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bw_timex: a software package for time-explicit life cycle assessment

Timo Diepers [1], **Amelie Müller** [2,3], **and Arthur Jakobs** [4]

1 Institute of Technical Thermodynamics, RWTH Aachen University, Germany **2** Institute of Environmental Sciences (CML), Leiden University, The Netherlands **3** Flemish Institute for Technology Research (VITO), EnergyVille, Belgium **4** Technology Assessment Group, Laboratory for Energy Analysis, Center for Nuclear Engineering and Sciences & Center for Energy and Environmental Sciences, Paul Scherrer Institut (PSI), Villigen PSI, Switzerland

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Summary

bw_timex is a Python package for time-explicit Life Cycle Assessment (LCA) that quantifies environmental impacts of products and processes over time. It accounts for:

- the timing of processes throughout the supply chain (e.g., end-of-life treatment occurs 20 years after construction),
- variable and/or evolving supply chains and technologies (e.g., increasing shares of renewable electricity in the future), and
- the timing of emissions (e.g., enabling the use of dynamic characterization functions).

To achieve this, bw_timex uses graph traversal to propagate temporal information through the product system and then automatically re-links Life Cycle Inventories (LCIs) across LCI databases representing specific points in time. The resulting time-explicit LCI reflects the current technology status within the product system at the actual time of each process. Moreover, bw_timex preserves the timing of emissions, enabling advanced dynamic characterization methods alongside standard static characterization factors.

Statement of need

LCA traditionally assumes a static LCI, in which all processes occur simultaneously and do not change over time. To add a temporal dimension in LCA, the fields of dynamic LCA (dLCA) and prospective LCA (pLCA) have emerged. While dLCA focuses on when emissions occur and how impacts are distributed over time, it typically assumes the underlying product system remains unchanged. Conversely, pLCA tracks how processes evolve using future scenarios but generally only assesses a single discrete point in time, overlooking that processes occur at different times across a product's life cycle. Both fields have seen open-source tool development in recent years, including `Temporalis` for dLCA and `premise` and `pathways` for pLCA. However, a comprehensive open-source package for joint dynamic-prospective LCA, i.e., time-explicit LCA, has been lacking until now.

bw_timex addresses this gap by providing a framework for time-explicit LCA calculations within the Brightway ecosystem. It enables accounting for both the timing of processes and emissions as well as the state of the product system at the respective points in time. This makes bw_timex particularly useful for studies involving variable or strongly evolving product systems, long-lived products, and biogenic carbon.

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References