Biogenic Carbon Accounting in a LCA framework

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CONSTRUCTION - PULP AND PAPER - WOODWORKING - TEXTILE - BIO-CHEMICALS

Presenter
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WP1: Shared modelling framework and learnings
T1.2: Framework for foreground life cycle inventory of bio-based sectors
T1.3: Framework for Life Cycle Impact Assessment

Massimo Pizzol (AAU)

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Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Problem: how to inventory carbon flows?

- Bio-based products have different lifetimes and end of lives
- Carbon uptake and release at different points in time
- The impact of carbon uptake and release depends on the timing
- *"A **dynamic** LCA approach allows for a consistent assessment of the impact, through time, of all GHG emissions (positive) and sequestration (negative)"* (Levasseur et al., 2013, 2010)

- What are the dynamics of carbon uptake and emissions in biobased products?
- How can we make a LCA inventory that considers these dynamics accurately?
- Will this LCA model improve the assessment of biobased products?

Levasseur, A., Lesage, P., Margni, M., Deschĕnes, L., Samson, R., 2010. Considering time in LCA: Dynamic LCA and its application to global warming impact assessments. Environ. Sci. Technol. 44, 3169–3174. https://doi.org/10.1021/es9030003
Levasseur, A., Lesage, P., Margni, M., Samson, R., 2013. Biogenic Carbon and Temporary Storage Addressed with Dynamic Life Cycle Assessment. J. Ind. Ecol. 17, 117–128. https://doi.org/10.1111/j.1530-9290.2012.00503.x

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When is a dynamic approach relevant?

- ✅**Long-rotation feedstocks** forest plantations (rotation times up to 150 years) with slow carbon uptake
- ✅**Long-lived products** wood and other construction materials with 100 years or more use stages

(see e.g. De Rosa et al. 2017, 2019 for examples)

- ❌ Less relevant for short-lived products from short-rotation feedstocks (e.g., plant-based bioplastic intended for food packaging).
    - Carbon uptaken and released quickly
    - Dynamic model still formally more accurate but practically “overkill”
- ✅ Short or long rotation feedstocks where **long-term carbon storage in soil**

De Rosa, M., Pizzol, M., Schmidt, J., 2018. How methodological choices affect LCA climate impact results: the case of structural timber. Int. J. Life Cycle Assess. 23, 147–158. https://doi.org/10.1007/s11367-017-1312-0
De Rosa, M., Schmidt, J., Brandão, M., Pizzol, M., 2017. A flexible parametric model for a balanced account of forest carbon fluxes in LCA. Int. J. Life Cycle Assess. 22, 172–184. https://doi.org/10.1007/s11367-016-1148-z

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Accounting for biogenic CO2

Credits: Lorie Hamelin
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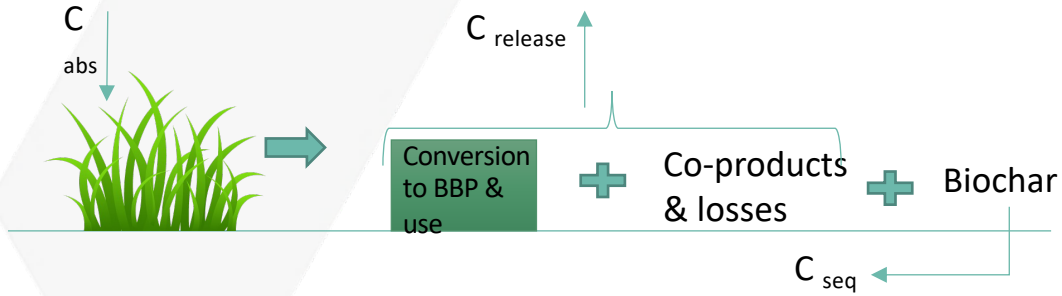
0/0 approach: Absorbed and released CO2 with a CF of 0 (kg CO2e/kg CO2; GWP metric). Induced sequestration with a CF of +1 (while flux accounted as minus).



Issues:

- False impression that there are no climate effects from use of biomass
- Important carbon flows made invisible
- Mass balance distorted when C emitted back as CH4, CO, etc.
- Temporary storage when biomass is harvested but not 'emitted' immediately is not reflected

Relevant litterature: Cucurachi et al. (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC129632;; TfS (2022). https://www.tfs-initiative.com/how-we-do-it/scope-3-ghg-emissions; EC (2018). https://eplca.jrc.ec.europa.eu/permalink/PEFCR_guidance_v6.3-2.pdf

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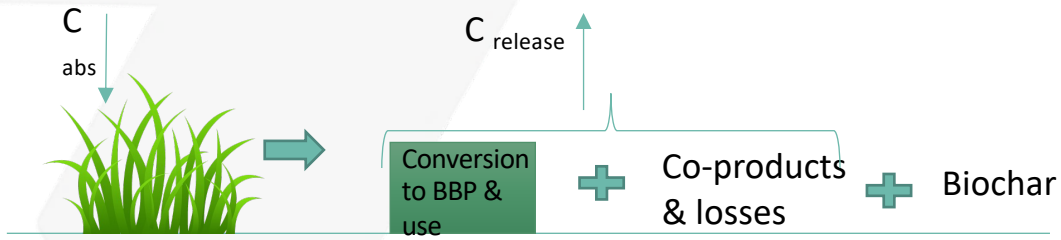
Accounting for biogenic CO2

-1/+1 Approach: Uptake from the atmosphere accounted with a CF of -1, releases to atmosphere with a CF of +1. Only net flows are accounted (so sequestration not assigned a flow).



Issues:

- Misleading results when system boundary is cradle-to-gate (C-negative products)
- How to account for the absorption ?
  - Equal to C in the product. Neglects C flows absorbed by the biomass but not converted to the product (crop residues, below-ground, conversion losses, etc.). This error can be problematic especially if these losses do not occur as CO2, or if they occur later in time.
  - Based on NPP / crop yield. To adopt this more rigorous approach, guidelines and suggestions of generic values needed

Relevant litterature: Cucurachi et al. (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC129632;; TfS (2022). https://www.tfs-initiative.com/how-we-do-it/scope-3-ghg-emissions; EC (2018). https://eplca.jrc.ec.europa.eu/permalink/PEFCR_guidance_v6.3-2.pdf

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How much are these used?

- 0/0 Used in PEF/PEFCR
- Most industrial guidelines seem to prefer +1/-1 approach

Table 2

Standard methods to account biogenic carbon.

Standardized guidance for product-level data	Approach
PEFCR (European Commission, 2017)[a], SIA 2032 (SIA, 2020)	0/0
PAS 2050 (BSI, 2011), EN 15804+A2; 2019 (CEN, 2019), ISO 14067 (ISO, 2018) and ISO 21930 (ISO, 2017a)	−1/+1

[a] For cradle to grave assessments of final products with a life time of less than 100 years.

Ouellet-Plamondon et al. (2023). https://doi.org/10.1016/j.jclepro.2023.136834

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Credits:

Agneta Ghose

Kíra Lancz

EN 16760:2015 Bio-based products: LCA

Common standard for: terminology, bio-based content determination, LCA, sustainability aspects, declaration tools. Based on ISO 14040/44, products partially or wholly derived from biomass *excluding: food, feed, energy.*

Fossil and biogenic carbon flows

- Biogenic carbon: “carbon derived from biomass”
- Both fossil and biogenic carbon need to be accounted for
- “GHG emissions and removals arising from fossil and biogenic carbon sources and sinks shall be included and listed separately in the inventory”

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EN 16760:2015 Bio-based products: LCA

Modelling fossil and biogenic carbon flows

-1/+1

- -1: atmospheric carbon fixation during growth
- +1: carbon emitted to air, water, soil during production AND carbon permanently sequestered
- Also include biogenic emission to air, water and soil at the end-of-life

0/0 also accepted (all C inventoried but then 0 value of characterization factor)

Temporal: ILCD method

- CFP[temp,Storage] = - Σm[i]*t[s]*GWP[IPCC,i]/100
- m = mass of GHG i removed; t[s] = time of temporal removal/storage
- t[s] to be documented separately
- Removal over 100 years = indefinitely stored

Why linear function of time when GWP is nonlinear?

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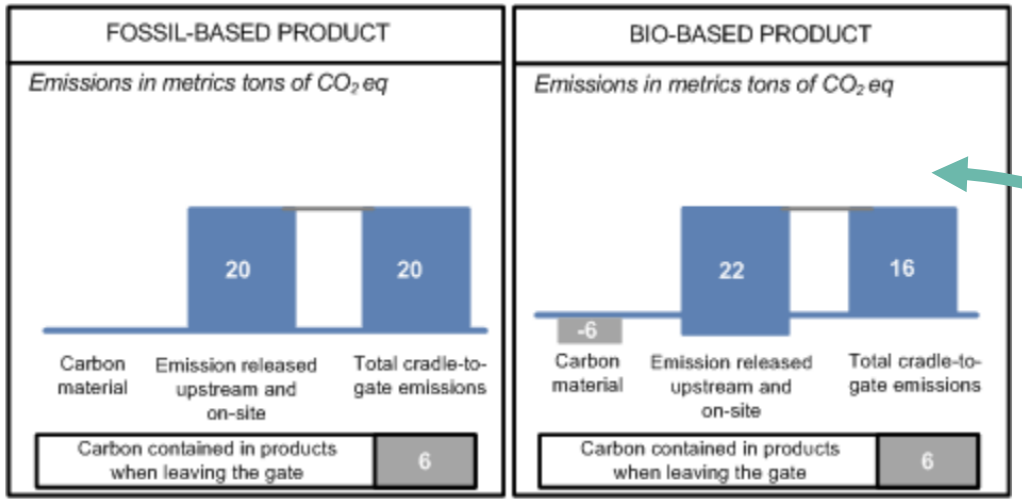

Figure B.1 — Cradle-to-gate inventory for a bio-based/fossil-based product

Example of misleading result?

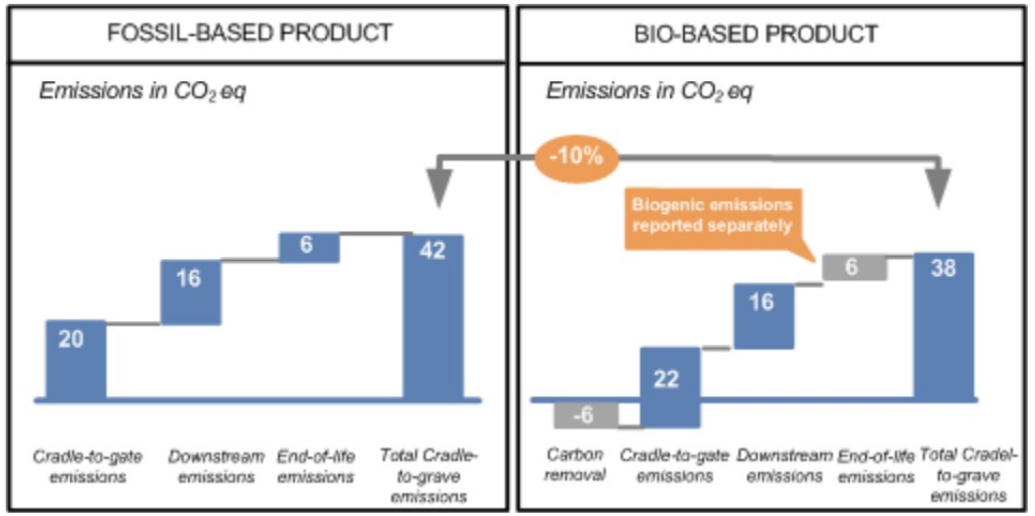

Figure B.2 — Cradle-to-grave inventory for a bio-based/fossil-based product

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Wrap-up: some best practices

- Accounting for all C flows, either absorbed or emitted, as they are (CO2, CO, CH4)
- Conservative choices on releases for cradle-to-gate studies to avoid C-negative products (and misinterpretations) = (no -1/0)
- C Bio/fossil/both? Include at least one indicator integrating both

Relevant litterature: Cucurachi et al. (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC129632; Ouellet-Plamondon et al. (2023). https://doi.org/10.1016/j.jclepro.2023.136834 ; TfS (2022). https://www.tfs-initiative.com/how-we-do-it/scope-3-ghg-emissions; EC (2018). https://eplca.jrc.ec.europa.eu/permalink/PEFCR_guidance_v6.3-2.pdf

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