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Environmental management — Life cycle assessment — Goal and scope definition and inventory analysis

Management environnemental — Analyse du cycle de vie — Définition de l'objectif et du champ d'étude et analyse de l'inventaire

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Contents

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch
Printed in Switzerland

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 3.

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 14041 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 5, *Life cycle assessment.*

Annexes A and B of this International Standard are for information only.

Introduction

This International Standard deals with two phases of Life Cycle Assessment (LCA), goal and scope definition and Life Cycle Inventory analysis (LCI), as defined in ISO 14040.

The goal and scope definition phase is important because it determines why an LCA is being conducted (including the intended use of the results) and describes the system to be studied and the data categories to be studied. The purpose, scope and intended use of the study will influence the direction and depth of the study, addressing issues such as the geographic extent and time horizon of the study and the quality of data which will be necessary.

The LCI involves the collection of the data necessary to meet the goals of the defined study. It is essentially an inventory of input/output data with respect to the system being studied.

In the interpretation phase of LCI (see clause 7 of this International Standard), the data are evaluated in light of the goal and scope, the collection of additional data, or both. The interpretation phase also typically results in an improved understanding of the data for reporting purposes. Since LCI is a collection and analysis of input/output data and not an assessment of the environmental impacts associated with those data, the interpretation of LCI results alone cannot be the basis for reaching conclusions about relative environmental impacts.

This International Standard may be used to:

— assist organizations in obtaining a systematic view of interconnected product systems;

— formulate the goal and scope of the study, define and model the systems to be analysed, collect the data and report the results of an LCI;

— establish a baseline of environmental performance for a given product[1] system by quantifying the use of energy flows and raw materials and emissions to air, water and land (environmental input and output data) associated with that system both for the whole system but also broken down by unit process;

— identify those unit processes within a product system where the greatest use of energy flows, raw materials and emissions occur with a view to making targeted improvements;

— provide data for subsequent use to help define ecolabelling criteria;

— help to set policy options, e.g. concerning procurement.

This list is not exclusive, although it does summarize the primary reasons why LCI studies are carried out.

Complementary International Standards ISO 14042 and ISO 14043 concerning further phases of LCA are under preparation (see Bibliography). A Technical Report providing examples of practice in carrying out an LCI as a means of satisfying certain provisions of ISO 14041 is also under preparation.

1) In this International Standard, the term "product" used alone is synonymous to "product or service".

Environmental management — Life cycle assessment — Goal and scope definition and inventory analysis

1 Scope

This International Standard in addition to ISO 14040 specifies the requirements and the procedures necessary for the compilation and preparation of the definition of goal and scope for a Life Cycle Assessment (LCA), and for performing, interpreting and reporting a Life Cycle Inventory analysis (LCI).

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, this publication do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 14040:1997, *Environmental management — Life cycle assessment — Principles and framework*.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 14040 and the following apply.

3.1
ancillary input
material input that is used by the unit process producing the product, but does not constitute a part of the product

EXAMPLE A catalyst.

3.2
coproduct
any of two or more products from the same unit process

3.3
data quality
characteristic of data that bears on their ability to satisfy stated requirements

3.4
energy flow
input to or output from a unit process or product system, quantified in energy units

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

3.5
feedstock energy
heat of combustion of raw material inputs, which are not used as an energy source, to a product system

NOTE It is expressed in terms of higher heating value or lower heating value.

3.6
final product
product which requires no additional transformation prior to its use

3.7
fugitive emission
uncontrolled emission to air, water or land

EXAMPLE Material released from a pipeline coupling.

3.8
intermediate product
input to or output from a unit process which requires further transformation

3.9
process energy
energy input required for a unit process to operate the process or equipment within the process excluding energy inputs for production and delivery of this energy

3.10
reference flow
measure of the needed outputs from processes in a given product system required to fulfill the function expressed by the functional unit

3.11
sensitivity analysis
systematic procedure for estimating the effects on the outcome of a study of the chosen methods and data

3.12
uncertainty analysis
systematic procedure to ascertain and quantify the uncertainty introduced into the results of a life cycle inventory analysis due to the cumulative effects of input uncertainty and data variability

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

4 LCI components

4.1 General

This clause outlines the key terminology and components of a life cycle inventory analysis.

4.2 Product system

A product system is a collection of unit processes connected by flows of intermediate products which perform one or more defined functions. Figure 1 shows an example of a product system. A product system description includes unit processes, elementary flows, and product flows across the system boundaries (either into the system or out of the system), and intermediate product flows within the system.

The essential property of a product system is characterized by its function, and cannot be defined solely in terms of the final products.

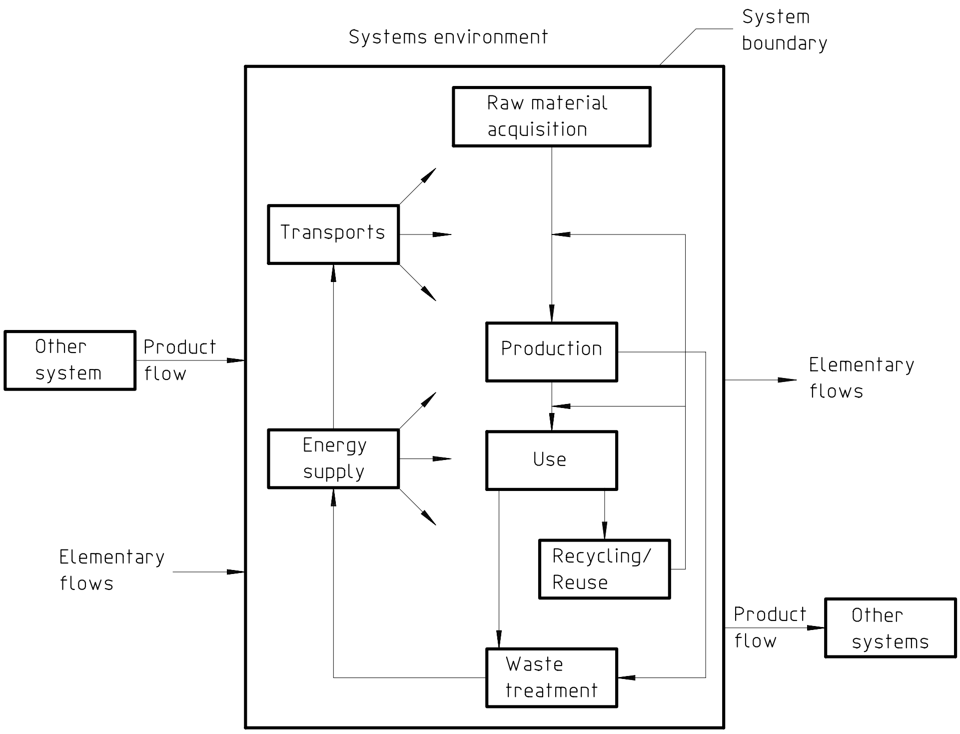

Figure 1 — Example of a product system for life cycle inventory analysis

4.3 Unit process

Product systems are subdivided into a set of unit processes (see Figure 2). Unit processes are linked to one another by flows of intermediate products and/or waste for treatment, to other product systems by product flows, and to the environment by elementary flows.

Examples of elementary flows entering the unit process are crude oil in ground and solar radiation. Examples of elementary flows leaving the unit process are emissions to air, emissions to water and radiation. Examples of intermediate product flows are basic materials and subassemblies.

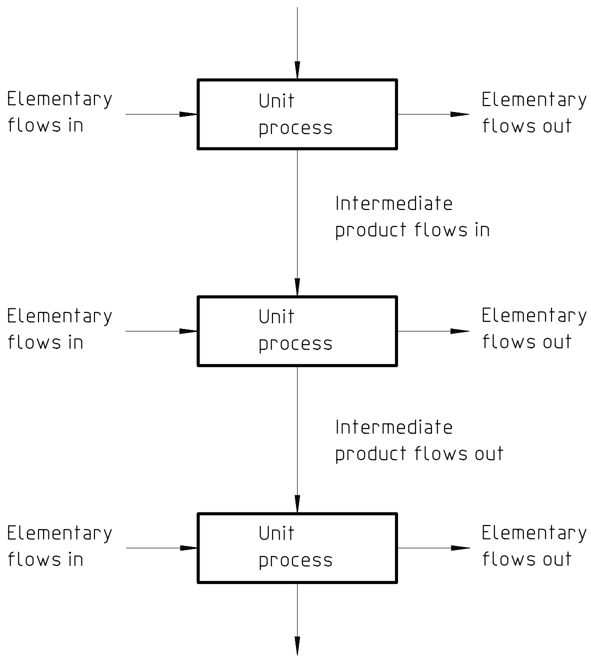

Figure 2 — Example of a set of unit processes within a product system

Dividing a product system into its component unit processes facilitates the identification of the inputs and outputs of the product system. In many cases, some of the inputs are used as a component of the output product, while others (ancillary inputs) are used within a unit process but are not part of the output product. A unit process also generates other outputs (elementary flows and/or products) as a result of its activities. The boundary of a unit process is determined by the level of modelling detail that is required to satisfy the goal of the study.

Because the system is a physical system, each unit process obeys the laws of conservation of mass and energy. Mass and energy balances provide a useful check on the validity of a unit process description.

4.4 Data categories

Collected data, either measured, calculated or estimated, are utilised to quantify the inputs and outputs of a unit process. The major headings under which data can be classified include:

— energy inputs, raw material inputs, ancillary inputs, other physical inputs;

— products;

— emissions to air, emissions to water, emissions to land, other environmental aspects.

Within these headings, individual data categories shall be further detailed to satisfy the goal of the study. For example, under emissions to air, data categories such as carbon monoxide, carbon dioxide, sulfur oxides, nitrogen oxides, etc. can be separately identified. Further description of such data categories is provided in 5.3.4.

4.5 Modelling product systems

LCA studies are conducted by developing models that describe the key elements of physical systems. It is often not practical to study all the relationships between all the unit processes in a product system, or all the relationships between a product system and the system environment. The choice of elements of the physical system to be modelled is dependent on the definition of the goal and scope of the study. The models used should be described and the assumptions underlying those choices should be identified. Further description is provided in 5.3.3 and 5.3.5.

5 Definition of goal and scope

5.1 General

The goal and scope of an LCA study shall be clearly defined and consistent with the intended application. The requirements of ISO 14040:1997, 5.1 apply.

5.2 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.

5.3 Scope of the study

5.3.1 General

The scope of the study shall consider all relevant items in accordance with ISO 14040:1997, 5.1.2

It should be recognized that an LCA study is an iterative technique, and as data and information are collected, various aspects of the scope may require modification in order to meet the original goal of the study. In some cases, the goal of the study itself may be revised due to unforeseen limitations, constraints or as a result of additional information. Such modifications, together with their justification, should be duly documented.

5.3.2 Function, functional unit and reference flow

In defining the scope of an LCA study, a clear statement on the specification of the functions (performance characteristics) of the product shall be made.

The functional unit defines the quantification of these identified functions. 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 defined the functional unit, the amount of product which is necessary to fulfill the function shall be quantified. The result of this quantification is the reference flow.

The reference flow is then used to calculate the inputs and outputs of the system. Comparisons between systems shall be made on the basis of the same function, quantified by the same functional unit in the form of their reference flows.

EXAMPLE In the function of drying hands, both a paper towel and an air-dryer system are studied. The selected functional unit may be expressed in terms of the identical number of pairs of hands dried for both systems. For each system, it is possible to determine the reference flow, e.g. the average mass of paper or the average volume of hot air required for one hand-dry, respectively. For both systems, it is possible to compile an inventory of inputs and outputs on the basis of the reference flows. At its simplest level, in the case of paper towel, this would be related to the paper consumed. In the case of the air-dryer, this would be largely related to the energy input to the air dryer.

If additional functions of any of the systems are not taken into account in the comparison of functional units, then these omissions shall be documented. For example, systems A and B perform functions x and y which are represented by the selected functional unit, but system A also performs function z, which is not represented in the functional unit. It shall then be documented that function z is excluded from this functional unit. As an alternative, systems associated with the delivery of function z may be added to the boundary of system B to make the systems more comparable. In these cases, the processes selected shall be documented and justified.

5.3.3 Initial system boundaries

The system boundaries define the unit processes to be included in the system to be modelled. Ideally, the product system should be modelled in such a manner that inputs and outputs at its boundary are elementary flows. In many cases there will not be sufficient time, data, or resources to conduct such a comprehensive study. Decisions shall be made regarding which unit processes shall be modelled by the study and the level of detail to which these unit processes shall be studied. Resources need not be expended on the quantification of such inputs and outputs that will not significantly change the overall conclusions of the study.

Decisions shall also be made regarding which releases to the environment shall be evaluated and the level of detail of this evaluation. In many instances those system boundaries defined initially will subsequently be refined on the basis of the outcome of the preliminary work (see 6.4.5). The criteria used to assist in the choice of inputs and outputs should be clearly understood and described. Further guidance on this process is provided in 5.3.5.

Any decisions to omit life cycle stages, processes or inputs/outputs shall be clearly stated and justified. The criteria used in setting the system boundaries dictate the degree of confidence in ensuring that the results of the study have not been compromised and that the goal of a given study will be met.

Several life cycle stages, unit processes and flows should be taken into consideration, e.g.:

- inputs and outputs in the main manufacturing/processing sequence;
- distribution/transportation;
- production and use of fuels, electricity and heat;
- use and maintenance of products;
- disposal of process wastes and products;
- recovery of used products (including reuse, recycling and energy recovery);

— manufacture of ancillary materials;

— manufacture, maintenance and decommissioning of capital equipment;

— additional operations, such as lighting and heating;

— other considerations related to impact assessment (if any).

It is helpful to describe the system using a process flow diagram showing the unit processes and their interrelationships. 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.

It should be decided which input and output data should be traced to other product systems, including the decisions about allocation. The system should be described in sufficient detail and clarity to allow another practitioner to duplicate the inventory analysis.

5.3.4 Description of data categories

The data required for an LCA study are dependent on the goal of the study. Such data may be collected from the production sites associated with the unit processes within the system boundaries, or they may be obtained or calculated from published sources. In practice, all data categories may include a mixture of measured, calculated or estimated data. Subclause 4.4 outlines the major headings for the inputs and outputs that are quantified for each unit process within the systems boundary. These data categories should be considered when deciding which data categories are used in the study. The individual data categories should be further detailed to satisfy the goal of the study.

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.

Emissions to air, water and land often represent discharges from point or diffuse sources, after passing through emissions control devices. The category should also include, when significant, fugitive emissions. Indicator parameters, e.g. biochemical oxygen demand (BOD), may also be used.

Other data categories for which input and output data may be collected include, for example, noise and vibration, land use, radiation, odour and waste heat.

5.3.5 Criteria for initial inclusion of inputs and outputs

During the scope definition, the initial set of inputs and outputs is selected for the inventory. This process recognizes that it is often not practical to model every input and output into the product system. It is an iterative process to identify the inputs and outputs which 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 typically 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 6.4.5).

The criteria and the assumptions on which they are established shall be clearly described. The potential effect of the criteria selected on the outcome of the study shall also be assessed and described in the final report.

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.

Several criteria are used in LCA practice to decide which inputs to be studied, including a) mass, b) energy and c) environmental relevance. 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 relevance should also be used as 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 those inputs that cumulatively contribute more than a defined percentage of the product system´s energy inputs;

c) environmental relevance: decisions on environmental relevance criteria should be made to include inputs that contribute more than an additional defined percentage to the estimated quantity of each individual data category of the product system. For example, if sulfur oxides were selected as a data category, a criterion could be established to include any inputs that contribute more than a predefined percentage to the total sulfur oxide emissions for the product system.

These criteria can also be used to identify which outputs should be traced to the environment, i.e. by including final waste treatment processes.

Where the study is intended to support a comparative assertion made to the public, the final sensitivity analysis of the inputs and outputs data shall include the mass, energy and environmental relevance criteria, as outlined in this subclause. All of the selected inputs identified by this process should be modelled as elementary flows.

5.3.6 Data quality requirements

Descriptions of data quality are important to understand the reliability of the study results and properly interpret the outcome of the study. Data quality requirements shall be specified to enable the goal and scope of the study to be met. Data quality should be characterized by both quantitative and qualitative aspects as well as by the methods used to collect and integrate those data.

Data quality requirements should be included for the following parameters:

— time-related coverage: the desired age of data (e.g. within the last five years) and the minimum length of time (e.g. one year) over which data should be collected;

— geographical coverage: geographical area from which data for unit processes should be collected to satisfy the goal of the study (e.g. local, regional, national, continental, global);

— technology coverage: technology mix (e.g. weighted average of the actual process mix, best available technology or worst operating unit).

Further descriptors which define the nature of the data, such as that collected from specific sites versus data from published sources, and whether the data should be measured, calculated or estimated, shall also be considered.

Data from specific sites or representative averages should be used for those unit processes that contribute the majority of the mass and energy flows in the systems being studied, as determined in the sensitivity analysis performed in 5.3.5. Data from specific sites should also be used for unit processes that are considered to have environmentally relevant emissions.

In all studies, the following additional data quality requirements shall be considered in a level of detail depending on goal and scope definition:

— precision: measure of the variability of the data values for each data category expressed (e.g. variance);

— completeness: percentage of locations reporting primary data from the potential number in existence for each data category in a unit process;

— representativeness: qualitative assessment of degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period and technology coverage);