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Stationary source emissions — Determination of greenhouse gas (GHG) emissions in energy-intensive industries

Part 6: Ferroalloy industry

National foreword

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Contents

Page

European foreword

This document (EN 19694-6:2016) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2017, and conflicting national standards shall be withdrawn at the latest by January 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate M/478 given to CEN by the European Commission and the European Free Trade Association.

EN 19694, *Stationary source emissions — Determination of greenhouse gas (GHG) emissions in energy-intensive industries* is a series of standards that consists of the following parts:

— *Part 1: General aspects*

— *Part 2: Iron and steel industry*

— *Part 3: Cement industry*

— *Part 4: Aluminium industry*

— *Part 5: Lime industry*

— *Part 6: Ferroalloy industry*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Overview of the ferro-alloy manufacturing process

Ferroalloy production involves a metallurgical reduction process that results in significant carbon dioxide emissions. These emissions are the results of a carbothermic reaction which is intrinsic to the process. In ferroalloy production, ore, carbon materials and slag forming materials are mixed and heated to high temperatures for smelting.

Submerged Electric Arc Furnaces (SEAF) with graphite electrodes, self- baking Søderberg or composite electrodes is the main process to produce ferro-alloys in Europe (see Figure 1). Smelting in an electric arc furnace is accomplished by conversion of electrical energy to heat. An alternating current applied to the electrodes creates current to flow through the charge between the electrode tips. The heat is produced by the electric arcs and by the resistance in the charge materials. Emissions from the smelting process are therefore not to combustion emissions. The furnaces may be open, semi-closed or closed.

The reduction process is the main source of direct CO_2 emissions. Other CO_2 sources include direct emissions from calcination of calcium, magnesium and other carbonates (e.g. limestone) in some processes and from non-smelting fuels (e.g. dryers for ladles and refractory linings, room heating), and indirect emissions from, e.g. external power production.

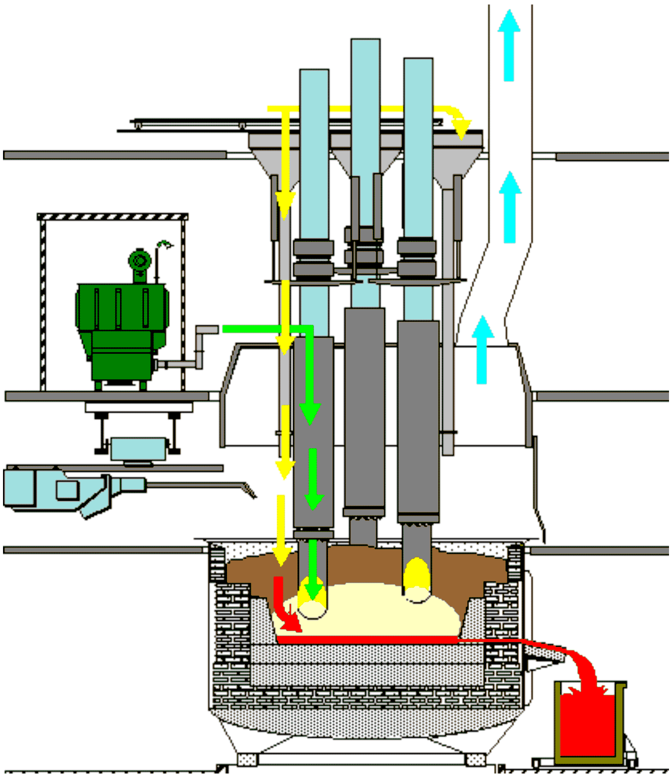

Figure 1 — Submerged Electric Arc Furnace (SEAF)

CO_2 from the smelting of raw materials

CO_2 emissions from reducing agents and electrode use

In the smelting process, CO_2 is released due to the carbothermic reduction of the metallic oxides occurring with the consumption of both carbonaceous reductants and carbon based electrodes. The carbon in the reductants reacts with oxygen from the metal oxides to form CO and then CO_2 (in different ways depending on the process), and the ores are reduced to molten base metals. For calculation, the assumption is that all CO is assumed to be converted in the furnace to CO_2.

The reductant carbon is used in the form of coke, coal, pet coke, anthracite, charcoal and wood-chips. The first four are fossil based and the charcoal and wood-chips are bio-carbon.

In the carbothermic process, only the fixed carbon content is used as a reducing agent, which means that volatile matter, ashes and moisture mostly leave the furnace with the off-gas and slag.

The nature of reducing agents, price and electrodes is depending of the localization of the plant, the raw material availability and it is presented in Table 1. It is variable from one site to another and from one year to another and also from one ferro-alloy to another.

Table 1 — Type of reducing agents and electrodes used in the electrometallurgy Sector

Reducing agents	Electrodes
Crude petroleum coke	Graphite electrode
Calcinated petroleum coke	Prebaked electrodes
Coal coke	Södeberg paste
Coke from coal	Composite electrode
Wood	
Calcinated wood	
Charcoal	
Graphite powder	
Anthracite	

CO_2 emissions are estimated with/calculated from the consumption of the reducing agents and electrodes, their carbon content and the carbon content of the final products[1].

ores + reducing agent → ferro-alloys/metal* + CO_2 + dust/by-product (i.e. slags)*

* amount of carbon can be found in the products

Default emission factors suggested in these documents are used, except where more recent, industry-specific data has become available.

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[1] The basic calculation methods used in this standard are compatible with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories issued by the Intergovernmental Panel on Climate Change (IPCC), and with the Regulation 601/2012 but the objectives of this standards are of different nature implying that the data gathered can cover a broader (or reduced) boundaries as compared to the objectives of the Regulation.

1 Scope

This European Standard provides a harmonized methodology for calculating GHG emissions from the ferro-alloys industry based on the mass balance approach[2]. It also provides key performance indicators over time of ferro-alloys plants. It addresses the following direct and indirect sources of GHG:

- Scope 1 – Direct GHG emissions from sources that are owned or controlled by the company, such as emissions result from the following sources:
  - smelting (reduction) process;
  - decomposition of carbonates inside the furnace;
  - auxiliaries operation related to the smelting operation (i.e. aggregates, drying processes, heating of ladles, etc.).
- Scope 2 – Indirect GHG emissions from:
  - the generation of purchased electricity consumed in the company's owned or controlled equipment.

This European Standard is to be used in conjunction with EN 19694-1, which contains generic, overall requirements, definitions and rules applicable to the determination of GHG emissions for all energy-intensive sectors, provides common methodological issues and defines the details for applying the rules. The application of this standard to the sector-specific standards ensures accuracy, precision and reproducibility of the results and is for this reason a normative reference standard. The requirements of these standards do not supersede legislative requirements.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 19694-1:2016, *Stationary source emissions — Determination of greenhouse gas (GHG) emissions in energy intensive industries — Part 1: General aspects*

3 Terms and definitions

For the purposes of this document, the terms and definitions in EN 19694-1 and the following apply.

3.1
auxiliaries
equipment consuming electricity/power related to the smelting process: fans, pumps, gas abatement systems (filter bags, venture scrubbers, etc.)

3.2
silica fume
amorphous silicon dioxide particles from the volatilization and vaporization of furnace feed materials in the manufacture of ferrosilicon and silicon, the process off-gas that contains silica fumes beings cleaned in a baghouse using fabric filters of the open or semi-closed SEAF

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[2] Based on European Commission Regulation 601/2012.

3.3
ferro-alloy

term used to describe concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium or tungsten

3.4
silicon

metalloid produced by carbo-thermic reduction of quartz in an electric submerged arc furnace

3.5
smelting

industrial process where one or more ores or ore concentrates are heated and reduced (i.e. chemically modified) by, e.g. aluminino-carbo-silico thermic reduction –to manufacture and mix the metals in one step

EXAMPLE Examples of smelted alloys are ferro-alloys.

3.6
Submerged Electric Arc Furnace
SEAF

electric arc-heating furnace in which the arcs are completely submerged under the charge. The arc forms between the electrode (graphite electrodes or self- baking Søderberg electrodes) and metal surface or bottom lining. The heat being produced by the electric arcs and by the resistance in the charge materials *initiates* the reduction process. The furnaces may be open, semi-closed or closed, which can depend upon the ferro-alloy to be produced. A commonly used technology is the submerged-arc (electric) furnace (SEAF).

3.7
fossil fuels

all fossil fuels listed by IPCC or any fuel which contains organic and inorganic carbon that is not biomass

3.8
biomass fuels

fuels with only biogenic carbon

3.9
Petcoke

petroleum coke, a carbon-based solid fuel derived from oil refineries

3.10
sintering/sinter

process to form a coherent mass by heating without melting

3.11
Søderberg electrodes

continuously self-baking carbon electrode used in electro-metallurgical furnaces for production of ferroalloys and silicon (the “Søderberg paste” is a preparation of coal tar pitch and carbonaceous dry aggregate)

3.12
composite electrodes

in composite electrodes the core is composed of graphite while the exterior is a self-baking carbon paste (which is a “Søderberg paste”)

3.13
pre-baked electrodes

carbonaceous paste (a mixing of coal tar pitch with a dry carbonaceous aggregate) is baked so as to carbonize coal tar pitch in order to form a solid pitch coke binder phase

4 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

AF	alternative fuels
CO	carbon monoxide
CO_2	carbon dioxide
EF	emission factor
EU ETS	The CO_2 Emissions Trading Scheme of the European Union
FA	ferro-alloys
FABP	ferro-alloys and related by-products
GHG	greenhouse gases
GJ	giga joule
IPCC	Intergovernmental Panel on Climate Change
KPI	key performance indicator
LHV	lower heat value (synonym for net calorific value)
m_n^3	normal m^3 (at 0 ºC and at a pressure of 1 atmosphere)
MIC	mineral components
SEAF	submerged electric arc furnace
TC	total carbon (the sum of TOC and TIC)
TIC	total inorganic carbon
TOC	total organic carbon
t	tonne (1.000 kg)

UNFCCC United Nations Framework Convention on Climate Change

5 Determination of GHGs – Principles

5.1 General

The determination of CO_2 emissions can be in principle done either through calculation (mass balance method) or through stack emission measurement.

The methodology described in this standard for GHG emissions determination is based on the mass balance method (7.2).

NOTE Industry have demonstrated that the mass balance method is more accurate than stack emission measurements with a lower level of uncertainty. Additionally, the mass balance method is much more cost effective. This has been clearly demonstrated during the field tests performed to develop this standard.

5.2 Major GHG in ferro-alloys

CO_2 is the only GHG relevant for the ferro-alloys industry.

5.3 Determination based on mass balance

In installations where carbon stemming from input materials used remains in the products or other outputs of the production, e.g. for the reduction of metal ores, a mass balance approach is applied. In installations where this is not the case, combustion emissions and process emissions are calculated separately.

Emissions from source streams are calculated from input or production data, obtained by means of measurement systems, and additional parameters from laboratory analyses including calorific factor, carbon content and biomass content. Standard factors may also be used; references to these factors are provided in the General Aspects Standard (see normative references).

The methodologies for determining emission factors in the mass balance approach are referred to as tiers. The increasing numbering of tiers from one (standard factors) upwards (specific factors) reflects increasing levels of accuracy, from Tier 1 as the International reference for emission factors (IPCC data) to Tier 3 as Industry specific (site-specific) reference.

5.4 Use of waste gas/heat recovery

Direct GHG emissions related to waste gas and heat recovery will be reported as scope 1 emissions. Waste gas including CO and CO_2 can be subtracted from the direct emission, when exported outside the boundaries of the location, as a negative carbon flow in the mass balance (for example when exporting waste gas to another installation).

6 Boundaries

6.1 General

Drawing appropriate boundaries is one of the key tasks in an emissions inventory process.

6.2 Operational boundaries

Operational boundaries refer to the types of sources covered by an inventory. A key distinction is between direct and indirect emissions related to the smelting process:

a) **Direct emissions** are emissions from sources that are owned or controlled by the reporting company. For example, emissions from smelting are direct emissions of the company owning (or controlling) the furnace.

b) **Indirect emissions** are emissions that result as a consequence of the activities of the reporting company but occur at sources owned or controlled by another company. For example, emissions from the generation of grid electricity consumed by a ferro-alloy company will qualify as indirect.

Clause 7 of this standard provides detailed guidance on the different sources of direct emissions occurring in ferro-alloys plants. Indirect emissions are addressed in Clause 8.

Companies shall use the operational boundaries outlined in Table 2 and the relevant process steps in Table 3, for the determination of the GHG emissions for the smelting/carbo-thermic reduction operations part of the ferro-alloy plant. Any deviation from these boundaries shall be reported and explained.

Table 2 — Operational boundaries

Included within boundaries	Excluded
Smelting (carbo-thermic reduction) Electrodes Reducing agents Non furnace fuels	**Mobile transport**
Electricity consumption for whole production process **Onsite power production** Waste heat recovery	**Room heating / cooling (negligible)** **Mobile transport in plant**
Stock inventories carbon materials	

Table 3 — Process steps

Process Step	**Scope**	**Inclusion?**
Smelting	Scope 1	Yes
Electricity consumption for whole production process	Scope 2	Yes
Onsite power production	Scope 1	Yes
Waste heat recovery	Scope 1	Yes
Room heating / cooling	Scope 1. Scope 2 when the used equipment is electrically powered	Yes, but negligible
Stock changes	Scope 1	Yes

6.3 Organizational boundaries

The major source of GHG emissions in the ferroalloys sector is the process-related emissions from the Submerged Electric Arc Furnaces operations, the reduction of the metallic oxides and the consumption of the electrodes during the process. There are practically no fuel related process emissions and heat is a negligible input factor in the production. The operational boundaries for this standard GHG emissions covers only the smelting/carbo-thermic reduction operations considered as core activities and the related auxiliaries.

7 Direct emissions and their determination

7.1 General

Direct emissions are emissions from sources of the respective plant. In ferro-alloys plants, direct GHG emissions may result from the following sources:

a) CO_2 emissions from reducing agents and electrode use in the smelting process;

b) raw materials (e.g. decomposition of limestone, dolomite, and carbon containing metal ores and concentrates);

c) combustion of conventional fuels (e.g. natural gas, coal and coke, or fuel oil);

d) combustion of biomass fuels.

Generally, companies are encouraged to measure the required parameters at plant level for specific raw materials. Where plant- or company-specific data are not available, standard or default factors should be used.

7.2 Mass balance approach

7.2.1 Generic approach

In the mass balance approach, the CO_2 quantity corresponding to each source stream included in the mass balance has to be calculated by multiplying the activity data related to the amount of material entering or leaving the boundaries of the mass balance, with the emission factor for each material.

The methodologies for determining, i.e. activity data and emission factors are referred to as tiers. The increasing numbering of tiers from one upwards reflects increasing levels of accuracy, with the highest numbered tier as the preferred tier.

For emission sources which emit more than 10 % of the total annual emissions of the installation, the operator shall preferably apply the highest tier given the less uncertainty. For all other emission sources, the operator shall apply at least one tier lower than the highest tier.

In case the application of the highest tier is technically not feasible or incurs unreasonable costs, a next lower tier shall be used for the relevant emission source, with a minimum of tier 1.

For marginal flows which jointly emit 1.000 t $CO_{2,eq}$ or less, or less than 2 % of the “total of all monitored items” (whichever is highest and not exceeding 20.000 t $CO_{2,eq}$), it is allowed to calculate activity data and emission factors using a conservative estimation, instead of using tiers (unless it is possible to use tiers without additional effort or costs).

With:

(a) Activity data

The operator shall analyse and report the mass flows into and from the installation and respective stock changes for all relevant fuels and materials separately (generally in GJ (for energy) or in t or m_n^3 for mass or volume).

Tier 1

Activity data over the reporting period are determined with a maximum uncertainty of less than ± 7,5 %.

Tier 2

Activity data over the reporting period are determined with a maximum uncertainty of less than ± 5 %.

Tier 3

Activity data over the reporting period are determined with a maximum uncertainty of less than ± 2,5 %.

Tier 4

Activity data over the reporting period are determined with a maximum uncertainty of less than ± 1,5 %.

(b) Emission factors

Emission factors are expressed as tCO_{2eq}/GJ, tCO_{2eq}/t or as tCO_{2eq}/m_n^3.

Tier 1 International reference for emission factors (IPCC data)

The emission factor of input or output streams is derived from reference emission factors for fuels or materials named in Annex A.

Tier 2 National reference

The operator applies country-specific emission factors for the respective fuel or material as reported by the respective Member State in its latest national inventory submitted to the Secretariat of the United Nations Framework Convention on Climate Change.

Tier 3 Industry specific reference

The emission factor of input or output stream shall be derived following the provisions of this standard in respect to representative sampling of fuels, products and by-products, the determination of their carbon contents and biomass fraction. These emission factors are usually determined by analysis of the carbon content. For the conversion of carbon content into the respective emission factor for CO_2 a factor of 3,664 [t CO_2/t C] shall be used.

In the absence of data analysis for one year and for the installation concerned, the factors used are from the average of measurements made on the site or sites in the corresponding year. When the number of analysis is insufficient (not shown), the factors used are from the average of the analysis conducted over the period 2005-2008 for the whole or sites.

Requirements for analysis should retain the preference for use of laboratories accredited in accordance with the harmonized standard general requirements for the competence of testing and calibration laboratories (e.g. EN ISO/IEC 17025) for the relevant analytical methods, and introduce more pragmatic requirements for demonstrating robust equivalence in the case of non-accredited laboratories. Company measurements are carried out by applying methods based on corresponding European Standards. Where such standards are not available or applicable, the methods shall be based on suitable International Standards (e.g. EN ISO 9001) or national standards or on industrial best practices, limiting sampling and measurement bias.

7.2.2 Sampling

The operator shall provide evidence that the derived samples are representative and free of bias. The respective value shall be used only for the delivery period or batch of fuel or material for which it was intended to be representative.

Generally, the analysis will be carried out on a sample which is the mixture of a larger number (e.g. 10 to 100) of samples collected over a period of time (e.g. from a day to several months) provided that the sampled fuel or material can be stored without changes of its composition.

The sampling procedure and frequency of analyses shall be designed to ensure that the annual average of the relevant parameter is determined with a maximum uncertainty of less than 1/3 of the maximum uncertainty which is required by the approved tier level for the activity data for the same source stream.

If the operator is not able to meet the allowed maximum uncertainty for the annual value or unable to demonstrate compliance with the thresholds, he shall apply the frequency of analyses as laid down in Annex B as a minimum, if applicable.

7.2.3 Alternate approach

The alternate approach for the **Tier 3** method is to use emission factors for the reducing agents only, which is adopted here. The simplified adopted formula is the following:

$$CO_2Em = REco/REEF \qquad (1)$$

where

CO_2Em are the emissions of **CO_2** (t);

REco are the total consumption of reducing agents or electrodes (t);

REEF is the emission factor of reducing agent or electrodes (tCO_2/t).

The emission factor of the reducing agent is based on its carbon content (simplified formula):

$$REEF = RECC \cdot 3.664 \qquad (2)$$

where

REEF is the emission factor of reducing agent or electrodes (tCO_2/t);

RECC is the carbon content of the reducing agent.

The total C-contents of reducing agents is calculated by the following formula.

$$RECCi = FFixC,i + Fvolatiles,i \cdot Cv \qquad (3)$$

where

RECC, i is the carbon content in reducing agent *i*, tonne C/tonne reducing agent;

FFixC,I is the mass fraction of Fix C in reducing agent *i*, tonne C/ tonne reducing agent;

Fvolatiles,I is the mass fraction of volatiles in reducing agent *i*, tonne volatiles/ tonne reducing agent;

Cv	is the carbon content in volatiles, tonnes C/tonne volatiles (unless other information is available, Cv = 0,65 is used for coal and 0,80 for coke).

Instead of calculating the carbon content using Formula (3), it is also possible to analyze the total carbon content directly using standard ISO 29541:2010.

In case of humidity in the reducing agent, the formula becomes:

$$RECC,i = \frac{(100 - \%\ H)}{100} \cdot (FFixC,i + Fvolatiles,i \cdot Cv) \qquad (4)$$

where

RECC, I	is the carbon content in reducing agent i, tonne C/tonne reducing agent;
FFixC,I	is the mass fraction of Fix C in reducing agent i, tonne C/ tonne reducing agent;
Fvolatiles,I	is the mass fraction of volatiles in reducing agent i, tonne volatiles/ tonne reducing agent;
Cv	is the carbon content in volatiles, tonnes C/tonne volatiles (unless other information is available, Cv = 0,65 is used for coal and 0,80 for coke);
% H	is % humidity contained in reducing agent or electrode.

$$REEFr_i = \frac{(100 - \%\ H)}{100} \cdot (FFixC,i + Fvolatiles,i \cdot Cv) \cdot 3.664 \qquad (5)$$

where

$REEFr_i$	is the emission factor in reducing agent i, (tCO_2/t);
FFixC,i	is the mass fraction of Fix C in reducing agent i, tonne C/ tonne reducing agent;
Fvolatiles,i	is the mass fraction of volatiles in reducing agent i, tonne volatiles/ tonne reducing agent;
Cv	is the carbon content in volatiles, tonnes C/tonne volatiles (unless other information is available, Cv = 0,65 is used for coal and 0,80 for coke);
% H	is % humidity contained in reducing agent or electrode.

Therefore, for the **Tier 3** method, it is necessary to determine the carbon contents of the reducing agents used in the production processes. But most ferroalloys producers analyse only on the basis of percentage of ash and volatiles and calculate:

Dry basis calculation (db)

$$Fix\ C\ \% = 100\ \% - \%\ Ash - \%\ Volatiles \qquad (6)$$

where

Fix C%	is % of fixed carbon in reducing agent;
% Ash	is % (ar) of ash contained product (reducing agent);
% Volatiles	is % of volatiles contained product (reducing agent).

As received basis calculation (ar)

$$Fix\ C\ \% = 100\ \% - \%H - \%\ Ash - \%\ Volatiles \qquad (7)$$

where

Fix C%	is % of fixed carbon in reducing agent;
% Ash	is % (ar) of ash contained product (reducing agent);
% Volatiles	is % of volatiles contained product (reducing agent);
% H	is the humidity contained in reducing agent or electrode.

The frequency of analysis of the raw materials/products for determining the emission factors are made as a minimum according to Annex B. They are determined based on internal analysis and suppliers to calculate their carbon content, except for wood.

An option is also to use certificates issues by independent laboratories at loading ports. Such certificates are supplied by the producer or trader of raw materials.

In the absence of data analysis for one year and for the installation concerned, the factors used are from the average of measurements made on the site or sites in the corresponding year. When the number of analysis is insufficient (not shown), the factors used are from the average of the analysis conducted over the period 2005 to 2008 for the whole or sites.

Requirements for analysis should retain the preference for use of laboratories accredited in accordance with the harmonized standard general requirements for the competence of testing and calibration laboratories (e.g. EN ISO/IEC 17025) for the relevant analytical methods, and introduce more pragmatic requirements for demonstrating robust equivalence in the case of non-accredited laboratories. Company measurements are carried out by applying methods based on corresponding European Standards. Where such standards are not available, the methods shall be based on suitable International Standards (e.g. EN ISO 9001) or national standards" or on industrial best practices, limiting sampling and measurement bias.

7.3 Process emissions

7.3.1 Overview

The calcination of limestone ($CaC0_3$) or dolomite ($(CaMg(CO_3)_2$ is considered under the process emission. These processes are used for the production of Mn and CaSi alloys.

7.3.2 Methods

For each type of input material used, the amount of CO_2 shall be calculated as follows:

CO_2 emissions = Σ activity data process input * emission factor * conversion factor

With:

(a) Activity data

Tier 1

Amounts [t] of input material and process residues used as input material in the process over the reporting period are determined with a maximum uncertainty of less than ± 5,0 %.

Tier 2

Amounts [t] of input material and process residues used as input material in the process over the reporting period are determined with a maximum uncertainty of less than ± 2,5 %.

(b) Emission factors

Tier 1

For carbonates, use of stoichiometric ratios given in the following table:

Table 4 — Stoichiometric emission factors

Carbonate	**Ratio [t CO_2 /t Ca-, Mg- or other Carbonate]**	**Remarks**
$CaCO_3$ (limestone)	0,440	
$MgCO_3$ (= Mg carbonate – not existing as natural carbonate $MgCO_3$-$CaCO_3$ (dolomite) intermediate between $CaCO_3$ and $MgCO_3$, typical content is Mg 30 % and CaO 20 %)	0,522	
general: X Y (CO_3) Z	Emission factor = [M CO_2]/{Y * [Mx] + Z * [M $CO_3{}^{2-}$]}	X = metal Mx = molecular weight of X in [g/mol] MCO_2 = molecular weight of CO 2 in [g/mol] $MCO_3{}^{-}$ = molecular weight of $CO_3{}^{2-}$ in [g/mol] Y = stoichiometric number of X Z = stoichiometric number of $CO_3{}^{2-}$

These values shall be adjusted for the respective moisture and gangue content of the applied carbonate material.

(c) Conversion factor

Tier 1

Conversion factor: 1.

Based on the principle that process emissions are coming from reducing agents, therefore the total carbon of the raw materials is converted to CO_2.

Tier 2

The amount of non-carbonate compounds of the relevant metals in the raw materials, including return dust or fly ash or other already calcined materials, shall be reflected by means of conversion factors with a value between 0 and 1 with a value of 1 corresponding to a full conversion of raw material carbonates into oxides.

The carbon content of sinter, slag or other relevant output as well as in filtered dust shall be derived following the provisions of this standard in respect to representative sampling and the determination of the carbon contents. In case filtered dust is re-employed in the process, the amount of carbon [t] contained shall not be accounted for in order to avoid double counting.

7.4 Combustion emissions

7.4.1 Overview

Combustion emissions concern auxiliaries operations to the smelting/carbo-reduction process such as:

— mobile gas burner;

— radiators(heat);

— drying of granules;

— hooding.

7.4.2 Methods

The uncertainty thresholds in the table below shall apply to tiers relevant to activity data requirements for which the operator shall use metering results based on measurement systems under its own control at the installation and carry out an uncertainty assessment so as to ensure that the uncertainty threshold of the relevant tier level is met.

The uncertainty thresholds shall be interpreted as maximum permissible uncertainties for the determination of source streams over a reporting period.

Production or processing of ferro-alloys

Table 5 — TIER overview activity data

		Tier 1	**Tier 2**	**Tier 3**	**Tier 4**
Process emissions	Each input material or process residue used as input material in the process [t]	± 5 %	± 2,5 %		
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %

Tier 2 for the carbon content is used by the operator by deriving it from country specific emission factors (standard factors used by a country for its national inventory submission to the UNFCCC) for the respective fuel or material.

Activity data are based on fuel consumption. The quantity of fuel consumed is expressed as energy content, i.e. in TJ. The emission factor is expressed as tCO_2/TJ. When a fuel is consumed, all the carbon in the fuel is oxidized to CO_2. The imperfections of the combustion process result in incomplete oxidation. Some carbon is burned or partly oxidized as soot or ash. The carbon not oxidized or partially oxidized is reflected in the oxidation factor, which is expressed as a fraction.

CO_2 emissions from combustion plants are calculated using the following formula. The calculation shall be performed for each fuel and for each activity.

$$CO_2 \text{ emissions } (tCO_{2,eq}) = CC \times LCV\,^{3} \times EF \times OF \quad (8)$$

where

CC is the quantity of fuel consumed during the reporting period (t or m_N^3);

LCV is the lower calorific value (TJ / t or TJ / m_N^3);

HCV is the high calorific value (MW.h / m_N^3);

EF is the fuel emission factor (tCO_2/TJ $tCO_2/MW.h$ HCV for natural gas/ LCV);

OF is the xxidation factor of fuel.

7.4.3 Calculation of the quantity of fuel

The quantification method of the fuel consumed, made on the basis of the charged amount of fuel as well as the variation of storage according to the formula:

$$\text{Fuel C} = \text{Fuel A} + (\text{Fuel D} - \text{Fuel F}) \quad (9)$$

where

Fuel C is the fuel consumed during the reporting period under review;

Fuel A is the fuel purchased during the reporting period under review;

Fuel D is the fuel stock at the beginning of the reporting period under review;

Fuel F is the fuel stock at the end of the reporting period in question.

7.4.4 Determination of the lower calorific value and the emission factor

Tier 2 for the lower calorific value and the emission factor is used by the operator by deriving them from country specific emission factors for the respective fuel or material.

The LCV and EF apply to fuels regardless of moisture, ash content and sulfur content.

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[3] For natural gas, HCV can be used.

7.4.5 Determination of the oxidation factor

The proportion of carbon is not oxidized or converted in the process is represented by means of an oxidation factor for the emissions of combustion or conversion factor for the process emissions. For oxidation factors, it is exempted from the requirement to apply the highest level possible. If different fuels are used in a facility and specific oxidation factors are calculated, the operator may determine an aggregate oxidation factor for the activity and apply to all fuels, or attribute 'incomplete oxidation to one major fuel stream and apply the value 1 for the others, except when using biomass.

7.5 Combustion of biomass fuels

CO_2 from biomass fuels is considered climate-neutral, because emissions can be compensated by re-growth of biomass in the short term. CO_2 from biomass fuels is reported as a “memo item”, but excluded from the national emissions totals (see EN 19694-1:2016, 12.5).

8 Indirect emissions

8.1 General

Indirect GHG emissions are emissions that are a consequence of the operations of the reporting entity, but occur at sources owned or controlled by another entity. Ferro-alloys production is associated with indirect greenhouse gas emissions from various sources. The main CO_2 emissions to be considered are from:

- external production of electricity consumed by ferro-alloys producers;
- transport of inputs (raw materials, fuels) and outputs (ferro-alloys, silica fumes, slags) by third parties are not considered.

8.2 CO_2 from external electricity production

8.2.1 General

The operator shall obtain the relevant emission factor for purchased electricity from the supplier. If relevant data are not available from the supplier, the operator shall use factors from recognized national sources for the national power grid. In the absence of other sources, the operator may use the latest emission factors for the country published by the International Energy Agency (IEA), (as outlined in Annex C).

A record shall be maintained of the reference factors and their source in the supporting evidence. Emissions associated with the consumption of electricity during transport and distribution (T&D losses) shall not be included in this calculation.

This standard differentiates between the different power sources (purchase, production on-site) and paths of power usage: use for ferro-alloy production, consumption of auxiliaries[4] (difference between gross and net power production of the power plant) and power sold externally. Power given to other non-ferro-alloys installations (outside the set boundaries) within the same plant shall be treated like power sold externally.

8.2.2 GHG from heat transfer

In closed electric arc furnace, the off-gas contains a very high percentage of CO, which is collected without being burned above the charge surface. This CO is a high quality fuel that can be used for:

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[4] It covers various support systems like fans, heat exchangers, raw material handling, keeping ladles warm, etc.

- electricity production and consumption on site (scope 1),
- as a synthesis gas that serves as raw material in chemical processes,
- as fuel for raw material preheating or coke drying.

In semi-closed furnace, an energy recovery system can be implemented; this highly depends upon the local circumstances (users).

Waste heat from off gases with temperature > 500 °C can be used in steam production and subsequent production of electricity. This is an option in cases where there are now alternatives to direct use of steam or hot water for industrial processes or district heating.

Production of electricity gives a reduced yield, typical 20 % to 30 % of the energy in the waste heat source, compared with more than 85 % if recovered directly and utilized as steam or hot water.

9 Baselines, acquisitions and disinvestments

GHG emissions performance is often measured relative to a past reference year (the "base year"). As a default, the "Kyoto base year" 1990[5] can be used as a reference. In many cases however, the lack of reliable and accurate historical data justifies the use of a more recent base year.

Acquisitions and divestitures, as well as the opening or closing of plants, will influence a company's emissions performance, both in absolute and specific terms. To ensure consistency of baselines (= emissions in and after the base year), companies shall apply the following rules in a consistent way:

- **Adjust the baseline for change by acquisition and divestiture**: Consolidated emissions reported for past years shall always reflect the current amount of shares held in a company. If a company is acquired, its past emissions shall be included in the consolidated emissions of the reporting company. This shall be done either back to the base year, or back to the year the acquired company came into existence, whichever is later. If a company is divested, past emissions shall be removed from the consolidated emissions. These adjustments shall be made in accordance with the consolidation rules (see 7.2).
- **No baseline adjustment for "organic" change**: In case of organic growth of production due to investment in new installations, capacity expansions or improved capacity utilization, the baseline shall not be adjusted. In the same sense the baseline shall not be adjusted for organic negative growth: Closure of kilns or decrease of production shall not result in a change of the baseline.

10 Reporting

10.1 General

GHG emissions monitoring and reporting has multiple goals, such as e.g. internal management of environmental performance, public environmental reporting, reporting for taxation schemes, voluntary or negotiated agreements, and emissions trading. Additional purposes can be, for example, performance benchmarking and product life cycle assessment.

GHG reports should be complete, consistent, accurate, relevant and transparent. The organization should determine the content, structure, public availability and methods of dissemination of GHG

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[5] Some Annex 1 countries with economies in transition have chosen other years than 1990 as their base year or base period (e.g., Bulgaria and Romania: 1989, Poland: 1988, Hungary: 1985-87). In addition, all Annex 1 countries can choose 1995 as their base year for hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

reports, based on requirements of the applicable GHG programme, internal reporting needs and the needs of intended users of the report.

The present standard has been designed as a flexible tool to satisfy these different reporting purposes.

The overall uncertainty of a GHG inventory should also be reported, see Clause 11 on uncertainty assessment.

A GHG report shall contain at least the following information (based on ISO 14064):

- description of the reporting organization;
- person responsible;
- reporting period covered;
- documentation of organizational boundaries;
- direct GHG emissions, quantified separately for each GHG, in tonnes of $CO_{2,eq}$;
- a description of how CO_2 emissions from the combustion of biomass are treated in the GHG inventory;
- if quantified, GHG removals, quantified in tonnes of $CO_{2,eq}$;
- explanation for the exclusion of any GHG sources or sinks from the quantification;
- energy indirect GHG emissions associated with the generation of imported electricity, heat or steam, quantified separately in tonnes of $CO_{2,eq}$;
- the historical base year selected and the base-year GHG inventory;
- explanation of any change to the base year or other historical GHG data, and any recalculation of the base year or other historical GHG inventory;
- reference to, or description of, quantification methodologies including reasons for their selection;
- explanation of any change to quantification methodologies previously used;
- reference to, or documentation of, GHG emission or removal factors used;
- description of the impact of uncertainties on the accuracy of the GHG emissions and removals data (including uncertainty assessment description and results, including measures to manage or reduce uncertainties).

10.2 Reporting periods

Reporting GHG emissions can be based on calendar or financial years. Changes in the reporting year should be clearly indicated. National regulations should be taken into account.

10.3 Performance indicators

10.3.1 General

The definition of emission totals and ratio indicators is highly dependent on the reporting context and purpose, such as: input to national inventories, GHG compliance regimes and emissions trading, industry benchmarking, etc. System boundaries for such reporting depend largely on conventions and practical requirements, rather than on scientific arguments.

Generally, the section on performance indicators is conceived as a flexible vessel where companies can introduce additional parameters according to their needs, for instance different emission (sub-) totals.

10.3.2 Denominator for specific, unit-based emissions

From a sustainable development and business point of view, the reporting of GHG efficiency – the specific or unit based emission – is at least as important as the reporting of absolute emissions. This raises the question how the denominator of the specific emissions should be defined.

The following denominators are appropriate in the ferro-alloys industry:

- t tapped ferro-alloy.

10.3.3 Denominator for other ratio indicators

Other ratio indicators which do not use GHG in the numerator can be used, such as:

- specific power consumption per tonne of ferro-alloy.

10.3.4 Key Performance Indicators (KPIs)

A number of KPIs have been determined for the ferro-alloys industry. The following list is not applicable for all plants. Each plant has to assess which ones are relevant to it:

- specific GHG per tonne of ferro-alloy produced in kg CO_2/t FA;
- specific indirect GHG from external power generation per tonne of tapped FA in kg CO_2/t FA;
- total Biomass fuel rate at plant level in %;
- specific total power consumption in kWh/t FA;
- specific total power consumption including auxiliaries in kWh/t FA.

10.3.5 Recovery of waste gas & waste heat

This standard offers the possibility of reporting voluntarily waste heat utilization within the plant (e.g. for preheating, coke drying) in order to allow a fair comparison between plants exporting heat and plants using the heat internally. The calculation has to be done separately and the total energy flow in GJ/a can be reported.

This standard distinguishes between waste heat recovery and separate on-site power generation. In any case, when applying in their voluntary reporting, companies should consider whether their actions indeed contribute to a global reduction in GHG emissions, or merely to a shift of emissions between different entities.

a) Recovery as electricity

For recovery as electricity the company's operator shall obtain the relevant emission factor for purchased electricity from the supplier. If relevant data are not available from the supplier, the operator shall use factors from recognized national sources for the national power grid. In the absence of other sources, the operator may use the latest emission factors for the country published by the International Energy Agency (IEA), (see http://www.ghgprotocol.org/calculation-tools for the latest update).

b) Internal use of heat

For internal use of heat the reduction in GHG emissions can be calculated by using national standards or European Standards for allocation of GHG quotas connected to heat recovery from utilizing hot water or steam.

11 Uncertainty of GHG inventories

11.1 Introduction to uncertainty assessment

11.1.1 Basic considerations

Applying the described mass balance method to determine GHG emissions of the ferro-alloy industry in this standard, the procedures for analysing the uncertainty of measured or calculated values should be considered as described in the following sections. They specify the general rules of the GUM (Guide to the Expression of Uncertainty in Measurement).

The overall uncertainty depends on the uncertainty of the different parameters:

a) Reporting of fuel quantities or production volumes;

b) Analyses of conventional parameters like carbon content, calorific values;

c) Representativeness of sampling.

Due to their scientific nature, the parameters required for estimating GHG emissions, such as fuel volumes, lower heating values and emission factors, are not precise point estimates, but involve an uncertainty that can be expressed as an uncertainty range or confidence interval.

The aggregate uncertainty of an emissions estimate for a plant or company will depend on the individual uncertainties of the underlying parameters.

Quantifying parameter uncertainties is demanding in terms of data and procedures. As a result, statements about the aggregate uncertainty of emissions estimates are inherently uncertain themselves and often involve a subjective component. Nevertheless, there are clear incentives to assess and minimize uncertainty:

— companies may want to rank the sources of uncertainty in their inventory in order to identify priority areas to focus on when improving inventory quality;

— some GHG reporting schemes, for example the monitoring guidelines for the EU ETS, set quantitative limits for the uncertainty of key parameters used to estimate emissions from ferro-alloys plants;

— with this background, it is recognized that uncertainty in GHG inventories is a longer-term challenge which deserves attention.

Table 6 identifies the sources of uncertainty which are typically the most relevant in a ferro-alloy company, along with measures to minimize them.

Table 6 — Typical major sources of uncertainty in ferro-alloy sector CO_2 inventories, and measures to minimize them[6]

Parameter	Measures to minimize parameter uncertainty

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[6] Electrode and limestone are not included in the list above because normally these inputs have a very stable carbon content and the activity data is much lower than for cokes. Therefore both components are not considered major sources of uncertainty.

Activity data of cokes	Use most accurate method available, such as draught survey
Sampling of cokes	Use the minimal frequency of analysis in Table B.1
Analysis of cokes	Use the right standards for analysis and an EN ISO/IEC 17025 laboratory
Sampling and analysis of alloy, slag and dust	Check for relevancy in uncertainty calculation; if needed, increase frequency

11.1.2 Materiality thresholds

Materiality thresholds are typically applied in the process of independent verification of GHG inventories. For example, a verifier could apply a pre-defined threshold of 5 % to determine whether a single or aggregate error in an inventory leads to a material misstatement. The level of such a threshold will depend on the purpose for which the inventory data are intended to be used.

A materiality threshold should not be interpreted as a permissible quantity of emissions which a company can leave out of its inventory. For example, exclusion of all sources which contribute less than 1 % to the overall emissions of a ferro-alloy plant would introduce a systematic bias which is not compatible with the guiding principle that an inventory should be *complete.* On the other hand, it is important to acknowledge that a company’s resources available for preparing a GHG inventory are always limited, and that companies should focus on reducing the uncertainty related to their main emission sources.

With this background, the present standard does not define a minimum threshold below which an emission source should be considered “immaterial”. Instead, companies are encouraged to apply simplified methods for quantifying their minor sources of CO_2.

11.2 Uncertainty of activity data

11.2.1 Measuring instruments for the determination of fuel and material quantities

The information on the uncertainty of a measuring instrument can be found in different sources:

- certificates on calibration under national metrological control (where the operational error limits the uncertainty under normal operational conditions),
- the specification from the manufacturer of an instrument, or
- an individual uncertainty assessment under operational conditions (e.g. via regular testing and adjustment of scales).

11.2.2 Aggregated uncertainties in case of mass balances

In case of mass balance, the aggregated uncertainty for the activity data has to be calculated via error propagation considering the diverse uncertainties of each involved weighing instruments.

11.3 Uncertainties of fuel and material parameters

The uncertainty of analysed parameters of fuels and materials depends mainly on:

- the analysing method,
- the analysing frequency (a decrease of uncertainty is possible by raising the analysing frequency), and
- representative sampling.

Also, the qualification and experience of the persons who perform the analyses influences the quality of analysing results.

11.4 Evaluation of the overall uncertainty of an GHG inventory

In order to determine the overall uncertainty of a GHG inventory, the assessed uncertainties beforehand regarding activity data and parameters have to be aggregated by the error propagation laws.

Annex A
(normative)

Tier 1 emission factors

This annex contains reference emission factors for the Tier 1 level that permit the use of non-activity-specific emission factors for the combustion of fuel. If a fuel does not belong to an existing fuel category, the operator shall use his expert judgement to assign the fuel used to a related fuel category, subject to the approval of the competent authority.

Table A.1 — Fuel emission factors related to net calorific value (NCV) and net calorific values per mass of fuel[7]

Fuel type description	**Emission factor** **(tCO_2/TJ)**	**Net calorific value** **(TJ/Gg)**
	2006 IPCC guidelines (except biomass)	**2006 IPCC guidelines**
Crude oil	73,3	42,3
Orimulsion	77,0	27,5
Natural gas liquids	64,2	44,2
Motor gasoline	69,3	44,3
Kerosene	71,9	43,8
Shale oil	73,3	38,1
Gas/diesel oil	74,1	43,0
Residual fuel oil	77,4	40,4
Liquefied petroleum gases	63,1	47,3
Ethane	61,6	46,4
Naphtha	73,3	44,5
Bitumen	80,7	40,2
Lubricants	73,3	40,2
Petroleum coke	97,5	32,5
Refinery feedstocks	73,3	43,0
Refinery gas	57,6	49,5
Paraffin waxes	73,3	40,2
White spirit and SBP	73,3	40,2
Petroleum products	73,3	40,2
Anthracite	98,3	26,7
Coking coal	94,6	28,2
Other bituminous coal	94,6	25,8

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[7] Annex VI to Commission Regulation 601/2012 of November 2011 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

Fuel type description	**Emission factor** **(tCO_2/TJ)**	**Net calorific value** **(TJ/Gg)**
	2006 IPCC guidelines (except biomass)	**2006 IPCC guidelines**
Sub-bituminous coal	96,1	18,9
Lignite	101,0	11,9
Oil shale and tar sands	107,0	8,9
Patent fuel	97,5	20,7
Coke oven coke and lignite coke	107,0	28,2
Gas coke	107,0	28,2
Coal tar	80,7	28,0
Gas works gas	44,4	38,7
Coke oven gas	44,4	38,7
Blast furnace gas	260,0	2,5
Oxygen steel furnace gas	182	7,1
Natural gas	56,1	48,0
Industrial wastes	143,0	n.a
Waste oils	73,3	40,2
Peat	106,0	9,8
Wood/wood waste	0	15,6
Other primary solid biomass	0	11,6
Charcoal	0	29,5
Biogasoline	0	27,0
Biodiesels	0	27,0
Other liquid biofuels	0	27,4
Landfill gas	0	50,4
Sludge gas	0	50,4
Other biogas	0	50,4
Other sources		
Waste tyres	85,0	n.a
Carbon monoxide	155,2	10,1
Methane	54,9	50,0

Annex B
(normative)

Minimum frequency of analysis

Table B.1 — Minimum frequency of analysis[8]

Fuel/material	**Minimum frequency of analyses**
Natural gas	At least weekly
Process gas (refinery mixed gas, coke oven gas, blast- furnace gas and convertor gas)	At least daily - using appropriate procedures at different parts of the day
Fuel oil	Every 20.000 tonnes and at least six times a year
Coal, coking coal, petroleum coke	Every 20.000 tonnes and at least six times a year
Solid waste (pure fossil or mixed biomass fossil)	Every 5.000 tonnes and at least four times a year
Liquid waste	Every 10.000 tonnes and at least four times a year
Carbonate minerals (including limestone and dolomite)	Every 50.000 tonnes and at least four times a year
Clays and shales	Amounts of material corresponding to 50.000 tonnes of CO_2 and at least four times a year
Other input and output streams in the mass balance (not applicable for fuels or reducing agents)	Every 20.000 tonnes and at least once every month
Other materials	Depending on the type of material and the variation, amounts of material corresponding to 50.000 tonnes of CO_2 and at least four times a year

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[8] Annex VII to Commission Regulation 601/2012 of November 2011 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

Annex C
(normative)

Country-wise emission factors for electricity

Table C.1 — Country-wise emission factors for electricity (tCO_2/MWh)[9]

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average 2001 - 2010
World	0,580	0,573	0,584	0,586	0,587	0,589	0,589	0,582	0,573	0,565	0,581
European Union	**0,403**	**0,407**	**0,407**	**0,396**	**0,391**	**0,395**	**0,399**	**0,378**	**0,360**	**0,350**	**0,388**
Austria	0,190	0,190	0,236	0,224	0,218	0,217	0,204	0,187	0,158	0,188	0,201
Belgium	0,277	0,272	0,278	0,285	0,275	0,263	0,254	0,254	0,218	0,220	0,259
Bulgaria	0,584	0,533	0,594	0,603	0,567	0,549	0,658	0,621	0,591	0,579	0,588
Denmark	0,443	0,438	0,474	0,403	0,369	0,459	0,425	0,398	0,398	0,360	0,419
Czech Republic	0,717	0,677	0,618	0,617	0,614	0,606	0,636	0,621	0,588	0,589	0,627
Estonia	1,047	1,007	1,011	1,029	1,048	0,965	1,048	1,084	1,078	1,014	1,033
Finland	0,218	0,238	0,303	0,258	0,164	0,265	0,238	0,177	0,190	0,229	0,230
France	0,061	0,066	0,070	0,067	0,079	0,072	0,076	0,072	0,078	0,079	0,072
Germany	0,544	0,544	0,512	0,503	0,486	0,483	0,504	0,476	0,467	0,461	0,497
Greece	0,834	0,817	0,781	0,780	0,779	0,731	0,752	0,748	0,725	0,718	0,765
Hungary	0,461	0,450	0,502	0,448	0,372	0,373	0,368	0,351	0,313	0,317	0,394
Ireland	0,668	0,635	0,600	0,575	0,584	0,537	0,510	0,471	0,452	0,458	0,545
Italy	0,482	0,503	0,511	0,497	0,486	0,509	0,475	0,452	0,411	0,406	0,473
Latvia	0,217	0,226	0,234	0,175	0,161	0,213	0,202	0,210	0,182	0,227	0,204
Lithuania	0,211	0,173	0,163	0,175	0,229	0,231	0,201	0,193	0,192	0,548	0,206
Luxembourg	0,461	0,401	0,403	0,393	0,389	0,387	0,381	0,385	0,376	0,410	0,393
Netherlands	0,493	0,480	0,484	0,467	0,454	0,452	0,455	0,442	0,420	0,415	0,454
Poland	0,858	0,849	0,849	0,833	0,818	0,821	0,820	0,815	0,799	0,781	0,824
Portugal	0,449	0,525	0,422	0,465	0,521	0,431	0,396	0,394	0,379	0,255	0,421
Romania	0,748	0,702	0,781	0,653	0,629	0,632	0,671	0,635	0,575	0,499	0,650
Slovakia	0,231	0,201	0,256	0,233	0,221	0,214	0,220	0,207	0,210	0,197	0,220
Slovenia	0,361	0,380	0,376	0,345	0,349	0,362	0,375	0,332	0,318	0,325	0,351
Spain	0,382	0,434	0,378	0,382	0,397	0,369	0,387	0,327	0,297	0,238	0,356
Sweden	0,023	0,029	0,037	0,023	0,019	0,023	0,017	0,018	0,019	0,030	0,024
United Kingdom	0,484	0,469	0,489	0,491	0,491	0,515	0,506	0,499	0,453	0,457	0,486

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[9] CO_2 emissions from fuel combustion highlights – Edition 2012 – pp 111 – IEA publications:

http://www.iea.org/publications/freepublications/publication/co2emissionfromfuelcombustionhighlights.pdf

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average 2001 - 2010
Other Europe	**0,313**	**0,297**	**0,316**	**0,303**	**0,333**	**0,362**	**0,320**	**0,322**	**0,320**	**0,309**	**0,320**
Albania	0,054	0,047	0,033	0,030	0,026	0,026	0,031	0,000	0,001	0,002	0,023
Bosnia Herzegovina	0,793	0,855	0,883	0,772	0,797	0,852	1,007	0,835	0,811	0,729	0,828
Croatia	0,395	0,450	0,508	0,381	0,397	0,403	0,497	0,435	0,356	0,305	0,411
Macedonia	0,923	0,851	0,809	0,797	0,791	0,784	0,871	0,905	0,800	0,687	0,819
Montenegro	0,000	0,000	0,000	0,000	0,341	0,386	0,352	0,456	0,274	0,405	0,373
Norway	0,002	0,002	0,003	0,003	0,002	0,003	0,004	0,003	0,011	0,017	0,005
Serbia	0,842	0,887	0,920	0,883	1,341	1,464	0,758	0,776	0,768	0,724	0,935
Switzerland	0,025	0,028	0,027	0,028	0,032	0,033	0,030	0,029	0,026	0,027	0,028
Turkey	0,552	0,481	0,451	0,426	0,438	0,452	0,494	0,511	0,496	0,460	0,476
C.I.S.	**0,651**	**0,664**	**0,679**	**0,656**	**0,697**	**0,733**	**0,700**	**0,697**	**0,654**	**0,616**	**0,675**
Azerbaijan	1,311	1,119	1,218	1,272	1,219	1,275	0,846	0,771	0,714	0,584	1,041
Belarus	0,608	0,604	0,590	0,609	0,590	0,595	0,577	0,595	0,618	0,585	0,597
Georgia	0,136	0,058	0,068	0,095	0,105	0,149	0,165	0,082	0,144	0,071	0,107
Kazakhstan	0,936	1,074	1,067	1,004	0,985	1,353	1,095	0,958	0,810	0,766	0,999
Moldova	1,010	0,912	0,930	0,593	0,596	0,575	0,603	0,578	0,597	0,583	0,694
Russia	0,668	0,681	0,691	0,677	0,732	0,749	0,723	0,727	0,684	0,639	0,698
Ukraine	0,402	0,412	0,471	0,394	0,432	0,458	0,468	0,475	0,417	0,419	0,436
Uzbekistan	0,833	0,831	0,804	0,780	0,780	0,774	0,811	0,723	0,756	0,734	0,782
North America	**0,571**	**0,531**	**0,537**	**0,530**	**0,525**	**0,507**	**0,511**	**0,495**	**0,474**	**0,481**	**0,515**
Canada	0,231	0,216	0,228	0,214	0,200	0,202	0,198	0,187	0,176	0,186	0,203
Cuba	0,580	0,792	0,815	0,820	0,832	0,767	0,750	0,733	1,063	1,012	0,820
Dominican Republic	0,658	0,675	0,700	0,704	0,649	0,668	0,675	0,634	0,591	0,589	0,651
El Salvador	0,342	0,351	0,335	0,312	0,301	0,310	0,315	0,273	0,276	0,223	0,300
Guatemala	0,421	0,484	0,435	0,323	0,299	0,345	0,369	0,343	0,349	0,286	0,360
Honduras	0,332	0,287	0,352	0,451	0,411	0,267	0,420	0,409	0,346	0,332	0,363
Mexico	0,561	0,558	0,571	0,495	0,509	0,482	0,479	0,430	0,455	0,455	0,496
Trinidad & Tobago	0,689	0,767	0,753	0,751	0,759	0,753	0,753	0,704	0,719	0,700	0,734
United States	0,625	0,576	0,579	0,577	0,574	0,552	0,560	0,545	0,517	0,522	0,562

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average 2001 - 2010**
South America	**0,158**	**0,149**	**0,149**	**0,155**	**0,156**	**0,161**	**0,162**	**0,172**	**0,162**	**0,180**	**0,161**
Argentina	0,267	0,258	0,275	0,308	0,313	0,366	0,391	0,365	0,363	0,367	0,332
Brazil	0,105	0,086	0,078	0,085	0,084	0,081	0,073	0,090	0,064	0,087	0,083
Chile	0,274	0,279	0,295	0,322	0,318	0,304	0,408	0,411	0,373	0,410	0,345
Colombia	0,165	0,154	0,152	0,117	0,131	0,127	0,127	0,107	0,176	0,176	0,143
Ecuador	0,272	0,266	0,256	0,291	0,378	0,423	0,328	0,256	0,313	0,389	0,320
Paraguay											
Peru	0,123	0,146	0,152	0,212	0,209	0,183	0,199	0,240	0,253	0,289	0,209
Uruguay	0,003	0,004	0,002	0,151	0,103	0,296	0,104	0,307	0,253	0,081	0,121
Venezuela	0,241	0,266	0,265	0,222	0,208	0,222	0,208	0,203	0,205	0,264	0,229
Africa	**0,619**	**0,610**	**0,628**	**0,649**	**0,634**	**0,627**	**0,616**	**0,667**	**0,641**	**0,637**	**0,634**
Algeria	0,621	0,632	0,632	0,632	0,606	0,621	0,597	0,596	0,643	0,548	0,610
Angola	0,496	0,460	0,510	0,290	0,273	0,260	0,300	0,330	0,465	0,440	0,378
Egypt	0,380	0,392	0,397	0,489	0,474	0,473	0,450	0,460	0,466	0,450	0,447
Ghana	0,109	0,256	0,278	0,085	0,147	0,276	0,360	0,215	0,187	0,259	0,218
Kenya	0,287	0,189	0,141	0,217	0,247	0,258	0,248	0,322	0,396	0,274	0,264
Libya	0,996	0,971	0,978	0,888	0,907	0,879	0,846	0,885	0,872	0,885	0,902
Mauritania	0,439,	0,433	0,438	0,442	0,451	0,496	0,475	0,484	0,477	0,477	0,461
Morocco	0,839	0,839	0,804	0,822	0,804	0,794	0,777	0,775	0,690	0,718	0,782
Nigeria	0,326	0,359	0,330	0,362	0,359	0,385	0,385	0,386	0,416	0,405	0,373
South Africa	0,829	0,809	0,849	0,871	0,851	0,831	0,827	0,948	0,906	0,927	0,866
Tunisia	0,584	0,564	0,489	0,477	0,469	0,492	0,506	0,494	0,472	0,463	0,498
Uganda	0,439	0,433	0,438	0,442	0,451	0,496	0,475	0,484	0,477	0,477	0,461
Zaire	0,001	0,001	0,001	0,001	0,001	0,002	0,003	0,004	0,003	0,003	0,002
Zimbabwe	0,848	0,717	0,515	0,572	0,572	0,658	0,660	0,660	0,660	0,660	0,647
Middle East	**0,706**	**0,709**	**0,701**	**0,690**	**0,684**	**0,676**	**0,659**	**0,676**	**0,688**	**0,675**	**0,684**
Iran	0,583	0,565	0,529	0,542	0,541	0,549	0,546	0,582	0,578	0,565	0,559
Israel	0,770	0,812	0,805	0,809	0,776	0,774	0,770	0,712	0,694	0,689	0,758
Jordan	0,702	0,740	0,680	0,682	0,660	0,626	0,587	0,589	0,581	0,566	0,628
Qatar	0,781	0,782	0,779	0,649	0,618	0,617	0,565	0,534	0,494	0,494	0,597
Saudi Arabia	0,778	0,751	0,737	0,754	0,739	0,749	0,726	0,736	0,757	0,737	0,745
Syria	0,559	0,596	0,620	0,571	0,607	0,612	0,623	0,627	0,629	0,594	0,606
United Arab Emirates	0,746	0,764	0,805	0,913	0,844	0,820	0,720	0,729	0,631	0,598	0,739

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average 2001 - 2010
Asia	**0,679**	**0,685**	**0,702**	**0,721**	**0,720**	**0,725**	**0,723**	**0,716**	**0,716**	**0,697**	**0,710**
Bangladesh	0,602	0,603	0,574	0,546	0,553	0,574	0,567	0,574	0,585	0,593	0,577
China	0,836	0,846	0,859	0,879	0,864	0,861	0,822	0,803	0,800	0,766	0,826
Hong Kong	0,720	0,725	0,795	0,749	0,755	0,754	0,775	0,757	0,763	0,723	0,752
India	0,921	0,907	0,892	0,931	0,923	0,922	0,946	0,950	0,945	0,912	0,926
Indonesia	0,682	0,678	0,716	0,708	0,719	0,736	0,768	0,747	0,745	0,709	0,723
Japan	0,403	0,424	0,446	0,429	0,431	0,420	0,454	0,440	0,416	0,416	0,428
North Korea	0,583	0,568	0,542	0,528	0,522	0,533	0,469	0,481	0,499	0,465	0,518
Korea	0,531	0,479	0,476	0,503	0,487	0,491	0,481	0,487	0,525	0,533	0,500
Malaysia	0,528	0,585	0,539	0,561	0,618	0,598	0,611	0,653	0,600	0,727	0,610
Mongolia	1,640	1,763	1,506	1,387	1,405	1,347	1,496	1,369	1,371	1,492	1,469
Myanmar	0,405	0,430	0,484	0,436	0,395	0,374	0,357	0,308	0,199	0,262	0,356
Pakistan	0,463	0,443	0,371	0,397	0,380	0,413	0,433	0,451	0,458	0,425	0,423
Philippines	0,478	0,446	0,449	0,448	0,491	0,429	0,443	0,483	0,475	0,481	0,463
Singapore	0,724	0,664	0,592	0,561	0,539	0,528	0,524	0,515	0,485	0,499	0,557
Sri Lanka	0,429	0,470	0,488	0,513	0,476	0,335	0,394	0,420	0,432	0,379	0,430
Taiwan (China)	0,787	0,774	0,808	0,812	0,811	0,816	0,815	0,795	0,786	0,768	0,797
Thailand	0,566	0,548	0,536	0,543	0,535	0,511	0,546	0,529	0,513	0,513	0,532
Vietnam	0,399	0,430	0,381	0,438	0,447	0,435	0,426	0,406	0,384	0,432	0,418
Oceania	**0,762**	**0,815**	**0,810**	**0,791**	**0,761**	**0,760**	**0,750**	**0,750**	**0,749**	**0,733**	**0,768**
Australia	0,860	0,929	0,918	0,899	0,859	0,859	0,850	0,847	0,852	0,841	0,871
New Zealand	0,205	0,177	0,213	0,196	0,237	0,231	0,196	0,215	0,167	0,150	0,198

Bibliography

[1] Commission Decision 2007/589/EC of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, JOL 229/1

[2] *Industrial Processes and Product Use*. Chapter 4. IPCC Guidelines for National Greenhouse Gas Inventories. Metal Industry Emissions, Vol. 3, 2006

[3] Commission Decision 2011/540/EU of 18 August 2011 on amending Decision 2007/589/EC as regards the inclusion of monitoring and reporting guidelines for greenhouse gas emissions from new activities and gases, JOL 244/1

[4] Commission Regulation 601/2012 of November 2011 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council

[5] Directive 2003/87/EC of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, JOL 275/32 Amended by Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004; L 338 18 13.11.2004

[6] Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008; L 83 13.1.2009

[7] MONITORING AND REPORTING GUIDELINES (MRG) OF THE EU ETS. (EC 2007), http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007D0589

[8] Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community

[9] Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009; L 140 63 5.6.2009

[10] Directive 2009/29/EC of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community, JOL 140/73

[11] ISO 20988, *Air quality — Guidelines for estimating measurement uncertainty*

[12] ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

[13] THE GREENHOUSE GAS PROTOCOL. *A corporate Accounting and Reporting Standard*. WBCSD-WRI, Revised Ed., 2004

[14] CO_2 emissions from fuel combustion highlights – Edition 2012 – pp 111 – IEA publications: WRI / WBCSD GHG Protocol, Guideline for Stationary Fuel Combustion, see www.ghgprotocol.org

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

[16] EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)*

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