International Standard

ISO 19870-1

First edition
2026-04

Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the hydrogen supply chain —

Part 1: Emissions associated with the production of hydrogen up to the production gate

Technologies de l'hydrogène — Méthodologie pour déterminer les émissions de gaz à effet de serre associées à la chaîne d'approvisionnement en hydrogène —

Partie 1: Émissions associées à la production d'hydrogène jusqu'au point de production

Reference number
ISO 19870-1:2026(en)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*, Subcommittee SC 1, *Hydrogen at scale and horizontal energy systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/CLC/JTC 6, *Hydrogen in energy systems,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 19870-1 cancels and replaces ISO/TS 19870:2023, which has been technically revised.

A list of all parts in the ISO 19870 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

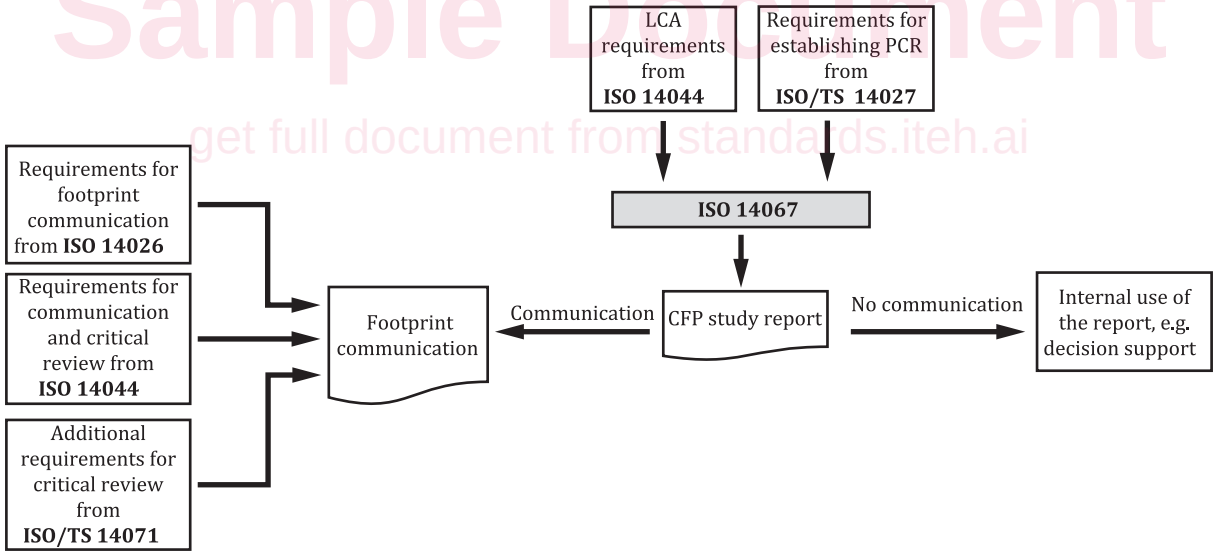
The Paris Agreement was adopted at the UN Climate Change conference (COP21) with the aims of strengthening the global response to the threat of climate change, restricting global temperature rise to below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1,5 °C above pre-industrial levels. To meet these goals, greenhouse gas (GHG) emissions need to be reduced by about 45 % from 2010 levels by 2030, reaching net zero in 2050 (IPCC, 2018; UNFCCC, 2021).

Initiatives on GHG mitigation rely on the quantification, monitoring, reporting and verification of GHG emissions and/or removals. International Standards that support the transfer of scientific knowledge into tools can help in reaching the targets of the Paris Agreement to address climate change.

ISO 14044 defines the requirements and guidelines identified in existing International Standards on life cycle assessment (LCA). The ISO 14060 series provides clarity and consistency for quantifying, monitoring, reporting and validating or verifying GHG emissions and removals to support sustainable development through a low-carbon economy. It also benefits organizations, project proponents and stakeholders worldwide by providing clarity and consistency on quantifying, monitoring, reporting and validating or verifying GHG emissions and removals.

ISO 14067 is based on the requirements and guidelines on LCA identified in ISO 14044 and aims to set specific requirements for the quantification of a carbon footprint (CFP) and a partial CFP. ISO 14067 defines the principles, requirements and guidelines for the quantification of the carbon footprint of products. Its aim is to quantify GHG emissions associated with the lifecycle stages of a product, beginning with resource extraction and raw material sourcing and extending through the production, use and end-of-life stages of the product.

Figure 1 illustrates the relationship between ISO 14067 and other ISO documents on LCA.



Key

PCR Product category rule

Figure 1 — Relationship between standards beyond the GHG management family of standards (source ISO 14067)

Hydrogen can be produced from diverse sources including renewables, nuclear and fossil fuels, with or without carbon capture, utilization and storage (CCUS). Hydrogen can be used to decarbonize numerous sectors.

A particular challenge is that identical hydrogen molecules can be produced and combined from sources that have different GHG intensities. Similarly, hydrogen-based fuels and derivatives will be indistinguishable and can be produced from hydrogen combined with a range of fossil and non-fossil inputs. Indeed, some of

the products made from hydrogen (e.g. electricity) can themselves be used in the production of hydrogen. Accounting standards for different sources of hydrogen along the supply chain (see Figure 2) is important for creating a market for low-carbon hydrogen, and these standards need to be agreed upon internationally. Additionally, there is the possibility that consumption gates are not located in proximity to hydrogen production gates, requiring hydrogen transport. ISO 14083[2] gives guidelines for the quantification and reporting of GHG emissions arising from transport chain operations.

A mutually recognized international framework that is robust, and that avoids miscounting or double counting of environmental impacts is needed. Such a framework will provide a mutually agreed upon approach to “guarantees" or “certificates” of origin, and will cover greenhouse gas inputs used for hydrogen production, conditioning, conversion and transport.

The ISO 19870 series aims at establishing methodologies that should be applied, in line with ISO 14067, to the specific case of the hydrogen supply chain, covering different production processes and other parts of the supply chain, such as conditioning hydrogen in different physical states, conversion of hydrogen into different hydrogen carriers and the subsequent transport up to the consumption gate.

The ISO 19870 series consists of the following parts:

— ISO 19870-1 on emissions associated with the production of hydrogen to production gate;

— ISO 19870-2 on emissions associated with the conditioning and transport of gaseous and liquid hydrogen up to consumption gate;

— ISO 19870-3 on emissions associated with the production, storage and transport of ammonia up to delivery gate and the conversion of ammonia into hydrogen;

— ISO 19870-4 on emissions associated with the storage and transport of hydrogen via LOHC.

This document considers the steps up to the production gate.

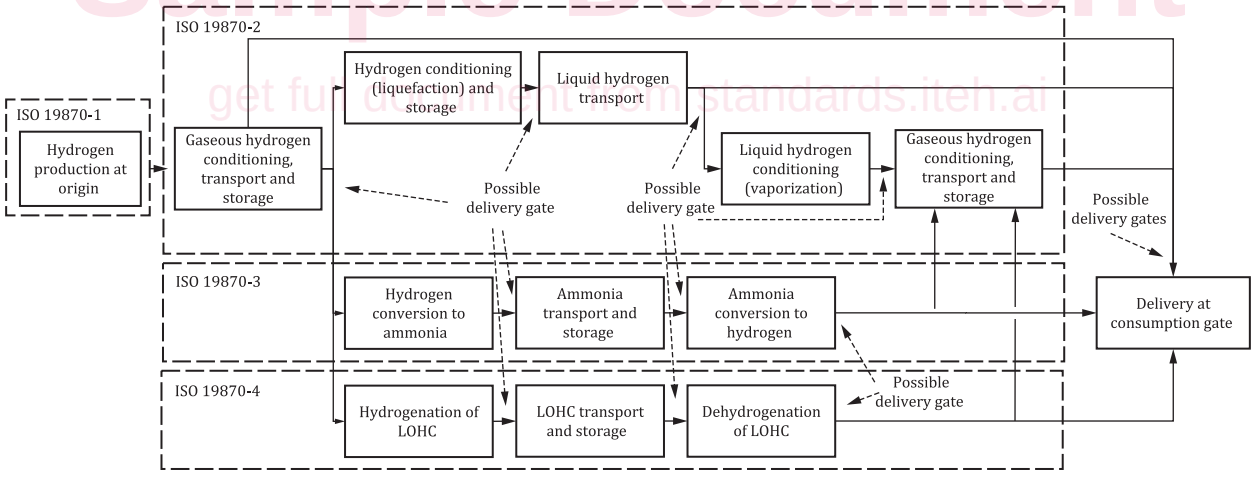


Figure 2 — Examples of the hydrogen supply chain and coverage of ISO 19870 series with the possible delivery gates

Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the hydrogen supply chain —

Part 1: Emissions associated with the production of hydrogen up to the production gate

1 Scope

There are numerous pathways to produce hydrogen. This document specifies a methodology for different hydrogen production pathways for determining the greenhouse gases (GHG) emissions associated with the hydrogen supply chain from the raw material extraction up to the production gate.

This document considers the GHG emissions associated with hydrogen production up to the production gate. This document applies to and includes every step within the production process up to the production gate (see Figure 2 in the Introduction).

NOTE Complementary documents in the ISO 19870 series will consider hydrogen conditioning, conversion and transport methods.

ISO 14044 requires the goal and scope of a life cycle assessment (LCA) be clearly defined and be consistent with the intended application. Due to the iterative nature of LCAs, it is possible that the LCA scope needs to be refined during the study. According to ISO 14040:2006, A.2, the goals and scope of LCAs correspond to one of the following two approaches:

a) an approach that assigns elementary flows and potential environmental impacts to a specific product system, typically as an account of the history of the product (see 4.1.2);

b) an approach that studies the environmental consequences of possible (future) changes between alternative product systems (see 4.1.3).

In this document, approach a) is referred to as an attributional approach, while approach b) is referred to as a consequential approach. Complementary information is accessible in the ILCD handbook[4].

A carbon footprint of a product (CFP) (3.1.2) or partial CFP (3.1.3) as defined by ISO 14067 can be estimated using either the attributional or the consequential approach, the latter corresponding to the use of "system expansion via substitution" to avoid allocation when a unit process yields multiple co-products. This document applies to the CFP for hydrogen production.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14067, *Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification*

ISO 14071, *Environmental management — Life cycle assessment — Critical review processes and reviewer competencies*

3 Terms, definitions and abbreviated terms

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms related to quantification of the carbon footprint of a product

3.1.1
allocation
partitioning the *input* (3.2.7) or *output* (3.2.9) flows of a process or a *product system* (3.2.3) between the product system under study and one or more other product systems

[SOURCE: ISO 14040:2006 and ISO 14040:2006/AMD 1:2020]

3.1.2
carbon footprint of a product
CFP
sum of *greenhouse gas emissions* (3.1.12) and *greenhouse gas removals* (3.1.4) in a *product system* (3.2.3), expressed as CO_2 *equivalent* (3.1.10) and based on a *life cycle assessment* (3.3.5) using the single impact category of climate change

Note 1 to entry: A CFP can be disaggregated into a set of figures identifying specific *GHG emissions* (3.1.12) and *removals* (3.1.4). A CFP can also be disaggregated into the stages of the *life cycle* (3.3.4).

Note 2 to entry: The results of the *quantification of CFP* (3.1.8) are documented in the CFP study report expressed in mass of CO_2e (3.1.10) per *functional unit* (3.2.13).

[SOURCE: ISO 14067:2018, 3.1.1.1]

3.1.3
partial CFP
sum of *greenhouse gas emissions* (3.1.12) and *greenhouse gas removals* (3.1.4) of one or more selected process(es) in a *product system* (3.2.3) expressed as CO_2e (3.1.10) and based on the selected stages or processes within the *life cycle* (3.3.4)

Note 1 to entry: A partial CFP is based on or compiled from data related to (a) specific process(es) or footprint information modules (defined in ISO 14026:2017, 3.1.4), which is (are) part of a *product system* (3.2.3) and can form the basis for quantification of a carbon footprint of a product (CFP). More detailed information on information modules is given in ISO 14025:2006, 5.4.

Note 2 to entry: The results of the quantification of the partial CFP are documented in the CFP study report expressed in mass of CO_2e (3.1.10) per declared unit.

Note 3 to entry: In this document, partial CFP of hydrogen extends from raw material extraction up to the production gate.

3.1.4
greenhouse gas removal
GHG removal
withdrawal of a *greenhouse gas* (3.1.9) from the atmosphere

[SOURCE: ISO 14067:2018, 3.1.2.6]

3.1.5
CFP study
all activities that are necessary to quantify and report the *carbon footprint of a product* (3.1.2) or a *partial CFP* (3.1.3)

[SOURCE: ISO 14067:2018, 3.1.1.4]

3.1.6
product category
group of products that can fulfil equivalent functions

[SOURCE: ISO 14025:2006, 3.12]

3.1.7
production batch
amount of products produced by a device between any two points in time selected by the operator

3.1.8
quantification of CFP
activities that result in the determination of the *carbon footprint of a product* (3.1.2) or a *partial CFP* (3.1.3)

Note 1 to entry: Quantification of the *carbon footprint of a product* (3.1.2) or the *partial CFP* (3.1.3) is part of the *CFP study* (3.1.5)

[SOURCE: ISO 14067:2018, 3.1.1.6]

3.1.9
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: For a list of *greenhouse gases* (3.1.9), see the latest IPCC Assessment Report.

Note 2 to entry: Water vapour and ozone, which are anthropogenic as well as natural *greenhouse gases* (3.1.9), are not included in the *carbon footprint of a product* (3.1.2).

Note 3 to entry: The focus of this document is limited to long-lived GHGs and it therefore excludes climate effects due to changes in surface reflectivity (albedo) and short-lived radiative forcing agents (e.g. black carbon and aerosols).

[SOURCE: ISO 14067:2018, 3.1.2.1]

3.1.10
carbon dioxide equivalent
CO_2 equivalent
CO_2e
unit for comparing the radiative forcing of a *greenhouse gas* (3.1.9) to that of carbon dioxide

Note 1 to entry: Mass of a greenhouse gas is converted into *CO_2 equivalents* by multiplying the mass of the *greenhouse gas* (3.1.9) by the corresponding *global warming potential* (3.1.11) or global temperature change potential (GTP) of that gas.

Note 2 to entry: In the case of GTP, *CO_2 equivalent* is the unit for comparing the change in global mean surface temperature caused by a greenhouse gas to the temperature change caused by carbon dioxide.

[SOURCE: ISO 14067:2018, 3.1.2.2]

3.1.11
global warming potential
GWP
index, based on radiative properties of *greenhouse gases* (3.1.9) (GHG) measuring the radiative forcing following a pulse emission of a unit mass of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide (CO_2)

Note 1 to entry: "Index" as used in this document is a "characterization factor" as defined in ISO 14040:2006, 3.37.

Note 2 to entry: A "pulse emission" is an emission at one point in time.

[SOURCE: ISO 14067:2018, 3.1.2.4]

3.1.12
greenhouse gas emission
GHG emission
release of a *greenhouse gas* (3.1.9) into the atmosphere

[SOURCE: ISO 14067:2018, 3.1.2.5]

3.1.13
greenhouse gas emission factor
GHG emission factor
coefficient relating activity data with the *greenhouse gas emission* (3.1.12)

[SOURCE: ISO 14067:2018, 3.1.2.7]

3.1.14
capital goods emission
CAPEX emission
GHG emissions (3.1.12) related to the manufacturing of capital goods

3.1.15
subdivision
virtual subdivision
decomposition of a unit process into physically or virtually distinguishable sub-process steps with the possibility to collect data exclusively for those sub-processes

3.1.16
hydrogen
gas mainly composed of hydrogen molecules.

Note 1 to entry: A hydrogen molecule is referred to as H_2.

3.1.17
physical relationship
relation between *co-products* (3.2.4) based on a chosen physical characteristic (e.g. mass, energy content, volume)

Note 1 to entry: A physical relationship can be used to:

a) allocate input flows to *co-products* (3.2.4) based on the specific function the inputs perform in relation to the individual *co-products* (3.2.4); and/or,

b) allocate *GHG emissions* (3.1.12) to the individual *co-products* (3.2.4),

3.2 Terms related to products, product systems and processes

3.2.1
product
any goods or service

Note 1 to entry: The product can be categorized as follows:

— services (e.g. transport);

— software (e.g. computer program, dictionary);

— hardware (e.g. engine mechanical part);

— processed materials (e.g. lubricant).

3.2.2
product flow
products (3.2.1) entering from or leaving to another *product system* (3.2.3)

[SOURCE: ISO 14040:2006, 3.27]

3.2.3
product system
collection of unit processes with *elementary flows* (3.2.14) and *product flows* (3.2.2), performing one or more defined functions and which models the *life cycle* (3.3.4) of a *product* (3.2.1)

[SOURCE: ISO 14044:2006, 3.28]

3.2.4
co-product
one of two or more *products* (3.2.1) coming from the same unit process or *product system* (3.2.3) that is not considered *waste* (3.3.15)

[SOURCE: ISO 14040:2006, 3.10, modified — added that a co-product is not considered a waste.]

3.2.5
conditioning
changing the physical conditions (e.g. temperature, pressure) of hydrogen for the purpose of its storage or transport

Note 1 to entry: In this document, examples are changing the pressure of gaseous hydrogen or liquefying gaseous hydrogen.

3.2.6
conversion
changing an input characterized by specific physical and chemical characteristics in an output characterized by different physical and chemical characteristics

Note 1 to entry: If the chemical characteristics are unchanged there is no conversion.

3.2.7
input
product (3.2.1), material or *energy flow* (3.2.15) that enters a unit process

Note 1 to entry: *Products* (3.2.1) and materials include raw materials, *intermediate products* (3.2.8) and *co-products* (3.2.4).

[SOURCE: ISO 14040:2006, 3.21]

3.2.8
intermediate product
output from a unit process that is input to other unit processes that requires further transformation within the system

[SOURCE: ISO 14040:2006, 3.23]

3.2.9
output
product (3.2.1), material or *energy flow* (3.2.15) that leaves a unit *process* (3.2.12)

Note 1 to entry: *Products* (3.2.1) and materials include raw materials, *intermediate products* (3.2.8), *co-products* (3.2.4) and releases (3.4.10).

[SOURCE: ISO 14044:2006, 3.25]

3.2.10
system boundary
boundary based on a set of criteria representing which unit *processes* (3.2.12) are a part of the system under study

[SOURCE: ISO 14040:2006/AMD 1:2020, 3.32]

3.2.11
system expansion
concept of expanding the *product system* (3.2.3) to include additional functions related to the *co-products* (3.2.4)

Note 1 to entry: The *product system* (3.2.3) that is substituted by the *co-product* (3.2.4) is integrated in the *product system* (3.2.3) under study. In practice, the *co-products* (3.2.4) are compared to other substitutable products, and the environmental burdens associated with the substituted product(s) are subtracted from the *product system* (3.2.3) under study. The identification of this substituted system is done in the same way as the identification of the upstream system for *intermediate product* (3.2.8)*inputs* (3.2.7). See also ISO/TR 14049:2012, 6.4

Note 2 to entry: The application of *system expansion* (3.2.11) involves an understanding of the market for the *co-products* (3.2.4). Decisions about *system expansion* (3.2.11) can be improved through understanding the way *co-products* (3.2.4) compete with other products, as well as the effects of any product substitution upon production practices in the industries impacted by the *co-products* (3.2.4).

Note 3 to entry: Can be referred to as *system expansion* (3.2.11) and also as expanding the *system boundary* (3.2.10).

[SOURCE: ISO 14044:2006/AMD 2:2020, D.2.1]

3.2.12
process
set of interrelated or interacting activities that transforms *inputs* (3.2.7) into *outputs* (3.2.9)

[SOURCE: ISO 14044:2006, 3.11]

3.2.13
functional unit
quantified performance of a *product system* (3.2.3) for use as a reference unit

Note 1 to entry: As the carbon footprint of a product treats information on a product basis, an additional calculation based on a declared unit can be presented.

[SOURCE: ISO 14040:2006, 3.20]

3.2.14
elementary flow
material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation

[SOURCE: ISO 14044:2006, 3.12]

3.2.15
energy flow
input (3.2.7) to or *output* (3.2.9) from a unit process or *product system* (3.2.3), quantified in energy units

Note 1 to entry: Energy flow that is an input can be called an energy input; energy flow that is an output can be called an energy output.

[SOURCE: ISO 14040:2006, 3.13]

3.2.16
feedstock
any material input to the hydrogen plant that is not generated at the hydrogen plant itself

Note 1 to entry: A non-exhaustive list can include:

— natural gas (e.g. for steam methane reforming);

— biomethane/renewable natural gas (e.g. for steam methane reforming);

Note 2 to entry: In many European countries, methane sourced from the degradation of biomass under anaerobic conditions is referred to as "biomethane". In the United States, it is referred to as "Renewable Natural Gas" or "RNG".

— biomass;

— coal (e.g. for gasification);

— liquid hydrocarbons (e.g. for catalytic reforming of naphtha);

— biogenic waste (e.g. for gasification);

— non-biogenic waste (e.g. for gasification);

— oxygen (e.g. for autothermal reforming);

— nitrogen

— water (e.g. for water electrolysis);

— steam.

Note 3 to entry: If a hydrogen plant both generates and utilizes a material (e.g. steam), only the portion that is received by the hydrogen plant from an external source is considered to be a feedstock. For example, steam generated within the hydrogen plant system boundary for use at the hydrogen plant is not considered to be a feedstock.

3.2.17
production gate
location of the end-outlet of the *product* (3.2.1) that leaves the production *system boundary* (3.2.10)

3.2.18
delivery gate
any location where the *product* (3.2.1) is transferred from one operator to another

3.2.19
consumption gate
location of the final delivery of the *product* (3.2.1) to its end-use

3.3 Terms related to life cycle assessment

3.3.1
cut-off criteria
specification of the amount of material or *energy flow* (3.2.15) or the level of significance of *greenhouse gas emissions* (3.1.12) associated with unit processes or the *product system* (3.2.3) to be excluded from a *CFP study* (3.1.5)

[SOURCE: ISO 14067:2018, 3.1.4.1, modified — Note 1 to entry omitted.]

3.3.2
evaluation
element within the life cycle interpretation phase intended to establish confidence in the results of the *life cycle assessment* (3.3.5)

Note 1 to entry: Evaluation includes completeness check, sensitivity check, consistency check, and any other validation that may be required according to the goal and scope definition of the study

[SOURCE: ISO 14040:2006]

3.3.3
fugitive emissions
emissions that are not physically controlled but result from the intentional or unintentional *releases* (3.3.10) of *GHGs* (3.1.9)

Note 1 to entry: They commonly arise from the production, processing, transmission, storage, and use of fuels and other chemicals, often through joints, seals, packing, gaskets, etc.

[SOURCE: 2004 GHG protocol, Chapter 4.6]

3.3.4
life cycle
consecutive and interlinked stages related to a *product* (3.2.1), from raw material acquisition or generation from natural resources to end-of-life treatment

Note 1 to entry: "Raw material" is defined in ISO 14040:2006, 3.15.

Note 2 to entry: Stages of a life cycle related to a product include raw material acquisition, production, distribution, use and end-of-life treatment.

[SOURCE: ISO 14067:2018, 3.1.4.2]

3.3.5
life cycle assessment
LCA

compilation and evaluation of the *inputs* (3.2.7), *outputs* (3.2.9) and the potential environmental impacts of *a product* (3.2.1) throughout its *life cycle* (3.3.4)

Note 1 to entry: "Environmental impact" is defined in ISO 14001:2015, 3.2.4.

[SOURCE: ISO 14067:2018, 3.1.4.3, modified — replaced "product system" with "product"]

3.3.6
life cycle inventory analysis
LCI
phase of *life cycle assessment* (3.3.5) involving the compilation and quantification of *inputs* (3.2.7) and *outputs* (3.2.9) for a product throughout its *life cycle* (3.3.4)

[SOURCE: ISO 14044:2006, 3.3]

3.3.7
location-based approach
approach using the average GHG emissions intensity of energy and feedstocks (e.g. electricity) supplied for utilization within a specific region

Note 1 to entry: This uses mostly grid-average emission factors in the location in which energy consumption occurs.

Note 2 to entry: This definition is derived from ISO 14067:2018, 6.4.9.4.4.

3.3.8
market-based approach
approach to assign the attributes of the *product* (3.2.1) produced by a specific producer to the *product* (3.2.1) consumed by or delivered to a specific user while the *product* (3.2.1) is physically distributed through a common infrastructure

Note 1 to entry: These choices (purchasing energy certificates or differentiated electricity product) may be reflected through contractual arrangements between the user and the producer.

3.3.9
process emissions
direct, including fugitive, emissions within the *system boundary* (3.2.10), including emissions associated with waste treatment and disposal, such as, but not limited to, emissions resulting from chemical conversions and combustion of solid, liquid and/or gaseous fuels or feedstocks

3.3.10
releases
emissions to air and discharges to water and soil

[SOURCE: ISO 14040:2006, 3.30]

3.3.11
sensitivity analysis
systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a *CFP study* (3.1.5)

[SOURCE: ISO 14067:2018, 3.1.4.7]

3.3.12
sensitivity check
process to determine whether the information obtained from a *sensitivity analysis* (3.3.11) is relevant for reaching the conclusions and for giving recommendations

[SOURCE: ISO 14040:2006/AMD1:2020, 3.43]

3.3.13
waste
substances or objects that the holder intends or is required to dispose of

Note 1 to entry: This definition is taken from the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (22 March 1989), but is not confined in this document to hazardous waste.

[SOURCE: ISO 14040:2006, 3.35]

3.3.14
biogenic waste
biogenic portion of *waste* (3.3.13)

Note 1 to entry: A non-exhaustive list can include:

— the biogenic portion of municipal solid waste (MSW),

— animal waste,

— sewage sludge,

— food industry residues,

— agricultural residues,

— food and agricultural waste (e.g. home food waste collection)

— forests that would traditionally be left to decompose naturally[5].