Quality assessment of life cycle inventory data for composites

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1 General Introduction

Environmental sustainability over the life cycle of a product is rising as a key driver in the selection of materials and manufacturing processes. Life cycle assessment (LCA) is increasingly used as a standardised, science-based decision-making support tool to quantify and identify potential environmental impacts through all phases of the product life.

A major step involved in completing a Life Cycle Inventory (LCI), and so an LCA study, is the collection, analysis, and quality check of data on the investigated processes, data to quantify the inputs and output (e.g., elementary flow of raw materials, energy, waste, and co-products) of the product system that crosses the LCA study system boundary.

Complete data is a critical aspect and an integral part of any scientific endeavor and protocol. Data quality in LCI is the key success factor in the acceptance of LCA results, due to the nature of the validity methodology. Data quality is rarely considered by the LCA community (i.e., Sensitivity and Uncertainty Analysis, expert peer and critical third-party reviewers) leading to low confidence in the LCA interpretation.

With LCA, there is no feedback mechanism to filter out faulty analyses. Here, confidence in outcomes can be based only on the quality of the input data and the quality of the models used [1].

The survey of unresolved problems in LCA conducted by Reap *et al* [2], identified that the data quality was one of the problems to be only partially solved by existing methods. Consequently, this limited the power and reliability of LCA reported by a number of authors [3].

The first Society of Environmental Toxicology and Chemistry (SETAC) and United Nations Environment Programme (UNEP) workshop on LCA in the late 90s and early 2000s recommended broad guidelines on reporting data quality characteristics and tools in response to current LCA data quality standards of ISO 14040 series (currently ISO 14044/44:2006).

Various entities within the LCA community have developed different methodologies to address and communicate the data quality of LCI data. There are two dominant examples of semi-quantitative methods. First, the pedigree matrix approach refined and used by Ecoinvent database. Second, the data quality ranking system and the related guidelines used by the International Reference Life Cycle Data System (ILCD) which are included in the Sphera (was Gabi) database as one of the Data Quality Indicators (DQI). Also, a qualitative pass/fail method is used by the USDA LCA Commons.

The LCA community is still plagued by the lack of reproducible data quality, and data quality assessment is not currently widely practiced in LCA studies [4].

A clear example is the data quality assessment (DQA) of the sources and the generation of the major LCA databases (i.e., Ecoinvent, Sphera). Despite that, they are most informed in the metadata and in the integrated LCI documentation. The metadata are not fully transparent. Questions arise about the clarity and the quality of the data generation and the reliability of the original sources.

Data quality might degrade from source to the data generator then to the data selection user. When specific materials data is not available, it is common practice to select “best fit proxies”. The closeness of the match will affect the total study DQA. It is common to make full LCA studies and environmental declarations from LCA results using different sources and different proxies without considering the DQA of the LCI and the implications on the quality of the LCA results. This is a risky approach, as the environmental conditions can have different study goals and scopes. Also they may be very different supply chains, technologies, models, different regions, and countries [5].

2. Background, Goal, and Scope.

Over the past decade, the composites industry has recognised the importance of environmental sustainability as a major emerging contributor in all sectors leading to a substantial increase in the number of LCAs conducted and published in both the academic and grey literature.

The current rigid standards and guidelines use the world's most consistent and transparent LCI databases (Ecoinvent, Sphera) in addition to the European reference Life Cycle Database (ELCD) and, specifically for composites, the European Composites Industry Association (EuCIA) Eco Impact calculator database. Close examination has revealed concerns about quality of the data used in the conducted LCA studies.

The concerns were related mainly to the following issues. The LCI data in databases is often harvested from the academic literature which is peer reviewed but not subjected to rigorous audit. All the polyester resin data traces back to the same industry report that has not explicitly described the goal and scope and does not have a clear system boundary. Further, the report is not directly accessible in the public domain.

Similar concerns relate to the reproducibility of the available LCAs studies in composites, the variability of data results, the variety of background data set modeling, in addition the proxy selection methods for the composites *in lieu* of specific data, to name a few.

The potential broad range of values available in composites LCI databases and the proxies selection may prove an issue for comparative LCA and provide misleading results leading to inaccurate conclusions and potentially condemning a composite solution relative to other materials.

The goal of this study is to provide LCA practitioners in the composites industry with an approach to assess the overall quality of LCI results by integrating the qualitative and quantitative information of input data, uncertainty, and sensitivity analysis of results.

The main objectives of the study:

- To review several LCA data quality assessment methods.
- To review the quality of composite materials data in the LCI databases and literature.
- To consider the implication of composites DQA on composites comparative LCA product results.
- To assess and integrate the DQA in the proxy selection methodology in LCI composite dataset.

Life cycle assessment (LCA) data quality issues and the approach are under investigation using a case study of a yacht production line.

Software Used

- SimaPro with Ecoinvent Database.
- Gabi with Sphera Database.
- Eco Impact Calculator for composites.
- Open LCA with USLCI Database.

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