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Environmental management — Life cycle assessment — Requirements and guidelines

Management environnemental — Analyse du cycle de vie — Exigences et lignes directrices

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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

ISO 14044 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 5, *Life cycle assessment*.

This first edition of ISO 14044, together with ISO 14040:2006, cancels and replaces ISO 14040:1997, ISO 14041:1998, ISO 14042:2000 and ISO 14043:2000, which have been technically revised.

Introduction

The increased awareness of the importance of environmental protection, and the possible impacts associated with products[1)], both manufactured and consumed, has increased interest in the development of methods to better understand and address these impacts. One of the techniques being developed for this purpose is life cycle assessment (LCA).

LCA can assist in

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

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

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

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

LCA addresses the environmental aspects and potential environmental impacts[2)] (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave).

There are four phases in an LCA study:

a) the goal and scope definition phase,

b) the inventory analysis phase,

c) the impact assessment phase, and

d) the interpretation phase.

The scope, including system boundary and level of detail, of an LCA depends on the subject and the intended use of the study. The depth and the breadth of LCA can differ considerably depending on the goal of a particular LCA.

The life cycle inventory analysis phase (LCI phase) is the second phase of LCA. It is an inventory of input/output data with regard to the system being studied. It involves the collection of the data necessary to meet the goals of the defined study.

The life cycle impact assessment phase (LCIA) is the third phase of the LCA. The purpose of LCIA is to provide additional information to help assess a product system's LCI results so as to better understand their environmental significance.

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1) In this International Standard, the term "product" includes services.

2) The "potential environmental impacts" are relative expressions, as they are related to the functional unit of a product system.

Life cycle interpretation is the final phase of the LCA procedure, in which the results of an LCI or an LCIA, or both, are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition.

There are cases where the goal of an LCA may be satisfied by performing only an inventory analysis and an interpretation. This is usually referred to as an LCI study.

This International Standard covers two types of studies: life cycle assessment studies (LCA studies) and life cycle inventory studies (LCI studies). LCI studies are similar to LCA studies but exclude the LCIA phase. LCI are not to be confused with the LCI phase of an LCA study.

Generally, the information developed in an LCA or LCI study can be used as part of a much more comprehensive decision process. Comparing the results of different LCA or LCI studies is only possible if the assumptions and context of each study are equivalent. Therefore this International Standard contains several requirements and recommendations to ensure transparency on these issues.

LCA is one of several environmental management techniques (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) and might not be the most appropriate technique to use in all situations. LCA typically does not address the economic or social aspects of a product, but the life cycle approach and methodologies described in this International Standard may be applied to these other aspects.

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 — Requirements and guidelines

1 Scope

This International Standard specifies requirements and provides guidelines for life cycle assessment (LCA) including

a) the goal and scope definition of the LCA,

b) the life cycle inventory analysis (LCI) phase,

c) the life cycle impact assessment (LCIA) phase,

d) the life cycle interpretation phase,

e) reporting and critical review of the LCA,

f) limitations of the LCA,

g) relationship between the LCA phases, and

h) conditions for use of value choices and optional elements.

This International Standard covers life cycle assessment (LCA) studies and life cycle inventory (LCI) studies.

The intended application of LCA or LCI results is considered during the goal and scope definition, but the application itself is outside the scope of this International Standard.

This International Standard is not intended for contractual or regulatory purposes or registration and certification.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14040:2006, *Environmental management — Life cycle assessment — Principles and framework*

3 Terms and definitions

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

NOTE These terms and definitions are taken from ISO 14040:2006 and are repeated for the convenience of users of this International Standard.

3.1
life cycle
consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal

3.2
life cycle assessment
LCA
compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

3.3
life cycle inventory analysis
LCI
phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle

3.4
life cycle impact assessment
LCIA
phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product

3.5
life cycle interpretation
phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations

3.6
comparative assertion
environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function

3.7
transparency
open, comprehensive and understandable presentation of information

3.8
environmental aspect
element of an organization's activities, products or services that can interact with the environment

[ISO 14001:2004; definition 3.6]

3.9
product
any goods or service

NOTE 1 The product can be categorized as follows:

— services (e.g. transport);

— software (e.g. computer program, dictionary);

— hardware (e.g. engine mechanical part);

— processed materials (e.g. lubricant);

NOTE 2 Services have tangible and intangible elements. Provision of a service can involve, for example, the following:

— an activity performed on a customer-supplied tangible product (e.g. automobile to be repaired);

— an activity performed on a customer-supplied intangible product (e.g. the income statement needed to prepare a tax return);

— the delivery of an intangible product (e.g. the delivery of information in the context of knowledge transmission);

— the creation of ambience for the customer (e.g. in hotels and restaurants).

Software consists of information and is generally intangible and can be in the form of approaches, transactions or procedures.

Hardware is generally tangible and its amount is a countable characteristic. Processed materials are generally tangible and their amount is a continuous characteristic.

NOTE 3 Adapted from ISO 14021:1999 and ISO 9000:2005.

3.10
co-product
any of two or more products coming from the same unit process or product system

3.11
process
set of interrelated or interacting activities that transforms inputs into outputs

[ISO 9000:2005, definition 3.4.1 (without notes)]

3.12
elementary flow
material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation

3.13
energy flow
input to or output from a unit process or product system, quantified in energy units

NOTE Energy flow that is an input may be called an energy input; energy flow that is an output may be called an energy output.

3.14
feedstock energy
heat of combustion of a raw material input that is not used as an energy source to a product system, expressed in terms of higher heating value or lower heating value

NOTE Care is necessary to ensure that the energy content of raw materials is not counted twice.

3.15
raw material
primary or secondary material that is used to produce a product

NOTE Secondary material includes recycled material.

3.16
ancillary input
material input that is used by the unit process producing the product, but does not constitute part of the product

3.17
allocation
partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems

3.18
cut-off criteria
specification of the amount of material or energy flow or the level of environmental significance associated with unit processes or product system to be excluded from a study

3.19
data quality
characteristics of data that relate to their ability to satisfy stated requirements

3.20
functional unit
quantified performance of a product system for use as a reference unit

3.21
input
product, material or energy flow that enters a unit process

NOTE Products and materials include raw materials, intermediate products and co-products.

3.22
intermediate flow
product, material or energy flow occurring between unit processes of the product system being studied

3.23
intermediate product
output from a unit process that is input to other unit processes that require further transformation within the system

3.24
life cycle inventory analysis result
LCI result
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

3.25
output
product, material or energy flow that leaves a unit process

NOTE Products and materials include raw materials, intermediate products, co-products, and releases.

3.26
process energy
energy input required for operating the process or equipment within a unit process, excluding energy inputs for production and delivery of the energy itself

3.27
product flow
products entering from or leaving to another product system

3.28
product system
collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product

3.29
reference flow
measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit

3.30
releases
emissions to air and discharges to water and soil

3.31
sensitivity analysis
systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study

3.32
system boundary
set of criteria specifying which unit processes are part of a product system

NOTE The term “system boundary” is not used in this International Standard in relation to LCIA.

3.33
uncertainty analysis
systematic procedure to quantify the uncertainty introduced in the results of a life cycle inventory analysis due to the cumulative effects of model imprecision, input uncertainty and data variability

NOTE Either ranges or probability distributions are used to determine uncertainty in the results.

3.34
unit process
smallest element considered in the life cycle inventory analysis for which input and output data are quantified

3.35
waste
substances or objects which the holder intends or is required to dispose of

NOTE The definition is taken from the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (22 March 1989) but is not confined in this International Standard to hazardous waste.

3.36
category endpoint
attribute or aspect of natural environment, human health, or resources, identifying an environmental issue giving cause for concern

3.37
characterization factor
factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator

NOTE The common unit allows calculation of the category indicator result.

3.38
environmental mechanism
system of physical, chemical and biological processes for a given impact category, linking the life cycle inventory analysis results to category indicators and to category endpoints

3.39
impact category
class representing environmental issues of concern to which life cycle inventory analysis results may be assigned

3.40
impact category indicator
quantifiable representation of an impact category

NOTE The shorter expression “category indicator” is used in this International Standard for improved readability.

3.41
completeness check
process of verifying whether information from the phases of a life cycle assessment is sufficient for reaching conclusions in accordance with the goal and scope definition

3.42
consistency check
process of verifying that the assumptions, methods and data are consistently applied throughout the study and are in accordance with the goal and scope definition performed before conclusions are reached

3.43
sensitivity check
process of verifying that the information obtained from a sensitivity analysis is relevant for reaching the conclusions and giving recommendations

3.44
evaluation
element within the life cycle interpretation phase intended to establish confidence in the results of the life cycle assessment

NOTE Evaluation includes completeness check, sensitivity check, consistency check, and any other validation that may be required according to the goal and scope definition of the study

3.45
critical review
process intended to ensure consistency between a life cycle assessment and the principles and requirements of the International Standards on life cycle assessment

NOTE 1 The principles are described in ISO 14040:2006, 4.1.

NOTE 2 The requirements are described in this International Standard.

3.46
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

4 Methodological framework for LCA

4.1 General requirements

See ISO 14040 for the principles and framework to be used to conduct an LCA.

LCA studies shall include the goal and scope definition, inventory analysis, impact assessment and interpretation of results.

LCI studies shall include definition of the 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.

An LCI study alone shall not be used for comparisons intended to be used in comparative assertions intended to be disclosed to the public.

It should be recognized that there is no scientific basis for reducing LCA results to a single overall score or number.

4.2 Goal and scope definition

4.2.1 General

The goal and scope of an LCA shall be clearly defined and shall be consistent with the intended application. Due to the iterative nature of LCA, the scope may have to be refined during the study.

4.2.2 Goal of the study

In defining the goal of an LCA, the following items shall be unambiguously stated:

— the intended application;

— the reasons for carrying out the study:

— the intended audience, i.e. to whom the results of the study are intended to be communicated:

— whether the results are intended to be used in comparative assertions intended to be disclosed to the public.

4.2.3 Scope of the study

4.2.3.1 General

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

— the product system to be studied;

— the functions of the product system or, in the case of comparative studies, the systems;

— the functional unit;

— the system boundary;

— allocation procedures;

— LCIA methodology and types of impacts;

— interpretation to be used;

— data requirements;

— assumptions;

— value choices and optional elements;

— limitations;

— data quality requirements;

— type of critical review, if any;

— type and format of the report required for the study.

In some cases, the goal and scope of the study may be revised due to unforeseen limitations, constraints or as a result of additional information. Such modifications, together with their justification, should be documented.

Some of the items above are specified in detail in 4.2.3.2 to 4.2.3.8.

4.2.3.2 Function and functional unit

The scope of an LCA shall clearly specify the functions (performance characteristics) of the system being studied. The functional unit shall be consistent with the goal and scope of the study. One of the primary purposes of a functional unit is to provide a reference to which the input and output data are normalized (in a mathematical sense). Therefore the functional unit shall be clearly defined and measurable.

Having chosen the functional unit, the reference flow shall be defined. Comparisons between systems shall be made on the basis of the same function(s), quantified by the same functional unit(s) in the form of their reference flows. If additional functions of any of the systems are not taken into account in the comparison of functional units, then these omissions shall be explained and documented. As an alternative, systems associated with the delivery of this function may be added to the boundary of the other system to make the systems more comparable. In these cases, the processes selected shall be explained and documented.

4.2.3.3 System boundary

4.2.3.3.1 The system boundary determines which unit processes shall be included within the LCA. The selection of the system boundary shall be consistent with the goal of the study. The criteria used in establishing the system boundary shall be identified and explained.

Decisions shall be made regarding which unit processes to include in the study and the level of detail to which these unit processes shall be studied.

The deletion of life cycle stages, processes, inputs or outputs is only permitted if it does not significantly change the overall conclusions of the study. Any decisions to omit life cycle stages, processes, inputs or outputs shall be clearly stated, and the reasons and implications for their omission shall be explained.

Decisions shall also be made regarding which inputs and outputs shall be included and the level of detail of the LCA shall be clearly stated.

4.2.3.3.2 It is helpful to describe the system using a process flow diagram showing the unit processes and their inter-relationships. Each of the unit processes should be initially described to define

- where the unit process begins, in terms of the receipt of raw materials or intermediate products,
- the nature of the transformations and operations that occur as part of the unit process, and
- where the unit process ends, in terms of the destination of the intermediate or final products.

Ideally, the product system should be modelled in such a manner that inputs and outputs at its boundary are elementary and product flows. It is an iterative process to identify the inputs and outputs that should be traced to the environment, i.e. to identify which unit processes producing the inputs (or which unit processes receiving the outputs) should be included in the product system under study. The initial identification is made using available data. Inputs and outputs should be more fully identified after additional data are collected during the course of the study, and then subjected to a sensitivity analysis (see 4.3.3.4).

For material inputs, the analysis begins with an initial selection of inputs to be studied. This selection should be based on an identification of the inputs associated with each of the unit processes to be modelled. This effort may be undertaken with data collected from specific sites or from published sources. The goal is to identify the significant inputs associated with each of the unit processes.

Energy inputs and outputs shall be treated as any other input or output to an LCA. The various types of energy inputs and outputs shall include inputs and outputs relevant for the production and delivery of fuels, feedstock energy and process energy used within the system being modelled.

4.2.3.3.3 The cut-off criteria for initial inclusion of inputs and outputs and the assumptions on which the cut-off criteria are established shall be clearly described. The effect on the outcome of the study of the cut-off criteria selected shall also be assessed and described in the final report.

Several cut-off criteria are used in LCA practice to decide which inputs are to be included in the assessment, such as mass, energy and environmental significance. Making the initial identification of inputs based on mass contribution alone may result in important inputs being omitted from the study. Accordingly, energy and environmental significance should also be used as cut-off criteria in this process.

a) **Mass**: an appropriate decision, when using mass as a criterion, would require the inclusion in the study of all inputs that cumulatively contribute more than a defined percentage to the mass input of the product system being modelled.

b) **Energy**: similarly, an appropriate decision, when using energy as a criterion, would require the inclusion in the study of those inputs that cumulatively contribute more than a defined percentage of the product system's energy inputs.

c) **Environmental significance**: decisions on cut-off criteria should be made to include inputs that contribute more than an additional defined amount of the estimated quantity of individual data of the product system that are specially selected because of environmental relevance.

Similar cut-off criteria may also be used to identify which outputs should be traced to the environment, e.g. by including final waste treatment processes.

Where the study is intended to be used in comparative assertions intended to be disclosed to the public, the final sensitivity analysis of the inputs and outputs data shall include the mass, energy and environmental significance criteria so that all inputs that cumulatively contribute more than a defined amount (e.g. percentage) to the total are included in the study.

All of the selected inputs identified through this process should be modelled as elementary flows.

It should be decided which inputs and outputs data have to be traced to other product systems, including flows subject to allocation. The system should be described in sufficient detail and clarity to allow another practitioner to duplicate the inventory analysis.

4.2.3.4 LCIA methodology and types of impacts

It shall be determined which impact categories, category indicators and characterization models are included within the LCA study. The selection of impact categories, category indicators and characterization models used in the LCIA methodology shall be consistent with the goal of the study and considered as described in 4.4.2.2.

4.2.3.5 Types and sources of data

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

Inputs may include, but are not limited to, use of mineral resources (e.g. metals from ores or recycling, services like transportation or energy supply, and use of ancillary materials like lubricants or fertilisers).

As part of emissions to air, emissions of carbon monoxide, carbon dioxide, sulfur oxides, nitrogen oxides, etc. may be separately identified.

Emissions to air, and discharges to water and soil, often represent releases from point or diffuse sources, after passing through pollution control devices. These data should also include fugitive emissions, when significant. Indicator parameters may include, but are not limited to,

— biochemical oxygen demand (BOD),

— chemical oxygen demand (COD),