# Attributional and consequential interpretations of the ISO 14044

Bo P. Weidema, 2018-01-26

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*This document summarizes the state of the discussions in the ISO TC207/SC5/TG1 drafting groups before the TG1 and SC5 meeting in Berlin where further progress on these issues were halted. It is provided here for historical documentation only.*

*The motivation for raising the discussion was that in practice, the ISO 14040 and 14044 are used for different goals and scopes (as outlined in Annex A.1 of ISO 14040), including some that were not originally foreseen when drafting the standard text. This has led to two different approaches to LCA (as mentioned in Annex A.2 of ISO 14040), which especially diverge in their interpretation of the requirements of ISO 14044. That the same requirement can be interpreted in two ways, and that these interpretations are not always clearly linked to the goal and scope of the assessments, has lead to the proliferation of guidelines that seek to promote their own interpretation of ISO 14044, with consequent unfortunate controversies that hamper the intended application of the standards.*

**The following definitions were proposed as additions to the definitions of ISO 14044:**
Attributional approach: system modelling approach in which inputs and outputs are attributed to the functional unit of a product system by linking and/or partitioning the unit processes of the system according to a normative rule.

NOTE 1: This approach corresponds to what in ISO 14040 Annex A.2 is called “approach A”

NOTE 2: The attributional approach attempts to provide information on what portion of global burdens can be associated with a product (and its life cycle).

Consequential approach: system modelling approach in which activities in a product system are linked so that activities are included in the product system to the extent that they are expected to change as a consequence of a change in demand for the functional unit.

NOTE: This approach corresponds to what in ISO 14040 Annex A.2 is called “approach B”

[Internal note: These definitions have been taken directly from the UNEP/SETAC document: Sonnemann G, Vigon B (2011). Global Guidance Principles for Life Cycle Assessment Databases. Paris/Pensacola: UNEP/SETAC Life Cycle Initiative.]

**Proposal for addition to ISO 14044, clause 4.2 Goal and scope definition (suggested location: end of clause 4.2.1 General):**
The choice of the attributional or consequential approach of the LCA study shall be transparently stated in the goal and scope chapter of the LCA report. That choice [should/shall] be justified taking into account the goal of the study, and the justification [should/shall] be transparently stated in the LCA report.

**Proposal for a new INFORMATIVE ANNEX to ISO 14044:**

**Allocation procedures**

**1 General**

Allocation becomes relevant when processes within the product system under study have significant inputs from other product systems or significant outputs to other product systems. Such processes are termed multifunctional processes. This means that the environmental burdens of a multifunctional process need to be shared between the system under study and other systems.

**2 Identification of different allocation situations**

The stepwise procedure how to deal with multifunctional processes as provided in Clause 4.3.4.2 can be illustrated by Figure B1, which shows the steps to identify the most appropriate approach.

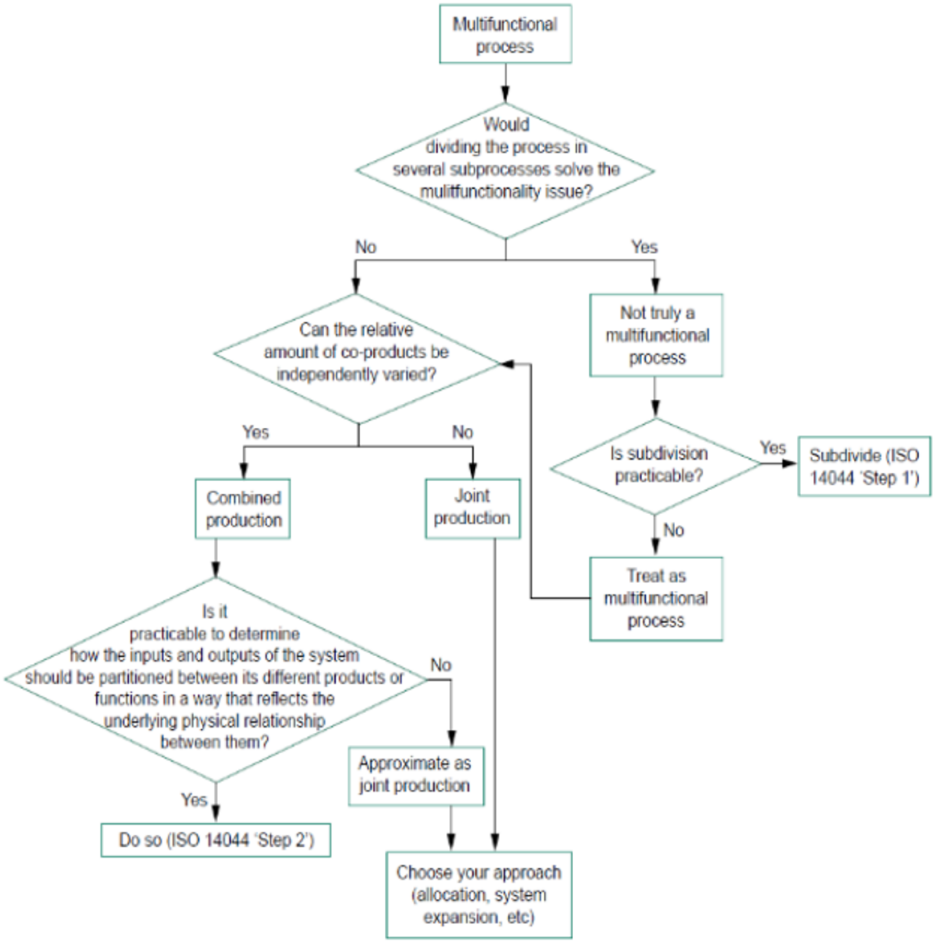


**Figure B1 Steps to identify the most appropriate allocation approach**

Three different situations can be discerned by the decision tree in Figure B1:

1) Situations where the multifunctional process can be sub-divided, so that each amount of input and output can be identified as belonging to specific sub-processes, which either belong completely to the system under study or are completely outside the system under study. In such situations, the specific sub-processes are no longer multifunctional, and allocation can be avoided, see 4.3.4.2, Step 1, point 1).
2) Situations of combined production, where the amount of one co-product can be changed independently of the amount of the other co-products. In such situations, it may be possible to identify the way in which the amounts of inputs and outputs are changed by the quantitative changes in each co-product, thus reflecting the underlying physical relationships between the inputs and outputs and the specific co-product. This corresponds to 4.3.4.2, Step 2
3) Situations of joint production, where the amount of co-products cannot be changed independently, i.e. their amounts are always produced in the same fixed proportion. In such situations, a physical relationship can therefore not

be established or used as the basis for allocation, and Step 1, point 1) and Step 2 of 4.3.4.2 cannot be applied.

### 3 Allocation approaches for joint production

In the situation of joint production, allocation often can be treated by calculating a credit based on the environmental benefit of the co-product which leaves the product system.

EXAMPLE: A multifunctional process includes fuel combustion and the combustion heat is used for district heating. In this case, the environmental benefit of district heating can be calculated because it avoids the use of a specific amount of natural gas for heating. The environmental burdens of the avoided natural gas can be subtracted from the environmental burdens of the multifunctional process.

When the quantification of the benefit of the co-product is not possible or practicable, allocation can be applied based on the market prices of the joint products, see 4.3.4.2, step 3.

EXAMPLE: The copper smelting process is a joint multifunctional process where $m_1$ of primary copper is produced together with a small quantity $m_2$ of gold. For the LCA of a copper cable only the environmental burdens of the smelting process related to copper has to be considered. For this purpose, these environmental burden are shared according to the market values of the copper fraction and the gold fraction i. e. according to the ratio $m_1p_1 : m_2p_2$, where $p_1$ and $p_2$ are the market prices per mass unit of copper and gold

When market prices are not available, the allocation factor can be determined by the LCA practitioner based on the ratio of estimated market values of the co-products.

### 4 Allocation procedures for recycling

For closed-loop recycling, see 4.3.4.3.3 a)

Open-loop end-of-life recycling can be considered as a process with the end-of-life product as product input and recycled material as product output, together with emissions and waste.

As in the situation of joint production, allocation often can be done by calculating a recycling credit based on the environmental benefit of the co-product, which leaves the product system. If a recycled material A typically displaces a primary material B, then the environmental burden of the acquisition of the primary material B (avoided burden) is taken into account as recycling credit. However, when a recycled material can displace a large number of different primary materials with different environmental burdens, this approach to apply allocation is not practicable.

As the recycling rate cannot be varied independently, physical allocation is not practicable. The number of cycles can only be determined in exceptional cases.

Therefore, market price allocation is the most frequently used option of those mentioned in 4.3.4.3.4.

When market prices are not available, the allocation factor can be determined by the LCA practitioner based on the ratio of estimated market values of primary material and recycled material.

When recycled material enters a product system, such recycled material carries an environmental burden if a recycling credit has previously been given to the product system where the recycled material comes from.

An example how to treat recycling for product carbon footprint studies is given in ISO 14067, Annex D. The approach, which is described there, can be applied for LCA studies, as well.

**Proposal for a new INFORMATIVE ANNEX to ISO 14044:**

**Applications of LCA**

**1 Introduction**

ISO 14040, Annex A clause A.2, states "*it is necessary to consider the decision-making context when defining the scope of an LCA i.e. the product systems studied should adequately address the products and processes affected by the intended application.*

*The examples of applications in ISO 14040 relate to decisions that aim for environmental improvements, which is also the overall focus of the ISO 14000 series. Therefore, the products and processes studied in an LCA are those affected by the decision that the LCA intends to support.*

*Some applications may not appear to immediately address improvements, such as LCA to be used for education or information about the product life cycle. However, as soon as such information is applied in practice, it is used in an improvement context. Therefore, special care is necessary to ensure that the information is applicable to the context in which it is likely to be applied.*

*Two possible different approaches to LCA have developed during the recent years. These are:*

*a) An approach which assigns elementary flows and potential environmental impacts to a specific product system typically as an account of the history of the product, and*

*b) An approach which studies the environmental consequences of possible (future) changes between alternative product systems."*

Approach a) corresponds to the attributional approach, and approach b) to the consequential approach.

This annex aims at clarifying how the requirements of this standard (ISO 14044) should be interpreted when applying each of the two approaches.

## 2 Attributional approach

### 2.1 System boundary in Attributional LCA

In practice, the product system is identified starting from the unit process(es) of the reference flow, tracing each cost item input to the next upstream unit process. The cost for one (purchasing) activity, is a revenue for the supplying activity. For each activity, a part of the revenue leaks out as wages, taxes, rents and profits (together known as “value added”). In a closed steady-state system, all the original revenue must eventually leave the system as value added, thus providing a clear delimitation of the activities included in the system.

### 2.2 Allocation of joint products [as defined by drafting group on allocation] in Attributional LCA

Attributional LCA implies that the stepwise allocation procedure of clause 4.3.4.2 (of ISO 14044), Step 1, point 2) is only relevant for expanding the system by adding functions related to the co-products to the functional unit and adding the related processes to the product system. Substitutions, illustrated in Figure 2, are only made in situations of closed-loop recycling.

For all other allocations of joint production, only Step 3 remains as an option. Since an underlying physical relationship between the inputs and outputs and the specific co-products cannot be established or used as the basis for allocation, the inputs and outputs should, as described in ISO 14044, “be allocated between the products and functions in a way that reflects other relationships between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.” Economic value of the products, i.e. the revenue that each product generates for the process to be allocated, is the only “other relationship” that is mentioned in ISO 14044, and any application of another relationship than economic value should therefore be specifically justified in the goal and scope.

Unless there is complete proportionality between the physical properties and the economic value for the joint products, the resulting systems will not be physically balanced. In general, a cost or revenue based product system will therefore not reflect the physical causalities of purchasing a product.

### 2.3 Application areas for the Attributional approach

This approach is relevant when the goal of the LCA is to account for the product system as described in clause 2.1 and 2.2 (of this annex), as in:

- environmental management accounting including analysis of significant environmental aspects in the product system as described above,
- management of the value chain or product system, as described above, and
- other applications where it is required to trace the value added of a product property backwards in the product system as described above.

## 3 Consequential approach

### 3.1 System boundaries in Consequential LCA

Consequential LCA seeks to model the potential environmental consequences of changes resulting from a (potential) decision. This implies modelling marginal changes when the studied changes are small, and incremental changes when the changes are larger, as opposed to the average modelling implied in Attributional LCA. For both marginal and incremental modelling ISO 14049, clause 6.4 applies: "The supplementary processes to be added to the systems must be those that would actually be involved when switching between the analysed systems. To identify this, it is necessary to know:

- whether the production volume of the studied product systems fluctuate in time (in which case different sub-markets with their technologies may be relevant), or the production volume is constant (in which case the base-load marginal is applicable),

- whether (…) the inputs are delivered through an open market, in which case it is also necessary to know:

    - whether any of the processes or technologies supplying the market are constrained (in which case they are not applicable, since their output will not change in spite of changes in demand),

    - which of the unconstrained suppliers/technologies has the highest or lowest production costs and consequently is the marginal supplier/ technology when the demand for the supplementary product is generally decreasing or increasing, respectively."

In practice, a product system is identified starting from the unit process(es) of the reference flow, tracing each required product input, physical or monetary, through the marginal supplier(s) of each product. In parallel to in the attributional product system (clause 2.1), the revenue generated by the original demand must eventually leave the product system as value added, thus providing a clear delimitation of the activities included in the product system. The activities included are limited to those that react to the change in revenue, corresponding to the first-order effects of the original spending. Implicitly, when comparing products with different prices, a consequential model will include first-order price rebound effect, while excluding second order (multiplier) effects, such as changes in consumption patterns that may result from the redistribution of the initial spending on the population groups that receive the primary factor income, or second order effects of stimulating specific activities, such as education, research and technological development, unless specifically stated in the goal and scope.

NOTE: The marginal suppliers/technologies can be divided in those that in response to a change in demand for the product will change their production output immediately or within the short-term (i.e. within the current production capacity), and those that in response to an *accumulated* change in demand for the product will change their production *capacity* in the long-term. The impacts from the long-term changes in capacity will typically by far dominate the sum of the short-term and long-term changes.

### 3.2 Allocation of joint products in Consequential LCA

Consequential LCA implies that in the stepwise allocation procedure of clause 4.3.4.2 (of ISO 14044), Steps 2 and 3 are not relevant for joint products, since allocation of joint products can in all cases be avoided by Step 1, point 1) or 2).

Step 1, point 2) in the stepwise procedure for allocation provided in Clause 4.3.4.2 of ISO 14044 is described as an expansion of the product system to include the additional functions related to the co-products. The system expansion is done by including the system that is substituted (avoided) by the dependent co-product, as illustrated by the example in Figure 2. Since the substituted system has a negative sign, the addition of this system is mathematically the same as a subtraction. There are also additional examples of this in Figure 15 and 16 in ISO 14049.

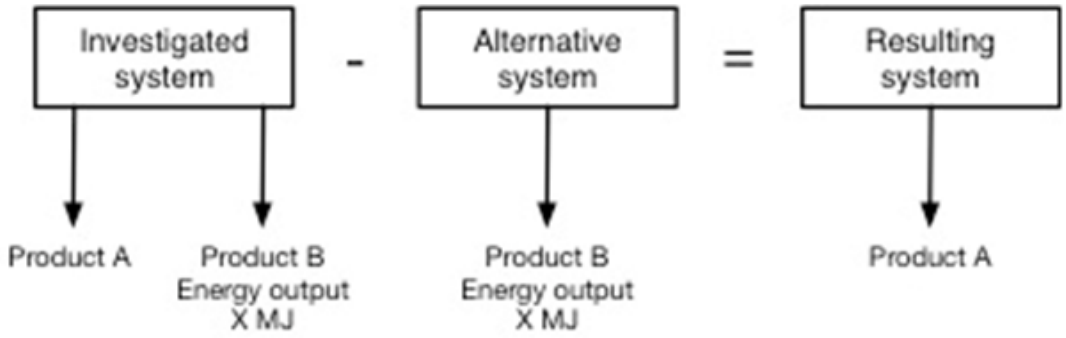


*Figure 2 [Figure B.2 from ISO 14041:1998 (withdrawn)]. Avoiding allocation when the investigated product system has two outputs: the determining product investigated (A) and the dependent product (B), here an energy product. The system boundaries for the investigated system are expanded with the other alternative product system that supplies the energy as a stand-alone output.*

### 3.3 Application areas for consequential LCA

Consequential LCA is relevant when the goal of the LCA is to support decisions that aim for environmental improvements, such as:

- identification of significant environmental aspects of products for improvement (ISO 14001, ISO 14004, ISO 14031, ISO/TR 14032) or for product standards (ISO Guide 64)
- product labelling and declarations that aim at influencing customer purchases (ISO 14020, ISO 14021, ISO 14025)
- design of products (ISO/TR 14062) or policies that aim for environmental improvements
- quantification, monitoring and reporting of environmental additionality of project outcomes (e.g. ISO 14064)
- analysis of significant environmental aspects in the system that is affected by the decisions