Comparison of the requirements of the GHG Protocol Product Life Cycle standard and the ISO 14040 series

Bo P. Weidema
2.-0 LCA consultants, Aalborg, Denmark
January 2022

Preface and acknowledgements

This report presents a comparison of the requirements of the GHG Protocol Product Life Cycle Standard and the ISO 14040 series, with the purpose of assessing to what extent a Life Cycle Assessment study performed according to ISO 14044:2006 and ISO 14067:2018 can be applied for reporting according to the GHG Protocol, and what possible additions or modifications may be required for this purpose. The study has been conducted for Mærsk A/S in January 2022 by Bo P. Weidema of 2.-0 LCA consultants.

Copenhagen, 17th January 2022

2.-0 LCA consultants, Denmark

Contents

When citing this report, please use the following reference:
Weidema B P. (2022). Comparison of the requirements of the GHG Protocol Product Life Cycle Standard and the ISO 14040 series. Aalborg, Denmark: 2.-0 LCA consultants.

Executive summary

Both the ISO LCA standards (ISO 14044 and ISO 14067) and the GHG Protocol for Product Life Cycles are open for different interpretations on how to link unit processes into products systems.

In the consequential approach activities are included in the product system to the extent that they are expected to change as a consequence of a change in demand for the functional unit, tracing each required product input, physical or monetary, through the marginal supplier(s) of each product, following verifiable cause-effect relationships, including the consequences of excess supply of by-products from joint production.

In the attributional approach, inputs and outputs are attributed to the functional unit of a product system by linking and/or partitioning the unit processes of the system according to a normative rule. In the ISO 14044 standard, the default approach for allocating to the products of joint production is allocation based on their economic value (revenue).

At first sight, the GHG Protocol for Product Life Cycles is clearly declared as following an attributional approach. However, a closer analysis reveals unclarities and contradictions that opens up for several interpretations, including the specific consequential and attributional interpretations of ISO 14044.

The requirements of the GHG protocol goes beyond the requirements of ISO 14044 on several issues related to carbon accounting, use of primary data for all processes under their ownership or control, reporting of procedures and process maps, and separate reporting of different parts of the overall climate footprints. These requirements are complementary and not in conflict with to those of ISO 14044. In a few cases, requirements to exclude specific issues from the climate footprint results (the effects of offsetting and delayed emissions) are modified by allowing separate reporting of these effects.

In conclusion, an ISO 14044 compliant LCA, whether attributional or consequential, can be used to provide data for the GHG reporting according to the GHG Protocol, provided that 10 additional requirements from the GHG Protocol are fulfilled. These requirements are listed in Box 1. However, when performing an ISO 14044 compliant consequential LCA that is intended to be used for reporting according to the GHG Protocol, particular care is recommended in explaining the system boundaries, the exclusion of constrained processes, and the underlying justifications, to directly address the unclarity in the GHG Protocol as to what is considered ‘attributable processes’.

Box 1. Additional requirements of the GHG Protocol compared to ISO 14044

- Collect primary data for all processes under their ownership or control;
- Report displaced emissions and removals separately from the studied product's end-of-life stage inventory;
- Report attributable processes in the form of a process map;
- Quantify and report biogenic and non-biogenic emissions and removals separately;
- Quantify and report land-use change impacts separately;
- Report when carbon contained in a product is not released to the atmosphere during waste treatment and therefore is considered stored;
- For significant processes, report any efforts taken to improve data quality;
- Do not include offsets in the calculated climate footprint result (Separate reporting is allowed);
- Apply the 100-year GWP factor to GHG emissions and removals to calculate the inventory results in units of CO_2 equivalent;
- Do not include weighting factors for delayed emissions when calculating the climate footprint result (Separate reporting is allowed);
- Quantify and report the cradle-to-gate and gate-to-gate inventory results separately or clearly state that confidentiality is a limitation to providing this information;
- If life cycle stages are defined, quantify and report the percentage of total inventory results by life cycle stage.

1 Objective and scope

This report compares the requirements of the GHG Protocol Product Life Cycle Standard (Bhatia et al. 2011) and the ISO 14040 series. The objective is to assess to what extent a study performed according to ISO 14044:2006 and ISO 14067:2018 can be applied for reporting according to the GHG Protocol, and what possible additions or modifications may be required for this purpose.

The overall international standards for Life Cycle Assessment (LCA) are ISO 14040:2006 and ISO 14044:2006, where the first provides the framework, while the second includes the specific requirements and guidelines. ISO 14067:2018 provides a few more requirements for climate footprints (called 'carbon' footprints by ISO).

In addition to these LCA standards, the World Resources Institute and the World Business Council for Sustainable Development has published a 'GHG Protocol Product Life Cycle Accounting and Reporting' (Bhatia et al. 2011) as part of a family of standards that include also 'GHG Protocols' for 'Corporate Accounting and Reporting', 'Corporate Value Chain (Scope 3) Accounting and Reporting' and 'Project Accounting'. These standards are widely used for corporate GHG reporting.

It is of interest to companies that use the GHG Protocol for reporting, whether their LCAs made according to ISO 14044 can also be used to provide data for the GHG reporting according to the GHG Protocol. This is the core question to be answered by this report.

2 Attributional or consequential modelling?

ISO LCA standards and the GHG Protocol for Product Life Cycles (Bhatia et al. 2011) have little guidance on how to link unit processes into products systems, and this has given rise to two different interpretations of the standards on this point, known as "attributional" and "consequential" approaches to modelling.

In the consequential approach activities are included in the product system to the extent that they are expected to change as a consequence of a change in demand for the functional unit (Sonnemann & Vigon 2011). Consequential modelling seeks to model the potential environmental consequences of changes resulting from a (potential) decision, or as expressed in Clause A.2 of ISO 14040:2006: "environmental consequences of possible (future) changes between alternative product systems". This implies modelling marginal or incremental changes, as opposed to the average modelling implied in the attributional approach. For both marginal and incremental modelling, Clause 6.4 of ISO 14049:2012, applies:
"The supplementary processes to be added to the systems must be those that would actually be involved when switching between the analysed systems. To identify this, it is necessary to know:

- whether the production volume of the studied product systems fluctuate in time (in which case different sub-markets with their technologies may be relevant), or the production volume is constant (in which case the base-load marginal is applicable),
- whether (…) the inputs are delivered through an open market, in which case it is also necessary to know:
  - whether any of the processes or technologies supplying the market are constrained (in which case they are not applicable, since their output will not change in spite of changes in demand),
  - which of the unconstrained suppliers/technologies has the highest or lowest production costs and consequently is the marginal supplier/ technology when the demand for the supplementary product is generally decreasing or increasing, respectively."

A consequential product system thus ensures additionality, i.e., that processes are only included to the extent that they are additional to a baseline without the studied change. In practice, the consequential product system is identified by starting from the unit process(es) of the reference flow, tracing each required product input, physical or monetary, through the marginal supplier(s) of each product, following verifiable cause-effect relationships, including the consequences of excess supply of by-products from joint production. The cost for the purchasing activity, is a revenue for the supplying activity. For each activity, a part of the revenue leaks out as wages, taxes, and profits (together known as "value added"). In a closed steady-state system, all the original revenue must eventually leave the system as value added, thus providing a clear delimitation of the unit processes included in the system. The processes included are limited to those that react to the change in revenue. The marginal suppliers and their technologies can be divided in those that in response to a change in demand for the product will change their production output immediately or within the short-term (i.e., within the current production capacity), and those that in response to an accumulated change in demand for the product will change their production capacity in the long-term. The impacts from the long-term changes in capacity will typically dominate the sum of the short-term and long-term changes. The ILCD Handbook (JRC-IEA 2010, p. 37) recommends that when LCA is used as decision-support, the LCI model should reflect the consequences of the decision. Nevertheless, the ILCD

Handbook has contributed to much confusion by calling such modelling 'attributional', in contrast to the definitions from UNEP (Sonnemann & Vigon 2011).

In the attributional approach, inputs and outputs are attributed to the functional unit of a product system by linking and/or partitioning the unit processes of the system according to a normative rule (Sonnemann & Vigon 2011), "typically as an account of the history of the product" (Clause A.2 of ISO 14040:2006). In Clause 4.3.4.2 of 14044:2006, the default approach for allocating to the products of joint production is allocation based on their economic value (revenue). Therefore, in parallel to the consequential product system, the attributional product system is identified by starting from the unit process(es) of the reference flow, tracing each cost item input to the next upstream unit process. The revenue generated by the original demand must eventually leave the product system as value added, thus providing a clear delimitation of the processes included in the product system. This can be seen as a 'value chain' perspective on LCA (Weidema et al. 2018). Note that unless there is complete proportionality between the physical properties and the revenues for the joint products, the resulting allocated product systems will not be physically balanced (Weidema 2018). In general, a value chain will therefore not reflect the physical causalities of purchasing a product.

Both the consequential and the attributional 'value chain' approach to linking are implemented in the ecoinvent 3 database, applying publicly available algorithms on the same set of unit process data.

At first sight, the GHG Protocol (Bhatia et al. 2011) declares itself clearly as following an attributional approach: "A GHG product inventory shall follow the life cycle and attributional approaches" and in Box 5.1: "Although not followed in this standard, the consequential approach can provide valuable insight in certain applications such as evaluating reduction projects or making public policy decisions". However, the GHG Protocol has its own definition of the 'attributional approach', namely: "An approach to LCA where GHG emissions and removals are attributed to the unit of analysis of the studied product by linking together attributable processes along its life cycle". 'Attributable processes' are in turn defined as "Service, material, and energy flows that become the product, make the product, and carry the product through its life cycle". Since processes are not flows, this opens up for three different interpretations, namely that what is meant could be either of the following:

1) "Attributable processes are *processes that are affected by the demand for the* "service, material, and energy flows that become the product, make the product, and carry the product through its life cycle". This would be an ISO 14044 conform consequential interpretation and is supported by the requirements of the GHG Protocol for dealing with co-products, which is identical to that of ISO 14044, namely "Companies shall avoid allocation wherever possible by using process subdivision, redefining the functional unit, or using system expansion" and the more specific system expansion procedures "For allocation due to recycling, companies shall use either the closed loop approximation method or the recycled content method", and only when this is not possible to apply allocation that reflects physical, economic, or other (causal) relationships between the products. Avoiding allocation through system expansion is not meaningful in a pure attributional interpretation.
2) "Attributable processes are *the processes in the value chain of the* "service, material, and energy flows that become the product, make the product, and carry the product through its life cycle".

This would be a 'value chain' interpretation, conform with the attributional interpretation of ISO 14044.

3) "Attributable processes are *the processes that supply the physical* "service, material, and energy flows that become the product, make the product, and carry the product through its life cycle". This is what has been called a 'supply chain' perspective on LCA (Weidema et al. 2018), which does not find support in the ISO 14044 and requires a further delimitation of the assessment to specific physical properties of the "service, material, and energy flows that become the product, make the product, and carry the product", a complication that is elaborated in the following paragraph.

The physical supply chain of materials and parts may be very different from the supply chain of information, energy, or other services to the same activity. For an unambiguous identification and to provide a physically consistent and balanced system, it is therefore necessary to specify a supply chain in terms of the physical (as opposed to economic) properties it supplies, e.g., mass, energy, or a specific elemental content. The supply chain of an activity is identified by tracing the investigated property backwards in the chain. The input of one activity is either the output of a supplying activity or an external input to the system. In a closed steady-state system, all the input must eventually enter the system as what, in LCA jargon, are called "elementary" flows, i.e., flows that come from the environment without previous human transformation, thus providing a clear delimitation of the activities included in the system. Taking the property mass as example, the sum of all mass inputs over a mass supply chain will equal the mass of the analysed product and all wastes and by-products from the system. When joint production activities are partitioned to obtain the supply chain for a single product, the mass balance for each single-product activity is maintained by partitioning each input proportionally to the share that each joint product has in the overall mass output. In LCA jargon this is known as "mass allocation". If two properties are not intrinsically linked, the supply chain of one property may at some point disengage from the supply chain of the other property, and it then becomes impossible to say which of the two chains should be followed. Thus, each specific supply chain analysis can only trace one specific property (or several intrinsically linked properties). Obviously, it is possible to overlay several supply chains, depending on the purpose of the analysis, and how many properties the decision maker wishes to take responsibility for.

In the GHG Protocol (Bhatia et al. 2011), there is no requirements on which property (or properties) that should be applied to define the attributional chain of processes. A 'value chain' interpretation appears to be in conflict with the statement of the GHG Protocol that "companies are not required to include non-attributable processes" and mentions as examples of these a large number of processes that *do* provide services to 'make the product', and which would be part of the value chain:

- Capital goods (e.g., machinery, trucks, infrastructure)
- Overhead operations (e.g., facility lighting, air conditioning)
- Corporate activities and services (e.g., research and development, administrative functions, company sales and marketing)
- Transport of the product user to the retail location
- Transport of employees to and from works

This seems to point at a narrower 'supply chain' delimitation to the processes that supply the physical materials and energy, which would nevertheless leave the outstanding challenge to separately trace the many different material properties of the product, a task for which there is currently no database and software support. Against this interpretation also speaks the statement at the top of the 'Requirements' Section 5.2 of the GHG Protocol, that "the accounting methodologies and requirements presented in this standard follow the life cycle approach as established by ISO LCA standards 14040 and 14044."

Furthermore, Clause 7.3.5 of the GHG Protocol opens up for the companies to define the inclusion of activities based on relevance, e.g., according to the consequential perspective of reduction potentials: "However, companies should include non-attributable processes in the inventory if they cannot be separated from attributable process data, or if the company determines that the process is relevant to the studied product. Relevance is determined by the company and may be based on many different factors including business goals and reduction potentials, product rules or sector guidance, and relative impact in relation to the rest of the inventory."

Finally, as already mentioned, both the 'value chain' and the 'supply chain' interpretation of the GHG Protocol is challenged by the requirement of the GHG Protocol to deal with co-products as in ISO 14044, namely whenever possible to avoid allocation through process subdivision, redefining the functional unit or using system expansion. If the 'value chain' or 'supply chain' interpretation was intended, there would not have been any reason to use substantial amounts of text on describing system expansion and add specific requirements on its specific implementations in the form of 'closed loop approximation' and 'recycled content' procedures.

In conclusion, in spite of defining its approach as 'attributional', the further definitions of this approach and the further requirements and allowances in the GHG protocol appears to support both an attributional and a consequential interpretation.

3 Carbon accounting

For obvious reasons, the GHG Protocol is limited to accounting for GHGs, more precisely emissions and removals of CO_2, CH_4, N_2O, SF_6, PFCs, and HFCs. A distinction is made between emissions and removals from biogenic sources, non-biogenic sources, and land-use change impacts.

A requirement of the GHG Protocol (Bhatia et al. 2011) that goes beyond the ones of ISO 14044 and ISO 14067 is that "Companies shall report when carbon contained in a product or its components is not released to the atmosphere during waste treatment and therefore is considered stored". ISO 14067 allows separate reporting of stored biogenic carbon, but not the inclusion of this in the climate footprint.

Requirements that go beyond those of ISO 14044 (but not beyond those of ISO 14067) are that:

- "Companies shall apply a 100-year GWP factor to GHG emissions and removals data to calculate the inventory results in units of CO_2 equivalent (CO_2e)" *)
- "Companies shall quantify and report the (…) biogenic and non-biogenic emissions and removals separately when applicable"

*) The term 'inventory result' is used differently in ISO ('outcome of a life cycle inventory analysis that catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment'), i.e., *before* impact assessment, and in the GHG Protocol ("The GHG impact of the studied product"), i.e., *after* impact assessment.

- "Companies shall quantify and report the (…) land-use change impacts separately when applicable"
- "Companies shall not include the following when quantifying inventory results: weighting factors for delayed emissions; offsets; and avoided emissions" *)[†]

With respect to the first of these four requirements, it is relevant to be aware that the 100-year GWP metric gives 4-5 times less weight to CH_4 emissions than if using direct radiative forcing that better reflect the speed of change and thus the main impacts on nature. The tendency in the LCA community is to work with separate metrics for the rate of change and the longer-term temperature effects mainly relevant for human health, as recommended by UNEP (Levasseur et al. 2016): "To represent the complexity of climate change impacts, more than one impact category is needed. Therefore, in LCA application, we recommend considering two separate impact categories for climate change (shorter-term related to the rate of temperature change, and long-term related to the long-term temperature rise)."

Also, the three issues in the last-mentioned requirement calls for commenting:
Delayed emissions: The wilful disregard for the effects of delayed emissions, which in ISO 14067 is explicitly formulated as "All GHG emissions and removals shall be calculated as if released or removed at the beginning of the assessment period without taking into account an effect of delayed GHG emissions and removals" is in direct conflict with the recommendation of ISO 14044 that "spatial and temporal differentiation of the characterization model relating the LCI results to the category indicator should be considered". The disregard for the effects of delayed emissions implies that no benefit is calculated for the temporal postponement of land use change (also known as indirect land use change), and no benefit is calculated for the temporal postponement of emissions when carbon-containing materials are kept in capital stocks or recycled as a material after use, so that they remain unreleased longer than they would have if they had been left in nature. Calculating CO_2 emitted in year 100 with the same impact factors as CO_2 emitted in year 0, fails to consider that an emission now creates more damage than the same emission later, because impacts on human health are expected to be mitigated through adaptation (Smith et al. 2014) and impacts on nature mainly depend on the speed of change, which is currently very high and decreases with the expected stabilisation and eventual decline of overall emissions (Collins et al. 2013). However, ISO 14067 allows that delayed emissions "may be documented separately" in the study report, and the GHG Protocol similarly suggests that "Companies may show the impact of delayed emissions and removals separately from the inventory results."
Offsets: Both ISO 14067 and the GHG Protocol define 'offsets' (GHG Protocol) or 'offsetting' (ISO 14067) as occurring 'outside the boundary of the product's life cycle' (GHG Protocol) or 'outside the product system' (ISO 14067), which makes it obvious that it should not be included in the calculation results, and must be declared separately from the LCA results, even for a product that is sold with an explicit declaration that part of the revenue from the product goes to offset an explicit amount of the impacts from the product's life cycle. However, the current definitions do not provide any explanation of what offsetting *is*, as opposed to the removals that occur as part of the product's life cycle and which it *is* required to include. A more precise and explicit definition of offsetting would be: "Activities that are performed with the explicit purpose of counterbalancing the effects of the impacts caused by the product system, but are not required

*) See footnote on the previous page.

for, occurring as consequences of, or intended to affect the amount of inputs and outputs from the product system itself."
Avoided emissions: It is unclear if this is just another word for offsets or if other forms of avoided emissions exist, considering that removals are *required* to be included in the inventory, and that the GHG protocol explicitly states that "Avoided emissions as defined here are not the same as emissions reductions that occur due to directly attributable reduction projects, or allocated emissions using the system expansion allocation method".

In spite of the above comments, there is nothing in the additional requirements of the GHG Protocol that could not be met by an LCA according to ISO 14044.

4 Additional requirements of the GHG Protocol for the Product Life Cycle

In addition to the above-mentioned requirements, the GHG Protocol (Bhatia et al. 2011) contains the following requirements that are not requirements in ISO 14044:

- "Companies shall collect primary data for all processes under their ownership or control"
- "For significant processes, companies shall report (…) any efforts taken to improve data quality"
- "When using the closed loop approximation method, companies shall report displaced emissions and removals separately from the studied product's end-of- life stage inventory"
- "Companies shall report attributable processes in the form of a process map"
- "Companies shall quantify and report the (…) cradle-to-gate and gate-to-gate inventory results separately or a clear statement that confidentiality is a limitation to providing this information"

Additional requirements that go beyond those of ISO 14044 (but not beyond those of ISO 14067) are that "Companies shall quantify and report the percentage of total inventory results by life cycle stage". However, there is no explicit requirement to have more than one life cycle stage.

While the mentioned additional requirements may involve some extra efforts, they are complementary and not conflicting with those of ISO 14044.

5 ISO 14044 series requirements not included in the GHG Protocol

Besides the additional requirements mentioned in Chapter 4, the GHG protocol (Bhatia et al. 2011) is generally less elaborate than ISO 14044 and ISO 14067. The additional or stricter ISO requirements are not described in detail here, considering that the scope of the current report is to assess the applicability of an ISO compliant LCA to fulfil the requirements of the GHG Protocol, and not vice versa.

Nevertheless, it is relevant to mention the GHG Protocol requirement that "Companies shall disclose and justify any exclusions of attributable processes in the inventory report". The corresponding requirements in ISO 14044 are that "decisions regarding the data to be included shall be based on a sensitivity analysis to determine their significance" and "The deletion of life cycle stages, processes, inputs or outputs is only permitted if it does not significantly change the overall conclusions of the study." Although the ISO 14044 requirements are stricter than the corresponding requirement of the GHG Protocol, the uncertainty of what is to be considered ‘attributable processes’ warrants particular care in explaining the system boundaries, the exclusion of constrained processes, and the underlying justifications, when performing an ISO 14044 compliant consequential LCA that is intended to be used for reporting according to the GHG Protocol.

6 Conclusion

In spite of the GHG Protocol framing its LCA approach as ‘attributional’, the closer analysis presented in Chapter 2 of this report shows that the GHG protocol supports both an attributional and a consequential interpretation. An LCA performed according to ISO 14044, whether consequential or attributional, can thus also be seen as conform with the GHG Protocol and can therefore be used to provide data for the GHG reporting according to the GHG Protocol, provided that the following additional requirements from the GHG Protocol are fulfilled:

- Collect primary data for all processes under their ownership or control;
- Report displaced emissions and removals separately from the studied product’s end-of-life stage inventory;
- Report attributable processes in the form of a process map;
- Quantify and report biogenic and non-biogenic emissions and removals separately;
- Quantify and report land-use change impacts separately;
- Report when carbon contained in a product is not released to the atmosphere during waste treatment and therefore is considered stored;
- For significant processes, report any efforts taken to improve data quality;
- Do not include offsets in the calculated climate footprint result (Separate reporting is allowed);
- Apply the 100-year GWP factor to GHG emissions and removals to calculate the inventory results in units of CO_2 equivalent;
- Do not include weighting factors for delayed emissions when calculating the climate footprint result (Separate reporting is allowed);
- Quantify and report the cradle-to-gate and gate-to-gate inventory results separately or clearly state that confidentiality is a limitation to providing this information;
- If life cycle stages are defined, quantify and report the percentage of total inventory results by life cycle stage.

References

Bhatia P, Cummis C, Brown A, Drauker L, Rich D, Lahd H. (2011). Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard. Washington DC: World Resources Institute and World Business Council for Sustainable Development.

Collins M, Knutti R, Arblaster J, Dufresne J-L, Fichefet T, Friedlingstein P, Gao X, Gutowski W J, Johns T, Krinner G, Shongwe M, Tebaldi C, Weaver A J, Wehner M. (2013). Long-term Climate Change: Projections, Commitments and Irreversibility. Pp. 1029-1136 in: Stocker et al.: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

JRC-IEA. (2010). International Reference Life Cycle Data System (ILCD) Handbook – General guide for Life Cycle Assessment – Detailed guidance. First edition March 2010. Publications Office of the European Union, Luxembourg. Available at <http://lct.jrc.ec.europa.eu/>

Levasseur A, de Schryver A, Hauschild M, Kabe Y, Sahnoune A, Tanaka K, Cherubini F. (2016). Greenhouse gas emissions and climate change impacts. Pp. 58-75 in Frischknecht & Jolliet: Global Guidance for Life Cycle Impact Assessment Indicators. Volume 1. Paris: United Nations Environmental Programme.

Smith K R, Woodward A, Campbell-Lendrum D, Chadee D D, Honda Y, Liu Q, Olwoch J M, Revich B, Sauerborn R. (2014). Human health: impacts, adaptation, and co-benefits. Pp. 709-754 in Field et al.: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Sonnemann G, Vigon B. (2011). Global Guidance Principles for Life Cycle Assessment Databases. Paris/Pensacola: UNEP/SETAC Life Cycle Initiative.

Weidema B P. (2018). In search of a consistent solution to allocation of joint production. Journal of Industrial Ecology 22(2):252-262.

Weidema B P, Pizzol M, Schmidt J, Thoma G. (2018). Attributional or consequential Life Cycle Assessment: A matter of social responsibility. Journal of Cleaner Production 174:305–314.