



BSI Standards Publication

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

Part 1: General aspects

National foreword

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émissions de gaz à effet de serre (GES) dans les
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généraux

Emissionen aus stationären Quellen - Bestimmung von
Treibhausgasen (THG) aus energieintensiven
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European foreword

This document (EN 19694-1:2016) 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of an identical text or by endorsement, at the latest by January 2017, and conflicting national standards shall be withdrawn at the latest by January 2017.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*

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1 Scope

This European Standard specifies the principles and requirements for the determination of GHG emissions from sector-specific sources as of the steel and iron, cement, aluminium, lime and ferroalloy producing industry.

This European Standard specifies in particular definitions and rules valid to all above enlisted sector-specific standards, provides common methodological issues and defines the details for applying the rules for the harmonized methods, which include:

- a) measuring, testing and quantifying methods for greenhouse gas (GHG) emissions of the above mentioned sector-specific sources in the cited standards;
- b) assessment of the level of GHG emissions performance of production processes over time, at production sites;
- c) establishment and provision of reliable, accurate and quality information for reporting and verification purposes.

The application of this standard to the other sector-specific standards in this series ensures accuracy, precision and reproducibility of the obtained results and is for this reason a normative reference standard, umbrella standard respectively.

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 14181:2014, *Stationary source emissions — Quality assurance of automated measuring systems*

EN 15259, *Air quality — Measurement of stationary source emissions — Requirements for measurement sections and sites and for the measurement objective, plan and report*

EN 15267-1, *Air quality — Certification of automated measuring systems — Part 1: General principles*

EN 15267-2, *Air quality — Certification of automated measuring systems — Part 2: Initial assessment of the AMS manufacturer's quality management system and post certification surveillance for the manufacturing process*

EN 15267-3:2007, *Air quality — Certification of automated measuring systems — Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources*

EN 15440:2011, *Solid recovered fuels — Methods for the determination of biomass content*

EN 19694 (all parts), *Stationary source emissions — Determination of greenhouse gas (GHG) emissions in energy-intensive industries*

EN ISO 13833, *Stationary source emissions — Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide — Radiocarbon sampling and determination (ISO 13833)*

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

EN ISO 14956, *Air quality — Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty (ISO 14956)*

EN ISO 16911-1:2013, *Stationary source emissions — Manual and automatic determination of velocity and volume flow rate in ducts — Part 1: Manual reference method (ISO 16911-1:2013)*

EN ISO 16911-2, *Stationary source emissions — Manual and automatic determination of velocity and volume flow rate in ducts — Part 2: Automated measuring systems (ISO 16911-2)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 absolute emission

absolute GHG emissions are expressed as a mass stream, for example in tonnes of CO₂e per year (t CO₂e/yr)

3.2 alternative fuel

AF
fuel materials or products used as a source of thermal energy and not classified as traditional fuel. In some industry wastes such as plastics, solvents, waste oil, end-of-life tires, etc. and different types of mixed or pure biomass fuels are used

3.3 base year

historical period specified for the purpose of comparing GHG emissions or other GHG-related information over time

Note 1 to entry: Base-year emissions may be quantified based on a specific period (e.g. a year) or averaged from several periods (e.g. several years).

3.4 biogenic CO₂

CO₂ obtained by the oxidation of biogenic carbon

3.5 biogenic carbon

carbon derived from biomass

3.6 biomass

material of biological origin excluding material embedded in geological formations and material transformed to fossilised material and excluding peat

Note 1 to entry: Biomass includes organic material (both living and dead), e.g. trees, crops, grasses, tree litter, algae, animals and waste of biological origin, e.g. manure.

3.7 carbon dioxide equivalent, CO₂e

unit for comparing the radiative forcing of a GHG to carbon dioxide

Note 1 to entry: The carbon dioxide equivalent is calculated using the mass of a given GHG multiplied by its global warming potential.

3.8

direct greenhouse gas emission

emission from greenhouse gas sources that are owned or controlled by the reporting organization

3.9

greenhouse gas emission factor

factor relating activity data to GHG emissions

3.10

energy indirect greenhouse gas emission

GHG emission from the generation of imported electricity, heat or steam consumed by the organization

3.11

equity share

percentage of economic interest in, or benefit derived from, a facility

Note 1 to entry: Under this approach, an organization (corporation, group) or a company consolidates its GHG emissions according to the (*pro rata*) equity share it holds in each operation, i.e. according to ownership. As an exception, no emissions are consolidated for so-called fixed asset investments where a company owns only a small part of the total shares of an operation and exerts neither significant influence nor financial control; other possible exceptions relate to the *economic substance* of a relationship [12].

3.12

facility

single local installation, set of installations or production processes (stationary or mobile), which can be defined within a single geographical boundary, organizational unit or production process

3.13

financial control

the ability of an organization to direct the financial and operating policies of an operation with a view to gaining economic benefits from its activities.

Note 1 to entry: The financial control usually exists if the organization has the right to the majority benefits of the operation, or if it retains the majority risks and rewards of ownership of the operation's assets. Under this approach, companies consolidate 100 % of the emissions of those operations over which they have financial control; as an exception, consolidation according to equity share is required for joint ventures where partners have joint financial control.

3.14

fossil carbon

carbon derived from fossil fuel or other fossil source

3.15

greenhouse gas

GHG

gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds

Note 1 to entry: GHGs include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF₆).

3.16
global warming potential
GWP

factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period of time

3.17
higher heat value
HHV

(= gross calorific value, GCV), often in GJ per tonne of fuel: The higher heat value includes the latent heat contained in water vapour, which is released when condensing water vapour so that all water is in liquid state.

Note 1 to entry: Compare 2006 IPCC Guideline, Vol. II, Section 1.4.1.2 [10].

3.18
greenhouse gas activity data
quantitative measure of activity that results in greenhouse gas emission"

Note 1 to entry: Examples of greenhouse gas activity data include the amount of energy, fuels or electricity consumed or material produced.

Note 2 to entry: Also referred to in the set of standards as "activity data".

3.19
greenhouse gas inventory
an organization's GHG sources and GHG emissions

3.20
greenhouse gas source
physical unit or process that releases a GHG into the atmosphere

3.21
key performance indicator
KPI
an industry used term for a type of measure of performance; KPIs are commonly used by organizations to evaluate its success or the success of a particular activity in which it is engaged

3.22
lower heat value
LHV
(= net calorific value, NCV), often in GJ per ton of fuel: the lower heat value excludes the latent heat contained in water vapour

3.23
loss on ignition
LOI
test used in inorganic analytical chemistry, particularly in the analysis of minerals. It consists of strongly heating ("igniting") a sample of the material at a specified temperature, allowing volatile substances to escape, until its mass ceases to change

3.24

mass balance

a relationship between input and output of a specific substance in a defined system, taking into account the formation or decomposition of that substance in the system

3.25

mixed fuels

term used in this Standard for referring to fuels that are a mix of biomass and fossil fuel, i.e. fuel with a certain biogenic carbon content

3.26

m_N^3

normal cubic meter (at 1 013,25 hPa and 273,15 K)

3.27

operational control

an organization's full authority to introduce and implement its operating policies at an operation

Note 1 to entry: This criterion is usually fulfilled if an organization is the operator of a facility, i.e. if it holds the operating license; under this approach, companies consolidate 100 % of the emissions of those operations over which they have operational control; as an exception, consolidation according to equity share is required for joint ventures where partners have joint operational control.

3.28

organization

company, corporation, firm, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration

3.29

other indirect greenhouse gas emissions

GHG emission, other than energy indirect GHG emissions, which are a consequence of an organization's activities, but arises from greenhouse gas sources that are owned or controlled by other organizations

3.30

plant

technical entity for production of a specific product.

Note 1 to entry: A plant consists of various tools necessary to the operation of a process.

3.31

process

single or multiple operations delivering a specific product or set of products

Note 1 to entry: Also referred to as activity but the term activity is more largely used in activity data which are the basis of GHG estimate.

3.32

process emission

emission from industrial processes including chemical and mineralogical transformations other than combustion

3.33

source stream

means any of the following:

(a) a specific fuel type, raw material or product giving rise to emissions of relevant greenhouse gases at one or more emission sources as a result of its consumption or production;

(b) a specific fuel type, raw material or product containing carbon and included in the calculation of greenhouse gas emissions using a mass balance methodology

3.34

specific emission

emission expressed on a per unit output basis, for instance in kg of CO₂e per tonne of product

3.35

TC

total carbon, the sum of TOC and TIC

3.36

TIC

total inorganic carbon: carbon, mostly bound in the mineral matter of materials (e.g. carbonates in fuel ashes)

3.37

TOC

total organic carbon

3.38

traditional fuel

fossil fuel defined by the International Panel on Climate Change (IPCC) guidelines, including mainly coal, petroleum coke, lignite, shale, petroleum products and natural gas

3.39

uncertainty

parameter associated with the result of quantification which characterizes the dispersion of the values that could be reasonably attributed to the quantified amount

Note 1 to entry: Uncertainty information typically specifies quantitative estimates of the likely dispersion of values and a qualitative description of the likely causes of the dispersion.

4 Symbols and abbreviations

AMS Automated Measuring System

GHG Greenhouse Gas

5 Introduction

The European Commission is of the opinion that with a view to international developments like sectoral agreements, and subject to existing legislation, the work for developing a methodology for assessing direct and indirect greenhouse gas (GHG) emissions from energy intensive industry and/or products is best achieved within the European Standardisation system which offers a suitable structure and gathers the necessary high level of competence and expertise.

The present standardization work is based on the results of the EC/EFTA programming Mandate M/431 to establish a programme of standards for assessing the GHG emissions in energy-intensive industries, which is a true dissemination result of the preparatory work for Mandate M/478 in terms of gap analysis of EN and ISO standards as well as existing protocols. Following this gap analysis the

European Commission sent in December 2010 the standardization mandate M/478 to CEN, CENELEC and ETSI for the development of European Standards in the field of greenhouse gas emissions.

The standardization work is coherent with EU policies, especially with the Energy and Climate package of January 2008, and the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan COM(2008) 397.

Section II of Mandate M/478 mandates the establishment of a set of EN standards, which contain harmonized and verified methods for measuring, testing and quantifying GHG emissions from five sector-specific industry sectors, and one standard on general aspects.

In particular, the standards contain harmonized methods for:

- a) measuring, testing and quantifying GHG emissions from sector-specific sources;
- b) assessing the level of GHG emissions performance of production processes over time, at production sites;
- c) establishing and providing reliable, accurate and quality information for reporting and verification purposes.

This standard deals with the general aspects and is a generic “umbrella standard” which defines common methodological issues and overall requirements, which are applicable to all sectors covered.

The basic vision of this framework standard of GHG emissions for energy intensive industries is to develop by experts of energy intensive industries under the umbrella of CEN and EC (Mandate M 478) a tool establishing common verified rules for the participating industries. This standard shall enable industry to manage the GHG emissions output of the production processes and to allow performance assessment between plants and over time. The objective is to improve continuously the reduction potential of the production processes by acting on the emission performance over time. Therefore the standard contributes to competitiveness of industry and is a tool formalizing business’ contribution in providing emission reductions in their operations and in developing low carbon technology solutions to the market.

Accounting and performance assessment of GHG shall be based on the principles as described in the following paragraphs.

For high **accuracy** it has to be ensured that the quantification of GHG emissions is systematically neither over nor below actual emissions, as far as may be judged, and that uncertainties are reduced as far as practicable (see also Chapter 9). Sufficient accuracy should be achieved to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

All relevant issues should be addressed in a factual and coherent manner, based on a clear audit trail, to aim at **transparency**. Any relevant assumptions should be disclosed and appropriate references should be made to the accounting and mass balance methodologies and data sources used.

Consistent methodologies should be used to allow for meaningful comparison of emissions over time. Any changes to the data, inventory boundary, methods, or any other relevant factors in the time series should be documented transparently.

It should be ensured that the GHG inventory appropriately reflects the **relevant** GHG emissions of the reporting entity and serves the decision-making needs of users – both internal and external to the organization.

The operator should account for and report on all GHG emission sources and activities within the chosen inventory boundary. To reach **completeness** any gaps should be avoided and any specific exclusion shall be disclosed and justified.

The standard aims to meet the following additional rules. Double counting at plant, organization, group, national, and international levels should be avoided. Different drivers of emissions (technological

improvement, internal and external growth) should be distinguishable. Emissions may be reported in absolute as well as specific (unit-based) terms. The full range of achieved direct and indirect GHG abatements should be reflected. The standard also provides a flexible tool supporting the needs of different monitoring and reporting purposes, such as: internal management and public corporate reporting of GHG emission performance according to the production processes on a production site.

The purpose of this standard is not to prescribe specific requirements for verification or certification of methods, measurements, calculations or resulting data.

However, due to the nature of the issues concerned, and their wide public interest, verification and certification should be prepared for. Hence the operator should organize files and records in such a way that they are easily retrievable and traceable.

Documentation of:

- personnel qualifications,
- methods applied,
- time series of measurements performed,
- calibration status of equipment used,
- calculations of emissions, etc.

These documents should be readily available for corporate internal verification, second party (i.e. customer) verification or third party certification if required by stakeholders.

Mandate M/478 distinguishes between "Measuring, testing and quantifying for greenhouse gas (GHG) emissions (...)" and "Assessing the level of greenhouse gas emissions performance of production processes (...)". Usually performance indicators are calculated from the inventory data.

Within this standard "Measuring, testing and quantifying for greenhouse gas (GHG) emissions" is understood to be the emissions inventory of a site (plant, facility) including energy flows and material flows leaving or entering the system boundaries. Typically, inventory data are absolute data. Inventory data should represent the original data set without any corrections, adaptations, etc. for example with regard to other energy indirect GHG emissions. This standard utilizes metric units.

Performance assessment has to consider sector-specific conditions. Performance assessment may be based on absolute and/or (product-) specific data and may require corrections or adaptations in order to allow a fair and transparent comparison of plants.

This standard is not appropriate for use of life cycle analysis and product carbon footprint.

6 System boundaries

6.1 Organizational boundaries

This standard may be applied based on an organization, facility or plant. The organization may comprise one or more facilities and a facility may comprise one or more plants. Facility-level and plant-level GHG emissions may be produced from one or more GHG sources.

The organization shall consolidate its facility-level GHG emissions by one of the following approaches:

- a) control: the organization accounts for all quantified GHG emissions from facilities over which it has financial or operational control; or
- b) equity share: the organization accounts for its portion of GHG emissions from respective facilities.

The organization may use a different consolidation methodology where specific arrangements are defined by a GHG programme or legal contract.

When a facility is controlled by several organizations, these organizations should adopt the same consolidation methodology.

The organization shall document which consolidation method it applies.

The organization shall explain any change to the selected consolidation method.

Guidance on applying control and equity share approaches to consolidate facility-level GHG emissions to the organization level is included in EN ISO 14064-1.

6.2 Operational boundaries

6.2.1 General

Operational boundaries refer to the types of sources covered by an inventory. They may cover all the existing activities of a sector or be limited to a part of them considered as core activities. As a guiding principle, all emission sources necessary for producing the reference product should be included.

In the context of operational boundaries EN ISO 14064-1 applies. In the context of operational boundaries, it is useful to recall the concept of scopes as defined in the revised WRI / WBCSD Protocol [12].

- **Direct greenhouse gas emissions** occur from sources that are owned or controlled by the organization. For example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc. (...). Direct CO₂ emissions from the combustion of biomass shall be quantified separately. Direct GHG emissions correspond to Scope 1 emissions in WRI / WBCSD Protocol [11].
- **Energy indirect greenhouse gas emissions** occur from the generation of purchased electricity, heat or steam consumed in the organization's owned or controlled equipment. These emissions physically occur at the facility where electricity, heat or steam is generated. Energy indirect GHG emissions correspond to Scope 2 emissions in WRI / WBCSD Protocol.
- **Other indirect greenhouse gas emissions** are a consequence of the activities of the organization, but occur from sources not owned or controlled by the organization. Some examples are listed in EN ISO 14064-1. Other indirect greenhouse gas emissions correspond to Scope 3 emissions in WRI / WBCSD Protocol.

In principle, operational boundaries shall cover direct GHG emissions and energy indirect greenhouse gas emissions. As far as they are needed for a fair and transparent comparison of plants/facilities, other indirect GHG emissions shall be included for the calculation of performance indicators. The sector-specific standards Part 2 to 6 give specific indication on how to set operational boundaries.

Absolute emissions (e.g. in tonnes CO_{2e} per year) shall be reported based on direct GHG emissions. Energy indirect GHG emissions should be reported separately. Performance assessment has to be based on energy direct GHG emissions, energy indirect GHG emissions and relevant other energy indirect GHG emissions as defined in the sector-specific standards.

6.2.2 Establishing operational boundaries

The organization shall establish and document its operational boundaries. The establishment of operational boundaries includes identifying GHG emissions associated with the organization's operations, facility or plant, categorizing GHG emissions into direct emissions, energy indirect emissions and other indirect emissions. The sector-specific standards shall define which of the other energy indirect emissions shall be quantified and reported. The organization shall explain any changes to its operational boundaries.

6.2.3 Direct GHG emissions

The organization shall quantify direct GHG emissions from facilities within its organizational boundaries.

Direct GHG emissions can arise from electricity, heat and steam generation carried out within the operational boundary. Direct GHG emissions from electricity, heat and steam generated and exported or distributed by the organization may be reported separately, but shall not be deducted from the organization's or facility's total direct GHG emissions.

NOTE The term "exported" refers to electricity, heat or steam that is supplied by the organization to users outside the organizational boundaries.

Where the generation of electricity, heat or steam solely uses fuel inputs, GHG emissions shall be accounted as direct GHG emissions of the electricity, heat or steam unit. When they solely use energy derived from on-site processes, e.g. waste heat or pressure, the direct GHG emissions shall be accounted as part of direct GHG emissions of the process producing the waste heat or pressure. When they use a combination of fuel inputs and energy derived from on-site process, the direct GHG emissions shall be pro-rated accordingly.

CO₂ emissions from the combustion of biomass shall be determined but reported separately from the direct GHG emissions.

With respect to the **performance assessment**, the sector-specific standards shall provide the requirements for the quantification and reporting of direct GHG emissions from the various types of electricity, steam or heat generation to ensure consistent and transparent performance comparisons. The sector-specific standards shall specify how to account for and assign direct GHG emissions from electricity, heat or steam which is exported or distributed.

6.2.4 Energy indirect GHG emissions

The organization shall quantify indirect GHG emissions from the generation of imported electricity, heat or steam consumed by the organization.

NOTE The term "imported" refers to electricity, heat or steam that is supplied from outside the organizational boundaries.

6.2.5 Other indirect greenhouse emissions

The organization shall quantify other indirect GHG emissions according to the requirements of the relevant sector-specific standard.

Total absolute emissions shall be reported as the direct GHG emissions and energy indirect emissions only. In respect of the **performance assessment**, direct GHG emissions, energy indirect emissions and, where required by the sector-specific standards, other indirect GHG emissions shall be quantified and reported to ensure consistent and transparent comparisons.

NOTE Examples of organizational activities that might result in other indirect emissions are included in EN ISO 14064-1.

6.2.6 GHG from electricity use and on-site power production

Within the **emissions inventory** GHG emissions from electricity imported within the system boundaries (externally purchased power) are accounted as indirect emissions. In accordance with requirements of the WRI / WBCSD Protocol (Chapter 4 and Appendix A) [11], emissions associated with the consumption of electricity during (off-site) transport and distribution (T&D losses) shall not be included in this calculation.

With respect to power generation within the boundaries of the reporting entity this standard distinguishes between power generation based on separate on-site power generation (e.g. in a power plant; separate fuels are used) and energy recovery (e.g. waste heat or pressure; no additional fuels used) including the combination of (gross is production, net output) both.

Where appropriate the sector-specific standards offer a more detailed description about how to report emissions from power use, on-site power production both by energy recovery and separate on-site power generation (OPG) as well as from power purchase and sales. Principally it should be differentiated between the different power sources (purchase, production on-site) and paths of power usage: use for production processes, consumption of power generation auxiliaries (difference between gross and net power production of the power plant) and power sold externally.

In case of producing power in a separate power plant on-site (i.e. within the system boundaries), the GHG emissions are accounted as direct emission of the power unit.

In the case of power generation from energy recovery originating from the respective process (e.g. cement kiln or blast furnace) any additional fuel used for power generation is accounted to this process and consequently emissions are accounted as direct GHG emissions for power generation.

In case of exporting energy flows across the system boundary the inventory should include the latter ones as well as – in case of power – indirect emissions deriving from them.

With respect to **performance assessment** in the sector-specific standards shall be laid down if and how absolute or product specific values or key performance indicators shall recognize any benefits e.g. from internal use or external delivery of heat or power generated on-site in order to allow a fair and transparent comparison of plants.

7 Performance assessment (principle)

Performance assessment has to provide a consistent and transparent framework allowing comparison of operations or evaluation of progress over time. For these reasons, the performance assessment is process-based and can be independent from organizational boundaries.

Sector-specific standards describe the methodology and KPI(s) used to carry out the performance assessment. As a general principle, performance will be assessed by means of KPI(s) expressed in GHG emissions per unit of reference product. However, such KPI(s) may be supplemented by others in order to give a broader view on performance.

8 General requirements for identifying, calculating and reporting of GHG emissions

8.1 Identification, calculation and reporting of GHG emissions

- a) Each operator shall identify and calculate GHG emissions, based on a monitoring plan taking into account the nature and functioning of the installation to which it applies.
- b) The monitoring plan shall be supplemented by written procedures, which the operator establishes, documents, implements and maintains for activities under the monitoring plan, as appropriate.
- c) The operator shall prepare an emission report for the relevant period.
- d) All records needed for the purpose of this standard shall be filed, kept and maintained to ensure traceability of the data and allow verification. A documented procedure shall be established to define the controls needed for the identification, storage, protection, retrieval, retention and disposition of records. Records shall remain legible, readily identifiable and retrievable.

8.2 Content of the monitoring plan

An operator shall develop a monitoring plan, i.e. GHG determination and reporting plan based on the standard for the sector-specific type of installation.

The monitoring plan shall consist of a detailed, complete and transparent documentation of the monitoring methodology of a specific installation and shall contain at least the elements laid down in Annex A and any other requirements laid down in the sector-specific standards.

Together with the monitoring plan, the operator shall comprise the following supporting documents:

- a) evidence for each source stream and emission source demonstrating compliance with the uncertainty thresholds for activity data and calculation factors, where applicable, as defined in sector-specific standards;
- b) the results of an assessment of quality and completeness of the achieved data.

9 Determination of GHG emissions: general requirements

9.1 General

GHG can be determined by direct measurement, mass balance techniques or mixtures of the two. The choice of appropriate methodology should be guided by the requirement to obtain accurate results with acceptable measurement uncertainties at reasonable costs.

The determination of GHG may be achieved by direct measurement using permanently installed analysers. This method is particularly useful in those instances where mass balance techniques are inappropriate e.g. for N₂O emissions. However, for sites using fuels and raw materials which display little compositional variation a mass balance based approach may be the most appropriate option both in terms of cost and measurement uncertainty. More information is given in the sector-specific standards.

9.2 Mass balanced based method

The carbon mass balance is a method for determining CO₂ emissions by balancing all carbon containing materials entering and leaving a system. Therefore, the carbon mass flow of the input streams has to be compared with the carbon mass flow of the output streams. The difference of both is the carbon loss in form of CO₂. Using mass-balance-based methodologies emissions from source streams are determined based on input or production data obtained by means of measurement systems and additional parameters from laboratory analyses (calorific factor, carbon content, biomass content, etc.) and/or standard factors.

For the determination of GHG emissions from materials, products and fuels, in principle the following data are needed:

- mass or volume flows (activity data);
- emission factors;
- calorific values (for fuels); and
- oxidation or conversion factors.

Activity data represents information on consumption of fuel, input material or production output expressed as energy [GJ] or as mass or volume [t or m_n^3] in the case of fuels and mass or volume in the case of raw materials or products [t or m_n^3] in a given reporting period, e.g. one year. The determination

of activity data by the operator may either be based on their measurement or calculation before or behind the process or based on a material balance of fuel or material:

$$\text{Material C} = \text{Material P} + (\text{Material S} - \text{Material E}) - \text{Material O}$$

where

Material C is material consumed during the reporting period;

Material P is material procured during the reporting period;

Material S is material stock at the beginning of the reporting period;

Material E is material stock at the end of the reporting period;

Material O is material used for other purposes (transportation or re-sold).

Emission factors are expressed as tCO₂e/GJ (combustion emissions), or tCO₂e/t or tCO₂e/m_N³ (process emissions). For the use of reference emission factors please refer to Chapter 12. For the conversion of carbon into the respective value for CO₂ the factor of 3,664 [tCO₂/t C] shall be used. Emission factors are usually determined by laboratory analyses.

Biomass is considered as CO₂ neutral. An emission factor of 0 [tCO₂e/GJ] or tCO₂e/t or tCO₂e/ m_N³] shall be applied to biomass (see also Chapter 13).

Lower heat values of fuels are usually expressed as GJ/t or GJ/m³. It is important to note that the applied calorific value always has to match the status of the fuel, especially with respect to the correct moisture content during its weighing (e.g. raw coal or dried coal). Lower heat values are usually determined by lab analyses.

An **oxidation factor** for combustion emissions or a **conversion factor** for process emissions shall be used to reflect the proportion of carbon, which is not oxidized or converted in the process. Oxidation factors are usually determined by laboratory analyses.

After discovering all relevant emission sources the amounts of fuels and materials and their corresponding parameters from the basis to calculate the GHG emissions of each source stream.

The **fuel emissions** are calculated according to the following formula:

$$\text{Emissions} = \text{fuel}_{\text{consumed}} \times \text{LHV} \times \text{EF} \times \text{OF} \quad (1)$$

where

Emissions total annual GHG emissions of the regarding fuel in t CO₂e /year;

fuel_{consumed} amount of fuel consumed in t/year;

LHV lower heat value in GJ/t;

EF emission factor in t CO₂e /t;

OF oxidation factor (dimensionless); an oxidation factor of 1 means complete oxidation.

Process or material specific emissions are to be calculated as follows:

$$Emissions = material_{consumed} \times EF \times CF \quad (2)$$

where

Emissions are the total annual GHG emissions of the regarding material in t CO₂e /year

material_{consumed} is the amount of material consumed in t/year

EF is the emission factor in t CO₂e /GJ

CF is the conversion factor (dimensionless); a conversion factor of 1 means complete conversion.

Where these general methods cannot be applied, the most appropriate method is described in the sector-specific part of the standard.

As a first step, all relevant input and output fuel and material mass flows of the plant have to be identified. If not available already, for that purpose a flow chart of the plant and/or relevant processes should be developed according to the system boundaries. The next step is to determine the amount of these mass flows on a yearly basis. These data are usually available in an organization's data system, based on measurements and/or supplier invoices. Therefore, also the places of scales, meters and other devices for the quantitative determination of each mass flow should be plotted in a flow chart. A low uncertainty level should be reached in the determination of activity data (see Chapter 11 for the requirements according uncertainties).

Besides the yearly amount of all relevant mass flows, additional information on several flow parameters is needed for the assessment of GHG emissions. Depending on the type of mass flow, the following parameters (see Table 1) have to be determined.

Table 1 — Type of mass flow and required parameters (examples)

	Type of mass flows	Required parameter	Measuring unit
GHG from combustion of fuels	Conventional fossil fuels	Lower heat value (LHV)	GJ/t
		Emission factor (EF)	t CO ₂ /GJ
		Oxidation factor (<i>if relevant</i>)	mass fraction
		Carbon content (<i>in case of a mass balance</i>)	t C/t
	Alternative fossil fuels and mixed fuels	Lower heat value (LHV)	GJ/t
		Emission factor (EF)	t CO ₂ /GJ
		Biomass fraction	mass fraction
		Oxidation factor (<i>if relevant</i>)	mass fraction
		Carbon content (<i>in case of a mass balance</i>)	t C/t
	Biomass fuels	Lower heat value (LHV)	GJ/t
		Emission factor (EF)	t CO ₂ /GJ
		Oxidation factor (<i>if relevant</i>)	mass fraction
Carbon content (<i>in case of a mass balance</i>)		t C/t	
GHG from processes	Raw materials containing carbonates	Content of relevant carbonates (e.g. CaCO ₃ , MgCO ₃) or CO ₂ content (EF)	mass fractions or t CO ₂ /t
		Conversion factor	mass fraction
	Raw materials containing organic carbon	Total organic carbon (TOC) content	mass fraction
	Output materials containing oxides from carbonate sources	Content of relevant oxides (e.g. CaO, MgO)	mass fraction
		Conversion factor	mass fraction
	Materials causing other GHG emissions (e.g. CH ₄ , N ₂ O)	Emission factor (EF)	t CO ₂ e/t
		Conversion factor	mass fraction

The parameters may be determined in different ways, by:

- a) laboratory analyses of material samples or
- b) using reference factors on regional, national or international (IPCC) level.

It is preferable to determine the fuel and material parameters by analysis if this may be done by an accredited laboratory or own or another competent laboratory.

9.3 Stack emission measurement based method

9.3.1 Direct measurement of greenhouse gases

Where GHG are measured directly by permanently installed automatic measuring systems, those instruments shall meet the requirements of EN 14181.

NOTE These are called AMS (Automatic Measuring Systems) in EN 14181 and EN 15267-1 to 15267-3 and other environmental protection monitoring standards developed under CEN TC 264, and that terminology will be used here. They are, however, called CEMS in MRR Regulation 601/2012 [9].

Presently such monitors are commercially available for the 3 most important components, CO₂, CH₄ and N₂O. Each operator may choose to measure, to calculate the concentration of one or more GHG as its own discretion, and to measure, or to calculate total volumetric flow. High attention shall be paid on consistency of the concentration and flow monitors as well as validation of the monitors.

9.3.2 Flow measurement

The chosen flow monitor shall fulfil the requirements in EN ISO 16911-1 and EN ISO 16911-2 and be certified according to EN 15267-1 to EN 15267-3, and the test certificate shall quote the achieved uncertainties during field test as standard deviation at lower point, zero if possible and span point.

These figures shall be used for calculation of total uncertainty, see below under 9.3.7.

9.3.3 Gas concentration measurement

The chosen gas monitor shall be tested and certified according to EN 15267-1 to EN 15267-3, and the test certificate shall quote the achieved uncertainties during field test as standard deviation at zero and span point.

The primary GHG components are CO₂, CH₄ and N₂O, and there are commercially available instruments to fulfil the task required under this standard with sufficient monitoring quality and certified by test in an accredited test house.

9.3.4 Installation of instruments

Flow monitors shall be installed according to the guideline in EN ISO 16911-2.

Gas concentration monitors shall be installed in accordance with EN 15259, and working platforms for maintenance, control and calibration of AMS shall be in accordance with EN 15259.

9.3.5 Calibration and quality assurance of AMS

The quality assurance (QA) of the installed AMS shall follow EN 14181.

Before installation of an instrument or combination of instruments, the expected uncertainty of the final installation shall be calculated in accordance with EN 14181 and EN ISO 14956 with information quoted from the EN 15267-3 test certificate of the AMS in question. This is in EN 14181 called "Quality assurance level 1" (QAL1), and it is a tool for the operator to secure that the intended installation will fulfil the required uncertainty limits.

The monitor or monitor combination shall be calibrated according to EN 14181 "quality assurance level 2" (QAL2) after initial installation and repeated every 5 years. The AMS shall be tested each year by an "annual surveillance test" (AST) according to EN 14181.

The valid calibration range is defined from 10 % below the lowest calibration point measured by the AMS during the QAL2 procedure to 10 % above the highest calibration point measured by the AMS during the QAL2 procedure.

The valid calibration range may be extended if an AST measurement is laying above the highest calibration point or below the lowest calibration point, with the 10 % margin calculated from these AST-points.

The deviation from EN 14181 on this point is needed to maintain the very tight uncertainty limits given in the EU Regulation 601/2012 [9] and calculated as described below in Annex E. EN 14181 is developed to manage pollutant measurements at very low concentrations and the assumption of a constant uncertainty band independent of concentration is justified in that process, but this standard shall ensure correct low uncertainty for all emissions, independent of the concentration. Therefore, a more strict regulation is required.

With an interval as stated in the test certificate according to EN 15267-3, called the “maintenance interval” the instrument shall be tested for its compliance with the accuracy expectations, called the “quality assurance level 3” (QAL3). Examples for calibration of flow volume and of a CO₂ calibration are found in Annex E, Figures E.1 and E.2.

9.3.6 Performance criteria of stack measurement equipment

An instrument used for monitoring GHG concentrations and volumetric flow shall as a minimum fulfil the test criteria in EN 15267-3.

In order to interpret the data in EN 15267-3 and EN 14181 an emission limit value ELV and given uncertainty, expressed as single sided 95 % confidence interval, shall be assumed, since there are no emission limit stipulated. Where such quality assurance requires emission limit values (ELVs) as necessary parameters for the basis of calibration and performance checks, the annual average hourly concentration of the GHG shall be used as a substitute for such ELVs.

An instrument used for compliance to this standard for monitoring CO₂ shall have a minimum certification range of 20 vol.% and maximum uncertainty of 5 % expressed for calibration purposes as 95 % confidence interval. Since certification range is a ½-hour average, the AMS shall be able to measure instantaneous values at least 2 x the certification range.

The minimum certification range and maximum uncertainty for CO-monitors and other GHG shall follow the limits stated in the relevant directive or local rules. The ability to measure instantaneous values shall follow the rules of EN 15267-3:2007, 5.2.1.b. If no such guidelines are available in relevant directives, EU decisions or local rules, best available technology shall be applied.

9.3.7 Expectable uncertainty

The monitor used shall be tested by an independent and accredited test house according to EN 15267-3, fulfilling the performance requirements stated below in the chapter, and the manufacturer shall fulfil the QA-requirements of EN 15267-1, EN 15267-2 and EN 15267-3.

The uncertainty as expressed in EN 14181 is understood as the single sided 95 % confidence interval for each individual ½-hours value in percentage of the measured value, including the random uncertainty contribution from the Standard Reference Method used for calibration.

10 General requirements for sampling, analyses and laboratory competency

10.1 Sampling and analyses: reference to standards or guidelines, methods, frequencies

Where calculation factors are determined by analyses, the operator shall establish a sampling plan for each carbon containing mass flows (source streams). This sampling plan shall give information on the methods used for the preparation, storage and transport of the samples, including information on responsibilities, locations, frequencies and quantities.

The operator shall ensure that the samples are representative for the relevant batch or delivery period and free of bias. To this purpose, the sampling methods shall be based on suitable EN, ISO or national

standards. Where such standards are not available, the methods shall be based on suitable draft standards or on industry best practice, limiting sampling and measurement bias.

The sampling frequency shall be such that it limits the uncertainty to acceptable levels. Special attention shall be paid to carbon containing mass flows with a high level of heterogeneity.

The sector-specific standards give specific instructions about the sampling of the main carbon containing mass flows of the sectors as well as indicative sampling rates.

The procedures applied for analyses of relevant data shall, where available, be according to a standardized method that limits measurement bias and has a known analysis uncertainty. European Standards shall be used if available. If European Standards are not available, suitable International Standards or national standards shall apply. Where no applicable standards exist, procedures may be carried out where possible in accordance with suitable draft standards or industry best practice guidelines. For applicable standards and guideline this standard refers to <http://www.ghgprotocol.org/calculation-tools/all-tools>. The sector-specific standards give more detailed guidance where required.

10.2 Competence of laboratories (certification, accreditation, experience)

The operator should ensure that - with respect to quality management and technical competence requirements - laboratories carrying out analyses should be certified in accordance with EN ISO 9001 [3] as a minimum requirement. Especially if external laboratories are performing measurements, that they should be accredited according to EN ISO/IEC 17025 [5] for the relevant analytical methods. With respect to technical competence, the operator shall provide evidence that the laboratory is competent and able to generate technically valid results using the relevant analytical procedures.

Such evidence shall cover at least the following elements:

- a) management of the personnel's competence for the specific tasks assigned;
- b) suitability of accommodation and environmental conditions;
- c) selection of analytical methods and relevant standards;
- d) where applicable, management of sampling and sample preparation, including control of sample integrity;
- e) where applicable, development and validation of new analytical methods or application of methods not covered by international or national standards;
- f) uncertainty estimation;
- g) management of equipment, including procedures for calibration, adjustment, maintenance and repair of equipment, and record keeping thereof;
- h) management and control of data, documents and software;
- i) management of calibration items and reference materials;
- j) quality assurance for calibration and test results, including regular participation in proficiency testing schemes, applying analytical methods to certified reference materials, or inter-comparison with an accredited laboratory;
- k) management of outsourced processes;
- l) management of assignments, customer complaints, and ensuring timely corrective action.

11 General information for the assessment of uncertainties

The Guide to the Expression of Uncertainty in Measurement (GUM) [7] is primarily concerned with the expression of uncertainty in the measurement of a well-defined physical quantity – the measurand – that may be characterized by an essentially unique value. The GUM provides general rules for evaluating and expressing uncertainty in measurement rather than detailed, technology-specific instructions. Furthermore, it does not discuss how the uncertainty of a particular measurement result, once evaluated, may be used for different purposes.

EN ISO 20988 [6] provides a comprehensive guidance and specific statistical procedures for uncertainty estimation in air quality measurement. It applies the general recommendations of the GUM to boundary conditions met in air quality measurement. The boundary conditions considered include measurands varying rapidly in time, as well as the presence of bias in a series of observations obtained under conditions of intended use of methods of air quality measurement. See (normative) Annex E for example calculations of the uncertainty of stack measurements.

Where standards for measurement of specific materials, energy consumption or any other emissions include the analysis of uncertainty such requirements shall be applied.

Explanations and exclusions applying to the above mentioned standards and the GUM are made in the sector-specific standards Part 2 to Part 6. These standards deal with the problems peculiar to specific fields of measurement or with the various uses of quantitative expressions of uncertainty.

12 Reference factors

12.1 Global Warming Potential (GWP) factors

The emissions of each GHG shall be calculated separately and then converted to CO₂ equivalents (CO₂e) on the basis of their global warming potential (GWP). The GWP for each GHG may be taken from the latest GWP (100 year) factors published by the Intergovernmental Panel on Climate Change (IPCC). A record shall be maintained of the reference factors and their source in the supporting evidence.

12.2 Process emission factors

Where required, process emission factors will be provided in the sector-specific standards.

12.3 Electricity emission factors

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), (see www.ghgprotocol.org/standard/tools.htm for the latest update).

A record shall be maintained of the reference factors and their source in the supporting evidence.

12.4 Fuel emission factors

Where a facility has total absolute emissions $\geq 50,000$ tonnes of CO₂e per annum, the operator shall determine fuel emission factors by sampling and analysing each fuel according to the relevant European Standards at a frequency defined in the sector-specific standards. Where a relevant European Standard is not available, the operator shall use an International Standard. If a relevant International Standard is not available, an appropriate national standard may be used. The operator may use fuel factors provided by the fuel supplier as long as the fuel is sampled and analysed in accordance with the requirements of this standard and the relevant sector-specific standard. If analysed data are available they should be used.

Fuel reference factors may be used:

- where a facility has total absolute emissions < 50,000 t of CO₂e per annum; or
- where a facility has total absolute emissions ≥ 50,000 t of CO₂e per annum but the GHG emissions from the particular fuel are ≤ 1,000 t of CO₂e per annum; or
- where the operator may demonstrate that it is not technically or economically feasible to sample or analyse the fuel;
- for traditional fuels (e.g. heavy or light fuel oil).

Under these circumstances, the operator shall use fossil fuel reference factors from recognized national sources such as the latest National Greenhouse Gas Inventory as submitted to the United Nations Framework Convention on Climate Change (UNFCCC) by the country in which the facility is located. Where national data is not available, the operator shall use the latest emission factor published by the IPCC or the World Business Council for Sustainable Development/World Resources Institute (WBCSD/WRI – [11]).

A record of the reference factors and their source shall be maintained in the supporting evidence, along with a justification of why it is not technically or economically feasible to sample and analyse a fuel where appropriate.

Where the emission factor is in the format, for example, kgCO₂/TJ, it shall be multiplied by the relevant calorific value factor for the fuel. The operator shall take care to use factors with the appropriate units. The operator shall ensure that an emission factor based on gross calorific value (GCV) (also called higher heat value (HHV)) is only used in conjunction with a gross calorific value factor and an emission factor based on net calorific value (NCV) (also known as lower heat value (LHV)) is only used in conjunction with a net calorific value factor.

12.5 Biomass fuel emission factors

The materials listed in Annex B are considered as 100 percent biomass fuels and by definition have an emission factor of zero. It is the operator's duty to show evidence on the biomass status if necessary.

GHG emissions from biomass fuels may be reported separately. Biomass emission factors for determination of the memo item may be measured in accordance with 12.4 or use reference factors from recognized national sources such as the latest National Greenhouse Gas Inventory as submitted to the United Nations Framework Convention on Climate Change (UNFCCC) for the Member State, the World Business Council for Sustainable Development (WBCSD) or the IPCC default emission factor of 110 kg CO₂/GJ for solid biomass may be used. This value lies in the range of different values for solid biofuels, which are specified as default emission factors in IPC C 2006 (Vol. II, Section 1.4.2.1).

A record shall be maintained of the reference factors and their source in the supporting evidence.

12.6 Mixed biomass containing fuel emission factors

The biomass fractions of mixed materials should be expressed as biogenic carbon related to total carbon. It may be considered as 100 % biomass and by definition that fraction of the mixed fuel has an emission factor of zero.

As most mixed fuels vary significantly in their composition over time and region the emission factors for the fossil fuel fraction of mixed biomass containing fuels shall be determined according to Chapter 13.

Fuel reference factors may only be used for fuels which – due to their production process and specifications – have a specific or characteristic composition (e.g. waste tires). For these fuels the operator shall use the relevant factors from recognized sources, such as the latest National Greenhouse Gas Inventory as submitted to the United Nations Framework Convention on Climate Change (UNFCCC)

for the Member State, the World Business Council for Sustainable Development (WBCSD) or the latest emission factor published by the IPCC.

The GHG emissions from the biomass fraction of mixed biomass fuels may be reported as a memo item. The biomass emission factors shall be determined in accordance with 12.5.

A record shall be maintained of the reference factors and their source in the supporting evidence.

13 Consideration of biomass

13.1 General

Alternative fuels or process input materials often contain a fraction of or exclusively consist of biomass. Because biomass takes part in the short carbon cycle, its direct CO₂ emissions from combustion are considered as climate neutral in this standard. That means the amount of emitted CO₂ correlates with the amount of accumulated CO₂ during the generation period before. The CO₂ emissions of those fractions shall be determined and reported separately.

When using, or switching to, biomass as a replacement for fossil energy or process feedstock, the operator should undertake the following considerations as a basis for decisions and GHG accounting, including reporting:

- the effect of the substitutes on the total GHG emission;
- the effect of the substitutes on the energy efficiency of the total process or process step;
- emission factors, including CO₂, N₂O and CH₄, for the biomass considered for replacement.

13.2 Reference to standards

The following standards provide additional requirements and assistance for consideration, analysing and reporting of biomass sources:

- EN 15440, *Solid recovered fuels – Methods for the determination of biomass content*;
- EN ISO 13833, *Stationary source emissions – Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide – Radiocarbon sampling and determination (ISO 13833)*;
- EN ISO 14064-1, *Greenhouse gases – Part 1: Specification with guidance at the organisational level for quantification and reporting of greenhouse gas emissions and removals*.

Further guidance on determination and calculation of emissions from biomass is given in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Suitable complementary national standards may be used.

13.3 Biomass

Biomass is described as organic matter consisting of, or recently derived from living organisms (especially regarded as fuel) excluding peat, xyloid lignite (fossil wood) and fossil fractions of mixed fuels and materials; includes products, by-products and waste derived from such material.

Alternative fuels (AF) serve as a substitute for conventional fossil fuels. They include fossil fuel-based fractions, such as, waste oil and plastics, and biomass fractions, such as waste wood and sewage sludge.

IPC C 1996 and 2006 guidelines for national GHG inventories require the following:

- CO₂ from biomass fuels is considered climate-neutral, because emissions can be compensated by re-growth of biomass in the short term. CO₂ from biomass fuels is reported separately,

- CO₂ from fossil fuel-derived wastes (also called alternative fossil fuels or fossil alternative fuels), in contrast, is not a priori climate-neutral. According to IPCC guidelines, GHG emissions from industrial waste-to-energy conversion are reported in the "energy" source category of national inventories, while GHG emissions from conventional waste disposal (landfilling, incineration) are reported in the "waste management" category,
- CO₂ from mixed fuels with biomass and fossil fractions: In the case that biofuels are combusted jointly with fossil fuels (e.g. pre-treated industrial and/or domestic wastes), a split between the fossil and non-fossil fraction of the fuel should be established and the emission factors applied to the appropriate fractions (IPC C 2006, Vol. II, Section 2.3.3.4).

To ensure consistency with the guidelines of IPCC (see 13.3), there is thus a need for transparent reporting of the direct CO₂ emissions resulting from AF combustion.

13.4 Reporting of emissions from biomass sources

GHG emissions from biomass fuels or from the biomass fraction of mixed fuels are determined referring to 12.5 and 12.6 and reported separately.

13.5 Analysing methods for biomass fractions

EN 15440 provides three methodologies to analyse the biomass content of solid alternative fuels. Especially for purposes regarding monitoring and reporting of GHG the selective dissolution method (SDM; EN 15440:2011, Annex A) or the ¹⁴C-method (EN 15440:2011, Annex C) may be applied.

The corresponding standards named in EN 15440 should also be taken into account (e.g. EN 15442 [2] and EN 15407 [1]).

For measuring biogenic CO₂ emissions from stationary sources (e.g. combustion gases from stacks), EN ISO 13833 may be applied. The standard also bases on the ¹⁴C-method and contains references to relevant standards in connection with measurements of stationary source emissions (e.g. EN 15259 and EN ISO 16911-1 and EN ISO 16911-2).

14 Verification and/or certification

For the purposes of transparency in reporting CO₂ emissions to stakeholders, the inventory and any associated assertion may be verified in accordance with the requirements identified in Annex C. EN ISO 14064-3 also gives guidance on the verification of GHG emissions and removals.

Annex A (normative)

Minimum content of the monitoring plan

The monitoring plan shall contain at least the following information:

a) general information

- 1) a description of the organization and activities for the scope considered,
- 2) a description of the procedure for managing the assignment of responsibilities,
- 3) a description of the written procedures of the data flow activities,
- 4) a description of the written procedures for the control activities established,
- 5) the version number and date of the monitoring plan.

b) a description of the sector-specific methodologies consisting of the following:

- 1) a detailed description of the mass-balance based methodologies applied,
- 2) where applicable and where the operator intends to make use of simplification for small source streams, a categorization of the source streams referring to the sector-specific standards
- 3) a description of the measurement systems used,
- 4) where applicable, the default values used for calculation factors indicating the source of the factor,
- 5) where applicable, a list of the analysis methods to be used,
- 6) where applicable, a description of the procedure underpinning the sampling plan for the sampling of fuel and materials to be analysed.

c) a description of the measurement-based methodologies for stack emissions, where applied, including the following:

- 1) any calculation formulae used for data aggregation and used to determine the emissions from each emission source as well as the method for determining whether valid hours or shorter reference periods for each parameter may be calculated, and for substitution of missing data,
- 2) a list of all relevant emission points,
- 3) where flue gas flow is derived by calculation, a description of the written procedure for these emission sources,
- 4) a list of all relevant equipment,
- 5) a description of the method, how CO₂ arising from biomass is to be determined and subtracted from the measured CO₂ emissions.

Annex B (informative)

List of biomass materials

Plants and parts of plants are:

- straw;
- hay and grass;
- leaves, wood, roots, stumps, bark;
- crops, e.g. maize and triticale.

The following materials are accounted as biomass wastes, products and residues:

- industrial waste wood (waste wood from woodworking and wood processing operations and waste wood from operations in the wood materials industry);
- used wood (used products made from wood, wood materials) and products and by-products from wood processing operations;
- wood-based waste from the pulp and paper industries, e.g. black liquor (with only biomass carbon);
- crude tall oil, tall oil and pitch oil from the production of pulp;
- lignin from the processing of plants containing lignocellulose;
- forestry residues;
- animal, fish and food meal, fat, oil and tallow;
- primary residues from the food and beverage production;
- plant oils and fats;
- manure;
- agricultural plant residues;
- sewage sludge;
- biogas produced by digestion, fermentation or gasification of biomass;
- harbour sludge and other waterbody sludges and sediments;
- landfill gas;
- charcoal;
- natural rubber or latex.

The biomass fraction of mixed materials are:

- the biomass fraction of flotsam from waterbody management;
- the biomass fraction of mixed residues from food and beverage production;
- the biomass fraction of composites containing wood;
- the biomass fraction of textile wastes;
- the biomass fraction of paper, cardboard, pasteboard;
- the biomass fraction of municipal and industrial waste;
- the biomass fraction of black liquor containing fossil carbon;
- the biomass fraction of processed municipal and industrial wastes;
- the biomass fraction of ethyl-tertiary-butyl-ether (ETBE);
- the biomass fraction of butanol;
- the biomass fraction of waste tyres resulting from natural rubber and fibres.

Fuels whose components and intermediate products have all been produced from biomass are:

- bioethanol;
- biodiesel;
- etherized bioethanol;
- biomethanol;
- biodimethylether;
- bio-oil (a pyrolysis oil fuel) and bio-gas;
- hydro-treated vegetable oil (HVO).

Annex C
(normative)

Requirements for assurance of GHG data

Item	Requirement
Assurance Level	Assurance shall be, at least, a limited assurance done at organization's level.
Assurer Reputation	The assurer shall be a recognized, independent third party assurance practitioner.
Scope of Assured Data	Assurance shall include all agreed KPIs according to the relevant sector-specific standards.
Frequency of Assurance	Assurance shall be carried out at least once every two years at organization level, assuring data from both years separately.
Coverage of Sites	Assurers shall decide the number and location of sites to be visited in order to check the accuracy and quality from representative source data.
Sampling Plan	Plants assured under other schemes (e.g. EU ETS, CDM) shall be counted as samples for GHG assurance, in order to avoid double verification.
Assurance Standard	Assurance should be conducted following specifications from this standard and the corresponding sector-specific parts of this standard and from ISA E 3410 [13], EN ISO 14064-3 [4] or a similar standard.
Materiality Threshold	The reported inventory total data can be accepted as valid for use if error(s) identified in the individual inventory KPIs - in aggregate - is less than or equal to $\pm 5\%$ of the inventory total declared by the reporting entity.
Assurance Statement	The assurer shall provide to the organization a written assurance statement summarizing the conclusions about the GHG inventory KPIs. The statement shall include information on the basis and scope of the assurance work conducted including explicit reference to the use of the EN 19694-1 to EN 19694-6, and to the number of locations visited and the corresponding % of GHG emissions covered by the visits.

Annex D
(normative)

Values of $k_v(N)$ and $t_{0,95(N-1)}$

Table D.1 — Values of $k_v(N)$ and $t_{0,95(N-1)}$

Number of parallel measurements, N	$k_v(N)$	$t_{0,95(N-1)}$
3	0,832 6	2,92
4	0,888 1	2,353
5	0,916 1	2,132
6	0,932 9	2,015
7	0,944 1	1,943
8	0,952 1	1,895
9	0,958 1	1,86
10	0,962 9	1,833
11	0,966 5	1,812
12	0,969 5	1,796
13	0,972 1	1,782
14	0,974 2	1,771
15	0,976 1	1,761
16	0,977 7	1,753
17	0,979 1	1,746
18	0,980 3	1,74
19	0,981 4	1,734
20	0,982 4	1,729
25	0,986 1	1,711
30	0,988 5	1,701

Source: EN ISO 16911-1:2013, Annex E.

Annex E (normative)

Uncertainty calculation for yearly output determined from stack measurements

E.1 Sources of errors

There are two sources of error when estimating the total amount of GHG as an annual emission from each of the two parameters, being volumetric flow rate and GHG-concentration:

- a) The random error from the up to 8760 1-hour measurements. This is an error originating from influence parameters, not under control by the monitoring system, which is assumed Gaussian distributed around the average reading.
- b) The error from the calibration, established at the last QAL2-procedure. This is an (unknown) systematic error of each 1-hour measurement originating from the fact, that it is only known with a certain probability where the calibration function (calibration line) is positioned.

E.2 Calculation of annual output

E.2.1 Using directly measured values

The annual output is calculated using the use volumetric flow and GHG concentration in operation condition, this way no other uncertainties are involved:

$$T_{annual\ total} = \sum_1^n T_i = \sum_1^n V_i \cdot C_i \quad (E.1)$$

where

T_i is the 1-hour emitted mass flow;

V_i is the 1-hour volumetric flow reading in operating condition;

C_i is the 1-hour GHG concentration reading in operating condition;

n is the number of 1-hour readings obtained in any single calendar year.

E.2.2 Using normalized values

If v_i or c_i or both are in normalized condition, the uncertainty contribution from temperature, pressure, humidity and oxygen measurements shall be added.

It is therefore recommended to use the mentioned parameters in operation condition.

If concentration is measured in standardized or semi-standardized condition, e.g. by an extractive gas analysis method, the uncertainty contribution from measurement of temperature and pressure for calculating the concentration back to operation condition (as the volumetric flow is measured), shall be added, using the method described below.

E.2.3 Propagation of random errors

An EU guideline to calculate the propagation of error is found in [11]. When the distribution of error is assumed Gaussian, the total error of a product (or division) of individual factors is expressed as:

$$u_t = \sqrt{\sum_1^n u_i^2} \quad (\text{E.2})$$

where

u_t is the combined relative random error of the result;

u_i is the relative random error of the i^{th} factor/divisor;

n is the number of factors/divisors in the formula.

In the case of the 1-hour mass emission is calculated from the 1-hour average of the volumetric flow in operating condition and the 1-hour average of the GHG concentration in operating condition, the total relative random uncertainty of each 1-hour mass emission contribution is:

$$u_i = \sqrt{u_{ci}^2 + u_{vi}^2} \quad (\text{E.3})$$

where

u_i is the relative uncertainty of the i^{th} 1-hour mass emission;

u_{ci} is the relative uncertainty of the i^{th} 1-hour concentration;

u_{vi} is the relative uncertainty of the i^{th} 1-hour volumetric flow.

The propagation of independent relative errors of summations (of differences) follows this formula:

$$u_t = \frac{\sqrt{\sum_1^n (U_i \cdot X_i)^2}}{\left| \sum_1^n X_i \right|} \quad (\text{E.4})$$

where

u_t is the relative uncertainty of the result of the summation (X_t);

U_i is the relative uncertainty for i^{th} addend, X_i ;

X_i is the i^{th} addend.

Since the annual mass emission is calculated as the summation of up to 8784 1-hour GHG mass emission calculations, the total uncertainty may be calculated using the above formula.

E.2.4 Calculating random uncertainty for CO₂

Since errors from pollutant monitoring according to EN 14181 are assumed constant in the monitoring range and in the time span from one QAL2 to the next QAL2 procedure, the random uncertainty of the annual GHG emission may be expressed as:

$$u_t = \frac{\sqrt{n \cdot \hat{U}^2}}{n \cdot \hat{X}} = \frac{\hat{U}}{\sqrt{n} \cdot \hat{X}} = \frac{\hat{u}}{\sqrt{n}} \quad (\text{E.5})$$

where

- u_t is the total uncertainty contribution for the annual emission;
- \hat{U} is the average random uncertainty of the 1-hour CO₂ emission in engineering units;
- \hat{u} is the average random relative uncertainty of the 1-hour CO₂ emission;
- X is the average of the 1-hour CO₂ emission in engineering units;
- n is the number of 1-hour readings in any calendar year.

As seen, the more 1-hour readings are aggregated in a calendar year, the less importance does the uncertainty of the 1-hour readings play. If a full calendar year is aggregated, consisting of 8760 1-hour readings, the 1-hour relative uncertainty shall be reduced by a factor of 93,6 to reach the uncertainty contribution from the monitoring process. If ½-hour readings are used, the ½-hour relative uncertainty shall be reduced by a factor of 132,4 to reach the uncertainty contribution from the monitoring process.

It may therefore be concluded, that the random error originating from the individual 1-hour or ½-hour reading in most cases may be neglected.

E.2.5 Total uncertainty

The error originating from systematic errors in the monitoring systems are not changed in the process of calculation an annual emission, but are carried on 1:1 to the result.

The systematic error from the monitoring equipment is the uncertainty of the calibration function, the lack of knowledge about where exactly the calibration function lays, see E.1 above.

From the QAL2-calibration according to EN 14181 the expanded uncertainty of a 95 % confidence interval for the calibration line is estimated as:

$$U_{95\%} = 1,96 \cdot s_D \quad (\text{E.6})$$

where

- $U_{95\%}$ is the one-sided 95 % confidence interval of the calibration function;
- s_D is the standard deviation obtained at the last QAL2 calibration according to EN 14181:2014, Formula (11).

$$s_D = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^N (D_i - \bar{D})^2} \quad (\text{E.7})$$

where

- N is the number of paired measurements calibration according to EN 14181:2014, Formula (16);

NOTE It is assumed that the measurements are Gaussian (normal) distributed and consequently the 95 % confidence interval is obtained by multiplying the standard deviation by a factor of 1,96.

For the total uncertainty the uncertainty contribution of the volumetric flow and the uncertainty contribution of the GHG concentration shall be considered. Therefore, the combined relative uncertainty is calculated as independent uncertainty of a product:

$$U_{\text{total}} = \sqrt{U_{95\%,\text{flow}}^2 + U_{95\%,\text{conc}}^2} \quad (\text{E.8})$$

where

U_{total} is the combined relative uncertainty expressed as 95 % confidence interval of the emission of one GHG from an emission source determined by AMS;

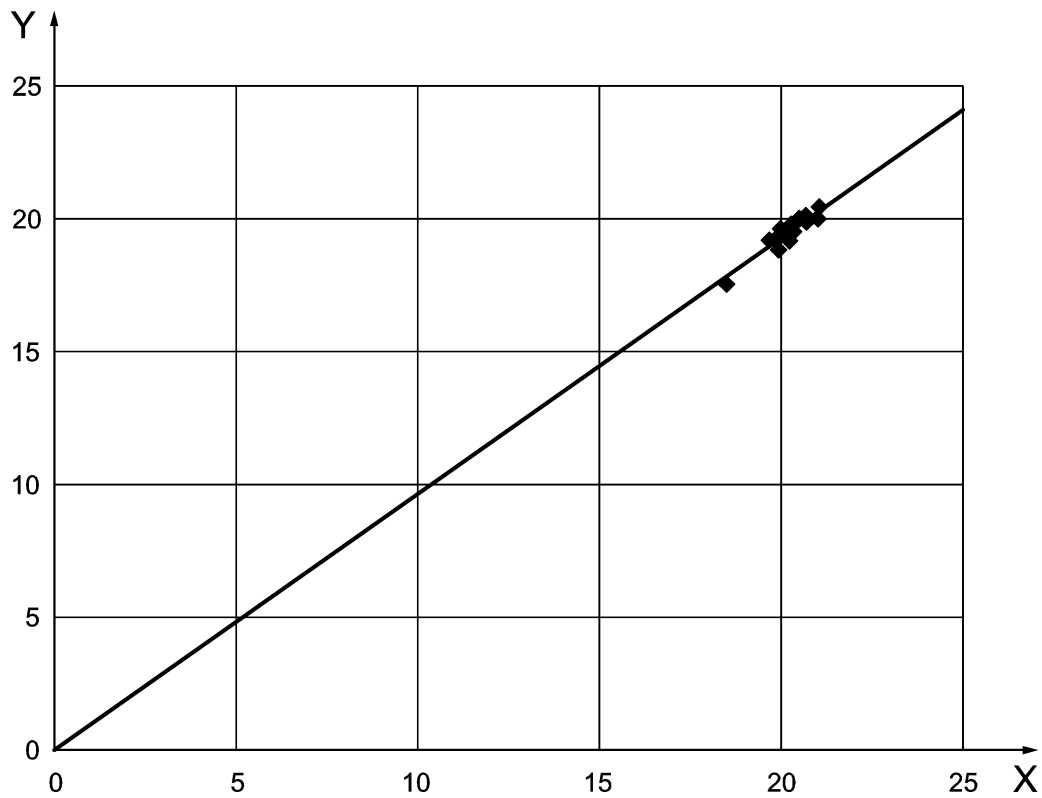
$U_{t95\%,\text{flow}}$ and $U_{t95\%,\text{conc}}$ are the relative expanded uncertainties of volume flow measurement and the concentration measurement.

If a QAL2 procedure is performed during a calendar year, and the uncertainty is changed, the uncertainty calculation shall be performed in 2 steps, covering the time before and after the new QAL2 data are implemented.

If one or both of those two parameters are measured in non-standardized conditions, the uncertainty of these measurements used to standardize shall be added to Formula (E.8).

If a method to measure the fossil share of the total CO₂-emission is implemented, the uncertainty of that shall be added to Formula (E.8).

E.2.6 Example



Key

X AMS [m/s]

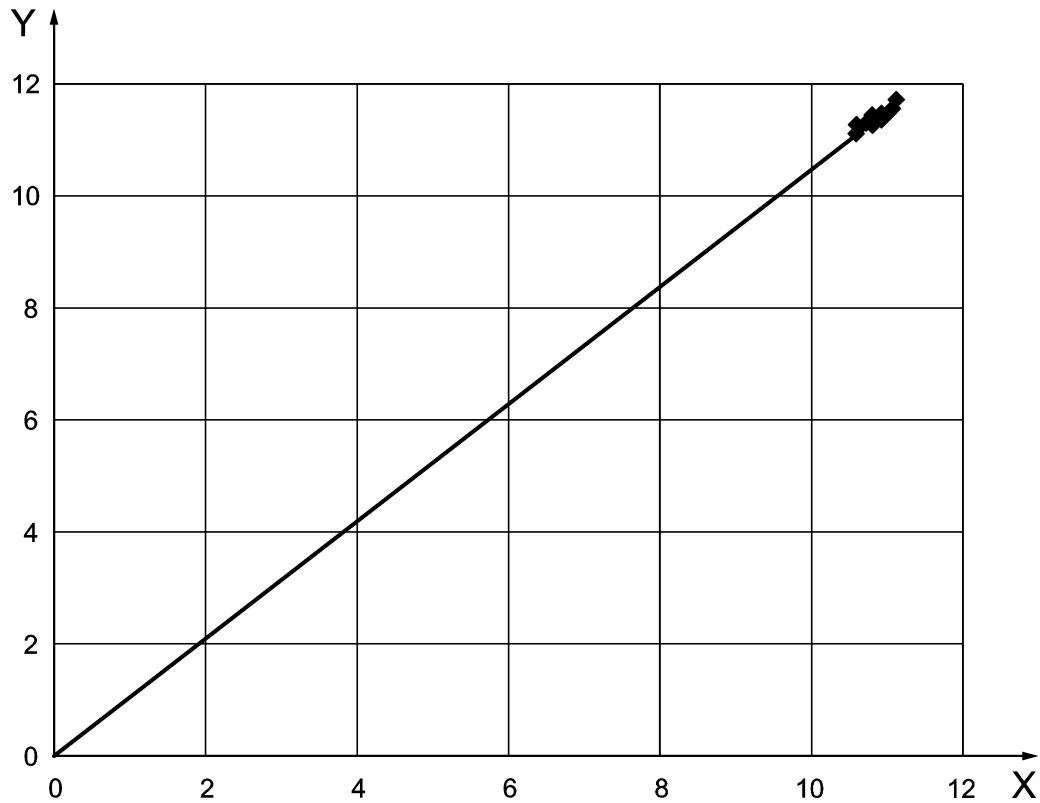
Y SRM [m/s]

$s_D = 0,171$ m/s

Average flow = 19,55 m/s

This gives $U_{95\%,flow} = 0,335$ m/s or 1,714 % of average as 95 % confidence interval

Figure E.1 — Example of a flow calibration



Key

X AMS [volume fraction in %]

Y SRM [volume fraction in %]

$s_D = 0,044\ 3$ vol % CO₂

Average CO₂ = 11,32 %

This gives $U_{95\%,conc} = 0,086\ 8$ vol % CO₂ or 0,767 % of average

Figure E.2 — Example of a CO₂ calibration

The total uncertainty as 95 % confidence interval is according to Formula (E.8).

$$U_{total\ year} = \sqrt{1,714^2 + 0,767^2} = 1,878\ \%$$

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