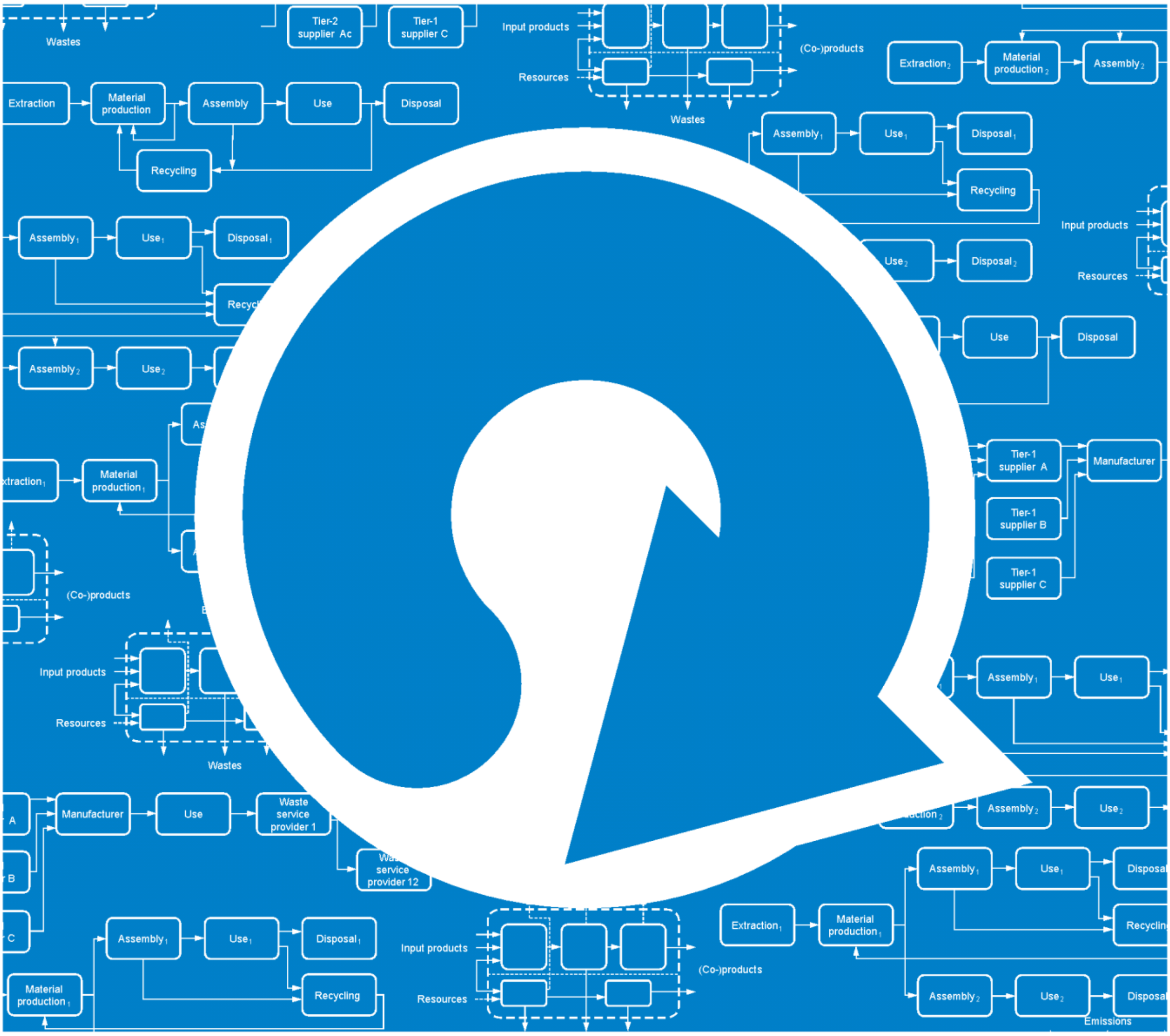
ILCD handbook

International Reference Life Cycle Data System



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Specific guide for Life Cycle Inventory data sets

First edition

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Preface

To achieve more sustainable production and consumption patterns, we must consider the environmental implications of the whole supply-chain of products, both goods and services, their use, and waste management, i.e. their entire life cycle from “cradle to grave”.

In the Communication on Integrated Product Policy (IPP), the European Commission committed to produce a handbook on best practice in Life Cycle Assessment (LCA). The Sustainable Consumption and Production Action Plan (SCP) confirmed that “*(…) consistent and reliable data and methods are required to asses the overall environmental performance of products (…)*”. The International Reference Life Cycle Data System (ILCD) Handbook provides governments and businesses with a basis for assuring quality and consistency of life cycle data, methods and assessments.

It condensed document provides guidance for developing Life Cycle Inventory (LCI) data sets, which contain all emissions and resources that are associated with the life cycle of the analysed process or product. The principal target audience of this document is the experienced Life Cycle Assessment practitioner in the public and private sector, aiming to develop consistent and good quality Life Cycle Inventory data sets.

It is accompanied by the more comprehensive "General guide for Life Cycle Assessment - Detailed guidance" document.

Executive summary

Overview

Life Cycle Thinking (LCT) and Life Cycle Assessment (LCA) are the scientific approaches behind modern environmental policy and business decision support related to Sustainable Consumption and Production (SCP).

The International Reference Life Cycle Data System (ILCD) provides a common basis for consistent, robust and quality-assured life cycle data and studies. Such data and studies are indispensible for coherent and reliable SCP policies and their implementation, such as Ecolabelling, Ecodesign, Carbon footprinting, and Green Public Procurement.

This guide is a component of the International Reference Life Cycle Data System (ILCD) Handbook. It provides guidance for developing Life Cycle Inventory (LCI) data sets, which contain all emissions and resources that are associated with the life cycle of the analysed process or product. This guide is based on and conforms to the ISO 14040 and 14044 standards on Life Cycle Assessment.

The principal target audience of this document is the experienced Life Cycle Assessment practitioner in the public and private sector, aiming to develop consistent and good quality Life Cycle Inventory data sets.

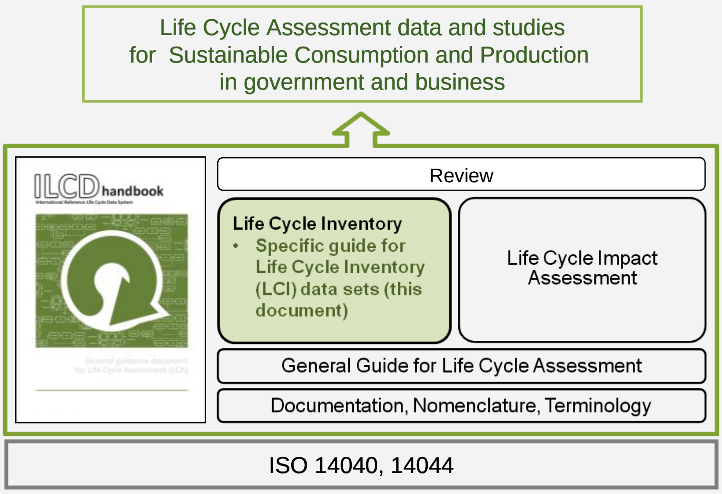
About the International Reference Life Cycle Data System (ILCD)

The International Reference Life Cycle Data System (ILCD) consists primarily of the ILCD Handbook and the ILCD Data Network. The ILCD Handbook is a series of technical documents providing guidance for good practice in Life Cycle Assessment in business and government.

The ILCD Handbook also serves as a "parent" document for developing ILCD compliant sector and product-group specific guidance documents, criteria and simplified tools.

The ILCD Data Network provides consistent and quality-assured life cycle data from various organisations that are compliant with the requirements of the ILCD Handbook.

Role of this document within the ILCD Handbook



This "Specific guide for Life Cycle Inventory (LCI) data sets" builds on its parent document "General guide for Life Cycle Assessment (LCA)". It draws on the provisions of the general guide and derives from them a focussed guidance for inventory data set development.

Two separate review documents provide the provisions for critical review of the resulting LCI data sets; they are referenced from this present document.

This guide is further supported with an LCI data set documentation format, a document on nomenclature and other conventions, and a terminology overview. These supporting documents and applications are available separately.

Approach, and key issues addressed in this document

This document is differentiated by the main types of questions that are addressed with LCA studies. These are micro-level decisions support studies for example on specific products, meso/macro-level decision support studies e.g. on strategic policy or technology questions, and accounting-type studies.

As in its parent document, the "General Guide for LCA", key methodological issues also of this document evolve among others around the questions of how to collect and develop data, how to model the life cycle of a system (e.g. product), and how to share impacts among co-products in case of co-production.

CONTENTS

FIGURES

TABLES

1 Introduction

Overview

This document follows the main structure of its parent document "General guide for Life Cycle Assessment (LCA) - Detailed guidance" and hence the ISO14044:2006 structure.

The Provisions that make up the main part of this document are complemented by brief introduction and overview paragraphs at the beginning of the principal chapters, and by the principal tables and figures that directly support the Provisions.

Note that the original chapter, figure and table numbers and cross-references to the main text chapters of the parent document "General guide to LCA - Detailed guidance" are kept to ease cross-checking with the detailed guidance texts.

Related topics addressed in other ILCD Handbook components

A number of nomenclature and other conventions help to improve compatibility of data sets developed along this document and ease the comprehension of LCA study reports; more details are provided in the separate document "Nomenclature and other conventions".

The electronic LCI data set format supports effective and compatible reporting of LCI work. It is supported by a data set editor application and a complete set of reference elementary flows, flow properties and units.

The detailed provisions for review of LCI and LCA work are given in the separate guidance documents on "Review schemes for Life Cycle Assessment (LCA)", "Reviewer qualification for LCI data sets", and "Review scope, methods, and documentation".

Provisions: 2 How to use this document

I) SHALL[1] - **ILCD Handbook compliance:** A LCI data set can claim compliance with the ILCD Handbook. For this they shall have been developed in line with the provisions of this document as specified in the "Provisions", including the provisions made in referenced documents and complementing information that may be given in the general guide for Life Cycle Assessment (LCA) – Detailed guidance, e.g. in supporting tables or in the "terms and concepts" boxes. The following applies to compliance statements (2.3[2]): [ISO+][3]

- I.a) The compliance statement shall refer to the applicable Situation A, B, C1, and/or C2.
- I.b) ILCD compliance is structured into five compliance aspects that shall all be met for full compliance: Data quality, Method, Nomenclature, Review, and Documentation (chapter 12.4 gives the details).

[1] The meaning of the SHALL, SHOULD and MAY settings is explained in Provision II) in this set of "Provisions: 2 How to use this document".

[2] The sub-chapter of the "General guide for Life Cycle Assessment (LCA) – Detailed guidance" that has more details on a specific provision is given in brackets at the end of the main provision.

[3] The meaning of the (ISO!) and [ISO+] settings is explained in Provision III) in this set of "Provisions: 2 How to use this document".

I.c) Partial compliance can be claimed in a structured way by referring to any of the above five aspects, but it shall be clearly communicated in such cases that full compliance has not been achieved.

I.d) LCI data sets, the overall data quality level attained should be documented in the data set as "High quality", "Basic quality", or "Data estimate" (see chapter 12.3 and tables of that chapter for details and definitions). The performed review type and reviewer(s), if any, shall also be identified in the data set.

I.e) When claiming compliance, the applied version or edition of the ILCD "Specific guide for Life Cycle Inventory (LCI) data sets" shall be identified in connection to the claim.

I.f) When a new version of an ILCD Handbook component has been published, the provisions of that new version shall be applied, overruling the ones of the former version. The provisions of the preceding version can per default still be applied for ongoing studies up to a maximum of 9 months after publication of the new version. These 9 months can be modified and overruled by different provisions of ILCD system operators. If a new version of any applicable ILCD component has been published but an older version is used, the name of the component and the publication date of the new version shall be clearly and in a prominent place be identified in the study report or other deliverable that claims compliance.

II) SHALL - **Shall, should, may:** The expression "SHALL", "SHOULD" and "MAY" in front of a (main) provision identifies its requirement status (2.3):

II.a) "SHALL": the provision is a mandatory requirement and must always be followed, unless for specifically named exceptions, if any.

II.b) "SHOULD": the provision must be followed; deviations are permissible if they are clearly justified in writing for the given case, giving appropriate details. Reasons for deviations can be that the respective provision or parts of it are not applicable, or if another solution is clearly more appropriate. If the permissible deviations and justifications are restricted, these are identified in the context of the provision.

II.c) "MAY": the provision is only a methodological or procedural recommendation. The provision can be ignored or the issue addressed in another way without the need for any justification or explanation. NOTE: Instead of "may" the equivalent term "recommended" is sometimes used.

II.d) The requirement status also applies to all subsequent provisions on a lower hierarchy-level (e.g. under a provision "II" also all sub-provisions "II.a", "II.b", etc.). If a provision is differentiated (e.g. a "should" or "may" under a "shall" provision), this is explicitly formulated in the provisions text.

III) **For information/orientation only - ISO specifications and additions:** Single provisions on items that are not covered by ISO 14044:2006 are generally marked as "[ISO+]"; additionally the right border of the frame next to that provision is a dashed orange line (instead of the default dotted-dashed green line). Provisions where the ILCD provisions are more strict or specific than that which follows from applying ISO 14044:2006 are generally marked as "[ISO!]"; furthermore, the right border of the frame next to that provision is a solid red line. [ISO+]

IV) MAY - **ISO conformity:** The document has been developed with the aim of being in line with ISO 14040 and 14044:2006, in the sense that an ILCD compliant study will also conform with ISO 14040 and 14044:2006. If conformity with ISO 14040 and 14044:2006 is aimed at for an LCI data set, it is nevertheless recommended to have this confirmed as part of a critical review.

V) SHALL - **Contradictions or inapplicabilities:** In the case of contradictions among provisions, or inapplicability of any provision in the ILCD Handbook (i.e. in this document and other ILCD Handbook documents), an LCI data set can claim compliance with the ILCD Handbook if the following three requirements are met by the study (2.4):

V.a) a) All other, unaffected provisions of the ILCD Handbook documents have been applied.

V.b) b) The general or case-specific contradiction or inapplicability is clearly identified and demonstrated. In such cases, the provision shall be used that best meets the ISO 14040 and 14044:2006 requirements.

V.c) c) If a critical review is required: The reviewer is confirming the compliance of the study or other deliverable to the above two requirements a) and b).

VI) MAY - **Differences A, B, C1, C2:** A condensed, indicative overview is given on the main LCI modelling differences among the Goal Situations A, B, C1, and C2 (2.2.3). [ISO+]

3 Key definitions

The following key definitions are newly introduced terms or ISO terms that are used by different LCA practitioners with different meanings. These definitions should be read first for a clearer understanding of this document.

Table 1 Key terms and definitions

Term	**Definition**
Allocation [or: Partitioning]	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. [Source: ISO 14044:2006]
Analysed decision	Decision that is subject to an LCA study. In contrast to LCI studies and most non-comparative LCA studies stand comparative LCA studies with a direct decision context. For these the LCA study analysis a decision rather than a single process or system. Such can be for example the decision on alternative materials that are evaluated to be used for a product, the purchase of alternatives products that are compared, the decision on a policy option that is analysed regarding its environmental impact implications, and the like.
Assumption scenario	Scenario for the analysed process or system that varies data and method assumptions with the purpose of evaluating the robustness of the study results and conclusions. If more than one alternative system or option are compared, each of them would have its own assumption scenarios.
Attributional modelling [or: descriptive, book-keeping]	LCI modelling frame that inventories the inputs and output flows of all processes of a system as they occur. Modelling process along an existing supply-chain is of this type.
Best attainable consensus	Partial or full agreement of the involved parties, steered by a chair or coordinator towards the broadest possible agreement on the issue at stake. In contrast to an entirely result-open process, here a solution that fits preset requirements (e.g. "define a reasonably worst case scenario") is to be found, i.e. the 'zero-option' is not an option.
Co-function	Any of two or more functions provided by the same unit process or system.
Co-product	Any of two or more products coming from the same unit process or system. [Source: ISO 14044:2006]
Comparative assertion	Environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. [ISO 14040:2006, ISO 14025:2006]
Comparative life cycle assessment	Comparison of LCA results for different products, systems or services that usually perform the same or similar function.
Consequential modelling	LCI modelling principle that identifies and models all processes in the background system of a system in consequence of decisions made in the foreground system
Disclosed to the public	The audience is not specifically limited and hence includes non-technical and external audience, e.g. consumers.

End-of-life product	Product at the end of its useful life that will potentially undergo reuse, recycling, or recovery.
Environmental impact	Potential impact on the natural environment, human health or the depletion of natural resources, caused by the interventions between the technosphere and the ecosphere as covered by LCA (e.g. emissions, resource extraction, land use).
Functional flow	One of the (co-)product flow(s) in the inventory of a process or system that fulfils the process' / system's function See also: Non-functional flow
Monofunctional process	Process or system that performs only one function.
Non-functional flow	Any of the inventory items that are not (co-)product flows. E.g. all emissions, waste, resources but also input flows of processed goods and of services.
Multifunctional process	Process or system that performs more than one function. Examples: Processes with more than one product as output (e.g. NaOH, Cl_2 and H_2 from Chloralkali electrolysis) or more than one waste treated jointly (e.g. mixed household waste incineration with energy recovery). See also: "Allocation" and "System expansion"
Life cycle inventory (LCI) data set	Data set with the inventory of a process or system. Can be both unit process and LCI results and variants of these.
Life cycle inventory (LCI) study	Life cycle study that provides the life cycle inventory data of a process or system.
Life cycle inventory analysis results (LCI results)	Outcome of a life cycle inventory analysis that catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment. (Source: ISO 14040)
Overall environmental impact	Total of impacts on human health, natural environment and resource depletion for the considered impact categories. It can be calculated either as normalised and weighted overall LCIA results of the analysed process / system, or assuming an even weighting across impacts, i.e. for each and any of the impact categories.
Product	Any good or service; see "System".
Recycling, reuse, recovery	Note: In lack of a common parent term, these three terms are used in this document to identify these and similar activities, such as refurbishing, further use and the like. Casewise also the term "recycling" alone is used and meant to cover the entirety of these activities. See also "Secondary good".
Relevant	For LCI data sets: Having a significant influence on or contribution to the overall environmental impact of the analysed process or system, resulting in a different quality level. For LCA studies: Having a significant influence on or contribution to the overall environmental impact of the analysed process or system, resulting

	in different conclusions or recommendations.
Secondary good	Secondary material, recovered energy, reused part or similar as the product of a reuse, recycling, recovery, refurbishing or similar process.
Substitution	Solving multifunctionality of processes and products by expanding the system boundaries and substituting the not required function with an alternative way of providing it, i.e. the process(es) or product(s) that the not required function supersedes. Effectively the life cycle inventory of the superseded process(es) or product(s) is subtracted from that of the analysed system, i.e. it is "credited". Substitution is a special (subtractive) case of applying the system expansion principle.
System	Any good, service, event, basket-of-products, average consumption of a citizen, or similar object that is analysed in the context of the LCA study. Note that ISO 14044:2006 generally refers to "product system", while broader systems than single products can be analysed in an LCA study; hence here the term "system" is used. In many but not all cases the term will hence refer to products, depending on the specific study object. Moreover, as LCI studies can be restricted to a single unit process as part of a system, in this document the study object is also identified in a general way as "process / system"
System expansion	Adding specific processes or products and the related life cycle inventories to the analysed system. Used to make several multifunctional systems with an only partly equivalent set of functions comparable within LCA.
System perspective	In contrast to a unit process or a part of a life cycle, the system perspective relates to the entire life cycle of an analysed system or process. For processes that implies that the life cycle is completed. This term is used mainly in context of identifying significant issues and quantifying inventory completeness / cut-off.
Unit process	Smallest element considered in the life cycle inventory analysis for which input and output data are quantified. (Source: ISO 14040) In practice of LCA, both physically not further separable processes (such as unit operations in production plants) and also whole production sites are covered under "unit process". See also "Unit process, black box", "Unit process, single operation", and "System".
Unit process, black box	A unit process that includes more than one single-operation unit processes.
Unit process, single operation	A unit process that cannot be further sub-divided into included processes.

Some, more complex terms and concepts are explained in more detail in boxes throughout the document. See the contents of these "Terms and concepts" after the "Contents" of this document.

4 The iterative approach to LCA

Figure 5 gives an overview of the main steps of carrying out an LCI study, including the iterations.

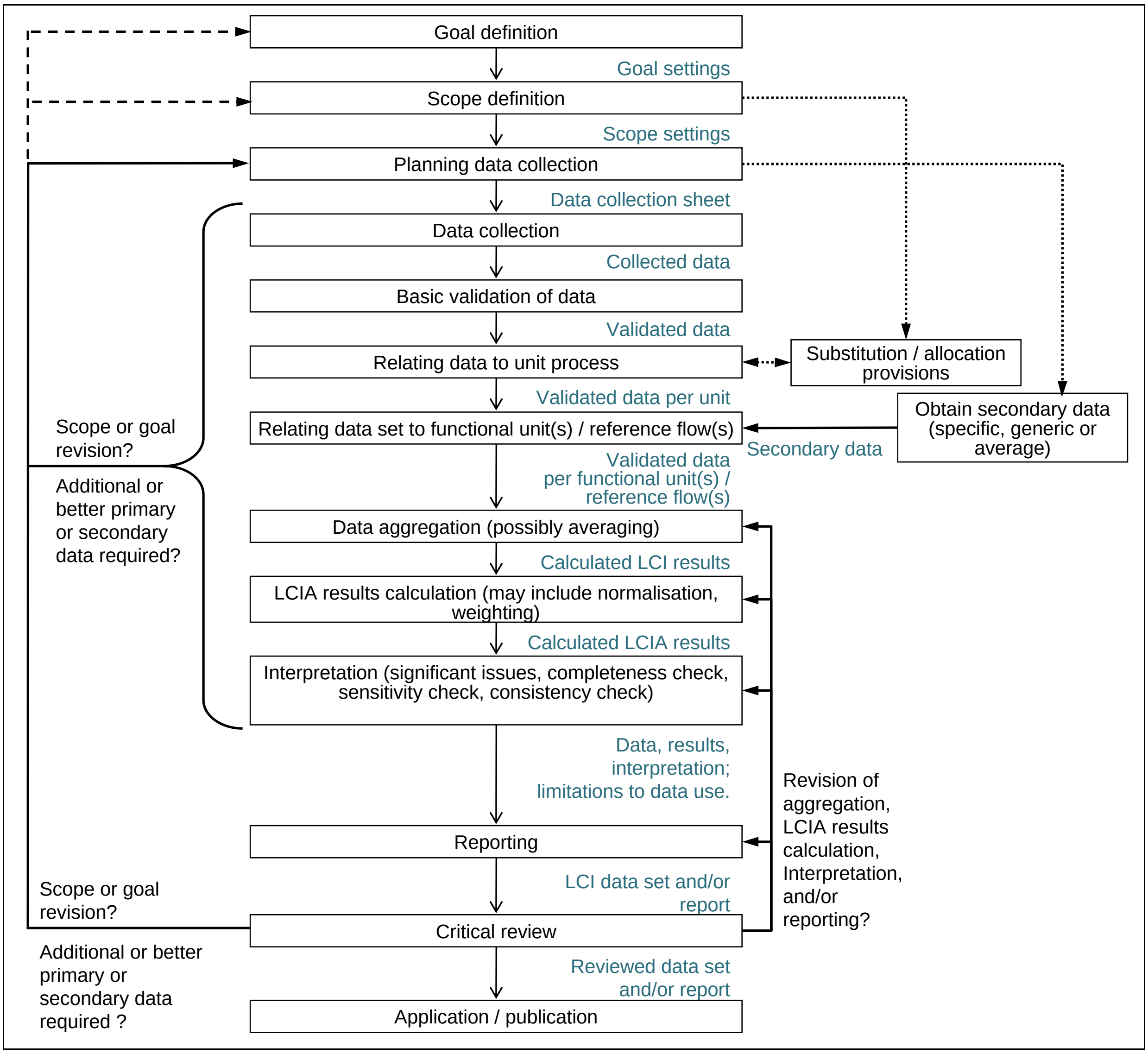


Figure 5 Details of the iterative approach to developing LCI data sets, with focus on inventory data collection and modelling (from ISO 14044:2006, modified).

Provisions: 4 The iterative approach to LCA

I) MAY - **Overview of iterative approach:** It is recommended taking an iterative approach to developing an LCI data set (for more detail see chapter 2.2.4):

I.a) Define the goal aspects as precisely as possible in the beginning of the study (see chapter 5.2).

I.b) Derive an initial scope definition from the goal definition as far as initial knowledge permits (see chapter 6).

I.c) Compile easily available Life Cycle Inventory data for the foreground and background system. Model the process or system (e.g. product) as far as the initial information and data permits (see chapter 7).

I.d) Calculate the LCIA results (see chapter 8).

I.e) Identify significant issues and perform first sensitivity, consistency and completeness checks on this initial model (see chapter 9).

I.f) Based on this go to the next iteration: Start with fine-tuning or revising the scope (in some cases even the goal), improve the life cycle model accordingly, etc.

I.g) Expect two to four iterations towards completing the study. This will mainly depend on the quality needs or ambition, the complexity of the analysed process(es) or system(s), on the specifically analysed question(s), and data availability and its quality. [ISO+]

I.h) Starting from the beginning of the study, document the details of the initial goal and scope definition, key LCI and LCIA items, and the key initial results of the sensitivity, consistency and completeness checks. Let this be guided by the main provisions of reporting required for the deliverable. During subsequent iterations, use this preliminary core report as work in progress and constantly revise, fine-tune and complete it towards the final report (be it a data set and/or a study report). [ISO+]

II) MAY - **Early identification of reviewers:** From the beginning of the study, it is recommended to identify and involve critical reviewer(s) and - if required or desired - interested parties, including when defining goal and scope. [ISO+]

All these provisions refer especially to the system(s) modelled under Situation B (i.e. for meso / macro-level decision support studies) .

5 Goal definition – identifying purpose and target audience

Introduction

The goal definition is the first phase of any life cycle assessment, independently whether the LCI data set is a single unit process data set or a cradle-to-grave data set of a system and whether it is intended to be used for monitoring or for a comparative assertion to be published.

During the goal definition among others the decision-context(s) and intended application(s) of the study are identified and the targeted audience(s) are to be named.

The goal definition is decisive for all the other phases of the LCA:

- The goal definition guides all the detailed aspects of the scope definition, which in turn sets the frame for the LCI work and LCIA work.
- The quality control of the work is performed in view of the requirements that were derived from the goal of the work.

Provisions: 5.2 Six aspects of goal definition

I) SHALL - **Intended applications:** Unambiguously identify the intended applications of the LCI data set. Table 3 gives the detailed list of applications that shall be used while other applications may be intended as well. Here below these applications are grouped by the extent of further LCI modelling and comparative aspects involved. (5.2.1).

I.a) Use with out further modelling (e.g. for an Environmental Product Declaration on the same product modelled).

I.b) Primary data for another LCI or LCA study (non-comparative)

I.c) Secondary data source or background data for another LCI or LCA study (non-comparative)

I.d) Primary data for another LCA study (comparative)

I.e) Secondary data source or background data for another LCA study (comparative)

II) SHALL - **Limitations of study:** Unambiguously identify and detail any initially set limitations for the use of the LCI data set. These can be caused by the following (5.2.2):

II.a) **Supports comparisons?:** Limited review, documentation, etc. (Data set does not fulfil the requirements for use in comparisons.)

II.b) **Impact coverage limitations** such as in Carbon footprint calculations

II.c) **Methodological limitations** of LCA in general or of specific method approaches applied

II.d) **Assumption limitations:** Specific or uncommon assumptions / scenarios modelled for the analysed system [ISO+]

II.e) The data set may have a limited selection of elementary flows according to scope e.g. carbon footprint with only 6 substances as CDM requirement [ISO+]

These and other limitations must be explicitly and clearly stated in the data set documentation

Note that the initially identified limitations may need to be adjusted during the later LCA phases when all the related details are clear.

Other possible limitations due to lack of achieved LCI data quality may also restrict the applicability; these are identified in the later interpretation phase of the study.

III) SHALL - **Reasons for study:** Unambiguously identify the internal or external reason(s) for developing the LCI data set and the specific decisions to be supported by its outcome, if applicable. Typical reasons are (incomplete list): (5.2.3). [ISO+]

III.a) **Internal:** Develop data for foreground/background system for e.g. weak point analysis or product development or benchmarking

III.b) **External:** Develop data to represent the present/most recent reality of the environmental inventory of the process or product system for use as background data

III.c) **Database developer perspective:** Develop descriptive high-quality generic LCI data on a product

The specific decisions depend on the specific goal of the study and need to be identified for the given case.

IV) SHALL - **Target audience of study:** Unambiguously identify the audience(s) to whom the results of the study are foreseen to be communicated (5.2.4).

V) SHALL - **Type of audience:** Classify the targeted audience(s) as being "internal", "restricted external" (e.g. specific business-to-business customers), or "public". Differentiate also between "technical" and "non-technical" audience (5.2.4). [ISO+]

- The target audience of LCI data set should be technical audience who has LCA knowledge, which can be "internal", "restricted external" (e.g. specific business-to-business customers), or "public" and technical.

VI) SHALL - **Comparisons involved?:** State whether the data set is intended to support comparisons or comparative assertions across systems (e.g. products) that are intended to be disclosed to the public (5.2.5). [ISO!]

VII) SHALL - **Commissioner:** Identify the commissioner of the study and all other influential actors such as co-financiers, LCA experts involved, etc. (5.2.6).

Provisions: 5.3 Classifying the decision-context

Applicable to Situation A, B, and C, differentiated.

Table 2 gives an overview of the resulting, practically relevant three archetypal goal situations that will be referred to throughout this document to provide the required, differentiated methodological guidance. This relates to the subsequent provisions on classifying the decision context of the LCI data set:

Table 2 Combination of two main aspects of the decision-context: decision orientation and kind of consequences in background system or other systems.

Decision support?		Kind of process-changes in background system / other systems	
		None or small-scale	**Large-scale**
	Yes	**Situation A** **"Micro-level decision support"**	**Situation B** **"Meso/macro-level decision support"**
	No	**Situation C** **"Accounting"** **(with C1: including interactions with other systems, C2: excluding interactions with other systems)**	

I) SHALL - **Identify applicable goal situation[4]:** Identify the type of decision-context of the LCI data set, i.e. to which of the archetypal goal situations A, B, C1, or C2 the study belongs. Draw on the goal aspects "intended applications" (chapter 5.2.1) and "specific decisions to be supported" (chapter 5.2.3)), as follows: [ISO!]

I.a) **Situation A - "Micro-level decision support":** Decision support, typically at the level of products, but also single process steps, sites/companies and other systems, with no or exclusively small-scale consequences in the background system or on other systems. I.e. the consequences of the analysed decision alone are too small to overcome thresholds and trigger structural changes of installed capacity elsewhere via market mechanisms[5]. For example;

- Development of specific, average or generic unit process or LCI results data sets for the identified intended application under Situation A

I.b) **Situation B - "Meso/macro-level decision support":** Decision support for strategies with large-scale consequences in the background system or other systems. The analysed decision alone is large enough to result via market mechanisms in structural changes of installed capacity in at least one process outside the foreground system of the analysed system. For example;

- Development of specific, average or generic unit process or LCI results data sets for the identified intended application under Situation B

It is important to note that the LCI modelling provisions for Situation B (see chapter 6.5.4.3) refer exclusively to those processes that are affected by these large-scale consequences. The other parts of the background system of the life cycle model will later be modelled as "Situation A", i.e. typically all the processes with a smaller contribution to the overall results.

I.c) **Situation C - "Accounting":** From a decision-making point of view, a retrospective accounting / documentation of what has happened (or will happen based on extrapolating forecasting), with no interest in any additional consequences that the analysed system may have in the background system or on other systems. Situation C has two sub-types: C1 and C2. C1 describes an existing system but accounts for interactions it has with other systems (e.g.

[4] More detail on archetypal goal situations provided in the general LCA – detail guidance chapter 5.3

[5] Note that these small-scale consequences shall not be interpreted, as *per se* resulting in large-scale consequences on installed capacity, i.e. shall be covered under Situation A.

crediting existing avoided burdens from recycling). C2 describes an existing system in isolation without accounting for the interaction with other systems.

I.c.i) Situation C1 - "Accounting with interactions":

- Development of specific, average or generic unit process or LCI results data sets for the identified intended application under Situation C1

I.c.ii) Situation C2 - "Accounting without interactions":

- Development of specific, average or generic unit process or LCI results data sets for the identified intended application under Situation C2

Note that any decision support that would be derived needs to employ the methods under Situation A or B, with Situation C having a preparatory role only. Note however that due to the simplified provisions of this document, the modelling of Situation A studies (micro-level decision support) is identical to that of Situation C1 studies, but not vice versa.

Table 3 maps widely used LCA applications to the required study deliverables and the corresponding goal situation A, B, or C.

Chapter 6.5.4 provides the overview of the LCI modelling provisions for Situation, A, B, and C.

Provisions: 5.4 Need for flexibility versus strictness

I) SHALL - **Product-group and process-type specific guides and PCRs:** [ISO+]

I.a) **Need for specific guides and PCRs:** To further the reproducibility of LCI data set, the development of ILCD-compliant sector, product-group or process-type specific guidance documents and/or Product Category Rules (PCR) is recommended. A specific guide or PCR is ILCD-compliant in its provisions, if these are in line (i.e. not contradicting) with the provisions of this document and other referenced ILCD Handbook documents. They can therefore be stricter or more specific, but not less.

I.b) **Specific guides and PCRs overrule ILCD Handbook:** If such guides or PCRs have been developed and approved in an ILCD-compliant review process, the provisions in these guides or PCRs shall be applied for the product-groups and process-types they cover. Therefore, they overrule the broader provisions of the ILCD Handbook. See also chapter 2.3.

The document "Review schemes for LCA" provides information on the applicable review type. The forthcoming specific documents on "Reviewer qualification" and "Review scope, methods and documentation" for product-group and process-type specific guides and PCRs give the complementary requirements.

Provisions: 5.5 Optionally extending the goal

I) MAY - **Extending the goal?:** Consider extending the goal to further uses / applications of the LCI study in order to benefit from synergies. [ISO+]

6 Scope definition - what to analyse and how

Introduction

During the scope definition phase the object of the LCI study (i.e. the exact product or other system(s) to be analysed) is identified and defined in detail. This shall be done in line with the goal definition. Next and main part of the scope definition is to derive the requirements on methodology, quality, reporting, and review in accordance with the goal of the study, i.e. based on the reasons for the study, the decision-context, the intended applications, and the addressees of the results.

When deriving the scope of an LCI study from the goal, the following scope items shall be clearly described and/or defined:

- The type(s) of the deliverable(s) of the LCI study, in line with the intend application(s) (chapter 6.3)
- The system or process that is studied and its function(s), functional unit, and reference flow(s) (chapter 6.4, which names case-specific provisions)
- LCI modelling framework and handling of multifunctional processes and products (chapter 6.5)
- System boundaries, completeness requirements, and related cut-off rules (chapter 6.6)
- LCIA impact categories to be covered and selection of specific LCIA methods to be applied as well as - if included - normalisation data and weighting set (chapter 6.7)
- Other LCI data quality requirements regarding technological, geographical and time-related representativeness and appropriateness (chapter 6.8)
- Types, quality and sources of required data and information (chapter 6.9), and here especially the required precision and maximum permitted uncertainties (chapter 6.9.2)
- Special requirements for comparisons between systems (chapter 6.10)
- Identifying critical review needs (chapter 6.11)
- Planning reporting of the results (chapter 6.12)

Before addressing the different aspects of the scope definition in more detail, two crosscutting requirements on LCA will be briefly addressed. Note that these require being explicitly checked and referred to in the sub-sequent work and be documented:

- Consistency of methods, assumptions, and data (chapter 6.2.1)
- Reproducibility (chapter 6.2.2)

Provisions: 6.2.1 Consistency of methods, assumptions and data

Applicable to all types of deliverables, implicitly differentiated.

I) SHALL - **Methods and assumptions consistency:** All methods and assumptions shall be applied in a sufficiently consistent way to all life cycle stages, processes, parameters, and flows of the analysed system(s), including across foreground and background system(s) as required in line with the goal of the study. This also applies to LCIA methods and factors and normalisation and weighting, if included.

II) SHALL - **Data consistency:** All LCI data shall be sufficiently consistent regarding accuracy, precision, and completeness, in line with the goal of the study.

III) SHALL - **Dealing with inconsistencies:** Any inconsistencies of the above shall be documented. The inconsistencies should be insignificant for the environmental impact results of the analysed system. Otherwise, this should result in revising the goal settings or the inconsistencies shall be explicitly considered when later reporting the achieved quality (in case of an LCI data set[6])

Provisions: 6.2.2 Reproducibility

I) SHALL - **Documentation for reproducibility:** Documentation of the methods, assumptions and data / data sources used in the development of LCI data set (see chapter 10 and separately available LCI data set format) shall be appropriate and transparent to the extent that would enable another LCA practitioner to sufficiently reproduce the results.

II) MAY - **Accompanying documentation process:** It is recommended to begin the documentation from the beginning of the project, electronically or on paper, and guided by the final need for reporting, and to revise / fine-tune the initial documentation over the course of the study. [ISO+]

III) SHALL - **Confidential information:** For underlying confidential or proprietary data and information that cannot be published, a separate confidential report may be foreseen. This report shall be made available to the critical reviewer(s) under confidentiality (in case a critical review is required or anticipated). See also chapter 10.3.4.

Note: The separately available LCA report template and LCI data set format support an appropriate and efficient technical documentation for informing expert users and reviewers. It is a starting point and reference to develop communication for a non-technical audience. [ISO+]

Deliverables and intended applications

Table 3 gives an overview, which type(s) of deliverables of the LCI/LCA study are required as input for each of the intended application[7]. It also shows to which of the three archetype goal situations each intended application typically belongs and which specific ISO standard relates to that type of deliverable, if any.

[6] See 6.3 for different types of deliverables of an LCI/LCA study.

[7] All LCA studies ultimately go back to unit processes and beyond that to the original measurements or modelling of the process emissions etc. However, the kind of LCI/LCA deliverable that is to be developed as direct starting point for the named LCA application can be e.g. an LCA study, an LCI results data sets, a product-groups specific KEPI-based tool, etc. LCI results and unit process data sets are also always interim steps of any specific LCA study. Note that typically a range of other information and data, specific software tools, as well as specific expertise and experience is required, of course. This is not further detailed here as out of the scope of this document.

Table 3 Most common types of LCI/LCA study deliverables required for specific LCA applications (indicative overview). The most suitable ones are to be decided upon depending on the specific case.

Application areas / Purposes	LCA applications (from perspective of life cycle information user or provider)	LCI / LCA type of deliverable and / or application required as direct input for the "LCA application"[8, 9, 10]	Applicable goal situation	Related ISO standard (next to 14040 and 14044:2006)
Product improvement	**Identification of Key Environmental Performance Indicators (KEPI) of a product group for Ecodesign / simplified LCA**	**d or e or iii; and f**	**A**	
	Weak point analysis of a specific product	**f and d**	**A**	**ISO/TR 14062**
	Detailed Ecodesign / Design-for-recycling	**F**	**A**	**ISO/TR 14062**
	Perform simplified KEPI-type LCA / Ecdesign study	**I**	**A**	
Product comparisons and procurement	**Comparison of specific goods or services**	**e, ii, or iv**	**A**	
	Benchmarking of specific products against the product group's average	**E**	**A**	
	Green Public or Private Procurement (GPP)	**e, ii, or iv**	**A**	**ISO 14015**
Communication	**Development of life cycle based Type I Ecolabel criteria**	**d, e, i, or iii**	**A**	**ISO 14024**

[8] Basic type as input for LCA application: **a** = Unit process data set; **b** = LCI results data set; **c** = LCIA results data set; **d** = LCA study, non-comparative; **e** = Comparative LCA study; **f** = Detailed LCI model of system. Application as input for other LCA applications: **i** = KEPIs-based tool; **ii** = EPD; **iii** = Criteria set for life cycle based Type I Ecolabel; **iv** = Life cycle based Type I Ecolabel of the system.

[9] Several LCA applications typically use at least alternatively the outcome of other LCA applications as input, e.g. Green Procurement often works with KEPI or Type I Ecolabel criteria. This is additionally indicated in the table.

[10] Note that LCA studies (d and e) as basic form of application can already directly provide the required LCA application, e.g. a weak point analysis of the specific product or the comparison of products in support of procurement. In that case the letters **d** and **e** are **underlined**.

Application areas / Purposes	LCA applications (from perspective of life cycle information user or provider)	LCI / LCA type of deliverable and / or application required as direct input for the "LCA application"[8, 9, 10]	Applicable goal situation	Related ISO standard (next to 14040 and 14044:2006)
	Development of Product Category Rules (PCR) or a similar specific guide for a product group	**e or d; and f**	**A**	**ISO 14025**
	Development of a life cycle based Type III environmental declaration (e.g. Environmental Product Declaration (EPD)) for a specific good or service	**d or i; and f**	**A**	**ISO 14025**
	Development of the 'Carbon footprint', 'Primary energy consumption' or similar indicator for a specific product	**d, i, or f**	**A**	**ISO 14025**
	Calculation of indirect effects in Environmental Management Systems (EMS)	**b or d**	**C1**	**ISO 14001**
	Greening the supply chain	**ii, iv, or e**	**A**	**ISO 14015**
	Providing quantitative life cycle data as annex to an Environmental Technology Verification (ETV) for comparative use	**ii, d, or i**	**A**	
Across several areas	**Development of specific, average or generic unit process or LCI results data sets for use in different applications**	**a or b**	**A, B, C1, or C2**	
	Clean Development Mechanism (CDM) and Joint Implementation (JI)	**d, ii, i, or f**	**A**	
Strategic decision support	**Policy development: Forecasting & analysis of the environmental impact of pervasive technologies, raw material strategies, etc. and related policy development**	**E**	**B**	
	Policy information: Identifying product groups with the largest environmental improvement potential	**E**	**B**	

Application areas / Purposes	LCA applications (from perspective of life cycle information user or provider)	LCI / LCA type of deliverable and / or application required as direct input for the "LCA application"[8, 9, 10]	Applicable goal situation	Related ISO standard (next to 14040 and 14044:2006)
Accounting	**Monitoring environmental impacts of a nation, industry sector, product group, or product**	**d or b**	**C1**	
	Policy information: Basket-of-products (or -product groups) type of studies	**E**	**C1**	
	Policy information: Identifying product groups with the largest environmental impact	**E**	**C1**	
	Certified supply type studies or parts of the analysed system with fixed guarantees along the supply-chain	**b, d, e, or ii**	**C1**	
	Corporate or site environmental reporting	**D**	**C1**	**ISO 14015, ISO 14031**
	Accounting studies that according to their goal definition do not include any interaction with other systems	**D**	**C2**	

Provisions: 6.3 Types of LCA deliverables and intended applications

Applicable to Situation A, B, and C, differentiated.

I) SHOULD - **Types of deliverables:** Derive from the intended application(s) identified in the goal definition (see chapter 5.2.1) and any potential pre-settings, the appropriate type(s) of deliverable(s) that the LCI study should provide. Table 3 gives an overview. The following types are most common, listed in order of increasing comprehensiveness and/or complexity: [ISO!]

- I.a) Life Cycle Inventory ("LCI") study and/or data set, in the following variants:
  - I.a.i) Unit process study and/or data set, with two sub-types:
    - I.a.i.1) Single operation unit process (variants: fixed or parameterised)
    - I.a.i.2) Black box unit process (variants: fixed or parameterised)
  - I.a.ii) Partly terminated system data set (variants: fixed or parameterised)
  - I.a.iii) Life Cycle Inventory results ("LCI results") study and/or data set
- I.b) Detailed LCI model of the analysed system

Note that it may be intended to accompany the LCI data set by its LCIA results.

Note that the different types of deliverables imply different requirements e.g. regarding reporting and review.

Provisions: 6.4 Function, functional unit, and reference flow

Note that for further processes that were identified as part of the life cycle model beyond the central process(es) that can be identified in the initial scope phase, these provisions will be applied only in the later iterations and in the LCI phase.

I) SHALL - **Identify system or process:** Identify in line with the goal and with the other scope settings the to-be-analysed system(s) or process(es)[11] (e.g. good, service, technology, strategy, country, etc.) and describe it/them in an unambiguous way (6.4.1).

II) MAY - **Photos, specifications:** Provide photos, and/or technical specifications, and/or descriptions of the system(s), if and as appropriate for the addressees (6.4.1). [ISO+]

III) SHALL - **Identify function(s) and functional unit(s):** One or more function(s) and quantitative, measurable functional unit(s) of each of the system(s) shall be clearly identified, if applicable and appropriate for the type of system (for exceptions see the following provisions on subchapter 6.4.6) (6.4.2).

IV) SHALL - **Functional unit, details:** The functional unit(s) shall be identified and specified in detail across all the following aspects (6.4.2, 6.4.3):

- IV.a) Function provided (what),
- IV.b) in which quantity (how much),

  Note that, even though the "how long" information is important, the use intensity and resulting

[11] Plural in case of comparisons.

Provisions: 6.4 Function, functional unit, and reference flow

overall quantity of the performed function is key to valid comparisons.

IV.c) for what duration (how long), and

IV.d) to what quality (in what way and how well is the function provided).

IV.e) Changes in the functional performance over time (e.g. due to ageing of the product) shall be explicitly considered and quantified, as far as possible. [ISO+]

V) MAY - **Obligatory and positioning properties:** If product systems are analysed, it is recommended to use obligatory and positioning properties for the quantitative and qualitative aspects of their function, respectively (6.4.4). [ISO+]

VI) SHALL - **Measurement methods:** ISO or national harmonised standards shall be used as measurement methods, as far as possible and wherever available and appropriate for use in an LCA context. Own measurement methods should only be used in case of unavailable or inappropriate harmonised standards only. They shall be clearly specified and documented and later be subject to critical review (6.4.5).

VII) SHOULD - **Alternatives and complements to the functional unit:** It is noted that a functional unit cannot always be given or is not appropriate / useful. In such cases, it should be replaced or complemented by another clearly defined, quantitative and measurable item as outlined below; deviations shall be concisely justified (6.4.6): [ISO!]

VII.a) **Materials and other application unspecific products:** A functional unit cannot generally be given. Only the reference flow that includes the main technical specification of the product should be provided. In this case, the reference flow is also the declared unit, but not the functional unit.

VII.b) **Multifunctional processes:** For each function one functional unit and/or reference flow should be given, as appropriate, depending on the kind of co-function / co-product (see other items in this sub-list). Otherwise the technical specification of the process and functions should be provided in the accompanying documentation.

VII.c) **Monofunctional systems:** For systems (e.g. products) with only one relevant function or combination of functions, the functional unit(s) should be specified. In addition, one reference flow with a clear and detailed system name should be provided. The functionally relevant technical specification should be provided as part of the reference flow name and/or in the accompanying documentation.

VII.d) **Multifunctional systems:** For multifunctional systems with multiple, parallel functions, the detailed technical specification should be provided. The corresponding functional units should be given in addition and when appropriate to the given case. One reference flow with a clear and detailed system name should be provided. (This one reference flow can be split up into each one reference flow for each function in case the data set is directly used in comparative studies. This to allow substitution of single functions to achieve equivalence of compared alternatives.)

VII.e) **Systems with alternative functions:** For systems with alternative functions, the most relevant alternative functions and functional units should be specified. In addition, one reference flow with a clear and detailed system name shall be provided. The functionally relevant technical specification should be provided as

Provisions: 6.4 Function, functional unit, and reference flow

part of the reference flow name and/or in the accompanying documentation.

VIII) SHOULD - **Highly variable functions:** For highly variable functions of processes and systems, the way that the variable and parameters relate to the system's performance and to its inventory should be documented. This should be in form of mathematical relations or in another suitable form. The use of parameterised data sets is recommended to support appropriate documentation and efficient use.

Detailed recommendations on the use of flow properties and units for product and waste flows are given in the separate document 'Nomenclature and other conventions'.

Provisions: 6.5.4 LCI modelling provisions for Situations A, B, and C

The following modelling provisions can be applied only in the Life Cycle Inventory phase. However, because the step of determining the LCI modelling and method approaches is part of the scope definition, the provisions are given here. They are also required to provide orientation to some of the remaining steps of the scope phase.

Note that the inventory of a unit process is basically identical for Situation A, B, and C, although some differences apply e.g. for required additional information, e.g. market size. What differs is which processes are within the system boundary, especially in the background system (what is addressed in chapter 7.2), and how the processes are combined to represent the life cycle model and how multifunctionality is solved; both are addressed in this chapter.

The following provisions draw on the provisions in the referenced LCI chapters. They are partly simplified compared to the 'full' consequential and attributional modelling provisions to improve practicality and applicability; this is highlighted in the respective provision.

I) SHALL - **LCI modelling provisions to be applied:** A specific combination of LCI modelling framework (attributional or consequential) and LCI method approaches (allocation or system expansion / substitution) is identified for each of the goal situations A, B, C1, and C2. The provisions cover scenario and uncertainty calculation. The provisions shall be applied as follows (6.5.4.1): [ISO!]

I.a) **Situation A - "Micro-level decision support":** (6.5.4.2)

I.a.i) **Life cycle model:** The life cycle model of the analysed system shall be modelled as an attributional model, i.e. depicting the existing supply-chain processes (for details see chapter 7.2.3).

I.a.ii) **Subdivision and virtual subdivision for black box unit processes and multifunctionality:** It shall be aimed at avoiding black box unit processes and solving multifunctionality by subdivision or virtual subdivision (see chapter 7.4.2.2), as far as possible. The following applies for cases of system-system relationships and cases of multifunctionality, if subdivision / virtual subdivision is not possible or not feasible:

I.a.iii) **Cases of system-system relationship:** if the analysed system's secondary function acts within a context system, where it only affects the existing processes' operation, system expansion shall be performed via substitution with the short-term marginal (for terms, concepts, and details see boxes in chapter 7.2.2 and chapter 7.2.3).

Provisions: 6.5.4 LCI modelling provisions for Situations A, B, and C

Note that the analysed system may also have influenced the installed capacity of the context system, if it had been considered when planning the context system. For example the heat generated by office equipment may have been considered when dimensioning the heating and cooling system of an office building.

Part-system relationships require no specific modelling provision, but the correct identification of the processes within the system boundary; see boxes in chapter 7.2.2.

I.a.iv) **Cases of multifunctionality - general:** (For terms, concepts, and details see chapter 7.2.4.6, but note the simplifications given here for Situation A):

I.a.iv.1) **Substitution of market mix of specific alternatives:** (Simplification compared to full consequential model): If for the not required[12] specific co-function, functionally equivalent alternative processes / systems are operated / produced to a sufficient[13] extent: the not required co-function shall, as far as possible, be substituted with the average market[14] consumption mix of the processes or systems that it supersedes, excluding the to-be-substituted function from this mix. If the to-be-substituted function has a small share in the overall environmental impact of the market mix, the market mix can be used instead, if the results are not relevantly changed.

I.a.iv.2) **Substitution of market mix of general, wider alternatives:** If such alternative processes / systems do not exist[15] or are not operated to a sufficient extent, alternative processes / systems of the not required co-function in a wider sense should be used

[12] I.e. in contrast to the one that is analysed or within the system boundary in the background system.

[13] "Sufficient" means that the not required co-function can quantitatively be absorbed by the market. That shall be assumed to be the case, if the annually available amount of the to-be-substituted co-function is not more than the annual amount produced by the annually replaced installed capacity of the superseded alternative process(es) or system(s) (see also paragraph on "Guidance for differentiating between Situation A and B" in chapter 5.3.6). ! Note that this refers to the amount of co-function provided by the analysed process. E.g. if the study refers to a specific producer that contributes only a small share to the total production of the co-function, only this small amount counts. I.e. it is very likely that it can be absorbed by the market. If the study refers to the total production of a certain product that has the not required co-products, there is the chance that this much larger amount of co-products cannot be absorbed by the market.

[14] This "market" is the market where the secondary function is provided. E.g. for products produced from end-of-life and waste management this is the market of the primary production at the time and the location (e.g. country, region or global etc. market) where the end-of-life product or waste is known or forecasted to undergo recycling, reuse, or energy-recovery. If this market cannot be clearly determined, the most likely market shall be assumed and well justified; this most likely market shall be on a continental scale or at least cover a group of countries / markets. For explanation of the "market" concept see chapter 6.8.3.

[15] As is the case e.g. for wheat grain and straw production, many oil refinery products, etc.

Provisions: 6.5.4 LCI modelling provisions for Situations A, B, and C

for substitution[16], applying the same provisions as set out in the preceding sub-provision.

I.a.iv.3) **Situation B?:** If also such alternative processes / systems for the wider function do not exist or do not meet the named requirements, the study is in fact a Situation B type study, as this implies large-scale consequences on other systems.

I.a.iv.4) **Allocation:** (Simplification compared to full consequential model): if modelling of substitution is not feasible[17] and generic data is not sufficiently accurate to represent the superseded processes / systems: the two-step allocation procedure of chapter 7.9.3 can be applied instead. Allocation shall however not be performed if it would relevantly favour the analysed process / system. This fact shall be argued or approximated. If allocation is performed, the resulting lack of accuracy shall be reported and explicitly be considered later in the results interpretation. For multifunctional products and the alternative second step in allocation, Quality Function Deployment (QFD) is the preferred alternative to market price allocation.

I.a.iv.5) **No substitution of main function(s):** (Simplification compared to full consequential model): The determining co-function(s) shall not be substituted (for term and concept see chapter 7.2.4.3). In the case the determining and dependent co-functions cannot be clearly identified, the determining co-function(s) should be assumed to be those that jointly contribute more than 50 % to the combined market value of all co-functions of the analysed multifunctional process or system[18]. (The market value is for this purpose the value of the co-functions as provided by the multifunctional process, i.e. without any further processing). In this case, the two-step allocation procedure shall be applied (see chapter 7.9.3).

I.a.iv.6) **Considering functional differences:** Differences in functionality between substituted and superseded function shall be considered either preferably by substituting the actually superseded amounts, or by substituting the market value

[16] E.g. for NaOH, as co-product of Chlorine production, apart from NaCl electrolysis no alternative route is operated to the sufficient extent. However, NaOH provides in a wider sense the function of neutralising agent (next to some other, quantitatively less relevant functions) and hence other, technically equivalent and competing neutralising agents such as KOH, $Ca(OH)_2$, Na_2CO_3, etc. can be assumed to be superseded; their mix would be used to substitute the not required NaOH. For the example of a wheat grain study and the not required co-product straw: instead of straw, other dry biomass (e.g. Miscanthus grass, wood for heating, etc.) provides equivalent functions and its market mix can be assumed to be superseded.

[17] "not feasible" refers to cases where many alternative processes / systems or alternatives for the function in a wider sense exist (e.g. where over 10 alternative processes / systems make up over 80 % of the market for the to-be-substituted function, and/or where the superseded processes / systems themselves have a number of co-functions.

[18] The reasoning is that in that case it is likely that the determining co-functions would be substituted.

Provisions: 6.5.4 LCI modelling provisions for Situations A, B, and C

corrected amount of the function (details see chapter 7.2.4.6).

I.a.v) **Cases of multifunctionality - waste and end-of-life treatment:** (For terms, concepts, and details see chapter 7.2.4.6 and annex 14.5, but note the simplifications given here for Situation A):

I.a.v.1) **Recyclability substitution of primary route market mix:** (Simplification compared to full consequential model): For waste and end-of-life treatment as cases of multifunctionality: system expansion shall be performed in accordance with the provisions for the cases of general multifunctionality. The avoided primary production of the reused part, recycled good, or recovered energy shall be substituted. This shall apply the recyclability substitution approach, with the simplification of substituting the average primary route market consumption mix of the market where the secondary good is produced.

I.a.v.2) **Recyclability substitution of general, wider alternatives:** For "open loop - different primary route" cases, the market consumption mix of alternative goods in a wider sense should be used for substitution, along the same provisions as set out in the preceding sub-provision.

I.a.v.3) **Situation B?:** Especially for the case of "open loop - different primary route" and for secondary goods with relevantly changed / downcycled properties, in addition verification is needed on whether for the reused part, recycled material, or recovered energy, functionally equivalent, alternative processes or systems, or functional equivalents in a wider sense exist. If this is the case it needs additional verification whether these are operated to a sufficient extent (as detailed above for the general cases of multifunctionality, see also footnote 58). Otherwise, the study is in fact a Situation B type study, as this implies large-scale consequences on other systems.

I.a.v.4) **Allocation:** (Simplification compared to full consequential model): if modelling the substitution is not feasible (see footnote 62) and generic data is not sufficiently accurate to represent the superseded processes / systems, then the two-step allocation procedure applied to waste/end-of-life given in annex 14.5 and chapter 7.9.3 can be applied instead. This shall not be done if it would relevantly favour the analysed process / system; this fact shall be argued or approximated. If allocation is performed, the resulting lack of accuracy shall be reported and explicitly be considered later in the results interpretation.

I.a.v.5) **Considering functional differences:** Differences in functionality between substituted and superseded function shall be considered either and preferably by substituting the actually superseded amounts. As second priority and if the superseded amounts are not known, market value correction of the amount

Provisions: 6.5.4 LCI modelling provisions for Situations A, B, and C

of the substituted function shall be performed.

Note that this applies to all cases of waste and end-of-life treatment that generate any valuable secondary good, i.e. "closed loop", "open loop - same primary route", and "open loop - different primary route" (concepts see 14.3).

To LCI data sets that are intended to support comparative studies, the reasonably best and worst case scenarios may be included within these data sets or be provided as complementary data sets.

I.b) **Situation B "Meso/macro-level decision support"** (6.5.4.3)**:**

I.b.i) **Provisions as for Situation A with two differences:** The above provisions for Situation A shall also be applied for Situation B, with two differences:

I.b.i.1) **Large-scale consequences:** Processes that have been identified as being affected by "big"[19] large-scale changes as a consequence of the analysed decision shall be modelled as the expected mix of the long-term marginal processes (for details see chapter 7.2.4).

I.c) **Situation C - "Accounting"** (6.5.4.4)**:**

I.c.i) **Provisions as for Situation A with two differences:** The provisions for Situation A shall also be applied for Situation C. With two differences:

I.c.ii) **Remaining cases of multifunctionality:** These shall be solved as follows:

I.c.ii.1) **Situation C1:** Multifunctionality of processes and systems shall be solved with substitution via system expansion, as in Situation A, but independently of the absolute amount of the not required co-function(s) that will be substituted[20]. The other provisions apply analogously.

I.c.ii.2) **Situation C2:** General cases of multifunctionality of processes and systems shall be solved with allocation (i.e. applying the two-step allocation procedure; for details see chapter 7.9.3). Cases of waste and end-of-life treatment shall be solved via allocation, as described in annex 14.4.1 (with the provisions being included in the 'Provisions' of chapter 7.9.3).

Note that Situation C1 is thereby modelled identically to Situation A, while independently of the size of the system or processes.

Note that substitution can lead to negative elementary flows or in rare cases even negative overall environmental impacts of the analysed systems. This must be explicitly addressed in reporting, explaining all implications and

[19] Large-scale ("big") consequences shall generally be assumed if the annual additional demand or supply that is triggered by the analysed decision exceeds the capacity of the annually replaced installed capacity of the additionally demanded or supplied process, product, or broader function, as applicable (see also chapter 5.3.6, under the paragraph heading "Guidance for clearly differentiating between Situation A and B").

[20] The reasoning is that the effect of superseding alternative processes / systems is existing, other than in Situation A where an additional amount of co-function is pushed into the market. I.e. in Situation C1, the check whether alternative processes / systems are operated or produced to a sufficient extent is unnecessary, as the superseding factually already occurs.

Provisions: 6.5.4 LCI modelling provisions for Situations A, B, and C

helping to avoid misinterpretation and misleading conclusions.

The main guidance on attributional LCI modelling is given in chapter 7.2.3.

Guidance on the two-step procedure for applying allocation is provided in chapter 7.9.3.

Main guidance on consequential LCI modelling is given in chapter 7.2.4.

Details on LCI modelling of reuse/recycling/recovery are provided in annex 14.4 (attributional) and annex 14.5 (consequential).

Provisions: 6.6 Deriving system boundaries and cut-off criteria (completeness)

Differentiated applicability to Situation A, B, and C.

Differentiated for attributional and consequential modelling.

Note that these provisions will be applied only in the LCI phase.

I) SHALL - **Scope of LCA:** The following shall be covered by the LCI study and data set(6.6.1):

I.a) potential impacts on the three areas of protection Human health, Natural environment, and Natural resources,

I.b) that are caused by interventions between Technosphere and Ecosphere, and this

I.c) during normal and abnormal operation, but excluding accidents, spills, and similar[21].

I.d) Other kinds of impacts outside the scope of LCA that are found relevant for the analysed or compared system(s) may be identified and their relevance be justified. [ISO+]

II) SHALL - **Processes within the system boundary:** The final system boundary/ies of the analysed system(s) shall as far as possible include all relevant life cycle stages and processes that

II.a) are operated within the technosphere, and

II.b) that need to be included along the provisions of identifying to-be-included processes under attributional or consequential modelling (see chapters 7.2.3 and 7.2.4, respectively), but with the specific provisions and simplifications for the applicable Situation A, B, or C (details see chapter 6.5.4).

II.c) Any relevant deviation / omission from the above shall be clearly documented. (6.6.1)

III) SHALL - **Flows across the system boundary:** Next to the reference flow(s) that provide the functional unit(s) and permissible waste flows (see 7.4.4.2), no relevant other flows shall cross the boundary between the analysed system(s) and the rest of the technosphere, as far as possible. Only elementary flows (including permissible

[21] I.e. excluding accidents, indoor and workplace exposure, as well as impacts related to direct application or ingestion of products to humans (see text and footnote in chapter 6.6.1).

Provisions: 6.6 Deriving system boundaries and cut-off criteria (completeness)

measurement indicators and flow groups, see 7.4.3.2) should cross the boundary between the analysed system(s) and the ecosphere. Any relevant deviation / omission from the above shall be reported. (6.6.1). [ISO!]

Note: see also chapter 7.4.4 with special provisions for specific types of processes.

IV) SHALL - **System boundary diagram:** The extent of the system model shall be identified and a schematic system boundary diagram be prepared[22, 23]. Next to the included life cycle stages, the following shall be provided for the different types of deliverables (6.6.2): [ISO!]

IV.a) **For single operation unit processes:** the process step to be represented.

IV.b) **For black box unit processes:** the to-be-represented e.g. process-chain, plant, site, etc. and the first and last process step included. This can be e.g. a **gate-to-gate data set** that represents a chain of operations of a production plant.

IV.c) **For LCI results:** the included life cycle stages. Finally, the first and/or last process step included shall be given, unless the life cycle starts or ends with the cradle or grave, respectively. These can be, among others:

IV.c.i) Cradle-to-gate data set: Covers the life cycle sections from resource extraction to the product, or

IV.c.ii) Cradle-to-grave data set: Covers the whole life cycle i.e. including the product's end-of-life

IV.d) Partly terminated system: as a variant of the two preceding forms while excluding selected single upstream or downstream products to increase its usability (e.g. an LCI result data set for an injection moulding machine, from which the electricity production has been excluded, thereby enabling the user to connect the specific country electricity-mix LCI data set when using it in that specific country in a product system model)

IV.e) In addition, for average/generic data set, it can represent a single, specific technology; an LCI results data set can represent a consumption mix or a production mix, clearly indicating its nature in the process name and other documentation.

IV.f) **Flow chart:** Especially for the foreground system, it is recommended to already prepare technical flow charts on the main process steps.

V) SHALL - **List of exclusions:** Prepare an initial list of any types of activities, specific processes, product and waste flows, elementary flows or other parts that would be foreseen to be excluded from the analysed system, if any (6.6.2). [ISO+]

Note that this initial list is to be (iteratively) updated to reflect the situation at the end of the study.

Note that any final exclusion will need to be justified referring to the cut-off criteria and may limit the

[22] The recommended formal system boundary template is found in Figure 35.

[23] Other systems that become part of the analysed system in case system expansion is applied should not be shown in this diagram, but the quantitatively most relevant cases of multifunctional processes (as identified in the sensitivity analysis) shall be listed. This includes the quantitatively relevant cases of part-system relationships, which only exceptionally require an expanded system boundary diagram (e.g. if the analysed product would be the "part" of a part-system relationship such shall be provided).

Provisions: 6.6 Deriving system boundaries and cut-off criteria (completeness)

applicability of the resulting data set or the conclusions that can be drawn from a comparative study.

VI) SHALL - **Part-system and system-system relationships:** For studies on parts that have a part-system relationship and on systems that have a system-system relationship, obtain data on the effects on the related systems and their data, as far as this is necessary in line with the goal and scope of the study (6.6.2). The related boxes in chapter 7.2.2 provide more information on this issue. [ISO!]

VII) SHALL - **System-external off-setting:** Off-set emissions (e.g. due to carbon off-setting by the Clean Development Mechanism, system-external carbon credits), and other, similar measures outside the analysed system shall not be included in the system boundaries, as far as they are relevant for the results. The related (reduced) emissions shall not be integrated into the inventory. (6.6.2). [ISO+]

VIII) SHALL - **Quantitative cut-off criteria:** Define the cut-off % value to be applied for the analysed system's product, waste and elementary flows that cross the system boundary, but that are not quantitatively[24] included in the inventory[25], as follows (6.6.3):

VIII.a) **Overall environmental impact:** The cut-off % value shall generally relate to the quantitative degree of coverage of the approximated overall environmental impact of the system[26]. For comparative studies the cut-off shall additionally also always relate to mass and energy. Two alternative options exist how to address the overall environmental impact: [ISO!]

VIII.a.i) a) apply the cut-off individually for each of the to-be-included[27] impact categories. This requires that the LCIA methods have been identified at that point; see chapter 6.7.7.

VIII.a.ii) b) apply the cut-off for the normalised and weighted overall environmental impact. This requires that the LCIA methods, normalisation basis and the weighting set have been identified at that point; see chapter 6.7.7.

VIII.b) **Identify the aimed-at % cut-off:** The aimed at quantitative cut-off / completeness percentage shall be identified as follows:

VIII.b.i) **For unit processes, LCI results:** the cut-off value has either already been defined in the goal phase (e.g. "Development of a single operation unit process data set of 95 % completeness") or is to be derived from the respective completeness need of the intended application in the iterative scope steps.

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[24] The respective flows shall however be foreseen to be identified and stay in the inventory, but without stating an amount and being marked as "missing relevant" or "missing irrelevant", as applicable. Details see Life Cycle Inventory chapter.

[25] Note that co-functions are initially part of the inventory and only later removed via allocation or addressed with system expansion/substitution.

[26] While the true absolute overall impact (i.e. the "100% completeness") cannot be known in LCA and other such models, it can be approximated in practice in an iterative manner and with sufficient precision to serve as practical guidance and use for cut-off.

[27] For studies with limited impact coverage (e.g. Carbon footprint), only these categories are to be considered, accordingly.

Provisions: 6.6 Deriving system boundaries and cut-off criteria (completeness)

Note that, unless it was initially defined, the cut-off can only roughly be approximated in the initial scope phase and has to be adjusted iteratively.

Note that later deviations from the initially set cut-off criteria, e.g. due to lack of data (see chapter 7.4.2.11.3 on dealing with missing data), are to be identified in the subsequent LCI data collection and modelling and are to be documented at the end of the LCI study. The finally achieved cut-off (and any possible deviations) shall be reported. Both may lead to a revision of the supported intended applications of the LCI data set. These issues are to be checked in the respective phase of the LCA work.

Provisions: 6.7 Preparing the basis for the impact assessment

Applicable to Situation A, B, and C. Few differences between A/B and C.

Note that an impact assessment is required for all types of LCI studies at least for systematically assessing and improving the overall data quality, including applying the cut-off rules as described in chapter 6.6.3.

Impact categories and LCIA methods:

I) SHALL - **Goal-conform selection of impact categories and LCIA methods:** Select the impact categories to be included and the corresponding LCIA methods in accordance with the goal of the study. [ISO!]

II) SHOULD - **Requirements for impact categories:**

II.a) All impact categories that are environmentally relevant[28] for the analysed process step or system shall be included, as far as possible and unless the goal definition would explicitly foresee exclusions (e.g. for Carbon footprint studies). Further ones can be included optionally.

Note that any relevant exclusion will need to be explicitly considered during interpretation and can lead to limitations for the further use of the data in case of an LCI study or data set.

III) SHALL - **Requirements for LCIA methods:** All included LCIA methods shall meet the following requirements[29] (6.7.2):

III.a) They should be internationally accepted and preferably additionally be endorsed by a governmental body of the relevant region where the decision is to be supported (Situation A, B) or where the reference of the accounted system[30] is located (Situation C).

III.b) They shall be scientifically and technically valid, as far as possible; the extent of

[28] As this can be judged only in view of the LCIA results, i.e. after LCI data collection, modelling, etc., it is recommended to initially foresee the inclusion of all of the default impact categories (see next action). If the impact assessment later shows irrelevance of one of more impact categories they can be left out; see also further provisions. For principally restricted assessments (e.g. Carbon footprint) see the respective action below.

[29] Under the ILCD, recommendations are under preparation on a complete set of such LCIA methods that provide characterisation factors for the ILCD reference elementary flows. These will relate to European and/or global scope, depending on their applicability.

[30] "Reference of the accounted system" refers to e.g. the country or region for which a consumption, production, or territorial indicator is modelled, or to the country in which the company is located that models accounting data for its key products.

Provisions: 6.7 Preparing the basis for the impact assessment

this fact shall be documented.

III.c) They shall have no relevant gaps in coverage of the impact category they relate to, as far as possible; otherwise the gap shall be approximated, reported and explicitly be considered in the results interpretation,

III.d) They shall be based upon a distinct identifiable environmental mechanism or reproducible empirical observation,

III.e) They shall be related exclusively to elementary flows (i.e. interventions between the technosphere and the ecosphere) during normal and abnormal operating conditions, but excluding accidents, spills, and the like. [ISO!]

III.f) They shall be free of double-counting across included characterisation factors, as far as possible and unless otherwise required by the goal of the study, and

III.g) They shall be free of value choices and assumptions, as far as possible; these shall be appropriately documented and if relevant they shall explicitly be considered in the results interpretation.

The development or identification of LCIA methods that are prepared to meet these requirements is supported with the separate guidance document "Framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators".

Note that LCI data set that intended to be used in comparative assertion studies any used LCIA method and factor may need to undergo a review under ISO in order to be eligible.

IV) SHOULD - **Default impact categories and category endpoints:** The selected LCIA methods in their entirety should by default cover all of the following impact categories and provide characterisation factors on midpoint level. It is recommended that they also provide modelled category endpoint factors that are coherent with the midpoint level and that cover all relevant damages to the three following areas of protection (6.7.2):

IV.a) **Impact categories ("midpoint level"):** Climate change, (Stratospheric) Ozone depletion, Human toxicity, Respiratory inorganics, Ionising radiation, (Ground-level) Photochemical ozone formation, Acidification (land and water), Eutrophication (land and water), Ecotoxicity (freshwater, marine, terrestrial), Land use, Resource depletion (of minerals, fossil and renewable energy resources, water, ...). [ISO!]

IV.b) **Category endpoints ("endpoint level"):** Damage to human health, Damage to ecosystem, Depletion of natural resources. These relate to the three areas of protection "Human health", "Natural environment", and "Natural resources", respectively. [ISO+]

V) SHOULD - **Location and time generic LCIA:** The LCIA methods should by default be location-generic and time-generic (but see later provision on derived LCIA methods). [ISO!]

VI) MAY - **LCIA methodologies:** It is recommended to select available LCIA methodologies that provide a complete set of single LCIA methods, rather than selecting and combining individual LCIA methods. [ISO!]

VII) SHOULD - **Excluding impact categories?:** Exclusions of any of the above impact categories should be justified as being not relevant for the analysed system(s). This can be done based on experience gained from detailed, complete studies for sufficiently

Provisions: 6.7 Preparing the basis for the impact assessment

similar systems and/or system group specific / Product Category Rule (PCR) type guidance documents. (6.7.2 and 6.7.3) [ISO+]

VIII) SHALL - **Adding impact categories?:** Check for the specific LCI study whether next to the default impact categories given above, additional, relevant environmental impacts[31] need to be included in accordance with the goal and scope. If so, identify or develop[32] the relevant LCIA methods to be applied. Note that these shall meet the same requirements as the other included LCIA methods (see above) (6.7.4).

IX) SHOULD - **Impacts outside the scope of LCA:** Impacts that are outside the LCA frame[33, 93] but for which scientific evidence exists that they are relevant for the analysed or compared system(s) should be clearly and individually be identified, including in the Summary and Executive summary of the report / data set. Their brief description should be foreseen in the further documentation. If it is foreseen to include them quantitatively, this requires potentially different modelling and analysis approaches and guidance. This should be done jointly with the LCI study, as far as possible, to ensure coherence, but inventory, impact assessment, etc. shall be kept separately for clear interpretation (6.7.4). [ISO!]

Note that this step is often possible only after the first or second iteration of LCI data collection and modelling, impact assessment, and interpretation.

X) SHOULD - **Missing characterisation factors:** If a characterisation factor is missing for an elementary flow of the analysed inventory, and that flow is known to contribute significantly to one or more of the included impact categories, considering the goal and scope of the LCI data set (6.7.4): [ISO+]

X.a) Check the potential importance of the missing characterisation factor by assuming a conservative value or reasonably worst case value based on chemical, physical, biological and/or other similarity to other elementary flows which contribute to the same impact category/ies in question.

Note that this procedure requires expert knowledge of an LCIA method developer, especially on fate and exposure modelling to be able to judge which similarities to consider and how; a good chemical and environmental sciences understanding is equally required.

X.b) Apply the assumed characterisation factor(s) to that elementary flow and investigate whether the total result for the affected impact category/ies is changed to a relevant degree (i.e. depending on the required completeness, accuracy, and precision).

X.c) If with this approach the contribution from this elementary flow cannot be

[31] Examples are Noise, Desiccation / Salination, Littering of land and sea, etc.

[32] ISO 14044 requires that all relevant impacts are to be covered. In practice of performing LCA studies, the development of new LCIA methods is a rare case. The separate guidance document "Development of Life Cycle Impact Assessment (LCIA) models, methods and factors" supports LCIA method developers in this step.

[33] The inventory related to impacts that are outside the frame of LCA shall not be mixed with the LCA impacts, i.e. need separate inventorying as separate items outside the general Inputs/Outputs inventory. The LCA frame covers potential impacts on the named three areas of protection that are caused by interventions between Technosphere and Ecosphere during normal and abnormal operation. I.e. Accidents, indoor and workplace exposure, as well as impacts related to direct application or ingestion of products to humans shall not be mixed but be modelled and inventoried separately (see also 6.8.2).

Provisions: 6.7 Preparing the basis for the impact assessment

classified as being not relevant, it should be attempted to get a more accurate and precise value for the missing characterisation factor and use that one for the further work.

Note that this factor will have to fulfil the same conditions as other factors of the respective impact category / method.

X.d) If the latter is not possible or the whole provision is not feasible (e.g. for cost or timing reasons), the fact of a missing relevant characterisation factor shall be reported and the potential influence of the missing factor shall be considered when reporting the achieved data quality.

X.e) If the conservative or reasonably worst case value does not show a relevant contribution from that elementary flow, the missing characterisation factor can be disregarded. It is recommended to report the fact of a "missing factor" nevertheless and marked as "missing unimportant", at least for those flows that lack relevance but are not fully negligible.

Note that this step is often only possible after the first or second iteration of LCI data collection and modelling, impact assessment, and interpretation.

XI) SHALL - **Location and time non-generic LCIA methods:** The potential use of LCIA methods that have been derived from the original, location-generic and time-generic ones (i.e. being not generic but e.g. spatially or otherwise further differentiated or modified) shall be justified along the goal and scope of the study. It shall be demonstrated that significantly different LCIA results are obtained than with the generic methods. The non-generic methods have to meet the other applicable requirements for selected LCIA methods (6.7.5). [ISO!]

Note that this step is often only possible after the first or second iteration of LCI data collection and modelling, impact assessment, and interpretation.

Note that LCIA results calculated from non-generic LCIA methods are later to be presented separately from the generic ones and discussed jointly.

Normalisation and weighting:

XII) SHALL - **Cut-off criteria:** Normalisation and weighting may have been used for defining the cut-off rules in chapter 6.6.3 (6.7.6). [ISO!]

XIII) MAY - **Results interpretation:** Normalisation and weighting are in addition optional steps under ISO 14044:2006 that are recommended to support the results interpretation. (6.7.6)

Note that the normalisation and weighting shall be made in accordance with the intended application of the LCI study.

XIV) SHALL – **Requirements for selecting normalisation basis and weighting set:** If used for defining the cut-off and/or in support of the interpretation of the results of the study, select a suitable normalisation basis and weighting set[34], along the following rules (6.7.6): [ISO!]

[34] The development of governmentally supported corresponding normalisation and weighting data in the different regions and countries or globally would be beneficial.

Provisions: 6.7 Preparing the basis for the impact assessment

XIV.a) **Normalisation basis:**

XIV.a.i) As normalisation basis the annual total environmental inventory globally should be preferred. Alternatively the territory-based or consumption-based annual total environmental inventory of the country or region should be used where the supported decisions are made (Situations A, B) or in which the accounting reference is located (Situation C). It is recommended to prefer the average citizen as normalisation basis instead of the global, regional or country total (i.e. the global, regional or country total divided by the number of citizen[35]).

XIV.a.ii) Ensure the relevance of the selected normalisation basis for the intended applications and target audience.

XIV.a.iii) Ensure a high degree of completeness and precision of the overall environmental impact covered and a similar degree of completeness and precision for all covered impact categories.

XIV.a.iv) Ensure a proper link with the used LCIA methods, i.e. relate to the same impact categories / areas of protection and use to a sufficient degree the same elementary flows.

XIV.a.v) Ensure technical compatibility with the to-be-used weighting set, i.e. relate to the same impact categories / areas of protection.

XIV.a.vi) As year for the normalisation basis the year should be used for which the latest data are available that meet the above requirements.

XIV.b) **Weighting set:**

XIV.b.i) The weighting set should represent the normative and other values globally or of the country or region where the supported decisions are made (Situations A, B), or the reference of the accounting (Situation C). The weighting set should preferably be endorsed by a governmental body of the country or region where the decision is to be supported (Situation A, B) or where the reference of the accounted system is located (Situation C).

XIV.b.ii) Ensure the relevance of the selected weighting set to the intended applications and target audience.

XIV.b.iii) The weighting set shall correctly refer to the used normalisation basis and to the midpoint level or endpoint level indicators of the used LCIA methods, as applied.

XIV.c) **Extension for added impact categories:** If in the course of the study a non-default impact category has been additionally included, corresponding data for

[35] This brings the values of the normalised impacts for goods and services down to a better communicatable and interpretable level (typical value range 10 to 0.00001 instead of 1E-7 to 1E-14).

Provisions: 6.7 Preparing the basis for the impact assessment

the normalisation basis and a weighting factor shall be additionally provided and used[36].

Provisions: 6.8.2 Technological representativeness

Applicable to Situation A, B, and C, differentiated.

Differentiated for attributional and consequential modelling.

Fully applicable for LCI results,. For unit processes only required to complete the system model for quality control.

Note that these provisions will be applied only in the LCI phase.

I) SHALL - **Good technological representativeness:** The overall inventory data shall have an as good as required technological representativeness, meeting the goal requirements of the study. (See also the accuracy requirements identified in chapter 6.9.2; note that technological, geographical and time-related representativeness are closely interrelated). For both analysed processes and systems, this includes all quantitative and qualitative aspects of the functional unit(s) and/or reference flow(s), and/or technical specification(s). This applies especially for those aspects, that matter in terms of leading to relevant differences in the LCI data.

II) SHALL - **Specific way or mode of process?:** Identify along the goal of the study and especially the intended applications whether the data needs to represent a specific way or mode of operating the technology / technique (e.g. a specific load factor for transport, or a specific start, closure etc. cycle step of a process, etc.), if this differs from the average, typical or integrated operation. [ISO+]

III) SHALL - **Different technologies for attributional and consequential modelling:** Note that attributional and consequential modelling often require very different processes (and to some degree also systems) for the background system. But see the simplifications set for all Situations, except for the processes that face "big" changes in Situation B (chapter 6.5.4): [ISO!]

III.a) **Attributional modelling:** It should be used:

III.a.i) **Foreground system:** Technology-specific primary data for the foreground system and for the specifications of the products and wastes that connect the foreground system with the background system. Secondary data of the actual suppliers / downstream actors should be preferred to other (third-party) secondary data. Technology-specific, generic or average data from third-parties should be used in those parts of the foreground system where this for the given case is of higher quality (i.e. more accurate, precise, complete) than available technology-specific primary or secondary data from suppliers / downstream actors.

[36] This is not required for use of non-generic LCIA methods and for additionally included single elementary flows / characterisation factors, unless this would relevantly change the results, what by default can be assumed to be not the case.

Provisions: 6.8.2 Technological representativeness

III.a.ii) **Background system:** Average technology as market consumption[37] mix data should be used.

III.b) **Consequential modelling:** It should be used:

III.b.i) **Foreground system:** The same applies as described above for attributional modelling. Here this includes the suppliers' / downstream actors' technology-specific secondary data of the contractually fixed or planned supply-chain.

III.b.ii) **Background system:** The short-term or long-term marginal technology mixes should be used, as appropriate for the applicable Situation A, B, C1, and C2. Among these, the named long-term technology mix only applies to those processes under Situation B that face "big" changes in consequence of the analysed decision, and - optionally - to the assumption scenarios. The technology mix of marginal processes should be identified, depending among others on the market conditions and the cost-competitiveness of the potential marginal processes.

The detailed provisions and terms / concepts are given in chapter 7.2.4.

III.c) **Using not fully representative data:** For both attributional and consequential modelling, the use of not fully technologically representative data is justifiable only if this is not relevantly changing the overall LCIA results compared to using fully representative data; otherwise the lower achieved representativeness shall be documented in the data set / report. For data provided for a competitor's product, lower representativeness shall not lead to higher overall environmental impacts of the LCIA results calculated for that product. For data provided for own products or for products without any competition situation (e.g. generic data from consultants or research projects for general background use), lower representativeness shall not lead to lower impacts of the overall LCIA results calculated for that product.

Note that this can be implemented only in the subsequent iterative steps of the LCA work.

IV) SHALL - **Non-scalable supplies:** For the life cycle model of Situation A, B, and C1, the following shall be applied: if the supply of a specific required function (e.g. product) cannot relevantly be increased in the analysed market and due to inherent constraints (e.g. as for hydropower in many countries) the market consumption mix of the specific function that the product provides (e.g. electricity in the above example) shall be used as far as possible, and not the data for the specific supplier/product. To not contradict the provisions on solving multifunctionality, this provision does not apply to required co-functions.[ISO!]

[37] This also applies if a market production mix data set is developed: the fact that the data set is to represent the production mix would be achieved by combining the representative mix of producing technologies of that market according to their production share. For the data in the background system of the individual routes nevertheless the respective consumption mix data are to be used.

Provisions: 6.8.3 Geographical representativeness

Applicable to Situation A, B, and C, differentiated.

Differentiated for attributional and consequential modelling.

Fully applicable for LCI data sets. For unit processes only required to complete the system model for quality control.

For LCI results,: be aware that the declared geographical scope of all later to be used inventory data needs to enable a correct impact assessment. This is to be checked especially carefully if a non-generic impact assessment (e.g. with differentiated characterisation factors by country, region or even site) is applied.

Note that these provisions will be applied only in the LCI phase.

I) SHALL - **Good geographical representativeness:** The overall inventory data shall have an as good as required geographical representativeness, according to the goal of the study (see the accuracy requirements identified in chapter 6.9.2). This applies especially, where this matters in terms of relevant differences in the LCI data of different geographical scope.

II) SHALL - **Different geographical scope for attributional and consequential modelling:** Note that attributional and consequential modelling may require processes/products of a different geographical scope in the background system. But see the simplifications set for all Situations, except for the processes that face "big" changes in Situation B (chapter 6.5.4): [ISO!]

II.a) **Attributional modelling:** It should be used:

II.a.i) **Foreground system:** Site or producer/provider specific data for the foreground system, supplier-specific data for the products that connect the foreground with the background system. Generic data of geographical mixes can be used also in parts of the foreground system if for the given case justified as being more accurate, precise, and complete than available specific data (especially for processes operated at suppliers).

II.a.ii) **Background system:** Average market consumption mix data for the background system.

II.b) **Consequential modelling:** It should be used:

II.b.i) **Foreground system:** Site or producer/provider specific data for the directly controlled processes of the foreground system, suppliers' site specific data of the contractually fixed or planned supply-chain of the foreground system plus for the products and wastes that connect the foreground with the background system. Generic data of geographical mixes can be used also in parts of the foreground system if for the given case justified as being more accurate, precise, and complete than available specific data (especially for processes operated at suppliers).

II.b.ii) **Background system:** The short-term or long-term marginal geographical mixes should be used for the background system, as appropriate for the applicable Situation A, B, C1, and C2. The geographical mix of the marginal processes should be identified, depending among others on the market conditions and cost-competitiveness of the potential marginal processes.

The detailed provisions and terms/concepts are given in chapter 7.2.4; but check for the simplified provisions for the applicable Situation A, B or C in chapter 6.5.4.

II.c) **Using not fully representative data:** For both attributional and consequential modelling, the use of not fully geographically representative data is justifiable only if this is not relevantly changing the overall LCIA results compared to using fully representative data; otherwise the lower achieved representativeness shall be documented in the data set / report.

Provisions: 6.8.4 Time-related representativeness

Fully applicable for LCI results. For unit processes only required to complete the system model for quality control.

Note that these provisions will be applied only in the LCI phase.

I) SHALL - **Good time-related representativeness:** The overall inventory data shall have an as good as required time-related representativeness, according to the goal of the study (see the accuracy requirements identified in chapter 6.9.2). This applies especially, where this matters in terms of relevant differences in the LCI data that represent a different time.

Note that the represented year of a process or system shall refer to the actually represented year and not the year when the data set was calculated or the year of publication of used secondary data sources.

II) SHALL - **Specific seasonal or diurnal situation?:** Check along the goal of the study and the intended applications whether the data needs to represent a specific seasonal or diurnal situation, if this differs from the average annual data. [ISO+]

III) SHOULD - **Time-related representativeness of future processes:** For processes that run more than 5 years in the future or past from the time of study (e.g. of the use and end-of-life stage of long-living products or in case of backward looking analysis), fully time-representative future/past scenario data should be used, if possible. If this is not possible: [ISO!]

III.a) **BAT and recent data:** For both attributional and consequential modelling, Best Available Technology (BAT) mix data should be used as second option, if BAT data can be argued to be sufficiently representative for the required time. The most recent data are the third option.

III.b) **Using not fully representative data:** Not fully time-representative data can be used only if this is not relevantly changing the overall LCIA results compared to using fully time-representative data; otherwise the lower achieved time-representativeness shall be documented in the data set / report

Note that time-related inventorying issues and how to inventory e.g. carbon storage and delayed emissions is necessarily addressed in the LCI chapter 7.4.3.7.

Provisions: 6.9 Types, quality and sources of required data and information

Applicable to Situation A, B, and C, implicitly differentiated.

Differentiated for attributional and consequential modelling.

Fully applicable to all types of deliverables, implicitly differentiated.

Some of the steps can be done only after the first iteration.

I) MAY - **Overview of the principle types of data and information:** It is recommended to prepare an overview of the principle types of data and information that will be required depending on the type of deliverable of the LCI study, unless this is done in the later step on "Planning data collection" (chapter 7.3). Depending on the study, these are e.g. technical information of the analysed process(es) or system(s), use and end-of-life management data/information, raw inventory data for foreground processes, statistical data e.g. on international trade, market delimitation information and other market characteristics, generic or average background LCI data sets, LCIA methods data sets, normalisation and weighting data, legal and other boundary conditions, etc. The previous scope chapters should be re-checked, including on different data representativeness needs for attributional and consequential modelling. (6.9.1)

Note: the detailed inventory-related data needs will be identified in the Life Cycle Inventory work (see 7.3).

II) SHOULD - **General requirements on data and data set quality:** Determine the general requirements on data and data set quality (details, terms and concepts see annex 12). Regarding newly collected LCI data this means the needs for representativeness, completeness, and precision. For third-party LCI data sets in addition method appropriateness and consistency, the use of ILCD-consistent elementary flows and nomenclature, appropriate documentation, and (potentially) an external review. (6.9.2)

Note that unless the quality requirements are directly quantified in the goal, the initial data and data set quality requirements can be set only after the first loop of data collection, results calculation, impact assessment, the identification of significant issues, and the evaluation. This is described in more detail in chapter 4. These requirements will typically need to be revisited and refined in the subsequent iterations.

III) SHOULD - **Potential sources for the required data, data sets, and information:** It is recommended to already identify potential sources for the required data, data sets and information, as far as possible. Details are decided in chapter 7.3 on "Planning data collection" (6.9.3, 6.9.4):

III.a) **Well-documented data:** Well-documented data and data sets should be preferred to allow judging the data appropriateness for use in context of the analysed system and to enable the (potential) critical reviewer to be able to perform an independent verification (6.9.3). [ISO!]

Note that if the deliverable of the study is intended to support comparisons, a minimum documentation scope is specified; see chapter 10.3.3.

III.b) **Pre-verified data:** It is recommended to prefer the use of externally and independently pre-verified data and data sets, as this provides an assurance of the claimed quality and reduces the effort and costs for review of the LCI/LCA work (6.9.3). [ISO+]

Note that different types of critical review are mandatory for different types of deliverables and applications (see 6.11).

Note: The ILCD Data Network is one suitable source for primary and secondary LCI data sets and potentially for LCIA methods. The related requirements make these data especially suitable for working in line with the ILCD Handbook. Statistical agencies, trade associations, governmental bodies, consultants and research groups are potential sources for data, data sets, and information.

Provisions: 6.11 Identifying critical review needs

Applicable to Situation A, B, and C, implicitly differentiated.

Fully applicable to all types of deliverables, implicitly differentiated.

I) SHALL - **Review?:** Decide whether a critical review shall be performed and if so: [ISO!]

I.a) **Review type:** Decide along the provisions of the separate document "Review schemes for Life Cycle Assessment (LCA)" which type of review is to be performed as minimum.

Note that an accompanying review can be beneficial. For Situation B, it can moreover help to organise the best attainable consensus among interested parties, which is required for certain scope decisions (see provisions of chapter 6.5.4).

I.b) **Reviewer(s):** It is recommended to decide at this point who is/are the reviewer(s). The minimum requirements on reviewer qualification are given in the separate documents "Reviewer qualification".

Notes: An overview of the review requirements and the reference to the review scope methods and documentation requirements are given in chapter 11.

Provisions: 6.12 Planning reporting

Applicable to Situation A, B, and C, implicitly differentiated.

I) SHALL - Reflecting on the main type of deliverable (i.e. study or data set) and in line with the decision on the target audience(s) and intended application(s) (see chapter 5.2), decide on form and level of reporting:

I.a) **Form of reporting:** Decide which form(s) of reporting shall be used to meet the need of the intended application(s) and target audience(s): [ISO!]

I.a.i) Data set,

I.a.ii) Data set plus detailed report.

I.a.iii) The electronic ILCD LCI data set format should be foreseen to be used for reporting.

Confidential information can be documented in a separate, complementary report that is not published but only made available to the reviewers under confidentiality.

Note that any form of reporting, also more condensed ones, shall ensure that the contained information cannot easily and unintentionally be misunderstood or misinterpreted beyond what is supported by the study.

I.b) **Level of reporting:** Decide which level of reporting shall be used in accordance with the defined goal. The main levels are:

I.b.i) internal

I.b.ii) external (but limited, well defined recipients)

I.b.iii) third-party report, publicly accessible

For the detailed reporting requirements see chapter 10.

7 Life Cycle Inventory analysis - collecting data, modelling the system, calculating results

Introduction

During the life cycle inventory phase the actual data collection and modelling of the system (e.g. product) is to be done. This is to be done in line with the goal definition and meeting the requirements derived in the scope phase. The LCI results are the input to the subsequent LCIA phase. The results of the LCI work also provide feedback to the scope phase as initial scope settings often needs adjustments.

Typically, the LCI phase requires the highest efforts and resources of an LCA: for data collection, acquisition, and modelling.

Note the limitation of the scope of the LCA approach: it relates exclusively to impacts that are potentially caused by interventions between the analysed system and the ecosphere, and caused during normal and abnormal operating conditions of the included processes, but excluding accidents, spills, and the like. See the related information in chapter 6.8.2.

If non-LCA effects are analysed, they must be inventoried, aggregated and interpreted separately from the life cycle inventory. This document is not explicitly providing guidance on these. While it may help to ensure taking a consistent approach, dedicated guidance and tools should be consulted or used.

Overview

The first steps of the LCI work further detail and concretize the requirements derived in the scope phase, e.g. on specific data sources to be used, planning data collection, etc. The requirements themselves are however always to be understood to be a scope issue.

The inventory phase involves the collection of the required data for …

- Flows to and from processes:
  - Elementary flows[38] (such as resources and emissions but also other interventions with the ecosphere such as land use),
  - Product flows (i.e. goods and services both as "product" of a process and as input/consumables) that link the analysed process with other processes, and
  - Waste flows (both wastewater and solid/liquid wastes) that need to be linked with waste management processes to ensure a complete modelling of the related efforts and environmental impacts.
- Other information identified in the scope definition as relevant for the analysed system. This includes statistical data (e.g. market mix data), process and product characteristics (e.g. functions and functional units), and all other data and information, except for those directly related to impact assessment.

The specific kind of life cycle inventory work depends on the deliverable of the study; not all of the following steps are required for all of these. In its entirety, life cycle inventory work means:

[38] The ILCD reference elementary flows should be used wherever possible and relevant, ensuring compatible inventories and avoiding multiple occurrences of the same flows in joint/aggregated inventories, when combining data sets from different sources.

- Identifying the processes that are required for the system (7.2.3 for attributional and 7.2.4 for consequential modelling),
- Planning of the collection of the raw data and information, and of data sets from secondary sources (7.3)
- Collecting (typically) for the foreground system unit process inventory data for these processes (7.4). An important aspect is the interim quality control and how to deal with missing inventory data (7.4.2.11)
- Developing generic LCI data, especially where average or specific data are not available and cannot be developed, typically due to restrictions in data access or budget (7.5)
- Obtaining complementary background data as unit process or LCI result data sets from data providers (7.6),
- Averaging LCI data across process or products, including for developing production, supply and consumption mixes (7.7)
- Modelling the system by connecting and scaling the data sets correctly, so that the system is providing its functional unit (7.8).
- This modelling includes solving multifunctionality of processes in the system. For this step see 7.9 for attributional modelling and – given the different modelling logic - chapter 7.2.4.6 for consequential modelling where this is integral part of the identification of included processes.
- Calculating LCI results, i.e. summing up all inputs and outputs of all processes within the system boundaries. If entirely modelled, only the reference flow ("final product") and elementary flows remain in the inventory (7.10).

These steps are done in an iterative procedure, as explained in chapter 4 and illustrated in Figure 4 and Figure 5.

7.1.3 Identifying processes in attributional modelling

Looking at the identification in a more functional/technical perspective, the following levels of processes should in principle[39] be attributed to the analysed process or system, starting from the system's functional unit or reference flow, i.e. its central process at level 0. Note that the steps below are no strict and exact, complete requirement, but help in structuring the process of identifying the to-be-included processes for which data is required (see also Figure 20):

Level 0 - central process or analysed system

- On level[40] 0 stands that process of the foreground system that directly provides the analysed functional unit(s) or reference flow(s) as its function:. Note that some of these processes are goods, while others are services or product-service systems. Some

[39] Note that in practice, the relevance of the various processes for the overall environmental impact of the analysed system differs widely. Typically only a quite limited number of processes and flows actually contribute to a relevant degree to the overall impact. The application of cut-off rules along with expert judgement helps in effectively and efficiently identifying the actually relevant processes to be attributed.

[40] Note that these levels are used as simple, pragmatic guidance and that the exact definition of the levels can be done somewhat differently, depending on the level of the process (i.e. black box or single operation) one looks at. This does not affect the applicability of the guidance as the levels only serve for rough orientation.

processes may physically be perceived as persons[41]. Also the use-phase of products is covered by this level. Note that the same applies when working with generic processes that combine properties of one or more processes. The same applies analogously in case wider systems are analysed: The difference is that more than one level 0 process is to be identified that together provide the system's functional unit.

Level 1 – physical embodiment in the good[42]

- On level 1 stand those goods that (partly or fully) physically end up in the analysed good or other goods that are part of the system.

Level 2 – contact with the central process or analysed good

- On level 2 stand those goods and services that only handle or touch the good or level 0 process by performing a supporting function that supports the provision of the analysed function. These level 2 processes include part-system relationships that need special attention; see the related box in chapter 7.2.2.

Level 3 – services for the central process or system

- On level 3 we find those processes that do not even touch the analysed process' equipment or analysed good or would provide a direct function for the provision of a service, but that are required to nevertheless run in the background in relationship to the process.

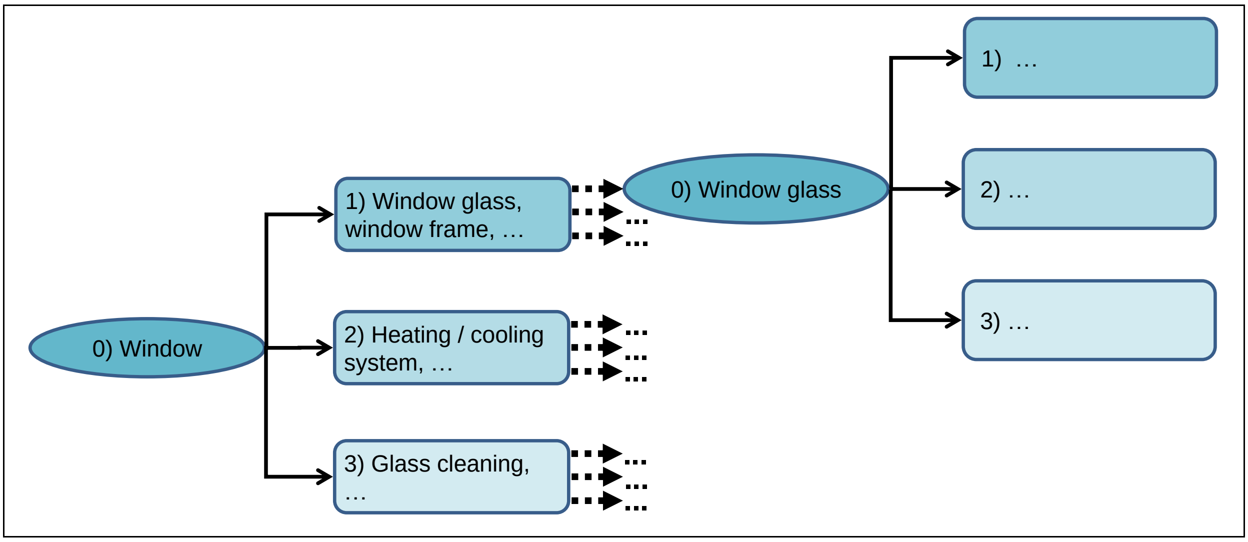

Figure 20 Identifying processes within system boundary, starting from the central process or analysed system. Example of a window, illustrative: The window is the analysed system and hence set as level 0 (oval to the left). After having identified the processes at the levels 1 to 3, each of them becomes a new level 0 process (here shown: "window glass" as oval in the middle). The related processes on the levels 1 to 3 are identified for each of the new level 0 processes, and so on.

[41] Note that by commonly applied convention the processes that meet the general individual needs of such persons (e.g. food, housing etc.) that e.g. as workers contribute to the production of goods etc. are NOT to be included into the analysed product system. In the cases of physically heavy human work as part of an analysed product system, the additional need for calories should however be included, if relevant according to the cut-off criteria.

[42] This step is not applicable to analysed services.

Indirect processes beyond level 3

- Beyond that level 3 we come to surrounding processes that in fact do not relate directly to the central process or system that we look at but to those processes that were identified in the levels 1 to 3. These indirect processes are identified by now looking at each of the processes that were identified as level 1 to 3 and that are part for the foreground system (or connect the foreground with the background system), applying the same logic of the levels 0 to 3 (see also Figure 20). This is repeated again for the next level processes identified in this way and so on. Note that this does not result in an endless list of processes to be included, as by applying cut-off rules - drawing on experience for similar processes and expert judgement - by far most of these can be excluded. (On applying cut-off rules see chapters 7.4.2.11 and 9.3.2).

Provisions: 7.2.3 Identifying processes in attributional modelling

Applicable to Situation A and C, as well as the life cycle model(s) of Situation B, except for those process steps that are affected by large-scale consequences. Also applicable to the assumption scenarios under Situation B for which it has been decided to apply attributional modelling.

Fully applicable for LCI results, partly terminated systems (and for unit processes only to complete the system model for completeness check and precision approximation).

For black box unit processes as deliverable, only those processes that are foreseen to be included are to be identified, as are the product and waste flows that enter or leave the unit process.

For single operation unit processes only the product and waste flows that enter or leave the unit process are to be identified and specified; the named technical flow diagram in that case only consists of one process plus product and waste flows.

I) SHALL - **Identifying processes within the system boundary:** All quantitatively relevant processes shall be identified that are to be attributed to the analysed system(s) and that lay within the system boundary: [ISO+]

I.a) **Start from central process:** This identification should start from the system's functional unit or the reference flow (i.e. from the central process of the foreground system or the analysed system itself). (7.2.3.2)

I.b) **Foreground system:** Stepwise it should be expanded to the entire foreground system. Following a descriptive "supply-chain - use - end-of-life" logic it shall as far as possible identify all relevant product and waste flows (or their functional units) that cross the border to or from the background system. (7.2.3.2)

I.c) **Background system:** The processes in the background system shall be identified in the same "supply-chain - use - end-of-life" logic as applied in the foreground system. A recommended systematic procedure for identification is detailed in the main text of the chapter. (7.2.3.2)

Note that it is established practice to embed the foreground system into a third-party or in-house developed general background system of LCI results and/or unit processes. That means that in practice the identification described above ends with the identification of the product and waste flows that connect the foreground system with the background system. Systems or processes that would be missing in such a general background system are for a given case collected or obtained from third parties as required for the analysed system.

I.d) **Justify and document exclusions:** Any exclusion of relevant individual processes or activity types shall be justified using the cut-off criteria (as defined in chapter 6.6.3). This can build on previous experience including as detailed in related system / product-group specific guidance documents or Product Category

Provisions: 7.2.3 Identifying processes in attributional modelling

Rules (PCRs). The systematic check is described jointly with the same procedure for unit process interim quality control and application of cut-off criteria in chapters 7.4.2.11 and 9.3.2, respectively. In principle all processes are to be inventoried that are to be attributed to the system, as far as they relevantly contribute to the overall environmental impact of the analysed system. This includes in principle - depending on the included life cycle stages and the system boundary in general - activities such as e.g. mining, processing, manufacturing, use, repair and maintenance, transport, waste treatment and other purchased services linked to the analysed system, such as e.g. cleaning and legal services, marketing, production and decommissioning of capital goods, operation of premises such as retail, storage, administration offices, staff commuting and business travel, etc. (7.2.3.2)

I.e) **Part-system and system-system relationships:** Part-system and system-system relationships need special attention (e.g. for energy related products) and correct inventorying (concepts see chapter 7.2.2.). (7.2.3.2)

I.f) **Technical flow diagram, lists of product as and waste from/to background system:** It is recommended using the system boundary scheme for overview. Technical flow diagrams of the foreground system and lists of the products and waste that link the foreground with the background system may be used to document the main resource bases, trade-partner countries for consumption mix data and production routes, etc. This can form the basis for the data collection planning and the starting point for later documentation. (7.2.3.1)

Note that individual processes within the background system may need to be identified as well - in context of identifying sensitive issues (see 9.2) or if required to meet the specific goal of the study.

The requirements regarding technological, geographical and time-related representativeness of the scope chapter 6.8 shall be met. (7.2.3.2)

Note that the resulting initial list of processes, product and waste flows typically will need a refinement in view of the results of the completed initial life cycle model, impact assessment and interpretation.

II) SHALL - **Initial processes' description:** It is recommended to provide an initial description of the identified unit processes of the foreground system, as well as the details of the functional units of those product and waste flows that link it to the background system. This should be updated in the iterative steps of LCI work and shall reflect in the end the final unit processes of the foreground system. (7.2.3.3)

7.1.4 Identifying processes in consequential modelling

Overview

Figure 21 provides a schematic overview of the provisions on identifying processes in consequential modelling; but note the simplified provisions set for Situation A and B in chapters 6.5.4.2 and 6.5.4.3.

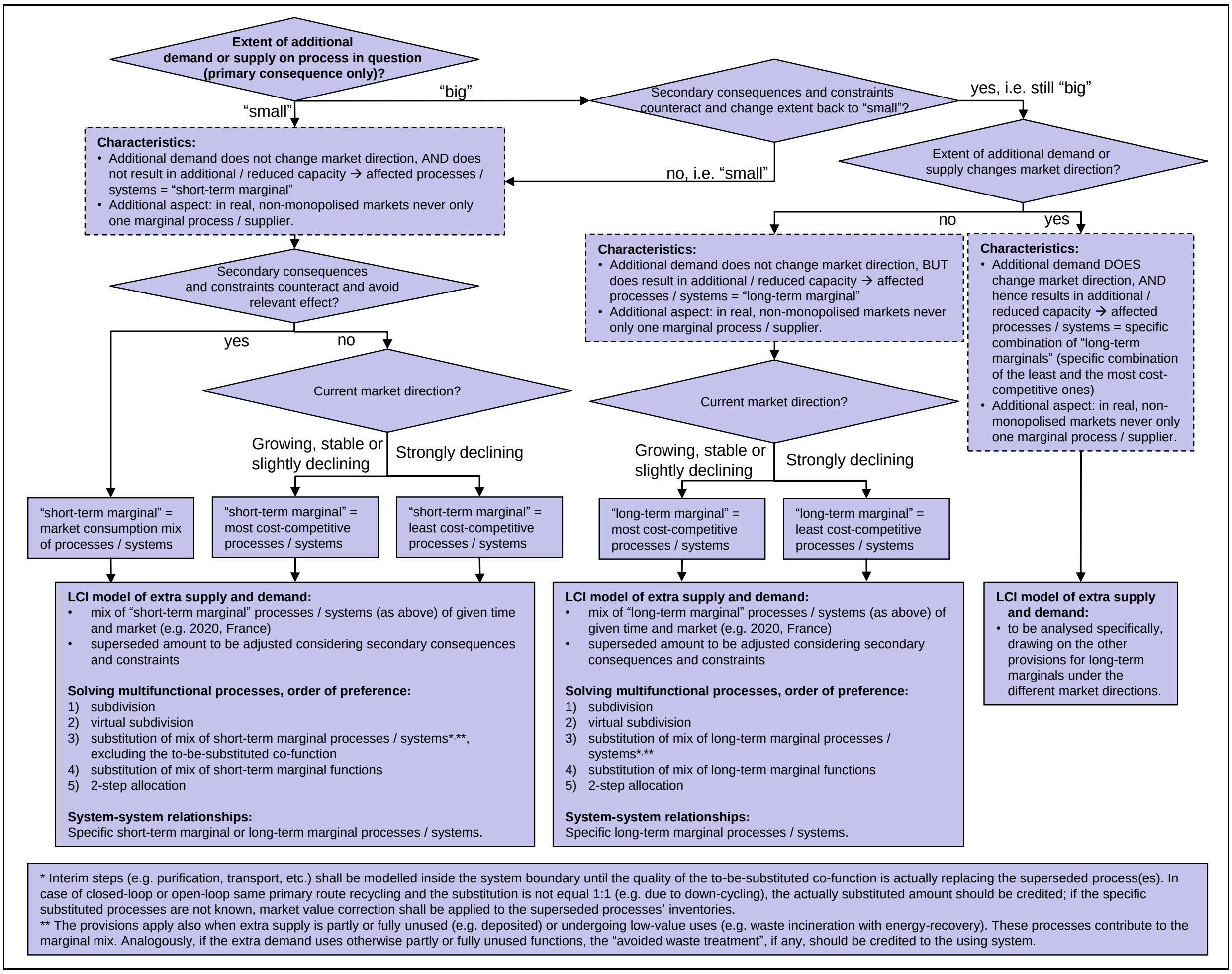

Figure 21 Decision tree for consequential modelling[43]. Terms, concepts, and explanations see text. Formal and detailed provisions see "Provisions".

Provisions: 7.2.4 Identifying processes in consequential modelling

Applicable for those processes in Situation B that have large-scale consequences, and for use in assumption scenarios in Situation B (if consequential elements are included in those).

Fully applicable to all types of deliverables, except for unit processes.

Expertise (7.2.4.1) [ISO+]

I) SHOULD - **Required expertise:** Experts in the following domains should be involved in the study, especially for identifying and modelling large-scale consequences:

  I.a) technology development forecasting (e.g. learning curves, experience curves),

  I.b) scenario development,

  I.c) market cost and market forecasting,

  I.d) technology cost modelling, and

[43] Note that the specific provisions for Situation A and B use some simplifications, as detailed in chapters 6.5.4.2 and 6.5.4.3.

Provisions: 7.2.4 Identifying processes in consequential modelling

I.e) general-equilibrium and partial-equilibrium modelling.

II) SHOULD - **Policy scenario experts required?:** The involvement of domain experts for policy scenarios is recommended regarding their function as setting constraints. In the case policy scenarios are explicitly analysed in the study, such experts should be involved.

Identifying consequences and constraints to be considered [ISO+]

III) SHALL - **Modelled consequences:** Identify among the following ones those consequences that will be modelled; this step may be taken separately case for each process. Their potential exclusion shall be justified by demonstrating at least argumentative / semi-quantitative that they are not relevant for the results; otherwise the exclusion shall be considered when reporting achieved accuracy: (7.2.4.2)

III.a) **Primary market consequences:**

III.a.i) SHALL - (a) Processes that are operated as direct market consequence of the decision to meet the additional demand of a product (i.e. “consequential modelling of direct consequences; applied for the full system”). This includes among many others also indirect land use effects.

III.a.ii) SHALL - (b) Processes that supersede / complement not required co-functions of multifunctional processes that are within the system boundary (i.e. “solving multifunctionality by substitution”, reducing the system boundary to exclude the not required function(s)).

III.b) **Secondary market consequences:**

III.b.i) SHOULD - Increased demand for a co-product if its market-price is reduced.

III.b.ii) SHOULD - Incentive-effects on a process to increase its efficiency due to a higher price for its product(s).

III.b.iii) SHOULD - Decreased demand for competing products of a co-product due to the decreased price of the co-product.

III.b.iv) SHOULD - Consumer behaviour changes

III.b.v) SHOULD - Further consequences should only be included if explicitly addressed in the goal of the study.

IV) SHALL - **Constraints:** Identify the constraints that will be included in the model and that may partly or fully prevent that the marginal process mix as identified along the primary and secondary consequences can directly be used in the system model. The likely specific effect of any included constraint shall be considered when identifying the effective marginal process(es). Their potential exclusion shall to be justified by demonstrating at least argumentative / semi-quantitative that they are not relevant for the results; otherwise the exclusion shall be considered when reporting achieved accuracy. The following constraints should be considered (7.2.4.3):

IV.a) Existing long-term supply-contracts or co-operations that cannot easily be changed.

Provisions: 7.2.4 Identifying processes in consequential modelling

IV.b) High costs that act as a barrier (e.g. limited mobility of some products due to high transport costs).

IV.c) Existing or expected political measures / legal constraints that stimulate perceived positive developments or counteract perceived negative developments. (E.g. a political binding target of X % of energy carrier Y in the fuel mix means that energy carrier X is already pre-set and cannot be assumed to be a long-term marginal product in consequence of the analysed decision.)

IV.d) Non-scalability of supply of products or natural resources; including of fully used, dependent co-products of joint production.

IV.e) Monopolies, i.e. lack of choice of the supplier or technology.

IV.f) It is recommended to also consider other constraints in place or expected to be in place that increase, decrease or block a primary or secondary consequence.

Identifying the mix of superseded processes /systems [ISO+]

V) SHOULD - **Stepwise identification of the mix of superseded processes / systems:** Identify the processes / systems within the system boundary that are superseded as consequence of the analysed decision on the investigated system(s) [44]. For each process the following steps should be applied, starting from the system's functional unit or reference flow to the entire foreground system and following the identified consequences and constraints of a theoretical "supply-chain - use - end-of-life" logic to include identifying as minimum all product and waste flows (or their functional units) that cross the border to the background system[45]: (7.2.4.4)

V.a) **Primary market consequence and the size of the effect:** First step - consider the primary market consequence and the size of the effect:

V.a.i) Identify the processes that are assumed to be additionally operated or taken out of operation as primary market consequence of the analysed decision and the directly related additional or reduced demand for a function/product, considering the following:

V.a.ii) Size of effect:, EITHER

V.a.ii.1) "small" - affecting only the extent of operation of one or more existing processes --> the short-term marginal process(es) are the ones that should be assumed to be superseded, OR

V.a.ii.2) "big" - resulting in additionally installed or de-installed capacity --> the long-term marginal processes are the ones that should be assumed to be superseded.

V.a.ii.3) The effect should generally be considered "small", if the annual amount of additional demand or supply is smaller than the

[44] See also the related decision tree diagram in Figure 21.

[45] It depends on the chosen background system model solution whether the processes of the background system also need to be individually identified or whether - if embedding the foreground system into an existing background system - this work has been already done.

Provisions: 7.2.4 Identifying processes in consequential modelling

average percentage of annual replacement of capacity (see chapter 5.3.6) of the annual supply of that function or system in the given market; if that average percentage is over 5 %, 5 % should be used instead. Otherwise it is "big". The percentage is for orientation only and can be for a given case changed to be smaller or bigger upon the argumentation that the change in demand or supply is directly triggering changes in demand and not only via a marginal accumulative effect in contribution to the general market demand/signal.

V.b) **Secondary consequences and constraints:** Second step - consider secondary consequences and constraints:

V.b.i) If the size of the effect of the primary market consequence is "small", check whether the secondary consequences and constraints in the market counteract the primary consequence (rebound), so that the net effect of the consequences is so small that it is not significantly different from being zero. In that case, the "short-term marginal" is best represented by the "average market consumption mix" of the processes / systems (but see next sub-provision).

V.b.ii) For the specific case of multifunctionality, a key constraint occurs if the required co-function is an already fully used, dependent co-function of a joint production process (e.g. copper ore mining with silver as dependent but fully used co-product, egg-laying chicken with the dependent co-"product" chicken being fully used for human food or animal fodder), as additional demand cannot be met by additional supply on a net basis. In that case, the required function/product will have to be produced in another way (e.g. for the above examples: silver from silver mine, or meat-chicken directly raised for food or fodder).

V.b.iii) If the size of the effect of the primary market consequence is "big", check next whether secondary consequences and market constraints counteract the primary consequence, so that the net overall effect is not "big" but "small".

V.b.iv) For those processes that are still facing "big" effects, explicitly consider that the affected processes might have been changed by the secondary consequences and constraints. This has to be analysed specifically to correctly identify the final effect / superseded processes.

V.c) **Market situation and the cost-competitiveness:** Third step - market situation and the cost-competitiveness of alternatives:

V.c.i) Market direction, EITHER

V.c.i.1) a "growing, stable, slightly declining market" (i.e. declining less than the average equipment replacement rate, OR

V.c.i.2) a "strongly declining market" (i.e. declining faster than the average equipment replacement rate).

The above named average displacement rate in % is obtained by dividing 100 years by the average or typical life time of the capital equipment, expressed in years.

Provisions: 7.2.4 Identifying processes in consequential modelling

V.c.ii) Based on this: analyse whether the extent of additional demand or supply for the effect "big" is changing the direction of the market, i.e. from a "strongly declining" market to a "slightly declining, stable, or growing" market OR vice versa.

V.c.iii) If this is NOT the case, the affected processes / systems are always the "long-term marginal" processes / systems.

V.c.iv) For all "small" and "big" cases in addition the cost-competitiveness of alternative processes / systems is relevant:

V.c.iv.1) If the market is "growing, stable, or slightly declining", the "short-term marginal" (for "small" effects) and the "long-term marginal" (for "big" effects) are the most cost competitive processes / systems.

V.c.iv.2) If the market is "strongly declining" the "short-term marginal" (for "small" effects) and the "long-term marginal" (for "big" effects) are the "least cost-competitive" processes / systems.

V.c.v) If in contrast the market direction IS changing, both the least and the most cost-competitive processes / systems are superseded and their specific type and share needs to be identified individually, drawing on the other provisions of this chapter.

V.d) **Identifying the mix of processes /systems:** Final step - identifying the mix of "short-term" or "long-term" marginal processes / systems:

V.d.i) In the consequential model, not only one single, short-term or long-term marginal process should be modelled but a mix of the most likely marginal processes, given the high uncertainty of market price forecasts and the often large differences of the environmental profiles among alternative marginal processes. To restrict the model to a single marginal process or system is only justifiable if there are no other, similarly cost-competitive processes or systems and hence the use of a single one is more appropriate.

V.d.ii) The final amount of function (process or system) that is superseded shall be approximated considering the combined effect of primary and secondary consequences and constraints.

Note that in case the market direction has changed as consequence of the analysed decision, the superseded processes are a specific combination of the least cost-competitive ones and partly the most cost-competitive ones.

Further provisions, comments, and recommendation on documentation (7.2.4.5) [ISO+]

VI) SHALL - Observe that:

VI.a) **Part-system and system-system relationships:** These need special attention (e.g. for energy related products) and correct inventorying. Note that these cases are modelled identically in attributional modelling.

VI.b) **Individual processes within the background system:** These may need to be

Provisions: 7.2.4 Identifying processes in consequential modelling

identified as well when identifying significant issues (see chapter 9.2) or if required to meet the specific goal of the study.

VI.c) **Meet representativeness requirements:** The requirements regarding technological, geographical and time-related representativeness shall be met.

VII) SHOULD - **Indirect land use changes:** The appropriate way how to consider indirect land use changes should be developed. If done this shall applying the general provisions on consequential modelling as applicable. This is unless specific provisions would be published under the ILCD. Such provisions might be part of a future supplement.

VIII) MAY - **Schematic consequential model diagram:** It is recommended using the system boundary scheme for overview. Schematic decision-consequence and flow diagrams of the most relevant consequences and marginal processes of the system(s) may be used to document the main identified consequences and constraints and the resulting resource bases, technologies, affected markets, etc. This can serve as basis for a data collection planning and later documentation.

Note again, that any exclusion of individual processes or activity types shall be justified using the cut-off criteria (see chapter 6.6.3). In principle all processes are to be inventoried that are operated in consequence of the analysed decision. This includes in principle - depending on the system boundary - activities such as e.g. mining, processing, manufacturing, use, repair and maintenance, transport, waste treatment and other purchased services such as e.g. cleaning and legal services, marketing, production and decommissioning of capital goods, operation of premises such as retail, storage, administration offices, staff commuting and business travel, etc.

IX) MAY - **Initial processes' description:** It is recommended to also provide an initial description of the identified unit processes of the foreground system and the detailed functional units of those product and waste flows that link it to the background system. This should complement the documentation of the consequences and constraints and be completed with details during the iterations of the LCI work. (7.2.4.7)

Solving multifunctionality of processes and systems (7.2.4.6) [ISO!]

X) SHALL - **Subdivision and virtual subdivision:** Subdivision and virtual subdivision shall be applied in preference to substitution. Provisions see chapter 7.4.2.2[46].

XI) SHALL - **Combined production:** For cases of truly combined production, the determining physical causality (i.e. the first of the two steps of allocation under attributional modelling) equally applies analogously; see chapter 7.9.3.2.

XII) SHALL - **Joint production:** For joint production, substitution as a special case of system expansion is the preferred solution to multifunctionality. This shall be done as follows:

XII.a) The same provisions shall apply as for general consequential modelling of the system.

XII.b) Note the specific constraint for already fully used, dependent co-products of joint production: since their production cannot be increased with that same

[46] Observe that virtual subdivison shall not be done if it "cuts" through physically not separable joint processes, as this would distort the substitution.

Provisions: 7.2.4 Identifying processes in consequential modelling

multifunctional process/technology, their additional provision cannot be modelled. Instead, alternative routes need to be modelled for their supply. This means that the determining co-product shall not be substituted.

XII.c) If for the not required co-function functionally equivalent alternative processes / systems are operated / provided in a commercially relevant[58] extent, the not required co-function shall be substituted with the mix of the superseded marginal processes (excluding the substituted process-route, if quantitatively relevant). Differences in functionality between superseding and superseded function shall be considered by correction of the actually superseded amount of the superseded process(es) or by market price correction of the superseded process(es)' inventory (if the superseded amount is not known in sufficient detail).

XII.d) If such alternative processes / systems do not exist[47] or are not operated in a commercially relevant extent, the provided function in a wider sense should be used for substitution[48].

Note that the substituted processes or products may also have secondary functions. This can theoretically lead to the problem of an eternally self-referring and/or very extensive, multiply extended system. As the amount of these secondary functions and their relevance within the overalls system goes down with each process step, this problem can be avoided / reduced by applying the cut-off rules.

Substitution for multifunctional processes and systems in reuse / recycling / recovery (7.2.4.6) [ISO!]

XIII) SHALL - **Recycling, recovery, reuse, further use:** Substitution shall be applied for cases of recycling, recovery, reuse, further use: (7.2.4.6, and for all details see annex 14.5)

XIII.a) **Applying general rules to these cases:** Substitution of products recycled or recovered from end-of-life product and waste treatment follows the same rules as for the general cases of multifunctionality. They shall be applied for all cases of waste and end-of-life treatment (i.e. "closed loop" and of "open loop - same primary route" and "open loop - different primary route"). Subdivision and virtual subdivision shall be applied in preference to substitution. Provisions see 7.4.2.2.

XIII.b) **Specific aspects and steps (true joint process, interim processes to secondary good, recyclability, ...):** Specific for reuse/recycling/recovery is that interim treatment steps occur more regularly and that often no truly equivalent alternative process / system exist[49]. In this context, also the true joint process of

[47] E.g. for wheat grain production, many refinery products, etc.

[48] E.g. as for NaOH apart from NaCl electrolysis, or if for a mobile phone the individual function SMS would not be available as commercially relevant, separate consumer product. NaOH provides the general function of neutralising agent and hence other, technically equivalent and competing neutralising agents, KOH, $Ca(OH)_2$, Na_2CO_3, etc. can be assumed to be superseded. For the case of wheat grain and straw production: instead of straw other dry biomass (e.g. Miscanthus grass, wood for heating, etc.) provides equivalent functions and can be assumed to be superseded.

[49] This is as secondary goods often have distinctly different properties from primary produced goods (e.g. recycled aged plastics vs. primary plastics), what makes a clear assignment to the equivalent or most similar process / system more difficult.

Provisions: 7.2.4 Identifying processes in consequential modelling

the secondary good is to be identified. Finally, the steps of reuse/recycling/recovery need to be modelled explicitly until the secondary good is obtained that is actually superseding an alternative process / system. The actual mix of superseded processes shall be identified for the given case and along the following steps:

XIII.b.i) The true joint process of the secondary good is that process step in the product's life cycle that provides the good with the closest technical similarity to the secondary good; the thereby identified primary good shall not have a lower market value than the secondary good[50].

XIII.b.ii) The recyclability substitution approach shall be used for substitution. That implies that all interim waste management, treatment, transport etc. steps are to be modelled and assigned to the analysed system including the step that is producing the valuable co-function (e.g. secondary metal bar).

XIII.b.iii) The amount/degree of recyclability shall refer to the actually achieved recyclability, i.e. accounting for all kinds of losses, e.g. loss due to incomplete collection, sorting, recovery, during recycling processing, rejection etc. In short, the recyclability is the %[51] of the amount of end-of-life product or waste that is found in the secondary good(s). For practical reasons and for long-living products this should per convention be the currently achieved recyclability for this product (or for new / projected products the achieved recyclability of comparable products in the same market). This can be another reference if the goal of the study explicitly relates to recyclability scenarios.

XIII.b.iv) The superseded process(es) / system(s) shall be identified applying the general consequential modelling guidance as detailed in the above provisions[52].

XIII.b.v) Also here not one marginal process should be used but the average

[50] This serves to avoid a potentially misleading upscaling of the superseded function's inventory in case of applying market value correction when correcting for the functional differences.

[51] Note that this % needs to relate to the appropriate property and unit of the secondary good, e.g. Mass in kg for recycled materials, Lower calorific value in MJ for recovered energy, Pieces in number for reused parts, etc.

[52] That means that the earlier named constraint for already fully used, dependent co-products of joint production also applies here: since the production of e.g. a recycled metal as dependent co-product cannot be increased with that same multifunctional process/technology (i.e. by producing more e.g. metal goods, what is of course not happening), its additional provision via primary production cannot be assumed. Instead, alternative routes need to be modelled for the supply of the recycled metal. As stated for the general case, the determining co-product shall not be substituted. The following example explains what that means and why for "closed loop" and "open loop - same primary route" cases nevertheless the primary production is to be substituted: Example: the determining co-product of primary and secondary metal is the primary metal. The secondary metal, after recycling, is the dependent co-product. If this one is fully used in the same or other products and from the perspective of the metal product made of primary metal, recyclability substitution is applied, substituting the secondary good by primary metal. From the perspective of the user of the secondary good "recycled metal", the metal primary production shall not be substituted, but alternative ways of supplying the recycled metal shall be modelled. This alternative way is however - what makes this case apparently specific - the primary production of that metal as this is the only way to increase the availability of the required metal on a net basis. Hence in both cases, primary production is to be substituted, but for different reasons.

Provisions: 7.2.4 Identifying processes in consequential modelling

inventories of several of the potential marginal processes.

XIII.b.vi) For application-unspecific secondary goods, any reduced technical properties of the secondary good should be corrected in the accredited inventory by using the market price ratio (value correction) of the secondary good to the primary produced replaced function.

XIII.b.vii) For application-specific uses of the secondary goods, sufficient functional equivalence with the superseded good shall be ensured and the credited inventory be reduced to the amount that is effectively superseded. In the case this cannot be determined, the market price ratio (value correction) shall be applied as in the application-unspecific case.

XIII.b.viii) Especially for the case of "open loop - different primary route" in addition it is to be checked whether commercially relevant alternative processes are operated. Otherwise, the provisions for the general case of solving multifunctionality under consequential modelling shall be applied.

XIII.b.ix) The other guidance aspects of this chapter on identifying the superseded processes (e.g. constraints, secondary consequences, etc.) apply analogously.

Note that for scenario formation in comparisons, the various primary and secondary consequences and constraints should be varied jointly when defining "reasonably best case" and "reasonably worst case" scenarios.

Provisions: 7.3 Planning data collection

Differentiated for attributional and consequential modelling.

Fully applicable to LCI data set

I) SHALL - **Identify newly required, study-specific unit processes:** Identify for which processes of the analysed system new, study-specific unit processes have to be developed with producer or operator specific primary and secondary data. This is typically the case for the entire foreground system (including for those parts of existing or planned contractual relationships). The use of technical process or flow diagrams is recommended. (7.3.2)

II) SHALL - **Average and generic data:** Identify for which parts of the analysed system the use of average or generic LCI data sets is more appropriate. Note that for a given case, average or generic data may be more accurate, complete and precise also for some processes of the foreground system. If such will be used, this shall be justified. (7.3.2)

Note that in case only a single unit process is the deliverable of the LCI study, only data for that process are to be collected, of course, and the provisions apply analogously.

III) MAY - **Identify data and information sources:** It is recommended to systematically identify sources for the required data and information. This includes considering working for the background system primarily with LCI results or with unit process data sets, which both have advantages and disadvantages that are for the given case to be evaluated. Combinations are possible if the data is consistent. Among the LCI data sources, primary and secondary sources can be differentiated. Guiding principle should be the availability and quality of the most appropriate data. Working with well documented and already reviewed data sets is recommended. This supports a correct use of the data sets, a sound documentation of the analysed system, and its review. (7.3.3, 7.3.5) [ISO+]

IV) MAY - **SI units:** It is recommended to aim at collecting data in the *Système international d'unités* (SI) units, to minimise conversion efforts and potential errors. [ISO+]

Note that SI units shall be used for reporting (see chapter 10.2).

V) SHOULD - **Multi-annual or generic data to be preferred?:** Evaluate along the goal of the study whether multi-annual average data or generic data should be preferred over annual average data as better representing the process / system. This applies for processes with strong inter-annual variations (e.g. agriculture; producer-specific data in general), to ensure sufficient time-related representativeness. (7.3.4) [ISO+]

VI) MAY - **Relevance-steered data collection:** It is recommended to steer the effort for data collection by the relevance of the respective data and information. Building on existing experience that sufficiently reflects the analysed process or system and that is of high quality is an essential guide. Product Category Rules (PCR) and product-group specific guidance documents can represent this experience. The following is meant to help focussing data collection efforts. The initial data quality and data set quality requirements as identified in 6.9.2 may need to be fine-tuned / adjusted in subsequent loops as follows (but see also chapter 4) (7.3.6): [ISO+]

VI.a) For the identification of quantitative LCI data quality needs, determine / estimate the accuracy, completeness and precision of the LCIA results that is required by the intended application (e.g. to allow identifying significant differences among compared alternative products).

VI.b) Translate these requirements to related requirements at the level of elementary flows by taking into account the impact potentials of the individual elementary flows and by disregarding the uncertainties / inaccuracies associated with the characterisation factors.

VI.c) Use these requirements on the elementary flows to determine the maximum permissible uncertainty, inaccuracy and incompleteness of the overall inventory of the to-be-collected or purchased processes' or systems' inventories.

Note that this includes systematic uncertainties from LCI methods and models applied and from assumptions made when setting up the system model.

VI.d) Use this information as indicative guidance on quality requirements in the collection or purchase of inventory data (i.e. unit process or LCI results and similar data sets). For secondary LCI data sets it is recommended to consider the following additional quality aspects: appropriate documentation, the use of compatible elementary flows and nomenclature, methodological consistency, and a completed qualified external review.

VII) SHOULD – **Average data:** Data for an average LCI result data set should be collected (including when it is compiled from existing data sources) from a representative selection of production sites, service operators and/or countries, representing the relevant average mix of technologies, resource bases and emission factors / abatement technologies for the aimed at represented product system. Similar aspects apply to average unit process data sets. [ISO+]

VIII) SHOULD – **Generic data:** Data for a generic LCI data set should be collected for the relevant characteristics of a representative range of processes or products, representing in a similar way as the average LCI data the relevant typical or representative mix of technologies, resource bases and emission factors / abatement technologies etc. for the represented process or product system. [ISO+]

IX) MAY – **Specific data collection forms:** It is recommended to develop data collection forms together with tailor-made flow charts. [ISO+]

Note that in case the later collected or purchased data sets do not meet the requirements, the results of the study may not meet the overall consistency, quality and review requirements.

Note that all publicly accessible data sources shall later be referenced.

Various descriptive information shall later be provided for all significant data, such as the data collection process, the age of the data and data quality indicators.

7.4 Collecting unit process LCI data

Provisions: 7.4.2.2 Avoiding black box unit processes by subdivision and virtual subdivision

Differentiated for attributional and consequential modelling.

Note that these provisions are to be applied to each unit process separately, in case more than one is modelled (e.g. in the foreground system of an analysed system).

I) SHOULD - **Multifunctionality solvable by subdivision?:** Investigate whether the analysed unit process is a black box unit process (concept see Figure 7): does it contain other physically distinguishable sub-process steps and is it theoretically possible to collect data exclusively for those sub-processes? Next, check whether subdivision can solve the multifunctionality of this black box unit process: can a process-chain within the initial black box unit process be identified and modelled separately - preferably process step by process step - that provides only the one required functional output?

II) SHOULD - Based on the outcome, the following steps should be followed:

II.a) **If possible subdivide:** If it is possible to collect data exclusively for those included processes that have only the one, required functional output: inventory data should be collected only for those included unit processes, i.e. subdivision be performed.

II.b) **If not possible, partially subdivide:** If this is not possible (i.e. the analysed unit process contains multifunctional single operation unit processes that are attributed to the required functional output) or not feasible (e.g. for lack of data access or for cost reasons): inventory data should be collected separately for at least some of the included unit processes, especially for those that are main contributors to the inventory and that cannot otherwise (e.g. by virtual subdivision - see more below) clearly be assigned to only one of the co-functions. [ISO+]

II.c) **If also not possible, virtually (fully or partly) subdivide:** If neither subdivision nor partial subdivision is possible or feasible, it should be checked whether it is possible by reasoning to virtually partly or fully sub-divide the multifunctional process based on process/technology understanding. This is the case wherever a quantitative relationship can be identified and specified that exactly relates the types and amounts of a flow with at least one of the co-functions / reference flow(s) (e.g. the specific mechanical parts or auxiliary materials in a manufacturing plant that are only used for the analysed product can be clearly assigned to that product by subdividing the collected data). For those processes where this can be done, a virtual subdivision should be done, separating included processes as own unit processes without separate data collection. [ISO+]

Note that under attributional modelling, singling out required process steps from a black box unit process by virtual subdivision can also improve the basis for a subsequent allocation, with more accurate results.

Note that virtual subdivision is applying the same logic as the physical causality as allocation principle, i.e. of depicting the quantitative inner relationships between the non-functional flows and the co-functions.

Note that under consequential modelling, actual or virtual partial subdivision within processes results in distortions in case substitution would later be used to separate entirely the analysed function.

III) MAY - **Other reasons to subdivide / virtually subdivide?:** If according to the initial step of these "Provisions" the unit process is a black box but is not multifunctional, check whether it would improve the reviewability of the data or whether it is required for the intended applications to subdivide or virtually subdivide the process. If so, it is recommended to fully or partly subdivide or virtually subdivide the process. [ISO+]

Provisions: 7.4.2.3 Describing what the unit process represents

Note that these provisions are to be applied to each unit process separately, in case more than one is modelled (e.g. in the foreground system of an analysed system).

I) SHALL - **Characterise the unit process:**

I.a) **Representativeness:** Characterise the unit process regarding the technology / technique, geographical / market scope, and the time (e.g. year, plus seasonal / diurnal differentiation, if applicable) it represents and any possibly limited representativeness. This characterisation includes identifying the relevant operating conditions and/or other factors influencing its inputs and outputs to a relevant degree. See chapter 6.8 for details.

I.b) **Reference flow(s) / functional unit(s):** If the deliverable is an LCI study or data set, one or more reference flows are the key identifiers and quantitative reference of the life cycle inventory and documentation. Determine and name the reference flow(s) as the amount of product(s) of the system that provide the function as specified in the functional unit. For recommendations on product flow naming see document "Nomenclature and other conventions". Also the functional unit(s) should be specified if appropriate and/or technical specifications be given (provisions for different process / system types see chapter 6.4.6). [ISO+]

Note that a variety of meta data about the process and/or its product(s) is later to be provided to the user and reviewer, e.g. on its technical applicability, method assumptions, who has modelled it, etc.

It is recommended to ensure proper documentation already on level of the single unit process, also if the deliverable is an LCI result, by using the ILCD data set format (see also chapter 10 on “Reporting”).

Provisions: 7.4.2.4 Types of input and output flows to collect

I) SHALL - **Types of input and output flows:** Quantitative data of all relevant[53] inputs and outputs that are associated with the unit process shall be collected /modelled, as far as possible. Where not possible, the gasp shall be documented and if they cannot be overcome be considered when reporting the achieved data quality and when interpreting results of a study. These flows typically include, if relevant for the modelled process / system:

I.a) Input of “consumed” products (i.e. materials, services, parts, complex goods, consumables, etc.), as product flows.

I.b) Input of wastes (only in case of waste servicing processes), as waste flows.

I.c) Input of resources from nature (i.e. from ground, water, air, biosphere, land, etc. and with possible further sub-compartment specifications as required by the impact assessment methodology to be applied), as elementary flows.

I.d) Emissions to air, water, and soil (with possible further sub-compartment specifications as required by the impact assessment methodology to be applied), as elementary flows

I.e) Other input and output side interventions with the ecosphere (if required by the applied LCIA methods), as elementary flows.

I.f) Output of wastes (e.g. solid, liquid, gaseous waste for waste management within the technosphere[54]), as waste flows.

I.g) Output of valuable goods and services provided by the process, as product flows.

Provisions: 7.4.2.5 Data and information types for specific, future and generic data sets

I) SHOULD - **Raw data types:** Raw data types that should be used for the process, as required: [ISO+]

I.a) **Measured data** collected by/at process operators should be preferred if possible and appropriate. Measurements are not only physical measurements of e.g. emissions but also other specific information for the operated process such as e.g. bills and consumption lists, stock/inventory changes, and similar.

I.b) **Element composition and energy content** of product and waste flows. This

[53] See Action on "applying cut-off rules" more below in this chapter.

[54] The emissions resulting from waste that is directly discarded into the environment shall be modelled as part of the LCI model, with the processes considered to be part of the technosphere (details see chapter 7.4.4.2).

data should later be inventoried as flow property information for these flows to support interim quality control, review, and improving data quality.

I.c) **Various other data** can be helpful (also for cross-checks) or even necessary (to fill gaps). These are e.g. recipes and formulations, part lists, patents, process engineering models, stoichiometric models, process and product specifications and testing reports, legal limits, market shares and sizes, data of similar processes, BAT reference documents, etc.

I.d) **Use stage information:** For modelling the use stage of consumer products and initial waste management, it is recommended to use surveys and studies that analyse the average or typical user behaviour to complement product specifications and user manuals. Information provided in product category rules (PCR) can be supporting.

II) MAY - **Tailor-made data collection forms:** It is recommended to use tailor-made data collection forms together with technical flow charts. Specific data collection forms are recommended over generic forms. [ISO+]

Provisions: 7.4.2.6 Reference amount of the reference flow

Differentiated applicability to Situations A, B, and C.

Differentiated for attributional and consequential modelling.

Differentiated applicable for different types of deliverables.

Note that these provisions are to be applied to each unit process separately, in case more than one is modelled (e.g. in the foreground system of an analysed system).

I) MAY - **"1 reference unit" for the reference flow:** It is recommended to use the amount of "1 reference unit" of the reference flow (e.g. "1 kg" Copper wire...) and to express the inventory of the process in relation to this amount. This is unless a different amount would be required for the intended application (e.g. "1 year of production" of a site). [ISO+]

II) SHALL - **Document absolute amount of the central process:** For LCI studies under Situation A and B, the absolute amount of the central process in the foreground system shall be documented. The total market size of the function of this process shall be documented. This shall be done with the sufficient precision to later check whether the product or waste flows that link the foreground with the background system and potentially further process steps in the background system or any multi-functional foreground processes need to be modelled under Situation B, i.e. whether the analysed decision has large-scale consequences beyond the foreground system. [ISO+]

Provisions: 7.4.2.7 Representativeness regarding operation conditions

Note that these provisions are to be applied to each unit process separately, in case more than one is modelled (e.g. in the foreground system of an analysed system).

I) SHALL - **Full operational cycle of the process, if required:** The collected inventory data for a specific process shall as far as possible and required to meet the goal represent the full operational cycle of the process. This includes all quantitatively relevant steps such as e.g. preparation, start, operation, closure, stand-by and cleaning as well as maintenance and repair of the process / system and under normal and abnormal operating conditions. This is unless the data set is meant to represent only a partial cycle. The above applies analogously also to services. The achieved representativeness of the data shall be documented.

II) SHOULD - **One full year as data basis:** For measured data of operated processes, data for at least one full year should be used as basis for deriving representative average data. A sufficient number of samples should be taken and the uncertainty be considered when reporting the precision.

III) SHOULD - **For parameterised processes:** The mathematical relations should represent the relevant changes of the inventory in dependency of the influential parameters, which can be e.g. technical, management, or others. This can include quantitative and qualitative relationships between inventory flows. [ISO+]

Note that the mathematical model and its relevant assumptions and limitations later will need to be documented as well.

Provisions: 7.4.2.8 Checking legal limits

Limited applicability for future processes beyond some years from present.

Note that these provisions are to be applied to each unit process separately, in case more than one is modelled (e.g. in the foreground system of an analysed system).

I) MAY - **Check legal limits:** It is recommended to check for the existence of relevant legal limits as guidance on which flows to in any case include. One may use existing legal limits of e.g. Japan, the EU, the US in case of limited environmental legislation in the country where the process is operated and as far as the limits are technically transferable. If the legal limits apply in the country / market in which the represented process is operated and are also enforced, they give an indication of the possible maximum values of the amounts of these flows. [ISO+]

Note that legal limit values - also of the country where they originally apply - normally cannot be used as inventory values, unless this is checked and justified for the modelled process and in line with the goal.

Provisions: 7.4.2.9 From raw data to unit process inventory

Note that these provisions are to be applied to each unit process separately, in case more than one is modelled (e.g. in the foreground system of an analysed system).

I) SHALL - **Correct scaling to the functional unit(s) / reference flow(s):** Correct scaling to the functional unit(s) / reference flow(s) shall be ensured when converting the raw data to inventory flows.

Note that the e.g. measured concentrations, annual numbers, relative stoichiometric data, yield percentages, etc. usually need to be mathematically processed to correctly relate to the functional unit of the unit process.

II) MAY - **Documentation of all steps:** It is recommended to document all data treatment steps from the raw data to the inventory flows of the unit process, such as averaging/aggregation, scaling, unit-conversion etc. This substantially facilitates the review process in case questions come up and it eases later updating of the data set. Details see chapter 10 on reporting. [ISO+]

Provisions: 7.4.2.10 Solving confidentiality issues

I) MAY - **Aggregation:** Confidential and proprietary information can be protected by aggregation to LCI results data set and partly terminated system data sets. [ISO+]

II) MAY - **Confidential report:** Transparency can be ensured by documenting confidential information in a separate "confidential report" that is made accessible only to the critical reviewers under confidentiality; see chapter 10.3.4.

Provisions: 7.4.2.11 Interim quality control

These provisions can be applied for the entire system or the single unit process that is analysed / developed.

Many of the following provisions on interim quality control are only recommendations, but the same controls may be part of a subsequent mandatory external review.

General approach (7.4.2.11.1)

I) SHALL - **Validity check:** A validity check of the collected data shall be performed during the process of data collection and unit process development, to confirm that the data is in line with the goal and scope requirements. The following provisions provides related operational recommendations on this requirement:

II) MAY - **Interim quality control as review along "interpretation" provisions:** For the interim quality control on the unit process level, it is recommended to apply the data quality related technical aspects of the critical review (chapter 11) regarding the scope and methods of review together with the guidance of chapter 9 on interpretation (especially significant issues, sensitivity check, completeness check, and consistency check). These steps can however be done in a less formal way. Among others, the following may be done at this point: [ISO+]

II.a) **All relevant flows?:** Does the unit process inventory include all relevant product, waste and elementary flows that would be expected based on e.g. the input of processed materials, of the nature of transformations occurring in the process, and/or based on experience gained with similar processes? Reflect the required technological, geographical and time-related representativeness.

II.b) **Flow amounts are proportionate?:** Are the amounts of the individual flows and of the chemical elements, energy and parts in the input and output in expected proportion to each other?

II.c) **Support control by impact assessment:** Controls may also be based on impact assessment results for the process as well as for the whole system. They may

Provisions: 7.4.2.11 Interim quality control

reveal errors in the inventory results through showing unexpected high or low values of contributing elementary flows. Compare the LCIA results with data of the same or similar processes / systems from other sources to identify possible problems. Make sure the other sources are of high quality and especially high completeness.

II.d) **Method consistency?:** On the system level, carefully check that methods have been applied consistently. This especially applies if combining data from different sources.

II.e) **Follow up on discrepancies:** Check and explain or correct any observed discrepancies in the inventory data by consulting additional data sources or technical experts for the analysed process.

II.f) **Report on findings:** It is recommended providing for the unit process data set an at least brief internal quality control report on the above findings.

II.g) **Reflect findings in data set quality indicators:** Make sure that the data set documentation appropriately describes the process and the identified accuracy, precision, and completeness as well as any limitations.

Obtaining better unit process data (7.4.2.11.2)

III) SHALL - **Dealing with initially missing data:** The potential importance of initially missing data shall be checked in the following way and relevant gaps shall be filled if possible and as detailed below: [ISO!]

III.a) SHOULD - **Identify relevance of initially missing data:** A reasonable worst case or at least conservative value for the missing data should be used in a first screening to see if they may influence the overall results of the LCI study. This reasonable worst case or conservative value may be derived by inference from knowledge of similar or related processes or from correlation or calculation from other flows of the process. This includes identifying and inventorying flows that were initially not known to occur in the analysed process but that could not be excluded entirely.

III.b) SHOULD - **Dealing with relevant, initially missing data:** If this screening shows that the missing data may be of importance, in further iterations of the LCA work it should be attempted to first identify whether the flow is actually occurring in the analysed process and if so to get the yet missing data. As second option sufficiently good estimates should be obtained. As third option, if also that is not possible, the gap should be kept and reported. (Details see separate provisions more below):

III.c) SHALL - **Filling data gaps with estimates of defined and minimum quality:**

III.c.i) SHALL - For each newly modelled unit process any initially missing data should be documented in a transparent and consistent way. At the end of the iterative steps of improving the data set, the finally missing data and the potential use of data estimates to fill data gaps shall be documented in a transparent and consistent way (see chapter 10 on reporting).

III.c.ii) MAY - For judging the relevance of an initial data gap, it is necessary to approximate the achieved accuracy, completeness and precision of the

Provisions: 7.4.2.11 Interim quality control

overall environmental impact on system level. This necessarily needs that the subsequent steps of modelling the life cycle and calculating LCI results and LCIA results need to be done first (see next chapters). It is recommended to do this in parallel to developing the unit process data set. For unit processes this means completing the life cycle model around the unit process with background data. Any limited completeness in the used background data shall be not considered when calculating the achieved degree of completeness for the unit process for the final reporting.

III.c.iii) MAY - For filling data gaps for single flows estimate data (sets) may be considered to be used. Such may be e.g.:

III.c.iii.1) generic or average data for missing specific data,

III.c.iii.2) average data of a group of similar products for missing inventory data for other, not yet analysed products of that group,

III.c.iii.3) correlation with other, more complete and high quality data for the same or similar process but from other data sources (e.g. industry average data for improving a producer-specific process),

III.c.iii.4) justified judgements of technical experts / process operators.

III.c.iv) SHALL - Data gaps shall generally be filled methodologically consistent data. Gaps of low relevance may also be filed with methodologically not fully but sufficiently consistent data sets while being developed along the guidance of this document and meeting the overall quality requirements as detailed below.

III.c.v) SHALL - Only data that increase the overall quality of the final inventory of the analysed system shall be used to fill data gaps. That means that the individual data / data set's overall quality (i.e. combined accuracy, precision, completeness, and methodological appropriateness and consistency) shall be equivalent to at least the "Data estimate" quality level; see annex 12.3).

Note that this shall include both the quality of the used data estimate and of the amount of the flow. That semi-quantitative approximation of the integrated data estimate plus flow amount quality shall be based at least on an individually, briefly justified expert judgement, explicitly considering the named shortcomings; this may be supported by uncertainty calculation and quantitative calculation of data accuracy.

Note that both the approach(es) used to estimate initially missing data and the resulting lack of representativeness, precision and methodological consistency on data set level is later to be clearly documented and explicitly considered when declaring the achieved data set quality.

Dealing with remaining unit process data gaps / missing data (7.4.2.11.3)

IV) SHALL - **Document remaining data gaps:** If data estimates cannot be made available that would meet the above requirements, the data gap shall be kept and be documented instead. The following provisions are made: [ISO!]

IV.a) **Missing qualitative information for a unit process inventory item:** The

Provisions: 7.4.2.11 Interim quality control

respective flow should be created and used in the regular inventory only if it is a product or waste flow. Little specified elementary flows (e.g. "Metals to air") shall not be kept in the regular inventory but this information shall be documented in another way. This can be either as clearly marked flows that shall not be combined with the elementary flows of the regular inventory when aggregating the data sets of the analysed system, The flows can be marked e.g. as "missing important" or "missing unimportant", as applicable (see more below), and be excluded from the aggregation. Or they can be documented exclusively in the descriptive information of the data set (e.g. as attached lists).

IV.b) **Missing quantitative information for a unit process inventory item:** The flow should be inventoried. If no quantitative information can be given, this has to be documented by marking the flow as “missing important” to avoid misleading readers, as the true value is not zero. The omission must be explicitly addressed and considered in the interpretation of the results. If a conservative estimate for a missing data fails to show any quantitative importance, a zero value may be entered for this data, but marking it as “missing unimportant”. If a mean value or a wide range of values (Min and Max) can be given, this should be entered in the inventory. Uncertainty information such as standard deviation and distribution type should be given if possible and if this information has sufficient precision. For both the above cases, the values shall not be aggregated when calculating LCI results. This can be achieved e.g. by marking theses inventory items as "missing important" or "missing unimportant", as applicable (see more below), and excluding such flows from the aggregation[55]. Or they can be documented exclusively in the descriptive information of the data set (e.g. as attached lists).

IV.c) **Missing qualitative and quantitative information:** See preceding two points that are to be combined.

IV.d) **Missing LCI data for processes / systems in the background system:** When aggregating the unit processes of the analysed system to LCI results, product and waste flows for which background data of sufficient quality is not available, these flows shall remain in the aggregated inventory, i.e. making the data set a "partly terminated system". The user of such data shall be explicitly informed in a prominent place that these parts of the system need to be still completed or the gap be considered in the further use and interpretation.

Note that any kind of worst case or conservative data and assumptions shall not be kept in the inventory of LCI data that are foreseen to be applicable for comparisons, unless the representing process operators or system producers themselves wish so (e.g. to align LCI data reporting with other values reported on e.g. site or company level). Note that reasonably worst-case data may however be used for scenarios and for checking the robustness of comparisons when doing the sensitivity analysis.

Note the specific requirements for product comparisons such as on e.g. the consistency of methods, data quality, and assumptions across the compared alternatives (for details see chapter 6.10).

[55] LCA software generally does not have empty values or text entries for the amount of an inventory flow, as it must be able to sum up the entries. If hence a value zero is (automatically) assigned, the classification "missing important" ensures that this gap is clearly documented and that flow can be treated differently.

Provisions: 7.4.3.3 Emission of measurement indicators and elementary flow groups

I) SHALL - **Measurement indicator and substance group elementary flows:** These shall be inventoried as follows: [ISO!]

I.a) **Avoid indicators and flow groups; with permissible exceptions:** Measurement indicator and substance group elementary flows shall be avoided in the inventory by splitting them up to single substances. Exclusively the following exceptions are permissible, while they should be split as well: COD[56], BOD, AOX, VOC, NMVOC, PAHs, PCBs, TOC, DOC, Nitrogen in Nitrogen compounds (excluding N_2, N_20), Phosphorus in Phosphorus compounds, Dioxins (measured as 2,3,7,8-TCDD human toxicity equivalents).

I.b) **Restrictions on partial splitting:** A partial splitting up of measurement indicators and substance group flows should be avoided. This is except for singling out exclusively elementary flows that have higher impacts than the average of the indicator / group and that should be singled out. Partial splits with singling out elementary flows with less than average impacts shall not be done. If singling out single substance elementary flows from the above indicators / flow groups, only the remainder amount of the indicator or flow group shall be inventoried.

I.c) **No double-counting:** Double-counting across the above indicators / flow groups and with the contained individual substances shall be avoided (i.e. correct is to inventory either "BOD" or "COD"; either "VOC" or "NMVOC" plus "Methane"; either "Nitrate" plus "Ammonia" plus ... or "Nitrogen in Nitrogen compounds"; etc.).

I.d) **Document composition:** If measured composition information of a split measurement indicator or substance flow group is not available, an assumed composition can be used. Approach and assumptions shall be documented.

Note that the composition of a measurement indicator or substance flow group can often be derived without direct measurement from process know-how (e.g. processed materials, educts, etc.) or those of sufficiently similar process can be considered[57].

I.e) **Do not combine measured flows:** Individually measured substances shall not be integrated/combined into measurement indicators and elementary flow groups but be inventoried individually.

II) MAY - **Use "Reminder flow" to keep originally measured indicator or flow group:** It is recommended to document the originally measured amount of the split indicator or flow group in the inventory as a “Reminder flow”. "Reminder flows" shall later be excluded from the impact assessment, i.e. have no characterisation factors and be clearly identified as "Reminder flows" (on naming see chapter 7.4.3.8). [ISO+]

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved

[56] COD = Chemical oxygen demand, BOD = Biological oxygen demand, AOX = Adsorbable organic halogenated compounds, VOC = Volatile organic compounds, NMVOC = Non-methane volatile organic compounds, PAH = Polycyclic aromatic hydrocarbons, PCB = Polychlorinated biphenyls, TOC = Total organic carbon, DOC = Dissolved organic carbon.

[57] Default-composition tables for different process-types and industries might be developed in PCR-type or sector-specific guidance documents.

data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

Provisions: 7.4.3.3 Emission of ionic compounds

I) SHALL - **Inventory easily water soluble salts as ions:** For data sets as deliverables, emissions to air, water, or soil of easily water-soluble ionic compounds (salts) shall be inventoried as separate ions, unless the selected LCIA methods would require otherwise. As convention, the limit is set at a solubility in water at 20°C of 10 µg/litre, above which the ions shall be inventoried separately, below which the compound shall be inventoried. This applies unless the selected LCIA method requires otherwise. [ISO!]

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

Provisions: 7.4.3.4 Emission of particles to air

I) SHALL - **Inventory only poorly water soluble compounds as particles:** Particulate matter (PM) emissions to air shall include only poorly water-soluble compounds below a solubility in water at 20°C of 10 ug/litre, as far as feasible. Expert judgement may be needed to identify the composition of the particles. [ISO!]

II) SHOULD - **Differentiate particle size classes:** Particles should be reported split up by particle size class <0.2 µm, 0.2-2.5 µm, 2.5-10 µm, >10 µm if the information is available. <10 µm may be used alternatively is a more differentiated information below 10 µm is not available. This applies unless the selected LCIA method requires otherwise. [ISO!]

III) SHALL - **Inventory particles additionally as the substances they are composed of:** Particles shall be inventoried as both PM and additionally as elementary flows of their environmentally relevant components (e.g. metals contributing to cancer effects), i.e. double counting their mass in the inventory, as far as possible. This applies analogously to other emissions with additive action schemes. [ISO!]

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

Provisions: 7.4.3.6 Resource elementary flows

I) SHALL - **Provisions for inventorying resource elementary flows:** Resource elementary flows shall be inventoried as follows, with exceptions only if necessary to meet the need of the applied LCIA method: [ISO!]

I.a) **Energy resources** (7.4.3.6.1)**:**

Provisions: 7.4.3.6 Resource elementary flows

I.a.i) **Non-renewable:** These shall be inventoried as type of energy resource and in few cases (only primary, secondary, tertiary crude oil and open pit or underground mining of hard coal) these should be differentiated exclusively by resource extraction type, if this information is available (e.g. "Crude oil, secondary extraction" but not "Crude, Tia Juana Light"; "Hard coal, underground" but not "Hard coal, Western Germany; 39.4 MJ/kg"). The energy/mass relationship shall be provided for all energy resource flows except for nuclear ores. The energy content shall be expressed in the Lower calorific value of the water-free resource, measured in the reference unit MJ. See also separate document "Nomenclature and other conventions".

Note that peat, biomass of primary forests, and some other biogenic energy resources are "non-renewable".

I.a.ii) **Renewable:** Renewable energy resources shall be inventoried as the amount of usable energy extracted from nature. E.g. for solar electricity and heat this relates to the amount of electricity and/or heat captured by the solar cells (i.e. not the total solar energy, but what is delivered directly by the cells as electricity and/or usable heat). For biomass from nature this is the amount physically embodied, measured as Lower calorific value, however of the water-free substance (i.e. measured as if the e.g. wood would be oven-dry). Note that biomass from fields and managed forests is no elementary flow. In that case, the named energy resources shall be inventoried directly as the respective elementary flows, e.g. "Solar energy" as "Renewable energy resources from air", expressed as Lower calorific value and measured in the reference unit MJ.

I.b) **Avoid geographical differentiation:** Resources shall not be inventoried geographically differentiated (i.e. "Lignite" but not "Lignite, Eastern Germany"). This applies unless the selected LCIA method requires otherwise. (7.4.3.6.1)

I.c) **Chemical element resources:** Resources for production of metals or other chemical elements should be inventoried as chemical element (e.g. "Iron - Resources from ground" elementary flow). (7.4.3.6.2)

I.d) **Functional/material resources:** These shall be inventoried as target material resource (e.g. "Schist", "Lime stone", "Anhydrite"). Few exceptions exist where the mineral itself is in industry understood to be the target good; these are reflected in the ILCD reference elementary flows (e.g. "Rock salt", etc.). Other exceptions and exclusively for resources not included in the ILCD reference elementary flows shall be justified by following analogous logic. (7.4.3.6.2)

I.e) **Flows for completing mass balance:** For completion of the mass balance, a complementary amount of "Inert rock", "Water", or "Air" (or other, as applicable) shall be inventoried for extracted resources (e.g. 0.96 kg "Inert rock" in case of mining 1 kg copper ore with 4 % copper content). (7.4.3.6.2)

I.f) **No minerals or ore bodies:** Inventorying of other minerals (unless these are functional / material resources such as "Granite") or of specific ore bodies shall not be done (i.e. "Copper", but not "Malachite" and not "Sulphidic copper-silver ore (3.5 % Cu; 0.20 % Ag)"). (7.4.3.6.2)

Provisions: 7.4.3.6 Resource elementary flows

Note that when applying the above rules double counting shall be avoided. Newly created elementary flows shall be checked whether they require carrying a characterisation factor for the applied LCIA method.

II) SHALL - **Land use and transformation:** Direct land use and land transformation shall be inventoried along the needs of the applied LCIA method (if included in the impact assessment)[58]. (7.4.3.6.3)

III) SHALL - **Emissions from land use and transformation:** If land use and/or land transformation are modelled, carbon dioxide and other emissions and related effects should be modelled as follows: [ISO!]

III.a) **Soil organic carbon changes from land use and transformation:** For CO_2 release from or binding in soil organic carbon (SOC) caused by land use and land transformation, the use of the most recent IPCC CO_2 emission factors shall be used, unless more accurate, specific data is available. Detailed provisions and table with the IPCC factors: see chapter 7.4.4.1 and annex 13. (7.4.3.6.3)

III.b) **Land use and transformation related CO2 emissions from biomass and litter:** For virgin forests and for soil, peat, etc. of all land uses shall be inventoried as "Carbon dioxide (fossil)". Emissions from biomass and litter of secondary forests shall be inventoried as "Carbon dioxide (biogenic)". This applies unless the selected LCIA method requires otherwise. (7.4.3.6.4)

III.c) **Nutrient losses:** Emissions of nutrients shall be modelled explicitly as part of the land management process. Detailed provisions see chapter 7.4.4.1.

III.d) **Other emissions:** Other emissions in result of land transformation (e.g. emissions from biomass burning, soil erosion etc.) should be measured or modelled for the given case or using authoritative sources. Detailed provisions see chapter 7.4.4.1. (7.4.3.6.3)

IV) MAY - **Water use:** It is recommended to differentiate at least: [ISO+]

IV.a) on the input side: surface freshwater, renewable groundwater, fossil / deep ground water, sea water

IV.b) on the output side: Emission/discharge of water in liquid form emission in form of steam

IV.c) Other water quality changes, especially by chemical substances shall be inventoried as separate elementary flows.

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

[58] While this document has been finalised no established and globally applicable practice was available, but several approaches with either only regional applicability or lack of practice experience. These work with fundamentally different inventorying approaches. Any specific recommendation or requirement on inventorying land use and conversion would be implemented and published via revised ILCD reference elementary flows and recommended LCIA methods, and/or a revision of this document.

Provisions: 7.4.3.7 Future processes and elementary flows

Implicitly differentiated for attributional and consequential modelling.

V) SHALL - **Separate inventory items for emissions more than 100 years into the future:** Emissions and other elementary flows that occur beyond the next 100 years from the time of the LCI study shall be inventoried separately (e.g. as "Emissions to water, unspecified (long-term)") from those that occur within the first 100 years (e.g. "Emissions to water, unspecified"). [ISO!]

Note that the ILCD reference elementary flows include a set of such long-term emissions to air, water and soil.

VI) SHALL - **Uptake of "Carbon dioxide" by plants:** This shall be inventoried under "Resources from air". This applies to all photosynthetic organisms. [ISO!]

Note that both the uptake of CO_2 from the atmosphere and the release of both fossil and biogenic CO_2 should be assigned characterisation factors for the impact assessment. The lack of knowledge whether a carbon dioxide or methane emission is biogenic or fossil (i.e. inventoried as e.g. "Carbon dioxide (unspecified)") therefore does not render the results erroneous.

VII) SHALL - **Inventory temporary carbon storage and delayed GHG emissions:** Only if "temporary carbon storage in bio-based goods" is considered, the temporary removal of carbon dioxide from the atmosphere, storage in long-living bio-based products or landfills, and delayed emission as CO_2 or CH_4 shall be modelled analogously to delayed emissions of fossil carbon dioxide and other greenhouse gases. The difference is that for fossil emissions the uptake from the atmosphere is not considered, but only the delayed emission[59]. See also chapter 9 on interpretation and note that the temporary storage shall only be considered if explicitly required to meet the specific goal of the study. If this is the case, it shall both be modelled as follows: [ISO+]

VII.a) Special correction elementary flows shall be used to inventory the amount of CO_2 that is emitted in the future. This can be both due to temporary storage as embodied biogenic carbon in long-living and land-filled bio-based goods and due to processes with fossil GHG emissions that take place in the future. If this is

[59] The logic behind accounting for biogenic carbon storage is that for the duration of storage the CO_2 is not exerting a radiative forcing. This makes sense only in case near-term radiative forcing is considered more relevant than future radiative forcing, as the later re-emitted biogenic CO_2 will still exert its full radiative forcing effect, only later. That is reflected by the commonly used one hundred years perspective for GWP100: the higher radiative forcing per unit (kg) of e.g. Methane and Nitrous oxide is weighted higher then the relatively lower radiative forcing per unit of CO_2, always for 100 years. To reward the temporary removal of CO_2 from the atmosphere is fully equivalent to the effect of avoided radiative forcing due to delayed emission of fossil carbon dioxide, methane, nitrous oxide, and other greenhouse gases: While the uptake of CO_2 from the atmosphere is unique for biomass and considered in the impact assessment as negative impact, it does not matter whether one burns a block of wood or of plastic and releases the CO_2 as emission: both biogenic and fossil CO_2 are identically contributing to radiative forcing when emitted. For Climate change it is the same whether one keeps a piece of wood or of plastic unburned for e.g. 60 years. If the time when an emission takes place is considered for biomass it must also be considered for fossil materials. Some examples/aspects: Note that on a net basis temporarily stored biogenic carbon has a negative Climate Change impact: at 60 years storage of e.g. 1 kg CO_2: CO_2 uptake (negative value -1 kg CO_2-eq.) plus emission after 60 years (+1 kg CO_2-eq.) minus the credit for 60 years temporary storage, = -1 + 1 - 0.6 = -0.6 kg CO_2-equiv. in total. For delayed fossil emissions the net impact is always positive: CO_2 emission minus credit for 60 years delayed emission, e.g. for 1 kg CO_2 = 1 - 0.6 = 0.4 kg CO_2-equiv. in total. Note that the difference between biogenic and fossil delayed emissions for the same time of delay is always the same (i.e. 1 kg CO_2-equiv. difference per kg CO_2 emitted), rewarding both biogenic carbon storage and long-living products.

Provisions: 7.4.3.7 Future processes and elementary flows

done, the following correction flows shall be used:

VII.a.i) "Correction flow for delayed emission of biogenic carbon dioxide (within first 100 years)" and "Correction flow for delayed emission of fossil carbon dioxide (within first 100 years)", respectively. Both as elementary flows and classified on the general level as "Emissions", measured in the reference flow property "Mass*years" of storage and the reference unit "kg*a". Both flows shall carry a GWP100 impact factor of "-0.01 kg CO_2-equivalents" per 1 kg carbon dioxide and 1 year of storage/delayed emission; this exclusively if "temporary carbon storage" is considered in the study.

VII.a.ii) "Correction flow for delayed emission of biogenic methane (within first 100 years)" and "Correction flow for delayed emission of fossil methane (within first 100 years)", respectively. Both as elementary flow and classified on the general level as "Emissions", measured in the reference flow property "Mass*years" of storage and the reference unit "kg*a". Both flows shall carry a GWP100 impact factor of "-0.25[60,61] kg CO_2-equivalents" per 1 kg methane and 1 year of delayed emission; this exclusively if "temporary carbon storage" is considered in the study.

VII.a.iii) "Correction flow for delayed emission of nitrous oxide (within first 100 years)". As elementary flow and classified on the general level as "Emissions", measured in the reference flow property "Mass*years" of storage and the reference unit "kg*a". This flow is to carry a GWP100 impact factor of "-2.98[154] kg CO_2-equivalents" per 1 kg nitrous oxide and 1 year of delayed emission; this exclusively if "temporary carbon storage" is considered in the study.

VII.a.iv) For other greenhouse gases analogous factors can be developed and used.

VII.b) The maximum amount of each correction flow that can be inventoried per kg delayed emission shall be 100 kg*a. That is if the delayed emission takes place exactly 100 years into the future. The correction flow shall be inventoried only if the emission is forecasted to take place at a maximum of 100 years into the future from the time of study. It shall not be inventoried if the emission takes place beyond the 100 years[62]: An emission that takes place more than 100 years into

[60] This factor uses the IPCC GWP100 factors of 2007 by multiplying the base-value for carbon dioxide of 0.01 with the substance-specific factor (e.g. 25 for methane, 298 for nitrous oxide (laughing gas, N_2O)). The substance-specific factor shall be adjusted in line with any ILCD recommendations on LCIA methods or updated factors from the IPCC if the former is not available.

[61] Note that both fossil and biogenic Methane carry the same factor, as the uptake of the CO_2 by the plants is to be modelled explicitly in any case (see chapter 7.4.3.6.4) and the elementary flow carries a GWP factor of -1 kg CO_2-equiv. per kg CO_2 uptake. Fossil and biogenic Methane would require different factors only if the uptake would not be modelled explicitly.

[62] The reason is that otherwise the LCIA results for the short-term perspective (first 100 years) would carry a full credit of negative climate change impacts while the long-term LCIA results carry the emission as it takes place beyond 100 years. If in results interpretation a short-term perspective is taken (and the long-term emissions excluded / discounted) an incorrect negative impact would be found.

Provisions: 7.4.3.7 Future processes and elementary flows

the future shall be reflected in the inventory exclusively by inventorying the future emissions with the long-term emission elementary flows such as e.g. “Carbon dioxide, biogenic (long-term)” as “Emissions to air”. I.e. in that case no correction flow is required but would be wrong.

VIII) SHALL - **Inventory future substitution analogous to delayed emissions:** The provisions for delayed greenhouse gas emissions as detailed above apply analogously for delayed reuse/recycling/recovery in case this is modelled with substitution. The same applies generally for substitution that occurs in the future. The respective "Correction flows..." shall be inventoried with negative values, i.e. debiting for the delay in the substitution. Note that only if “temporary carbon storage and delayed emissions " is required to meet the specific goal of the study the correction flows will be considered and result in an additional contribution to the Climate change impacts. [ISO+]

IX) SHALL - **Document details and assumptions on delayed emissions / substitution:** The information about the assumed storage time or time of future reuse/recycling/recovery and other cases of substitution, as well as the amounts and substances of the emissions in the unit process shall be documented and made available for review. [ISO+]

X) SHALL - **Provision for long-term / quasi-permanent storage of potential emissions:** The quasi-permanent storage of CO_2 and other potential emissions in dedicated long-term storage forms (e.g. injection into former natural gas fields) shall be accounted for by inventorying no emissions at all, if the respective storage form can guarantee that it is not emitted to the atmosphere for at least 100,000 years (duration set by convention). [ISO+]

XI) SHALL - **Document details and assumptions on long-term / quasi-permanent storage:** The information about the storage form and assumed storage time shall be concisely documented and made available for review. This documentation shall be done via a respective waste inventory flow. [ISO+]

Note: The other inventory work is done as usual: I.e. inventorying emissions that occur within 100 years from present with the normal elementary flows (e.g. “Methane, biogenic” as “Emissions to air”).

Note that only if "temporary carbon storage" is considered in the study, in the later interpretation the results shall be analysed individually with and without the credit, showing explicitly the effect of the credit for storage/delayed emissions.

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

Provisions: 7.4.3.8 Reminder flows

I) MAY - **Use reminder flows to keep original information for specific purposes:** It is recommended to use reminder flows to inventory the original information of split measurement indicators and sum flows (see 7.4.3.2). They may be used to keep other flows in LCI results inventories for information purposes. [ISO+]

II) SHALL - **Exclude reminder flows from impact assessment:** Reminder flows shall not carry an LCIA impact factor. [ISO+]

III) SHALL - **Clearly identify reminder flows in the flow name:** The fact of being a reminder flow shall also be identified in the flow name (e.g. "VOC, reminder flow, not impact relevant"). [ISO+]

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

Provisions: 7.4.4.1 Modelling agro- and forestry systems

Applicable to Situation A, B, and C, differentiated.

Differentiated for attributional and consequential modelling.

I) SHALL - **Agro- and forestry systems:** Their modelling shall be done as follows: [ISO!]

I.a) **Inventory net interventions:** Only the net interventions related to human land management activities shall be inventoried. Interventions that would occur also if the site was unused shall not be inventoried (e.g. not the basic Nitrate leaching resulting from N input via rain):

I.a.i) **Reference system under attributional modelling:** The "no use" reference system shall be the independent behaviour of the site, starting from the status of the land at that moment when the area of the analysed system is prepared for the modelled system.

I.a.ii) **Indirect land use under consequential modelling:** The indirect land use (mix) shall be modelled (provisions see chapter 7.2.4.4); net interventions may need to be modelled for those indirect land uses / transformations.

Note that land transformation happening in the past may need to be allocated to the analysed system.

I.b) **Model site as part of the technosphere:** Of the applied fertilisers and agrochemicals (e.g. fungicides) only the amounts that leave the site (i.e. the field, plantation, managed forest etc.) shall be inventoried as emissions to air or water, as appropriate.

I.c) **Carried over nutrients as co-functions:** Any remaining nutrients such as N in crop residues are a co-product of the crop are an input for the production of the next crop. These cases of multifunctionality shall be solved in principle via system expansion (consequential modelling) or allocation (attributional modelling), applying the same provisions are foreseen for other cases of multifunctionality; see 7.2.4.6 and 7.9, respectively. Also emissions especially of Nitrate, Phosphate and other substances that are part of the nutrient system of the land and crop should be modelled as they occur during the respective land use.

I.d) **Model immobile substances to cross the system boundary over time:** Strongly soil-bound heavy metals and Persistent Organic Pollutants (POPs) that remain in the site for many decades shall be inventoried as "Emissions to soil, unspecified". Leaching of these substances to the groundwater shall not be

Provisions: 7.4.4.1 Modelling agro- and forestry systems

inventoried additionally, but is covered via the impact assessment of this emission to soil. In contrast, surface erosion by water and wind and related mass flow transfer of these substances together with the eroded soil to waterways or air shall be inventoried as "Emission to fresh water" or "Emission to air", respectively. These losses are directly related to the operation of the cropping process, hence belong to its inventory.

Note that the amount inventoried as emission to soil is to be reduced by the respective erosive losses. Double-counting shall be avoided.

I.e) **Model emissions form land use and transformation:** Carbon dioxide and other emissions resulting from land use and land transformation shall be modelled as follows, for both attributional and consequential modelling:

I.e.i) **CO_2 emissions:** These shall be calculated using the most recent Intergovernmental Panel for Climate Change (IPCC) factors per default, unless more accurate, specific data is available. Other, relevant inventory items should be measured or modelled for the given case or using similar authoritative sources, if available. Formulas for assignment to different subsequent land uses see below. The data, tables, factors and formula for calculating this CO_2 inventory that is to be shared as detailed below, is given in annex 13.

I.e.ii) **Two cases of inventory related to land transformation:** The land transformation related direct and indirect inventory shall be allocated to the following crops by used/occupied land area and duration of cropping, as follows. Two cases are to be differentiated: **a) inventory items that occur over a longer period than one year, exponentially reaching a new quasi-equilibrium** (e.g. CO_2 emissions from loss of soil organic carbon due to biodegradation of e.g. humus). **b) inventory items that occur in direct context of the transformation and not longer than one year afterwards** (e.g. machine use during conversion and peak emissions e.g. from biomass burning)

I.e.ii.1) **For case a)**, and for both attributional and consequential models, the inventory should be assigned to the land use functions in proportion to the inventory that occurs during the time the land use function is occupying the land or otherwise blocking it for other uses (e.g. include 1 year fallow as part of crop rotations). For loss / binding of CO_2 in form of soil organic carbon, towards reaching the equilibrium of the land use after transformation, a default period of 20 years shall be assumed. This is meant to reflect about 90 % the main losses / binding.

I.e.ii.2) For simplification, the total loss shall be assumed to occur in a triangularly shaped distribution with time over the period until the about 90 % loss / binding towards the new equilibrium have been reached. Formula 1 shall be used to allocate the calculated total emission/binding to the crops; if the above default period can be demonstrated to be different from 20 years, Formula 2 shall be used instead.

Provisions: 7.4.4.1 Modelling agro- and forestry systems

I.e.ii.3) Formula 1 $X = \frac{100*2}{20+1} * \frac{20-i}{20}$

- X = % of inventory to be allocated to the year i of the analysed crop
- 20 = number of years after transformation over which the inventory is to be allocated, i.e. until when 90 % of the losses / bindings of the CO_2 from / into the soil have occurred. The number of years is counted from the transformation onwards.
- i = number of years after transformation during which the analysed crop is cropped; the first year after transformation is year i = 0 (Additional condition: if i > 20-1 then X = 0, i.e. nothing shall be allocated after 20 years).

I.e.ii.4) If the initial years after transformation are without harvest (e.g. as typical for in plantations), the inventory shall be assigned to the first harvest / function of the land use after transformation.

I.e.ii.5) If only one kind of crop is harvested (e.g. fruits of a 25 year running fruit tree plantation without wood use), the entire inventory can be allocated to the total amount of the crop, independently of the specific year when the crop has been harvested; i.e. each kg has the same inventory.

I.e.ii.6) In the case more than one crop is harvested per year, the calculated inventory for that year shall be linearly allocated between these crops over the time of that year that they use the land or block it for other uses; i.e. for simplification no further differentiation needs to bee made between months earlier and later in that year.

I.e.ii.7) If the land use function (e.g. harvesting of wood) occurs after the considered period (here: 20 years), the entire inventory shall be assigned to that function, i.e. not only the share of that year, i.e. the inventory of preceding years is assigned to the crops harvested later, as otherwise it would be lost / not accounted for.

I.e.ii.8) If a joint production e.g. of annual crops and a final crop occurs (e.g. latex during the years and rubber wood at the end), the final crop should be considered to have been harvested after half the total period.

I.e.ii.9) The % share of the total inventory that shall be allocated to a given year (assuming the crop occupies that land for the full year or otherwise prevents its use for a full year), is then calculated using Formula 1 (see above).

I.e.ii.10) For land uses during the considered period but that are shorter than one year, the inventory shall be linearly shared among the uses according to their duration of using or blocking the land.

I.e.ii.11) **For case b)** and per default for sub-annual, annual and bi-annual crops, the total amount of uses over which the

Provisions: 7.4.4.1 Modelling agro- and forestry systems

"production" inventory of the land transformation is to be shared shall be 20 years. This is unless the foreseeable duration of the transformed land use is shorter, ending foreseeably with nature or no use other than short-term/managed fallow (e.g. slash-and-burn agriculture of 3 years use before abandoning). Or the foreseeable minimum use is longer (e.g. plantations with 30 years plantation cycle). In that case, that duration of one plantation / use cycle shall be used.

I.e.ii.12) The % share of the total inventory that shall be assigned to a given year of land use (assuming the crop occupies that land for the full year or otherwise prevents its use for a full year), is then proportional to the duration of land use / blocking it for other uses. I.e. other than for the preceding case of soil carbon changes it does not depend how long after transformation the land use occurs, as long as it is within the period that is considered as defined above.

I.e.ii.13) **Other emissions resulting from land use and land transformation (with equilibrium, excluding nutrients):**

I.e.ii.14) Other emissions that occur over a longer period than one year after transformation, but in an exponential way, should be measured or modelled for the given case or using authoritative sources with generic data if available. The following Formula 2 can be applied, being the general form of Formula 1:

I.e.ii.15) The % share of the total inventory that shall be assigned to a given year (assuming the crop occupies that land for the full year or otherwise prevents its use for a full year), is then calculated using Formula 2.

I.e.ii.16) Formula 2 $X = \frac{100*2}{n+1} * \frac{n-i}{n}$

- X = % of inventory to be allocated to the year i of the analysed crop
- n = number of years after transformation over which the inventory is to be allocated, i.e. until when 90 % of the losses / bindings have occurred. The number of years is counted from the transformation onwards.
- i = number of years after transformation during which the analysed crop is cropped; the first year after transformation is year i = 0 (if i > n-1 then X = 0, i.e. nothing shall be allocated after the number of considered years).

I.e.ii.17) Note that the total amount of the loss of XY and the actual duration of the main losses until about 90 % of the equilibrium of the land use are reached need to be identified first.

I.e.ii.18) **Emissions of items without an equilibrium:**

I.e.ii.19) Emissions that do not have an equilibrium state or that reach that state in a not exponential way, (e.g. soil erosion) need to

Provisions: 7.4.4.1 Modelling agro- and forestry systems

be modelled differently, while following an analogous reasoning as the other inventory items addressed in this chapter. These losses are directly related to the operation of the cropping process, hence belong to its inventory.

I.e.iii) If the natural goods from the converted land are also at least partly used (e.g. harvested primary forest wood), they shall be considered one function as part of the multifunctional system.

I.e.iv) The same provisions apply analogously to land transformation between other than agricultural, pastoral or forestry uses.

I.e.v) Emissions that do not have an equilibrium state or reach that state in a not exponential way, (e.g. soil erosion) need to be modelled differently, while following an analogous reasoning as the other inventory items addressed in this chapter.

Temporary removal of carbon dioxide from the atmosphere by plants and release at end-of-life: see chapter 7.4.3.7.3.

Indirect land use is an issue under consequential modelling and is in chapter 7.2.4.4.

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality ..

Provisions: 7.4.4.2 Modelling waste treatment

I) SHALL - **Waste and end-of-life product deposition:** This shall be modelled as follows: [ISO!]

I.a) **Model waste management completely:** Waste and waste water treatment shall be modelled consistently to the boundary between technosphere and ecosphere; otherwise this shall be clearly documented and be explicitly considered in later interpretation. This modelling includes all treatment steps up to and including disposal of any remaining waste to waste deposits or landfills and inventorying the emissions from these sites to/from the ecosphere. Two exceptions are radioactive wastes and wastes in underground deposits (e.g. mine filling), which should be kept as specific waste flows in the inventory, unless detailed, long-term management and related interventions have been entirely modelled also for these.

I.b) **Modelling discarding of goods into nature:** For unmanaged landfilling, discharge, and littering (i.e. discarding goods individually into nature) the related individual interventions that enter the ecosphere shall be modelled as part of the LCI model. This also applies analogously to other interventions than emissions, if the used LCIA method covers such. The littered / landfilled good should be additionally inventoried as reminder flow.

I.c) **Modelling waste as output:** Waste flows should be modelled following the material flow logic. That means inventorying the waste on the output side of those processes where it is generated (e.g. production waste or end-of-life product as output of the use stage). For waste management processes that means that the waste flows should accordingly be modelled on the input side if the process, with any potentially produced secondary goods and remaining wastes being on the output side. This eases mass and element balancing. For cost calculation purposes, the cost of the waste treatment service may be assigned to the waste flow as additional flow property.

Note: The use of generic waste treatment models / processes may be considered to limit time and resources required for data collection.

Provisions: 7.4.5 Naming and other conventions

I) SHALL - **Elementary flows:** [ISO+]

I.a) **Use ILCD reference elementary flows:** The 19000+ pre-defined ILCD reference elementary flows, flow properties (named "properties" in ISO/TS 14048 and "quantities" in ISO 31) and unit groups shall be used per default, if available.

I.b) **Define new elementary flows consistently:** New elementary flows shall be created meeting the methodological requirements of this document (see chapter 7.4.3). They shall per default be measured in flow properties (e.g. upper or lower calorific value) and units (e.g. MJ or kWh) applying the guidance given in the separate document "Nomenclature and other conventions". Exceptions are only possible if a different unit (e.g. one year of production) is explicitly required for the intended applications; in that case the use of not ILCD-compliant units shall be brought to the awareness of the data set user.

I.c) **Use ILCD elementary flow categories:** New elementary flows shall be classified in the elementary flow categories and sub-categories as defined in the guidance document "Nomenclature and other conventions" (e.g. "Emissions to fresh water", "Resources from ground", etc.). If required for the applied LCIA method (see chapter 6.7.5), differentiated compartments may be used.

II) SHOULD - **Product and waste flows and processes:** The naming and classification of product and waste flows as well as processes should apply the recommended nomenclature and they should be measured in the flow properties and units given in the guidance on "Nomenclature and other conventions". [ISO+]

III) SHALL - **Flow properties and unit groups:** The assignment and naming of new flow properties and unit groups shall apply the recommended nomenclature given in the guidance on "Nomenclature and other conventions". [ISO+]

Note that the need to create new units is a rare exception for LCA practitioners; creating new flow properties will be seldom. For LCIA method developers the need to create new unit groups occurs frequently.

Note that if the above provisions cannot be fully met, this shall be explicitly considered when reporting achieved data quality. Note that LCI data sets' inventories that do not meet the above requirements are not compliant with the ILCD nomenclature.

Provisions: 7.6 Selecting secondary LCI data sets

Note that these provisions also apply to the development of unit process and partly terminated system data sets as deliverables, as the cut-off rules need to be evaluated in the system's perspective.

Attributional and consequential modelling and the Situations A, B and C need at least partially differently modelled data sets.

I) SHALL - **Use consistent secondary data sets:** The secondary data (generic, average or specific data sets) to be used in the system model shall be methodologically sufficiently consistent among each other and with the primary data sets that were specifically collected.

II) SHOULD - **Quality-oriented selection of secondary data sets:** Secondary data sets should be selected according to their data quality in a stricter sense, i.e. their technological, geographical and time-related representativeness, completeness and precision. Their reference flow(s) and/or functional unit(s) should moreover be sufficiently representative for the specific processes, good or service that they are meant to represent in the analysed system.

III) MAY - **Prefer pre-verified data sets:** It is recommended to give preference to already critically reviewed data sets ("pre-verified data") as this limits the effort for an review of the analysed system: only the appropriate use of these data sets in the analysed system needs to be reviewed. [ISO+]

IV) MAY - **Prefer well-documented data sets:** It is recommended to give preference to data sets that are supported by a comprehensive and efficiently organised documentation. This allows the modeller (and later a reviewer) to judge the data set's quality and its appropriateness for the analysed system. [ISO+]

The combined use of data from different sources is facilitated by using either single operation unit process data set background systems that can be adjusted / re-modelled by the user to be consistent with the analysed system, or by using LCI results data sets that are consistent with the methodology applied in the analysed system.

7.8 Modelling the system

Provisions: 7.8 Modelling the system

Applicable to Situation A, B, and C, differentiated.

Differentiated for attributional and consequential modelling.

Applies also to the development of unit process and partly terminated system data sets as deliverables, but only to quantify the achieved completeness and precision, as they need to be evaluated in the system's perspective.

I) SHALL - **Scale inventories correctly:** The inventories of all processes within the system boundary shall be correctly scaled to each other and to the functional unit(s) and/or reference flow(s) of the analysed system[63].

II) SHALL - **Complete system model:** No quantitatively relevant product or waste flows shall be left unmodelled / unconnected, with exception of the reference flow(s) that quantitatively represent(s) the system's functional unit (additional provisions on waste flows see 7.4.4.2). Otherwise these flows shall be clearly documented and the resulting lack of accuracy and completeness be considered in the interpretation of results. [ISO!]

Note that for unit processes all and for partly terminated systems selected inventories of the corresponding products and/or wastes modelling processes are intentionally left out of the system boundary. Their systems are nevertheless completed, while only for applying the cut-off rules.

III) SHALL - **Set parameter values:** Set the parameter values to the required values in all used parameterised process data sets, if any. [ISO+]

IV) MAY - **Perform another round of interim quality control:** It is recommended to pre-check during modelling whether the data set or system is properly modelled and meets the quality requirements as identified/fine-tuned in the scope phase; the provisions for interim quality control of unit processes apply analogously (see chapter 7.4.2.11). For filling initial data gaps of included processes and systems estimate data sets may be considered to be used. Such may be e.g.: [ISO+]

IV.a) generic or average data sets for missing specific processes / systems,

IV.b) average data sets of a group of similar processes or systems (e.g. products) for missing processes / systems for other, not yet analysed processes or systems of that group,

IV.c) correlation with other, more complete and high quality process data sets for the same or similar process but from other data sources (e.g. industry average data for improving a producer-specific process).

V) SHALL - **Use consistent data to fill data gaps:** Data gaps shall be filled methodologically consistent data sets, while gaps of low relevance may also be filed with methodologically not fully but sufficiently consistent data sets while being developed along the guidance of this document and meeting the overall quality requirements as detailed below. [ISO!]

VI) SHALL **Use sufficiently quality LCI data sets top fill gaps:** Only data and data sets that increase the overall quality of the final inventory of the analysed system shall be used to fill data gaps. That means that the individual data or data set's quality shall be equivalent to at least the "Data estimate" quality level. See also chapter 7.4.2.11.3 and annex 12.3. Remaining data gaps shall be reported. [ISO!]

Note that both the approach(es) used to fill initial data gaps and the resulting lack of representativeness, precision and methodological consistency of the whole data set is later to be clearly documented and

[63] This can be visualised by having all processes connected with each other via their reference flows of interim products and wastes, in the correct amounts. Starting from central process and the amount(s) of the system's functional unit(s) or reference flow(s), all other processes are stepwise, relatively scaled. LCA software with graphical modelling interface shows the system in this way and/or the user is modelling the system explicitly by connecting the processes on that interface. Depending on the modelling approach implemented in the software, other mechanisms can be found that serve the same scaling purpose.

explicitly considered when declaring the achieved data set quality.

Note that the final check on the achieved overall environmental completeness / cut-off is detailed in chapter 9.3.2.

Note that decisions on any omissions of life cycle stages, types of activities, individual processes or elementary flows must be clearly reported and should be justified by the fact that they do not contribute significantly to the LCI results in view of the intended application(s) of the outcome of the LCI study. Otherwise they need to be reported and considered when declaring the achieved data set quality and/ drawing conclusions and recommendations from the study.

Provisions: 7.9.2 Avoiding allocation by subdivision or virtual subdivision

Applicable to Situation C2. Applicable to cases of Situation A, B, C1 only if subdivision, virtual subdivision and substitution/system expansion were not possible or feasible, as identified along the specific provisions for these Situations (see 6.5.4).

Applicable only to attributional modelling, unless in consequential modelling substitution is not possible or feasible.

I) SHALL - **Analyse whether allocation can theoretically be avoided by subdivision:** Investigate whether the analysed unit process is a black box unit process (concept see Figure 7): does it contain other physically distinguishable sub-process steps and is it theoretically possible to collect data exclusively for those sub-processes? Next, check whether subdivision can solve the multifunctionality of this black box unit process: can a process or process-chain within the initial black box unit process be identified and modelled separately that provide only the one required functional output?

II) SHALL - **Aim at avoiding allocation by subdivision or virtual subdivision:** Based on the outcome, the following steps shall be followed:

II.a) **Subdivision:** If it is possible to collect data exclusively for those included processes that have only the one, required functional output: inventory data should be collected only for those included unit processes.

II.b) **Partial subdivision:** If this is not possible (i.e. the analysed unit process contains multifunctional single operation unit processes that are attributed to the required functional output) or not feasible (e.g. for lack of access or cost reasons): inventory data should be collected separately for at least some of the included unit processes, especially for those that are main contributors to the inventory and that cannot otherwise (e.g. by virtual subdivision - see later provision) clearly be assigned to only one of the co-functions. [ISO+]

II.c) **Virtual subdivision:** It should be checked whether it is possible by reasoning to virtually partly or fully sub-divide the multifunctional process based on process/technology understanding. This is the case wherever a quantitative relationship can be identified and specified that exactly relates the types and amounts of a flow with at least one of the co-functions / reference flow(s) (e.g. the specific mechanical parts or auxiliary materials in a manufacturing plant that are only used for the analysed product can be clearly assigned to that product by subdividing the collected data). For those processes where this can be done, a virtual subdivision should be done, separating included processes as own unit processes. Chapter 7.4.2.2 provides additional details on the approach. [ISO+]

II.d) **Justify need for allocation and document potential distortion:** If the preceding sub-steps are not possible and a real or virtual separation is not feasible, allocation is the approach that shall be applied (see next chapter). In addition and only if subdivision is theoretically possible but was not performed, it should be demonstrated/argued at least via quantitative approximation or reasoning that the decision for allocation does not lead to relevant differences in the resulting inventory, compared to a subdivision. If it leads to relevant differences, the respective cases shall be documented and shall later be explicitly considered when assessing the achieved accuracy of data sets. [ISO!]

Note that virtual subdivision can also improve the basis for allocation, with more accurate results.

Provisions: 7.9.3 Solving multifunctionality by allocation

These provisions are applicable only for Situation C2 and for those cases in Situation A, B and C, if subdivision, virtual subdivision and substitution/system expansion was not possible or feasible, along the given provisions (see 6.5.4).

I) SHALL - **Share inventory between co-functions by allocation:** If allocation is to be done, the environmental burden of the concerned processes shall be shared between the co-function(s) of the process or system by allocation. (7.9.3.1)

II) SHALL - **Differentiate multifunctional processes and multifunctional products:** These two cases shall be differentiated [ISO!]. (7.9.3.2)

III) SHALL - **Two-step procedure for multifunctional processes:** The following two-step procedure[64] shall be applied [ISO!]: (7.9.3.2)

III.a) **First step and criterion "determining physical causality":** As first criterion, the “determining physical causal relationships” between each non-functional flow and the co-functions of the process shall be identified and used as allocation criterion. This relationship is the one that determines the way in which quantitative changes of the products or functions delivered by the system change the other inputs and outputs. Within this step, process-related inventory flows (e.g. spontaneous NOX in incineration, consumption of auxiliary materials) should be differentiated from function (product) related inventory flows (e.g. the NOx from the nitrogen in the incinerated fuel, materials or parts ending up at least partly in the co-products).

Note that often a combined, multiple allocation of the different non-functional flows to the co-functions is necessary, applying different criteria for the different flows.

Note also that the preceding step of virtual subdivision is applying the same logic as physical causality allocation.

III.b) **Checklist for "determining physical causality" criteria:** If this is not possible or for any remaining inventory items, the following list gives guidance which criteria should be analysed by default whether they are the "determining physical causal relationship" to be used for allocation in different cases of co-servicing and co-production processes:

III.b.i) **Services:**

[64] The need is seen to develop supplementing practice-manuals in line with the ILCD and with explicit allocation-criteria/rules for main process and product groups, to further enhance practicability and reproducibility. This could follow the same general logic as applied when developing Product Category Rules (PCR) in support of Environmental Product Declarations (EPD).

Provisions: 7.9.3 Solving multifunctionality by allocation

- Goods transport: time or distance AND mass or volume (or in specific cases: pieces) of the transported good
- Personal transport: time or distance AND weight of passengers including luggage
- Staff business travel: added value of system
- Staff commuting: added value of system
- Retailing: time (duration) of shelf-life AND mass or volume of good
- Storage and shelter, i.e. buildings and other three-dimensional infrastructure: time (duration) of use AND volume of good OR area occupied by the good
- Storage and other functions provided by places and other two-dimensional infrastructure: time (duration) of use AND area occupied by the good
- Transport and communication on roads, railways, pipes, cables, and other one-dimensional infrastructure: time (duration) AND intensity (e.g. road wearing impact by vehicles of different weight) OR bandwidth of use.
- Heating/cooling of space (keeping a temperature): time (duration of heating/cooling) AND area or volume heated/cooled (depending whether the space is used by area such as in offices, or by volume such as in staple storage halls or retail freezers)
- Heating/cooling of goods (reaching a target temperature): heat capacity of good
- Private administration services: person time or cost charged for admin services OR market value of sales
- Public administration services: person time or cost charged for admin services OR number of cases serviced
- Cleaning services (of objects of similar cleaning technologies): surface area cleaned (or as fall-back option: time (duration) of cleaning)
- Guarding services: share of product's value among guarded products AND/OR the production/provision facilities' value of the product among guarded site/object, depending what is the purpose of the guarding
- Marketing services: share of product implicitly or explicitly addressed by marketing (e.g. corporate marketing: share of product's value in corporate turnover)
- Teaching/training services: person time (duration) of training AND number of individuals taught/trained
- R&D services (of objects of similar R&D): person time OR cost charged for R&D services

III.b.ii) **Production processes:**

- Extraction processes: for process-related flows the market value, for product-related flows the specific physical properties of the co-products
- Chemical conversion and waste processing (including incineration): quantitative change of the to-be-allocated flows in dependency of

Provisions: 7.9.3 Solving multifunctionality by allocation

quantitative changes in the products or functions delivered by the system. If unknown: the chemical or physical properties that determine the amount of the other flows

- Manufacturing (including physical transformation processes) and mechanical waste processing: length, surface, volume, or mass OR number of items OR time of processing
- Recycling, energy-recovery, reuse: see specific provisions in chapter 7.9.3 and details on allocation of waste inputs see annex 14.4.
- General processes by other capital goods' input directly to multifunctional processes (e.g. the processing machines themselves, but not buildings etc.): time (duration) of use OR mass, volume, length of produced good

III.c) **Justify selection from checklist:** In the case alternatives are given in the above provisions, the chosen alternative shall be concisely justified.

III.d) **Justify other criteria:** If another specific relationship is applied that is not listed above, that choice shall be concisely justified including explaining why none of the default provisions is applicable or the most suitable ones, along the guidance given in the text.

III.e) **Justify non-existence of determining physical causality:** If a "determining physical causal relationships" does not exist (i.e. it is not in the above list and no other can be identified), this shall be concisely justified. Only in that case the second allocation step should be applied (see below); otherwise the resulting lack of accuracy and potential distortion is to be documented and explicitly be considered in the results interpretation (7.9.3.3).

IV) SHOULD - **Second step and criterion "market price":** As second, general allocation criterion for multifunctional processes, the market price of the co-functions should be applied. If this is done, the price shall refer to the specific condition and at the point the co-functions leave or enter[65] the multifunctional unit process or are provided. This means for processes that the known, calculated or approximated market price shall relate to e.g. the specific technical characteristics in quantity and quality such as purity, compressed or not, packaged or not, etc. as well as bulk or small amounts, etc. at the point it leaves the process. If this cannot be done, the resulting lack in accuracy and potential distortion of the results shall be documented and be considered in the results interpretation.

V) SHOULD - **Two-step procedure for multifunctional products** (e.g. consumer products): The following two-step procedure[183] shall be applied (7.9.3.2): [ISO!]

V.a) **First step and criterion "determining physical causality":** As first criterion the “determining physical causal relationships” between each non-functional flow and the co-functions of the product should be identified and applied. The above guidance for multifunctional flows can be applied analogously.

V.b) **Use virtual subdivision principle to perform explicit allocation:** As an initial step, analogously as above for multifunctional processes, the logic of virtual subdivision should be applied to virtually subdivide the multifunctional product.

[65] "Enter" in case of waste and end-of-life treatment services.

Provisions: 7.9.3 Solving multifunctionality by allocation

V.c) **Second step and criterion "QFD" or "market price":**

V.c.i) **Preferred second criterion - Quality Function Deployment:** If the above cannot be done, the Quality Function Deployment (QFD) should be used to identify the relevance of the co-function from the user's perspective. If a QFD does not exist and cannot be developed (e.g. due to cost or timing reasons), the second, general allocation criterion of "market price" of equivalent products for the single co-functions can and shall be applied (see below).

V.c.ii) **Alternative second criterion - market price:** If the QFD is not feasible, allocation by market price should be done in analogy to the preceding case for multifunctional processes. For products, the representative price of products that provide an equivalent to each single function should be used to allocate among the co-functions of the multifunctional product. (7.9.3.3) [ISO+]

VI) SHALL - **Attributional modelling of reuse, recycling, recovery:** The following provisions shall be applied in attributional modelling of recycling and related (the corresponding detailed explanations are found in annex 14.4): [ISO!]

VI.a) **Follow general rules for multifunctionality, observing specific aspects:** Allocation of products from end-of-life product and waste treatment shall apply the same general rules as other cases of multifunctionality, with two specific aspects:

VI.a.i) **Dealing with waste and end-of-life products of negative market value that generate secondary goods:** Specific is firstly that in case the market value of the end-of-life product or waste is below zero (e.g. soiled postconsumer packaging waste), the appropriate process step at the system boundary to the next life cycle is to be identified, i.e. where the allocation is to be applied. This process step is that one where the valuable co-function is created after one or more initial treatment processes have taken place (e.g. sorted plastic fraction of the above waste).

VI.a.ii) **True joint process to be identified:** Specific is secondly that for end-of-life products and waste the true joint process is to be identified, which is separated by various e.g. manufacturing steps from the step where the end-of-life product occurs (for the concept see Figure 29):

VI.a.ii.1) For waste or end-of-life products with a market price equal or above zero, the true joint process is that process earlier in the life cycle of the system, where the good (e.g. a aluminium bar) is technically approximately equivalent to the secondary good of the waste or end-of-life product (e.g. aluminium scrap from construction demolishing). Note that for "open loop - different primary route" recycling this step might necessarily involve abstraction to the basic properties of the two products. These two products that have been identified as described above are then considered co-products of the true joint process.

VI.a.ii.2) For waste and end-of-life products with a market value below zero, the true joint process is that one, which produces that product that is about equivalent to the first valuable product that

Provisions: 7.9.3 Solving multifunctionality by allocation

is produced from the initial waste treatment processes, as described in the preceding provision. These two products that have been identified as described above are then considered co-products of the true joint process.

VI.a.ii.3) In the case of multiple functions from the waste or end-of-life product (e.g. a complex consumer product is discarded for recycling of its many materials and for energy recovery), there is each one true joint process for each of them that shall be identified.

VI.b) **Provisions:** The following provisions can be derived that shall be applied, differentiating between wastes / end-of-life products with negative and positive market value:

VI.b.i) **Negative market value:** If the market price of the waste / end-of-life product is below zero (see also Figure 33 and explanations in annex 14.4.1.3):

VI.b.i.1) The waste / end-of-life management / treatment processes until excluding the process where the pre-treated waste crosses the "zero market value" border (i.e. when a process is generating a function with positive market value) shall be allocated exclusively to the first system. In the case the exact process step or the waste and/or secondary good properties cannot be clearly identified, the resulting lack of accuracy shall be reported and later be considered in the results interpretation.

VI.b.i.2) Subsequently, the two-step allocation procedure shall be applied between the valuable secondary good and its co-product from the true joint process (i.e. see the next provision). This involves a second, additional allocation exclusively of the inventory of that process step that has produced the first valuable product after the initial waste treatment steps, as follows:

VI.b.i.3) The inventory exclusively of the process step that produces a valuable product (secondary good) should be allocated with the market value criterion between the secondary good(s) and the (potentially pre-treated) waste / end-of-life product that enters this process step. The burdens that are allocated to the pre-treated waste / End-of-life product belong to the first system, the ones assigned to the secondary good(s) to the second system(s). Note that the market value of the pre-treated waste / End-of-life product is below zero and that hence the absolute value of its (negative) market price[66] should be used when calculating the allocation key; the rest of the allocation calculation is the same.

VI.b.i.4) After that, the two-step allocation is applied between the valuable secondary good and the true joint process, as follows in the next

[66] E.g. if the market value / gate fee is „-1 US$" this would be „1 US$".

Provisions: 7.9.3 Solving multifunctionality by allocation

provision, i.e. analogous to the case when the waste or end-of-life product have a positive market price.

VI.b.ii) **Market value equal or above zero:** If the market price of the waste / end-of-life product is equal or above zero, the two-step allocation procedure shall directly be applied between the process step that generates the waste or end-of-life product and the true joint process. The following procedure shall be applied (details see annex 14.4.1.2):

VI.b.ii.1) As first criterion, the “determining physical causal relationships” between each non-functional flow and the co-functions of the process shall be identified and applied. This is worked out as follows:

VI.b.ii.2) Two sub-cases are to be differentiated: the first one is where the secondary good is undergoing none or limited changes in the inherent properties (e.g. metal recycling, fibre recycling) and the second one is where it undergoes relevant changes in the inherent properties (e.g. energy recovery from mixed polymer waste). The first sub-case applies to all "closed loop" and "open loop - same primary route" situations. The second sub-case applies to all "Open loop - different primary route" situations.

VI.b.ii.3) For the first sub-case, the total number of cycles and the therefrom derived the total amount of uses (considering the loss at each cycle; concept see text) is determined and used for allocation across the many uses including the initial production up to the true joint process. In result the following formula can be developed for an infinite number of loops (considering the losses at each loop) (detailed steps see annex 14.4.1):

VI.b.ii.4) $e = (P + W) * (1 - r) + R * r$

- with
- e : average LCI per unit of material, part, or energy carrier
- r : average recycling rate [0...1), incorporating both collection efficiencies and processing efficiencies
- P : LCI of primary production per unit of material, part, or energy carrier
- W : LCI of final waste management per unit of discarded material, part, or energy carrier
- R : LCI of effort for reuse/recycling/recovery per unit of material, part, or energy carrier

VI.b.ii.5) The allocation formula is to consider in addition the change in the inherent properties of the secondary good.

VI.b.ii.6) If the above cannot be done because information that is required for applying the formula cannot be obtained or at least approximated, the second step of "market value" allocation needs to be applied. In that case, it must be detailed and justified why

Provisions: 7.9.3 Solving multifunctionality by allocation

the above cannot be applied. It shall be also demonstrated that the market value allocation is not disfavouring any competitor product, if the results are intended to be used for comparisons.

VI.b.ii.7) For the second sub-case, i.e. where the recycled/recovered/reused good undergoes relevant changes in the inherent properties, the true joint process is the one along the production chain that produces the minimum required quality[67] of the good to generate the secondary good. (E.g. in case of soiled low value LDPE post-consumer plastic waste that is incinerated to recover the energy: As the LDPE is incinerated and basically only the lower calorific value is of interest, the minimum required good is even before the production of the LDPE - the crude oil (incl. transport to the country of LDPE production) is meeting the minimum requirements in this case.) Based on this, the general two-step allocation procedure shall be applied between the secondary good and the function(s) or the true joint process (provisions see more above).

VI.b.ii.8) If several functions are generated from the waste / end-of-life product (e.g. different metals recovered), this shall be done individually with each of the true joint processes.

VII) SHALL - **System-wide consistent application of allocation:** Consistency shall be ensured as far as possible, using the same allocation criteria for the different co-functions of any specific process and across all similar processes within the system boundary. Otherwise, the lack of consistency and its effect on accuracy, precision and completeness shall be considered when stating the quality of a data set..

VIII) SHALL - **100 % rule:** The sum of the inventories allocated to all co-products shall be equal to the inventory of the system before allocation was done.

7.10 Calculating LCI results

Provisions: 7.10 Calculating LCI results

Applies to all types of deliverables of the study, while for unit process and partly terminated system data sets as deliverables only to quantify the achieved completeness and precision, as they need to be evaluated in the system's perspective.

I) SHALL - **Apply calculation procedures consistently:** The same calculation procedures shall be applied consistently throughout the analysed system(s) when aggregating the processes within the system boundary for obtaining the LCI results.

[67] Note that this provision ensures that the ISO 14044 provision on considering the change in inherent properties of the secondary good.

II) SHALL - **Calculate and aggregate the inventory data of the system(s):** (See also 7.8. If the model is correctly prepared, the first two following sub-bullets can be skipped):

II.a) Determine for each process within the system boundary how much of its reference flow is required for the system to deliver its functional unit(s) and/or reference flows(s) (i.e. the extent to which the process is involved in the system).

II.b) Scale the inventory of each process accordingly. This way it relates to the functional unit(s) and/or reference flow(s) of the system.

Note that if parameterised process data sets are used in the system model, the parameter values are to be set before scaling and aggregation.

II.c) The correctly scaled inventories of all processes within the system boundary shall be aggregated (summed up) for that system.

II.d) Calculation of averaged data set: The exact method depends on product system characteristic e.g. production, consumption, or supply average. Typically, statistical data is used. In addition, two main types of averaging exist. Process averaging and System averaging (details and illustration see chapter on "Average data set").[ISO+]

II.e) If the intended application of the results requires a location non-generic impact assessment (as identified in 6.7.5), aggregation of the elementary flows above the required location type or level (e.g. the level of a single site/plant, a region, a country, an environmental sub-compartment, etc.) should be avoided in the LCI results calculation. The same applies for other differentiations (e.g. of environmental sub-compartments or archetypes of emission situations) if those are required for the intended application and impact assessment methods to be used. [ISO+]

II.f) If the disaggregated data cannot be publicly disclosed (e.g. for confidentiality reasons), it is recommended to foresee performing the impact assessment on the disaggregated level and providing the LCIA results together with the aggregated LCI results. [ISO+]

Note that also in this case (as in all cases) the reviewers shall have (at least confidential) access to all underlying data.

III) SHOULD - **Ensure that reference flow(s) is/are only product and waste flow(s):** Note that after aggregation, the reference flow(s) is/are the only product and/or waste flow(s) that should remain in the LCI results inventory, with two exceptions:

III.a) **For partly terminated systems:** The inventories of selected products and/or waste flows were left out of the system boundary - typically intentionally - and the flows are kept in the inventory. Note however that for the purpose of quantifying the achieved completeness via the cut-off rules of environmental impact, also these selected product and waste flows are to be considered via integrating the inventories of the respective production and waste treatment processes.

III.b) **For radioactive waste and waste in underground waste deposits (e.g. mine filling):** These waste flows can be kept in the inventory for direct use in interpretation (see chapter 7.4.4.2).

IV) SHALL - **Highlight and explicitly consider remaining non-functional product or waste flows:** Any product and waste flows that remain in the inventory and that are non-functional flows shall be highlighted in the report and/or data set: Either they require to be modelled when later using the data set (e.g. by complementing the data set with a yet missing background LCI data set for e.g. a specific chemical consumed, or modelling the management/treatment of a specific waste). Or this gap / missing data needs to be explicitly considered in interpretation and conclusions drawn when using the data set later in an LCA study..

8 Life Cycle Impact Assessment - calculating LCIA results

Introduction

Life Cycle Impact Assessment (LCIA) is the phase in an LCA where the inputs and outputs of elementary flows that have been collected and reported in the inventory are translated into impact indicator results related to human health, natural environment, and resource depletion.

Note that the LCIA phase applies to LCI data sets exclusively to quantify the achieved completeness and precision, as they needs to be evaluated in the system's perspective. However, LCIA results may be appended to an LCI data set.

It is important to note that LCA and the impact assessment is analysing the potential environmental impacts that are caused by interventions that cross the border between technosphere and ecosphere and act on the natural environment and humans, often only after fate and exposure steps. The results of LCIA should be seen as environmentally relevant impact potential indicators, rather than predictions of actual environmental effects. LCA and LCIA are equally distinct from risk based, substance specific instruments.

See also the related notes in the guidance document “Framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators”.

Overview

LCIA is composed of mandatory and optional steps, as reflected also by the subchapters:

- Based on classification and characterisation of the individual elementary flows, which is usually done by LCIA experts that provide complete sets of LCIA methods for use by LCA practitioners[68] (see separate guidance document "Framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators"), the LCIA results are calculated by multiplying the individual inventory data of the LCI results with the characterisation factors (8.2)
- In a subsequent[69], optional step, the LCIA results can be multiplied with normalisation factors that represent the overall inventory of a reference (e.g. a whole country or an average citizen), obtaining dimensionless, normalised LCIA results (8.3)
- In a second optional step these normalised LCIA results can be multiplied by a set of weighting factors, that indicate the different relevance that the different impact categories (midpoint level related weighting) or areas-of-protection (endpoint level related weighting) may have, obtaining normalised and weighted LCIA results that can be summed up to a single-value overall impact indicator (8.4). Note that a weighting set always involves value choices.

The LCIA phase prepares additional input for the interpretation phase of the LCI study.

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[68] Note that the development or variation/adjustment of LCIA methods is never done by the vast majority of normal LCA practitioners, but by special LCIA experts, whose LCIA methods and factors the LCA practitioners use and rely on. For this reason and also to avoid that LCIA methods are selected after the LCI results have been calculated and based on interests, the aspects of selecting or adjusting LCIA methods are entirely addressed in the scope chapter 6.7. This current chapter refers hence exclusively to the calculation of the LCIA results.

[69] ISO 14044 also foresees an optional "Grouping" step. No specific recommendations are given here. If it is decided to apply a grouping step, the ISO 1444 provision can be applied.

Provisions: 8.2 Calculation of LCIA results

Note that this provision applies to LCI data sets as deliverables only to quantify the achieved completeness and precision, as they needs to be evaluated in the system's perspective. However, LCIA results may be appended to an LCI data set.

Note: If third-party LCIA methods are used that correctly provide characterisation factors for all used elementary flows, the first two following provisions mean to exclusively control that this has been done correctly. For any newly created elementary flow however, the characterisation factor has to be assigned and/or developed (see also chapter 6.7.4):

I) SHALL - **Classification of elementary flows:** All elementary flows of the inventory shall be assigned to those one or more impact categories to which they contribute ("classification") and that were selected for the impact assessment in the scope definition of the study.

II) SHALL - **Characterisation of elementary flows:** To all classified elementary flows each one quantitative characterisation factor shall be assigned for each category to which the flow relevantly contributes ("characterisation"). That factor expresses how much that flow contributes to the impact category indicator (at midpoint level) or category endpoint indicator (at endpoint level). For midpoint level indicators this relative factor typically relates to a reference flow (e.g. it may be expressed in "kg CO_2-equivalents" per kg elementary flow in case of Global Warming Potential). For endpoint level indicators it typically relates to a specific damage that relates to the broader area of protection. Examples are e.g. species loss measured e.g. as potentially displaced fraction of species for an affected area and duration (pdf*m^2*a), or damage to Human health measured e.g. in Disability Adjusted Life Years (DALYs). (For terms and details refer to the separate document "Framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators").

III) SHALL - **Calculate LCIA results per impact category:** For each impact category separately, calculate the LCIA indicator results by multiplying[70] the amount of each contributing (i.e. classified) elementary flow of the inventory with its characterisation factor. The results may be summed up per impact category, but summing up shall not be done across impact categories.

Note that this is done with either the midpoint level (impact potential) or the endpoint level (damage) factors, as had to be decided in scope chapter 6.7.7.

IV) SHALL - **Separately calculate LCIA results of long-term emissions:** LCIA results of long-term emissions (i.e. beyond 100 years from the time of the study) shall be calculated separately from the LCIA results that relate to interventions that occur within 100 years from the time of study. [ISO!]

Note: Given the different extent of uncertainty, these two sets of results will later be presented separately while discussed jointly.

V) SHALL - **Separately calculate non-generic LCIA results, if included:** In the case additional or modified, non-generic (e.g. geographically or otherwise differentiated) characterisation factors or LCIA methods are used, the results applying the original,

[70] Certain LCIA methods use non-linear relationships for the characterisation; if such are used the calculation is non-linear.

generic LCIA methods shall be calculated (and later be presented and discussed) separately as well. [ISO!]

VI) SHOULD - **Keep results of non-LCA impacts separate:** For LCIA results of impacts that are outside the LCA frame[93] but that were considered relevant for the analysed or compared system(s) and have been included quantitatively, the inventory, impact assessment, etc. shall be kept separately for clear interpretation. [ISO+]

Note that classification and characterisation of all elementary flows is typically already done in combined LCI / LCIA database packages or LCA software. In any case this is to be checked responsibly by the LCA practitioner. The step of manual classification and assigning characterisation factors applies hence especially to newly created or imported elementary flows. It is one of the most widely found errors to not classify and characterise newly introduced flows despite of their environmental relevance. The "frequent errors" box in the main text of this chapter provides some guidance for identifying and solving such cases.

Provisions: 8.3 Normalisation

For unit process, partly terminated system, LCI results data sets this step is required only if the use of normalised and weighted LCIA results has been selected to quantify the achieved completeness and precision (these need to be evaluated in the system's perspective).

I) Normalisation is mainly applied for two purposes:

I.a) MAY - **Normalisation to support interpretation:** In support of the interpretation of the results of the study, normalisation is an optional step under ISO.

The decision whether to include normalisation in the interpretation has been made in scope chapter 6.7.7.

I.b) MAY - **Normalisation use in cut-off quantification:** For quantification of the achieved completeness / cut-off, in a first step the indicator results for the different impact categories may be normalised by expressing them relative to a common reference, the normalisation basis (“normalisation”). [ISO+]

The decision whether to include normalisation in the cut-off has been made in scope chapter 6.7.7.

The specific normalisation basis has been identified in the scope chapter 6.7.6.

II) SHALL - **Calculate normalised LCIA results per impact category:** If normalisation is applied, the "normalised LCIA results" shall be calculated by dividing the LCIA results by the normalisation basis. This shall be done separately for each impact category (for midpoint level approaches) or area of protection (for endpoint level approaches).

Note that normalised results shall not directly be summed up across different impact categories as this would imply an even weighting of all impact categories. This is unless this even weighting is intended and identified explicitly as weighting when communicating the results.

Provisions: 8.4 Weighting

For unit process, partly terminated system, LCI results data sets this step is required only if the use of normalised and weighted LCIA results has been selected to quantify the achieved completeness and precision (these need to be evaluated in the system's perspective).

I) Weighting is mainly applied for two purposes:

I.a) MAY - **Weighting to support interpretation:** In support of the interpretation of the results of the study, as an additional, optional element one may perform a “weighting” or other valuation of the - method-wise normalised or not normalised - indicator results.

The decision whether to include weighting in the interpretation has been made in scope chapter 6.7.7.

I.b) MAY - **Weighting use in cut-off quantification:** For quantification of the achieved completeness / cut-off, as second[71] step the normalised indicator results for the different impact categories may be weighted across the indicators (“weighting”). [ISO+]

The decision whether to include weighting in the cut-off has been made in scope chapter 6.7.7.

The specific weighting set has been identified in the scope chapter 6.7.6.

II) SHALL - **Calculate weighted LCIA results per impact category:** If weighting is applied, to obtain "weighted LCIA results", the (typically normalised) LCIA results shall be multiplied by the weighting set, separately for each impact category (for midpoint level approaches and in case of having calculated category-wise endpoint results) or Area of protection (for endpoint results that cover each a whole area of protection). The resulting weighted LCIA results can be summed up across the impact categories or areas of protection, respectively.

Note that the setting or selection of weighting factors necessarily involves value choices.

[71] Note that some weighting methods work without a separate, preceding normalisation, as the normalisation is part of the weighting step.

9 Life cycle interpretation

Introduction

For LCI studies and data sets, the Interpretation phase of an LCA has one main purpose:

- During the iterative rounds of the LCI study, the interpretation phase serves to steer the work towards improving the Life Cycle Inventory model to meet the needs derived from the study goal.

The life cycle interpretation is the phase of the study where the results of the other phases are hence considered collectively and analysed in the light of the achieved accuracy, completeness and precision of the applied data, and the assumptions, which have been made throughout the LCI study. It serves to steer the improvement of the LCI model.

Some of the elements of the interpretation (namely completeness and sensitivity analysis, as well as potentially uncertainty analysis for the determination of precision) are hence applied throughout the LCI study. This is done together with quality checks on the level of unit process data, LCI results and applying impact assessment as part of the iterative loops which are used in the drawing of the system boundaries and collection of inventory data (see chapter 4).

For LCI data set, the interpretation proceeds through only two activities as schematically illustrated in Figure 25 and detailed in the subchapters of this chapter:

- First, the significant issues (i.e. the key processes, parameters, assumptions and elementary flows) are identified (as discussed in chapter 9.2).
- Then these issues are evaluated with regard to their sensitivity or influence on the overall results of the LCA. This includes and evaluation of the completeness and consistency with which the significant issues have been handled in the LCI/LCA study (chapter 9.3).

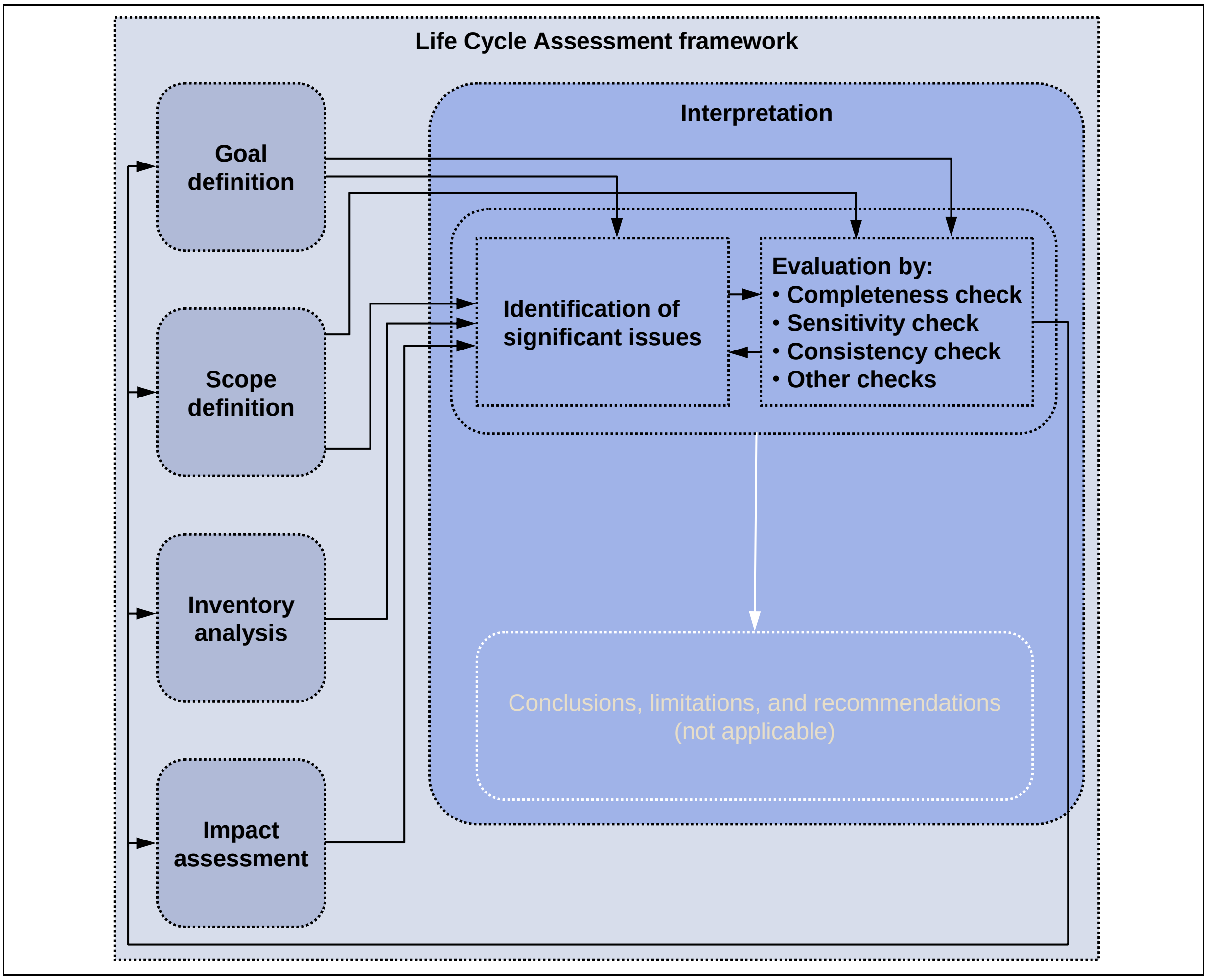

Figure 25 The elements of the interpretation phase and their relations to other phases of the LCA and within the interpretation phase (from ISO 14044:2006, modified)

Provisions: 9.2 Identification of significant issues

For unit process, partly terminated systems, LCI results data sets, this provision assist to improve the data quality during the iterative loops of developing the LCI data or the system model. (Findings may also be included in an LCI study report.)

I) SHALL - **Identify significant issues:** These can be among the following:

I.a) **Inventory items:** Main contributing "key" life cycle stages, processes, product, waste and elementary flows, parameters. This part is also known as weak point analysis or gravity analysis. Use contribution analysis techniques.

I.b) **Impact categories:** Main contributing "key" impact categories (only identifiable if weighting was applied). Use contribution analysis techniques.

I.c) **Modelling choices and method assumptions:** Relevant modelling choices, such as applied allocation criteria / substitution approaches in the inventory analysis, assumptions made when collecting and modelling inventory data for key processes and flows, selecting secondary data, systematic choices on technological, geographical, and time-related representativeness, methodological consistency, extrapolations, etc. Use scenario analysis techniques.

I.d) **Commissioner and interested parties:** The influence of the commissioner and interested parties on decisions in goal and scope definition, modelling choices, weighting sets and the like. Discuss influences on final results and recommendations. [ISO!]

Note: For analysing the significant issues of unit processes and partly terminated systems complete the system model as appropriate (e.g. cradle-to-gate) with a background system before the contribution analysis is done (see chapters 7.8). Focus the contribution analysis to the unit process / partly terminated system itself (i.e. the significant flows, assumptions, parameters, processes etc. within the original system boundary).

Note: the "informative" annex B of ISO 14044:2006 provides a range of examples of life cycle interpretation, including but not only on the identification of significant issues.

Provisions: 9.3.2 Completeness check

For unit process, partly terminated systems, LCI results data sets, this provision is assist to improve the data quality during the iterative loops of developing the LCI data or the system model. (Findings may also be included in an LCI study report.)

I) SHALL - **Evaluate LCI model completeness (cut-off):** The cut-off rules as defined in the scope phase (see chapter 6.6.3) shall be systematically applied to ensure that the final data set inventory/ies meets the pre-defined or goal-derived data quality requirements (see chapter 6.9.2). Evaluate the completeness of the inventory data in relation to the initially defined cut-off criteria in terms of:

I.a) **Process coverage:** Coverage of all relevant processes in the system

I.b) **Elementary flow coverage:** Coverage of all relevant elementary flows in the inventories for the processes of the system (and in particular the key processes identified under Significant issues – see chapter 9.2), that have characterisation factors for the relevant impact categories (according to the goal and scope of the LCI study and data set)

I.c) **Operationalise cut-off approximation:** The cut-off criteria / approach and percentage as defined in the scope phase shall be used (see 6.6.3). This may be operationalised using stepwise the following cut-off rules for flow properties, pre-checking property by property the achieved completeness across all flow types and balancing the aggregated numbers in the inputs against those of the outputs: [ISO+]

I.c.i) **For product flows:** “mass” (of individual key chemical elements), “energy content”, “market value” (or “production/provision cost”, especially for purchased services).

I.c.ii) **For waste flows:** “mass” (of individual key chemical elements), “energy content”, “treatment cost”.

I.c.iii) **For elementary flows:** “mass” (of individual key chemical elements and only for the environmentally relevant flows, i.e. excluding not or less relevant flows such as e.g. incineration air consumed and waste steam leaving the process as emission to air), “energy content”.

I.d) **Additional relevance criteria for elementary and waste flows:** Also those emissions and wastes should be include in the data collection that have a low mass and energy content but a known relevance for the respective type of processes or industry (using e.g. legal limits and expert judgement). [ISO+]

I.e) **Approximating the 100 % value:** The 100 % reference of completeness may be approximated by using "best approximation" values for all initially missing information and data, using among others information from similar processes and expert judgement. This missing information and data can be especially: [ISO+]

I.e.i) kind and quantity of initially missing flows,

I.e.ii) element composition and energy content of all flows that relevantly contribute to the total mass of the flows,

I.e.iii) cost of all goods and services that relevantly contribute to the total production cost and production value

I.e.iv) environmental impact of yet missing background data sets for consumed goods and services.

I.f) **Estimating precision of 100 % value approximation:** The precision of the 100 % approximation may be judged from analysing the share of the different quality levels of the data that make up the inventory: a higher share of low quality data also makes the 100 % approximation less precise. [ISO+]

I.g) **Completeness of impact:** As last step, and using the quantitative cut-off value decided upon in chapter 6.6.3, approximate the achieved degree of completeness / cut-off. [ISO+]

I.h) **Leaving out negligible flows:** It is an option to leave out negligible flows that jointly make up less than 10 % of the share of impact that is cut off (e.g. if the completeness is 95 %, 5 % are cut-off. 10 % of these 5 % are 0.5 % that are considered negligible.) It is recommended however to not leave them out. [ISO+]

Note that the LCIA methods and (potentially) normalisation and weighting for use in defining the cut-off was decided in the scope phase, see chapter 6.7.7.

Note that for unit processes and partly terminated systems the completeness is to be judged in relation to the unit process and partly terminated system itself. I.e. any lack of completeness of other processes that were added exclusively to complete the system model for the completeness check shall be disregarded when quantifying the achieved completeness.

II) SHOULD - **Improve completeness, if needed:** In the case of insufficient completeness, the inventory analysis (and sometimes the impact assessment) phases should be revisited to increase the degree of completeness. It is recommended to focus on the key life cycle stages, processes and flows identified as significant issues. This improvement of the LCI data is however to be started by potentially fine-tuning or revising goal and scope, i.e. with a complete iteration (see chapters 2.2.4 and 4, and related Figure 4 and Figure 5).

III) SHALL - **Report final completeness; potentially revise scope or goal:** If the aimed at completeness has been achieved, or if it cannot be increased further, the finally achieved degree of completeness shall to be reported (as % degree of completeness / cut-off).

Provisions: 9.3.3 Sensitivity check (of accuracy and precision)

This provision applies to all types of deliverables of the study, but for unit process, partly terminated systems, LCI results and LCIA results data sets as deliverables only to improve the data quality during the iterative loops of developing the LCI data or the system model. (Findings may also be included in an LCI study report.)

I) SHALL - **Check sensitivity of results:** Check to what extent the accuracy and precision of the overall results meets the requirements posed by the intended applications. Aim at improving it to the required level, as follows:

I.a) **Sensitivity of significant issues:** Identify the most sensitive among the significant issues identified earlier (chapter 9.2) and analyse the sensitivity of these for the overall results, along with their stochastic and systematic uncertainty estimates. The outcome is determining for the accuracy and precision of the overall results and the strength of the conclusions, which can be drawn from LCA studies that subsequently use the developed LCI data set and should be reported together with the data set. Be aware that calculated uncertainty figures may not include the often determining systematic uncertainties caused by model assumptions, data gaps, and lack of accuracy.

I.a.i) **Sensitivity of LCI items:** Evaluate the sensitivity of the LCIA results (or weighted LCIA results, if applied) to key flows, process parameter settings, flow properties, and other data items such as recyclability, life-time of goods, duration of services steps, and the like. Assess how sensitive inventory items influence the data representativeness, and precision. [ISO!]

I.a.ii) **Sensitivity of LCIA factors:** Evaluate the sensitivity of the LCIA results (or weighted LCIA results, if applied) considering the often widely differing uncertainty of the results due to uncertainties in the impact assessment (e.g. Human toxicity, Ecotoxicity etc. with high uncertainties and Global warming, Acidification, etc. with lower uncertainty). [ISO!]

I.a.iii) **Sensitivity of modelling choices and assumptions:** Evaluate the sensitivity of the LCIA results (or weighted LCIA results, if applied) to different modelling choices and method assumptions ("method issues"), e.g. quantitative and qualitative aspects of the functional unit, superseded processes, allocation criteria, etc. [ISO!]

I.b) **Improve robustness of sensitive issues data, parameters, impact factors, assumptions, etc. as possible:** In the case of lack of quality for some of the significant issues, revisit the inventory analysis and/or the impact assessment phases to improve the concerned data (for data issues), impact factors (for LCIA issues), or try to qualify and discuss the sensitive assumption or choice (for method issues). As for data completeness, also the improvement of the LCI data precision is however to be started by potentially fine-tuning or revising goal and scope, i.e. with a complete iteration (see chapters 2.2.4 and 4).

I.c) **Report final achievements; potentially revise scope or goal:** If the certainty of key issues meets the needs, or if it cannot be reduced to obtain the accuracy and precision that is required by the application of the LCI data set, it shall be decided whether the scope or even the goal needs to be revised or re-defined. (chapter 9.4).

Provisions: 9.3.4 Consistency check

These provisions applies to all types of deliverables of the study, but for unit process data sets as deliverable only to improve the data quality during the iterative loops of developing the LCI data or the system model. (Findings may also be included in an LCI study report.)

For partly terminated systems, LCI results data sets they serve in addition to ensure method consistency across the processes of the model.

I) SHALL - **Data quality sufficiently consistent?:** Check whether any differences in data quality *per se* (i.e. accuracy, completeness, and precision) and in the selected data sources for the different processes in the system(s) are consistent with the goal and scope of the study. This is especially relevant for comparative studies.

II) SHALL - **Method choices consistent?:** Check whether all methodological choices (e.g. LCI modelling principles, allocation criteria or system expansion / substitution approach, system boundary, etc.) are consistent with the goal and scope of the study including the intended applications and target audience. This shall be judged by checking whether the method provisions have been met that are given in relation to the applicable Situation A, B, or C1 / C2. [ISO!]

Note that method consistency applies on both unit process level (i.e. consistent approach to develop unit process from raw data) and system level (i.e. consistently modelling the system). This aspect is especially relevant when combining data from different sources.

III) SHALL - **Consistent impact assessment?:** Check whether the steps of impact assessment (including normalisation and weighting, if included) have been consistently applied and in line with goal and scope.

IV) SHALL - **Evaluate relevance of inconsistencies:** Evaluate the relevance / significance of any identified inconsistencies (as above) for the results and document them, including when reporting the achieved method consistency and appropriateness.

10 Reporting

Introduction

The results of the LCI data set shall be completely and accurately reported without bias to the intended audience. The results, data, methods, assumptions and limitations shall be transparent and presented in sufficient detail to allow the reader to comprehend the complexities and trade-offs inherent in the LCA. The report shall also allow the results to be used in a manner consistent with the goals and scope of the study.

The needs of different audiences should be recognized and addressed when presenting or disseminating the study. Target audiences can be internal, (defined) external, or public, and technical or non-technical. These audiences can include companies, trade associations, government agencies, environmental groups, scientific/technical communities, and other non-government organizations, as well as the general public / consumers. Communication in the public domain is especially critical because the risks of misinterpretation are heightened when LCA-derived information is provided to audiences not familiar with the complexity of the methodology and related limitations that may apply.

Good reporting of LCI studies provides the relevant project details, the process followed, approaches and methods applied, and results produced. This is essential to ensure reproducibility of the results and to provide the required information to reviewers to judge the quality of the results and appropriateness of conclusions and recommendations (if included).

The complete reporting should also contain the data used and should ensure transparency and consistency of all the methodologies and data employed. It should constitute the primary input to the scientific/technical audience and be a base from which summary reports to other target audiences could be prepared. These latter summaries need to be tailored to the recipient requirements and include appropriate reference to the primary report and related review reports in order to ensure that they are not taken out of context.

Confidentiality interests around sensitive or proprietary information and data are to be met, while confidential access to at least the reviewers is to be granted to support the review of the data set and/or report. Separate, complementary confidential reports can serve this purpose.

Provisions: 10.2 Reporting principles

Fully applicable to all types of deliverables, implicitly differentiated.

I) SHALL - **Report complete and unbiased:** The LCI data set including all descriptive information shall be completely and accurately reported without bias to the intended audience.

II) SHALL - **Use SI units:** Per default the *Système international d'unités* (SI) units shall be used for reporting.

III) SHALL - **Reproducibility and target audience to guide reporting:** Results, data, methods, assumptions and limitations shall be transparent and presented in sufficient detail to allow the reader to comprehend the complexities and trade-offs inherent in the study and LCA in general. Reporting of technical details shall be guided along the aim to ensure an as good as possible reproducibility of the results and of any conclusions and recommendations (if included). (On reporting of confidential or proprietary information see more below). Consider the technical and LCA methodology understanding of the target audience.

IV) SHALL - **Reporting LCIA results:** Depending on the intended applications, the LCIA results may also be reported in the study report or data set. If done, this shall meet the following requirements: [ISO!]

IV.a) The intended way of reporting LCIA results was identified in the scope definition in accordance with the intended application of the LCI study and any prescription given in the goal definition.

IV.b) For transparency reasons, the LCIA results shall be published jointly with the LCI results. In the case of normalised or weighted LCIA results the previous steps (classification and characterisation) shall equally be reported.

IV.c) Impact assessment results at endpoint (damage) level shall be supplemented by midpoint level impact category results (unless the endpoint LCIA method does not have a midpoint interim step) and also by the LCI results.

I) SHALL - **Items that require separate inventory items:** [ISO!]

I.a) **Long-term emissions:** Inventory emissions within the first 100 years from the time of the study and those beyond that time limit, as separate elementary flows.

I.b) **Carbon storage, delayed emissions, delayed recycling:** Only if such is included in line with an explicit goal requirement: Separately document carbon storage and delayed emissions / reuse/recycling/reuse credits as special inventory flows. These shall per default be excluded from the impact assessment, unless required by the goal. If included, both the results that consider these items and the results that do consider them shall be shown..

Note that if the study is intended to support a comparative assertion to be disclosed to the public, no form of numerical, value-based weighting of the indicator results is permitted.

Provisions: 10.3 Three levels of reporting requirements

Fully applicable to all types of deliverables, implicitly differentiated.

I) SHALL - The following form and level of reporting shall be done:

I.a) The required level of reporting was identified in chapter 6.12. [ISO+]

I.b) **Use ILCD data set format:** The ILCD data set format should be used for reporting LCI data sets. [ISO+]

I.c) **Enclose / reference report to data sets:** It is recommended to accompany data sets with a LCI study report.

I.d) **Use / combine correct level(s) of reporting:** These specific levels go back to the three main levels of reporting that have a different set of requirements under ISO 14044:2006 that shall be used: “Reports for internal use”, “Third-party report”, “Report on comparative studies to be disclosed to the public”. In detail:

I.e) MAY - **Reports for internal use** (recommendation only) (10.3.1): [ISO+]

I.e.i) Document results and conclusions of the LCA in a complete, accurate and unbiased way.

Provisions: 10.3 Three levels of reporting requirements

I.e.ii) Especially regarding inventory data, it is recommended to document the data on the level that it enters the calculations before its unit or property conversion, scaling, etc. (i.e. as "raw data") to provide appropriate information for reviewers and users. This information may be provided together with calculations such as conversions, scaling factors applied, averaging, extrapolations, etc.

I.e.iii) Consider to address some of the requirements to third-party reports or public reports also in internal reports as this will strengthen the robustness and hence reliability of the results.

I.f) SHALL - **Third-party reports** (10.3.2): The third-party report is a reference document for any third party to whom the communication is made. The report can be based on confidential information, while this information itself does not need to be included in the third-party report. It is recommended to meet confidentiality interests by making sensitive and proprietary data and information available only to the critical reviewers under confidentiality as a separate confidential report. [ISO+]

I.g) In addition to the requirements on reports for internal use, the following components and aspects shall be included in the third-party report[72]: [ISO!]

II) SHALL - **Executive summary** (for non-technical audience) [ISO+]

III) SHALL - **Technical summary** (for technical audience / LCA experts) [ISO+]

IV) SHALL - **Main report**, with the following aspects:

Note that the following items and the [ISO+] and [ISO!] marks do relate to the general structuring and items to be included only; the exact items to be reported are identified in the other Provisions of this document.

IV.a) General aspects:

IV.a.i) date of report;

IV.a.ii) statement that the study has been conducted according to the requirements of ISO 14044:2006 and the ILCD Handbook. [ISO!]

IV.b) Goal of the study:

IV.b.i) intended application(s);

IV.b.ii) method, assumptions or impact coverage related limitations; [ISO!]

IV.b.iii) reasons for carrying out the study and decision-context;

IV.b.iv) the target audiences;

IV.b.v) statement as to whether the study intends to support comparative assertions intended to be disclosed to the public

IV.b.vi) commissioner of the study and other influential actors, including *LCA practitioner (internal or external).* [ISO+]

[72] The parts in italics are directly taken from ISO 14044, chapter 5.2, but removing ISO-internal chapter-references. A few aspects have been moved to other places, but all are covered.

Provisions: 10.3 Three levels of reporting requirements

IV.c) Scope of the study:

IV.c.i) function, including

IV.c.i.1) statement of performance characteristics, and

IV.c.i.2) any omission of additional functions in comparisons;

IV.c.ii) functional unit(s), including

IV.c.ii.1) consistency with goal and scope,

IV.c.ii.2) definition,

IV,c.ii.3) result of performance measurement;

IV.c.iii) reference flow(s)

IV.c.iv) LCI modelling framework applied, i.e. according to Situation A, B, or C, including [ISO!]

IV.c.iv.1) uniform application of the procedures

IV.c.v) system boundary, including

IV.c.v.1) types of inputs and outputs of the system as elementary flows should be provided,

IV.c.v.2) decision criteria on system boundary definition, and on individual or systematic inclusions and exclusions [ISO!]

IV.c.v.3) omissions of life cycle stages, activity types*, processes,* or flows,

IV.c.v.4) quantification of energy and material inputs and outputs, and

IV.c.v.5) assumptions about electricity production;

IV.c.vi) cut-off criteria for initial inclusion of inputs and output, including

IV.c.vi.1) description of cut-off criteria and assumptions,

IV.c.vi.2) effect of selection on results,

IV.c.vi.3) inclusion of mass, energy and environmental cut-off criteria.

IV.c.vii) data quality requirements should be included (in addition to the finally achieved quality)

IV.c.viii) LCIA scope settings, including

IV.c.viii.1) impact categories and category indicators considered, including a rationale for their selection and a reference to their source;

IV.c.viii.2) descriptions of or reference to all characterization models, characterization factors and methods used, including all assumptions and limitations;

IV.c.viii.3) any differentiations, additions or modifications of original, default LCIA method with justifications [ISO!]

IV.c.viii.4) descriptions of or reference to all value-choices used in relation

Provisions: 10.3 Three levels of reporting requirements

to impact categories, characterization models, characterization factors, normalization, grouping, weighting and, elsewhere in the LCIA, a justification for their use and their influence on the results, conclusions and recommendations;

IV.c.viii.5) a statement that the LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. and, when included as a part of the LCA, also

IV.c.viii.6) a description and justification of the definition and description of any new impact categories, category indicators or characterization models used for the LCIA,

IV.c.viii.7) a statement and justification of any grouping of the impact categories,

IV.c.viii.8) any further procedures that transform the indicator results and a justification of the selected references, weighting factors, etc.,

IV.c.ix) included comparison between (product) systems

IV.c.x) modifications of the initial scope together with their justification should be provided

IV.d) Life cycle inventory analysis:

IV.d.i) data collection procedures;

IV.d.ii) qualitative and quantitative description of unit processes, at least of the foreground system*;* [ISO!]

IV.d.iii) references of all publicly accessible data sources (sources for all data used and individual identification for the key processes / systems); [ISO!]

IV.d.iv) calculation procedures (preferably including the steps from raw data to foreground system unit process(es))*;* [ISO!]

IV.d.v) validation of data, including

IV.d.v.1) data quality assessment, and

IV.d.v.2) treatment of missing data;

IV.d.vi) sensitivity analysis for refining the system boundary;

IV.d.vii) specific substitution or allocation procedures for key multifunctional processes (and products in case the study directly compares multifunctional products)*, including* [ISO!]

IV.d.vii.1) justification of the specific procedures

IV.e) Life cycle impact assessment results calculation*, where applicable:*

IV.e.i) the LCIA procedures, calculations and results of the study;

IV.e.ii) limitations of the LCIA results relative to the defined goal and scope of the LCA;

IV.e.iii) the relationship of LCIA results to the defined goal and scope;

Provisions: 10.3 Three levels of reporting requirements

IV.e.iv) the relationship of the LCIA results to the LCI results;

IV.e.v) any analysis of the indicator results, for example sensitivity and uncertainty analysis or the use of environmental data, including any implication for the results, and

IV.e.vi) data and indicator results reached prior to any normalization, grouping or weighting shall be made available together with the normalized, grouped or weighted results.

IV.f) Life cycle interpretation:

IV.f.i) the results;

IV.f.ii) assumptions and limitations associated with the applicability of the data set [ISO!]*;*

IV.f.iii) data quality assessment;

IV.f.iv) full transparency in terms of value-choices, rationales and expert judgements.

IV.g) Critical review, where applicable:

IV.g.i) name and affiliation of reviewers;

IV.g.ii) critical review reports;

IV.g.iii) *responses to recommendations.*

V) SHALL - **Annex:** The annex serves to document elements that would inappropriately interrupt the reading flow of the main part of the report, and are also of a more detailed or tabular technical nature and for reference. It should include: [ISO!]

V.a) Questionnaire/ data collection template and raw data,

V.b) list of all assumptions (It should include those assumptions that have been shown to be irrelevant),

V.c) full LCI results.

VI) MAY - **Confidential report:** If prepared, the confidential report shall contain all those data and information that is confidential or proprietary and cannot be made externally available. It shall however be made available to the critical reviewers under confidentiality.

11 Critical review

Introduction

The scope and type of critical review desired should have been defined in the scope phase of an LCA, and the decision on the type of critical review should have been recorded (see chapter 6.11).

The critical review is one of key feature in the LCA. Its process shall assure among others whether

- the methods used to carry out the LCA are consistent with this guidance document and thereby also with ISO 14040 and 14044:2006,
- the methods used to carry out the LCA study are scientifically and technically valid,
- the data used are appropriate and reasonable in relation to the goal of the study,
- the interpretations reflect the limitations identified and the goal of the study, and
- the study report is transparent and consistent.

The detailed review requirements regarding what to review and how, and how to report the outcome of the review are given in the separate document "Review scope, methods, and documentation".

More details on the minimum required level/type of review for each specific type of deliverables of the LCI study can be found in the separate document “Review schemes for Life Cycle Assessment (LCA)”.

Eligibility of reviewers is addressed in the separate document "Reviewer qualification".

Provisions: 11 Critical review

Applicable to Situation A, B, and C, implicitly differentiated.

Fully applicable to all types of deliverables, implicitly differentiated.

I) SHALL - **See chapter 6.11 for key decisions made on the critical review:** The scope and type of critical review desired should have been defined in the scope phase of an LCA (see chapter 6.11). The following provisions repeat these key provisions that otherwise have to be applied at this point: [ISO!]

I.a) **Identify minimum critical review type:** Identify along the separate document “Review schemes for Life Cycle Assessment (LCA)” whether a critical review shall be performed and which review type shall be applied as a minimum. This depends on the kind of deliverable of the study, its foreseen decision-context, the kind of intended audience (internal / external / public and technical / non-technical), and whether a comparison is part of the study.

I.b) **Select eligible reviewers:** If a critical review is to be done, eligible reviewer(s) shall be selected. Eligibility of reviewers is addressed in the separate document "Reviewer qualification".

II) SHALL - **Review scope, methods, and documentation:** The selected reviewer(s) shall perform the review and report its outcome along the provisions of the separate document "Review scope, methods, and documentation"[73]. [ISO!]

[73] This document was under preparation when the present document has been finalised. Until it has been published under the ILCD Handbook the relevant ISO 14040 and 14044 requirements shall be met as a minimum.

12 Annex A: Data quality concept and approach

Introduction

The following components and aspects of data quality are used or referenced in various chapters of this document.

The "ILCD data quality indicators" allow classifying the achieved data quality of LCI data:

- Overall data quality
  - Technological representativeness
  - Geographical representativeness
  - Time-related representativeness
  - Completeness
  - Precision / uncertainty
  - Methodological appropriateness and consistency[74]

In the context of LCA studies, especially including comparisons, this information can then be used to judge in how far the data quality supports conclusions and recommendations from the study.

In order to support a quality classification of data sets, the overall data quality (i.e. the integrated "Overall data quality" of the different data quality indicators) and the complementary items are combined to a set of "Overall data set quality". Given the interest to single out method principles and approaches applied "Method" is additionally used also as criterion for the Overall data set quality.

The resulting five criteria can be used to classify data sets[75] as being in line with e.g. the different ILCD Handbook requirements, as follows:

- (Overall) data quality
- Method
- Nomenclature
- Review
- Documentation

This includes the possibility to set fixed requirements for data quality e.g. minimum requirements, or classes of quality such as "high quality". The latter is used related to completeness or data when quantifying cut-offs etc. Chapter 12.3 provides some more details.

Table 5 describes the concept of the ILCD data quality indicators / components in more detail.

[74] „Method" is included as data quality item, as e.g. technological representativeness and the LCI modelling frameworks applied (attributional and consequential) strongly interrelate.

[75] This is helpful when externally communicating in a harmonised and comparable way the achieved quality of data sets and when searching for data of specific quality characteristics e.g. in the ILCD Data Network.

Table 5 Overall inventory data quality (validity) and its main 6 aspects

Indicator / component	**Definition / Comment**	**Chapters**
Technological representativeness (TeR)	"Degree to which the data set reflects the true population of interest regarding technology, including for included background data sets, if any." Comment: i.e. of the technological characteristics including operating conditions.	6.8.2
Geographical representativeness (GR)	"Degree to which the data set reflects the true population of interest regarding geography, including for included background data sets, if any." Comment: i.e. of the given location / site, region, country, market, continent, etc.	6.8.3
Time-related representativeness (TiR)	"Degree to which the data set reflects the true population of interest regarding time / age of the data, including for included background data sets, if any." Comment: i.e. of the given year (and - if applicable – of intra-annual or intra-daily differences).	6.8.4
Completeness (C)	"Share of (elementary) flows that are quantitatively included in the inventory. Note that for product and waste flows this needs to be judged on a system's level." Comment: i.e. degree of coverage of overall environmental impact, i.e. used cut-off criteria.	6.6.3
Precision / uncertainty (P)	"Measure of the variability of the data values for each data expressed (e.g. low variance = high precision). Note that for product and waste flows this needs to be judged on a system's level." Comment: i.e. variance of single data values and unit process inventories.	6.9.2
Methodological appropriateness and consistency (M)	"The applied LCI methods and methodological choices (e.g. allocation, substitution, etc.) are in line with the goal and scope of the data set, especially its intended applications and decision support context. The methods also have been consistently applied across all data including for included processes, if any." Comment: i.e. correct and consistent application of the recommended LCI modelling framework and LCI method approaches for the given Situation A, B, or C.	6.5.4

The following quality levels of Table 6 and definitions of Table 7 should be used for documenting what has been achieved for the final data and for each of the data quality indicators:

Table 6 Quality levels and quality rating for the data quality indicators, and the corresponding definition (for the three representativeness and the methodological appropriateness and consistency criteria) and quantitative completeness and precision / uncertainty ranges in %.

Quality level	Quality rating	Definition	Completeness overall environmental impact	Precision / uncertainty overall env. impact (relative standard deviation in %)[76]
Very good	1	"Meets the criterion to a very high degree, having or no relevant need for improvement. This is to be judged in view of the criterion's contribution to the data set's potential overall environmental impact and in comparison to a hypothetical ideal data quality."	≥ 95 %	≤ 7 %
Good	2	"Meets the criterion to a high degree, having little yet significant need for improvement. This is to be judged in view of the criterion's contribution to the data set's potential overall environmental impact and in comparison to a hypothetical ideal data quality."	[85 % to 95 %)	(7 % to 10 %]
Fair	3	"Meets the criterion to a still sufficient degree, while having the need for improvement. This is to be judged in view of the criterion's contribution to the data set's potential overall environmental impact and in comparison to a hypothetical ideal data quality. "	[75 % to 85 %)	(10 % to 15 %]
Poor	4	"Does not meet the criterion to a sufficient degree, having the need for relevant improvement. This is to be judged in view of the criterion's contribution to the data set's potential overall environmental impact and in	[50 % to 75 %)	(15 % to 25 %]

[76] This does exclude the uncertainty of the LCIA method, the normalisation basis, and the weighting set but only of the LCI results, however in view of the overall environmental impact. For log-normally distributed results, the confidence intervals shall be used that are obtained with the percentages given in the table and under normal distribution.

		comparison to a hypothetical ideal data quality."		
Very poor	5	"Does not at all meet the criterion, having the need for very substantial improvement. This is to be judged in view of the criterion's contribution to the data set's potential overall environmental impact and in comparison to a hypothetical ideal data quality."	$<$ 50 %	$>$ 25 %
Additional options, not being quality levels:				
Not evaluated / unknown	5	"This criterion was not judged / reviewed or its quality could not be verified / is unknown."	na	na
Not applicable	0	"This criterion is not applicable to this data set, e.g. its geographical representativeness cannot be evaluated as it is a location-unspecific technology unit process."	na	na

The overall data quality shall be calculated as detailed in Formula 3:

Formula 3
$$DQR = \frac{TeR + GR + TiR + C + P + M + X_w * 4}{i + 4}$$

- *DQR* : Data Quality Rating of the LCI data set; see Table 7
- *TeR, GR, TiR, C, P, M* : see Table 5
- *Xw* : weakest quality level obtained (i.e. highest numeric value) among the data quality indicators
- *i* : number of applicable (i.e. not equal "0") data quality indicators

Table 7 Overall quality level of a data set according to the achieved overall data quality rating

Overall data quality rating (DQR)	Overall data quality level
≤ **1.6**[77]	"High quality"

[77] This means that not all quality indicator need to be "very good", but two can be only "good". If more than two are only good, the data set is downgraded to the next quality class.

>1.6 to ≤3	"Basic quality"
>3 to ≤4	"Data estimate"

For structuring the approach of developing ILCD Handbook compliant data and studies, the ILCD compliance is composed of five groups of aspects: Data quality, Method, Nomenclature, Review, and Documentation[78].

These aspects shall also be used when referring only to selected of the ILCD compliance criteria and reporting this partial compliance in a structured way, e.g. when documenting LCI data sets, using the ILCD reference data set format.

The requirements for claiming ILCD compliance for data sets and studies are found in chapter 2.3.

Note that exclusively the "Data quality" compliance is further differentiated by different levels of achieved data quality. The other compliance criteria can only either have been achieved or not; there is not further differentiation.

Table 9 gives more details on the compliance criteria.

Table 9 ILCD compliance of LCI studies and data sets. Compliance aspects, components, brief description and main corresponding chapters (indicative).

Aspect	Components	Description / Comment	Main chapters
Quality	Completeness	Details see Table 5, Table 6, and Table 7.	Chapter 12.3
	Technological representativeness		
	Geographical representativeness		
	Time-related representativeness		
	Precision / uncertainty		
	Methodological appropriateness[79] and consistency		
Method	Application of LCI modelling and method provisions of this document	Adhering to the provisions for the selection and LCI modelling of the applicable goal situation A, B, or C.	Chapter 6.5.4, and referenced chapters.
	Application of other method provisions of this document	Adhering to the other method provisions of this document.	Other chapters with method provisions.

[78] Following the same logic of this set of 5 compliance aspects, also the overall quality of LCIA methods can be described and assessed. More detailed provisions for this are still to be developed.

[79] See text for reason to include “method…” in both data quality and as separate item “Method”

Nomenclature	Correctness and consistency of applied nomenclature	Appropriate naming of flows and processes, consistent use of ILCD reference elementary flows, appropriate and consistent use of units, etc.	Chapter 7.4.3 and separate document "Nomenclature and other conventions".
	Correctness and consistency of applied terminology	Correct and consistent use of technical terms (LCA and other domains).	Key terms of chapter 3, "terms and concepts" boxes throughout the document, and application of the separate terminology.
Review	Appropriateness of applied review type	Selection of the applicable review type.	Chapter 11 and separate document "Review schemes for Life Cycle Assessment (LCA)".
	Correctness of applied review scope	Correct scope of what is reviewed.	Separate document on "Review scope, methods, and documentation".
	Correctness of applied review methods	Correct methods of how to review each of the items within the review scope.	Separate document on "Review scope, methods, and documentation".
	Correctness of the review documentation[80]	Correct scope, form and extent of what is documented about the final outcome of the review.	Separate document on "Review scope, methods, and documentation".
Documentation	Appropriateness of documentation extent	Appropriate coverage of what is reported / documented.	Chapter 10.
	Appropriateness of form of documentation	Selection of the applicable form(s) of reporting / documentation.	Chapter 10.3.
	Appropriateness of documentation format	Selection and correct use of the data set format or report template, plus review documentation requirements.	See separate ILCD data set format (separately

[80] The documentation of the review findings belongs to the "Review" part, since it does not relate to the documentation of the object of the data set.

			available files).

13 Annex B: Calculation of CO_2 emissions from land transformation

Formula 4 and Formula 5 serve to calculate the soil organic carbon stock of the initial and final land use. Formula 6 provides the final prescription.

Formula 4 $$SOCi = SOCn * LUF_1 * LMF_1 * IL_1$$

with

- *SOCi* = Initial soil organic carbon stock of initial land use "1", given in [t/ha]
- *SOCn* = Native soil organic carbon stock (climate region, soil type); Table 10, given in [t/ha]
- *LUF* = Land use factor; Table 11, dimensionless
- *LMF* = Land management factor; Table 12 and Table 13, dimensionless
- *IL* = Input level factor; also Table 12 and Table 13, dimensionless

Formula 5 $$SOCf = SOCn * LUF_2 * LMF_2 * IL_2$$

with

- *SOCf* = Final soil organic carbon stock of land use "2", i.e. after transformation, given in [t/ha]

Formula 6 $$CO2 = (SOCi - SOCf) * \frac{44}{12}$$

with

- CO2 = resulting CO_2 emissions from soil (given in [t/ha]) as the difference in soil carbon stocks multiplied by the atomic weight of CO_2 and divided by the atomic weight of C.

Note that this is the total amount of CO_2 that has to be allocated to the individual crops and/or crop years after conversion, as detailed in chapter 7.4.4.1.

Table 10 Native soil carbon stocks under native vegetation (tonnes C ha-1 in upper 30 cm of soil) (IPCC 2006)

Climate Region	High activity clay soils	Low activity clay soils	Sandy soils	Spodic soils	Volcanic soils	Wetland soils
Boreal	68	NA	10	117	20	146
Cold temperate, dry	50	33	34	NA	20	97
Cold temperate, moist	95	85	71	115	130	

Warm temperate, dry	38	24	19	NA	70	88
Warm temperate, moist	88	63	34	NA	80	
Tropical, dry	38	35	31	NA	50	86
Tropical, moist	65	47	39	NA	70	
Tropical, wet	44	60	66	NA	130	
Tropical montane	88	63	34	NA	80	

Table 11 Land use factors (IPCC 2006)

Land-use	**Temperature regime**	**Moisture regime**	**Land use factors (IPCC default)**	**Error (±)**[81]
Long-term cultivated	**Temperate/Boreal**	**Dry**	0.80	9 %
		Moist	0.69	12 %
	Tropical	**Dry**	0.58	61 %
		Moist/Wet	0.48	46 %
	Tropical montane	**n/a**	0.64	50 %
Permanent grassland	**All**		1.00	
Paddy rice	**All**	**Dry and Moist/Wet**	1.10	50 %
Perennial/Tree Crop	**All**		1.00	50 %
Set-aside (< 20 yrs)	**Temperate/Boreal and Tropical**	**Dry**	0.93	11 %
		Moist/Wet	0.82	17 %
	Tropical montane	**n/a**	0.88	90 %

Table 12 Land management and input level factors for cropland (IPCC 2006)

Land management (for cultivated land only)				
Land-use management	**Temperature regime**	**Moisture regime**	**Land management and input level factors (IPCC**	**Error (±)**[81]

[81] Error = two standard deviations, expressed as a percent of the mean; where sufficient studies were not available for a statistical analysis a default, a value based on expert judgement (40 %, 50%, or 90%) is used as a measure of the error. NA denotes 'Not Applicable', for factor values that constitute reference values or nominal practices for the input or management classes. This error range does not include potential systematic error due to small sample sizes that may not be representative of the true impact for all regions of the world

			defaults)	
Full tillage	**All**	**Dry and Moist/Wet**	1.00	NA
Reduced tillage	**Temperate/Boreal**	**Dry**	1.02	6 %
		Moist	1.08	5 %
	Tropical	**Dry**	1.09	9 %
		Moist/Wet	1.15	8 %
	Tropical montane	**n/a**	1.09	50 %
No tillage	**Temperate/Boreal**	**Dry**	1.10	5 %
		Moist	1.15	4 %
	Tropical	**Dry**	1.17	8 %
		Moist/Wet	1.22	7 %
	Tropical montane	**n/a**	1.16	50 %
Input level (for cultivated land only)				
Low input	**Temperate/Boreal**	**Dry**	0.95	13 %
		Moist	0.92	14 %
	Tropical	**Dry**	0.95	13 %
		Moist/Wet	0.92	14 %
	Tropical montane	**n/a**	0.94	50 %
Medium input	**All**	**Dry and Moist/Wet**	1.00	NA
High input without manure	**Temperate/Boreal and Tropical**	**Dry**	1.04	13 %
		Moist/Wet	1.11	10 %
	Tropical montane	**n/a**	1.08	50 %
High input with manure	**Temperate/Boreal and Tropical**	**Dry**	1.37	12 %
		Moist/Wet	1.44	13 %
	Tropical montane	**n/a**	1.41	50 %

Table 13 Land management and input level factors for grassland (IPCC 2006)

Land management (for grassland only)			
Land-use management	**Temperature regime**	**Land management and input level factors (IPCC**	**Error (±)[81]**

		defaults)	
Nominally managed (non-degraded)	**All**	1.00	NA
Moderately degraded	**Temperate/Boreal**	0.95	13 %
	Tropical	0.97	11 %
	Tropical Montane	0.96	40 %
Severely degraded	**All**	0.70	40 %
Improved grassland	**Temperate/Boreal**	1.14	11 %
	Tropical	1.17	9 %
	Tropical Montane	1.16	40 %
Input level (for improved grass land only)			
Medium	**All**	1.00	NA
High	**All**	1.11	7 %

16 Annex E: System boundary template

Introduction

A recommended system boundary template for LCA practitioners / technical audience is provided. It is recommended to use a less formalised and more illustrative template for non-technical audience.

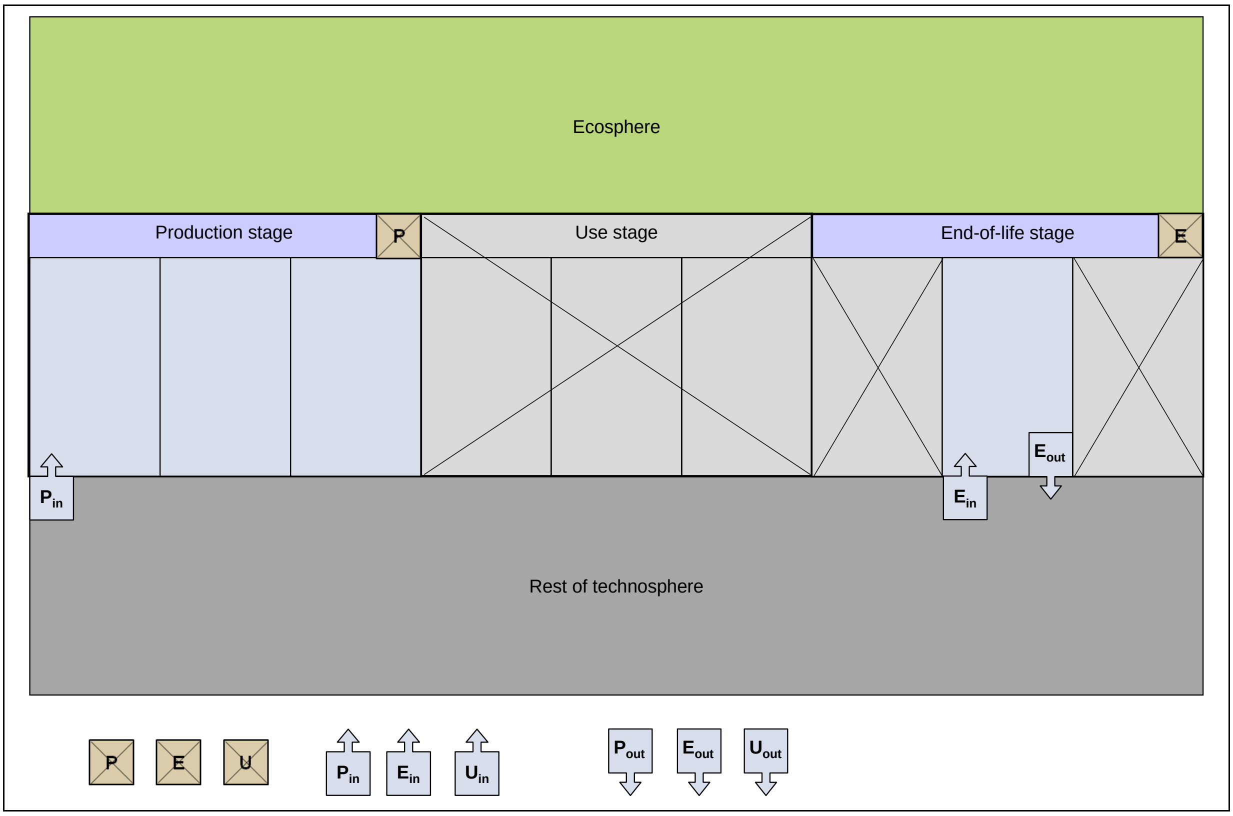

Figure 35 System boundary diagram template for technical audience. This example sketches a system (e.g. it could be a partly terminated system data set of an electric heater, excluding use stage but including the main recycling step). The diagram shows that the system includes the production stages up to the production of the final product plus the recycling / recovery, while excluding specific initial waste management steps (e.g. collection) and final depositing. These excluded steps would be listed separately, referring to the boxes E_{in} and E_{out}. The system also has at least one product or waste flow in the input (P_{in}) that needs to be completed when using the data of that system. Additionally the fist and last process step of the end-of-life stage would need to be named to ensure correct use of the data set when completing the system.

18 Annex G: Development of this document

Based on and considering the following documents

The background document has been drafted taking into account amongst others the following existing sources:

Harmonised ISO standards

- ISO 14040: 2006 Environmental management - Life cycle assessment – Principles and framework
- ISO 14044: 2006 Environmental management - Life cycle assessment - Requirements and guidelines

A large number of LCA manuals of business associations, national LCA projects, consultants and research groups as well as scientific LCA publications have been analysed and taken into account. The detailed list is provided more below.

Drafting

This document was initially drafted by contractors (see list below) with support under the European Commission Joint Research Centre (JRC) contract no. contract no. 383136 F1SC concerning "Development of a technical guidance handbook on Life Cycle Assessment".

This work has been funded by the European Commission, partially supported through Commission-internal Administrative Arrangements (Nos 070402/2005/414023/G4, 070402/2006/443456/G4, 070307/2007/474521/G4, and 070307/2008/513489/G4) between DG Environment and the Joint Research Centre.

Invited stakeholder consultations

An earlier draft version of this document has been distributed to more than 60 organisations and groups.

These include the 27 EU Member States, various European Commission (EC) services, National Life Cycle Database Initiatives outside the European Union, business associations as members of the Business Advisory Group, Life Cycle Assessment software and database developers and Life Cycle Impact Assessment method developers as members of the respective Advisory Groups, as well as other relevant institutions.

Public consultation

A public consultation was carried out on the advanced draft guidance document from June 10, 2009 to August 31, 2009.

This included a public consultation workshop, which took place from June 29 to July 2, 2009, in Brussels.

Disclaimer: Involvement in the development or consultation process does not imply an agreement with or endorsement of this document.

Overview of involved or consulted organisations and individuals

The following organisations and individuals have been consulted or provided comments, inputs and feedback during the invited or public consultations in the development of this document:

Invited consultation

Internal EU steering committee:

- European Commission services (EC),
- European Environment Agency (EEA),
- European Committee for Standardization (CEN),
- IPP Regular Meeting Representatives of the 27 EU Member States

National database projects and international organisations:

- United Nations Environment Programme, DTIE Department (UNEP-DTIE)
- World Business Council for Sustainable Development (WBCSD)
- Brazilian Institute for Informatics in Science and Technology (IBICT)
- University of Brasilia (UnB)
- China National Institute for Standardization (CNIS)
- Sichuan University, Chengdu, China
- Japan Environmental Management Association for Industry (JEMAI)
- Research Center for Life Cycle Assessment (AIST), Japan
- SIRIM-Berhad, Malaysia
- National Metal and Material Technology Center (MTEC), Focus Center on Life Cycle Assessment and EcoProduct Development, Thailand

Advisory group members

Business advisory group members:

- Alliance for Beverage Cartons and the Environment (ACE)
- Association of Plastics Manufacturers (PlasticsEurope)
- Confederation of European Waste-to-Energy plants (CEWEP)
- European Aluminium Association
- European Automobile Manufacturers' Association (ACEA)
- European Cement Association (CEMBUREAU)
- European Confederation of Iron and Steel Industries (EUROFER)
- European Copper Institute
- European Confederation of woodworking industries (CEI-Bois)
- European Federation of Corrugated Board Manufacturers (FEFCO)
- Industrial Minerals Association Europe (IMA Europe)
- Lead Development Association International (LDAI)
- Sustainable Landfill Foundation (SLF)
- The Voice of the European Gypsum Industry (EUROGYPSUM)
- Tiles and Bricks of Europe (TBE)
- Technical Association of the European Natural Gas Industry (Marcogaz)

Disclaimer: Involvement in the development or consultation process does not imply an agreement with or endorsement of this document.

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Existing provisions

The guidance document has been drafted starting from the following existing sources:

Harmonised standards

- ISO 14040:2006 Environmental management - Life cycle assessment – Principles and framework
- ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines

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Abstract

Life Cycle Thinking (LCT) and Life Cycle Assessment (LCA) are the scientific approaches behind modern environmental policy and business decision support related to Sustainable Consumption and Production (SCP). The International Reference Life Cycle Data System (ILCD) provides a common basis for consistent, robust and quality-assured life cycle data and studies. Such data and studies are indispensible for coherent and reliable SCP policies and their implementation, such as Ecolabelling, Ecodesign, Carbon footprinting, and Green Public Procurement. This guide is a component of the International Reference Life Cycle Data System (ILCD) Handbook. It provides guidance for developing Life Cycle Inventory (LCI) data sets, which contain all emissions and resources that are associated with the life cycle of the analysed process or product. This guide is based on and conforms to the ISO 14040 and 14044 standards on Life Cycle Assessment. The principal target audience of this document is the experienced Life Cycle Assessment practitioner in the public and private sector, aiming to develop consistent and good quality Life Cycle Inventory data sets.

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