IEooc_Methods4_Exercise6a: Compilation of process inventories for LCA from literature sources

Goal: *Learn about the standard procedure for extracting data from the literature and using them in your own LCA in openLCA. Follow the four steps: (1) Convert raw data to a material and energy flow analysis diagram. (2) Scale down stocks down to represent them as consumption of fixed capital flows. (3) convert process descriptions to unit process inventories. (4) Add unit process inventories as foreground processes to the ecoinvent database.*

Note: *For this exercise an ecoinvent licence for openLCA is needed. If no license is at hand, the exercise can be modified, using the freely available life cycle databases on the openLCA Nexus.*

Background: For a given functional unit, a product system needs to be constructed, which describes the section of the global economy that covers the production, use, and recycling/disposal stages of all products and services that are part of the functional unit's reference flow. In standard LCA, with the Leontief IO model, the flows in the product system x are determined by the model equation $x = Ly$, where $L = (I-A)^{-1}$ is the Leontief matrix, y the reference flow for the functional unit, I the unit matrix of ones on the diagonal, and A the technology matrix, where each column describes the unit processes of the different production technologies and markets.

The processes described by A are typically divided into foreground and background processes, where foreground processes are specific to the functional unit at hand and describe the production, use, and recycling/disposal stages that are directly linked to the reference flows. For example, if the functional unit is a dinner for two, the reference flow might include a tomato salat, and a specific regional tomato farming process would then be part of the foreground system. Background processes describe the production, use, and recycling/disposal stages of generic products and services used at higher supply chain stages. For example, the electricity and natural gas input to the fertilizer production for the tomato farming would be modelled via the generic electricity mixes and natural gas markets in the background process database (e.g., ecoinvent), unless the research question/goal&scope definition requests us to include more specific data.

Scope: For a given functional unit, often, new foreground process inventories have to be added to an existing database. Data sources for these foreground processes include the scientific literature, company or industry association reports, or internal data.

This exercise-tutorial contains a description of the canonical steps to follow when extracting process descriptions from the literature and using them in an own LCA as foreground data.

Industrial Ecology Open Online Course (IEooc)

Part II Methods

Methods part 4 (Life cycle assessment)

http://www.teaching.industrialecology.uni-freiburg.de/

Task: Conduct a simple cradle-to-gate analysis of hydrogen production, focussing on climate pressure and primary energy demand. Use foreground data supplied by a literature source (Bareiß et al., 2019). Goal and scope: Here, functional unit and reference flow shall be identical: 1 kg of H_2, dried, with a standard quality of 5.0 and 30 bar pressure at 60 °C operating temperature.

Hint: This exercise is partly a tutorial, so it's recommended to check with the sample solution for this exercise regarding what is expected for the different steps.

Steps to be taken:

1) Define the MEFA process diagram and convert to an LCA flow diagram for the reference flow. (No numbers are needed at this stage.)
2) Quantify both the MEFA and the LCA process descriptions with the available data from the main source (Bareiß et al., 2019) for its designed capacity and over its actual lifetime. Use the "near future" technology variant in the reference, cover both the electrolyser (Tables 1 and 2) and the ancillary materials (balance of plant, Table 3) and document your calculations!
3) Convert the LCA process description into a unit process for the reference flow 1 kg of H_2.
4) Define the LCA product system (graphical) by linking the electrolyser process (foreground) to a generic background of material and energy supply as well as recycling and waste treatment.
5) Transfer your LCA product system description to openLCA+ecoinvent and document this step.

References

Bareiß, K., de la Rua, C., Möckl, M., & Hamacher, T. (2019). Life cycle assessment of hydrogen from proton exchange membrane water electrolysis in future energy systems. *Applied Energy*, *237*, 862–872. https://doi.org/10.1016/j.apenergy.2019.01.001

This paper is available open access, the data relevant for this work can be found in Tables 1, 2, and 3.