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Environmental management — Life cycle assessment — Principles and framework

Management environnemental — Analyse du cycle de vie — Principes et cadre

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Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 14040 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 5, *Life cycle assessment.*

Annex A of this International Standard is for information only.

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Introduction

The heightened awareness of the importance of environmental protection, and the possible impacts associated with products[1)] manufactured and consumed, has increased the interest in the development of methods to better comprehend and reduce these impacts. One of the techniques being developed for this purpose is Life Cycle Assessment (LCA). This International Standard describes the principles and framework for conducting and reporting LCA studies, and includes certain minimal requirements.

LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by

- compiling an inventory [2)] of relevant inputs and outputs of a product system ;
- evaluating the potential environmental impacts associated with those inputs and outputs ;
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. cradle-to-grave) from raw material acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences.

LCA can assist in

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

- decision-making in industry, governmental or non-governmental organizations (e.g. strategic planning, priority setting, product or process design or redesign) ;

- selection of relevant indicators of environmental performance, including measurement techniques ; and

- marketing (e.g. an environmental claim, ecolabelling scheme or environmental product declaration).

This International Standard recognizes that LCA is still at an early stage of development. Some phases of the LCA technique, such as impact assessment, are still in relative infancy. Considerable work remains to be done and practical experience gained in order to further develop the level of LCA practice. Therefore, it is important that the results of LCA be interpreted and applied appropriately.

If LCA is to be successful in supporting environmental understanding of products, it is essential that LCA maintains its technical credibility while providing flexibility, practicality and cost effectiveness of application. This is particularly true if LCA is to be applied within small- and medium-sized enterprises.

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1) In this International Standard, the term "product" used alone not only includes product systems but can also include service systems.

2) An inventory may include environmental aspects which are not directly related to the inputs and outputs of the system.

The scope, boundaries and level of detail of an LCA study depend on the subject and intended use of the study. The depth and breadth of LCA studies may differ considerably depending on the goal of a particular LCA study. However, in all cases, the principles and framework established in this International Standard should be followed.

LCA is one of several environmental management techniques (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) and may not be the most appropriate technique to use in all situations. LCA typically does not address the economic or social aspects of a product.

Because all techniques have limitations, it is important to understand those that are present in LCA. The limitations include the following.

- The nature of choices and assumptions made in LCA (e.g. system boundary setting, selection of data sources and impact categories) may be subjective.

- Models used for inventory analysis or to assess environmental impacts are limited by their assumptions, and may not be available for all potential impacts or applications.

- Results of LCA studies focused on global and regional issues may not be appropriate for local applications, i.e. local conditions might not be adequately represented by regional or global conditions.

- The accuracy of LCA studies may be limited by accessibility or availability of relevant data, or by data quality, e.g. gaps, types of data, aggregation, average, site-specific.

- The lack of spatial and temporal dimensions in the inventory data used for impact assessment introduces uncertainty in impact results. This uncertainty varies with the spatial and temporal characteristics of each impact category.

Generally, the information developed in an LCA study should be used as part of a much more comprehensive decision process or used to understand the broad or general trade-offs. Comparing results of different LCA studies is only possible if the assumptions and context of each study are the same. These assumptions should also be explicitly stated for reasons of transparency.

This International Standard provides principles and framework and provides some methodological requirements for conducting LCA studies. Additional details regarding methods are provided in the complementary International Standards ISO 14041, ISO 14042 and ISO 14043 concerning the various phases of LCA .

This International Standard, like other International Standards, is not intended to be used to create non-tariff trade barriers or to increase or change an organization's legal obligations.

Environmental management — Life cycle assessment — Principles and framework

1 Scope

This International Standard specifies the general framework, principles and requirements for conducting and reporting life cycle assessment studies. This International Standard does not describe the life cycle assessment technique in detail.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of the publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 14041: –[3] *Environmental management - Life cycle assessment - Goal and scope definition and life cycle inventory analysis*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
allocation
partitioning the input or output flows of a unit process to the product system under study

3.2
comparative assertion
environmental claim regarding the superiority or equivalence of one product versus a competing product which performs the same function

3.3
elementary flow
(1) material or energy entering the system being studied, which has been drawn from the environment without previous human transformation

(2) material or energy leaving the system being studied, which is discarded into the environment without subsequent human transformation

3.4
environmental aspect
element of an organization's activities, products or services that can interact with the environment

[3] To be published.

3.5
functional unit
quantified performance of a product system for use as a reference unit in a life cycle assessment study

3.6
input
material or energy which enters a unit process

NOTE : Materials may include raw materials and products.

3.7
interested party
individual or group concerned with or affected by the environmental performance of a product system, or by the results of the life cycle assessment

3.8
life cycle
consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal

3.9
life cycle assessment
LCA
compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

3.10
life cycle impact assessment
phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system

3.11
life cycle interpretation
phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are combined consistent with the defined goal and scope in order to reach conclusions and recommendations

3.12
life cycle inventory analysis
phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle

3.13
output
material or energy which leaves a unit process

NOTE : Materials may include raw materials, intermediate products, products, emissions and waste.

3.14
practitioner
individual or group that conducts a life cycle assessment

3.15
product system
collection of materially and energetically connected unit processes which performs one or more defined functions

NOTE : In this International Standard, the term "product" used alone includes not only product systems but can also include service systems.

3.16
raw material
primary or secondary material that is used to produce a product

3.17
system boundary
interface between a product system and the environment or other product systems

3.18
transparency
open, comprehensive and understandable presentation of information

3.19
unit process
smallest portion of a product system for which data are collected when performing a life cycle assessment

3.20
waste
any output from the product system which is disposed of

4 General description of LCA

4.1 Key features of LCA

The following list summarizes some of the key features of the LCA methodology.

- LCA studies should systematically and adequately address the environmental aspects of product systems, from raw material acquisition to final disposal.

- The depth of detail and time frame of an LCA study may vary to a large extent, depending on the definition of goal and scope.

- The scope, assumptions, description of data quality, methodologies and output of LCA studies should be transparent. LCA studies should discuss and document the data sources, and be clearly and appropriately communicated.

- Provisions should be made, depending on the intended application of the LCA study, to respect confidentiality and proprietary matters.

- LCA methodology should be amenable to the inclusion of new scientific findings and improvements in the state-of-the-art of the technology.

- Specific requirements are applied to LCA studies which are used to make a comparative assertion that is disclosed to the public.

- There is no scientific basis for reducing LCA results to a single overall score or number, since trade-offs and complexities exist for the systems analysed at different stages of their life cycle.

- There is no single method for conducting LCA studies. Organizations should have flexibility to implement LCA practically as established in this International Standard, based upon the specific application and the requirements of the user.

4.2 Phases of an LCA

Life cycle assessment shall include definition of goal and scope, inventory analysis, impact assessment and interpretation of results, as illustrated in figure 1.

LCA results may be useful inputs to a variety of decision-making processes. Applications of LCA such as the examples listed in figure 1 are outside the scope of this International Standard.

Life cycle inventory studies shall include definition of goal and scope, inventory analysis and interpretation of results. The requirements and recommendations of this International Standard, with the exception of those provisions regarding impact assessment, also apply to life cycle inventory studies.

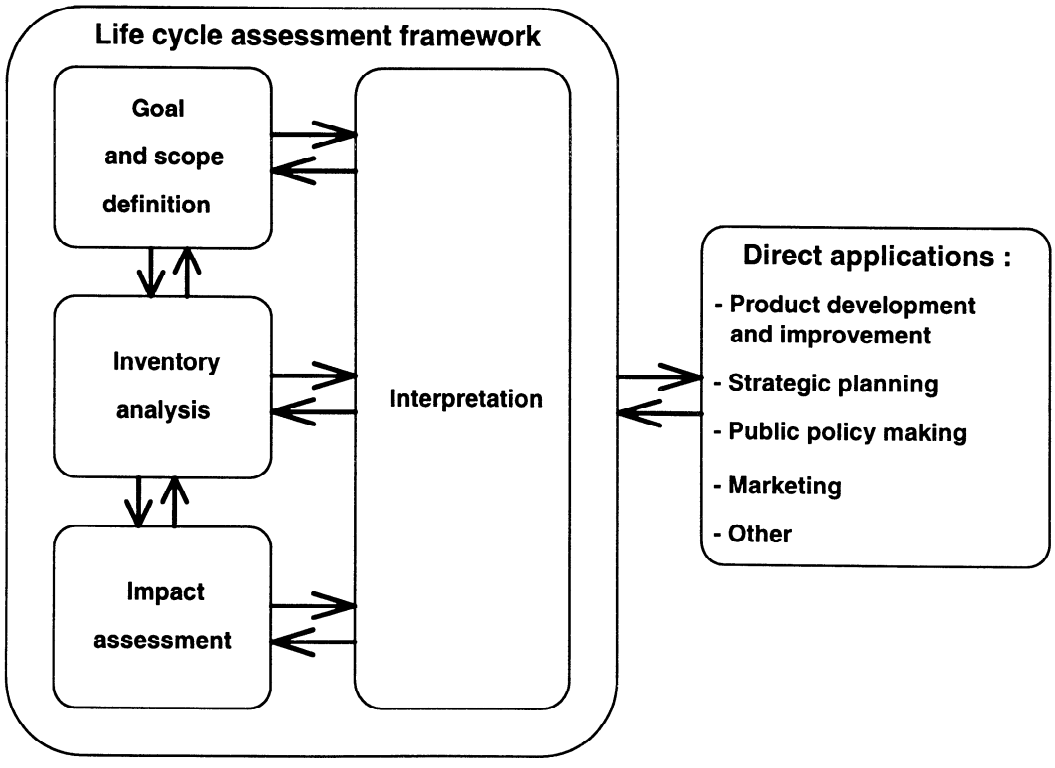

Figure 1 : Phases of an LCA

5 Methodological framework

In addition to the general requirements specified below, it is a requirement of this International Standard that the definition of goal and scope and the inventory comply with the respective provisions of ISO 14041.

5.1 Definition of goal and scope

The goal and scope of an LCA study shall be clearly defined and consistent with the intended application.

5.1.1 Goal of the study

The goal of an LCA study shall unambiguously state the intended application, the reasons for carrying out the study and the intended audience, i.e. to whom the results of the study are intended to be communicated.

5.1.2 Scope of the study

In defining the scope of an LCA study, the following items shall be considered and clearly described :

- the functions of the product system, or, in the case of comparative studies, the systems ;
- the functional unit ;
- the product system to be studied ;
- the product system boundaries ;
- allocation procedures ;
- types of impact and methodology of impact assessment, and subsequent interpretation to be used ;
- data requirements ;
- assumptions ;
- limitations ;
- initial data quality requirements ;
- type of critical review, if any ;
- type and format of the report required for the study.

The scope should be sufficiently well defined to ensure that the breadth, the depth and the detail of the study are compatible and sufficient to address the stated goal.

LCA is an iterative technique. Therefore, the scope of the study may need to be modified while the study is being conducted as additional information is collected.

5.1.2.1 Function and functional unit

The scope of an LCA study shall clearly specify the functions of the system being studied. A functional unit is a measure of the performance of the functional outputs of the product system. The primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related. This reference is necessary to ensure comparability of LCA results. Comparability of LCA results is particularly critical when different systems are being assessed to ensure that such comparisons are made on a common basis.

A system may have a number of possible functions and the one selected for a study is dependent on the goals and scope of the study. The related functional unit shall be defined and measurable.

EXAMPLE : The functional unit for a paint system may be defined as the unit surface protected for a specified time period.

5.1.2.2 System boundaries

The system boundaries determine which unit processes shall be included within the LCA.

Several factors determine the system boundaries, including the intended application of the study, the assumptions made, cut-off criteria, data and cost constraints, and the intended audience.

The selection of inputs and outputs, the level of aggregation within a data category, and the modelling of the system shall be consistent with the goal of the study. The system should be modelled in such a manner that inputs and outputs at its boundaries are elementary flows.
The criteria used in establishing the system boundaries shall be identified and justified in the scope of the study. LCA studies used to make a comparative assertion that is disclosed to the public shall perform an analysis of material and energy flows to determine their inclusion in the scope of the study.

5.1.2.3 Data quality requirements

Data quality requirements specify in general terms the characteristics of the data needed for the study. Data quality requirements shall be defined to enable the goals and scope of the LCA study to be met. The data quality requirements should address :

- time-related coverage ;
- geographical coverage ;
- technology coverage ;
- precision, completeness and representativeness of the data ;
- consistency and reproducibility of the methods used throughout the LCA ;
- sources of the data and their representativeness ;
- uncertainty of the information.

Where a study is used to support a comparative assertion that is disclosed to the public, the above-mentioned data quality requirements shall be addressed.

5.1.2.4 Comparisons between systems

In comparative studies, the equivalence of the systems being compared shall be evaluated before interpreting the results. Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundaries, data quality, allocation procedures, decision rules on evaluating inputs and outputs and impact assessment. Any differences between systems regarding these parameters shall be identified and reported.

In the case of comparative assertions disclosed to the public, this evaluation shall be conducted in accordance with the critical review process of section 7.3.3. Another requirement for comparative assertions disclosed to the public is that an impact assessment shall be performed.

5.1.2.5 Critical review considerations

Critical review is a technique to verify whether an LCA study has met the requirements of this International Standard for methodology, data and reporting. Whether and how to conduct a critical review, as well as who conducts the review, shall be defined in the scope of the study.

In general, critical reviews of an LCA are optional and may utilise any of the review options outlined in 7.3.

A critical review shall be conducted for LCA studies used to make a comparative assertion that is disclosed to the public and shall employ the critical review process outlined in 7.3.3.

5.2 Life cycle inventory analysis

5.2.1 General description of life cycle inventory

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

The process of conducting an inventory analysis is iterative. As data are collected and more is learned about the system, new data requirements or limitations may be identified that require a change in the data collection procedures so that the goals of the study will still be met. Sometimes, issues may be identified that require revisions to the goal or scope of the study.

5.2.2 Data collection and calculation procedures

The qualitative and quantitative data for inclusion in the inventory shall be collected for each unit process that is included within the system boundaries.

The procedures used for data collection may vary depending on the scope, unit process or intended application of the study.

Data collection can be a resource-intensive process. Practical constraints on data collection should be considered in the scope and documented in the study report.

Some significant calculation considerations are outlined in the following.

- **Allocation procedures** are needed when dealing with systems involving multiple products (e.g. multiple products from petroleum refining). The materials and energy flows as well as associated environmental releases shall be allocated to the different products according to clearly stated procedures, which shall be documented and justified.

- **The calculation of energy flow** should take into account the different fuels and electricity sources used, the efficiency of conversion and distribution of energy flow as well as the inputs and outputs associated with the generation and use of that energy flow.

5.3 Life cycle impact assessment

The impact assessment phase of LCA is aimed at evaluating the significance of potential environmental impacts using the results of the life cycle inventory analysis. In general, this process involves associating inventory data with specific environmental impacts and attempting to understand those impacts. The level of detail, choice of impacts evaluated and methodologies used depends on the goal and scope of the study.

This assessment may include the iterative process of reviewing the goal and scope of the LCA study to determine when the objectives of the study have been met, or to modify the goal and scope if the assessment indicates that they can not be achieved.

The impact assessment phase may include elements such as, among others :

- assigning of inventory data to impact categories (classification) ;
- modelling of the inventory data within impact categories (characterization) ;
- possibly aggregating the results in very specific cases and only when meaningful (weighting).

NOTE : Data prior to weighting should remain available.

The methodological and scientific framework for impact assessment is still being developed. Models for impact categories are in different stages of development. There are no generally accepted methodologies for consistently and accurately associating inventory data with specific potential environmental impacts.

There is subjectivity in the life cycle impact assessment phase such as the choice, modelling and evaluation of impact categories. Therefore, transparency is critical to impact assessment to ensure that assumptions are clearly described and reported.

5.4 Life cycle interpretation

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

The findings of this interpretation may take the form of conclusions and recommendations to decision-makers, consistent with the goal and scope of the study.

The interpretation phase may involve the iterative process of reviewing and revising the scope of the LCA, as well as the nature and quality of the data collected consistent with the defined goal.

The findings of the interpretation phase should reflect the results of any sensitivity analysis that is performed.

Though subsequent decisions and actions may incorporate environmental implications identified in the findings of the interpretation, they lie beyond the scope of the LCA study, since other factors such as technical performance, economic and social aspects are also considered.

6 Reporting

The results of the LCA shall be fairly, completely and accurately reported to the intended audience. The type and format of the report shall be defined in the scope phase of the study.

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 study. The report shall also allow the results and interpretation to be used in a manner consistent with the goals of the study.

When the results of the LCA are to be communicated to any third party, i.e. interested party other than the commissioner or the practitioner of the study, regardless of the form of communication, a third-party report shall be prepared. This report constitutes a reference document, and shall be made available to any third party to whom the communication is made.

The third-party report shall cover the following aspects:

a) general aspects :

1) LCA commissioner, practitioner of LCA (internal or external) ;
2) date of report ;
3) statement that the study has been conducted according to the requirements of this International Standard.

b) definition of goal and scope;

c) life cycle inventory analysis : data collection and calculation procedures;

d) life cycle impact assessment : the methodology and results of the impact assessment that was performed;

e) life cycle interpretation :

1) the results ;
2) assumptions and limitations associated with the interpretation of results, both methodology and data related ;
3) data quality assessment.

f) Critical review :

1) name and affiliation of reviewers ;
2) critical review reports ;
3) responses to recommendations.

For comparative assertions, the following issues shall also be addressed by the report :

- analysis of material and energy flows to justify their inclusion or exclusion ;
- assessment of the precision, completeness and representativeness of data used ;
- description of the equivalence of the systems being compared in accordance with 5.1.2.4 ;
- description of the critical review process.

7 Critical review

7.1 General description of critical reviews

The critical review process shall ensure that.

- the methods used to carry out the LCA are consistent with this International Standard ;
- the methods used to carry out the LCA 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 ;
- the study report is transparent and consistent.

Since this International Standard does not specify requirements on the goals or uses of LCA, a critical review can neither verify nor validate the goals that are chosen for an LCA, or the uses to which LCA results are put.

The scope and type of critical review desired shall be defined in the scope phase of an LCA study.

7.2 Need for critical review

A critical review may facilitate understanding and enhance the credibility of LCA studies, for example by involving interested parties.

The use of LCA results to support comparative assertions raises special concerns and requires critical review, since this application is likely to affect interested parties that are external to the LCA study. In order to decrease the likelihood of misunderstandings or negative effects on external interested parties, critical reviews shall be conducted on LCA studies where the results are used to support comparative assertions.

However, the fact that a critical review has been conducted should in no way imply an endorsement of any comparative assertion that is based on an LCA study.

7.3 Critical review processes

If an LCA study is to be critically reviewed, the scope of the critical review should be defined during the goal and scope definition phase of the study. The scope should identify why the critical review is being undertaken, what will be covered and to what level of detail, and who needs to be involved in the process.

Confidentiality agreements regarding the content of the LCA study should be entered into as needed.

7.3.1 Internal expert review

A critical review may be carried out internally. In such a case, it shall be performed by an internal expert independent of the LCA study.

This expert should be familiar with the requirements of this International Standard and have the necessary scientific and technical expertise.

A review statement is prepared by the person conducting the LCA study and then reviewed by the internal, independent expert. The review statement may also be prepared in its entirety by the internal, independent expert.

The review statement shall be included in the LCA study report.

7.3.2 External expert review

A critical review may be carried out externally. In such a case, it shall be performed by an external expert, independent of the LCA study.

This expert should be familiar with the requirements of this International Standard and have scientific and technical expertise.

A review statement is prepared by the person conducting the LCA study and then reviewed by the external, independent expert. The review statement may also be prepared in its entirety by the external, independent expert.

The review statement, comments of the practitioner and any response to recommendations made by the reviewer, shall be included in the LCA study report.

7.3.3 Review by interested parties

An external independent expert is selected by the original study commissioner to act as chairperson of a review panel. Based on the goal, scope and budget available for the review, the chairperson selects other independent qualified reviewers.

This panel may include other interested parties affected by the conclusions drawn from the LCA study, such as government agencies, non-governmental groups, or competitors.

The review statement and review panel report, as well as comments of the expert and any responses to recommendations made by the reviewer or by the panel, shall be included in the LCA study report.

Annex A

(informative)

Bibliography

[1] ISO 14042: —[4], *Environmental management - Life cycle assessment - Life cycle impact assessment.*

[2] ISO 14043 : —[4], *Environmental management - Life cycle assessment - Life cycle interpretation.*

[4] To be published.

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