeR (*) | |
| **Data Quality Statement** (***)(*) | |
| **Data Acquisition** | |
| Source and Reliability | Not documented |
| **Information sources** | |
| Validation | |
| Validation note | The OEKOBAU.DAT has been modified to fulfill Clim'Foot scope (single criteria-carbon) Characterisation factors used may be different from the ones defined in Clim'Foot. |
| **General information** (***)(*) | |

***Emission Factors***

In this database LCI the input and output are reported in term of process, nerveless the DB reports the environmental impact in term of GWP.



Process Data set: Gypsum plaster (CaSO4 alpha semihydrate) (en)

www.oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=2ab1085e-c4f9-43e0-aad8-9a7c4c8154c6&stock=OBD_MULTILANG_06_2015&lang=en

Administrative information

Environmental indicators

Indicators of life cycle

| Indicator | Direction | Unit | Production A1-A3 |
|---|---|---|---|
| Use of renewable primary energy (PERE) | Input | MJ | 0.08305 |
| Use of renewable primary energy resources used as raw materials (PERM) | Input | MJ | 0 |
| Total use of renewable primary energy resources (PERT) | Input | MJ | 0.08305 |
| Use of non renewable primary energy (PENRE) | Input | MJ | 3.837 |
| Use of non renewable primary energy resources used as raw materials (PENRM) | Input | MJ | 0 |
| Total use of non renewable primary energy resource (PENRT) | Input | MJ | 3.837 |
| Use of secondary material (SM) | Input | kg | 0 |
| Use of renewable secondary fuels (RSF) | Input | MJ | 0.00004281 |
| Use of non renewable secondary fuels (NRSF) | Input | MJ | 0.0004489 |
| Use of net fresh water (FW) | Input | m3 | 0.08551 |
| Hazardous waste disposed (HWD) | Output | kg | 0 |
| Non hazardous waste dispose (NHWD) | Output | kg | 0.2011 |
| Radioactive waste disposed (RWD) | Output | kg | 0.00005679 |
| Components for re-use (CRU) | Output | kg | 0 |
| Materials for recycling (MFR) | Output | kg | 0 |
| Materials for energy recovery (MER) | Output | kg | 0 |
| Exported electrical energy (EEE) | Output | MJ | 0 |
| Exported thermal energy (EET) | Output | MJ | 0 |

Indicators of the impact assessment

| Indicator | Unit | Production A1-A3 |
|---|---|---|
| Acidification potential of soil and water (AP) | kg SO2-Equiv. | 0.0002927 |
| Depletion potential of the stratospheric ozone layer (ODP) | kg CFC 11-Äquiv. | 1.691E-10 |
| Formation potential of tropospheric ozone (POCP) | kg Ethene-Equiv. | 0.00003297 |
| Abiotic depletion potential for fossil resources (ADPF) | MJ | 3.697 |
| Global warming potential (GWP) | kg CO2-Equiv. | 0.2604 |
| Eutrophication potential (EP) | kg Phosphate-Equiv. | 0.00003565 |
| Abiotic depletion potential for non fossil resources (ADPE) | kg Sb-Equiv. | 1.224E-8 |

**Figure 7 Clipboard of xml file of OEKOBAU.DAT**

The emission factor is 2.60E-1 kg$CO_2$eq/1kg Gypsum plaster (CaSO4 alpha semihydrate).

# 6 Energy sector

The Emission Factors of energy sectors should be covered completely to perform the CFO. Table 15 shows the categories considered in the ADEME DB. For the all data covered in table at least two emission factors should be calculated:

- for the fuels one about the combustion of fuels in the stationary source and one about the production (upstream),
- for electricity, heat or steam purchased by the company, one about the production of electricity, heat, steam at plant and one for the losses of electricity on the grid and other losses for the heat or steam distribution

**Note**
For the combustion of fuels in the stationary source, it is possible use the EF of the National mix but it is not suitable to have different emission factors for different technology e.g. boilers, turbine, furnace, ecc. For this kind of specification there are default values in the IPCC (2006).

**Table 15 Categories considered in cartography of ADEME database**

| **Type-1** | **Type -2** | **Subtype** |
|---|---|---|
| **Combustibles** | Fossils | Solids |
| | | Liquids |
| | | Gas |
| | Organic | Solids |
| | | Liquids |
| **Electricity** | Electricity mix | Grid |
| | Power plants | Conventional |
| | | Renewable |
| Heating/cooling grid | heating network | Heating/cooling grid |
| | Cooling network | |

## 6.1 Fuels

The description of the type of fuels is reported in the IPCC 2006 (volume 3 Energy). As describe in the IPCC 2006 (volume 3 Energy) two types of fuels deserve special attention: Biomass and Waste.

- ***"Biomass*** data are generally more uncertain than other data in national energy statistics. The AFOLU Volume 4 Chapter 4 (Forest Land) provides an alternative method to estimate activity data for fuel wood use". "CO2 emissions from biomass combustion are not included in national totals, but are recorded as an information item for cross-checking purposes as well as avoiding double counting".
- ***"Waste:*** Waste incineration may occur in installations where the combustion heat is used as energy in other processes. In such cases, this waste must be treated as a fuel and the emissions should be reported in the energy sector. When waste is incinerated without using the combustion heat as energy, emissions should be reported under wasteincineration. In both cases methodologies are provided in IPPC 2006 Volume 5 Chapter 5".

From the IPCC 2006 (volume 2 Energy) "the carbon content of fuels may vary considerably both among and within primary fuel types on a per mass or per volume basis:

- For **natural gas**, the carbon content depends on the composition of the gas which, in its delivered state, is primarily methane, but can include small quantities of ethane, propane, butane, and heavier hydrocarbons. Natural gas flared at the production site will usually contain far larger amounts of non-methane hydrocarbons. The carbon content will be correspondingly different. Carbon content per unit of energy is usually less for light refined products such as gasoline than for heavier products such as residual fuel oil.
- For **coal**, carbon emissions per tonne vary considerably depending on the coal's composition of carbon, hydrogen, sulphur, ash, oxygen, and nitrogen". Nerveless by converting to energy units this variability is reduced. Therefore in the IPCC 2006 (volume 2 Energy) the default content of C is reported for the fuels in term of kg/GJ. Moreover they assume that all content of C in the fuels is converted in $CO_2$ emission after the combustion.

### *6.1.1 Example on fuels Emission Factor calculation: Italian combustion mix and production of Natural gas*

In the report the example on emission factors for natural gas is considered.
As reported in the ADEME DB the category of combustible is divided in two phases, the combustion and upstream.
In the example two emission factors are calculated, one for the combustion phase and another for the upstream phase. For the combustion, the data are collected by NIR-2015 and this data is representative of Italy. For the upstream phase no information is reported in the NIR, so the data are collected by ELCD database with the process "Natural Gas; from onshore and offshore production incl. pipeline and LNG transport; consumption mix, at consumer; desulphurised" -1 kg, see
Figure 8.

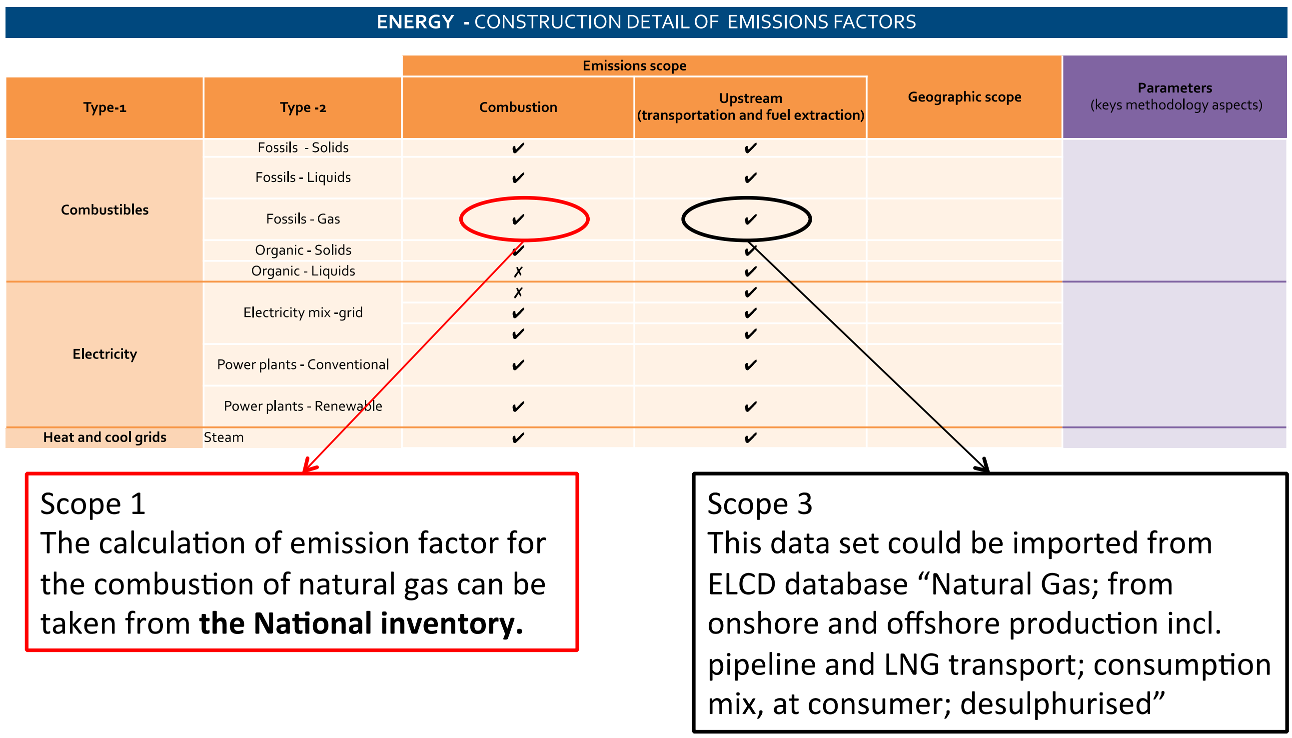



**Figure 8 Scheme to calculate the emission factors for the natural gas**

#### 6.1.1.1 Italian Combustion mix of Natural gas

The calculation of emission factor for the combustion of natural gas was taken from the NIR-2015.

In Italy the emission factors of natural gas is calculated as total emissions of this source because the origin of the gases used by final consumer cannot be tracked. The values for the inventory are reported in

Figure 9.

In particular for natural gas combustion the Italian NIR reports that the average natural gas and carbon content of the natural gas used in Italy is estimated, using international trade statistical data and considering the Italian production and the mix imported.

All the information, reported in the metadata, is collected from the Italian NIR (2015). The NIR report data for 1000 $m^3$ of methane production so all data have to be divided for 1000.

Emission factor name: *Italian Natural gas combustion*

***Metadata***

The metadata of natural gas Italian combustion mix are reported in Table 16, the data are collected by the NIR (2015), and are related to 1 $m^3$

**Table 16 Metadata of 1 $m^3$ natural gas Italian combustion mix**

| Information | Description of content |
|---|---|
| **Process name (***)(*)** | Natural gas Italian combustion mix |
| **Synonym** (***) | Methane Italian combustion mix |
| ID Number | xxxxx |
| Copyright | **Clim'Foot project** |
| Data collector's organisation | ENEA |
| Source | Italian National Inventory Report (2015) |
| Creation date | 2016 |
| Modification Date | |
| **Activity Description** | |
| **Unit (*)** | 1 |
| **Technical Description** (***)(*) | $m^3$ |
| Technological representativeness –TeR (*) | Emission of combustion independent from the type of use, representative of Italian mix consumed. The boundary is gate-to-gate |
| Uncertainty | |
| **Year(s) of validity (*)** | |
| Time representativeness –TiR (*) | 2015 |
| Geographic Reference (***) (*) | |
| Geographical representativeness – GeR (*) | Italy |
| **Data Quality Statement** (***)(*) | |
| **Data Acquisition** | The data set reports only the CO2 emission estimated. Data are Italian national average. |
| Source and Reliability | |
| **Information sources** | |
| Validation | |
| Validation note | |

| **General information** (***)(*) | |
|---|---|
| Information | This emission doesn't consider the efficiency of different combustion engine. Italian Greenhouse Gas Inventory 1990 – 2013 - National Inventory Report 2015. |

**Elementary flows calculation**

The Italian NIR reports as available data only the tonne of $CO_2$ emitted from 1000 std $m^3$ of Methane during the combustion, as shown in Figure 9. The NIR reports data from 1990 until 2013.

Since 1990 natural gas has been produced in Italy and imported by pipelines from Russia, Algeria and the Netherlands: each year the quantities of natural gas imported or produced in Italy are published by the Ministry of Economic Development. Each natural gas transmitted by the grid operator is regularly analysed at importing gates, for budgetary reasons.

For the calculation of the emission factor an average of the last 5 years is considered because the annual change can be large as methane content can considerably vary and also carbon content varies significantly depending on the quantity of Natural gas imported in percentage from the several country. Indeed natural gas properties are more stable referring to the country of origin, with small variations in chemical composition from year to year. Speciation of gas from each import is regularly published by national transmission grid operator (Snam Rete Gas).

| | $t\ CO_2$ / TJ (stechiometric) | $t\ CO_2$ / TJ | $t\ CO_2 / 10^3$ std cubic mt | $t\ CO_2$ / toe |
|---|---|---|---|---|
| Natural gas (dry) IPCC '96 | 56.061 | 55.780 | 1.925 | 2.334 |
| Natural gas, IPCC '06 average | 56.100 | 56.100 | 1.931 | 2.347 |
| lower | 54.300 | | | |
| upper | 58.300 | | | |
| **National Emission Factors** | | | | |
| Natural gas , 1990 | 55.608 | 55.330 | 1.911 | 2.315 |
| Natural gas, 1995 | 55.703 | 55.425 | 1.922 | 2.319 |
| Natural gas , 2000 | 55.753 | 55.599 | 1.937 | 2.326 |
| Natural gas , 2001 | 55.702 | 55.578 | 1.931 | 2.325 |
| Natural gas , 2002 | 56.257 | 56.163 | 1.945 | 2.350 |
| Natural gas, 2003 | 55.874 | 55.812 | 1.950 | 2.335 |
| Natural gas, 2004 | 55.874 | 55.843 | 1.954 | 2.336 |
| Natural gas, 2005 | 55.870 | 55.870 | 1.954 | 2.338 |
| Natural gas, 2006 | 55.947 | 55.947 | 1.959 | 2.341 |
| Natural gas, 2007 | 55.917 | 55.917 | 1.957 | 2.340 |
| Natural gas, 2008, with 8190 lhv | 57.196 | 57.196 | 1.960 | 2.393 |
| Natural gas, 2009, with 8190 lhv | 57.418 | 57.418 | 1.968 | 2.402 |
| Natural gas, 2010, with 8190 lhv | 57.527 | 57.527 | 1.971 | 2.407 |
| Natural gas, 2011, with 8190 lhv | 57.044 | 57.044 | 1.955 | 2.387 |
| Natural gas, 2012, with 8190 lhv | 57.220 | 57.220 | 1.961 | 2.394 |
| Natural gas, 2013, with 8190 lhv | 56.989 | 56.989 | 1.953 | 2.384 |

*Source: ISPRA elaborations*

**Figure 9 the $CO_2$ emission for Italian Natural gas from 1990 until 2013.**

From this data the average of the last 5 years and the correlated deviation standard is calculated with the Equation 1 and 2.

**Table 17 Average and standard deviation of GHG emission for 1m3 of Natural gas combusted in Italy**

| Emission | Average (kg) | standard deviation (st) |
|---|---|---|
| CO2 kg for 1m$^3$ of Natural gas combustion | 1.96E+00 | 7.86E-03 |

**Table 18 elementary flows for 1m$^3$ of Natural gas combusted in Italy**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | $CO_2$(fossil) | kg | 1.96E+00 | St 7.86E-03 |

## *Characterization factors*

**Table 19 GHG gases reported in CO2eq for 1m$^3$ of Natural gas combusted in Italy**

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| $CO_2$(fossil) | kg | 1.96E+00 | 1 | kg$CO_2$ eq | 1.96E+00 | |

The total emission is kg $CO_{2eq}$ 1.96E+00

***Emission factor***

1.96E+00 kg$CO_{2eq}$/1m$^3$ natural gas Italian combustion mix

#### *6.1.1.2 Production of natural gas*

This data set was imported by ELCD database “Natural Gas; from onshore and offshore production incl. pipeline and LNG transport; consumption mix, at consumer; desulphurised” -1 kg.

**Table 20 the metadata of Natural Gas (EU-27) production**

| Information | Description of content |
|---|---|
| **Process name (***)(*)** | **Natural Gas (EU-27) production** |
| **Synonym** (***) | Methane (EU-27) production |
| ID Number | |
| Copyright | http://lca.jrc.ec.europa.eu/lcainfohub/datasets/elcd/processes/3d602e55-aaa2-44e3-adb9-40f49eb1a915_02.00.000.xml, PE internationa |
| Data collector's organisation | ENEA |
| Source | ELCD database |
| Creation date | 31/12/2010 |
| Modification Date | |
| **Activity Description** | |
| **Amount** | 1 |
| **Unit (*)** | kg |

| | |
|---|---|
| **Technical Description** (***)(*) | technology mix;consumption mix, at consumer;onshore and offshore production incl. pipeline and LNG transport. The boundary is gate-to-gate |
| Technological representativeness – TeR (*) | good |
| Uncertainty | |
| **Year(s) of validity (*)** | 2010 |
| Time representativeness –TiR (*) | good |
| Geographic Reference (***) (*) | EU-27 The data set represents the country / region specific situation, focusing on the main technologies, the region specific characteristics and / or import statistics. |
| Geographical representativeness – GeR (*) | good |
| **Data Quality Statement** (***)(*) | Good overall data quality. Natural gas mix EU-27 information is based on official statistical information. Energy carrier extraction and processing data are of sufficient good quality. Inventory is partly based on primary industry data, partly on secondary literature data. |
| **Data Acquisition** | |
| Source and Reliability<br>- | The data sources for the complete product system are sufficiently consistent: The data on the energy carrier supply chain is based on statistics with country / region specific transport distances and energy carrier composition as well as industry and literature data on the inventory of exploration, extraction, processing and in case of LNG, liquefaction and regasification. LCI modelling is fully consistent. |
| Validation | |
| Validation note | |
| **General information** (***)(*) | **No official approval by producer or operator** |
| Information | The original ELCD II dataset has been modified to fulfill Clim'Foot scope (single criteria-carbon)<br>The origin of data are IEA Statistics - Natural Gas Information 2004, 2004;MWV - Mineralölversorgung mit Pipelines, 2000;Greenhouse gas Emissions from the Russian Natural Gas Export Pipeline |

***Elementary flows***

**The**

Table 21 reports the elementary flows selected from the example Natural Gas; from onshore and offshore production incl. pipeline and LNG transport; consumption mix, at consumer; desulphurised – report in the output.

Table 21 the elementary flow of of Natural Gas (EU-27) production

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | $CH_4$ (fossil) | kg | 6.91E-03 | |
| Output | Emissions | Emissions to air | $CO_2$ (fossil) | kg | 2.86E-01 | |
| Output | Emissions | Emissions to air | $N_2O$ | kg | 5.00E-06 | |
| Output | Emissions | Emissions to air | $SF_6$ | kg | 5.42E-09 | |

### *Elementary flows*

The Figure 10 reports the elementary flows selected from the example Natural Gas.

Figure 10 GHG gases reported in $CO_{2eq}$ of Natural Gas (EU-27) production

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| $CH_4$ (fossil) | kg | 6.91E-03 | 30 | kgCO2 eq | 2.07E-01 | |
| $CO_2$ (fossil) | kg | 2.86E-01 | 1 | kgCO2 eq | 2.86E-01 | |
| $N_2O$ | kg | 5.00E-06 | 265 | kgCO2 eq | 1.30E-03 | |
| $SF_6$ | kg | 5.42E-09 | 23500 | kgCO2 eq | 1.27E-09 | |

### *Emission factor*

EXAMPLE: Emission factor Calculation

| | | |
|---|---|---|
| $CH_4$ (fossil) | $kgCO_{2eq}$ | 2.07E-01+ |
| $CO_2$ (fossil) | $kgCO_{2eq}$ | 2.86E-01+ |
| $N_2O$ | $kgCO_{2eq}$ | 1.30E-03+ |
| $SF_6$ | $kgCO_{2eq}$ | 1.27E-09= |
| Total | **$kgCO_2eq$** | **4.94E-01** |

### *Emission Factor*

**0.49 $kgCO_2eq$/1kg of natural gas production**

#### *6.1.1.3 Conclusion*

If the two processes are used at the same time, it is necessary to have the same measurement unit. In

Table 22 the emission factors of natural gas for combustion and production with different unit are reported. The natural gas density ranges between 0.7-0.9 kg/$m^3$ STP. A density of 0.778 kg/$m^3$ was assumed considering a low calorific value of 44.1 MJ/kg from the ELCD database and an average value of the natural gas Italian mix 34.29 MJ/$m^3$ STP (ISPRA, 2015). Therefore the EF of natural gas production is 0.38 kg $CO_2eq/m^3$ STP of natural gas production.

Table 22 Emission factors of natural gas for combustion and production with different unit

| Sector | Name of process | Emission factors unit | Emission factor quantity | Conversion factor |
|---|---|---|---|---|
| Scope1: /Energy/fuel/gas/Combustion | Italian natural gas mix combustion | $kgCO_{2}eq/m^{3}$ natural gas combustion | 1.96E+00 | |
| Scope 3: /Energy/fuel/gas/ | Natural Gas (EU-27) production | $kgCO_{2}eq$/1kg of methane production | 4.90E-01 | |
| Scope 3: Energy/fuel/gas/ | Natural Gas (EU-27) production | $kgCO_{2}eq/m^{3}$ of methane production | 3.80E-01 | Density of natural gas 0.778 $kg/m^{3}$ |

The emission factors referred to $1m^3$ can be used together.

## 6.2 Electricity

As mention in paragraph 3.2, in Scope 2 the organization collects the emissions from the production of the purchased energy used by the company (electricity, heat or steam), which do not have to include the transmission and distribution losses because they are accounted for in Scope 3.

Thus for the electricity in the database the following EFs should be reported :

- National electricity mix at production (IT, HR, GR, HU and EU);
- National electricity losses on the grid (IT, HR, GR, HU and EU);
- electricity production at plant, for different plants e.g. thermic, hydroelectric, geothermic, ecc.

**Note**
For the National electricity mix at production, it is suitable report the latest mix production available, because this sector is in evolution and the use of renewable source are increasing each year.

### *6.2.1 EFs of Italian electricity mix, at net production and losses*

This EF is calculated collecting data from the report developed by Italian National Institute for Environmental Protection and Research, ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale). The report is " Fattori di emissione atmosferica di $CO_2$ e sviluppo delle fonti rinnovabili nel settore elettrico" ($CO_2$ Emission and development of renewable source in electric sector)(2015b). This report is an example of the source of data referred to National Sectorial experts.

The report includes information on the Italian electricity production for the years from 1990 until 2013.
For the National database the Italian electricity mix at production is reported only for 2013, the latest mix production available for Italy.

**Table 23 Italian electricity mix at production for 2005, 2010, 2011, 2012, 2013**

| Data | 2013 | |
|---|---|---|
| Source | GWh | % |
| Hydroelectric | 54,672 | 19% |
| Electricity from fossil fuels | 192,987 | 67% |
| Geothermic | 5,659 | 2% |
| Electricity from wind | 15,360 | 5% |
| Photovoltaic | 21,126 | 7% |
| Total | 289,803 | |

Ispra (2015b) reports the $CO_2$ emission from the Italian mix gross production for the years from 1990 until 2013; for the 2013 the $gCO_2$/kwh are 337.43 the losses on the grid are 6.7%.

***<u>Italian electricity mix, at net production</u>***
***Metadata***

**Table 24 the metadata of Italian electricity mix at production**

| Information | Description of content |
|---|---|
| **Process name (***)(*)** | Italian electricity mix at net production |
| **Synonym** (***) | |
| ID Number | |
| Copyright | Clim'Foot |
| Data collector's organisation | ENEA |
| Source | ISPRA report 212/15, 2015 |
| Creation date | 25/05/2015 |
| Modification Date | |
| **Activity Description** | |
| **Amount** | 1 |
| **Unit (*)** | kWh |
| **Technical Description** (***)(*) | The mix of electricity production is composed for 2013 of 19% Hydroelectric, 67% Electricity from fossil fuels, 2% Geothermic and 5% Electricity from wind and 7% photovoltaic. In the estimation of technology mix of electricity production all plants existing in Italy divided by technology are considered for about 60 typologies, and type of fuel used. The electricity production is the net of the losses grid, that are 6.7%. The boundary is gate-to-gate. |
| Technological representativeness – TeR (*) | good |

| | |
|---|---|
| Uncertainty | |
| **Year(s) of validity (*)** | 2013 |
| Time representativeness –TiR (*) | good |
| Geographic Reference (***) (*) | Italy |
| Geographical representativeness – GeR (*) | good |
| **Data Quality Statement** (***)(*) | Good overall data quality. |
| **Data Acquisition** | |
| Source and Reliability | |
| **Information sources** | |
| Validation | |
| Validation note | |
| **General information** (***)(*) | |
| Information | The data set report only the $CO_2$ emissions the $CH_4$ and $N_2O$ are less than 0.003% |

### *Elementary flows*

For the calculation of the emission factor, ISPRA (2015b) reports only the emissions of $CO_2$ after deducting grid losses.

**Table 25 elementary flow for 1kWh of Italian electricity mix at production**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | $CO_2$(fossil) | kg | 3.15E-01 | |

### *Characterization factors*

**Table 26GHG gases reported in $CO_{2eq}$ 1kWh of Italian electricity mix at production**

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| $CO_2$(fossil) | kg | 3,37E-01 | 1 | kg$CO_2$ eq | 3.15E-01 | |

The total emission is kg$CO_{2eq}$ 3.15E-01.

### *Emission factor*

3.15E-01 kg$CO_2$eq/1kWh of Italian electricity mix at net production

### ***Italian electricity mix, at grid losses***

### *Metadata*

**Table 27 the metadata of Italian electricity grid losses**

| Information | Description of content |
|---|---|
| **Process name (***)(*)** | Italian electricity grid losses |
| **Synonym** (***) | |
| ID Number | |

| | |
|---|---|
| Copyright | Clim'Foot |
| Data collector's organisation | ENEA |
| Source | ISPRA report 212/15, 2015 |
| Creation date | 25/05/2015 |
| Modification Date | |
| **Activity Description** | |
| **Amount** | 1 |
| **Unit (*)** | kWh |
| **Technical Description** (***)(*) | The Italian losses at grid for the 2013 is 6.7%. The boundary is gate-to-gate |
| Technological representativeness –TeR (*) | good |
| Uncertainty | |
| **Year(s) of validity (*)** | 2013 |
| Time representativeness –TiR (*) | good |
| Geographic Reference (***) (*) | Italy |
| Geographical representativeness –GeR (*) | good |
| **Data Quality Statement** (***)(*) | Good overall data quality. The data are estimated. |
| **Data Acquisition** | |
| Source and Reliability | |
| **Information sources** | |
| Validation | |
| Validation note | |
| **General information** (***)(*) | |
| Information | The data are referred to the losses grid for the distribution of 1kwh of electricity. |

***Elementary flows***

For the calculation of the emission factor, the ISPRA (2015b) reports only the emissions of $CO_2$ the data are used to grid losses.

**Table 28 elementary flow for 1kWh Italian of electricity grid losses**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | $CO_2$(fossil) | kg | 2.26E-02 | |

***Characterization factors***

**Table 29 GHG gases reported in $CO_{2eq}$ of 1kWh of Italian electricity grid losses**

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| $CO_2$(fossil) | kg | 2.26E-02 | 1 | kgCO2 eq | 2.26E-02 | |

The total emission is kg$CO_{2eq}$ 2.26E-02

***Emission factor***

EMISSION FACTORS IS

2.26E-02 kg$CO_2$eq/1kWh of Italian electricity grid losses

# 7 Transport

The Emission Factors of transport sector should be covered completely to perform the CFO. Table 30 shows the categories considered in the ADEME DB. For the all data covered in the table at least two emission factors should be calculated, one about the combustion of fuels in the mobile source and one about the production (upstream) of the fuels. This distinction is necessary because in the GHG Protocol Corporate Accounting and Reporting Standard the direct emission due to the transport owned or controlled by the company should be accounted for in term of mobile combustion of fuel in the company, while the production of fuel is considered an upstream emission.

**Note**
The production of fuels is reported in the Energy sector/fuels, in section 6.

**Table 30 Categories of transport considered in cartography of ADEME database**

| Type-1 | Type -2 | Subtype |
|---|---|---|
| Freight | Air | |
| | Road | |
| | Rail | |
| | Sea/Rivers | |
| People | Air | |
| | Road | |
| | Rail | |
| | Sea/Rivers | |
| | | |
| | | |

For this sector the IPCC (2006) reports the default emission factors, related to the type of transport (air, water, road, railway), the type of fuels and the type of engine. The latest updates refer to 2006 but many improvements in the engines and technologies have been developed since then. Moreover for the road transport more recent sources exist, such as the Copert model.

## 7.1 Example: Road transport

The IPCC defines that the $CO_2$ emissions for mobile combustion are based on the carbon content of the fuels and should present 100% oxidation of the fuel carbon. The Figure 11 report the default $CO_2$ emission factor of road transportation.

TABLE 3.2.1
ROAD TRANSPORT DEFAULT $CO_2$ EMISSION FACTORS AND UNCERTAINTY RANGES [a]

| Fuel Type | Default (kg/TJ) | Lower | Upper |
|---|---|---|---|
| Motor Gasoline | 69 300 | 67 500 | 73 000 |
| Gas/ Diesel Oil | 74 100 | 72 600 | 74 800 |
| Liquefied Petroleum Gases | 63 100 | 61 600 | 65 600 |
| Kerosene | 71 900 | 70 800 | 73 700 |
| Lubricants [b] | 73 300 | 71 900 | 75 200 |
| Compressed Natural Gas | 56 100 | 54 300 | 58 300 |
| Liquefied Natural Gas | 56 100 | 54 300 | 58 300 |


TABLE 3.2.1
ROAD TRANSPORT DEFAULT $CO_2$ EMISSION FACTORS AND UNCERTAINTY RANGES [a]

| Fuel Type | Default (kg/TJ) | Lower | Upper |
|---|---|---|---|
| Motor Gasoline | 69 300 | 67 500 | 73 000 |
| Gas/ Diesel Oil | 74 100 | 72 600 | 74 800 |
| Liquefied Petroleum Gases | 63 100 | 61 600 | 65 600 |
| Kerosene | 71 900 | 70 800 | 73 700 |
| Lubricants [b] | 73 300 | 71 900 | 75 200 |
| Compressed Natural Gas | 56 100 | 54 300 | 58 300 |
| Liquefied Natural Gas | 56 100 | 54 300 | 58 300 |


Figure 11 Default $CO_2$ emission factor of road transportation

The IPCC defines that the $CH_4$ and $N_2O$ emissions for mobile combustion depend largely upon the combustion and emission control technology presents in the vehicles. The Figure 12 presents the $N_2O$ and $CH_4$ emission factors related to type of vehicles and fuels about the Copert IV model (2006).

**Figure 12 Emission factor $N_2O$ and $CH_4$ for European**

| TABLE 3.2.5 EMISSION FACTORS FOR EUROPEAN GASOLINE AND DIESEL VEHICLES (mg/km), COPERT IV MODEL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Type | Fuel | Vehicle Technology/ Class | $N_2O$ Emission Factors (mg/km) | | | | $CH_4$ Emission Factors (mg/km) | | | |
| | | | Urban | | Rural | Highway | Urban | | Rural | Highway |
| | | | Cold | Hot | | | Cold | Hot | | |
| Passenger Car | Gasoline | pre-Euro | 10 | 10 | 6.5 | 6.5 | 201 | 131 | 86 | 41 |
| | | Euro 1 | 38 | 22 | 17 | 8.0 | 45 | 26 | 16 | 14 |
| | | Euro 2 | 24 | 11 | 4.5 | 2.5 | 94 | 17 | 13 | 11 |
| | | Euro 3 | 12 | 3 | 2.0 | 1.5 | 83 | 3 | 2 | 4 |
| | | Euro 4 | 6 | 2 | 0.8 | 0.7 | 57 | 2 | 2 | 0 |
| | Diesel | pre-Euro | 0 | 0 | 0 | 0 | 22 | 28 | 12 | 8 |
| | | Euro 1 | 0 | 2 | 4 | 4 | 18 | 11 | 9 | 3 |
| | | Euro 2 | 3 | 4 | 6 | 6 | 6 | 7 | 3 | 2 |
| | | Euro 3 | 15 | 9 | 4 | 4 | 7 | 3 | 0 | 0 |
| | | Euro 4 | 15 | 9 | 4 | 4 | 0 | 0 | 0 | 0 |
| | LPG | pre-ECE | 0 | 0 | 0 | 0 | 80 | | 35 | 25 |
| | | Euro 1 | 38 | 21 | 13 | 8 | | | | |
| | | Euro 2 | 23 | 13 | 3 | 2 | | | | |
| | | Euro 3 and later | 9 | 5 | 2 | 1 | | | | |
| y Vehicles | Gasoline | pre-Euro | 10 | 10 | 6.5 | 6.5 | 201 | 131 | 86 | 41 |
| | | Euro 1 | 122 | 52 | 52 | 52 | 45 | 26 | 16 | 14 |
| | | Euro 2 | 62 | 22 | 22 | 22 | 94 | 17 | 13 | 11 |
| | | Euro 3 | 36 | 5 | 5 | 5 | 83 | 3 | 2 | 4 |
| | | Euro 4 | 16 | 2 | 2 | 2 | 57 | 2 | 2 | 0 |

### *7.1.1 Example on Emission Factor Calculate: average gasoline Italian car passengers*

The data to calculate the emission factor come from different source, from the Italian NIR (2015) and from IPCC (2006).

***Metadata***

**Table 31 Metadata of 1km of average Italian gasoline passenger car**

| Information | Description of content |
|---|---|
| **Process name (***)(*)** | Average Italian gasoline passenger car |
| **Synonym** (***) | |
| ID Number | xxxxx |
| Copyright | **Clim'Foot project** |
| Data collector's organisation | ENEA |
| Source | Italian National Inventory Report (2015) |
| Creation date | 2016 |
| Modification Date | |
| **Activity Description** | |
| **Amount** | 1 |
| **Unit (*)** | Km |

| | |
|---|---|
| **Technical Description** (***)(*) | Mobile combustion emission of average passenger car representative of Italian mix. The boundary is gate-to-gate |
| Technological representativeness –TeR (*) | |
| Uncertainty | |
| **Year(s) of validity (*)** | 2015 |
| Time representativeness –TiR (*) | |
| Geographic Reference (***) (*) | Italy |
| Geographical representativeness – GeR (*) | |
| **Data Quality Statement** (***)(*) | The data set reports the CO2, CH4, N2O calculated as reported in IPPC (2006), considering the Italian average. |
| **Data Acquisition** | |
| Source and Reliability | |
| **Information sources** | |
| Validation | |
| Validation note | |
| **General information** (***)(*) | Italian Greenhouse Gas Inventory 1990 – 2013 - National Inventory Report 2015 |

### *Elementary flows*

In Italian NIR (2015) reports average fuel consumption and mileage for main vehicle categories and road typse for the year 2013. Table 33 reports the technological characteristics of Italian passenger Car (PC) and effective mileage for gasoline PC, where the circulating fleet has been calculated as stock data multiplied by effective mileage (%) (see Table 32).

**Table 32 type of vehicles in percentage. Source NIR (2015)**

| | |
|---|---|
| **4%** | **pre-EURO** |
| **3%** | **Euro I** |
| **15%** | **Euro II** |
| **28%** | **Euro III** |
| **50%** | **Euro IV + Euro V + Euro VI** |

The euro V and VI have been included in the Euro IV because the data from the IPPC (2006) account for information until EURO IV.

**Table 33 km travelled by gasoline PC for type of vehicles and type of road (HW-High way; RUR, rural road; URB, urban road)**

| Type of road | Type of vehicles | km |
|---|---|---|
| HW | Pre-Euro | **1.24E+09** |

| | | |
|---|---|---|
| HW | Euro I | **9.33E+08** |
| HW | Euro II | **4.66E+09** |
| HW | Euro III | **8.70E+09** |
| HW | Euro III | **1.55E+10** |
| **tot** | | |
| | | **2.15E+09** |
| RUR | Pre-Euro | **1.61E+09** |
| RUR | Euro I | **8.07E+09** |
| RUR | Euro II | **1.51E+10** |
| RUR | Euro III | **2.69E+10** |
| RUR | Euro III | |
| **tot** | | **1.39E+09** |
| | | **1.04E+09** |
| URB | Pre-Euro | **5.20E+09** |
| URB | Euro I | **9.71E+09** |
| URB | Euro II | **1.73E+10** |
| URB | Euro III | **1.20E+11** |
| URB | Euro III | **1.24E+09** |
| **tot** | | **9.33E+08** |

Using the data from Table 32 and Table 33the emission of $CH_4$, $N_2O$ are calculated, as reported in

Table 34.

**Table 34 fuel combustion from gasoline Italian PC**

| Operating Condition | km Travelled | CH4 (mg/km) | N2O (mg/km) | $CH_4$ (kg) | $N_2O$ (kg) |
|---|---|---|---|---|---|
| HW pre Euro | 1.24E+09 | 41 | 6.5 | 5.10E+04 | 8.08E+03 |
| HW Euro I | 9.33E+08 | 14 | 8 | 1.31E+04 | 7.46E+03 |
| HW Euro II | 4.66E+09 | 11 | 2.5 | 5.13E+04 | 1.17E+04 |
| HW Euro III | 8.70E+09 | 4 | 1.5 | 3.48E+04 | 1.31E+04 |
| HW Euro IV | 1.55E+10 | 0 | 0.7 | 0.00E+00 | 1.09E+04 |
| | | | | | |
| RUR pre Euro | 2.15E+09 | 86 | 65 | 1.85E+05 | 1.40E+05 |
| RUR Euro I | 1.61E+09 | 16 | 17 | 2.58E+04 | 2.74E+04 |
| RUR Euro II | 8.07E+09 | 13 | 4.5 | 1.05E+05 | 3.63E+04 |
| RUR Euro III | 1.51E+10 | 2 | 2 | 3.01E+04 | 3.01E+04 |
| RUR Euro IV | 2.69E+10 | 2 | 0.8 | 5.38E+04 | 2.15E+04 |
| | | | | | |
| UR pre Euro | 1.39E+09 | 131 | 10 | 1.82E+05 | 1.39E+04 |
| UR Euro I | 1.04E+09 | 26 | 22 | 2.70E+04 | 2.29E+04 |
| UR Euro II | 5.20E+09 | 17 | 11 | 8.84E+04 | 5.72E+04 |

| | | | | | |
|---|---|---|---|---|---|
| UR Euro III | 9.71E+09 | 3 | 3 | 2.91E+04 | 2.91E+04 |
| UR Euro IV | 1.73E+10 | 2 | 2 | 3.47E+04 | 3.47E+04 |
| **Sum total** | **1.20E+11** | | | **9.11E+05** | **4.64E+05** |

For each gases the sum of all emissions is divided by the total km travelled to have the emission of mobile combustion of average Italian gasoline PC for 1 km, as reported in Table 36.
For the calculation of $CO_2$, the emission factor for gasoline reported in

TABLE 3.2.1
ROAD TRANSPORT DEFAULT $CO_2$ EMISSION FACTORS AND UNCERTAINTY RANGES [a]

| Fuel Type | Default (kg/TJ) | Lower | Upper |
|---|---|---|---|
| Motor Gasoline | 69 300 | 67 500 | 73 000 |
| Gas/ Diesel Oil | 74 100 | 72 600 | 74 800 |
| Liquefied Petroleum Gases | 63 100 | 61 600 | 65 600 |
| Kerosene | 71 900 | 70 800 | 73 700 |
| Lubricants [b] | 73 300 | 71 900 | 75 200 |
| Compressed Natural Gas | 56 100 | 54 300 | 58 300 |
| Liquefied Natural Gas | 56 100 | 54 300 | 58 300 |

Figure 11 is considered, with the total amount of 69.300 (kg/TJ)
For $CO_2$ EF is provided in kg/TJ, thus we need to have the gasoline consumption in TJ.
The conversion factor from kg gasoline to TJ is 4,36E-05.
Table 35 shows the consumption of gasoline in Italy for years 2013 for different road (NIR, 2015).

**Table 35 Gasoline consumption in Italy for different road 2013**

| | **Gasoline consumption (kg)** |
|---|---|
| **HW (HighWay)** | 1.57E+09 |
| **RUR (Rural)** | 2.40E+09 |
| **URB (Urban)** | 2.85E+09 |
| tot | 6.82E+09 |

The total gasoline consumption was multiplied by the conversion factor to have the annual consumption of gasoline, which is 2.97E+05 TJ
This value was then multiplied by 6.93E+04 kg/TJ to calculate the kg of $CO_2$ emitted in Italy by gasoline PC during 2013, which is 2.06E+10kg.
To calculate the kg of $CO_2$ emitted for km travelled, the amount of 2.06E+10kg of $CO_2$ emitted in Italy by gasoline PC was divided by the total km travelled to get 1.72E-01 kg$CO_2$/km as reported in Table 37.

**Table 36 the elementary flow of mobile combustion of Italian gasoline PC for 1 km**

| Class | Category level 1 | Category lev 2 | Flow | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Output | Emissions | Emissions to air | $CH_4$ (fossil) | kg | 7.62E-06 | |
| Output | Emissions | Emissions to air | $CO_2$ (fossil) | kg | 1.72E-01 | |
| Output | Emissions | Emissions to air | $N_2O$ | kg | 3.88E-06 | |

***Characterization flows***

The Table 37reports the Characterization flows in CO2eq of mobile combustion of Italian gasoline PC for 1 km.

**Table 37 GHG gases reported in $CO_{2eq}$ of mobile combustion of Italian gasoline PC for 1 km**

| flow | Unit | Quantity | Characterization factor | IdUnit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| $CH_4$ (fossil) | kg | 7.62E-06 | 30 | kgCO2 eq | 2.29E-04 | |
| $CO_2$ (fossil) | kg | 1.72E-01 | 1 | kgCO2 eq | 1.72E-01 | |
| $N_2O$ | kg | 3.88E-06 | 265 | kgCO2 eq | 1.03E-03 | |

***Emission factor***

EXAMPLE: Emission factor Calculation

| | | |
|---|---|---|
| CH4 (fossil) | $kgCO_{2eq}$ | 2.29E-04+ |
| CO2 (fossil) | $kgCO_{2eq}$ | 1.72E-01+ |
| N2O | $kgCO_{2eq}$ | 1.03E-03+ |
| Total | **$kgCO_{2eq}$** | **1.73E-01** |

***Emission Factor***

**The EMISSION FACTOR IS**

**1.73E-01 $kgCO_{2eq}$/km**

# 8 Data quality management and Uncertainty

The purpose of this chapter is to define how to set a data quality management plan, data quality control and verification/validation of the data which will be included in the national carbon footprint databases.
The target group for this report is the managers and the contact persons involved in the data collection and elaboration, and the database managers. The guideline provides technical guidance and recommendations for the procedures to be used for data treatment, and includes minimum requirements for data quality documentation according to the current initiatives at international level.

## 8.1 Establishing data quality management plan

A data quality management plan (DQMP) is a combination of procedures to properly manage data and their quality, to increase the robustness of the calculated emissions factors, both within the project partners (and managers of the DB) and for the users of the organisation carbon footprint calculation tool.

It is aimed at :

- Providing routine and consistent checks to ensure data integrity, correctness, and completeness;
- Identifying and addressing errors and omissions;
- Documenting and archiving inventory material and record all quality-related activities.

The DQMP consists of two main parts:

- procedures to enable the publication of the emissions factors, from the identification of the data sources to the calculation and validation of the data;
- rules for defining and calculating the quality of the emissions factors.

The main steps in defining and setting procedures for data management are described in Figure 13.

| | |
|---|---|
| Description of scopes and activities included | Detailed definition of the level of disaggregation and coverage of emissions factors (especially for scope 3) |
| Identification of person(s) responsible for DMP | Identification – for each partner – of the person responsible for the DMP and for the maintenance and update of the EF database |
| Data collection procedure | Criteria for the selection of data sources and for their update |
| Calculation methodologies | Methodological guidelines on EF calculation |
| Data transmission, storage, plan for update | Storage of the EF in the database, schedule the update, depending on the processes (different requirements need to be set) |

**Figure 13 Procedures to manage data**

The steps involve the following activities:

- **Description of scopes and activities included**
  This involves the definition of the emission factors to be included in the national databases, in terms of sector coverage and their disaggregation level, i.e. fuel production and fuel combustion. A detailed list of processes that enable the calculation of CFO for Scope 1 and 2 has been provided in Annex 4, together with a first proposal of processes and products to cover scope 3.
- **Identification of person(s) responsible for DMP**
  For each partner, a person responsible for the data management plan should be identified. This person is in charge of defining the data collection priorities (i.e. which sectors and processes are the most relevant for enabling the CFO in the country), is responsible for the calculation of the EF, is the contact point for the national EFs database, is responsible for uploading EFs into the national database, storing them and defining a plan for their update.
- **Data collection procedure**
  Data collection procedure are defined within the methodological guidance, in terms of main references from which data can be retrieved. However, additional and different sources might be necessary and available in the different countries. The contact person of the national database is responsible for defining and documenting specific procedures, when these deviates from those defined in the methodological guidance.
  These data collection procedure, shall be documented and should include:
  - General specifications of data collection methods and units, and when necessary specific instructions for individual properties;
  - References to relevant data collection instructions, manuals, handbooks, standards, etc;
  - A list of personnel responsible, if different from the data contact point of the national database;
  - A description of any subjective choices and compromises to the theoretical data requirements defined in the methodological guidance of the project;
- **Calculation methodologies**
  Data calculation procedure are defined within the methodological guidance, in terms of elaboration of the EF. In addition, the contact person of the national database is responsible for defining and documenting specific calculation rules for elaborating EF; in case different sources than those defined in the methodological guidance are used. This is aimed at increasing the transparency of the EFs calculation, their robustness and update.
- **Data transmission, storage, plan for update**
  The data collected and elaborated have to be uploaded and stored into the national database. An update of the EFs should be scheduled, also for the after LIFE: this will be defined among the partners, building upon the feedback from the implementation test with companies. The required frequency of updates cannot be defined by default, as it depends on the variation and development in the property for which data are to be collected. For example, for mature technologies, such as the BOF steel production, data collection on GHG emissions at 5-year intervals may be adequate, while annual updates may be required for technologies in more rapid development.

In the following paragraphs, a detailed description of the two main steps of the DQMP will be provided, namely the data collection procedures and the data quality assessment.

### 8.1.1 Data collection procedures

In the scope for a data collection system, the following issues are considered:

- *Objectives* of the data collection system and *data requirements*, in terms of included items (processes, environmental mechanisms, groups of people) and the properties for which data are to be collected, and the quality requirements for these data. These elements have been defined in the methodological document.

– Procedure for identification and treatment of data gaps in processes and flows.
At this stage it is also useful to consider the required completeness of the data collection system for EFs and how data gaps (i.e. useful emission factors which are however not easily retrievable from the existing European and national data sources) are to be identified and avoided. Data gaps may exist when: i) data does not exist for a specific input/product; ii) data exists for a similar process but it has been generated in a different region or using a different technology or in a different time period. Whenever a data gaps is identified, the contact point of each national dataset has to record it and inform the partner responsible for the Clim'Foot database.

– Required frequency of data collection, location of data collection points, data collection methods and units, and how this matches the nature of the properties for which data are to be collected (type of data to be collected, natural variation versus requirements on precision, accessibility to measurement points, etc.).
The required frequency of data collection depends on the variation and development of the product's manufacturing for which data are to be collected, compared to precision required.
For mature technologies data collection at 5-year intervals may be adequate, while annual updates may be required for technologies in rapid development.
The data collection locations should be selected to reflect the desired representativeness of the data in view of the factors that may influence geographical variability (climate, soil type, raw material quality, legislation/regulatory differences, availability and costs of raw materials, labour and capital). Accessibility of measurement points and equipment (e.g. own production plants versus a supplier's production plant) and costs of measurement may also influence the choice of location.
The choice of data collection method depends on the required precision and the type of data to be obtained, which depend on the level of influence of the managers of the data collection of the analysed system.
For measurements, national or preferably international standards for the reference sector should be used whenever possible.
Legislation or authoritative requirements may also prescribe specific standards of measurement to be applied. Measured data have the advantage of being up-to-date and specific, while calculated data have the advantage of being based on theoretical models and not being affected by the possible errors of individual measurements.

– Personnel involved, both at management and operational level.
Personnel for data collection should be assigned on the basis of their technical qualifications (required skills and knowledge of procedures). Links to other parts of the organisation can be advantageous to ensure coordination and resource savings in data collection.

– <u>Required documentation, validation and communication of the data to fulfil the objective.</u>

  A validation phase is planned before and after the implementation of the data collection system (to prevent inconsistencies or incomplete information) and during its functioning (to correct any deficiencies). It is responsibility of the contact person of the national database to verify that all the documentation requirements will be fulfilled, and that the data are validated (i.e. verification of the calculation).

A schematic representation of the data collection procedure and elaboration is provided in Figure 14.

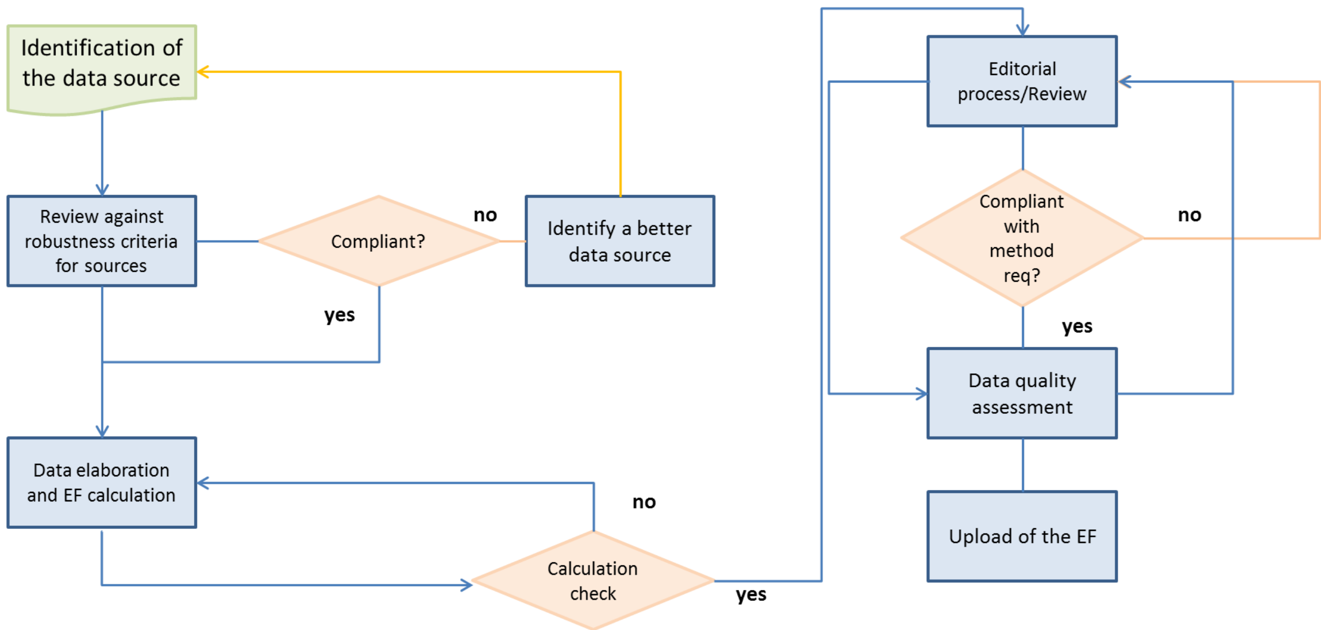



Figure 14 Procedure for data collection and elaboration

When a data source has been identified, a first evaluation of its robustness has to be carried out, i.e. check whether it comes from robust and reliable sources, such as those included in the methodological guidance of Clim'Foot project. If the robustness of the source is guarantee, then the calculation of the EFs can be carried out, otherwise a better source needs to be identified. After the calculation, the editorial process can start, during which the review of the calculation is performed, and the data quality of the resulting EF is calculated. Finally, the EF can be uploaded into the national database.

### *8.1.2 Data gaps*

Data gaps on emission factors exist when there is no specific or generic data available that is sufficiently representative of the given process. For most processes where data may be missing it should be possible to obtain sufficient information to provide a reasonable estimate of the missing data. Missing information can be of different types and have different characteristics, each requiring separate resolution approaches.

Data gaps may exist when:

- Data does not exist for a specific input/product, or
- Data exists for a similar process (proxy) but:
  - The data has been generated in a different region;
  - The data has been generated using a different technology;
  - The data has been generated in a different time period.

Data gaps stemming during the data collection will be treated according to the hierarchy reported below:

- Proxy data as much as possible representative of the reference sector will be selected from specific literature sources. The update of the data and the adjustment of the geographical context will be performed with the support of high skilled experts with a deep knowledge of the product system under study.

- Generic data will be selected based on expert judgment

## 8.2 Data quality assessment

This section describes how the data quality should be assessed.
Different approaches to data quality assessment have been developed, in particular:

- requirements available in the GHG standards and guidelines

    - ISO 14064-1:2006 quality limited to the criterion "uncertainty" (of emissions factors)

    - GHG Protocol: data quality indicators (Pedigree matrix, non-updated release), namely representativeness (technological, temporal, geographical, completeness, reliability). Qualitative approach (no scoring system)

    - PAS 2050: relevance, completeness, consistency, accuracy and transparency

- developments occurring in the LCA field:

    - ISO 14044 requirements (qualitative)

    - PEF/OEF requirements (scoring system)

    - LCI databases own systems

In order to develop a DQ assessment suitable to be used in the framework of the Clim'Foot project, the following requirements have been considered:

- Development of a scoring system, to be displayed also in the CF calculator;

- Favour the transition towards EF databases.

From a general perspective, the quality criteria need to be evaluated at two different levels: i) ***general level***, i.e. the extent to which the EF represents the declared characteristics of the data sources from which it has been elaborated; ii) ***case-specific***, meaning how well the EF factor is suitable for the assessment of the CFO of a specific company, i.e. the extent to which it is fit for purpose. The aim of this section is to provide indications for the data quality evaluation at the level of emission factor, without considering the specific application.
On the basis of these requirements and, considering the initiatives on data quality at European and international level, the following criteria have been defined:

- ***time representativeness (TiR)*** = degree to which the dataset reflects the specific conditions of the system being considered regarding the time/age of the data and including background process datasets, if any. It refers to the data collection and not to the data publication.

- ***technological representativeness (TeR)*** = degree to which the dataset reflects the true population of interest regarding technology, including for included background process datasets, if any.
- ***geographical representativeness (GeR)*** = degree to which the dataset reflects the true population of interest regarding geography, including for included background process datasets, if any.
- ***Uncertainty (U) (see section 8.3)***

A semi-quantitative assessment of the overall emission factors shall be calculated summing up the achieved quality rating for each of the quality criteria, divided by the total number of criteria. The Data Quality Rating (DQR) result is used to identify the corresponding quality level. This evaluation shall be done according to the following formula and Table 38.

$$DQR=\frac{TiR+TeR+GR+U}{4}$$

The formula and the Table 38 below are an adaptation of the latest indications provided within the Environmental Footprint initiative. The aim is to test them during the voluntary programme with organisations, collect the feedback from the users' perspective and deliver a new release of the formula and the criteria by the end of the project. As default approach, whenever not enough information is available to set a score, a poor level (quality rating 4) for the respective parameter is considered.

**Table 38Quality level and rating for the quality criteria (Adapted from: Guidance for the implementation of the EU PEF during the EF pilot phase -Version 5.0 and Ecoinvent Data Quality Guidelines, May 2015)**

| Quality level | Quality rating | TiR | TeR | GR | U |
|---|---|---|---|---|---|
| **Very good** | 1 | The TiR is not older than 4 years with respect to the reference year of the data source | The technologies used are exactly the same as the technologies covered by the data | The process takes place in the same country as the one the data is valid for. | ≤ 10% |
| **Good** | 2 | The TiR is not older than 6 years with respect to the reference year of the data source | The technologies used are included in the mix of technologies covered by the data | The process takes place in the geographical region (e.g. Europe) for which the data is valid for. | 10% to 20% |
| **Fair** | 3 | The TiR is not older than 8 years with respect to the reference year of the data source | The technologies used are similar to those covered by the data | The process takes place in one of the geographical regions for which the data is valid for. | 20% to 30% |
| **Poor** | 4 | The TiR is not older than 10 years with | The technologies used show several | The process takes place in a country that is not | 30% to 50% |

| | | | | | |
|---|---|---|---|---|---|
| | | respect to the reference year of the data source | relevant differences compared to the technologies covered by the data | included in the geographical region(s) the data is valid for, but sufficient similarities are estimated based on expert judgement. | |
| **Very poor** | 5 | The TiR is older than 10 years with respect to the reference year of the data source | The technologies used are not representative for the technologies covered by the data | The process takes place in a different country than the one for which the data is valid for. | > 50% |

## 8.3 Uncertainty

When developing an emission factor, the issue of uncertainty and its evaluation arises. There is abundance of typologies and terminologies related to the word "uncertainty", such as:

- systematic errors, random errors;
- data uncertainty, model uncertainty, completeness uncertainty;
- scenario uncertainty, parameter uncertainty, model uncertainty;
- uncertainty vs. accuracy vs. variability vs. sensitivity.

Moreover, different sources of uncertainty can be identified:

- ***Parameter uncertainty***: a measure of how close the data used to calculate emissions are to the true actual data and emissions. Examples are GWP values (± 35% for the 90% confidence interval), GHG emission measurement and calculation. The estimated uncertainty of emissions from individual sources (e.g. power plants, motor vehicles, dairy cattle) is either a function of instrument characteristics, calibration and sampling frequency of direct measurements, or (more often) a combination of the uncertainties in the emission factors for typical sources and the corresponding activity data.
- ***Model uncertainty***: limitations in the ability of the modelling approach used to reflect the real world;
- ***Scenario uncertainty***: methodological choices allocation, product use assumption, EoL assumptions

As far as the data quality is concerned, parameter uncertainty (U) is evaluated in the framework of the national databases, in agreement with the Product Environmental Footprint Guidelines (EC 2014) and Ecoinvent Data Quality Guidelines (Weidema et al., 2015).
However, a quantitative assessment of U is not always available in the sources of data that will be used for developing the emission factors, and/or in some cases it can be too complex to calculate. Currently, a diversity of approaches can be identified in the LCI (life cycle inventory) and CF databases :

- Pedigree Matrix: it is represented as combination of two elements: i) basic uncertainty (variation and stochastic errors of values which describe the exchanges); ii) additional uncertainty (due to use of estimates, incompleteness in the sample, extrapolation, etc), via data quality indicators, namely "reliability", "completeness", "temporal correlation", "geographic correlation", and "further technological correlation". Each characteristic is divided into five quality levels with a score between 1 and 5. A set of five indicator scores is attributed to each individual input and output exchange. Overall uncertainty is increased by the addition of normal distributions to the underlying normal distribution derived from the basic uncertainty. A normal uncertainty distribution is attributed to each score of the five characteristics. Each of these distributions has a mean value of zero, and a variance based on expert judgement, .

- Expert judgments
- No uncertainty reported, but additional metadata for better describing the data (e.g., sample, reliability).
- Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC). The uncertainties in the emission factors and activity data are described using probability density functions. Where data are available to do so, the shape of the probability density function should be determined empirically. Otherwise, expert judgement can be used.

Given the variety of approaches used to assess it, in the context of Clim'Foot project it is proposed to ***express U according to the different types of information documented in the original data sources***. Therefore, it can be expressed as standard deviation, percentage or according to expert judgment. For the latter, it can be evaluated considering the following aspects:

- The procedure for the data collection (related to the origin of the data), which can be based on estimations, measurements or calculation.
- The size of the sample used for the calculation of the data reported

Then, according to the information available for the above-reported aspects, the uncertainty of the data can be evaluated considering the categories reported in the first column of the Table 38.
In the following sections are reported some examples to illustrate how the data quality can be calculated.

## 8.4 Data quality levels

Based on the overall score resulting from the application of the DQ formula, the following data quality levels can be identified (Table 39):

Table 39 Data Quality levels

| Overall data quality rating (DQR) | Overall data quality level |
|---|---|
| **≤ 1.6** | Excellent quality |
| **1.6 to 2.0** | Very good quality |
| **2.1 to 3.0** | Good quality |
| **3.1 to 4.0** | Fair quality |
| **> 4** | Poor quality |

## 8.5 Examples of how to calculate the DQR

In this section examples of how to calculate the DQR are reported and discussed, considering the data used for illustrative purposes in the previous sections of the methodology report.

### *8.5.1 Scope 1 -DQ for the EFs for composting process in Italy (NIR)*

In this example the data quality for the composting process reported in section 5.3.1. is calculated.
As far as the first parameter is concerned (TiR), the reference year shall be considered. In this case the data have been collected in 2013, thus the data are not older than 4 years. This means a score equal of 1.
Regarding the technological representativeness, the composting for which the data have been collected is an average of the main available technologies (composting from selected waste and mechanical-biological treatment plants). Therefore, the TeR can be considered to be good (score equal to 2).
If we consider that this EFs will populate the Italian DB, the geographical representativeness is very good since the data are collected in the same country (score equal to 1).
The uncertainty is declared to be very high, since the direct emissions are estimated (based on literature). In particular, the $CO_2$ emissions and the emissions factors have an uncertainty of 100%, because are calculated based on an average input waste. However, this is a common approach in the waste sector and considering that for the activity data an uncertainty of 20% is declared, an average score of 4 (poor) is assigned. More in general, the same default approach shall be applied when the information available does not allow to define a quality level for the uncertainty and when the information reports a high uncertainty.
Applying the DQ formula, the overall rating is 2 ((1+2+1+4)/4) which corresponds to a very good quality.

### *8.5.2 Scope 3- DQ of a Life Cycle Inventory (LCI) - Gypsum plaster (CaSO4 alpha semihydrate) (en) from Okobau.dat*

This example refers to the one already mentioned in section 5.3.2. We consider that this EF will be used for implementing the Croatian DB. The information useful for evaluating the TiR are reported in key data set information (reference year:2007), therefore the score is 4.
The TeR is good because the technology used for the production is included in the mix of technologies used for the gypsum plaster production.
Regarding the GeR, it is evaluated to be good since it is included in the geographical region (Europe) in which the dataset is valid.
No information is available about the uncertainty, neither regarding the type of data used for creating the process nor the sample size. Therefore, a conservative approach has been applied and a fair value has been assigned.
The overall quality rating is 3 ((4+2+2+4)/4), which corresponds to a poor quality.

## 8.6 knock-out criteria

Knock-out criteria have not been defined since the mandatory fields in the metadata description defined an entry level requirements.

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GHG Protocol Corporate Value Chain (Scope 3) Standard - This standard provides instruction on how a company should perform a scope 3 GHG inventory, which includes emissions from throughout a company's value chain.

GHG Protocol Product Life Cycle Standard The Product Life Cycle Standard instructs users on accounting for the emissions of a product's full life cycle; users can learn to focus efforts on the greatest GHG reduction opportunities in order to develop more sustainable products.

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## Annex 1: Emission factors of GHG

| Gases- common name | Chemical formula | Characterization Factor |
|---|---|---|
| HFC-23 | CHF3 | 12400 |
| HFC-32 | CH2F2 | 677 |
| HFC-41 | CH3F | 116 |
| HFC-125 | CHF2CF3 | 3170 |
| HFC-134 | CHF2CHF2 | 1120 |
| HFC-134a | CH2FCF3 | 1300 |
| HFC-143 | CH2FCHF2 | 328 |
| HFC-143a | CH3CF3 | 4800 |
| HFC-152 | CH2FCH2F 0.4 | 16 |
| HFC-152a | CH3CHF2 | 138 |
| HFC-161 | CH3CH2F | 4 |
| HFC-227ca | CF3CF2CHF2 | 2640 |
| HFC-227ea | CF3CHFCF3 | 3350 |
| HFC-236cb | CH2FCF2CF3 | 1210 |
| HFC-236ea | CHF2CHFCF3 | 1330 |
| HFC-236fa | CF3CH2CF3 | 8060 |
| HFC-245ca | CH2FCF2CHF | 716 |
| HFC-245cb | CF3CF2CH3 | 4620 |
| HFC-245ea | CHF2CHFCHF2 | 235 |
| HFC-245eb | CH2FCHFCF3 | 290 |
| HFC-245fa | CHF2CH2CF3 | 858 |
| HFC-263fb | CH3CH2CF3 | 76 |
| HFC-272ca | CH3CF2CH3 | 144 |
| HFC-329p | CHF2CF2CF2CF3 | 2360 |
| HFC-365mf | CH3CF2CH2CF3 | 804 |
| HFC-43-10 | CF3CHFCHFCF2CF3 | 1650 |
| HFC-1132a | CH2=CF2 | <1 |
| HFC-1141 | CH2=CHF | <1 |
| (Z)-HFC-1225ye | CF3CF=CHF(Z) | <1 |
| (E)-HFC-1225ye | CF3CF=CHF(E) | <1 |
| (Z)-HFC-1234ze | CF3CH=CHF(Z) | <1 |
| HFC-1234yf | CF3CF=CH2 | <1 |
| (E)-HFC-1234ze | CF3CH=CHF | <1 |
| (Z)-HFC-1-1336 | CF3CH=CHCF3(Z) | <1 |
| HFC-1234zF | CF3CH=CH2 | <1 |
| HFC-1345zFc | C2F5CH=CH2 | <1 |
| 3,3,4,4,5,5,6,6,6-Nonafluorohex-1-ene C4 | C4F9CH=CH2 | <1 |
| 3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluoroo-1-ene | C6F13CH=CH2 | <1 |

| | | |
|---|---|---|
| 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-Heptadecafluorodec-1-ene | C8F17CH=CH2 | <1 |

Figure 15 Emission factor for Hydrochlorofluorocabons

| Gases- common name | Chemical formula | Characterization Factor |
|---|---|---|
| PFC-14 | CF4 | 6630 |
| PFC-116 | C2F6 | 11100 |
| PFC-c21 | c-C3F6 | 9200 |
| PFC-218 | C3F8 | 8900 |
| PFC-318 | c-C4F8 | 9540 |
| PFC-31-10 | c-C5F8 | 9200 |
| Perfluorocyclopentene | c-C5F8 | 2 |
| PFC-41-12 | n-C5F12 | 8550 |
| PFC-51-14 | n-C6F14 | 7910 |
| PFC-61-16 | n-C7F16 | 7820 |
| PFC-71-18 | C8F18 | 7620 |
| PFC-91-18 | C10F18 | 7190 |
| Perfluorodecalin (cis) Z | Z-C10F18 | 7240 |
| Perfluorodecalin (trans) | E-C10F18 | 6290 |
| PFC-1114 | CF2=CF2 | <1 |
| PFC-1216 | CF3CF=CF2 | <1 |
| Perfluorobuta-1,3-diene | CF2=CFCF=CF2 | <1 |
| Perfluorobut-1-ene | CF3CF2CF=CF2 | <1 |
| Perfluorobut-2-ene | CF3CF=CFCF3 | <1 |

Figure 16 Emission factor for Perfluorocarbons

# Annex 2: examples from the ELCD database

**Beverage carton converting;Converting;converting mix, at plant;beverage carton**

Table of Contents: Process information - Modelling and validation - Administrative information - Inputs and Outputs

## Process information

**Key Data Set Information**

| | |
|---|---|
| Location | EU-27 |
| Geographical representativeness description | Data has been collected from the main 3 beverage carton producers in Europe. Two of the 3 beverage carton producing companies collected data from all of their sites in Europe (sites are located in Spain, Germany, Hungary, France, Serbia, Ukraine, Sweden, Netherlands, Russia, Italy, UK, Denmark and Finland). The third delivered data from its main site, stating that the same technologies are used at all three sites of that company, so that therefore the data from the site located in Germany can be considered representative for the other European sites of this producer. Altogether data has been collected from 20 European sites. |
| Reference year | 2009 |
| Name | Base name; Treatment, standards, routes; Mix and location types<br>Beverage carton converting;Converting;converting mix, at plant;beverage carton |
| Use advice for data set | The LCI data set should explicitly be used in LCI/LCA studies for beverage cartons (it is not suitable for other carton products). To use this parameterised data set in LCI/LCA studies the users have to add the raw materials PE granulate, LPB and aluminium foil themselves. See the "General Comment on Data Set" for further details and where to get information on specific composition ratios. |
| Technical purpose of product or process | Beverage Cartons are used for the packaging of non-carbonated softdrinks, milk and other liquid dairy products and non-carbonated water. |
| Classification | Class name / Hierarchy level<br>Systems / Packaging |
| General comment on data set | The manufacture of transport packaging materials, such as typically cardboard or shrink foil required for delivery to the filler is excluded in the LCI dataset presented here. It should be noted that it might be appropriate to consider the production of these materials when conducting a LCA study on beverage cartons. It is recommended to contact ACE regarding the question if this LCI dataset on converting is applicable in a specific study context. It is recommended to contact the beverage carton producer regarding detailed material composition of the beverage carton under examination. Note: VOC emissions from process depend on the printing technology applied and could considerably differ from the average value given here for a specific site or beverage carton product. Note: Air emissions from on-site fuel use for a specific site depend on the actually applied flue gas cleaning technology. This technology could be different from the average technology underlying this dataset in case of a particular site or in a regional context with a particular legal framework. Area of beverage cartons have to be calculated into mass of raw materials needed by the user. (advice can be requested at ACE). This parameterised data set is a gate-to gate data set that lists the inputs and outputs directly connected to the converting of LDPE granulate, liquid packaging board and aluminium foil to beverage carton. Beverage Cartons vary widely in composition depending on filled product and required functionality. There is therefore no one average carton or carton composition. The converting process is however broadly similar for all cartons and the representative parameterised process is designed to allow users to enter the appropriate package specification i.e. how much liquid packaging board, aluminium foil and plastic resin is used in the particular package under study, as well as specify the appropriate electricity supply for the converting factory location. For guidance a typical one litre aseptic carton for milk might for example comprise 78.5% board, 16.5% PE and 5% aluminum foil; while a typcial one litre chilled carton could be 82.5% liquid packaging board and 17.5% LDPE. For more specific guidance on package specification please contact ACE or the specific package material provider. This data set is intended for the use by LCA practitioners |
| | Copyright? Yes Owner of data set (contact data set) The Alliance for Beverage Cartons and the Environment (ACE) |

**Quantitative reference**

| | |
|---|---|
| Reference flow(s) | beverage carton - generic - 1000.0 m2 (Area) |

**Time representativeness**

| | |
|---|---|
| Data set valid until: | 2014 |
| Time representativeness description | The LCI result is based on annual average data from industry. |

**Technological representativeness**

| | |
|---|---|
| Technology description including background system | Liquid Packaging Board and Polyethylen (low density) are laminated into Beverage Carton. For aseptic cartons aluminium foil is added to the laminate. The Beverage Carton is printed after this process. |
| Flow diagramm(s) or picture(s) (source data set) | |

## Modelling and validation

**LCI method and allocation**

| | |
|---|---|
| Type of data set | *Unit process, single operation* |
| LCI method principle | *Attributional* |
| Deviation from LCI method principle / explanations | none |
| LCI method approaches | |
| Deviations from LCI method approaches / explanations | none |
| Modelling constants | Capital goods are not included. |
| Deviation from modelling constants / explanations | none |

**Data sources, treatment, and representativeness**

| | |
|---|---|
| Data cut-off and completeness principles | All relevant mass and energy flows are included in the inventory. No Cut-Off criteria is applied, Completeness therefore 100% |
| Data selection and combination principles | Coverage of the main European converters, site specific data weighted by production volumes. All emissions of on-site burned fuels were calculated using emission factors by GEMIS 4.0. For directly connected consumption of electricity a European average grid mix by IFEU based on EUROSTAT data has been used. |
| Deviation from data selection and combination principles / explanations | none |
| Data treatment and extrapolations principles | Site specific data weighted by production volumes. |
| Deviation from data treatment and extrapolations principles / explanations | none |
| Data source(s) used for this data set (source data set) | Converting of Beverage Cartons |
| Percentage supply or production covered | 95.0 % |
| Data collection period | 2009-2010 |

**Completeness**

| | |
|---|---|
| Completeness product model | *All relevant flows quantified* |

**Validation**

| | |
|---|---|
| Review | *Independent external review*<br>Scope of review / Method(s) of review<br>*Unit process(es), single operation* / *Compliance with ISO 14040 to 14044* |
| Data quality indicators | Name / Value<br>*Overall quality* / *Good*<br>*Methodological appropriateness and consistency* / *Very good*<br>*Precision* / *Fair*<br>*Completeness* / *Good*<br>*Geographical representativeness* / *Good*<br>*Time representativeness* / *Very good*<br>*Technological representativeness* / *Good* |
| Review details | The dataset has been reviewed on compliance with ILCD entry level requirements. The presented documentation of the dataset is considered correct, clearly describing how the dataset has been built up and what it represents in terms of production, technology, geography and time. This is considered appropriate for the intended application: Parameterized gate-to-gate LCI dataset for the converting of beverage cartons for use in LCI/LCA The gate-to-gate input and output flows, boundaries and cut-off criteria have been found to have a high level of completeness including all relevant flows of inputs of raw materials and energy. The detail of reported waste is limited to one flow and did not include the treatment. There are data gaps for the elementary flows, emission to air. Their overall environmental relevance was not assessed. The secondary data from various sources may include similar data gaps. This may cause some inconsistencies by combining them in the parameterized dataset. |
| Reviewer name and institution (contact data set) | Angeline de Beaufort, consultant environmental affairs |
| Complete review report (source data set) | ILCD entry level requirements review report |

**Compliance declarations**

| Compliance system name (source data set) | Approval of overall compliance | Nomenclature complianceNomenclature compliance | Methodological complianceMethodological compliance | Review complianceReview compliance | Documentation complianceDocumentation compliance |
|---|---|---|---|---|---|
| ILCD Data Network - Entry-level | *Fully compliant* | *Fully compliant* | *Fully compliant* | *Fully compliant* | *Fully compliant* |

## Administrative information

**Commissioner and goal**

| | |
|---|---|
| Commissioner of data set (contact data set) | The Alliance for Beverage Cartons and the Environment (ACE) |
| Intended applications | Parameterized gate-to-gate LCI dataset for the converting of beverage cartons for use in LCI/LCA studies only. |

**Data set generator / modeller**

| | |
|---|---|
| Data set generator / modellerData set generator / modeller (contact data set) | Institue for Energy- and Environmental Research GmbH |

**Data entry by**

| | |
|---|---|
| Time stamp (last saved) | 2012-10-26T15:47:30.996+02:00 |
| Data set format(s) (source data set) | ILCD format |
| Converted original data set from: (source data set) | Converting of Beverage Cartons |
| Official approval of data set by producer/operator: (contact data set) | The Alliance for Beverage Cartons and the Environment (ACE) |

**Publication and ownership**

| | |
|---|---|
| UUID of Process data set | 6118e7c9-98ce-46f9-a3df-95cc3f8f8b2e |
| Data set version | 03.00.000 |
| Permanent data set URI | |
| Workflow and publication status | *Data set finalised; unpublished* |
| Owner of data set (contact data set) | The Alliance for Beverage Cartons and the Environment (ACE) |
| Access and use restrictions | na |

## Inputs and Outputs

**Inputs**

| Type Of Flow | Classification | Flow | Variable | Resulting amount | Mean amount | Data source type | Data derivation type / status |
|---|---|---|---|---|---|---|---|
| *Elementary flow* | Resources / Resources from ground / Non-renewable energy resources from ground | natural gas; 44.1 MJ/kg | | 102.59 MJ (Net calorific value) | 102.59 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Energy carriers and technologies / Electricity | electricity mix | | 310.47 MJ (Net calorific value) | 310.47 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Energy carriers and technologies / Crude oil based fuels | light fuel oil | | 0.0282 kg (Mass) | 0.0282 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Resources / Resources from water / Renewable material resources from water | water | | 110.0 kg (Mass) | 110.0 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Energy carriers and technologies / Natural gas based fuels | LPG - liquefied petroleum gas | | 15.48 MJ (Net calorific value) | 15.48 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Systems / Paints and chemical preparations | printing ink | | 1.7 kg (Mass) | 1.7 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Systems / Packaging | corrugated board boxes | | 10.0 kg (Mass) | 10.0 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Materials production / Plastics | polyethylene low density foil(PE-LD) | | 0.6 kg (Mass) | 0.6 | *Mixed primary / secondary* | *Unknown derivation* |

**Outputs**

**Outputs**

| Type Of Flow | Classification | Flow | Variable | Resulting amount | Mean amount | Data source type | Data derivation type / status |
|---|---|---|---|---|---|---|---|
| *Product flow* | Systems / Packaging | beverage carton - generic | | 1000.0 m2 (Area) | 1000.0 | *Mixed primary / secondary* | *Unknown derivation* |
| *Product flow* | Deposited goods / Hazardous waste | Hazardous waste (unspec.) | | 0.32 kg (Mass) | 0.32 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | volatile organic compound | | 0.0978 kg (Mass) | 0.0978 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | carbon dioxide (fossil) | | 6.6 kg (Mass) | 6.6 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | nitrous oxide | | 1.2E-4 kg (Mass) | 1.2E-4 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | carbon monoxide | | 0.00251 kg (Mass) | 0.00251 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | methane | | 6.04E-4 kg (Mass) | 6.04E-4 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | non-methane volatile organic compounds | | 6.01E-4 kg (Mass) | 6.01E-4 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to air / Emissions to air, unspecified | nitrogen dioxide | | 0.00665 kg (Mass) | 0.00665 | *Mixed primary / secondary* | *Unknown derivation* |
| *Elementary flow* | Emissions / Emissions to soil / Emissions to agricultural soil | sulfur dioxide | | 1.47E-4 kg (Mass) | 1.47E-4 | *Mixed primary / secondary* | *Unknown derivation* |

**Figure 17 Example of the dataset on beverage carbon from ELCD database**

| Natural Gas;from onshore and offshore production incl. pipeline and LNG transport;consumption mix, at consumer;desulphurised | |
|---|---|
| Table of Contents: Process information - Modelling and validation - Administrative information - Inputs and Outputs | |
| **Process information** | |
| **Key Data Set Information** | |
| Location | EU-27 |
| Geographical representativeness description | The data set represents the country / region specific situation, focusing on the main technologies, the region specific characteristics and / or import statistics. |
| Reference year | 2002 |
| Name | Base name; Treatment, standards, routes; Mix and location types<br>Natural Gas;from onshore and offshore production incl. pipeline and LNG transport;consumption mix, at consumer;desulphurised |
| Use advice for data set | The data set can be used by power plants, industries and end consumers. Combination with individual unit processes using the natural gas mix enables the generation of user-specific (product) LCAs. |
| Technical purpose of product or process | Natural gas for final consumers. |
| Classification | Class name / Hierarchy level<br>Energy carriers and technologies / Natural gas based fuels |
| General comment on data set | Good overall data quality. Natural gas mix EU-27 information is based on official statistical information. Energy carrier extraction and processing data are of sufficient to good data quality. Inventory is partly based on primary industry data, partly on secondary literature data. |
| | Copyright? Yes   Owner of data set (contact data set) PE INTERNATIONAL |
| **Quantitative reference** | |
| Reference flow(s) | natural gas - 1.0 kg (Mass) |
| **Time representativeness** | |
| Data set valid until: | 2010 |
| Time representativeness description | Annual average |
| **Technological representativeness** | |
| Technology description including background system | The natural gas mix EU-27 merges natural gas from the respective production countries to a natural gas mix, which represents the average natural gas of the EU-27. The natural gas mix consists of the indigenous production inside the EU-27 and imports from exporting countries outside the EU-27. The pie chart "Natural Gas Mix EU-27" below shows the 2002 natural gas mix. The following modelling was used for the natural gas transportation: Imports: Starting from an exporting country / region natural gas is either transported via pipeline directly to the border of the EU-27 or as liquefied natural gas (LNG) via LNG vessels. In case of LNG import, the natural gas is first transferred in pipelines to the next LNG terminal within the exporting countries, liquefied and then exported via LNG vessels to the EU-27. In the LNG terminal of the destination country / region the LNG is regasified. From the border or the LNG port an average country / region specific distance for the natural gas regional distribution (via pipeline) is estimated. National production: For national onshore production inside the EU-27 the same distance as for regional distribution of imports was taken into account. For national offshore production inside the EU-27 an additional transport between gas field and shore is considered. The data set considers the whole supply chain of natural gas i.e. exploration, production, processing (e.g. desulphurisation) and in case of LNG import, liquification / regasification of LNG, the long distance transport and the regional distribution to the final consumer. Losses occurring during transportation via pipeline or vessel are included. |
| Flow diagramm(s) or picture(s) (source data set) | |
| Flow diagramm(s) or picture(s) (source data set) | |
| **Modelling and validation** | |
| **LCI method and allocation** | |
| Type of data set | *LCI result* |
| LCI method principle | *Attributional* |
| Deviation from LCI method principle / explanations | None |
| LCI method approaches | *Allocation - net calorific value* |
| Deviations from LCI method approaches / explanations | For the combined crude oil, natural gas and natural gas liquids production allocation by net calorific value is applied. |

**Figure 18 Dataset on Natural Gas; from onshore and offshore production incl. pipeline and LNG transport;consumption mix, at consumer; desulphurised – 1kg", retrieved from the ELCD database.**

ref: http://eplca.jrc.ec.europa.eu/ELCD3/resource/processes/3d602e55-aaa2-44e3-adb9-40f49eb1a915?format=html&version=03.00.000

## Annex 3: unit of measurement

| Unit of mesurament | | | |
|---|---|---|---|
| **Quantity** | **Unit** | **Conversion factor** | **note** |
| Mass | kg | 1 | kilograms (Predefined) |
| | Qli | 100 | |
| | t | 1000 | |
| | g | 0,001 | grams |
| | mg | 0,000001 | milligram |
| | microgram | 0,000000001 | micrograms |
| | ng | 0,000000000001 | nanograms |
| Energy | MJ | 1 | Mega-Joule |
| | J | 0,000001 | Joule (Predefined) |
| | KJ | 0,001 | Kilo-Joule |
| | kWh | 3,6 | kilowatt per hour |
| | kCal | 0,0041868 | kilocalories |
| Volume | $m^3$ | 1 | predefined |
| | l | 0,001 | litres |
| *Gas Volume* | *$Nm^3$* | *1* | *Normal meter cube* |
| Distance | km | 1 | |
| | m | 0,001 | |
| Transport | t.km | 1000 | tons per km |
| | kg.km | 1 | |
| Area | $m^2$ | 1 | |
| Other | Unit | 1 | |
| *Noise* | *dB* | *1* | |
| *Radioactivity* | *kBq* | *1* | |
| | *mBq* | *0,000000001* | |
| *Land use* | *m2a* | *1* | |

## Annex 4: list of EF for the CLim'Foot project

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Europel/country specifi |
| **Fuel** | **Fossil** | **Solid** | Lignite production | JRC | Europe |
| | | | lignite combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | hard coal production | JRC | Europe |
| | | | steam coal combustion | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | **Liquid** | Heavy fuel oil prodution | JRC | Europe |
| | | | Heavy fuel oil combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Kerosene production | JRC | Europe |
| | | | Kerosene combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Light fuel oil production | JRC | Europe |
| | | | Light fuel oil combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Diesel production | JRC | Europe |
| | | | Diesel combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |

| | | | | | |
|---|---|---|---|---|---|
| | | | Gasoline production | JRC | Europe |
| | | | Gasoline combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Lubricants production | | 1 |
| | | | Lubricants combustion | | |
| | | | Naphtha production | JRC | Europe |
| | | | Naphtha combustion | | |
| | | Gas | Natural Gas production | JRC | Europe |
| | | | Natural Gas combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | LPG production | | Europe |
| | | | LPG combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Butane production | Bilan GES | Europe |
| | | | Butane combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Propane production | Bilan GES | Europe |
| | | | Propane combustion | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | | | |
| | **Organic** | **Solid** | Biomass production | | Europe |
| | | | pellets producton | Bilan GES | Europe |
| | | | Wood log | Bilan GES | Europe |
| | | | Sawdust production | Bilan GES | Europe |
| | | | Woodchips production | Bilan GES | Europe |
| | | **Liquid** | Biodisel production | | Europe |
| | | | | | |
| | | **Gas** | biogas production | | Europe |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| **Process and fugitive** | **Cooling and refrigerant** | **cooling** | Note: Could include air cooling for buildings, transport, etc. | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | **refrigerant** | Note: Usually related to product storage | | |
| | **Industrial** | **Decarbonisation** | | | |
| | | **Other** | | | |
| | **Agriculture** | **Soil** | Note: related to N20 emission from fertilizers | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | **Waste** | **Solid** | Note this could be moved as well in "indirect emissions" | | |
| | | | Waste inceneritor national | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Waste incineration of untreated wood (10,7% water content) | JRC | Europe |
| | | | Waste incineration of glass/inert material | JRC | Europe |

| | | | | | |
|---|---|---|---|---|---|
| | | | Waste incineration of biodegradable waste fraction in municipal solid waste (MSW); | JRC | Europe |
| | | | Waste incineration of municipal solid waste (MSW); | JRC | Europe |
| | | | Waste incineration of paper fraction in municipal solid waste (MSW);average European waste-to-energy plant | JRC | Europe |
| | | | | JRC | Europe |
| | | | Landfill of glass/inert waste; | JRC | Europe |
| | | | landfill | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | **liquid** | Waste water treatment | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Waste water treatment;domestic waste water | JRC | Europe |
| | | | Waste water treatment;industrial waste water organic contaminated | JRC | Europe |

| | | | | | |
|---|---|---|---|---|---|
| | | | Waste water treatment;industrial waste water slightly organic and anorganic contaminated | JRC | Europe |
| | | | | | |
| **LULUCF** | **LUC** | | Note: Only CO2 | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| | **Forestry** | | | NIR, or IPPC(2006) | country specific IT, HR, GR, HU |
| **Electricity** | **Average grid** | | | | |
| | **Type of production** | **Fossil/ nuclear** | fuel | | |
| | | **s** | EU electricity mix at grid hight voltage | JRC | |
| | | | EU electricity mix at grid medium voltage | JRC | |
| | | | Italian electricity mix at net production | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Italian electricity mix, at grid losses | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | production of nuclear energy | | Europe |
| | | | avereg | | |
| | | | | | |
| | | **renewable** | elctricity from wind medium voltage | JRC | Europe |
| | | | elctricity from wind low voltage | | Europe |
| | | | elctricity from water low voltage | JRC | Europe |

| | | | | | |
|---|---|---|---|---|---|
| | | | elctricity from water  medium voltage | JRC | Europe |
| | | | | | |
| | | | production of fotovoltaic pannel | | Europe |
| | **steam** | | Process steam from Heavy fuel oil 90% | JRC | Europe |
| | | | Process steam from natural gas 90%; | JRC | Europe |
| | | | | | |
| | | | | | |
| **Heating /cooling grid** | **heating network** | | Heat;residential heating systems from light fuel oil (low sulphur), | JRC | Europe |
| | | | Heat;residential heating systems from natural gas, condensing boiler, | JRC | Europe |
| | | | Heat;residential heating systems from wood pellets | JRC | Europe |
| | | | | | |
| | **Cooling network** | | | | |
| **Transport** | **Freight** | **Air** | | | |
| | | | plane cargo | JRC | Europe |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | **Road** | Articulated lorry transport | JRC | Europe |
| | | | Lorry transport | JRC | Europe |
| | | | Small lorry transport | JRC | Europe |
| | | | Articulated lorry transport | - | country specific IT, HR, GR, HU |
| | | | Lorry transport | - | country specific IT, HR, GR, HU |
| | | | Small lorry transport | | country specific IT, HR, GR, HU |
| | | | | | |
| | | **Rail** | disel railway | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | electric railway | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | disel railway | JRC | Europe |
| | | | electric railway | JRC | Europe |
| | | | | | |
| | | | | | |
| | | **Sea/Rivers** | Barge | JRC | Europe |
| | | | Bulk carrier ocean | JRC | Europe |
| | | | Container ship ocean; | JRC | Europe |
| | | | | | |
| | | | | | |
| | **People** | **Air** | plane passenger | Bilan GES | Europe |
| | | | plane passenger | Bilan GES | Europe |
| | | | plane passenger | Bilan GES | Europe |

| | | | | | |
|---|---|---|---|---|---|
| | | | plane passenger | Bilan GES | Europe |
| | | | plane passenger | Bilan GES | Europe |
| | | **Road** | Small car <= euro III | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Small car >= euro IV | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Medium car <= euro III | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Medium car >= euro IV | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Large car <= euro III | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Large car >= euro IV | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | Average car | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | **Rail** | disel railway | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | | electric railway | NIR or IPPC(2006) | country specific IT, HR, GR, HU |
| | | **Sea/Rivers** | ferry passenger | | country specific IT, HR, GR, HU |
| | | | ferry car | | country specific IT, HR, GR, HU |
| | | | | | |
| | | | | | |
| **Products and** | **Agriculture** | **Vegetable** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **process** | | | | | |
| | | **Meat** | | | |
| | | **Liquid** | | | |
| | **Agro industy** | **Vegetable base** | | | |
| | | **Meat base** | | | |
| | | **Mixed base** | | | |
| | | **Liquid** | | | |
| | **Plastics &chemical products** | **Plastics** | Polyethylene terephthalate (PET) | JRC | Europe |
| | | | Polyethylene terephthalate (PET) | JRC | Europe |
| | | | Polyethylene terephthalate fibres (PET) | JRC | Europe |
| | | | polyethylene, HDPE, | Plastics Europe | Europe |
| | | | polyethylene, LDPE, | Plastics Europe | Europe |
| | | | Polypropylene granulate (PP) | Plastics Europe | Europe |
| | | | Polypropylene fibres (PP) | JRC | Europe |
| | | | Polystyrene (general purpose) granulate (GPPS) | JRC | Europe |

| | | | | | |
|---|---|---|---|---|---|
| | | | Acrylonitrile-Butadiene-Styrene granulate (ABS) | JRC | Europe |
| | | | polyvinyl chloride;from emulsion proces (E-PVC) | Plastics Europe | Europe |
| | | | polyvinyl chloride;from suspension process (S-PVC); | Plastics Europe | Europe |
| | | | Nylon 6 (PA6) | Plastics Europe | Europe |
| | | | Naylon 6.6 (PA6.6) | Plastics Europe | Europe |
| | | | Polyurethane (PUR and PU) | | Europe |
| | | | styrene-butadiene rubber (SBR) | | Europe |
| | | | olymethyl methacrylate (PMMA) beads | JRC | Europe |
| | | | | | |
| | | | | | |
| | | **Chemicals** | Fertilize | Bilan GES | Europe |
| | | | pesticides | Bilan GES | Europe |
| | | | Benzene | JRC | Europe |
| | | | Oxygen | JRC | Europe |
| | | | Nitrogen | JRC | Europe |

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|---|---|---|---|---|---|
| | | | Sulphur | JRC | Europe |
| | | | Titanium Dioxide | JRC | Europe |
| | | | | | |
| | **Metals** | **Steel** | Steel tinplate | JRC | Europe |
| | | | Steel hot dip galvanized | JRC | Europe |
| | | | Steel hot dip galvanized, including recycling; | JRC | Europe |
| | | | Steel hot rolled coil | JRC | Europe |
| | | | Steel hot rolled coil, including recycling | JRC | Europe |

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| | | **Aluminium** | Aluminium extrusion profile;primary productio | JRC | Europe |
| | | | Aluminium sheet;primary production | JRC | Europe |
| | | | Aluminium recycling 100% lingot | | Europe |
| | | | Aluminium average recycling lingot | | Europe |
| | | **Copper** | Copper sheet | JRC | Europe |
| | | | Copper tube | JRC | Europe |
| | | | Copper wire | JRC | Europe |
| | | **Other** | Lead sheet | JRC | Europe |
| | | | Lead | JRC | Europe |
| | | | Lead primary and secondary mix | JRC | Europe |
| | | | Special high grade zinc | JRC | Europe |
| | **Machine and equipment** | **Electric and electronics** | | | |

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| | | **IT and office equipments** | | | |
| | | **Others** | | | |
| | **Minerals and non metals** | | Sand | JRC | Europe |
| | | | Gravel | JRC | Europe |
| | | | Gypsum stone (CaSO4-dihydrate) | JRC | Europe |
| | | | Calcium carbonate | JRC | Europe |
| | | | Lime (CaO; finelime) | oekobaudat | Europe |
| | | | Gravel | JRC | Europe |
| | | | Clay | oekobaudat | Europe |
| | | | Bentonite granular, | JRC | Europe |
| | | | Bentonite powder, | JRC | Europe |
| | | | Very fine milled silica sand d50 = 20 micrometer; | JRC | Europe |

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| | | **Asphalt concrete for roads** | | | |
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| | | **Granulat/pierre de carrière** | | | |
| | | **Glass** | Container glass | JRC | Europe |
| | | | Continuous filament glass fibre (assembled rovings) | JRC | Europe |
| | | | Continuous filament glass fibre (direct rovings); | JRC | Europe |
| | | | Continuous filament glass fibre (dry chopped strands) | JRC | Europe |
| | | | Continuous filament glass fibre (wet chopped strands | JRC | Europe |
| | **Wood** | | Spruce log with bark | JRC | Europe |
| | | | Spruce wood | JRC | Europe |
| | | | Pine log with bark | JRC | Europe |
| | | | Pine wood | JRC | Europe |
| | **Paper and carton** | | cartonboard sheets | JRC | Europe |
| | | | Corrugated board boxes; | JRC | Europe |
| | | | corrugated board sheets | JRC | Europe |

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| | | | Liquid Packaging Board (LPB) production | JRC | Europe |
| | | | | | |
| | **Buildings and Construction** | **Buildings** | Lightweight concrete block | JRC | Europe |
| | | | Aerated concrete block, density 485 kg/m3 | JRC | Europe |
| | | | Facing brick; clay- based | oekobaudat | Europe |
| | | | Mortar | oekobaudat | Europe |
| | | | tiles, glazed | oekobaudat | Europe |
| | | | tiles, unglazed | oekobaudat | Europe |
| | | | Gypsum plaster (CaSO4 beta hemihydrates);technology mix of natural gypsum (45%) and gypsum from flue gas desulphurisation (55%);production mix, at plant;grinded and purified product | JRC | Europe |
| | | **Cements, lime and plaster** | Ready-mix concrete C20/25; C20/25 | oekobaudat | Europe |
| | | | Ready-mix concrete C30/37; C30/37 | oekobaudat | Europe |
| | | | Cement | JRC | Europe |
| | | | Aerated concrete block, density 433 kg/m3 | JRC | Europe |
| | | **Road** | Asphalt binder | oekobaudat | Europe |
| | | | Bitumen production | bitumenuk | Europe |
| | **water** | | Drinking water from groundwater | JRC | Europe |
| | | | Drinking water from surface water | JRC | Europe |

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| | | | De-ionised water from groundwater | JRC | Europe |
| | | | De-ionised water from surface water | JRC | Europe |
| | | | | | |
| | **Other** | | | | |
| **Services** | | | Note: usually expressed in kgCO2e/k€ | | |