



BSI Standards Publication

**Bio-based products — Life cycle assessment —
Additional requirements and guidelines for
comparing the life cycles of bio-based products
with their fossil-based equivalents**

National foreword

This British Standard is the UK implementation of EN 18027:2025.

The UK participation in its preparation was entrusted to Technical Committee MI/2, Bio-based products.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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English Version

Bio-based products - Life cycle assessment - Additional requirements and guidelines for comparing the life cycles of bio-based products with their fossil-based equivalents

Produits biosourcés - Analyse du cycle de vie -
Exigences et lignes directrices supplémentaires
concernant la comparaison des cycles de vie de
produits biosourcés avec leurs équivalents d'origine
fossile

Biobasierte Produkte - Ökobilanzen - Zusätzliche
Anforderungen und Leitlinien für den Vergleich der
Lebenszyklen von biobasierten Produkten mit ihren
fossilen Pendanten

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European foreword

This document (EN 18027:2025) has been prepared by Technical Committee CEN/TC 411 “Bio-based products”, the secretariat of which is held by SIS.

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of an identical text or by endorsement, at the latest by October 2025, and conflicting national standards shall be withdrawn at the latest by October 2025.

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

This document is complementary to EN 16760:2015 *Bio-based products – Life cycle assessment*.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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Introduction

Bio-based products from forestry and agriculture have a long history of application, such as paper, board and various chemicals and materials. The last decades have seen the emergence of new bio-based products in the market. Some of the reasons for the increased interest lie in the benefits of bio-based products in relation to the depletion of fossil resources and climate change. Bio-based products can also provide additional product functionalities. These developments have triggered a wave of innovation with the development of knowledge and technologies allowing new transformation processes and product development.

Acknowledging the need for common standards for bio-based products, the European Commission issued mandate M/492¹, resulting in a series of standards developed by CEN/TC 411 during 2012-2017, with a focus on bio-based products other than food, feed and biomass for energy applications. This document was developed after the expiration of the mandate, upon the initiative of CEN/TC 411/WG 4.

The standards of CEN/TC 411 “Bio-based products” provide a common basis on the following aspects:

- common terminology;
- bio-based content determination;
- life cycle assessment (LCA);
- sustainability aspects; and
- declaration tools.

It is important to understand what the term bio-based product covers and how it is being used. The term ‘bio-based’ means ‘derived from biomass’. Bio-based products (bottles, insulation materials, wood and wood products, paper, solvents, chemical intermediates, composite materials, etc.) are products which are wholly or partly derived from biomass. It is essential to characterize the amount of biomass contained in the product by, for instance, its bio-based content or bio-based carbon content.

The bio-based content of a product does not provide information on its environmental impact or sustainability, which can be assessed through LCA and sustainability criteria. In addition, transparent and unambiguous communication within bio-based value chains is facilitated by a harmonized framework for certification and declaration.

This document has been developed with the aim to set a framework for fair comparisons between fossil-based and bio-based product systems through LCA. Today, some comparisons have been made in a way which (consciously or unconsciously) disadvantages the bio-based product systems related to a number of aspects. Often, this is due to an incorrect application of LCA, and not being in full conformance with the international LCA standard EN ISO 14044. In this document some of these issues are addressed when setting the framework for how a correct study is to be performed.

The general methodology to perform LCAs of products is described in the standard mentioned above as well as in EN ISO 14040, EN ISO 14067 and, more specific for bio-based products, in EN 16760 and EN ISO 22526-1 to EN ISO 22526-3 and ISO 22526-4. However, significant problems often arise when it comes to making well-balanced comparative LCAs between bio-based and fossil-based product systems. This document provides additional requirements and guidelines to enable practitioners to perform comparative LCA studies involving bio-based products with equivalent fossil-based products and to disclose the results. Fossil resource use increases the total amount of carbon in the biosphere while bio-

¹ A mandate is a standardization task embedded in European trade laws. Mandate M/492 was addressed to the European Standardization bodies, CEN, CENELEC and ETSI, for the development of horizontal European Standards for bio-based products.

based systems can operate in a renewable way within this system (where harvesting and growth rates are in balance). When biomass grows, the plant captures carbon dioxide (CO₂) from air or water. This CO₂ can either be stored as products or in soil, or released when the biomass decays or burns (at the end of life).

This document sets requirements for comparisons between fossil-based and bio-based product systems. There can in some cases be many other options (which can be better than both the fossil-based and bio-based option), but this is outside of the scope of this document.

1 Scope

This document provides requirements and guidelines for comparing the life cycles of bio-based products with their fossil-based equivalents.

NOTE The term “equivalents” generally refers to the “functional equivalence”.

This document builds on existing LCA methodology and provides requirements and guidance on specific topics relevant for making well-balanced comparisons.

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.

EN ISO 14025:2010, *Environmental labels and declarations — Type III environmental declarations — Principles and procedures (ISO 14025:2006)*

EN ISO 14040:2006,² *Environmental management — Life cycle assessment — Principles and framework (ISO 14040:2006)*

EN ISO 14044:2006,³ *Environmental management — Life cycle assessment — Requirements and guidelines (ISO 14044:2006)*

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

EN 16575:2014, *Bio-based products — Vocabulary*

EN 16760:2015, *Bio-based products — Life Cycle Assessment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 14040:2006, EN ISO 14044:2006, EN 16575:2014 and the following 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

carbon footprint of a product

CFP

sum of *GHG emissions* (3.5) and *GHG removals* (3.6) in a product system, expressed as CO₂ equivalents and based on a life cycle assessment 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 and removals. A CFP can also be disaggregated into the stages of the life cycle.

[SOURCE: EN ISO 14067:2018, 3.1.1.1]

² As impacted by EN ISO 14040:2006/A1:2020.

³ As impacted by EN ISO 14044:2006/A1:2018 and EN ISO 14044:2006/A2:2020.

3.2

carbon dioxide equivalent

CO₂ equivalent

CO₂e

unit for comparing the radiative forcing of a GHG (3.3) to that of carbon dioxide

Note 1 to entry: Mass of a GHG is converted into CO₂ equivalents by multiplying the mass of the GHG by the corresponding GWP (34) or GTP of that gas.

Note 2 to entry: In the case of GTP, CO₂ equivalent is the unit for comparing the change in global mean surface temperature caused by a GHG to the temperature change caused by CO₂.

[SOURCE: EN ISO 14067:2018, 3.1.2.2]

3.3

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 GHGs, see the latest IPCC Assessment Report.

[SOURCE: EN ISO 14067:2018, 3.1.2.1]

3.4

global warming potential

GWP

index, based on radiative properties of *GHGs* (3.3), 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 (CO₂)

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: EN ISO 14067:2018, 3.1.2.4]

3.5

greenhouse gas emission

GHG emission

release of a *GHG* (3.3) into the atmosphere

[SOURCE: EN ISO 14067:2018, 3.1.2.5]

3.6

greenhouse gas removal

GHG removal

withdrawal of a *GHG* (3.3) from the atmosphere

[SOURCE: EN ISO 14067:2018, 3.1.2.6]

3.7**greenhouse gas emission factor****GHG emission factor**

coefficient relating activity data with the *GHG emission* (3.5)

[SOURCE: EN ISO 14067:2018, 3.1.2.7]

3.8**organization**

person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives

Note 1 to entry: The concept of organization includes, but is not limited to, sole-trader, company, corporation, firm, enterprise, authority, partnership, charity or institution, or part or combination thereof, whether incorporated or not, public or private.

[SOURCE: EN ISO 14067:2018, 3.1.5.1]

3.9**supply chain**

those involved, through upstream and downstream linkages, in processes and activities relating to the provision of products to the user

Note 1 to entry: In practice, the expression “interlinked chain” applies from suppliers to those involved in end-of-life processing, which may include vendors, manufacturing facilities, logistics providers, internal distribution centres, distributors, wholesalers and other entities that lead to the end user.

[SOURCE: EN ISO 14067:2018, 3.1.5.2]

3.10**primary data**

quantified value of a process or an activity obtained from a direct measurement or a calculation based on direct measurements

Note 1 to entry: Primary data need not necessarily originate from the product system under study because primary data might relate to a different but comparable product system to that being studied.

Note 2 to entry: Primary data can include GHG emission factors (3.7) and/or GHG activity data (defined in ISO 14064-1:2006, 2.11).

[SOURCE: EN ISO 14067:2018, 3.1.6.1]

3.11**site-specific data**

primary data (3.10) obtained within the product system

Note 1 to entry: All site-specific data are primary data but not all primary data are site-specific data because they may be obtained from a different product system.

Note 2 to entry: Site-specific data include *GHG emissions* (3.5) from GHG sources as well as *GHG removals* (3.6) by GHG sinks for one specific unit process within a site.

[SOURCE: EN ISO 14067:2018, 3.1.6.2]

3.12

secondary data

data which do not fulfil the requirements for *primary data* (3.10)

Note 1 to entry: Secondary data can include data from databases and published literature, default emission factors from national inventories, calculated data, estimates or other representative data, validated by competent authorities.

Note 2 to entry: Secondary data can include data obtained from proxy processes or estimates.

[SOURCE: EN ISO 14067:2018, 3.1.6.3]

3.13

uncertainty

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

Note 1 to entry: Uncertainty can include, for example:

- parameter uncertainty, e.g. *GHG emission factors* (3.7), activity data;
- scenario uncertainty, e.g. use stage scenario, end-of-life stage scenario;
- model uncertainty.

Note 2 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.

[SOURCE: EN ISO 14067:2018, 3.1.6.4]

3.14

fossil carbon

carbon that is contained in fossilized material

Note 1 to entry: Examples of fossilized material are coal, oil and natural gas and peat.

[SOURCE: EN ISO 14067:2018, 3.1.7.3]

3.15

land use

LU

human use or management of land within the relevant boundary

Note 1 to entry: In this document, the relevant boundary is the boundary of the system under study.

Note 2 to entry: Land use is often referred to as “land occupation” in life cycle assessment (LCA).

[SOURCE: EN ISO 14067:2018, 3.1.7.4]

3.16

direct land use change

dLUC

change in the human use of land within the relevant boundary

Note 1 to entry: In this document, the relevant boundary is the boundary of the system under study.

Note 2 to entry: Land use change happens when there is a change in the land-use category as defined by the IPCC (e.g. from forest land to cropland).

[SOURCE: EN ISO 14067:2018, 3.1.7.5]

3.17

indirect land use change

iLUC

change in the use of land which is a consequence of *direct land use change* (3.16), but which occurs outside the relevant boundary

Note 1 to entry: In this document, the relevant boundary is the boundary of the system under study.

Note 2 to entry: Land use change happens when there is a change in the “land-use category” as defined by the IPCC (e.g. from forest land to cropland).

EXAMPLE If land use on a particular parcel of land changes from food production to biofuel production, land use change might occur elsewhere to meet the demand for food. This land use change elsewhere is indirect land use change.

[SOURCE: EN ISO 14067:2018, 3.1.7.6]

4 Abbreviations

BPP	Biotic production potential
C	Carbon
CF	Characterization factor
CFP	Carbon footprint of products
CH ₄	Methane
CO	Carbon monoxide
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalents
dLUC	Direct land use change
EOL	End-of-life
EPD	Environmental product declaration
EU	European Union
GHG	Greenhouse gas
GWP	Global warming potential
HANPP	Human appropriation of net primary production
iLUC	Indirect land use change
IPCC	The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment

LU	Land use
LUC	Land use change
LULUC	Land use and land use change
m ²	Square meter
m ² × a	Square meter times year
m ² a	Square meter per annum (i.e. year)
MP	Microplastics
MPEP	Microplastic emission potential
N ₂ O	Nitrous oxide
NPP	Net primary production
PCR	Product category rules
PDF	Potentially disappeared fraction (of species)
PE	Polyethylene
PEF	Product environmental footprint
PEFCR	Product environmental footprint category rules
PET	Polyethylene terephthalate
PLA	Poly lactide, polylactic acid
PP	Polypropylene
PS	Polystyrene
RMPEP	Relative index MPEP
SOC	Soil organic carbon
SOC ₀	Soil organic carbon at time zero
SOC _(0-T)	Soil organic carbon at time zero minus T
SOM	Soil organic matter
US	United States
WWTP	Wastewater treatment plant

5 General principles for LCA studies which compare bio-based with fossil-based products

5.1 General

The principles from EN ISO 14040:2006, 4.1 apply for this document. They are followed in both planning, conducting, and reviewing an LCA study. These principles are further elaborated in 5.2-5.8 below to cover the comparison of bio-based products with their fossil-based equivalents.

5.2 Life cycle perspective

There are many possible differences between the product systems of bio-based products and their fossil-based equivalents, the most prominent being in the supply chain and at end-of life. Therefore, comparisons are only possible using a life-cycle perspective.

Due to different supply chains (e.g. agriculture and forestry vs. mining and extraction), data availability, quality and appropriateness can deviate considerably between the systems under study.

Also, end-of-life for products can differ considerably due to the specific properties (such as recyclability) and the availability of different treatment options.

Bio-based and fossil-based carbon flows are treated consistently in comparative studies that handle both flows, or in comparisons of studies that handle one or the other of the two flows, taking into account the different attributes between these flows.

5.3 Environmental focus

LCA focuses on addressing environmental aspects and impacts for distinctively different product systems related to the safeguards natural resources, human health, and ecosystems. Due to the different nature of the supply chains also different economic and social impacts can be observed, see 7.4.1.1. These impacts are typically out of scope but can be addressed in broader assessments.

5.4 Relative approach (and functional unit)

Functional equivalence is crucial for meaningful comparisons and corresponding interpretations. An absolute functional equivalence can be demonstrated for products during their use phase.

5.5 Iterative approach

Iterations between LCA phases help to support proper interpretation when making comparisons.

5.6 Transparency

Transparency is a key principle for LCA studies comparing bio-based and fossil-based product systems, as for all LCA studies. In particular, this is relevant where conventions (e.g. carbon modelling) and value choices are applied. Transparency along all four phases of an LCA study (goal and scope, inventory, impact assessment and interpretation) helps to ensure proper interpretation (8.3) and appropriate reporting (8.4), including the enabling of a critical review (8.5).

5.7 Comprehensiveness

The consideration of all aspects of the natural environment, human health, and resources in LCA avoids burden shifting and identifies trade-offs.

For bio-based and fossil-based product systems this includes impacts of both systems, understanding the different impact pathways in an overall perspective.

Impacts can be driven by emissions (e.g. contribution to global warming or eutrophication) which are harmful for the natural environment or can be related to other inventory data like resource depletion, land occupation or land transformation (7.4.1.2).

5.8 Priority of scientific approach

Decisions for comparing bio-based with fossil-based product systems are preferably based on natural science, in particular for modelling decisions related to carbon flows, carbon content, carbon storage and emissions and removals. If conventions or value choices are used to determine the difference between two product systems, they are transparently documented and investigated during interpretation.

6 General requirements for LCA studies which compare bio-based with fossil-based products

When performing LCA according to this document, the requirements in EN ISO 14040, EN ISO 14044, EN ISO 14067 and EN 16760 shall be met.

The comparison of bio-based and fossil-based products relates to many challenges as there are inherent differences between the systems and a balanced modelling is difficult to achieve. To support a meaningful interpretation and appropriate reporting, data collection and documentation shall be guided by the principles for LCA in general and the specific aspects of comparing bio-based with fossil-based in particular, where e.g. the feedstock or raw material (such as oil, wood or crops) sourcing can be the dominating or discriminating stage of the life cycle.

Due to different supply chains data availability, quality and appropriateness can deviate considerably between bio-based and fossil-based raw material and the same can be valid for different end-of-life options. In addition, temporal boundaries can deviate.

This asymmetry between the systems shall be considered through a careful set up of any LCA study that intends to compare the product systems and shall be considered also when comparing the outcome of different studies of bio-based and fossil-based systems. Differences can be compared given that the modelling follows the same principles and assumptions, and the context of each study are equivalent.

LCA offers a variety of techniques to limit bias introduced by such asymmetries and ensure comparability. Main techniques are:

- sensitivity analysis for any modelling assumption based on value choices or conventions; and
- statistical procedures to explore the relevance of data gaps.

Given that asymmetries cannot be avoided, the transparent documentation of limitations related to goal and scope of the study and further reporting requirements of value choices, rationales, and expert judgements, followed up with a comprehensive critical review, are pre-requisites for meaningful conclusions to be drawn.

EN ISO 14044:2006 sets requirements for comparative studies, which shall be the basis when making comparisons between bio-based and fossil-based product systems, see text box below.

EN ISO 14044:2006, 4.2.3.7 Comparisons between systems

In a comparative study, the equivalence of the systems being compared shall be evaluated before interpreting the results. Consequently, the scope of the study shall be defined in such a way that the systems can be compared. Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundary, data quality, allocation procedures, decision rules on evaluating inputs, and outputs and impact assessment. Any differences between systems regarding these parameters shall be identified and reported. If the study is intended to be used for a comparative assertion intended to be disclosed to the public, interested parties shall conduct this evaluation as a critical review.

Furthermore, the requirements for comparability set in the bullet list of EN ISO 14025:2010, 6.7.2 shall be met, see below for the list (adapted to the scope of this document):

- a) The products compared have at least one identical function.
- b) The goal and scope definition for the LCA of the product, according to ISO 14040, has the following characteristics:
 - the functional unit is identical and expressed in the same measurement system;
 - the system boundary is equivalent;
 - the description of data is equivalent;
 - the criteria for the inclusion of inputs and outputs are identical; and

- the data quality requirements including coverage, precision, completeness, representativeness, consistency, reproducibility, sources and uncertainty are equivalent.
- c) For the inventory analysis:
- the methods of data collection are equivalent;
 - the calculation procedures are identical; and
 - the allocation of material and energy flows and releases is equivalent.
- d) Impact category selection and impact assessment method, if applied, are identical. The relevant impact categories should be assessed, with any exclusions justified.
- NOTE: The selection of impact categories is part of the iterative nature of an LCA,
- e) Predetermined parameters for reporting of LCA data (inventory data categories and impact category indicators) are identical.
- f) Requirements for provision of additional environmental information, including any methodological requirements (e.g. specifications for hazard and risk assessment) are equivalent.
- g) Materials and substances to be declared (e.g. information about product content, including specification of materials and substances that can adversely affect human health and/or the environment, in all stages of the life cycle) are equivalent.

In order to compare bio-based and fossil-based product systems based on information modules, either the environmental impacts of omitted life cycle stages of the products shall not be significant, or the data of omitted life cycle stages shall be identical within the accepted uncertainty of the data. In this context, determination of significance shall take account EN ISO 14044:2006, 4.2.3.3.3.

7 Guidance and requirements for goal and scope, inventory and impact assessment

7.1 General

For comparing bio-based with fossil-based product systems all aspects in Clause 7 for both systems shall be comprehensively addressed. Annex A contains examples and further guidance related to these aspects.

7.2 Guidance and requirements on biogenic and fossil carbon flows

7.2.1 Modelling considerations for carbon flows

7.2.1.1 General

There are different ways to handle carbon containing elementary flows in a life cycle inventory, different approaches to handle allocation of carbon flows for a process or processes shared by more than one product system, including those at end-of-life; and different approaches to treatment of fossil and biogenic carbon flows in life cycle impact assessment.

The main issues arising for fossil and biogenic carbon flows respectively are:

- Different methodological approaches can reveal or obscure that fossil carbon, once extracted from the ground, can ultimately be released as a CO₂ emission to the atmosphere. If a methodological approach obscures the CO₂ emission, it shall be described.

- Some methodological approaches do not take into account that biogenic CO₂ has been removed from the atmosphere nor take into account any benefit where such CO₂ is not subsequently emitted.
- The impact assessment for carbon flows, removal, and emissions, can be seen with two different time perspectives: long term or short term. With long-term perspective all removals and emissions are accounted for as occurring now, with short term perspective removals and emissions accounted for up to a specified time horizon. The choice of time perspective is inherently a value judgment which will impact the end result.
- The use of only the short-term perspective can obscure the fact that fossil carbon once extracted from the ground can ultimately be released as a CO₂ emission to the atmosphere. On the other hand, the use of only the long-term perspective does not allow sufficient differentiation between the CO₂ emissions from incineration and landfilling since the immediate emissions of incineration and the future emissions from landfill are treated equally.

NOTE 1 Non-CO₂ emissions are captured using the short-term perspective but the long term CO₂ emissions from landfill would not be sufficiently differentiated from the immediate CO₂ emissions from incineration.

The complete picture is only obtained with the use of both perspectives but is not common practice.

Comparative studies should present both time perspectives but as a minimum, in a comparison between bio-based and fossil materials, the selected approach shall be stated and justified in the goal and scope. Any interpretation of the results shall be restricted to that specific scope. It shall also be consistently applied to both product systems.

NOTE 2 Most often 100 years is used as the time horizon for short-term perspective.

NOTE 3 Guidance on how to handle algae grown with fossil CO₂ can be found in A.1.1.1.

7.2.1.2 Life cycle inventory (LCI)

Greenhouse gas (GHG) emissions and removals arising from fossil carbon sources and biogenic carbon sources and sinks shall be included and listed separately in the inventory.

The GHG inventory shall cover all carbon flows in such a way that the effect of choices related to stored or released carbon (biogenic or fossil, respectively) and storage period(s) at the product end-of-life can be assessed in sensitivity analyses during the interpretation phase (see 8.3). The biogenic and fossil carbon can also flow into other products by mechanical, chemical, or organic recycling.

Multi-functionality shall be handled, if possible, by subdivision or by system expansion to avoid allocation (following EN ISO 14044).

Where allocation cannot be avoided it is important to realize that allocation can introduce problems for the accounting of biogenic carbon flows. Using different approaches for handling of biogenic carbon in allocation situations can lead to different results and conclusions and the selected approach for that allocation shall be stated and justified in the goal and scope.

Biogenic and fossil carbon content and flows shall be allocated reflecting the physical flows according to stoichiometric rules irrespective of the allocation chosen for the process. Alternative allocation approaches can lead to the modelled biogenic and fossil carbon flows not reflecting the actual physical content and flows.

NOTE EN 16485:2014 contains examples on how to allocate biogenic carbon.

For cradle to gate studies, biogenic or fossil carbon content in the products shall be reported separately to allow to calculate carbon emissions in end-of-life.

The ideal comparison should be made for cradle to grave. If relative comparisons (difference expressed in %) are to be done cradle to gate, then the downstream stages of the product systems should be modelled, and all assumptions related should be clearly documented and should be adapted for both product systems.

7.2.1.3 Impact assessment

To carry out life cycle impact assessments, all biogenic and fossil carbon emissions and removals should be considered. The impacts shall be reported separately, e.g. climate change – biogenic, climate change – fossil. Two examples can be found in A.1.2.

The short-term perspective, which captures the rate of change, should use GWP100 as the metric and the long-term perspective, which accounts for the final equilibrium temperature, should use GTP100 as the metric.

7.2.2 Quantification of biogenic GHG removals and emissions

7.2.2.1 General

There are different ways to deal with biogenic carbon removals and emissions in LCA. Annex B provides an overview of the different approaches used in LCA standards.

The main issues that can be observed are:

- There is a need for a harmonized and transparent approach on how the biogenic carbon removals and emissions are to be handled including time perspectives in impact assessment. The inconsistency in approaches of handling the removals and emissions of biogenic CO₂, in the life cycle inventory and when performing impact assessments results in different outcomes and interpretations.
- There are different approaches regarding how to report biogenic carbon removals and emissions in cradle to gate studies e.g. whether biogenic carbon removals are to be included as a negative emission when the positive emissions from the end-of-life is not included in the scope.

7.2.2.2 Life cycle inventory

Biogenic carbon is captured as CO₂ from the atmosphere and sequestered during biomass growth, a process commonly referred to as photosynthesis. This biogenic carbon can at the end of the life cycle be emitted as CO₂, CO or CH₄ as a result of the oxidation and/or reduction of biogenic carbon in the product by means of its transformation or degradation (e.g. incineration, biodegradation, landfilling). The inventory of biogenic carbon flows shall include both the removals and the emissions with dedicated elementary flows e.g. carbon dioxide (biogenic). Biogenic carbon emissions and removals shall be included and shall each be reported separately in both cradle to gate and cradle to grave assessments.

For cradle to gate studies, biogenic carbon content in the products shall be reported separately to allow calculation of biogenic carbon emissions in end of life.

7.2.2.3 Impact assessment

As described in EN 16760:2015, one of the below two approaches may be applied for modelling CO₂ emissions and removals related to biomass:

- a) The CO₂ incorporated in biomass during the growth phase is inventoried as a removal during the cultivation/growth phase, and as an emission when it is released at end-of-life or throughout the life cycle. The CO₂ removal shall then be characterized in the LCIA as –1, while emissions of biogenic CO₂ correspondingly shall be characterized in the LCIA as +1 (referred to as the –1/+1 approach). Or,

- b) The CO₂ incorporated in biomass during the growth phase and the corresponding emissions throughout the entire life cycle are both characterized with a characterization factor of zero (referred to as the 0/0 approach).

NOTE 1 Characterization factors are used to quantify the potential impact of the modelled CO₂ emissions and uptakes (within the climate change impact category).

Other biogenic GHG emissions (e.g. CH₄) should always be characterized as they often have a higher radiative forcing than CO₂.

For bio-based products, the biogenic carbon shall be quantified applying the –1/+1 approach. For these products, there are different end-of-life options. This includes incineration, mechanical and chemical recycling, industrial composting, *in situ* biodegradation, and landfilling. The 0/0 approach shall only be used when the biogenic carbon taken up is totally oxidized and released as CO₂. This can be the case for energetic use of biomass.

A simplified approach for –1/+1 is to consider for the removal (–1) the biogenic CO₂ embedded in the bio-based product by using stoichiometry or the biogenic carbon content. This approach may be used if there is a lack of completeness and accuracy of the biogenic carbon emissions during the production of the bio-based product.

NOTE 2 EN 16485:2014 contains examples on how to calculate embedded CO₂.

7.2.3 Biogenic carbon storage in products

7.2.3.1 General

Biogenic carbon storage is the sequestration of carbon in products for a certain period resulting in a temporary reduction of the CO₂ concentration in the atmosphere, see E.3 in EN ISO 14067:2018 for further guidance. If biomass is harvested and biogenic carbon is stored in bio-based products, emissions can be temporarily delayed or avoided long-term. This can lead to a temporary or long-term reduction of CO₂ in the atmosphere, and, therefore, not increase global warming. A distinction is made between carbon that is released within a short-term (temporary storage) and long-term (beyond a longer and specified time-horizon, and which is then considered as “permanent” storage). If the effect of timing of biogenic removals and emissions are considered, the temporal horizon should be consistent with the storage period.

The main issues are:

- According to the standards and guidelines reviewed in Annex B, delayed emissions due to temporary carbon storage are not included in the final footprint result but some allow them to be provided as additional information. By using this approach, an advantage of some bio-based products, i.e. the possible delay in emissions can be missed. Yet, there is increased interest in standardization and in policy to incorporate this consideration of time and the potential of bio-based products to provide temporary or permanent carbon storage.

EXAMPLE One such effort is the carbon removal certification within the EU [17].

- There is no harmonized methodological approach in calculating the benefit of delayed emissions. There are different approaches presented and further guidance and consensus are needed for the appropriate method for assessment.
- The benefit from delayed emissions depends on the chosen time horizon. Most often 100 years is used as the time horizon, this is a value choice and not based on a scientific definition. Most standards do not report any specific time horizon after which carbon removed from the atmosphere (e.g. during

biomass growth) is considered as no longer released, and hence as permanently stored. Value choices also apply to the definition of a minimum time, if any, to factor in the benefits of a temporary carbon storage (e.g. minimum 10 years or 20 years or 50 years of storage in the product, before being released back to the atmosphere).

- The lifetime of many products is much shorter than 100 years. For many packaging products the lifetime is short and the possibility of the recycling of these products in new products and storing carbon for longer duration is not considered, although the same carbon sequestered can stay in the economy for a longer time period. If carbon can remain in the loop by stimulating recycling of bio-based products, this is advantageous.

7.2.3.2 Goal and scope

It shall be assessed whether accounting of time is relevant or not for the product in scope.

The choice of time period should be transparently reported and justified, based on scientific evidence to the extent possible, and sector guidance or product category rules can be a source of this information when available.

7.2.3.3 Life cycle inventory

For a cradle to grave study, an inventory shall be made considering the temporal profile of the emissions and the possible period of storage of carbon in the product before reaching end-of-life stage, following what is stated in the goal and scope.

7.2.3.4 Impact assessment

7.2.3.4.1 Accounting for temporary storage

To better capture the impact of time, dynamic approaches have been developed which consider use of time dependent characterization factors for the calculation of GWP. Dynamic LCA approach may be followed for such more accurate estimation of the impact of delayed emissions.

If the accounting of delayed emissions is declared as relevant in the objectives of the study, it should be taken into account but reported separately. See 6.4.8 EN ISO 14067:2018 for assessing the effect of the timing. For the assessment of effects due to temporary biogenic carbon storage, the method proposed in the ILCD Handbook [14] may be followed. This is based on linear discounting of emissions over a 100-year time period. An example on how this can be calculated can be found in A.2.

7.2.3.4.2 Accounting for permanent carbon storage

The portion of the stored carbon not emitted to the atmosphere within the chosen time period may be treated as “permanently” stored. Carbon storage below the chosen time period shall not be counted as permanent storage.

7.3 Guidance and requirements for establishing systems for a comparison based on functional relevance

7.3.1 Data requirements and sources / Data asymmetry

7.3.1.1 General

Data quality has an important influence on the outcome of the LCA study and shall be consistently handled and transparently reported for studies comparing bio-based and fossil-based products.

Data quality should be equivalent as far as possible between compared product systems. If this is not possible, a sensitivity analysis should be performed, and a conservative approach should be followed. When there are differences in data quality between the compared bio-based and fossil-based product