भारतीय मानक

पर्यावरण प्रबंध — जीवन चक्र मूल्यांकन — लक्ष्य एवं विषय क्षेत्र की परिभाषा तथा सामग्री-सूची विश्लेषण

Indian Standard

ENVIRONMENTAL MANAGEMENT — LIFE CYCLE ASSESSMENT — GOAL AND SCOPE DEFINITION AND INVENTORY ANALYSIS

ICS 13.020

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Environmental Management Sectional Committee, CHD 34

NATIONAL FOREWORD

This Indian Standard which is identical with ISO 14041 : 1998 'Environmental management — Life cycle assessment — Goal and scope definition and inventory analysis', issued by the International Organization for Standardization (ISO), was adopted by the Bureau of Indian Standards on the recommendation of the Environmental Management Sectional Committee (CHD 34) and approval of the Chemical Division Council.

This International Standard has been prepared by Technical Committee ISO/TC 207 'Environmental Management'. The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. However, attention is particularly drawn that wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

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.

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

Indian Standard

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.

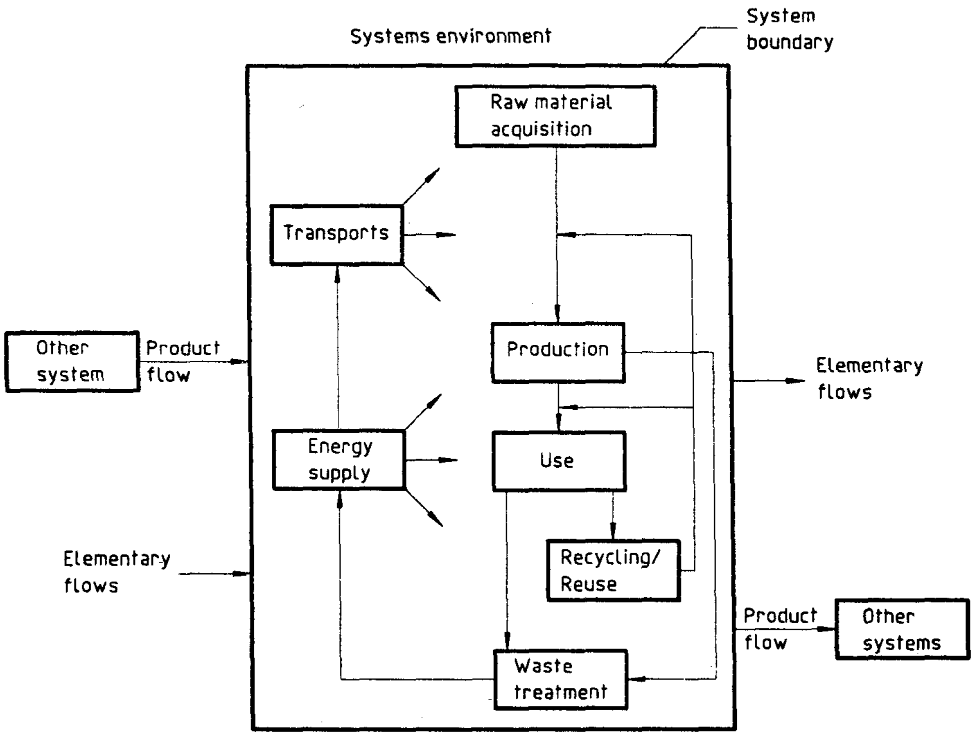

Figure 1 — Example of a product system for life cycle inventory analysis

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.

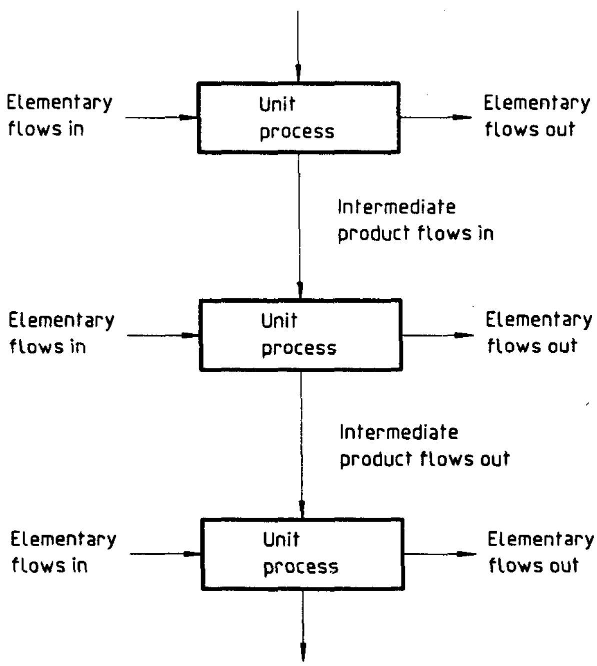

Figure 2 — Example of a set of unit processes within a product system

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);

— consistency: qualitative assessment of how uniformly the study methodology is applied to the various components of the analysis;

— reproducibility: qualitative assessment of the extent to which information about the methodology and data values allows an independent practitioner to reproduce the results reported in the study.

Where a study is used to support a comparative assertion that is disclosed to the public, all data quality requirements described in this subclause shall be included in the study.

5.3.7 Critical review

The type of critical review (see ISO 14040:1997, 7.3) shall be defined.

Where the use of the study is intended to make a comparative assertion that is disclosed to the public, a critical review shall be conducted as presented in ISO 14040:1997, 7.3.3.

6 Inventory analysis

6.1 General

The definition of the goal and scope of a study provides the initial plan for conducting an LCA study. A life cycle inventory analysis (LCI) is concerned with the data collection and calculation procedures. The operational steps outlined in Figure 3 should be performed.

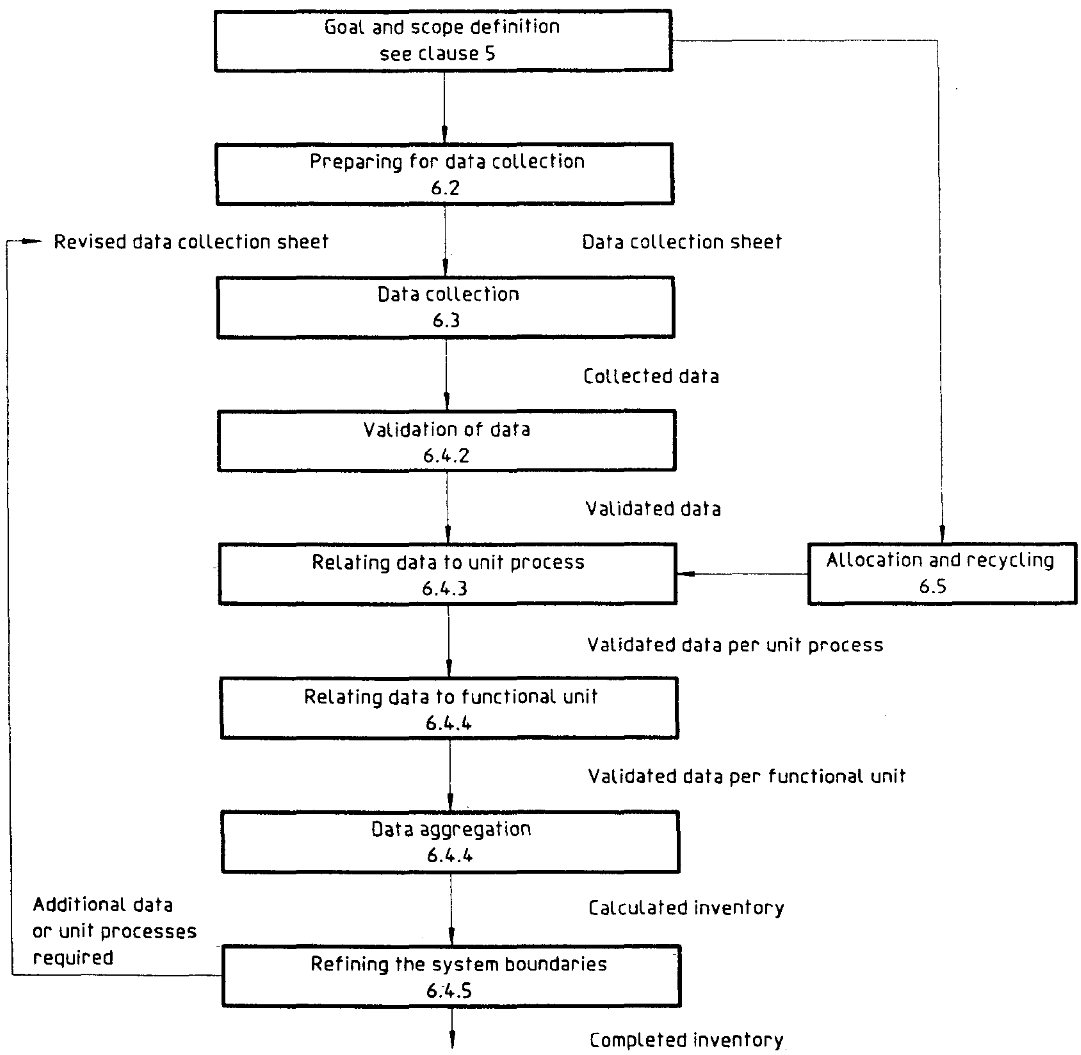

Figure 3 — Simplified procedures for inventory analysis
(some iterative steps are not shown)

6.2 Preparing for data collection

The definition of the scope of an LCA study establishes the initial set of the unit processes and associated data categories. Since data collection may span several reporting locations and published references, several steps are helpful to ensure uniform and consistent understanding of the product systems to be modelled.

These steps should include:

— drawing of specific process flow diagrams that outline all unit processes to be modelled, including interrelationships;

— description of each unit process in detail and listing of data categories associated with each unit process;

— development of a list that specifies the units of measurement;

— description of data collection techniques and calculation techniques for each data category, to assist personnel at the reporting locations to understand what information is needed for the LCA study; and

— provision of instructions to reporting locations to document clearly any special cases, irregularities or other items associated with the data provided.

An example of a data collection sheet is provided in annex A.

6.3 Data collection

The procedures used for data collection vary with each unit process in the different systems modelled by an LCA study. Procedures may also vary due to the composition and qualification of the participants in the study and the need to satisfy both proprietary and confidentiality requirements. Such procedures and reasons should be documented.

Data collection requires thorough knowledge about each unit process. To avoid double counting or gaps, a description of each unit process shall be recorded. This involves the quantitative and qualitative description of the inputs and outputs needed to determine where the process starts and ends, and the function of the unit process. Where the unit process has multiple inputs (e.g. multiple effluent streams into a water treatment plant) or multiple outputs, data relevant for allocation procedures shall be documented and reported. Energy inputs and outputs shall be quantified in energy units. Where applicable, the mass or volume of fuel should also be recorded.

When data are collected from published literature, the source shall be referenced. For those data collected from literature which are significant for the conclusions of the study, the published literature which supplies details about the relevant data collection process, the time when data have been collected and about further data quality indicators, shall be referenced. If such data do not meet the initial data quality requirements, this shall be stated.

6.4 Calculation procedures

6.4.1 General

Following the data collection, calculation procedures are needed to generate the results of the inventory of the defined system for each unit process and for the defined functional unit of the product system that is to be modelled.

When determining the elementary flows associated with production of electricity, account shall be taken of the production mix and the efficiencies of combustion, conversion, transmission and distribution. The assumptions made shall be clearly stated and justified. Whenever possible, the actual production mix should be used in order to reflect the various types of fuel that are consumed.

Inputs and outputs related to a combustible material, e.g. oil, gas or coal, can be transformed into an energy input or output by multiplying it by the relevant heat of combustion. In this case it shall be reported if the higher heating value or the lower heating value is used. The same calculation procedure should be consistently applied throughout the study.

Several operational steps are needed for data calculation. These are described in 6.4.2 to 6.4.5 and 6.5 below. All calculation procedures shall be explicitly documented.

6.4.2 Validation of data

A check on data validity shall be conducted during the process of data collection. Validation may involve establishing, for example, mass balances, energy balances and/or comparative analyses of emission factors. Obvious anomalies in the data appearing from such validation procedures require alternative data values which comply with the data quality requirements as established according to 5.3.6.

For each data category and for each reporting location where missing data are identified, the treatment of the missing data and data gaps should result in:

— a "non-zero" data value which is justified;

— a "zero" data value if justified; or

— a calculated value based on the reported values from unit processes employing similar technology.

The treatment of missing data shall be documented.

6.4.3 Relating data to unit process

For each unit process, an appropriate reference flow shall be determined (e.g. 1 kg of material or 1 MJ of energy). The quantitative input and output data of the unit process shall be calculated in relation to this reference flow.

6.4.4 Relating data to functional unit and data aggregation

Based on the flow chart and system boundaries, unit processes are interconnected to allow calculations on the complete system. This is accomplished by normalizing the flows of all unit processes in the system to the functional unit. The calculation should result in all system input and output data being referenced to the functional unit.

Care should be taken when aggregating the inputs and outputs in the product system. The level of aggregation should be sufficient to satisfy the goal of the study. Data categories should only be aggregated if they are related to equivalent substances and to similar environmental impacts. If more detailed aggregation rules are required, they should be justified in the goal-and-scope-definition phase of the study or should be left to a subsequent impact-assessment phase.

6.4.5 Refining the system boundaries

Reflecting the iterative nature of LCA, decisions regarding the data to be included shall be based on a sensitivity analysis to determine their significance, thereby verifying the initial analysis outlined in 5.3.5. The initial product system boundaries shall be revised as appropriate in accordance with the cut-off criteria established in the scope definition. The sensitivity analysis may result in:

— exclusion of life cycle stages or unit processes when lack of significance can be shown by the sensitivity analysis;

— exclusion of inputs and outputs which lack significance to the results of the study;

— inclusion of new unit processes, inputs and outputs that are shown to be significant in the sensitivity analysis.

The results of this refining process and the sensitivity analysis shall be documented. This analysis serves to limit the subsequent data handling to those input and output data which are determined to be significant to the goal of the LCA study.

6.5 Allocation of flows and releases

6.5.1 General

Life cycle inventory analysis relies on being able to link unit processes within a product system by simple material or energy flows. In practice, few industrial processes yield a single output or are based on a linearity of raw materials inputs and outputs. In fact, most industrial processes yield more than one product, and they recycle intermediate or discarded products as raw materials. Therefore, the materials and energy flows as well as associated environmental releases shall be allocated to the different products according to clearly stated procedures.

6.5.2 Allocation principles

The inventory is based on material balances between input and output. Allocation procedures should therefore approximate as much as possible such fundamental input-output relationships and characteristics. The following principles are applicable to coproducts, internal energy allocation, services (e.g. transport, waste treatment), and to recycling, either open- or closed-loop:

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

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

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

The allocation procedure used for each unit process of which the inputs and outputs are allocated shall be documented and justified.

6.5.3 Allocation procedure

On the basis of the principles mentioned above, the following stepwise procedure[2)] shall be applied.

a) **Step 1**: Wherever possible, allocation should be avoided by:

  1) dividing the unit process to be allocated into two or more subprocesses and collecting the input and output data related to these subprocesses;

  2) expanding the product system to include the additional functions related to the coproducts, taking into account the requirements of 5.3.2.

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

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

Some outputs may be partly coproducts and partly waste. In such cases, it is necessary to identify the ratio between coproducts and waste since the inputs and outputs shall be allocated to the coproducts part only.

Allocation procedures shall be uniformly applied to similar inputs and outputs of the system under consideration. For example, if allocation is made to usable products (e.g. intermediate or discarded products) leaving the system, then the allocation procedure shall be similar to the allocation procedure used for such products entering the system.

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2) Formally, Step 1 is not part of the allocation procedure.

6.5.4 Allocation procedures for reuse and recycling

The allocation principles and procedures in 6.5.2 and 6.5.3 also apply to reuse and recycling situations. However, these situations require additional elaboration for the following reasons:

a) reuse and recycling (as well as composting, energy recovery and other processes which can be assimilated to reuse/recycling) may imply that the inputs and outputs associated with unit processes for extraction and processing of raw materials and final disposal of products are to be shared by more than one product system;

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

c) specific care is needed for system boundaries definition regarding recovery processes.

Several allocation procedures are applicable for reuse and recycling. Changes in the inherent properties of materials shall be taken into account. Some procedures are outlined conceptually in Figure 4 and are distinguished in the following to illustrate how the above constraints can be addressed:

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

— an open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties. The allocation procedures for the shared unit processes mentioned in 6.5.3 should use, as the basis for allocation:

  — physical properties;

  — economic value (e.g. scrap value in relation to primary value); or

  — the number of subsequent uses of the recycled material (see ISO/TR 14049, in preparation).

In addition, particularly for the recovery processes between the original and subsequent product system, the system boundaries shall be identified and justified, ensuring that the allocation principles are observed as described in 6.5.2.

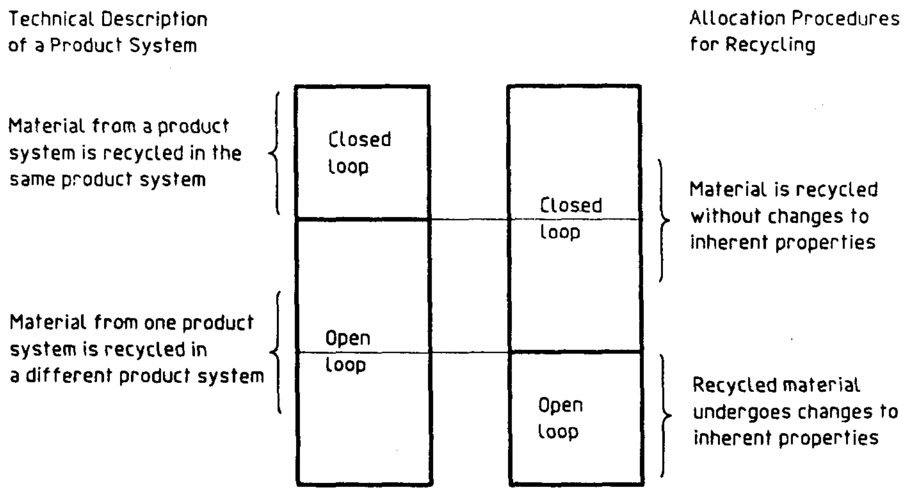

Figure 4 — Distinction between a technical description of a product system and allocation procedures for recycling

7 Limitation of LCI (interpreting LCI results)

The results of the LCI shall be interpreted according to the goal and scope of the study. The interpretation shall include a data quality assessment and sensitivity analyses on significant inputs, outputs and methodological choices in order to understand the uncertainty of the results. The interpretation of an inventory analysis shall also consider the following in relation to the goal of the study:

a) whether the definitions of the system functions and the functional unit are appropriate;

b) whether the definitions of the system boundaries are appropriate;

c) limitations identified by the data quality assessment and the sensitivity analysis.

The results should be interpreted with caution because they refer to input and output data and not to environmental impacts. In particular, an LCI study alone shall not be the basis for comparisons.

In addition, uncertainty is introduced into the results of an LCI due to the cumulative effects of input uncertainties and data variability. Uncertainty analysis as applied to LCI is a technique in its infancy. Nevertheless it would help to characterize uncertainty in results using ranges and/or probability distributions to determine uncertainty in LCI results and conclusions. Whenever feasible, such analysis should be performed to better explain and support the LCI conclusions.

The data quality assessment, sensitivity analyses, conclusions and any recommendations from the LCI results shall be documented. The conclusions and recommendations shall be consistent with findings from the above mentioned considerations.

8 Study report

The results of an LCI study shall be fairly, completely and accurately reported to the intended audience as described by the relevant parts of clause 6 of ISO 14040:1997. If a third-party report is required, it shall cover all items marked with an asterisk. All additional items should be considered.

a) Goal of the study:

   1) reasons for carrying out the study*;

   2) its intended applications*;

   3) the target audiences*.

b) Scope of the study:

   1) modifications together with their justification;

   2) function:

      i) statement of performance characteristics*;

      ii) any omission of additional functions in comparisons*;

   3) functional unit:

      i) consistency with goal and scope*;

      ii) definition*;

      iii) result of performance measurement*;

4) system boundaries:

    i) inputs and outputs of the system as elementary flows;

    ii) decision criteria;

    iii) omissions of life cycle stages, processes or data needs*;

    iv) initial description of the unit processes;

    v) decision about allocation;

5) data categories:

    i) decision about data categories;

    ii) details about individual data categories;

    iii) quantification of energy inputs and outputs*;

    iv) assumptions about electricity production*;

    v) combustion heat*;

    vi) inclusion of fugitive emissions;

6) criteria for initial inclusion of inputs and outputs:

    i) description of criteria and assumption*;

    ii) effect of selection on results*;

    iii) inclusion of mass, energy and environmental criteria (comparisons*);

7) data quality requirements.

c) Inventory analysis:

1) procedures for data collection;

2) qualitative and quantitative description of unit processes*;

3) source of published literature*;

4) calculation procedures*;

5) validation of data:

    i) data quality assessment*;

    ii) treatment of missing data*;

6) sensitivity analysis for refining the system boundaries*;

7) allocation principles and procedures:

    i) documentation and justification of allocation procedure*;

    ii) uniform application of allocation procedure*.

d) Limitations of LCI:

   1) data quality assessment and sensitivity analysis;

   2) the system functions and functional unit(s);

   3) the system boundaries;

   4) uncertainty analysis;

   5) limitations identified by the data quality assessment and sensitivity analysis;

   6) conclusions and recommendations.

Annex A
(informative)

Examples of a data collection sheet

A.1 General

The data input sheets found on the following pages are examples which can be used as guidelines. The purpose is to illustrate the nature of the information which can be collected from a reporting location for a unit process.

Care and attention should be given to the selection of data categories used on the sheets. The data categories and the level of specification need to be consistent with the goal of the study. As such, the examples of data categories shown on the following pages are strictly illustrative. Some studies require highly specified data categories and, for example, would use specific compounds to inventory the emissions to land as opposed to the more generic data categories shown here.

These sample sheets may also be accompanied by specific instructions on collecting the data and completing the input sheets. Questions regarding the inputs may also be included to help further characterize the nature of the inputs as well as the manner in which the amounts reported were derived.

The sample sheets can be modified by adding columns for other factors, e.g. quality of data (uncertainty, measured/calculated/estimated).

A.2 Example of data sheet for upstream transportation

In this example, the names and tonnages of the intermediate products for which transportation data are required are already recorded in the model of the system to be studied. It is assumed that the transportation mode between the two concerned unit processes is road transport. Equivalent data sheets should be used for rail or water transport.

Name of intermediate product	**Road transport**			
	Distance km	**Truck capacity** tonnes	**Actual load** tonnes	**Empty return** (Yes/No)

The consumption of fuel and the related air emissions are calculated using a transportation model.

A.3 Example of data sheet for internal transportation

In this example, internal transportation in a plant is inventoried. The values are collected for a specific period of time and show the actual amounts of fuel used. Additional columns in the data sheet will be required if minimum and maximum values from different time periods are required.

Internal transportation raises allocation issues, as does total electricity consumption for a site, for instance.

Air emissions are calculated using a fuel consumption model.

	Total amount of input transported	Total consumption of fuel
Diesel oil		
Gasoline		
LPG[a]		

[a] Liquified Petroleum Gas.

A.4 Example of data sheet for unit process

<table>
<tr><td>Completed by:</td><td colspan="4">Date of completion:</td></tr>
<tr><td>Unit process identification:</td><td colspan="4">Reporting location:</td></tr>
<tr><td>Time Period: Year</td><td colspan="2">Starting month:</td><td colspan="2">Ending month:</td></tr>
<tr><td colspan="5">Description of unit process: (attach additional sheet if required)</td></tr>
<tr><td>Material inputs</td><td>Units</td><td>Quantity</td><td>Description of sampling procedures</td><td>Origin</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Water consumption[a]</td><td>Units</td><td>Quantity</td><td colspan="2" rowspan="3"></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Energy inputs[b]</td><td>Units</td><td>Quantity</td><td>Description of sampling procedures</td><td>Origin</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Material outputs
(including products)</td><td>Units</td><td>Quantity</td><td>Description of sampling procedures</td><td>Destination</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">NOTE The data in this data collection sheet refer to all unallocated inputs and outputs during the specified time period.</td></tr>
</table>

[a] For example surface water, drinking water, etc.

[b] For example heavy fuel oil, medium fuel oil, light fuel oil, kerosene, gasoline, natural gas, propane, coal, biomass, grid electricity, etc.

A.5 Life Cycle Inventory Analysis data collection sheet

Unit process identification:			Reporting location:
Emissions to air [a]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Emissions to water [b]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Emissions to land [c]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Other releases [d]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Describe any unique calculations, data collection, sampling, or variation from description of unit process functions (attach additional sheets if necessary).			

a For example, Cl_2, CO, CO_2, dust/particulate, F_2, H_2S, H_2SO_4, HCl, HF, N_2O, NH_3, NO_x, SO_x, Organics: hydrocarbons, PCB, dioxins, phenols; metals Hg, Pb, Cr, Fe, Zn, Ni, etc.

b For example, BOD, COD, acids as H^+, Cl^-, CN^-, detergent/oils, dissolved organics (please list compounds included in this data category), F^-, Fe ions, Hg, hydrocarbons (please list), Na^+, NH_4^+, NO_3, organochlorine (please list), other metals (please list), other N (please list), phenols, phosphate, SO_4, suspended solids, etc.

c For example, mineral waste, mixed industrial, municipal solid waste, toxic wastes (please list compounds included in this data category).

d For example, noise, radiation, vibration, odour, waste heat, etc.

Annex B
(informative)

Examples of different allocation procedures

B.1 General

The examples in this annex illustrate the allocation procedures mentioned in 6.5.3. The examples are simplified and are constructed for illustrative purposes only.

B.2 Avoiding allocation

Wherever possible, allocation should be avoided or minimized. Two methods to achieve this are mentioned in 6.5.3.

a) Subdivide the process into subprocesses. Identify which are pure joint processes and which are only caused by one of the products. Only pure joint processes should be allocated.

EXAMPLE 1: Production of sodium hydroxide.

Sodium hydroxide is manufactured by the electrolysis of sodium chloride solution, unavoidably giving the coproduction of chlorine and hydrogen. The process is a fully joint process and allocation is necessary – but not *all* the subprocesses at the factory should be allocated between the coproducts. By dividing the processes at the factory into subprocesses it is possible to identify processes that relate to one of the coproducts only, e.g. the compression installation for pumping chlorine into pressurized storage tanks. The compression installation is used by the chlorine only. Hence, it is not possible to allocate the process at the factory as an overall process. Subdivision and identification of the pure joint processes is necessary.

Internal transport processes of the coproducts at the factory and material-handling processes will often be attributed to one of the coproducts only.

EXAMPLE 2: Coproduction of flour, husk, germ and bran.

The production of flour is illustrated in Figure B.1. At a mill, the grain is ground into flour and the coproducts are husk, germ and bran. Husk, germ and bran are mainly used as fodder for animals. The grinding process is only necessary for the flour production. Hence, the milling process should be included under the flour production only. The previous processes (planting, fertilizing and production of fertilizer, harvesting, drying of grain, etc.) are necessary for all the products and shall be allocated among all of them.

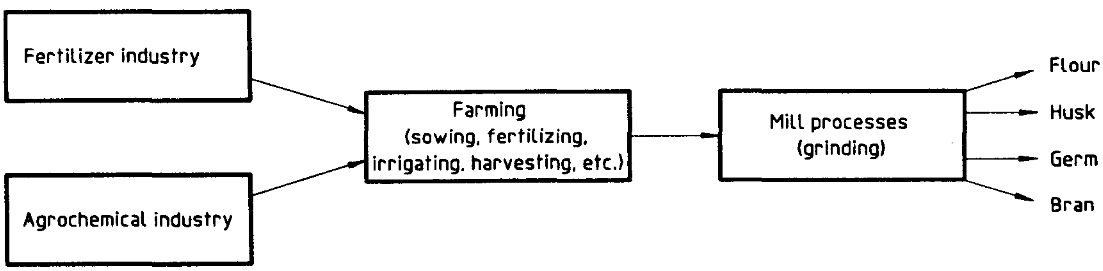

Figure B.1 — Production of flour, husk, germ and bran

b) Include further processes and thereby expand the system boundaries, thus avoiding allocation. Expansion of the system boundaries requires that:

— the object of the study is a *change*, i.e. a comparison between two alternative scenarios for the same product;

- the nature and extent of the change that will actually occur, as a consequence of the decision which the LCA is to support, can be predicted with a fair degree of certainty; and
- data are available for the joint systems in question.

The questions should be asked: How would this service be performed if it was not performed by the system? If the service was not performed, was would the long-term marginal effects be?

EXAMPLE 3: Utilizing the energy from waste incineration.

One of the widely used examples of avoiding allocation by expanding the system boundaries is when utilizing the energy output from waste incineration as an input to another product system.

The allocation problem arises because the investigated product system has two outputs: the product or service investigated (A) and the energy output from the incineration (B). This allocation problem is often solved by expanding the system boundaries, as illustrated in Figure B.2.

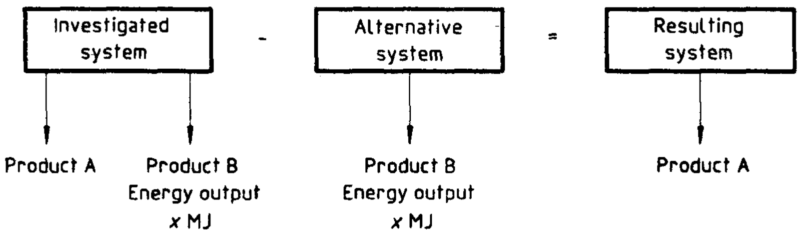

Figure B.2 — Expanding system boundaries for waste incineration

The method of avoiding allocation by expanding the system boundaries is only applicable when the alternative method is known. Assumptions about what is actually replaced by the output of the alternative system shall be well documented. If the conditions cannot be met, the procedure of system expansion is not applicable and allocation will be required.

B.3 Allocation by physical relationships

EXAMPLE 1: Cadmium in waste incineration.

In waste incineration a lot of products are treated together. The outputs (e.g. air emissions) have to be allocated between these products — but not all the outputs. It is obvious that the disposed products that contain cadmium are the waste that causes the cadmium emissions. Hence, the cadmium emissions should only be included under cadmium containing products.

EXAMPLE 2: Transport.

When a lorry is loaded, the maximum load limit can be reached for two reasons: either because the lorry is only permitted to drive with x ton of goods or because there is no more space. Transport of goods with a high density (e.g. metals) will often reach the weight limit, while transport of goods with a low density (e.g. new, empty plastic bottles) reaches the volume limit.

When transporting two products on the same lorry, allocation of the inputs and outputs (e.g. energy consumption and emissions) between the two products is necessary. Identification of the *cause* of the limit is necessary: What is the reason for not loading any more goods on the lorry? Transport of steel and copper together — the reason is probably weight, and the allocation should be based on mass. Transport of different empty packagings — the reason is probably volume, hence the allocation should be based on density of the packagings. In both cases physical allocation is used.

EXAMPLE 3: Lacquering of two different metal parts A and B.

Two different metal parts A and B are lacquered in the same paint line. The lacquer consumption, the energy inputs, and the emissions of volatile organic compounds (VOC), etc., are only known for the combined lacquering. The LCA study requires the relevant data for product A only.

In this case, allocation can be avoided by performing an experimental run where only product A is lacquered.

If there are technical or economic reasons why such a test run cannot take place, then allocation is necessary. Physical allocation is possible if the ratio between product A and product B can be varied without changing the inputs and outputs. If the ratio between A and B is changed without changing the sum of the masses of A and B this can result in different quantities of lacquer, hence mass allocation is not correct. If the ratio between A and B can be changed without changing the sum of the surfaces to be lacquered, then the inputs and outputs also will remain constant. Therefore, the surface to be lacquered can be considered as the correct physical parameter. The allocation factor can be calculated as the surface to be lacquered of all parts of A divided by the total surface to be lacquered of all parts (A plus B) which are lacquered in the same time period.

Actually, this identification of the causal relationships is not true allocation — it is rather an analysis of the system and the causes of the inputs and outputs.

Bibliography

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

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

[3] ISO/TR 14049, *Environmental management — Life cycle assessment — Examples for the application of ISO 14041.*

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