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Packaging — Report on criteria and methodologies for life cycle analysis of packaging

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National foreword

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Foreword

This document (CEN/TR 13910:2010) has been prepared by Technical Committee CEN/TC 261 “Packaging”, the secretariat of which is held by AFNOR.

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 supersedes CR 13910:2000.

This Technical Report defines and describes how to apply Life Cycle Assessment (LCA) to packaging and distribution systems. The expression "Life Cycle Analysis", applied in the EU Packaging Directive, is in this report considered as identical to the concept of "Life Cycle Assessment" in the EN ISO 14040 standards.

This Technical Report has been prepared by the CEN Working Group, CEN/TC 261/SC 4/WG 1/TG 1, which has been considering the aspects of life cycle assessment specific to packaging, in order to fulfil the "Mandate 200 rev.3 to CEN for Standardisation and a study related to packaging and packaging waste", requested by the EU Commission.

Introduction

Packaging is an integral part of modern society providing means for protection, presentation, information and distribution of products to industry, trade and consumers.

In 1994 the European Parliament and the European Council adopted a Directive on Packaging and Packaging Waste, covering all types of packaging placed on the market in the European Community and all packaging waste, whether used or released at the industrial, commercial, office, shop, service, household level or at any other level, regardless of the material used.

The Directive aims to harmonise national measures concerning the management of packaging and packaging waste in order to, on the one hand, prevent any impact thereof on the environment of all Member States, as well as of third countries, or to reduce such impact, thus providing a high level of environmental protection, and, on the other hand, to ensure the functioning of the internal market and to avoid obstacles to trade, and the distortion and restriction of competition within the European Community. The two objectives are on an equal footing.

Article 10 of the Directive states that the European Commission shall promote the preparation of European standards relating to the essential requirements referred to in Annex II of the Directive and, in particular, the preparation of European Standards relating to, among others:

— criteria and methodologies for life-cycle analysis of packaging.

The present Technical Report covers the work of CEN to meet that requirement.

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1 Scope

This Technical Report establishes a set of best practice guidelines for undertaking those aspects of life cycle assessment specific to packaging and distribution systems.

2 Normative references

The following referenced documents are indispensable for the application 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 14040:2006, *Environmental management — Life cycle assessment — Principles and framework (ISO 14040:2006)*

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

3 Terms and definitions

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

This section defines the LCA and packaging specific terms used in this report. The LCA terms are based on definitions given in EN ISO 14040:2006, and the packaging terms are based on definitions in the European Parliament and the Council Directive on Packaging and Packaging Waste (94/62/EC) and terms and definitions referred to in EN 13193 unless stated otherwise.

3.1
life cycle assessment
LCA
compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

3.2
life cycle inventory analysis
LCI
phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a product throughout its life cycle

3.3
life cycle impact assessment
LCIA
phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product

3.4
life cycle interpretation
phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations

3.5
packaging
all items made of any material of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer

NOTE In this report the goods are referred to as "packaged product" or just "product", in order to distinguish it from the packaging.

3.6
sales packaging
primary packaging
packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase

3.7
grouped packaging
secondary packaging
packaging conceived so as to constitute at the point of purchase a grouping of a certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale

NOTE It can be removed from the product without affecting its characteristics.

3.8
transport packaging
tertiary packaging
packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packaging in order to prevent physical handling and transport damage

NOTE Transport packaging does not include road, rail, ship and air containers.

3.9
used packaging
packaging or packaging material remaining after the removal of the product it contained

3.10
distribution system
necessary physical arrangements (packing, storage, transport and merchandising) to bring a product from its manufacturing stage, to its final stage of consumption/use

3.11
collection system
necessary physical arrangements (sorting, collecting, transport and storage) to bring used packaging from the point of consumption to the point of reuse, recovery or final disposal

3.12
functional unit of packaging
quantified performance of a product system of packaging, for use as a reference unit in an LCA study

3.13
carbon footprint
overall amount, expressed in terms of CO_2 equivalents, of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions associated with a product, using LCA methodology

NOTE Carbon footprint essentially coincides with the impact category that has generally been referred to under the name "global warming potential" (GWP) in most LCAs to date. Both terms are meant as a measure of the potential contribution to the global phenomenon of climate change, which may also include regional side-effects such as storms and local cooling.

3.14
critical review
process intended to ensure consistency between a life cycle assessment and the principles and requirements of the standards on life cycle assessment

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3.15
interested party
individual or group concerned with or affected by the environmental performance of a product system, or by the results of the life cycle assessment

3.16
allocation
partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems

4 Criteria and methodology for life cycle assessment of packaging

4.1 General

According to EN ISO 14040, an LCA shall include the following phases: definition of goal and scope, inventory analysis, impact assessment and interpretation of results, as illustrated in Figure 1, below.

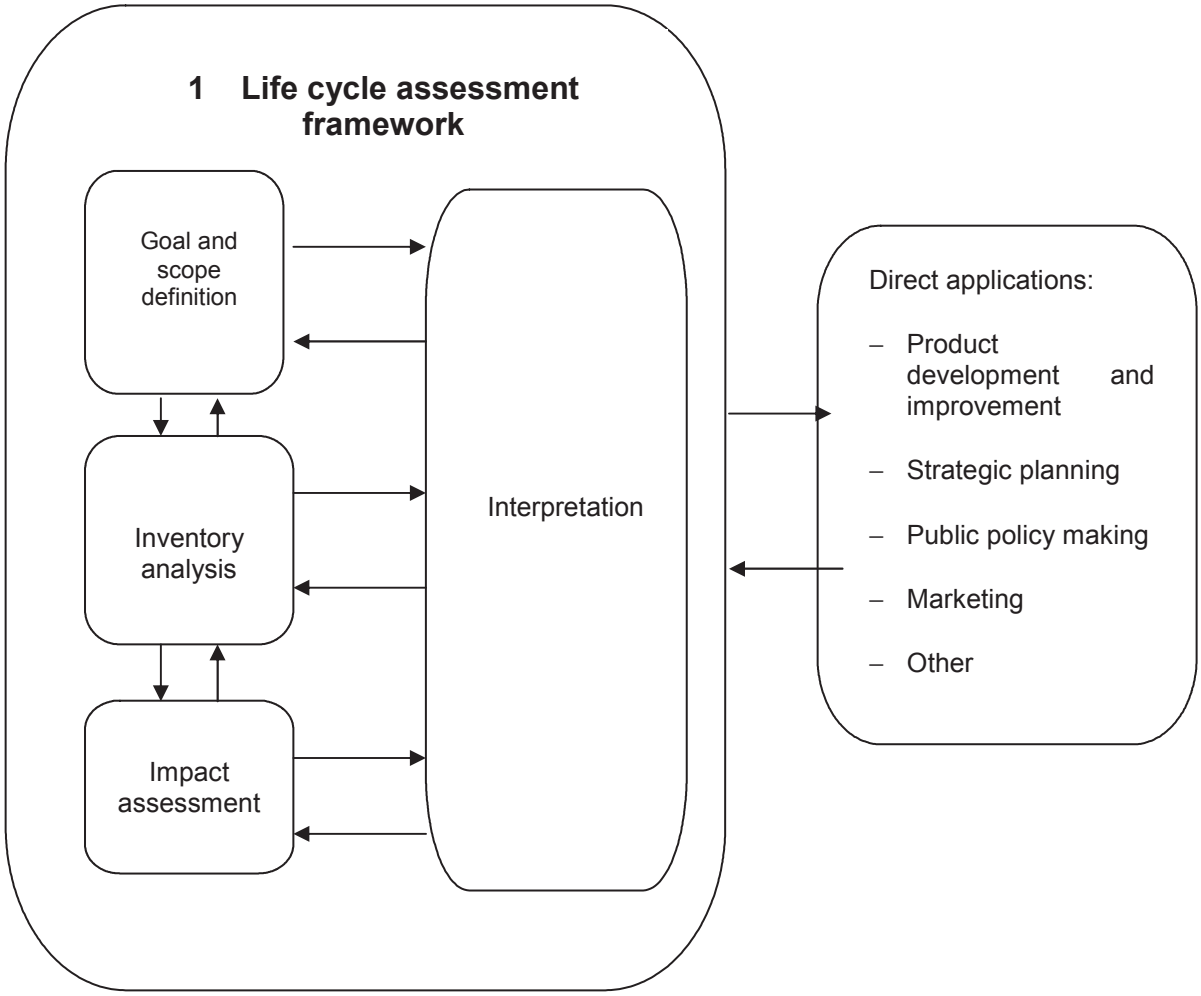

Figure 1 — Phases of an LCA

Applications

LCA can assist in:

— identifying opportunities to improve the environmental performance of products at various points in their life cycle;

— informing decision-makers in industry, government or non-government organizations (e.g. for the purpose of strategic planning, priority setting, product or process design or redesign);

— the selection of relevant indicators of environmental performance, including measurement techniques;

and

— marketing (e.g. implementing an ecolabelling scheme, making an environmental claim, or producing an environmental product declaration).

It is recommended to address those or other intended applications of a dedicated packaging LCA study in the goal and scope section.

4.2 Goal and scope definition

4.2.1 General

The goal and scope of an LCA study of packaging shall be clearly defined, documented and consistent with the intended application. As illustrated in Figure 1 above, the goal and scope definition should be used as a reference all through the study, and in the reporting of the results.

In defining the goal of such an LCA, the following items shall be unambiguously stated: the intended application, the reasons for carrying out the study, the intended audience and whether the results are intended to be used in comparative assertions intended to be disclosed to the public. In addition, the following comments on how packaging is actually used have to be taken into account.

Packaging is always used to pack products, resulting in a strong link between the packaging and the packaged product. Packaging is used to facilitate handling and transportation through the logistic chain, to protect the product, prevent product losses and give relevant information. This means that all packaging items, for example closures, labels, communicative devices (e.g. RFID) and printing inks have to be taken into account.

Packaging is one component of a distribution system. A change of packaging will therefore often cause changes in this system, resulting in changes in resource consumption, emissions and hence in the environmental impact of the total system. Following the cradle-to-grave definition in EN ISO 14040:2006, LCA studies of packaging should therefore include the distribution system, the wastage of packaging material and products, the relevant collection systems, as well as recovery and/or disposal operations.

Primary, secondary and tertiary packaging have a direct influence upon each other's function, construction and dimensions. They are all integral parts of the distribution system and should be included in the LCA.

In some cases, the production or use of products may be influenced by a change of packaging, which should also be considered in an LCA study.

To assess impact categories for packaging in isolation from the packaged product and the distribution system should therefore be avoided as the packaging system is designed to fulfil its functions in relation to the contained product and the physical distribution system.

Most packaging only follows the packaged product through a certain part of its life cycle, hence an LCA of the packaging system should include all the steps of the life cycle of the packaging. The life cycle of a packaging system is illustrated in Figure 2, below.

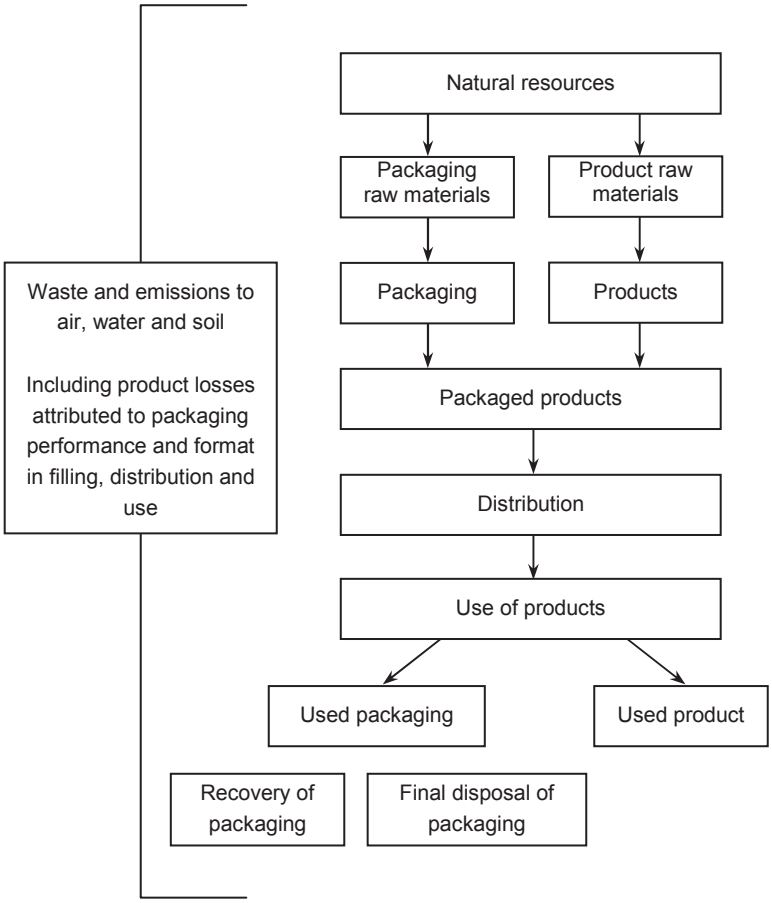

Figure 2 — Illustration of the life cycle of a packaging system

EXAMPLE 1 Transportation system should be considered in the LCA boundaries.

The consideration here could apply to different packaging configurations within one packaging system or across different packaging systems.

An example for the first case is when Yoghurt pots packed in strong boxes can be loaded to greater heights in a large vehicle. Weaker boxes cannot be put on top of each other to the same extent. Hence, more transportation capacity is needed and therefore more fuel is used per ton of products transported. An example for the second case is when the alternative is to distribute yoghurt in glass containers or plastic containers. Again, more transportation capacity might be needed if a glass container is used and therefore more fuel is used per ton of products transported.

Results for the overall packaging system will change with the distribution distance applied in a dedicated LCA study. Thus, the settings of the transportation system model should also include a rationale for and documentation of the selected distribution logistics and distances.

Furthermore, when packaging components from different raw materials are compared against each other, disadvantages in the transportation step might be balanced by advantages in the recovery efficiency of the different materials. Assessment of the transportation system should not be done without consideration of the overall packaging system including end-of-life fate.

EXAMPLE 2 Primary and secondary packaging should be considered.

An LCA of yoghurt includes the comparison of primary packs from different packaging raw materials for the same yoghurt product. In this case it is important to define the adequate weight and raw material composition of the primary packs. For both packs this packaging definition should reflect comparable technical standards. Moreover, the compared types of primary pack might also be associated with different settings of secondary (and tertiary) packaging. For instance if in one

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case primary packs are wrapped in a shrink foil and in the other case are assembled by using a cardboard tray, this will influence the LCA results of the individual packaging systems and thus the comparative results. In such a case secondary (and tertiary) packaging cannot be omitted in the LCA.

EXAMPLE 3 Packaged product loss and waste should be considered.

Different packaging configurations can lead to different levels of product damage, spoilage, loss or waste. A reduction of transport packing for yoghurt might lead to increased product loss that more than offsets any apparent improvement from the packaging when considered alone. Differences in product loss or waste might occur at any point in the packaging life cycle from filling, through distribution and retail, to the point of final consumption. If the functional unit is based on consumption of a specified amount of yogurt, then loss, spoilage or waste at the point of consumption should also be considered. For instance an overlarge package size might result in yoghurt not being consumed before the due date or a particular package design might make the package difficult to empty. In both cases the loss of product and its associated life cycle impacts should be considered.

The above examples illustrate that the whole system has to be included, i.e. primary, secondary and tertiary packaging, as well as the implications of the transport and product wastage. For packaging and distribution systems, the choice of functional unit, definition of system boundaries and application of allocation require special attention.

4.2.2 Function, functional unit and reference flow

According to EN ISO 14044, when defining the scope of an LCA study, a clear statement of the functions (performance characteristics) of the product system, or in the case of comparative studies, the systems shall be made. The functional unit enables the quantification of these identified functions. The functional unit shall be consistent with the goal and scope of the study. The primary purpose of a functional unit is to provide a reference to which the inputs and the outputs are normalised (in a mathematical sense). The functional unit shall be clearly defined, measurable, and provide a reference to which the input and output data are normalized. The choice of functional unit depends on the goal of the study. The reasons for choice of functional unit should be carefully considered and stated.

Having defined the functional unit, the amount of packaging that is necessary to fulfil the function shall be quantified. The result of this quantification is the reference flow.

For a packaging, the functional unit is typically expressed in units of mass of packaging materials normalised to the unit volume/unit mass/unit activity of the packaged product. Alternatively, the functional unit may be expressed as the number of packaging units, i.e. packs necessary to fulfil a given function. The unit activity is based on the defined function of the system, e.g. to supply an adequate quantity to allow one litre of fresh milk to be consumed by the end user. This example could result in a reference flow equivalent to x kg of packaging material needed to supply 1 l of fresh milk or alternatively to the number of units of packaging.

The definition of the functional unit can be more general, e.g. the total production of one product by one company, or the whole market for one product in a certain region if LCAs are used to optimise distribution systems.

Furthermore, it is important to define the packaging performance, which is linked to the packaged product. This might include: required strength of the packaging, required protection during transportation, preserving the quality of foodstuffs, protection against light penetration, prevention of residue production, etc. Legal requirements in relation to the packaged product (e.g. foodstuffs), and the performance of the packaging in relation to machinery, might also be relevant to take into consideration.

The packaged product should be characterised when it is put on the market taking into account losses through the system and those processes/transports/services necessary to deliver a given quantity of the packaged product in a state fit for its purpose.

EXAMPLE 1 Necessary requirements for packaging.

Reviewing the yoghurt example: when conducting a life cycle inventory of packaging for yoghurt, the condition of the yoghurt should be taken into consideration:

— What are the preservation qualities of the yoghurt in different packaging?

— What are the requirements for the packaging? In what manner is the yoghurt prepared relative to the demands of the packaging (e.g. sterilised yoghurt versus "live" yoghurts)?

— Does the packaging fulfil the transportation requirements?

EXAMPLE 2 At point of sale.

The delivery of 1 000 l of yoghurt to the final consumer typically does not correspond to 1 000 l of manufactured yoghurt, owing to losses occurring during processing, packing and distribution including exceeded shelf life in the store/shop. In this example, the delivery of 1 000 l of yoghurt may correspond to the manufacture of 1 100 l of yoghurt.

EXAMPLE 3 At point of consumption.

In other instances, it might be appropriate to characterise the functional unit at the point of use/consumption. The delivery of 1 000 l of yoghurt typically does not correspond to 1 000 l of yoghurt consumed owing to losses occurring during use: Some of the yoghurt is discarded because of adhesion to the packaging, some of it may have been spilt, some of it discarded because it is too old, etc. In this example, the delivery of 1 000 litres of yoghurt may correspond to the consumption of 800 l of yoghurt.

It should be understood that life cycle assessment should not be undertaken without taking into account the relationship that exists between the product and its packaging.

4.2.3 Allocation

The methodological requirements regarding allocation are described in EN ISO 14044. ISO/TR 14049 provides generic examples of possible implementations. According to EN ISO 14044, allocation relies on being able to link unit processes within a product system by simple material or energy flows. The following allocation principles are applicable to co products, internal energy allocation, services (e.g. transport, waste treatment), and to recycling, either open- or closed-loop:

— the study shall identify the processes shared with other product systems and deal with them according to the procedure summarised below;

— the sum of the allocated inputs shall be equal to the unallocated inputs of the unit process and the sum of the allocated outputs shall equal the unallocated outputs of the unit process;

— whenever several alternative allocation procedures seem applicable, a sensitivity analysis shall be conducted to illustrate the consequences of departure from the selected approach.

The allocation procedures described in EN ISO 14044 can be summarised as:

Step 1: Whenever possible, allocation should be avoided by:

— dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub processes;

— expanding the product system to include the additional functions related to the co products.

Step 2: Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them, i.e. they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system. The resulting allocation will not necessarily be in proportion to any simple measurement such as the mass or molar flows of co-products.

Step 3: Where a physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way which reflects other relationships between them. For example, input and output data might be allocated between co products in proportion to the economic value of the products.

These allocation principles and procedures also apply to reuse and recycling situations. Here, EN ISO 14044 gives additional guidance and requirements:

— reuse and recycling may imply that the inputs and outputs associated with unit processes for extraction and processing of raw materials and final disposal of products are to be shared by more than one product system;

— reuse and recycling may change the inherent properties of materials in subsequent use;

— specific care should be taken when defining system boundary with regard to recovery processes.

Several allocation procedures are applicable for reuse and recycling:

a) a closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials. However, the first use of virgin materials in applicable open-loop product systems may follow an open-loop allocation procedure outlined in b);

b) an open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.

The allocation procedures for reuse and recycling should use, as the basis for allocation, if feasible, the following order:

c) physical properties (e.g. mass);

d) economic value (e.g. market value of the scrap material or recycled material in relation to market value of primary material); or

e) the number of subsequent uses of the recycled material (see ISO/TR 14049).

An allocation can be avoided if the system is expanded so as also to include the secondary use system. If this solution is not chosen, an allocation situation is at hand.

When allocation cannot be avoided it is recommended to apply different allocation methods as a means of sensitivity analysis.

Credits given to account for co-products of production processes or for secondary products obtained through recovery of used products (i.e. co-products of a product system) do not constitute a system expansion. They are rather an approach to allocate co-products. Crediting shall therefore follow allocation requirements as defined in this technical report

EXAMPLE 1 Allocation for transportation of packaged products.

A life cycle assessment of a packaging includes the transport of the packaged product and the packaging from the producer to the user. During this transport, both packaging and products are transported. When the products are not included in the system boundaries of the life cycle assessment, an allocation of the transport energy consumption and the emissions should be calculated. This means that a method for the determination of the share of the environmental aspects due to the packaging and the products should be developed, in order to enable the calculation of the environmental aspect related to the packaging itself. Specific characteristics of the packaging (e.g. the form, the strength, requirements for filling and how stackable the packaging is) have an influence on the transport, and this should be entirely allocated to the packaging. This means that the allocation rule should be carefully chosen, and the transport phases carefully analysed.

Since markets demand specific products, delivered in specific quantities and specific states at specific times to specific locations, all this information should be used to define the system boundaries and functional unit. The packaged product in the packaging system should be specifically described. Although the packaged product might not be included in the packaging system, it is the focus of the packaging specification and can significantly influence re-use, recovery, recycling, and disposal options.

There are particular instances when a life cycle assessment should be conducted without separating the products from its packaging.

EXAMPLE 2 Allocation of product.

When product losses occur in the packaging system, the life cycle inventory data of the product should be included for the fraction of the product that is lost. For example, the use of some packaging may result in product loss, as the consumers do not use the entire product due to packaging characteristics. This could apply to certain packaging types used, for instance, for toothpaste, fruit syrup, yoghurt or ketchup.

There are particular instances when the results of the life cycle inventory of a packaging system should be seen in relation to the results from the total distribution function, i.e. with the product included.

EXAMPLE 3 Allocation in open-loop recycling of post-consumer packaging waste.

A used plastic package is recovered and recycled in order to be used as a secondary raw material in a different packaging system (an example for product systems coupled in such a way are a PET bottle recycled into a PET flake which is converted into a rigid deep-drawn PET package). The PET raw material therefore has two uses (first as a bottle, then as a rigid packaging) and it must be considered how to allocate the effect of PET production between both product systems. The way this is usually approached in practice is to look at the overall benefit achieved by replacing virgin raw material (here in the rigid PET packaging product system) with secondary raw material (here PET flakes from the PET bottle product system). The allocation procedure shares the environmental savings (often referred to as "credit") between both product systems.

As there is no scientifically unambiguous and generally accepted way to do this, conventions have to be applied. Whatever convention is chosen, it shall always be in agreement with the allocation principles of EN ISO 14044. For instance, one could decide to account the full credit to the product system which provided the recyclate or − the opposite way – to the product system which takes up the recyclate. However, the credit cannot be accounted fully to both product systems at the same time as this would violate the rule that the overall result after allocation shall equal the total result before allocation. It is therefore important to ensure that the credit is only accounted for once. This does of course imply the option to share the credit between the two product systems in a defined ratio.

Whatever allocation conventions are chosen there are a number of points it should be critically scrutinized against:

— it should be in accordance with the objectives of a study;

— it should be explained in the study report by making reference as to how it aligns with the EN ISO requirements;

— it should be consistently applicable across all product systems;

— it should not permit double counting;

— it should have internal logic and should not contradict common sense.

One should also bear in mind that being a convention by EN ISO standard it is indispensable to carry out sensitivity analysis in order to analyse the relevance of the chosen allocation procedure **and its impact** on the final LCA result.

4.2.4 Data Quality

The data quality of a life cycle assessment should be assured by following the basic principles and requirements in EN ISO 14040:2006, 5.2.4 and EN ISO 14044:2006, 4.2.3.6. Note that life cycle methodology is still developing and future modification of these basic principles could occur.

Data quality requirements specify in general terms the characteristics of the data needed for the study. Descriptions of data quality are important to understand the reliability of the study results and properly interpret the outcome of the study (EN ISO 14040:2006, 5.2.4).

Data selected for an LCA depend on the goal and scope of the study. Such data may be collected from the production sites associated with the unit processes within the system boundary, or they may be obtained or calculated from other sources. In practice, all data may include a mixture of measured, calculated or estimated data (EN ISO 14044:2006, 4.2.3).

The data quality requirements should address the following aspects (EN ISO 14044:2006, 4.2.3.6.2):

a) time-related coverage: age of data and the minimum length of time over which data should be collected;

b) geographical coverage: geographical area from which data for unit processes should be collected to satisfy the goal of the study;

c) technology coverage: specific technology or technology mix.

One of the most difficult steps in an LCA for a packaging and distribution system is the data collection. Data is often hard to find, is requested from a large number of different activities, and may be confidential. Data collection should therefore be expected to be a time consuming process. ISO/TS 14048 describes handling and transparent reporting of LCI data.

Methodological choices, precision, completeness and representativeness of data, as well as review processes may vary from one database to another. If data from databases is used, it should if possible be extracted from databases meeting the same requirements to ensure consistency.

To this end the European Commission, through the EU Platform on LCA is coordinating the International Reference Life Cycle Data System (ILCD) [2], which will ensure a common set of quality, method, documentation, nomenclature and review requirements for different LCA applications. The ILCD will also include datasets from the European Reference Life Cycle Database (ELCD) [3], which provides a number of life cycle inventory data sets of the most common goods and services representing the EU scenario.

Packaging and distribution systems are individually customised and therefore difficult to generalise. Great caution must therefore be exercised when considering using secondary data from databases particularly where this data is poorly documented, the sources not evident and the applicability for the given study hard to determine.

For packaging and distribution systems, the differences e.g. in distribution distances and energy models for different countries are important sources of variation and full transparency is essential for data used and the assumptions made.

4.2.5 Boundary between packaging and the products

It is important to make a clear description of the boundary between the packaging and the packaged product. The packaged products (and aspects of their processing) are usually not included in the life cycle assessment of a packaging system.

However, some particular aspects of the packaged product should be considered when they are directly connected to the packaging. For an illustration of a typical system boundary between the packaging and the packaged product, see the schematic drawing in Figure 3.

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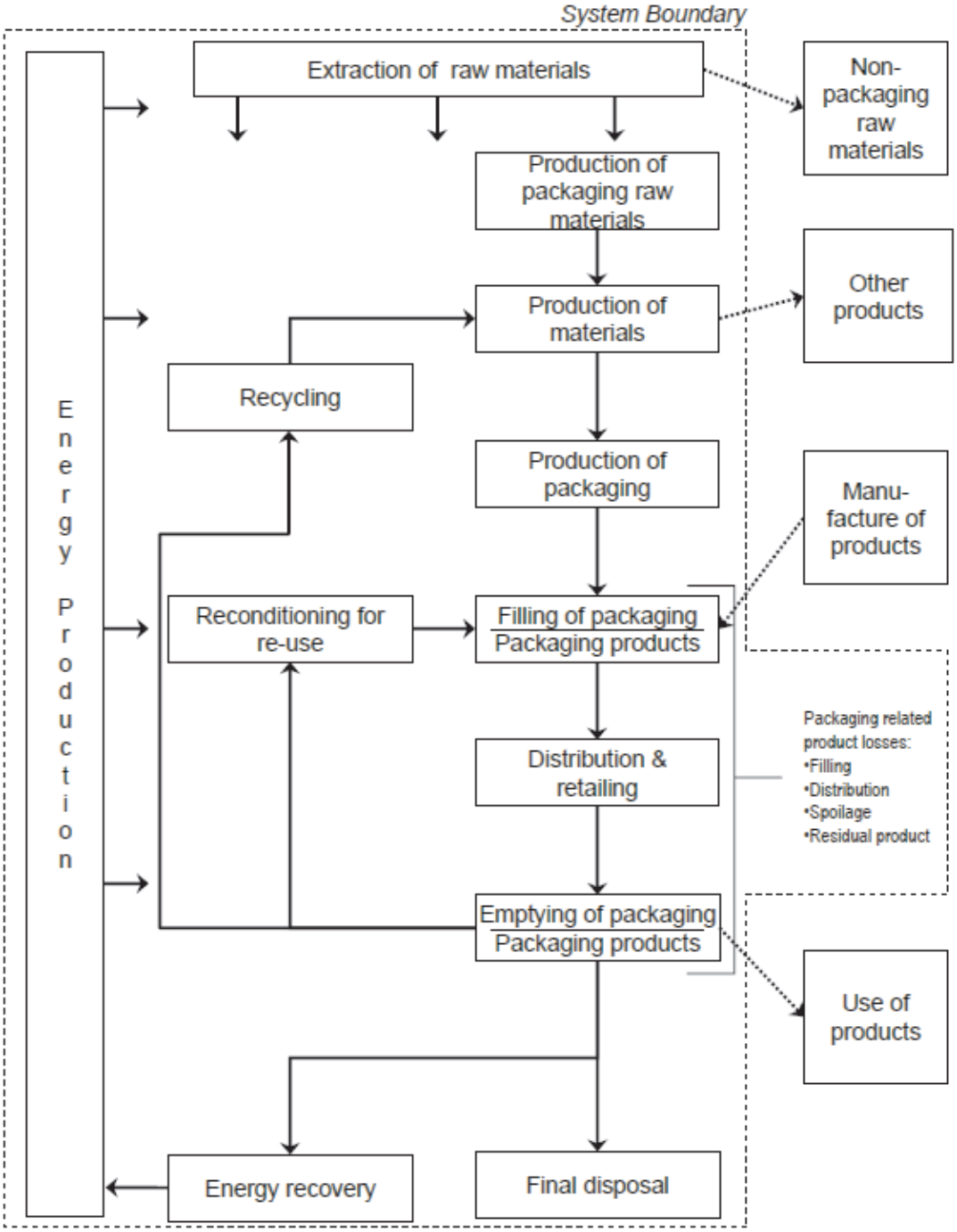

Figure 3 — Example of the boundaries of a packaging LCA

NOTE All processes described in Figure 3 are normally associated with transportation; this should always be considered when LCA of a packaging is performed.

4.3 Life cycle inventory analysis

Life cycle inventory analysis is covered by EN ISO 14044 and EN ISO 14040. Provisions of this standard shall fully apply to life cycle inventory analysis of packaging.

Inventory analysis involves data collection and calculation procedures to quantify the relevant inputs and outputs of a product system. These inputs and outputs include the use of resources, and the emissions to air, water and soil associated with the system. Interpretations may be drawn from these data, depending on the goals and scope of the LCA. These data also constitute the input to the life cycle impact assessment.

4.4 Life cycle impact assessment

4.4.1 General

Life cycle impact assessment is covered by EN ISO 14044. Provisions of this standard shall fully apply to life cycle impact assessment of packaging.

Special attention shall be drawn to the arrangements applicable to reporting and critical review, as well as to those applicable to comparative assertions intended to be disclosed to the public.

According to EN ISO 14044, impact categories should be internationally accepted. Characterisation models and factors should be scientifically and technically valid and category indicators should be environmentally relevant.

In the context of the International Reference Life Cycle Data System (ILCD) [2], the Joint Research Centre of the European Commission, is developing recommendations on LCIA models and factors. These recommendations address both impact categories on midpoint level and areas of protection and reflect the level of scientific consensus on the different models and factors.

EN ISO 14044 states that the selection of impact categories shall reflect a comprehensive set of environmental issues related to the product system being studied, taking goal and scope into consideration.

A key strength of LCA is the ability to look not just along the length of the life cycle but also across a breadth of different impact categories. A well conducted study can help prevent burden shifting, not only between life cycle stages but also between impact categories.

Restricting an assessment to one impact category, as in for example carbon footprinting, gives only partial, and therefore potentially misleading, information.

4.4.2 Single impact category indicators

4.4.2.1 General

Despite the requirements of the EN ISO standards quoted in the above clauses, single impact category indicators − such as carbon footprint, water footprint and energy footprint − are becoming increasingly promoted and used, for instance for policy making or for marketing purposes, including product comparisons. Such indicators are easy communication tools but they are of limited meaning from an overall environmental perspective: they give only a partial view of the total picture illustrating the interactions of the system with the environment.

Decisions based on such single impact category indicators may be useful for pursuing very specific objectives, for instance in determining political priorities of the moment or comparison of products from a very specific aspect or perspective. They do not however provide for the risk of shifting environmental burdens of the system under study from one phase to another phase of the life cycle, or from one environmental aspect to another.

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When single impact category indicators are used, in order to properly reflect the part of the reality they are deemed to represent, they should always take into account all the stages of the life cycle of the system.

As the underlying assumptions and choices (boundaries, allocation rules, data selection, choice of scenarios, etc.) may have a significant influence on the results of the calculation and of the assessment, it is also of critical importance that these assumptions and choices are clearly explained and properly documented and justified (see 4.3 and 4.4 above).

Eventually, it is also part of the role of the reviewer(s) to ensure that the assumptions and choices made for calculating these single impact category indicators fit with the goal and scope of the assessment and that the limitations associated with their use are properly highlighted for a good understanding of the results by the targeted audience (see the requirements quoted in the relevant following clauses).

NOTE The "Ecological Footprint", expressing humanity's demand on nature in land or sea area terms, is not a single aspect indicator and is not the result of an EN ISO-compliant life cycle assessment.

4.4.2.2 Carbon footprint

The carbon footprint is a sub-set of the data covered by a more complete Life Cycle Assessment (LCA). One of the key impact categories considered in an LCA is climate change, typically using the IPCC [1)] characterization factors for CO_2 equivalents. Hence, a carbon footprint is a life cycle assessment with the analysis limited to emissions that have an effect on climate change.

Although building upon a life cycle approach, carbon footprints address only impacts on climate change; they give only fragmentary, and thus possibly misleading, information. When exclusively carbon footprint data are used to support decisions or to improve goods and services, other important environmental impacts are neglected while often running opposite to climate change, resulting in a "shifting of burdens". Achieving sustainable consumption and production requires the consideration and evaluation of all relevant environmental impacts at the same time. This can only be ensured by the more complete Life Cycle Assessment.

Single issue or impact indicators, such as carbon footprint, for packaging should be avoided as the packaging system is designed to fulfil its function in relation to the contained product and the physical distribution system.

4.5 Life cycle interpretation

4.5.1 General

Interpretation is the phase of LCA in which the findings from the inventory analysis and the impact assessment are combined together, or, in the case of life cycle inventory studies, the findings of the inventory analysis only, consistent with the defined goal and scope in order to reach conclusions and recommendations.

Life cycle interpretation is covered by EN ISO 14044 and EN ISO 14040. The provisions of these standards shall fully apply to life cycle interpretation of packaging.

According to EN ISO 14044 the results of the LCI or LCIA phases shall be interpreted according to the goal and scope of the study, and the interpretation shall include an assessment and a sensitivity check of the significant inputs, outputs and methodological choices in order to understand the uncertainty of the results.

When defining the goal and scope of a dedicated packaging LCA study special attention should be drawn to :

a) time, where it has to be considered that:

1) www.ipcc.ch.

1) an LCA study of packaging relates to one or more specific packaging and distribution systems at one defined point in time; and

2) packaging characteristically has a short life cycle and is subject to a continuous change of specifications to adapt to for example, changing consumer preferences;

b) geography, where it has to be considered that:

1) a packaging system may consist of a multitude of different raw materials with supply chains spread across several countries or even continents;

2) the characteristics of packaging and packaging systems may change between different geographies (e.g. specific market requirements; culturally influenced consumer preferences; specific market structures, distribution channels and waste management infrastructure; differing climate conditions);

c) technology.

As a first step within "interpretation" it should be checked which reference (time, geography, technology) has been aimed at in the dedicated study and whether the data and modelling choices used support the intended data quality and representativeness and thus the goals of the study. If the data used do not fully support the intended data quality there is a potential limitation of the use of the results.

In addition, if the study is a comparative one it is necessary to check whether the time, geographical and technical references are symmetrically met across the packaging systems compared. Again, if this is not the case there is a further potential limitation of the study to be dealt with.

A very common issue in interpretation of results of impact assessments is related to use of LCA software. LCA software usually has built-in inventory datasets and built-in impact assessment algorithms in order to calculate impact indicator results from the modelled life cycle inventories. While this is very convenient and practical, the risk is that asymmetries in the inventories remain undiscovered. Toxicity impact categories may be especially affected.

To date, toxicity assessment methods still have to face considerable data asymmetries of inventory datasets. In aggregated datasets such asymmetries are often "masked" by the fact that asymmetric process data are combined with generic energy generation data. The latter – due to their generic character − are usually based on extensive inventory lists. Thus, while the aggregated datasets available for free or in commercial databases may appear symmetric, examination of the underlying unit process data is likely, in many cases, to reveal asymmetries.

Consistency checks in this area during study interpretation are of the utmost relevance in order to avoid wrong conclusions when considering LCIA results.

4.5.2 Key data points, setting and assumptions

The following areas are of particular importance when interpreting packaging LCA results:

a) Packaging specifications

Packaging specifications implicitly define the amount of raw materials required in a packaging system. Usually environmental impacts related to raw material production have a significant contribution to its overall environmental impact profile. In the interpretation phase it should be checked if the packaging specification applied is consistent with the goal and intended application of the study.

b) End-of-life disposal and recovery

In many cases the precise end-of-life fate of individual packaging in individual geographies is not known. Therefore it is often necessary to refer to assumptions and qualified estimates. On the other hand, the LCA results of a packaging system may easily change according to the specific mix of end-of-life routes

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(e.g. recycling versus landfill) chosen. Again, it is recommended to check during the interpretation phase whether the end-of-life routes applied are appropriate for the specific packaging materials and geographies and whether they are consistent with the goal and intended application of the study.

Likewise, the energy that may be recovered through the incineration of the used packaging should be accounted for in terms of the displaced technology which is representative of the specific European region where the incineration takes place.

c) Allocation in open loop recycling

Due to the obligations set by the European Packaging and Packaging Waste Directive in EU Member States a large share of used packaging is recovered either as energy or recycled as secondary materials. The related benefit (i.e. the credits for substitution of virgin materials or primary energy) should be treated according to the requirements for allocation addressed EN ISO 14044 and in 4.2.3 of this Technical Report.

According to the allocation method chosen, overall LCA results of a packaging system can vary substantially. In the interpretation phase it is therefore recommended to check whether allocation has been applied according to EN ISO 14044 rules and also whether it has been applied consistently for recyclate inputs and outputs of the same packaging system as well as across several packaging systems in the case of comparative assertions.

d) Grid mixes behind electricity assumed for converting of packaging raw materials and the finished packaging

There is significant variation in the energy models in place in different European regions. The choice of energy model shall reflect the identified geographical boundaries of the packaging system.

This very often does not allow a high degree of generalization of study conclusions. In the interpretation phase it should therefore be checked whether the conclusions and recommendations are consistent with the scope of the study.

4.5.3 Limitations, uncertainties and significance of results

Despite the scientific background and the power of LCA as a tool for assessing the environmental impacts of product systems, limitations exist. EN ISO 14044 insists repeatedly on the importance of taking these limitations into proper account.

All areas previously addressed in this subsection bear the potential of adding limitations to the study through the existence of uncertainties, asymmetries and the introduction of subjective aspects, for instance. through assumptions. On the other hand, the objective of conducting an LCA is to obtain robust results for reliable decision making. In order to be able to evaluate the robustness of a study's results it is necessary to analyse to which extent the known uncertainties, asymmetries and subjective aspects may influence the results.

For this purpose it is recommended to work along the following steps when dealing with a packaging LCA:

a) identify significant parameters and issues (e.g. using the previously described check of key data and settings);

b) scrutinise the underlying data and assumptions;

c) conduct a sensitivity analysis to find out whether uncertainties around datasets and settings can significantly change the study results (e.g. by using alternative datasets, or by changing the settings within certain ranges).

In the case that a sensitivity analysis shows that LCA results and the related conclusions may change by the choice of datasets or settings, this also indicates that there are limitations to the study. Such limitations shall be clearly stated in the LCA report.

EXAMPLE 1 The results of a study are valid for a certain recycling rate, but change below that rate. Then it should be stated that those results cannot be generalized and only apply for recycling rates within a range x to y.

Beyond the specific limitations which can only be identified in the course of an individual LCA study there are also implicit limitations given already by the initial scope of a packaging LCA.

EXAMPLE 2 A study of current systems would not indicate which would be the best option in, for example, five years time. This would require a separate study using different data, reflecting future opportunities not always apparent at the point when the study is conducted.

A distribution system is dependent on local conditions, which may vary considerably throughout Europe. Results of a study for a specific geography can therefore not automatically be applied to other geographies.

All limitations, even the implicit ones, shall be clearly stated in a packaging LCA report.

5 Presentation and communication

The presentation and communication of a life cycle assessment should follow the principles and requirements given in EN ISO 14040 and EN ISO 14044.

6 Critical review

The establishment of a critical review procedure should follow the principles and requirements given in EN ISO 14040 and EN ISO 14044.

7 Further requirements and aspects to consider

7.1 General limitations of LCA as a tool/method

LCA typically excludes spatial, threshold and dose-response information, and combines emissions or activities over space and time. Therefore, LCA does not characterize the risk or safety of a technology. That is better performed by risk assessment.

In order to contribute to the overall objective of sustainable development, LCA is only one tool in the toolbox and any decision making process should also take into account social and economic aspects such as function value of the packaging, e.g. protection, hygiene, safety, consumer acceptance, costs and convenience.

7.2 Limitations in the context of specific areas of application of packaging LCAs

7.2.1 General

Applying an LCA to packaging is one of several tools available for the continuous improvement of the environmental performance of packaging systems. The life cycle approach encompasses the whole life cycle of the packaging, i.e. material extraction, manufacture of packaging, service performance to the packaged product, post-use collection, recovery or disposal. It should be stressed that the results of the inventory analysis stage represent a solid basis for the improvement of industrial processes involved with packaging, as well as of the packaging itself.

Another application of LCA in packaging is to provide support for the design of new packaging for improved environmental performance.

LCAs can also be used for marketing purposes, for strategic planning or for better informing deciders in policy making.

7.2.2 Comparative packaging LCAs

Comparative LCAs on packaging may be considered as one of the elements supporting decision-making processes. However, great caution and consideration are necessary, as a number of limitations are applicable and very significant interpretation issues arise. LCA cannot be used to decide whether a packaging fulfils the essential requirements, nor can it serve to justify prohibiting the use of packaging which meets those requirements. LCA is a method which only examines the impact on the environment, and leaves aside Directive 94/62/EC's other, equally important, aim, which is to ensure the functioning of the internal market. [2)]

Only significant differences should be noted and the proportionality test is recommended to judge the environmental impact of the packaging in relation to the impact of the product it contains.

According to the EN ISO standards on LCA, a critical review is mandatory for comparative assertions disclosed to the public, "since this application is likely to affect interested parties that are external to the LCA study" (EN ISO 14040:2006).

Comparison of inventory results for different packaging shall only be made in case of the same packaging purpose. This usually results in a different quantity of packaging depending on the material used.

This, however, is not sufficient to ensure a correct comparison, as differences in system boundaries (e.g. raw material acquisition and allocation rules), system functions, assumptions, data quality, etc. unavoidably occur. Even small differences can have decisive consequences, and incorrect use of packaging life cycle inventory results can lead to wrong conclusions. Such misuse of life cycle inventory analyses might be a problem for the packaging sector, as well as for packaging users, and should be avoided.

LCA of different materials used for the same packaging purpose should be interpreted with great caution. There is no certainty that one packaging material can fulfil the same functions as another material.

An inventory analysis is not a life cycle assessment, and the environmental effects of the inventory are not evaluated in life cycle inventory analysis. Users should keep in mind, that the results of a life cycle inventory analysis should not be over-interpreted.

It is highly recommended to explain the range of uncertainty of the results, due for instance to the assumptions made, to the quality of the data, and to uncertainties on end-of-life scenarios, and the threshold under which differences in results can be considered as insignificant.

7.2.3 Packaging function and logistics

The main purpose of packaging is to rationalise distribution of product and thereby save resources in logistics and prevent resources being lost by protecting the quality of the products.

The packaging design is therefore a trade-off between the resources needed for packaging, and the potential savings of resources in the distribution system and those achieved through avoiding product losses.

Special attention should be drawn to the geographical boundaries of the distribution system which should reflect the fact that the proper functioning of the internal market involves the long-distance transportation of goods. [3)]

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2) ECJ Advocate General, Ruiz-Jarabo Colomer, in Case C-246/99 Comission v Kingdom of Denmark, point 38.

3) Conclusions in Case C-246/99, point 47 as well as judgments in Cases C-463/01 Commission v Germany and C-309/02 Radlberger & Spitz.

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Annex A
(informative)

Cross-references

EN ISO 14040 standards, EU Directives and other CEN Reports	**CEN Report on LCA of Packaging**
EU Directive on packaging and packaging waste (94/62/EC)	Introduction
EN ISO 14040, *LCA — Principles and framework*	1 Scope
EN ISO 14040*, LCA — Principles and framework* EN ISO 14044, *LCA — Requirements and guidelines* ISO/TS 14048*, LCA — Data documentation format* EN 13193, *Packaging and the environment — Terminology*	2 Normative references
EN ISO 14040, *LCA — Principles and framework* EU Directive on packaging and packaging waste (94/62/EC) ISO/TC 207, Terms and definitions EN 13193, *Packaging and the environment — Terminology*	3 Terms and Definitions
EU Directive on packaging and packaging waste (94/62/EC)	4 Criteria and methodology for LCA of packaging
EN ISO 14040:2006, *LCA — Principles and framework*, 4.2 EN ISO 14044:2006, *LCA — Requirements and guidelines*, Introduction	4.1 General
EN ISO 14040:2006, *LCA — Principles and framework*, 5.2 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.2	4.2 Goal and scope definition
EN ISO 14040:2006, *LCA — Principles and framework*, 5.2.2 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.2.3.2	4.2.2 Function, functional unit and reference flow
EN ISO 14040:2006, *LCA — Principles and framework*, 5.3.4 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.3.4	4.2.3 Allocation
EN ISO 14040:2006, *LCA — Principles and framework*, 5.2.4 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.2.3.6	4.2.4 Data quality
EN ISO 14040:2006, *LCA — Principles and framework*, 5.2.3 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.2.3.3	4.2.5 Boundary between packaging and the products
EN ISO 14040:2006, *LCA — Principles and framework*, 5.3 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.3	4.3 Life cycle inventory analysis
EN ISO 14040:2006, *LCA — Principles and framework*, 5.4 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.4	4.4 Life cycle impact assessment
EN ISO 14040:2006, *LCA — Principles and framework*, 5.5 EN ISO 14044:2006, *LCA — Requirements and guidelines*, 4.5	4.5 Life cycle interpretation
EN ISO 14040:2006, *LCA — Principles and framework*, Clause 6 EN ISO 14044:2006, *LCA — Requirements and guidelines*, Clause 5	5 Presentation and communication
EN ISO 14040:2006, *LCA — Principles and framework*, Clause 7 EN ISO 14044:2006, *LCA — Requirements and guidelines*, Clause 6	6 Critical review

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[1] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste

[2] International Reference Life Cycle Data System (ILCD): http://lct.jrc.ec.europa.eu/eplca/deliverables/international-reference-life-cycle-data-system-ilcd-handbook

[3] European Reference Life Cycle Database (ELCD): http://lct.jrc.ec.europa.eu/assessment/data

[4] EN 13193:2000, *Packaging — Packaging and the environment — Terminology*

[5] ISO/TS 14048:2002, *Environmental management — Life cycle assessment — Data documentation format*

[6] ISO/TR 14049:2000, *Environmental management — Life cycle assessment — Examples of application of ISO 14041 to goal and scope definition and inventory analysis*

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