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Aalborg, 2009-08-21

To:
European Platform on Life Cycle Assessment
European Commission
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Italy

Response to the public consultation on a set of guidance documents of the International Reference Life Cycle Data System (ILCD) Handbook

In response to your invitation for public consultation, please find attached our comments.

Our comments relate to one of the documents only: The general guidance document for LCA.

In addition to our specific comments in the comment template, please allow us to provide some general observations:

It is unclear which of the recommendations in the draft Handbook should be understood as requirements, and which are meant as advice. We recommend the use of the unambiguous terms “shall” and/or “should”, rather than “are to be” etc.

We appreciate that the draft Handbook recognizes that consequential modelling is the theoretically most appropriate choice for LCAs that are intended for decision support, providing more meaningful results, better reflecting the societal benefit (General guidance p. 203-204).

However, the draft Handbook proceeds to dissuade the use of consequential modelling with 8 arguments (p. 56-57 and 204-209), which are all undocumented and factually incorrect, as we shall demonstrate below. Furthermore, throughout the handbook, attributional modelling is presented as depicting “the physical reality”, the system “as it is”, or even “as it is in reality”, ignoring the fact

that an attributional model is just as much a model of reality as a consequential model[1]. It thus appears as if the authors have already in advance decided that the attributional model is "more real" than the consequential. This obvious prejudice introduces an unwarranted bias in the recommendations in favour of attributional modelling.

These biased and unjustified recommendations, especially when coming from a supposedly authoritative body as the EU Commission, are likely cause serious damage not only to the public, which has an interest in unbiased policy advice, but also directly to our business as the globally leading supplier of consequential LCAs.

If these biased and unjustified recommendations are maintained in the final version of the handbook, we therefore reserve the right to take legal action against the Commission on grounds of the market distortion caused by these unsubstantiated recommendations that discriminate against our main product, of which we are able to demonstrate superior quality.

The 8 unsubstantiated arguments used to dissuade the use of consequential modelling (p. 56-57 and 204-209) are:

- has limited reproducibility,
- involves considerable subjectivity,
- require more data, currently lacking,
- has higher uncertainty,
- has a higher complexity,
- includes uncertain rebound effects,
- is difficult to communicate,
- is more costly.

These 8 arguments are not only lacking documentation; they are also all factually wrong:

- Re. reproducibility, consequential modelling for LCA follows a strict guideline (Weidema 2003, latest revised in Weidema & Ekvall 2009), aiming at unambiguity and allowing very little room for interpretation, requiring use of documented, reproducible, empirical market data that can be validated by reviewers. Two practitioners following the same guideline will therefore have a high probability of arriving at the same result.
- Re. subjectivity, it must be noted that both attributional models and consequential models are – as indicated by their name – models. Only the data describing a unit process, for a site or an enterprise, for a specific time period, with its inputs and outputs that can be balanced, can be said to be objective. As soon as a product life cycle is considered, modelling – and therewith subjectivity – becomes necessary. If subjectivity is understood as the number of normative assumptions/judgements required in a model, there are in fact more normative assumptions in an attributional model than in a consequential model. For both models, a judgement is required each time two unit processes are linked. In both models, the judgement concerns which process(es) to link to each specific input. In an attributional model, an average of allocated unit processes is assumed or chosen. In a consequential

[1] Both models are static, linear, homogeneous models. The only difference is that consequential models include exogenously determined market reactions, while attributional models do not. Instead, attributional models resort to a partitioning (allocation) of multi-product processes, resulting in a model with single-output processes that do not exist in "the physical reality".

model, marginal producers are identified. Since an allocation rule is always a normative choice (in the sense that it cannot be challenged with scientific arguments), while the identification of a marginal producer can be substantiated and justified by reference to observable changes in production volume of different producers over time, and thus is amenable for scientific challenge and validation, the number of normative assumptions are per definition larger in an attributional model.

- Re. the data requirements, a consequential model involves fewer and more easily accessible data than an attributional model at the same level of detail. Both types of models require market data to delimit the markets for which marginal suppliers or averages are determined. Consequential models require more data on production costs (competitiveness), which is much easier to obtain than data on environmental emissions. In our 13 years of experience of performing consequential modelling, we have never encountered data availability as a problem. A much more important aspect of data requirements is the use of averages in attributional models, which per definition includes all suppliers to the markets and thus a much larger number of process datasets than required for the consequential models, which exclude processes that do not change as a result of a decision. Since data collection is the largest cost item in the production of an LCA, this difference in data requirements is also the main reason why consequential LCAs can be supplied at much lower costs than attributional LCAs.
- Re. uncertainty, the main source of uncertainty in a consequential model is the actual variability and lack of precision in the underlying data. In an attributional model, the main source of uncertainty is the bias introduced by the lack of accuracy in the method, i.e. that the average data and use of allocation leads to a result that does not reflect the actual consequences of the decision studied. Since the actual consequences can only be determined with a consequential model, the only way to determine the true uncertainty (accuracy) of an attributional model is to compare it with its consequential counterpart. Since this is very seldom done, the true uncertainty of attributional models is largely unknown. Attributional models are therefore often presented as having very low uncertainty, because only the precision is measured, while the accuracy (methodological bias) is ignored. When both models are compared on their combined precision and accuracy, the comparison clearly is in favour of the consequential models, because of their larger accuracy. We also refer to our recent column in Journal of Industrial Ecology 13(3):354-356 “Avoiding or ignoring uncertainty?” which deals with this issue as a specific comment to Figure 17 of the draft Handbook (p. 206).
- Re. complexity, consequential models are clearly less complex than attributional models, at the same level of detail, partly because of the lower number of unit processes included, but also because of the avoidance of allocation, which is a notoriously complex procedure, especially if performed according to the suggestions in the draft Handbook. Allocation furthermore makes a model more complex because it requires one new single-output process for every single co-product, while in consequential models no additional processes are added, since the dependent co-products simply remain in the co-producing processes as negative inputs, thereby also maintaining mass and energy balances and the full range of validation options that this provides. From the text of the draft handbook (especially p. 102-104 and 205-206) it appears that the authors confuse consequential modelling with general equilibrium modelling, and that it may be from this confusion that the concern for complexity arises. It is important to understand that unlike general equilibrium modelling, consequential modelling in LCA is a static, linear homogeneous model, not concerned with

short-term changes, and therefore a much more simplified, unambiguous, and rule-based modelling approach.

- Re. inclusion of uncertain rebound effects, this topic is identical to that of uncertainty dealt with above. You may choose to leave out certain rebound effects, but if these rebound effects are actually expected to occur, your result will be less accurate than if you include them. So you have the choice between a more correct (accurate) but imprecise system that includes rebound effects and a precisely incorrect (inaccurate) system that excludes rebound effects. Because it adds to the accuracy of the results, we find that the potential for inclusion of rebound effects is an advantage of consequential modelling, not a drawback.
- Re. communication difficulties, attributional and consequential models encounter different difficulties, depending also on the communication context. The main communication difficulty with consequential models is that the models only include those processes that change as a result of a decision, and that these processes are not always the processes that one would intuitively think should be included. At a first glance, a consequential model may therefore appear counter-intuitive, but when the context is communicated and the model is investigated more in detail, the communication difficulties disappear. Conversely, attributional models may appear easy to understand at first glance, because they follow a more static logic, but the communication difficulties appear at closer examination, when the need arises to explain e.g. the subjective choices of allocation factors, the artificial nature of allocated processes that have no real-life parallel, and the lack of mass and energy balances for the allocated systems that violates the well-known natural law of conservation of mass and energy. We would argue that it is a larger communication difficulty to explain the normative choices and artificial nature of attributional system models than to overcome the initial counter-intuitive appearance of a fully explainable consequential model.
- Re. costs, we can find no reason that consequential modelling should be more costly at the same level of quality. As documented above, consequential modelling requires less data, and since data is the main cost of an LCA, we find that consequential modelling reduces costs.

Besides the deplorable disregard for the true merits of consequential modelling, we are very concerned about the recommended mixing of the two modelling approaches. The draft Handbook recommends to use an attributional approach to modelling but to introduce elements of consequential modelling for specific situations (see e.g. p. 57), notably recycling. This will lead to an inconsistent model, which cannot be solved in practice, as we demonstrate in Annex 1 to this letter. An attempt to construct a system model according to this recommendation will at best fail, and could in the worst case lead to misleading conclusions. We therefore strongly advice against any attempt at mixing attributional and consequential approaches.

Considering the commendable ambition to take into account all previous LCA guidance documents (General guidance p. 3), it is surprising to find that the work of previous EU projects, notably Weidema et al. (2003), are not listed in the Explanatory Memorandum. We also find a surprising lack of references to previous work for specific recommendations, e.g. the list of data quality indicators in Annex 11 is presented without reference to and regard for the previous work of Weidema & Wesnæs (1996) and Weidema (1998).

Surprisingly, the general guidance document does not appear to have been written from the perspective of practical application, but rather from a position of academic discourse. Several of the recommendations, e.g. for allocation and cut-offs, are far from current practice in attributional modelling, and are unnecessarily complicated. Throughout the document, the examples given are

ill-chosen, since they are mostly open for interpretation, thus not providing the desired clarity, as we also point out in our detailed comments.

While some concepts are described in unnecessary detail, other important aspects are missing, such as:

- A detailed description of market delimitation, including the concept of market niches (it appears, see p. 80: “market information (exclusively for consequential modelling)” that the authors think that attributional modelling can be done without procedures to identify the markets for which averages are derived),
- The concept of determining and dependent co-products, which is a key concept in consequential modelling, without which several misunderstandings occur (such as the impossible attempt to find a product displaced by a determining product).

As we point out in our detailed comments, several key concepts of LCI modelling have been misunderstood by the authors, such as:

- That the ISO allocation hierarchy should recommend the use of non-causal properties (p. 54)
- The crediting of avoided waste treatment (note 42, p. 107)
- That stable or stagnating markets should be treated differently from growing markets (p. 108, and note 104, p. 205)
- The introduction of valuation aspects (discounting for GWP and recycling credits) into the inventory analysis (p. 193 and 230)
- That value-correction is a consequential approach (p. 107 and 227)
- That the substitution of recyclates is independent of the market trend for recyclates (p. 107 and 228)
- That the “short-term marginal” is related to installation of capacity (p. 229).

Besides being confusing to the reader, most of these misunderstandings contribute to make consequential modelling appear unclear, ambiguous or even ridiculous.

The document, as it appears now, is best suited to scare people away from using LCA, which can hardly have been the intention. We therefore recommend to re-write the document, seeking assistance of additional authors with extensive real-life experience with the two modelling types.

Yours sincerely

Jannick H. Schmidt and Bo Weidema
Respectively CEO and majority partner of 2.-0 LCA consultants

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Annex 1.

System expansion and avoided average supplies: Impossible combination

By Jannick H Schmidt, 2.-0 LCA consultants & Aalborg University, Denmark, 24th April 2009

Sometimes it is suggested that system expansion can be done in two different ways. Assume we have a multiple product output process supplying the product subject to study and a dependent co-product. The two suggested ways of doing system expansion are:

Option 1: Include all emissions from the multiple product output process, and subtract the emissions related to the marginal supply of the dependent co-product

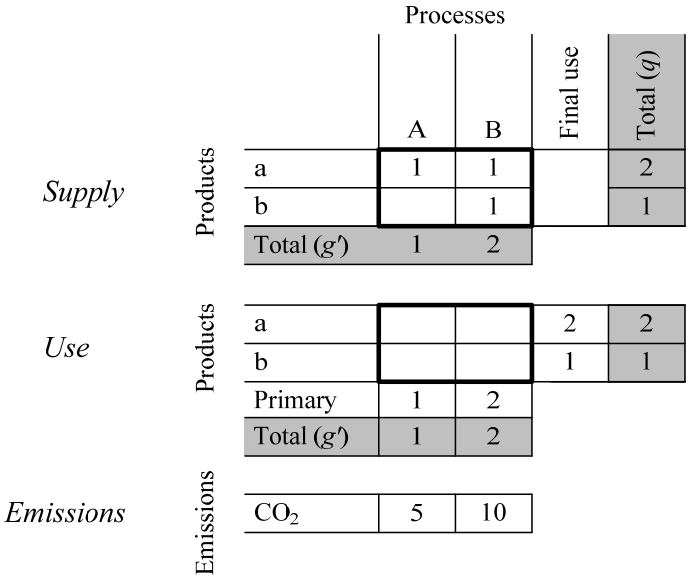
Option 2: Include all emissions from the multiple product output process, and subtract the emissions related to the average supply of the dependent co-product

In the following it is explained that only option 1 is possible.

Assume we have:

Processes: We have two processes A and B, and two products a and b.
Supply: A supplies only a, and B supplies both a and b.
Use: The two processes A and B have no inputs from other processes
Emissions: The two processes have only CO_2 emissions.
Marginal supplies: The marginal supplier of product a is process A, and the marginal supplier of product b is process B
Co-product: product a is a dependent co-product from process B

In order to have an overview and to attach fictive numerical numbers, the data have been arranged in the supply-use format below.



Functional unit: We want to analyse 1 unit of product b supplied by process B:

Option 1: Include all emissions from the multiple product output process (B), and subtract the emissions related to the marginal supply of the dependent co-product (a)

This is easy:

Total emissions from B relating to 1 unit b and 1 unit a => 10 CO2
minus
Emissions from marginal supply of 1 unit a => 5

Resulting emissions relating to b = 10 – 5 = 5

Option 2: Include all emissions from the multiple product output process (B), and subtract the emissions related to the average supply of the dependent co-product (a)

This is impossible:

From the figure (supply use), it can be derived that the average supply of product a is 50% from process A and 50% from process B (each of the two processes supplies 1 unit of product a)
Then we try system expansion where average supply is avoided:

Total emissions from B relating to 1 unit b and 1 unit a => 10 CO2
minus
Emissions from average supply of a => ***this can't be determined since this also includes co-products from process B; we have an insolvable system***

Template for comments

Date: 2009-08-21	Document Title**:** General guidance document for LCA

Commenter: Bo Weidema and Jannick H Schmidt, 2.-0 LCA consultants

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Page	**Chapter No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/Table/Note** (e.g. Table 1)	**Type of com-ment[2]**	**Comment (justification for change)**	**Proposed change**	**JRC comments / observations**
14, 17, 28-31, and more			ge, te	The four so-called “goal situations” do not follow the reasoning for differences in the modelling approach. The two criteria that require differences in the modelling approach are 1) the distinction short-term/long-term, understood as changes within the existing capacity and changes that demand capacity changes, respectively, and 2) the distinction small/large, where small is understood as not affecting the determining parameters of the overall market situation, that is, the direction of the trend in market volume and the constraints on and production costs of the involved products and technologies. The consequences of the decision can thus be assumed linearly related to the size of the change and both an increase and a decrease in production volume will affect the same processes. A decision is defined as large when it affects the overall market situation, and therefore may bring into play new suppliers, new markets, or even new products and technologies. The consequences can therefore not be assumed linearly related to the size of the change and increases and decreases in the production volume may affect different processes. For large decisions, it is therefore necessary to take the direction of change into account. In practical LCA, the distinction short-term/long-term is seldom relevant (see below), so the only relevant distinction is the latter (small/large) corresponding to goal situations I+II and III, respectively. Thus, it is not obvious why it is necessary to distinguish goal situations I and II, except that these of course relate to different temporal data because of their difference in time horizon. This is, however, not a methodological difference. The distinction may have come from an inappropriate use of the term “short-term”. A short-term change affects only capacity utilisation, but not capacity itself. A long-term change affects also capital investment (installation of new machinery or phasing out of old machinery). Large changes will always affect capital investment. In the draft Handbook text, the term appears to cover changes that do not affect the background system, although the correct definition is provided on p. 57. Thus, there appears to be some confusion in the way this term is used. Also, it should be taken into account that even the effect of small, short-term changes can seldom be isolated to the short-term perspective, since each individual short-term purchase decision will contribute to the accumulated trend in the market volume, which is the basis for decisions on capital investment (long term changes). This is obvious in free market situations (where market signals play a major role when planning capacity adjustments) with a short capital cycle (fast turnover of capital equipment, as for example, in the electronics and polymer industries), but it is also true for markets with a long capital cycle (as for example, in the building and paper industries). Thus, pure short-term effects of small, short-term changes (effects within the existing production capacity, including reduction in current capacity) are only of interest in markets where no capital investment is planned (for example, industries in decline), or where the market situation has little influence on capacity adjustments (monopolised or highly regulated markets, which may also be characterised by surplus capacity). An example of a substitution with a short-term effect only would be an isolated decision to remove heavy metals from the components of a product, which – all other things equal – would not involve capital investment in the metal industry, since heavy metals are already being phased out. Since such situations are very seldom in reality, it appears unnecessary to reserve a separate goal situation for such short-term decision situations. Consider a factory in which several production lines exist, some using an older technology, which is more polluting and	Improve explanations as provided here, merge situations I and II, consider other and different goal situatons for different types of attributional modelling.	

1 Type of comment: **ge** = general **te** = technical

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				more expensive to run, and some with a new technology (less polluting, less costly to run). Small, short-term fluctuations in demand will affect the capacity utilisation of the production line with the older technology (since this is the most costly to run), while the line with the new technology will be utilised as much as possible, and will therefore not be affected. If the demand increases beyond what can be covered by the current capacity, new machinery will be installed, and here the factory may choose to install the newest technology even though it is more costly to acquire, or it may decide to buy a cheaper, but more polluting technology. Whatever the choice, this can be said to be the long-term result of the change in demand and the additional environmental exchanges from the factory are now those coming from the newly installed machinery. It is therefore these exchanges that it would be reasonable to ascribe to the change in demand. Once the new machinery has been installed, further changes in short-term demand will still affect the older technology (since this is still the most costly to run). It is important to understand that even though the short-term fluctuation constantly will affect the older technology in the short-term, it is the accumulated changes in the short-term demands that make up the long-term changes, which eventually lead to the installation of the new machinery. The long-term effect of the demand is therefore the additional exchanges from the newly installed technology, and the short-term effects can be seen as a mere background variation for this long-term effect. Thus, the long-term effect should also be guiding for decisions that at first sight appear short-term, such as individual purchase decisions, and the product declarations that support such decisions. Re. the goal situation 4, this does not cover all the situations where an attributional model could be relevant. In addition to monitoring (which is, by the way, irrelevant if the monitoring is not used for anything, i.e. to take action if needed, which is therefore also a decision support situation), consequential modelling is less relevant the following decision situations, and an attributional model could therefore be considered: • Studies at a societal level, where the entire environmental impact of all human activities is studied, with the aim of identifying areas for improvement, disregarding whether such improvements shall be sought through product-oriented policies or through direct regulation of the individual activities. In such a situation, it would not be reasonable to limit the study to those activities that can be affected by changes in demands, but to include all activities, also those that are not linked to any consequential product system, and for which a policy-driven improvement can only be achieved through direct regulation. One can argue that since the objective of such a study is not product-oriented, LCA is simply not the (only) relevant assessment technique. An attributional model, where all activities in society are included in proportion to a specific attributional rule, such as revenue, would better reflect the objective of such a study. Once improvement options are identified by such a model, those improvement options that have upstream or downstream consequences can then afterwards be studied with a consequential model. The IMPRO study on meat and dairy products is an example of such an attributional study at the level of EU-27, where the identified improvement options were analysed with a consequential model. • Studies on environmental taxation, where the focus is less on the consequences of the tax, but rather on who is to carry the burden. Often, studies on taxes or quota systems are performed for a specific administrative area, and any consequences outside this administrative area are discounted. Although the consequences of a tax on a product or an activity can be studied by a consequential model, this model cannot say anything about the attribution of the tax and its fairness. An attributional model, where all activities in society are included in		

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				proportion to their perceived contribution to the taxed activity variable, whether or not this changes as a consequence of the tax, would better reflect the objective of such a study. • Studies that seek to avoid blame or to praise or reward for past good behaviour, for example avoiding blame that a specific deplorable activity, such as slavery, occurs in the product system, or rewarding producers that have invested in a praiseworthy technology such as wind-power. While a consequential model can answer the question whether the deplorable or praiseworthy activity *changes* as a consequence of buying the product, it cannot tell how much of the deplorable or praiseworthy activity *exist* in the product system, simply because a consequential product system does not *exist*, it *happens*. An attributional model, where activities are included in proportion to a specific attributional rule, for example mass, energy or revenue, would better reflect the objectives of such studies. However, it is naïve to think that one single attributional modelling principle is appropriate for all these different decision situations.		
29			te	It is unlikely that "end-of-life activities of the product system", i.e. post-consumer waste treatment, can influence the product system design in any relevant way. For example, a change in recycling rate would just mean that certain recycling processes will change, not the direction of the trend in market volume and the constraints on and production costs of the involved products and technologies.	Delete "end of life"	
45	4.4.5		te	Missing here is a distinction between markets and market niches (A *market niche* is a sub-category of a market segment, where a part of the customers consider only niche products substitutable, although the majority of the customers allow substitution between products from the niche and other products in the segment), and the implications of this distinction for the system modelling (Although different products traded in the same market segment or niche by definition have the same obligatory product properties, they may very well be different with respect to *non-market* properties, the properties that do not play a role for the customer's preferences. For example, while all beverage containers must fulfil the obligatory product property of non-leakage, different (refillable) beverage containers in the same market segment may differ in terms of ease of cleaning before refilling. Such non-market product properties may still give rise to consequences that should be included in the product system. For example, the beverage container that is easier to clean may affect the type and amount of cleaning agent used. This can be done *either* by modelling the downstream activities explicitly for the product in question, rather than for the average, *or* by moving the difference in the downstream activities relative to the averages from the downstream activities to instead be an input to the producing process, in parallel to the way downstream waste treatment and recycling activities are modelled as inputs of waste treatment services, rather than as downstream activities.)	Add definitions and explanations are provided here.	
48, 49, 61, 65, 95,			ge, te	Attributional models are presented here as depicting a given system "as it is" or even "as it is in reality" (p. 61 and 65) or as depicting "the physical reality" (p. 96), although it should be obvious that attributional models are models, and as such do not reflect the physical reality any more than consequential models. Since attributional modelling apply partitioning (allocation) of multi-product processes, the attributional models contain single-output processes that do not exist in "the physical reality" (has anyone ever seen 20% of an oil mill with 1 kg seed cake and no oil coming out and only 0.3 kg oil	Describe instead attributional models as "depicting a given system according to a	

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96				seeds coming in – because the rest of the oil seeds are allocated to the oil in another non-existing oil mill). It appears as if the authors have already in advance decided that the attributional model is "more real" than the consequential. This obvious prejudice introduces an unwarranted bias in the recommendations in favour of attributional modelling.	supply chain logic", avoiding the use of "as it is" and "reality".	
48	4.5.2		te	It is incorrect to describe consequential models as dynamic. The consequential models are static, linear, homogeneous models, just like attributional models. The only difference is that consequential models include exogenously determined market reactions, while attributional models do not. Also, the technosphere does not "behave as a market", it *includes* markets (many markets, not one).	Change as indicated.	
49			te	The example is misleading. There is no reason that electricity should come from a wider market mix of producers or technologies. Furthermore, Brazil does not have one electricity mix, since its regional electricity markets are isolated because of the large geographical extension of Brazil.	Use a more unambiguous and correct example.	
53			te	The heat and electricity example is ambiguous, since the market situation (whether heat or electricity is the dependent co-product) depends on the time of day and year (as well as geographical conditions). Anyway, it does not make sense to describe substitution without first introducing the distinction between determining and dependent co-products.	Use a more unambiguous example. Describe determining and dependent co-products before example.	
54			te	It is not clear why "under attributional modelling system expansion is appropriate while substitution is inappropriate", since these two operations are mathematically congruent. We would argue that both procedures are inappropriate in attributional modelling, since they lead to inconsistent and/or mathematically unsolvable systems. Since attributional modelling implies the use of averages, imagine that the average electricity supply is 90% coal based and 10% from heat production (with co-generation of electricity). If you then are considering an LCA of 1 unit of heat (which is co-produced with say 1 unit of electricity), then you should account for the co-product (electricity) using system expansion. Thus, you should subtract the burden related to 1 unit electricity, i.e. 90% coal based electricity and 10% from heat plant. But since the heat is co-generated with electricity, you will actually also need to subtract some heat… and so on… You will end up with an unsolvable calculation. A more mathematical description of the problem is provided in Annex 1 to this response.	Delete this nonsense. Do *not* recommend the use of consequential procedures in attributional modelling.	
54		Last paragraph	te	ISO does *not* recommend or authorize the use of non-causal properties. The ISO text is "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 that reflects other relationships between them." A relationship is always causal, cf. ISO Step 2: "they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions	Correct the text to reflect the ISO standard correctly.	

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				delivered by the system"		
55			te	That allocation is applied also in consequential modelling, is not because "allocation often better captures the consequences, due to various mechanisms including secondary consequences, next to having advantages in applicability and reproducibility". The only reason for using allocation in consequential LCA is if you are forced to use an attributional background database where allocation has been performed in such an intransparent way that the original multifunctional process cannot be reconstructed or that time constraints do not allow such a reconstruction. Allocation can never produce a more correct result, since it will inevitably violate the mass and energy balances.	Delete this nonsense.	
55			te	The goat example is misleading, since protein content is not a causal relationship (the inputs and outputs of a goat does not change with quantitative changes in the protein content of goats milk, meat and hides. You should not give an example of a procedure that is not recommended.	Delete or find a correct example that reflects the recommendations of the Handbook.	
56		Last paragraph	ge, te	The 8 reasons for not using consequential modelling ("limited reproducibility caused by several subjective/judgement components, by lack of data and high uncertainty of market forecasting as well as the inherent complexity, counteracting secondary consequences (rebound effects), difficulties in communication business-to-business, to stakeholders and to the general public, and additional costs involved") are incorrect, as has been documented in the cover letter to this response.	Delete and recommend the use of consequential modelling, *with an adequate, correct and exemplified description of this modelling!!*	
57			ge	The coffee-machine example is ambiguous. Only if surplus (unused) heat is available is it correct to talk about short-term effects only. If heat is produced on demand, the reduction in demand for space heating as a result of the coffee-machine, will affect the long-term installation of capacity for heat production and distribution. Thus, whether to use allocation or system expansion would depend on the market situation? No argument is provided why system expansion is the right choice for short-term marginals, when it is recommended for long-term marginals.	Delete this nonsense	
57, 58			te	"Same-route recycling" with substitution of market averages leads to inconsistent and and/or mathematically unsolvable systems (see comment for page 54 and Annex 1 to this response). The same is true for the cases covered by the third (last) bullet point on the top of p. 58. By the way: The two bullets cover the same situation, since all by-products are used within the same systems that produce them, because practically all processes are interlinked in a real-life-reflecting system model.	Delete this nonsense	
61			te	The suggestion to use ecosphere instead of environment does not appear justified. Is it more obvious that a dam or a human being belongs to the ecosphere, than to the environment?	Re-consider nomenclature	

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61			ge, te	It is *not* correct that there is "limited guidance in ISO on types of processes to include" and that "In ISO this step is only addressed implicitly; no clear guidance is given which activities or processes actually relate to the analysed product.". The guidance in ISO 14049, clause 6.4, reads: "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), • for each sub-market independently, whether a specific unit process is affected directly (in which case this unit process is applicable), or 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." This is actually a rather good description of how to do consequential system modelling, considering that this text was written in 1998.	Delete and use the ISO text instead, with adequate explanations.	
62			te	It is not correct that "the number of all activities that are part of the product system is indefinite, also due to the existence of virtually eternal loops". Any system contains a definite number of processes are definite, and the fact that the same process is used several times in a system calculation does not make the number of processes indefinite. Even if each process in a system was linked directly to all other processes, the number of processes remains the same and the system is easily solvable by matrix inversion.	Delete this nonsense	
62			te	The description of cut-offs is an obvious place where this guidance handbook can be slimmed. With the current data availability, there are no processes for which data (estimates) are not available, and modern LCA practice does not use cut-offs.	Delete all descriptions about cut-off procedures	
63			te	The description of foreground and background processes is unclear on several points. The text describes how to deal with a situation of a *producer* of a product, but not how to understand the terms foreground and background when the functional unit is defined as a *use* of a product. Does "those parts of the product system that are specific to the product in question" mean "those parts that are not used for other products" or was another meaning intended? Why is the foreground system limited to tier 1? Should not any process in the supply chain that is under direct control or decisive influence of the producer be part of the foreground system, disregarding which tier in the supply chain this process is	Clarify text	

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				placed? Footnote 24 is simply incomprehensible. That consequential modelling should not deal with supply-chain relations is factually wrong (see also comment for p. 102), and it is not obvious why one should not be able to define foreground and background in a consequential model.		
65		System boundary diagram	te	Is such a diagram useful? In modern LCA practice, all processes in the World are included in the system, so it does not provide much information with respect to system boundaries.	Delete whole Chapter	
66		Emission off-setting	te	A clear definition is required of what distinguishes an offsetting product from all other products. We suggest “An off-set is a non-material product with a negative accumulated impact (from one or more emissions)”. The addition in brackets is required unless an impact assessment method is specified, allowing for example to define “carbon off-set” as “a non-material product with a negative accumulated GWP” even if the impact from this product is positive fro other emissions or impact categories.	Delete or add definition as provided.	
69		List of impact category midpoints	te	“Land use” is not an impact but a human activity. “Land use impacts” is an impact category.	Add “impacts” after “land use”	
69		List of impact category endpoints	te	Consider adding “man-made environment” or “heritage” or is this not intended to be included?	Consider adding “man-made environment” or “heritage”	
74			ge, te	It is not the aim of LCA to reflect the physical reality, neither the existing nor the expected. Only an unallocated unit process can be said to reflect a physical reality.	Delete this nonsense	
75, 100	4.8.2, 5.2.1.6		te	If it is possible to identify the direct supplier as non-scalable (example: hydropower), then why should this supplier be included in the average mix used? If it is possible to identify any supplier, direct or indirect, as non-scalable, why include these suppliers in the averages used, instead of applying the consequential model, which is then apparently easy to identify?? The logic does not appear to have been carried through to its conclusion.	Correct or clarify the logic	
76		Last bullet in Actions	te	Unclear in which situations a *production* mix can be relevant.	Explain or delete last sentence	
76	4.8.3		te	The example of France – or electricity in general - is problematic, as it requires a rather substantial documentation to justify that France as an administrative unit constitutes a separate electricity market, i.e. a market with negligible import, which would be required for French electricity to be the correct dataset for an energy-using product in France.	Use a less demanding example	

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80	4.9.1	2nd paragraph	te	Market information is not only relevant for consequential modelling. Also in attributional modelling, market information is required to identify and justify the delimitations of the markets for which the suppliers are averaged, see also the previous comment.	Delete "(exclusively for consequential modelling)"	
82	4.9.3		te	As it stands, the sentence "Data for attributional modelling are different from those for consequential modelling" is incorrect. The unit process datasets required for a consequential model is a subset of the unit process datasets required for an attributional model (since an attributional model always includes all processes in the World to provide its average values, while the consequential models eliminate those processes that are not affected by the studied decision,	Delete, rewrite or explain	
84		Consultation note	ge	Our response to the consultation question would be a clear Yes. If not, the ISO requirement could be circumvented, as also suggested in the consultation note.	Extend the interpretation as suggested.	
91-92		Accidents and other non-LCA impacts	ge	The requirement to keep data on accidents, health impacts from use of products, workplace exposure, and indoor emissions completely separate from the other LCI and LCIA data appears an unnecessary strict requirement. It should be left to the scope definition of the individual LCA to determine when and where the different indicators should be presented separately or together.	Delete section	
97		Consultation note	ge	We are also not aware of any previous publication that defines attributional modelling. The Handbook therefore appears to be the first publication where this approach is described in terms of procedural guidance.		
102	5.2.2.1		ge, te	That consequential modelling has no supply-chain logic is incorrect. Rather, consequential models include the changes in a product's supply chain that are caused by a change in demand for the product as a result of the studied decision.	Correct as described	
102-103	5.2.2.1, 5.2.2.2.		ge, te	The description here gives an impression of consequential modelling as a difficult and disputed technique with many open options. However, in practice there exists only one detailed guideline on consequential modelling that all practitioners in this field refers to, namely the results from the Danish methodology consensus project published in *Weidema B P. (2003)* · Market information in life cycle assessment. Copenhagen: Danish Environmental Protection Agency. (Environmental Project no. 863). http://www2.mst.dk/Udgiv/publications/2003/87-7972-991-6/pdf/87-7972-992-4.pdf and recently updated in *Weidema B P, T Ekvall (200*9) · Consequential LCA. Chapter for CALCAS deliverable D18 "Guidelines for applications of deepened and broadened LCA". http://www.lca-net.com/files/consequential_LCA_CALCAS_final.pdf These guidelines are aimed at unambiguity and allow very little room for interpretation, requiring use of documented, reproducible, empirical market data that can be validated by reviewers. Two practitioners following the same guideline will therefore have a high probability of arriving at the same result. It is therefore notoriously incorrect as stated in the draft text here, that there is no possibility to identify which consequences to include in a generally applicable, generic way.	Revise text to reflect actual practice	
104		Line 14	te	It is incorrect that attributional modelling may better reflect reality when additional consequences (in the text called secondary consequences) are included in the consequential model. It would be pure coincidence if an attributional model would approximate the resulting effect of two counteracting chains of consequences, since there is nothing in the	Delete "In such cases attributional modelling may	

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				attributional modelling approach that can motivate such a congruence in results.	better reflect reality"	
104		Bullets 3 to 8	te	If following the two above mentioned guidelines, these six types of consequences are all to be included in a consequential model, in clearly specified situations, according to clearly stated procedures. Thus, according to these guidelines, it is not a free choice whether these consequences are to be included or not. (re. the last two bullets 9&10, these are not to be included in general, but may be included in separate scenarios). What should be noted is that consequential modelling in LCA is not the same as General Equilibrium modelling. Consequential models are static, linear, homogeneous models that assume full elasticity of supply in the long term (just like attributional models) *unless* it can be documented that suppliers are constrained. Consequential models are therefore much more simplified, unambiguous, and rule-based than General Equilibrium models, which are dynamic models with estimated short-term elasticities.	Include the more specific guidance from the existing consequential guidelines as to how to identify and calculate these types of consequences.	
105		4th bullet	te	The coffee-machine example is ambiguous. Only if surplus (unused) heat is available is it correct to talk about short-term effects only. If heat is produced on demand, the reduction in demand for space heating as a result of the coffee-machine, will affect the long-term installation of capacity for heat production and distribution. As mentioned in the comment for p. 14, the situation of short-term impacts only is very seldom in practice and may be skipped.	Delete	
105		Last three bullets	te	The important distinction to make is between on the one hand markets that are decreasing rapidly (at a higher pace than what can be covered by the decrease from regular, planned phasing out of capital equipment), where the affected suppliers will typically be the least competitive, typically using an older technology, and on the other hand markets that are increasing, stable or slowly decreasing at a rate *less* than the average replacement rate for the capital equipment, and for which new capacity therefore must be installed, typically involving a modern, competitive technology, and where any change will affect the decision on this capacity adjustment. With an average capital turnover of 30 years, the rate of replacement of capital equipment is 3.33% per year, which would therefore be the appropriate borderline market growth-rate between the two situations.	Change as suggested.	
106	5.2.2.4	2nd paragraph	te	As mentioned in the comment for p. 61, the guidance for identifying the superseded processes is given in ISO 14049, clause 6.4, to which reference is given in ISO 14044.	Provide the correct reference to ISO 14049.	
106-107		Paragraph over both pages	te	As mentioned above, the coffee-machine example does not unambiguously exemplify a short-term situation.	Change example	
107		Footnote 42	te	A product can only be landfilled once. If the co-product normally ends up in a landfill, the co-producing consequential life-cycle model includes the corresponding landfilling process. If the product is now re-used in another life cycle and therefore only landfilled after this re-use, the re-using life cycle will also include the landfilling process. If the re-using life cycle was not credited for the landfilling process already included in the supplying life-cycle, the landfilling would be double-counted.	Delete (and add the correct explanation)	

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				The "avoided land-filling" credit is therefore required, and it would be a violation of the ISO 100%-rule for allocation not to include this credit.		
107		Recycling credits; bullet 1	te	The „market value-corrected recycling potential approach" is *not* a consequential approach. In consequential modelling, recycling is – in accordance with ISO 14044 - not treated any different than any other co-product situations.	Delete	
107		Recycling credits; bullet 2	te	Introducing discounting in the inventory is an unwarranted mixing of impact assessment into the inventory. If discounting is desired, the important issue is to ensure that the inventory contains the necessary temporal information about the emissions, but the actual discounting should be postponed to the impact assessment as it contains strong elements of valuation. Furthermore, it is unwarranted to apply discounting to recycling credits, if discounting is not applied to all other future emissions as well.	Delete (and add requirement that temporal information is maintained in inventory results)	
107		Recycling credits; bullet 3, footnote 43	te	In consequential modelling, the superseded process is the marginal supplier (see also ISO 14049, clause 6.4), *not* the market mix (see comment for page 54 and 2nd paragraph of p. 108). Assuming „recycling in China and substitution of the Japanese primary production" is allegedly a conservative (worst-case) assumption. In general, worst-case assumptions are dissuaded, at least for the final model: "Conservative estimates or processes must however not stay in the final process or product system model" (quoted from p. 122).	Delete	
107		Last paragraph	te	The consequences of an increase in supply of a co-product for recycling (and any other co-product) *do* depend on whether the demand for the recyclate is growing, stable or falling. In consequential modelling it is therefore incorrect not to distinguish between these situations (see also comment for last three bullets on p. 105, for a precise distinction of the relevant situations)	Delete	
108		First paragraph	te	The national electricity mix is only relevant in those cases where the affected electricity market is nationally defined (i.e. not when more independent electricity grids occur within one nation, nor when one electricity market spans over several nations)	Delete	
108		2nd paragraph	te	Using market mixes or averages for superseded processes leads to inconsistent and/or mathematically unsolvable systems. Imagine that the average electricity supply is 90% coal based and 10% from heat production (with co-generation of electricity). If you then are considering an LCA of 1 unit of heat (which is co-produced with say 1 unit of electricity), then you should account for the co-product (electricity) using system expansion. Thus, you should subtract the burden related to 1 unit electricity, i.e. 90% coal based electricity and 10% from heat plant. But since the heat is co-generated with electricity, you will actually also need to subtract some heat… and so on… You will end up with an unsolvable calculation. A more mathematical description of the problem is provided in Annex 1 to this response.	Delete	
108		Consultation note	te	Indirect land use is a result of a demand for land, or more specifically "land use rights". Thus, it is (or can be) modelled by including the input of land use rights to the land using processes. As with any other input to a process, the supply of such	Add explanation on how to model the	

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				land use rights are modelled in attributional models by the average of the market for land use rights (which is composed of new land taken into production, land already in production, as well as an increase in productivity on existing land), and in consequential models by the marginal supply to this market.	market for land use rights in attributional and consequential modelling.	
108	5.2.2.5	Last two lines	te	It is incorrect to apply averages in case of stagnating markets. The important distinction to make is between on the one hand markets that are decreasing rapidly (at a higher pace than what can be covered by the decrease from regular, planned phasing out of capital equipment), where the affected suppliers will typically be the least competitive, typically using an older technology, and on the other hand markets that are increasing, stable or slowly decreasing at a rate *less* than the average replacement rate for the capital equipment, and for which new capacity therefore must be installed, typically involving a modern, competitive technology, and where any change will affect the decision on this capacity adjustment.	Delete	
129-131	5.7.2.3.2		ge, te	The concept of allocating physical inputs according to the way they are physically embodied in the outputs is not a logic that can be found in ISO 14044. ISO 14044 requires that the partitioning "should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system". However, for a joint production (i.e. when the output of co-products cannot be varied, and the process therefore subdivided) there is no way that the inputs or outputs can change relative to each other. There is no way that the amount of wood in beams, planks, slabs, wood chips, and saw-dust can increase or decrease with a change in the ratio of these products. The concept of allocating physical inputs according to the way they are physically embodied in the outputs is rather a complicated version of a traditional allocation according to physical properties, for which there is no support to be found in ISO 14044. It is also correct as stated in the comment for public consultation on p. 129 that this procedure is quite complex, since it requires that every single element in the inputs are traced to the product outputs in which it is embodied. Such a breakdown of inputs and outputs in elementary composition is a both data intensive and calculation intensive. In practice, it can probably only be done for a few key elements such as carbon. Finally, the procedure does not appear to have any relevance in a life cycle context (but would be relevant for material flow accounting), since at the level of a product life cycle, including the use phase, all physical inputs eventually become emissions and would therefore according to the procedure not be ascribed to the product. An exception, where the procedure would indeed be relevant is for elements contained in biomass harvested in the wild, when the resource input is represented or calculated as a negative emission.	Delete this section	
129		Footnotes 55 and 56	te	The described procedure *is* an allocation by mass, but restricted to allocation of those inputs that are not lost as waste or emissions. It is important to not that the procedure only ensures that "all products as a minimum have in their inventory exactly the amount of elementary, material and energy resources of which they are composed" if applied to the co-products at the point of substitution (which is unfortunately not described in the Handbook text). If this is not done, the procedure would introduce an unfortunate bias in the assessment between co-products that are (at the specific point in time) wastes and those by-products that have a (small) economic value.	Correctly describe (if section is kept)	
130		4th	te	It is not obvious why the inventory of NaCl cannot be subdivided according to the mass of the two elements Na and Cl,	Clarify (If section is	

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		paragraph		when this is possible for all other components of the inputs?	kept)	
130		Last line	te	When referring to standard conditions, the standard must be specified (IUPAC?)	Add reference (if section is kept)	
131-	5.7.2.3.3		te	Most of the key examples in this section (e.g. NaCl electrolysis, mining) are not reflecting physical causality as specified in ISO 14044. ISO 14044 requires that the partitioning "should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system". As explained above, this requires that the co-products can be individually varied and that the inputs and outputs to be allocated then vary with this variation. As correctly stated at the top of p. 133: "this step is identical to the earlier described process of a virtual sub-division of a unit process along a qualitative understanding of that process".	Correct to reflect that this step is identical to subdivision.	
135	5.7.2.3.4		te	It is important to note that the economic value of the co-products shall be determined at the point of substitution, i.e. where they enter into another product life cycle in place of another input. It is here that the true value of the co-product is reflected and can be determined in the form of market prices. If, as apparently suggested in the text here, the economic values of the co-products are determined at the split-off point, the necessary treatment processes will not be correctly included in the supplying product system. Furthermore, the economic value at the split-off point is practically very hard to determine and will have to involve many uncertain assumption, since this point is typically situated within a unit process and the co-products are seldom traded at this point.	Make explicit that the economic value of the co-products shall be determined at the point of substitution.	
184-185	12.5.1	Text and footnote 84	te	An option that would avoid the double-counting of the mass would be to exclude the mass of the particulate indicators from the mass balance and to add an inventory item "mass of particulates not accounted for as individual substances" with the sole purpose of entering the mass balance.	Consider to use this recommendation	
188		Inventorying convention for waste	te	To avoid having both a physical waste flow and an economic flow of waste treatment service, which are essentially linked, it is practical to add the economic flow (i.e. the cost of the waste treatment) as a property to the physical flow of the waste.	Consider to use this recommendation	
189	12.9		te	The system boundary suggested here is unclear. Since unit processes have a temporal boundary, a mass balancing principle shall be applied over this boundary, so that net accumulation of a substance is recorded in the inventory, disregarding the nature of this substance (pesticide, nutrient, heavy metal, carbon, etc.)	Clarify the description	
190-191	12.10.2.1		te	The same technology assumptions should be applied to all processes that are expected to take place at the same point in time. To use BAT for the foreground processes and not for the background processes leads to a mix of technology assumptions that would depend on what is included in the foreground of a specific system, and could therefore lead to identical processes being BAT and not-BAT in two compared systems. Therefore, if BAT is recommended for foreground systems, it should be recommended for the background system also.	Remove the distinction between foreground and background systems	
193-	12.10.4		te	It is a misunderstanding that the GWP100 implies a disregard for impacts beyond 100 years. The GWP100 is exclusively	Delete (and add	

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194				a characterisation convention that specifies the GW impact equivalence of different gases in proportion to the share of the gas that is present in the atmosphere after 100 years. The full, infinite impacts of the emitted gases are (or can) still be attributed to the GWP100, but the GWP100 implies that more will be attributed to the short-lived gases than to the long-lived gases than if e.g. GWP500 had been chosen. The implied over-emphasis on short-lived gases can be seen as an expression that the short-term increase in GWP is seen as more important than an long-term increase, i.e. a kind of discounting, which is however different from a complete discounting of impacts beyond 100 years. The GWP100 can therefore not be used as an argument for discounting emissions of greenhouse gases linearly over 100 years. Introducing discounting in the form of a counter-weighting indicator ("Carbon dioxide temporary storage (within first 100 years)") appears to be an unnecessarily complicated way of accounting for the discounting. It would be adequate to ensure that the inventory contains the necessary temporal information about the emissions, and then apply the appropriate discounting factors to each year's emission. Furthermore, it is not obvious why the discounting (here called "storage benefit") should not apply to all greenhouse gas emissions, fossil or not. Discounting only storage of biogene carbon implies an unwarranted bias relative to products that postpone the emission of fossil carbon. Likewise, it is unwarranted to apply discounting to carbon, if discounting is not applied to all other future emissions as well. The argument that global warming is a short-term problem only can be applied to most other environmental problems as well, and should be included by the scenario modelling in the impact assessment. In any case, the introduction of discounting in the inventory is an unwarranted mixing of impact assessment into the inventory. If discounting is desired, it should be postponed to the impact assessment as it contains strong elements of valuation.	requirement that temporal information is maintained in inventory results)	
204-209			ge, te	The comparison, as summarised in the Table on p. 208-209 is not based on any documented information and it is therefore difficult to provide specific arguments for the errors made in the assessment. We have provided a point-by-point analysis in the cover letter to this response, clearly documenting why the comparison and the conclusion is inadmissible. See also our comment for p. 56, last paragraph: The 8 reasons for not using consequential modelling ("limited reproducibility caused by several subjective/judgement components, by lack of data and high uncertainty of market forecasting as well as the inherent complexity, counteracting secondary consequences (rebound effects), difficulties in communication business-to-business, to stakeholders and to the general public, and additional costs involved") are incorrect, as has been documented in the cover letter to this response.	Delete biased and undocumented assessment and recommend the use of consequential modelling, *with an adequate, correct and exemplified description of this modelling!!*	
205		Footnote 104, last sentence	te	It is incorrect that attributional modelling is equivalent to the theoretically appropriate consequential modelling in case of a (more or less stagnant) market. The important distinction to make is between on the one hand markets that are decreasing rapidly (at a higher pace than what can be covered by the decrease from regular, planned phasing out of	Delete	

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				capital equipment), where the affected suppliers will typically be the least competitive, typically using an older technology, and on the other hand markets that are increasing, stable or slowly decreasing at a rate *less* than the average replacement rate for the capital equipment, and for which new capacity therefore must be installed, typically involving a modern, competitive technology, and where any change will affect the decision on this capacity adjustment.		
206-207		No supply chain logic	ge, te	That consequential modelling has no supply-chain logic is incorrect. Rather, consequential models include the changes in a product's supply chain that are caused by a change in demand for the product as a result of the studied decision. Thereby, the consequential models provide clear measures and recommendations for improvements that can actually be achieved, rather than the theoretical measures and recommendations of attributional models, which may relate to non-existing impacts from processes that are not and cannot be affected in reality. Since consequential models are based on unallocated unit processes, identical to those of more performance based, descriptive instruments, such as environmental reporting / EMS, and supply-chain management, the consequential models can contribute a supply-chain perspective to these instruments, where an attributional model would provide incompatible, unbalanced process information that can lead to confusion and errors in the conclusions. The two last paragraphs of the section are therefore notoriously incorrect and counter-factual.	Delete	
207			ge, te	Although line 4 from the bottom states that "it is getting clear quickly", the only thing that is getting clear is that the authors have an unclear understanding of consequential modelling. The whole section seems to miss the fact that a consequential model can *in isolation* investigate the production of an additional amount of product, and when comparing a choice between two comparable product options, these two isolated models can simply be subtracted, resulting in one comparative model. The need to include all relevant alternatives in a comparison before being able to conclude which of the alternatives is preferable, is an obvious requirement, which should also be applicable to attributional models.	Delete	
210	13.4.6	First paragraph	te	The heat and electricity example is ambiguous, since the market situation (whether heat or electricity is the dependent co-product) depends on the time of day and year (as well as geographical conditions). Anyway, it does not make sense to describe substitution without first introducing the distinction between determining and dependent co-products.	Use a more unambiguous example. Describe determining and dependent co-products before example.	
210	13.4.6	No generally applicable solution for solving multi-	te	It is incorrect that there is no generally applicable solution for solving multi-functionality. Not even theoretically is it possible to encounter situations of indefinite system expansions, where one superseded product has by-products that supersedes others etc. This was already proven theoretically in 2001 (and repeated in the abovementioned guidelines of consequential modelling) and in spite of a public challenge to provide just one single example of a co-product that cannot be handled by system expansion, no such examples have yet been presented. The three examples given in the text here	Delete and use the provided examples to show the contrary.	

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		functionality		(sulphur dioxide, NaCl electrolysis, and petroleum refining) can be used to illustrate this point: Sulphur is (as of 2002) produced in excess of demand, due to the regulations on removal of sulphur dioxide from fuels and flue gases. Additional sulphur supply is therefore deposited, and additional demand (within current amount deposited) taken from these deposits. Here, sulphur acts also as the stable deposit form for sulphur dioxide and sulphuric acid. Chlorine gas is the determining product of NaCl electrolysis (meaning that the electrolysis capacity would not be increased without a specific additional demand for chlorine gas). While the by-product NaOH can be produced by the alternative route of caustification of sodium carbonate (soda ash), a market analysis shows that NaOH is currently produced in excess of any demand that could make this route economically interesting. An additional supply of the by-product NaOH instead replaces the least essential uses of NaOH, i.e. those uses where NaOH can readily displace sodium carbonate (soda ash) directly, e.g. in pulp and paper, water treatment, and certain chemical sectors where it is used as a neutralising agent. The displacement rate is 1.325 kg Sodium carbonate for each 1 kg of NaOH. An increase in demand for NaOH will be met by an increased use of sodium carbonate for the mentioned uses. If there is a further increase in demand for NaOH for essential applications, without a simultaneous increase in demand for chlorine, the caustification process will again be able to play a role as an alternative production route for NaOH, as has been the case previously. (see also M Wesnæs, B Weidema (2006) · Long-term market reactions to changes in demand for NaOH. Study for Novozymes. Copenhagen: 2.-0 LCA consultants. http://www.lca-net.com/files/naoh.pdf). The products of the petroleum refinery industry can largely be varied independently in response to changes in demand, via changes in the raw material sourcing and in the process conditions. Neither allocation nor system expansion are therefore relevant procedures, since the refinery process is simply sub-divided to provide process descriptions for an increased output of each desired co-product without an increase in the output of the other co-products. A number of minor refinery products (gas, sulphur, electricity) are treated by system expansion and have obvious alternative production routes. The three concluding bullet points in the text are therefore incorrect: • The need for additional data for system expansion, which are readily available from industry sources is counter-acted by the reduced need for data for the average upstream inputs when only data for marginal suppliers are needed, thus resulting in an overall reduction in costs • The expanded system includes fewer processes and is therefore less complex, hence having less potential error-sources. The expanded system avoids the notoriously complex allocation procedures, and the additional need for interpretation of e.g. the subjective choices of allocation factors, the artificial nature of allocated processes that have no real-life parallel, and the lack of mass and energy balances for the allocated systems that violates the well-known natural law of conservation of mass and energy. • The modelling of market reactions and superseded processes are based on industry data and has therefore a high degree of acceptance by industry stakeholders, especially as compared to subjective and inexplicable		

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				allocation procedures that can lead to endless discussions among industry stakeholders with different interests in the results.		
213	13.7	First paragraph	ge, te	The benefits of consequential modelling are far from "theoretical", as documented above and in our cover letter, while the alleged disadvantages are not documented.	Delete biased and undocumented assessment and recommend the use of consequential modelling, *with an adequate, correct and exemplified description of this modelling!!*	
213	13.7	First bullet	te	The only way to find out whether the consequences are counter-acted by cross-elasticities and rebound effects is to investigate these in practice using a consequential model. There is no way that an attributional model can approximate the resulting effect of two counteracting chains of consequences, since there is nothing in the attributional modelling approach that can motivate such a balancing effect.	Delete	
213	13.7	Second bullet	te	Real-life uncertainties of consequential models, i.e. the actual variability and lack of precision in the underlying data, are not a reason to discard the modelling approach, but rather a reason to improve the data if possible, and if not then to communicate this actual uncertainty to the decision-maker. An attributional model will always be more uncertain (inaccurate) than the corresponding consequential model at the same level of detail. For an attributional model, the main source of uncertainty is the bias introduced by the lack of accuracy in the method, i.e. that the average data and use of allocation leads to a result that does not reflect the actual consequences of the decision studied. Since the actual consequences can only be determined with a consequential model, the only way to determine the true uncertainty (accuracy) of an attributional model is to compare it with its consequential counterpart. Since this is very seldom done, the true uncertainty of attributional models is largely unknown. Attributional models are therefore often presented as having very low uncertainty, because only the precision is measured, while the accuracy (methodological bias) is ignored. When both models are compared on their combined precision and accuracy, the comparison clearly is in favour of the consequential models, because of their larger accuracy. We also refer to our recent column in Journal of Industrial Ecology 13(3):354-356 "Avoiding or ignoring uncertainty?" which deals with this issue as a specific comment to Figure 17 of the draft Handbook (p. 206).	Delete	
214	13.7		te	Also for the far future, there is no reason to believe that attributional models should give a better or less uncertain reflection of consequences of decisions than consequential models, mainly because the attributional models do not even *seek* to model consequences.	Delete	

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215	14		ge	Note that the current definition of recycling and recyclate covers all types of co-products and all situations of multi-functionality that are not already dealt with by subdivision, and that the definition of "different primary route" (p. 219) in practice cannot be distinguished from "same primary route". When at the same time suggesting to use substitution in all cases of recycling for goal situations I, II and III (p. 57, 210, 213), the guideline effectively recommends the use of substitution for all cases of co-production for these goal situations. It therefore appears unnecessary to present the use of consequential modelling for this as a special case. The entire chapter makes an unnecessarily complicated matter out of the very simple issue of using the same rules for all cases of recycling as for co-production. The chapter could easily be slimmed and at the same time made easier to read, especially when the allocation recommendations have been revised according to our suggestions.	Slim Chapter as suggested.	
220	14.3.1.2	Introduction, line1	te	The term "point of origin" is normally known as the "split-off point". However, performing allocation at the split-off point must be dissuaded, since it leads easily to arbitrariness in the way the intermediate treatment processes (before the co-product enters into the next life cycle at the point of substitution) are allocated, depending on whether the treatment is modelled as a separate process to be allocated or as part of a "black-box" co-producing process or (most correctly) as a service input to the co-producing process. Furthermore, the economic value at the split-off point is practically very hard to determine and will have to involve many uncertain assumption, since this point is typically situated within a unit process and the co-products are seldom traded at this point. Thus, in proper attributional modelling, the economic values of the co-products are determined at the point of substitution, i.e. where they enter into another product life cycle in place of another input. It is here that the true value of the co-product is reflected and can be determined in the form of market prices.	Consider using traditional terminology and allocation procedures at the point of substitution.	
222		Consultation note	te	It is obvious that the correction factor for reduced quality needs to be introduced to obtain a correct result.	Add correction factor for reduced quality (if these complicated formulas are maintained)	
223	14.3.1.3		te	To let the cut-off between two life cycles depend on the economic value of the recyclate does not reflect the physical reality (that the amount of recyclate depends on the supplying life cycle and therefore should be treated in the same way as other downstream processes such as waste treatment and use phases) and is to invite arbitrariness (because the cut-off point will depend on fluctuating prices that are hard to determine because they are seldom market-based, and because the intermediate treatment process can sometimes be modelled as a separate process to be allocated or as part of a "black-box" co-producing process or as a service input to the co-producing process). A more correct allocation, completely unambiguous and reflecting the physical reality (also solving the problem suggested in footnote 111), is obtained if the point of substitution is used as point of allocation for all recyclates (co-products) and wastes, disregarding whether their economic value is above or below zero at any point in time between the split-off point	Recommend the same point of allocation (the point of substitution) for all recyclates (co-products) and wastes, as in current good practice.	

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				and the point of substitution.		
225	14.4.1		te	The recycling approach is presented here as if it is independent of the market trend for the recyclate. The more correct description would distinguish between whether the recyclate is fully utilised or not (see the guidelines on consequential modelling referred to above as well as the comment to footnote 42)	Improve description to reflect also situations where the recyclate is not fully utilised.	
227. 228, 229		227 Footnote 120 on p. 228 229, 4th paragraph	te	Value-correction is *not* a consequential approach. In consequential modelling, changes in the properties of the recyclate are reflected 1) in the nature or rate of the possible substitutions, where reduction in a technical property can lead to the recyclate being treated on a separate market where the nature or rate of substitution is different depending on the reduction in technical properties, and 2) by including the downstream consequences of the reduced technical property (or any other difference in non-market properties from the product it displaces) in the modelled product system of the supplying life cycle, in parallel to what was described for other differences in non-market properties in the comment for p. 45. Value-correction does not reflect these consequences properly, and can best be described as some kind of economic allocation with all the problems this entails in the form of violation of mass balances etc.	Delete and describe correct modelling instead.	
227		Second-last paragraph		The use of averages as superseded process is inconsistent and leads to mathematically unsolvable systems as pointed out above (comment for p.54 and Annex 1). And what does this example intend to illustrate here in a discussion of value-correction?	Delete	
228		Second bullet		It is incorrect that additionally available recyclate would supersede the average market mix in case of stagnating markets. The important distinction to make is not related to the market trends directly, but only indirectly in terms of a distinction between situations where the recyclate (or co-product) is fully utilised (bullet 1) and situations where the recyclate is not fully utilised *even after treatment* (bullet 3). There is no in-between situation.	Delete and describe instead with the correct distinctions.	
228		Third bullet		The important distinction to make is not related to the market trends directly, but only indirectly in terms of a distinction between situations where the recyclate (or co-product) is fully utilised after treatment (bullet 1) and situations where the recyclate is not fully utilised, *even after treatment* (bullet 3). In the case where the recyclate is not fully utilised after treatment, it is incorrect to credit the supplying life cycle, since any additional supply will not be used, but sent to final waste treatment, while an additional demand will lead to displacement of the final waste treatment (see also sulphur example above). This is independent of the way recyclability is defined. This also implies that the footnote 121 is incorrect, since not giving credit to the re-using life cycle for the landfilling process already included in the supplying life-cycle, would imply a double-counting of the landfilling and a violation of the ISO 100%-rule for allocation (see also comment to footnote 42).	Delete and describe instead with the correct distinctions.	
229		Third paragraph		The market price of the recyclate can only be different from the product it supersedes if 1) it can be distinguished as a recyclate 2) it has a lower quality, which implies that it is a different product in terms of functional unit. The other issues	Correct the text to reflect market	

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				are not relevant for *changes* in the amount of recycling. If additional scrap material is supplied in a situation of full utilisation, this will increase the recycling, while an increased demand will not. In this situation, the credit for substitution exactly provides an incentive to increase supply to recycling. If additional scarp material is demanded in a situation where there is not full utilisation, this will make recycling increase, while an increase in supply will not. In this situation, the low burden of the scrap (and the credit for avoided final waste treatment) exactly provides an incentive to increase use of recyclate.	reactions correctly as described.	
229	14.4.2.5	Last paragraph		The “short.term marginal” is per definition (see page 57) not *installed* but a change within existing capacity.		
230		First bullet		The identification of a marginal producer is not more subjective or normative than any other aspect of LCi modelling, in the sense that it can be substantiated and justified by reference to observable changes in production volume of different producers over time, and thus is amenable for scientific challenge and validation.	Delete	
230	14.4.2.6			Introducing discounting (here wrongly labelled depreciation) in the inventory is an unwarranted mixing of impact assessment into the inventory. If discounting is desired, the important issue is to ensure that the inventory contains the necessary temporal information about the emissions, but the actual discounting should be postponed to the impact assessment as it contains strong elements of valuation. Furthermore, it is unwarranted to apply discounting to recycling credits, if discounting is not applied to all other future emissions as well.	Delete (and add requirement that temporal information is maintained in inventory results)	

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