TECHNICAL REPORT

ISO/TR 14049

Second edition
2012-06-01

Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis

Management environnemental — Analyse du cycle de vie — Exemples illustrant l'application de l'ISO 14044 à la définition de l'objectif et du champ d'étude et à l'analyse de l'inventaire

Reference number
ISO/TR 14049:2012(E)

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Foreword

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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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 14049 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 5, *Life cycle assessment*.

This second edition cancels and replaces the first edition (ISO/TR 14049:2000), which has been technically revised.

Introduction

The heightened awareness of the importance of environmental protection, and the possible impacts associated with products manufactured and consumed, has increased the interest in the development of methods to better comprehend and reduce these impacts. One of the techniques being developed for this purpose is Life Cycle Assessment (LCA). To facilitate a harmonized approach, a family of standards on life cycle assessment (LCA), including ISO 14040, ISO 14044 and this Technical Report, is being developed by ISO. These International Standards describe principles of conducting and reporting LCA studies with certain minimal requirements.

This Technical Report provides supplemental information to ISO 14044:2006, based on several examples on key areas of ISO 14044 in order to enhance the understanding of the requirements of ISO 14044.

With respect to the various phases of LCA, methodological requirements for conducting LCA studies are provided in ISO 14040 and ISO 14044.

Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis

1 Scope

This Technical Report provides examples about practices in carrying out a life cycle inventory analysis (LCI) as a means of satisfying certain provisions of ISO 14044:2006. These examples are only a sample of the possible cases satisfying the provisions of ISO 14044. They offer "a way" or "ways" rather than the "unique way" for the application of ISO 14044. These examples reflect only portions of a complete LCI study.

2 General

The examples focus on six key areas of ISO 14044:2006 as indicated in Table 1.

In some key areas there is more than one example. The reason is that in many cases more than one practice exists. The decision about the application of one or the other practices is goal dependent and can vary e.g. from the product system under investigation or in the stages over the life cycle. The examples are described in the context of the corresponding provisions of ISO 14044 and with the specific use.

In the description of the different cases, whenever possible, the following structure has been adopted:

— context of ISO 14044;

— overview;

— description of the examples.

Table 1 — Cross references between ISO 14044:2006 and examples in this Technical Report

ISO 14044:2006	Examples in this Technical Report
0 Introduction	
1 Scope	
2 Normative reference	
3 Terms and definitions	
4 Methodological framework for LCA	
4.1 General requirements	
4.2 Goal and scope definition	
4.2.1 General	
4.2.2 Goal of the study	
4.2.3 Scope of the study	
4.2.3.1 General	
4.2.3.2 Function and functional unit	3 Examples of developing functions, functional units and reference flows 4 Examples of distinguishing functions of comparative systems
4.2.3.3 System boundary	5 Examples of establishing the inputs, outputs and boundary of unit process 10 Examples of performing sensitivity analysis
4.2.3.4 LCIA methodology and types of impacts	
4.2.3.5 Types and sources of data	5 Examples of establishing the inputs, outputs and boundary of unit process
4.2.3.6 Data quality requirements	9 Examples of conducting data quality assessment
4.2.3.7 Comparisons between systems	4 Examples of distinguishing functions of comparative systems
4.2.3.8 Critical review considerations	
4.3 Life cycle inventory analysis (LCI)	
4.3.1 General	
4.3.2 Collecting data	
4.3.3 Calculating data	
4.3.3.1 General	
4.3.3.2 Validation of data	9 Examples of conducting data quality assessment
4.3.3.3 Relating to unit process and functional unit	3 Examples of developing functions, functional units and reference flows
4.3.3.4 Refining the system boundary	10 Examples of performing sensitivity analysis
4.3.4 Allocation	
4.3.4.1 General	6 Examples of avoiding allocation
4.3.4.2 Allocation procedure	7 Examples of applying allocation
4.3.4.3 Allocation procedures for reuse and recycling	8 Examples of applying allocation procedures for recycling
4.4 Life cycle impact assessment (LCIA)	
4.5 Life cycle interpretation	
5 Reporting	
5.1 General requirements and considerations	
5.2 Additional requirements and guidance for third-party reports	
5.3 Further reporting requirements for comparative assertion intended to be disclosed to the public	
6 Critical review	
6.1 General	
6.2 Critical review by internal or external expert	
6.3 Critical review by panel or interested parties	
Annex A (informative)	Example of a data collection sheets
Annex B (informative)	Examples of life cycle interpretation

3 Examples of developing functions, functional units and reference flows

3.1 Context of ISO 14044

ISO 14044:2006, 4.2.3.2, states:

"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."

ISO 14044:2006, 4.2.3.3, states:

"*An appropriate flow shall be determined for each unit process. The quantitative input and output data of the unit process shall be calculated in relation to this flow. Based on the flow chart and the flows between unit processes, the flows of all unit processes are related to the reference flow. The calculation should result in all system input and output data being referenced to the functional unit".*

3.2 Overview

In defining a functional unit and determining the reference flows, the following steps can be distinguished:

— identification of functions;

— selection of functions and definition of functional unit;

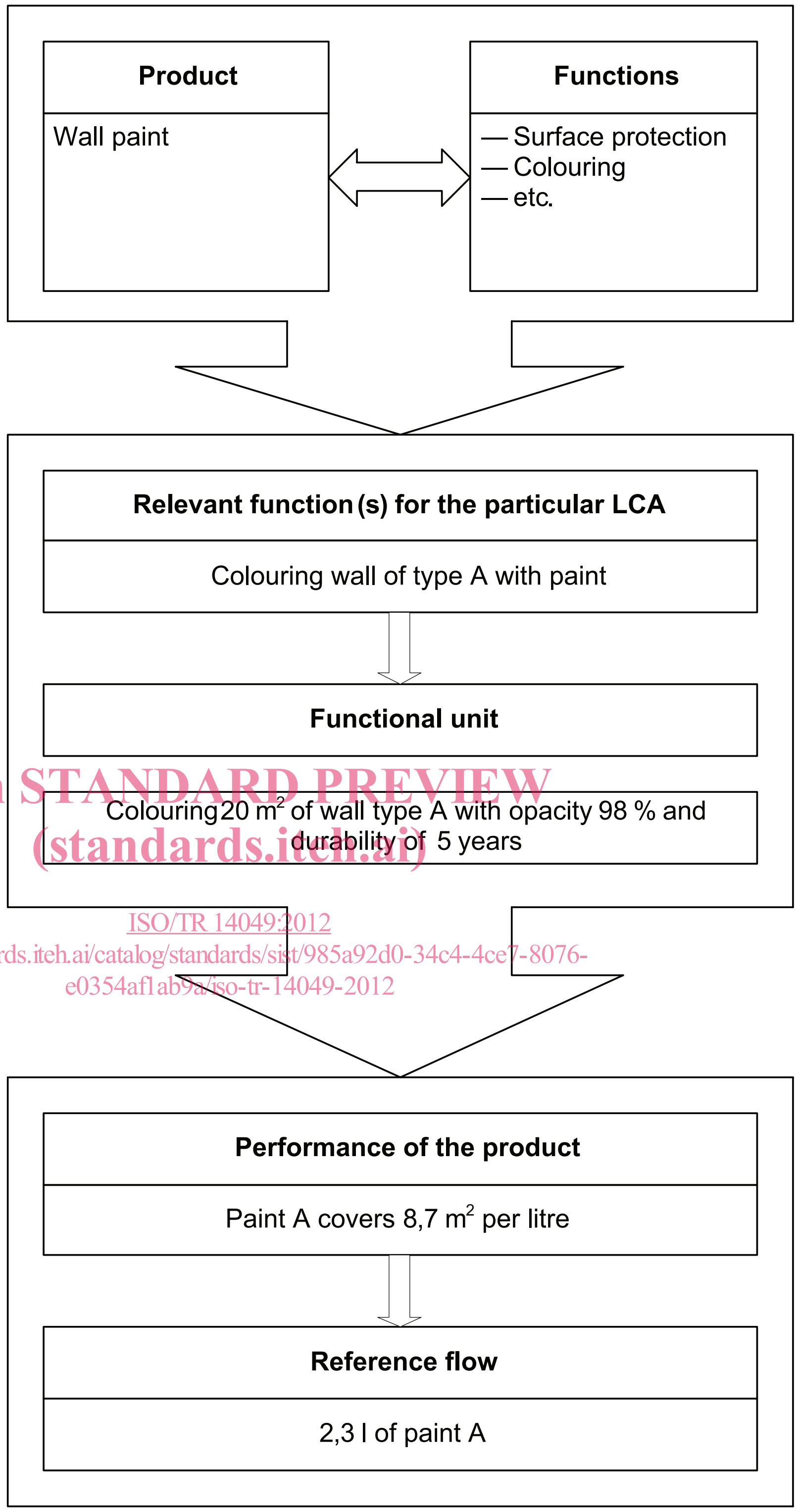
— identification of performance of the product and determination of the reference flow.

The sequence of these steps is depicted in Figure 1 using the example of paint. This example is also used in the following text (3.3 to 3.5). Further examples are given in 3.6.

3.3
Identification of functions

3.4
Selection of functions and definition of functional unit

3.5
Identification of performance of the product and determination of the reference flow



NOTE It is possible to start with either the product or with the function itself.

Figure 1 — Overview of the example

3.3 Identification of functions

The purpose of the functional unit is to quantify the service delivered by the product system. The first step is thus to identify the purpose served by the product system, i.e. its function or functions.

The starting point for this procedure may be a specific product to be studied (e.g. wall paint) or it may be the final need or goal, which in some cases may be fulfilled by several distinct products (e.g. wall decoration, which may be fulfilled by both paint and wallpaper or a combination of these).

The functions are typically related to specific product or process properties, each of which may:

— fulfil specific needs and thereby have a use value, which typically creates economic value to the supplier of the product;

— affect the functioning of other economic systems (e.g. wallpaper may have a - small - insulation effect, thus affecting the heat requirement of the building).

3.4 Selection of functions and definition of functional unit

Not all functions may be relevant for a particular LCA. Thus, out of all the possible functions, the relevant ones are identified.

For a solid interior wall, for example, surface protection may be unnecessary, while colouring is a relevant function of paint.

Subsequently, the relevant functions are quantified in the functional unit, which may be expressed as a combination of different parameters.

For wall colouring, the functional unit typically needs to specify the area to be covered (e.g. 20 m^2), the type of wall (especially regarding its absorption and binding properties), the ability of the paint to hide the underlying surface (e.g. 98 % opacity), and its useful life (e.g. 5 years).

In the case of multifunctional units, the different quantities are sometimes linked, e.g. a wall covering insulation material may be available with a pre-coloured surface, which makes colouring unnecessary, thus delivering both insulation and colouring. The functional unit could then be:

> "20 m^2 wall covering with a heat resistance of 2 m·K/W, with a coloured surface of 98 % opacity, not requiring any other colouring for 5 years."

Other examples of multifunctional units are given in Table 2.

Table 2 — Examples of functional units for systems with multiple functions

Example No.	**(1)**	**(2)**
System	**Paper recycling**	**Cogeneration**
Functions	— Recovery of waste paper, and — Production of de-inked pulp — etc.	— Generation of electric power, and — Production of steam — etc.
Selected function for a particular LCA	— Recovery of waste paper, or — Production of de-inked pulp	— Generation of electric power, or — Production of steam
Functional unit	— Recovery of 1 000 kg waste paper, or — Production of 1 000 kg pulp for newsprint	— Generation of 100 MW electricity, or — Production of 300 000 kg steam per hour at 125 °C and 0,3 MPa (3 bar)

3.5 Identification of performance of the product and determination of the reference flow

Having defined a certain functional unit, the next task is to determine the quantity of product which is necessary to fulfil the function quantified by the functional unit. This reference flow is related to the product's performance, and is typically determined as the result of a standardized measurement method. Of course, the nature of this measurement and calculation depends on the studied product.

For paint, the reference flow is typically expressed as the amount of litres necessary for covering the surface area as defined by the functional unit. For example, in a standardized test, paint A may be determined to cover 8,7 m^2 per litre (i.e. the performance of the product). Using the example illustrated in Figure 1, this requires 2,3 l to cover the 20 m^2 of the functional unit, provided that the conditions in the standardized test are similar to those required by the functional unit (with regard to surface type and opacity).

The functional unit may already be expressed in terms of quantities of products, so that the functional unit and the reference flow are identical. Table 2 gives examples of such functional units, which are already expressed in terms of quantities of products.

3.6 Additional examples

The following three examples in Table 3 further illustrate the procedure in developing functions, functional units, and reference flows.

Table 3 — Further examples of developing functions, functional units, and reference flows

Example No.	**(1)**	**(2)**	**(3)**
Product	Light bulb	Bottle	Hand drying
Functions	— Providing illumination — Generating heat — etc.	— Protection of beverage — Facilitating handling — Part of product image — etc.	— Drying hands — Removing bacteria — etc.
Selected function for a particular LCA	Providing illumination (outdoor lamp only)	Protection of beverage	Drying hands (hygienic function judged irrelevant)
Functional unit	300 lx in 50 000 h matching the daylight spectrum at 5 600 K.	50 000 l of beverage protected between tapping and consumption	1 000 pairs of hands dried
Performance of the product	100 lx with a lifetime of 10 000 h	0,5 l one-way bottle	One paper towel for drying one hand
Reference flow	15 daylight bulbs of 100 lx with a lifetime of 10 000 hours	100 000 one-way bottles of volume 0,5 l	2 000 paper towels

4 Examples of distinguishing functions of comparative systems

4.1 Context of ISO 14044

ISO 14044:2006, 4.2.3.2 and 4.2.3.7, addresses situations dealing with product systems with one or more functions and the requirement that comparisons of systems be done with the same functional unit.

ISO 14044:2006, 4.2.3.2, states:

"*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.*"

ISO 14044:2006, 4.2.3.7, states:

"In a comparative study, the equivalence of the systems being compared shall be evaluated before interpreting the results. Consequently, the scope of the study shall be defined in such a way that the systems can be compared. Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundary, data quality, allocation procedures, decision rules on evaluating inputs, and outputs and impact assessment. Any differences between systems regarding these parameters shall be identified and reported. If the study is intended to be used for a comparative assertion intended to be disclosed to the public, interested parties shall conduct this evaluation as a critical review."

4.2 Overview

When comparing product systems, special attention should be paid to confirm that the comparison is based on the same functional unit and equivalent methodological considerations, such as performance, system boundaries, data quality, allocation procedures, decision rules on evaluating inputs and outputs. In this clause, some possible approaches are described and illustrated by examples.

The general steps to be taken in comparative studies are illustrated in Figure 2.

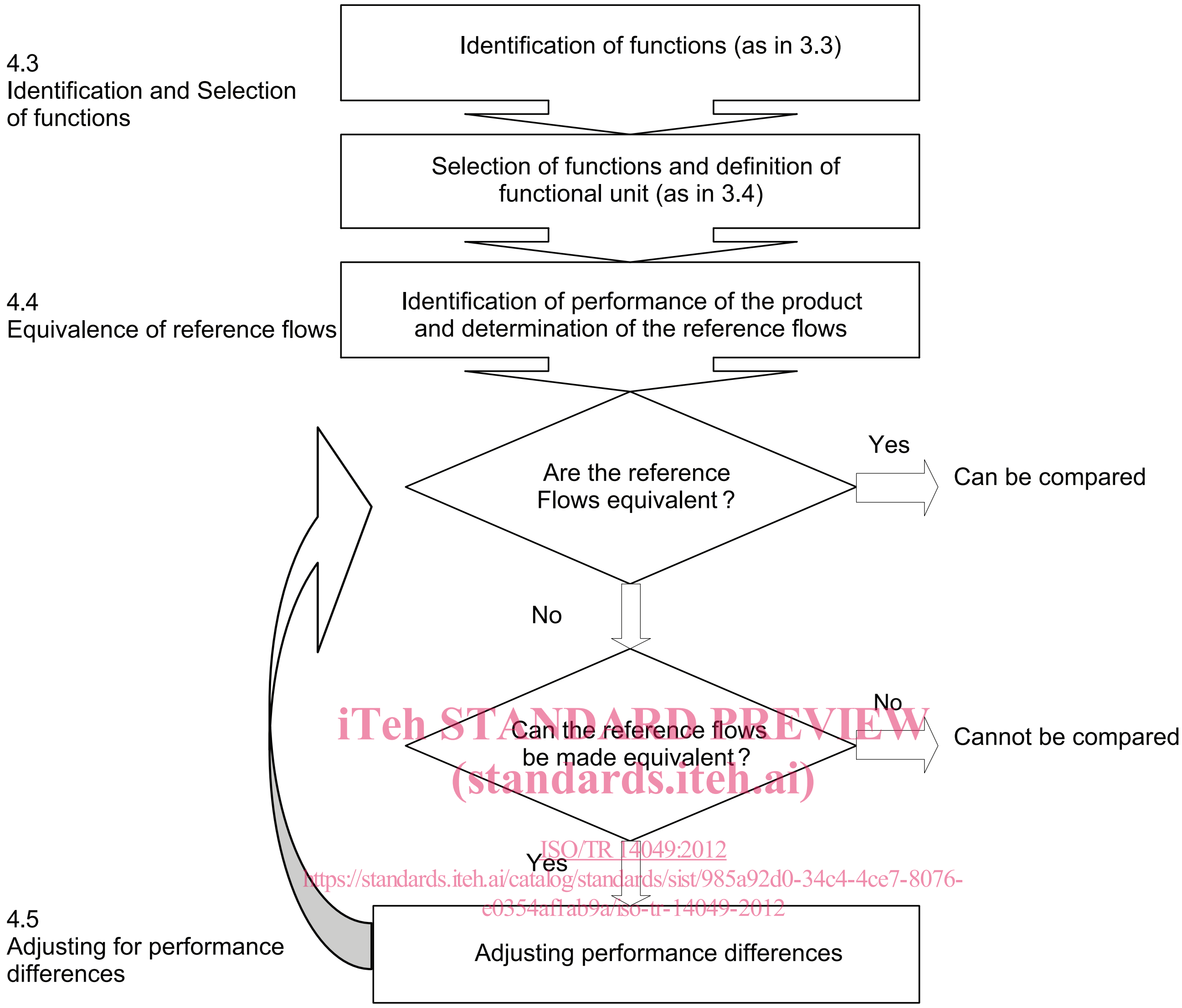


Figure 2 — Overview of the steps in comparative studies

4.3 Identification and selection of functions

The definition of the functional unit is closely bound to the goal of the study. If the goal is to compare product systems, special care should be paid to ensure that the comparison is valid, that any additional functions are identified and described, and that all relevant functions are taken into account.

EXAMPLE 1 A study on waste management should include other functions than simply disposing of waste (i.e. the functions performed by the recycling systems in providing recycled material or energy).

EXAMPLE 2 A study on electric household equipment should include the waste heat delivered to the building in which the equipment operates, as this influence the amount of heating and/or cooling required.

For comparative studies, the selection of functions becomes much more important than in non-comparative studies. Referring to the functions in Table 3:

— for bottles (example 2), leaving out of the image function of the packaging may lead to comparison of packaging that are technically similar (i.e. containing the same volume of beverage), but which the producer or customer will not accept as comparable;

— for hand-drying systems (example 3), leaving out the hygienic function may be regarded as unacceptable, e.g. in the food industry, where the bacteria-removing ability of paper towels may be regarded as such an advantage that a comparison to electrical hand-drying systems may not even be considered.

4.4 Equivalence of reference flows

The functional unit of the paint example from Clause 3 was "colouring 20 m^2 of wall type A with opacity 98 % and durability of 5 years". This functional unit can be supplied by several different reference functions:

— 2,3 l of paint A;

— 1,9 l of paint B;

— 1,7 l of paint C, etc.

These reference flows are calculated based on a test using standard conditions, concerning e.g. surface type and opacity.

The standardised test conditions and measurement methods should be appropriate to the intended comparison: In the hand drying example (example 3 in Table 3), it may be irrelevant to use a standardized test based on the technical properties of the paper such as mass, absorption-power and tensile strength, if the actual weight of paper used depends on the dispenser design. A more appropriate measure would then be data collected by weighing the paper stock at the start and the end of an adequate period in which the number of hands dried are determined by electronic surveillance of actual wash basins located in relevant institutions. Similarly, technical specifications of an electrical hand drier, such as the volume of air and its temperature, may be irrelevant as a basis for calculating the reference function, if the actual running time of the device is fixed by other factors, e.g. a built-in timer. Then, all that is needed is the running time and the electrical capacity of the equipment.

In the case of the light bulb (example 1 in Table 3), the functional unit of "300 lx in 50 000 h" may be provided by:

— 5 times 3 bulbs of 100 lx with a lifetime of 10 000 h each, or

— 10 times 2 bulbs of 150 lx with a lifetime of 5 000 h each.

The underlying premises of comparing 3 bulbs of 100 lx with 2 bulbs of 150 lx are:

— that the light spectrum of the two bulb types are comparable (or that the difference is acceptable to the user);

— that the 3 and 2 bulbs, respectively, can be placed so that the distribution of light is equal (or that the difference is acceptable to the user);

— that the sockets and other fixtures are not affected by the choice (in which case they would have to be included in the comparison).

Also, the two light bulbs were regarded as comparable in spite of their difference in lifetime. This difference is simply taken into account in the calculation of the reference flow. However, for long-lived products, such as refrigerators with lifetimes of 10 or 20 years, technology development may be a factor that cannot be disregarded. One refrigerator with a lifetime of 20 years cannot simply be compared to two successive, present-day refrigerators with a lifetime of 10 years. The refrigerators available 10 years from now are certain to be more energy efficient (i.e. lower energy input per functional unit) than the present, the energy efficiency of the second refrigerator of the 10 + 10 option is determined by a trend projection, while the energy efficiency of the 20 years option is fixed.