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Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the production, conditioning and transport of hydrogen to consumption gate

Méthodologie pour déterminer les émissions de gaz à effet de serre associées à la production, au conditionnement et au transport d'hydrogène jusqu'au point de consommation

(The scope of this document is to establish a methodology and analytical framework to determine the GHG emissions related to a unit of produced hydrogen up to the consumption gate)

DTS stage

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 ~~documents~~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).

Field Code Changed

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*, Subcommittee SC 1, ~~HYDROGEN @~~*Hydrogen at scale and horizontal energy systems*.

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

~~In order to strengthen~~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 ~~by keeping a~~ restricting global temperature rise ~~this century well~~ to below 2 °C above pre-industrial levels and ~~to pursue~~pursuing efforts to limit the temperature increase ~~even further~~ to 1~~.~~5 °C~~, the Paris Agreement has been established at the COP 21 in Paris, on 12 December 2015. Green House Gas~~ 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).

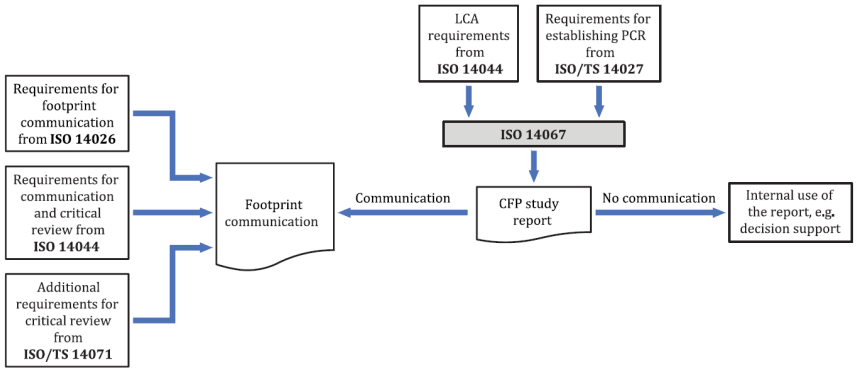
~~ISO produces documents that support the transformation of scientific knowledge into tools that will help address climate change.~~ GHG initiatives on mitigation rely on the quantification, monitoring, reporting and verification of GHG emissions and/or removals. International Standards that support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

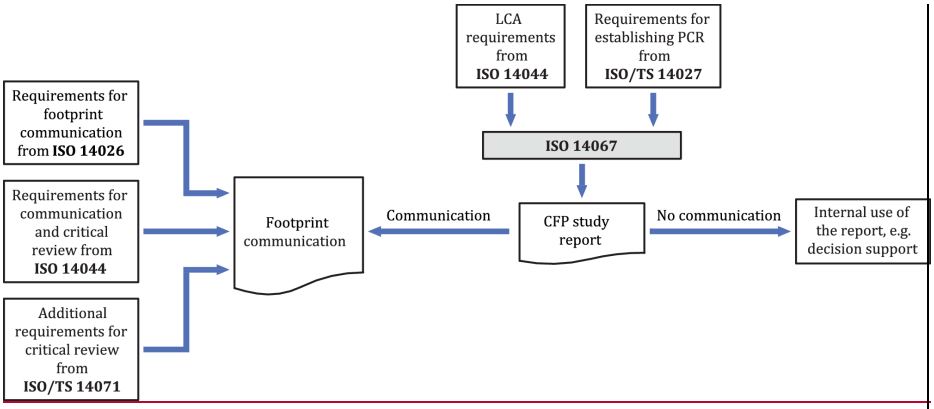
ISO 14040 and ISO 14044 define the principles, requirements and guidelines identified in existing International Standards on ~~Life Cycle Assessment~~life cycle assessment (LCA). The ISO 14060 ~~family~~series provides clarity and consistency for quantifying, monitoring, reporting and validating or verifying 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.

~~The~~ ISO 14067 ~~document~~ is based on the principles, requirements and guidelines on LCA identified in ~~existing International Standards on LCA,~~ ISO 14040 and ISO 14044~~,~~ and aims to set specific requirements for the quantification of a ~~Carbon Foot Print~~carbon footprint (CFP) and a partial CFP.

~~It~~ISO 14067 defines the principles, requirements and guidelines for the quantification of the carbon footprint of products. ~~The~~Its aim ~~of ISO 14067~~ 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.

~~It is related to~~Figure 1 illustrates the relationship between ISO 14067 and other ISO documents on LCA ~~as illustrated below:~~.





PCR: Product category rule

Figure 1 — Relationship between standards beyond the GHG management family of standards (source ISO 14067:2018)[1]

Hydrogen can be produced from diverse sources including renewables, nuclear and fossil fuels using ~~Carbon Capture, Utilization, and Storage~~carbon capture, utilization and storage (CCUS) to reduce the emissions associated with its production. Hydrogen can be used to decarbonize numerous sectors including transport, industrial manufacturing~~,~~ and power generation.

A particular challenge is that identical hydrogen molecules can be produced and combined from sources ~~with~~that have different GHG intensities. ~~Likewise~~Similarly, hydrogen-based fuels and ~~products~~derivatives will be indistinguishable and ~~might result~~can be produced from hydrogen ~~being~~ combined with a range of fossil and low-carbon inputs. Indeed, some of the products made from hydrogen (e.g. electricity) ~~could~~can themselves be used in the production of hydrogen. Accounting standards for different sources of hydrogen along the supply chain (see Figure 2) will be fundamental to creating a market for low-carbon hydrogen, and ~~that~~ these standards need to be agreed upon internationally. ~~Moreover,~~ Additionally, there is the possibility that consumption gates ~~may~~are not ~~be~~ located ~~nearby the~~ in proximity to hydrogen production gates ~~and~~, requiring hydrogen transport ~~will be needed.~~. ISO 14083~~:2023 is presenting a~~ gives guidelines for the quantification and reporting of GHG emissions arising from transport chain operations.

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

This document aims at increasing the methodologies that should be applied, in line with ISO 14067, to the specific case of the hydrogen value chain, covering different production processes and other parts of the value 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.

[1] ~~PCR: Product Category Rule~~

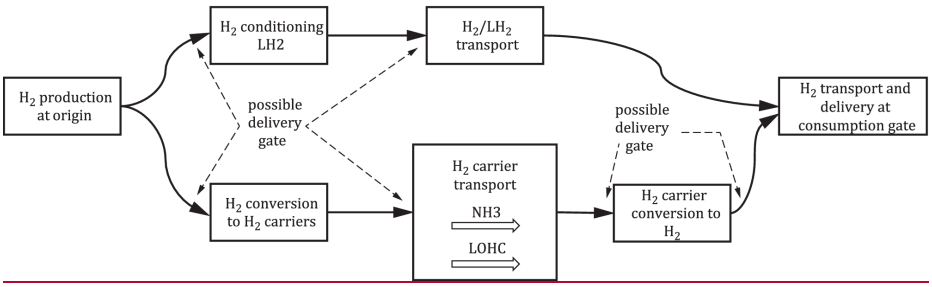


Figure 2 — Examples of hydrogen supply chain

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Méthodologie pour déterminer les émissions de gaz à effet de serre associées à la production, au conditionnement et au transport d'hydrogène jusqu'au point de consommation

1 Scope

As required by ISO 14044, requires the goal and scope of an LCA shallto be clearly defined and shall be consistent with the intended application. Due to the iterative nature of LCA, it is possible that the LCA scope may haveneeds to be refined during the study.

According to ISO 14040, Annex A.2, Two possible different approaches to LCA have developed:

one whichThis document specifies methodologies that can be applied to determine the carbon footprint of a product (CFP) or partial CFP of a hydrogen product in line with ISO 14067. The goals and scopes of the methodologies correspond to either approach a) or b), given below, that ISO 14040:2006, A.2 gives as two possible approaches to LCA.

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, and .

one whichb) An approach that studies the environmental consequences of possible (future) changes between alternative product systems.

These two approachesApproaches a) and b) have become known as attributional and consequential, respectively. with complementary information accessible in the ILCD handbook [1]. This document determines methodologies that may be applied to determine the Carbon Foot Print of a Product (CFP) or Partial CFP of hydrogen product in line with ISO 14067, for goal and scopes corresponding to either approach a) or b).[1]

There are numerous pathways to produce hydrogen from various primary energiesenergy sources. This document describes the requirements and evaluation methods applied to several hydrogen production pathways of interest: electrolysis, steam methane reforming (with carbon capture and storage), co-production and coal gasification (with carbon capture and storage), auto-thermal reforming (with carbon capture and storage), hydrogen as a co-product in industrial applications, and hydrogen from biomass waste as feedstock. Additional pathways may be added in future revisions of this document.

This document also considers the GHG emissions due to the conditioning or conversion of hydrogen, respectively, into different physical forms and chemical carriers: 1)

— hydrogen liquefaction, 2) the ;

— production, transport and cracking of ammonia as a hydrogen carrier, and 3) ;

— hydrogenation, transport and dehydrogenation of liquid organic hydrogen carriers (LOHCs) and is completed with the consideration of).

This document considers the GHG emissions due to hydrogen and/or hydrogen carriers' transport up to the consumption gate.

It is possible that future revisions of this document will consider additional hydrogen production, conditioning, conversion and transport methods.

This document applies to and includes every single delivery along the supply chain up to the final delivery to the consumption gate. (see Figure 2 in the Introduction).

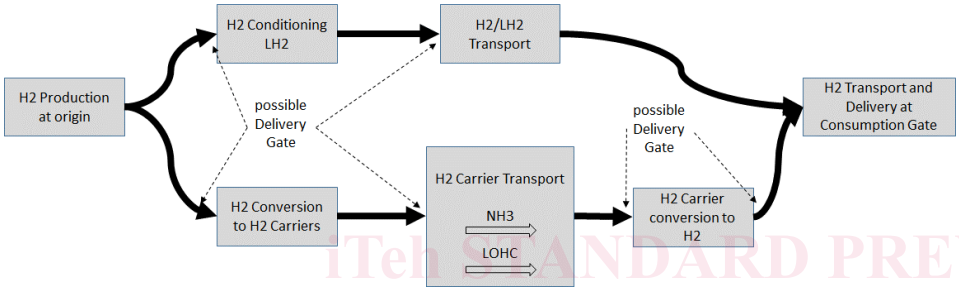

Figure 1 — Examples of hydrogen supply chain

This document also provides additional information related to evaluation principles, system boundaries and expected reported metrics in the form of Annexes A to J, that are accessible via the online ISO portal (https://standards.iso.org/iso/ts/19870/ed-1/en).

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 14040:2006, *Environmental Management management — Life Cycle Assessment cycle assessment — Principles and Framework framework*

ISO 14044, *Environmental Management management — Life Cycle Assessment cycle assessment — Requirements and Guidelines guidelines*

ISO 14067: 2018, *Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification*

ISO 14083:2023, *Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations*

EN 16258:2012 Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)

ISO/TS 14071, *Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006*

3 Terms and definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply. The terms and definitions used by various international organisations (e.g. IEC, ISO) have been adopted whenever possible.

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

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

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

3.1 Quantification of the Carbon Footprint of a Product

3.1.1
allocation
Partitioningpartitioning the *input* (3.2.8) or *output* (3.2.10) 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 [SOURCE: ISO 14040:2006/AMD 1:2020]

3.1.2
carbon footprint of a product,
CFP

Sumsum 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* (3.4.5) 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*. (3.4.4).

Note 2 to entry: The results of the *quantification of* the *CFP* (3.1.8) are documented in the CFP study report expressed in mass of CO_2e (3.1.11) per *functional unit*. (3.2.14).

[SOURCE: ISO 14067:2018, 3.1.1.1]

3.1.3
partial CFP
Sumsum 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_2 *equivalents* (3.1.10) and based on the selected stages or processes within the *life cycle* (3.4.4)

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.

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

[SOURCE: ISO 14067:2018]

3.1.5
permanent GHG removal
The process of removing greenhouse gases from the atmosphere and locking it away for decades, centuries, or millennia

3.1.6
CFP study
Allall activities that are necessary to quantify and report athe *carbon footprint of a product* (3.1.2) or a *partial CFP* (3.1.3)

[SOURCE: ISO 14067:2018]

3.1.76
product category
Groupgroup of products that can fulfil equivalent functions

[SOURCE: ISO 14025:2006, 3.12]

3.1.87
production batch
Amountamount of products produced by a device between any two points in time selected by the Operator for which the quantity of it is calculatedoperator

3.1.9
3.1.8
quantification of CFP
Activitiesactivities that result in the determination of athe *carbon footprint of a product* (3.1.2) or a *partial CFP* (3.1.3)

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

[SOURCE: ISO 14067:2018]

3.1.9

3.1.10
greenhouse gas,

GHG
~~Gaseous~~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 (currently carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O)). Other GHGs are not considered relevant for this document.

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.~~11~~10
carbon dioxide equivalent~~,~~
CO_2 ~~Equivalent,~~ equivalent
CO_2e
~~Unit~~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.~~12~~11
global warming potential~~,~~
GWP
~~Index~~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]

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

[SOURCE: ISO 14067:2018]