Has ISO 14040/44 Failed Its Role as a Standard for Life Cycle Assessment?

Bo Weidema

The role of a standard is to provide uniform rules for a procedure, so as to minimize or eliminate unnecessary variation in its performance, typically with the aim of reducing costs. The basic standard for performing life cycle assessment (LCA) was published by the International Organization for Standardization (ISO) as ISO 14040/41/42 in 1996 and reorganized, largely unchanged, into ISO 14040/44 in 2006.

In recent years, we have seen a proliferation of guidelines that interpret the basic ISO 14040/44 standards for LCA, either for a specific geography as, for example, the BPX 30-323 for France and the Product Environmental Footprint Guideline for the European Union, a specific sector with the so-called product category rules (PCRs) that seek to regulate the production and communication of LCA information for products within the product category, or a specific topic as in carbon or water footprints.

Unfortunately, these guidelines, as currently published, sometimes cover the same product categories and markets without adequate or reasonable justification, and they reflect different interpretations of ISO 14044 with respect to system boundaries (cut-off rules, which unit processes to link to specific inputs, and rules for handling coproducts).

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Interestingly, all these interpretations claim to be based on—if not directly to be in accord with—ISO 14040/44. If this is really true, it points to a serious failure of ISO 14040/44 to fulfill its role as a standard, that is, to minimize or eliminate unnecessary variation.

Different application areas, whether geographical, sectoral, or related to specific impact categories, may indeed require different kinds of data, specific definitions of functional units to make comparisons fair, and specific impact assessment methods. These are all issues that are *not* regulated in ISO 14040/44 and where specific guidelines are therefore relevant. Yet, all the current specific guidelines also specify further requirements for the *life cycle inventory modeling* that deviate more or less from the ISO 14044 requirements. These disparities in interpretation of the ISO 14044 standard are *not* caused by differences across geographies, product groups, or impact categories and cannot be justified by reference to scientific disagreements. At best, the disparities can be explained by the vagueness of ISO 14044 on key methodological points, which makes it possible for everyone to get away with their own interpretation. Thus, a more unambiguous wording of ISO 14044 could help to reduce the current disparity in LCI modeling requirements in the geographical, sectoral, and impact-specific guidelines.

The most critical vagueness in the current ISO 14044 relates to which unit processes to include in a product system and how to link these unit process data sets together. This has given rise to different interpretations, notably the attributional and consequential interpretation:

- An attributional product system is composed of the activities that *have contributed* to the production, consumption, and disposal of a product, that is, tracing the contributing activities backward in time (which is why data on specific or market average suppliers are relevant in such a system).
- A consequential product system is composed of the activities that are *expected to change* when producing, consuming, and disposing of a product, that is, tracing the consequences forward in time (which is why data on marginal suppliers are relevant in such a system).

Several different attributional product systems can be constructed for the same product, depending on whether the activities included are selected for their contribution to the cost of the product, the mass of the product, or some other selected

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contribution. The most common procedure is to trace the monetary flows between unit processes, using revenue allocation: an allocation where all economic expenditures in a unit process are allocated to all outputs in proportion to the revenue generation of the latter. This system model thus answers the following question: "What are (the environmental impacts related to) the activities that contribute to the cost of the product?" An issue that is often overlooked is that revenue allocation makes it impossible to maintain the mass and elemental balances of the resulting product systems (Weidema and Schmidt 2010). This, of course, complicates the interpretation of what is meant by "the environmental impacts related to . . . the product."

When mixing allocation keys (mass, revenue, 100% to determining products, and so on) within the same product system, it becomes obscure which question the model is supposed to answer. Mixing consequential and attributional modeling (marginal vs. average/allocated) within the same product system, of course, has the same problem as when mixing allocation keys: It becomes unclear which question the analysis is supposed to answer.

Consequential modeling is based on the description in ISO 14049, clause 6.4 (original without italics): "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 submarkets 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."

Because technological, coproduct, or market constraints are often found in practice, the results of consequential systems often differ substantially from the corresponding attributional systems based on average, allocated inputs. It is therefore of utmost importance to add to ISO 14044 the more detailed description of the consequential modeling from ISO 14049 and other, more recent specific descriptions, such as the one describing the implementation in ecoinvent v3 (Weidema et al. 2013). It would also be helpful to add to the ISO 14044 a clear, complete, and unambiguous description of at least one attributional model, and to clarify the difference to the consequential model, especially specifying for which questions each model is relevant.

The issue of the differences in system models cannot be separated from the issue of the so-called allocation hierarchy in clause 4.3.4.2 of ISO 14044, which provides a step-wise procedure for handling coproduction, that is, for reducing multiproduct systems to single-product systems. This allocation hierarchy is being interpreted differently by different practitioners, which can be referred back to a lack of clarity in the initial sentence:

> "The study shall identify the processes shared with other product systems and deal with them according to the step-wise procedure presented below.
> a) Step 1: Wherever possible, allocation should be avoided by . . . "

Some practitioners focus on the "should" in the last sentence, which allows them to interpret the allocation hierarchy as a recommendation, that is, not as a requirement, so that any allocation rule can be applied as long as it is made explicit. Other practitioners focus on the "shall" in the initial sentence and interpret the quote as a requirement always to avoid allocation (by subdivision and system expansion), because this is always possible by one of these approaches. The proponents of the "shall" interpretation point out that a more liberal interpretation would be at odds with the very purpose of providing a standard, because a liberal interpretation would allow practitioners to allocate as much or as little as they may desire of the total environmental impacts to the product system of interest.

The allocation hierarchy could be significantly simplified if a separate description was made for situations of combined production with variable relationships between the coproducts, such as found in petroleum refineries that can regulate the outputs to meet variation in demands, and situations of joint production with fixed relationships between the coproducts, such as found in chlor-alkali electrolysis. This would clarify that step 2 in the ISO hierarchy is exclusively intended for situations of combined production, but equally applicable in consequential and attributional models, and would correct the common misunderstanding that this step is identical to allocation according to mass or energy, a misunderstanding that has become more common after the explanatory sentence "The resulting allocation will not necessarily be in proportion to any simple measurement such as the mass or molar flows of coproducts" fell out in the transcription of the text from ISO 14041 to ISO 14044. For situations of joint production, substitution (system expansion) would be the only relevant option for consequential modeling, whereas a separate option should be provided for attributional modeling. Probably, at least revenue allocation should be described (maybe with additional rules for how to deal with prices that fluctuate over time and place, currency conversion, taxes and subsidies, nonmarket products, the point of allocation, value correction, and whether any of the resulting mass imbalances should be corrected for). Any other allocation key than revenue will have the problem that it cannot be applied consistently to all cases of coproduction, which would then require additional rules for when to apply which allocation key.

There is a different, but related, conflict in interpretation with respect to the allocation rules for recycling, both among practitioners and guidelines. The difference in interpretation is related to—or at least amplified by—an ambiguity in ISO 14044, clause 4.3.4.3, which, on the one hand begins, with the sentence "The allocation principles and procedures in 4.3.4.1 and 4.3.4.2 also apply to reuse and recycling situations" but, on the other hand, provides an additional allocation hierarchy for reuse and recycling with a *different* order than the one in clause 4.3.4.2. The simplification of the allocation hierarchy suggested in the previous paragraph would eliminate the need for any separate rules for recycling.

The proliferation of PCR program operators and guidelines with different definitions and rules for the same product groups, and different interpretations of the basic LCA standards, lead to increased costs for industry seeking to comply with these guidelines, and increased confusion among end users of the environmental information, who, in the end, are paying for all the diversity, without any added value or benefit to the environment, thus further reducing the likelihood that we will identify truly sustainable solutions and implement them efficiently. This cannot be in the long-term interest of industry, consumers, and society at large.

References

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About the Author

Bo Weidema is a professor at the Danish Center for Environmental Assessment at Aalborg University in Aalborg, Denmark.

Address correspondence to:
Professor Bo Weidema
Aalborg University
Danish Center for Environmental Assessment
Skibbrogade 5, 1 Aalborg 9000, Denmark
Email: bow@lca-net.com