LCA

(LIFECYCLE ASSESSMENT)

Written by:

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Manufacturers face growing regulatory, societal, and business pressure to adopt sustainable production practices, hence the need for a better way to gain insights into the impacts of production processes. A lifecycle assessment, or LCA, facilitates transparent and credible environmental accounting, typically throughout the entire lifecycle of a product. It does this by breaking down the product lifecycle in various inputs and outputs at each stage of the process, such as the extraction of raw materials, logistics, production, and disposal, recycling, or reuse.

The results of an LCA span several environmental categories, such as those impacting climate change, toxicity, particulate matter, acidification, land transformation, and water use. These impact categories depend on the particular impact method used within an LCA. When an LCA focusses on a single category, such as climate change or water usage, the results are often called footprints. Normally, however, an LCA will assess the impact on several effects or categories by applying an extensive impact assessment method.

An LCA report should typically include the entire lifecycles of several products. An LCA is used to compare the impact of several similar products or different scenarios. This is called a cradle-to-

grave LCA, which incorporates the end-of-life treatment of the product. Some reports may, however, be more limited in their scope. These are cradle-to-gate reports, which address the extraction of raw materials in a manufacturing stage. Cradle-to-gate reports are better-suited to intermediary products or materials, since they can be used to aggregate the impacts of the production of more complex products. An LCA can also take on other forms, spanning specific segments of a production process, such as gate-to-gate, and closed-loop production models.

LCAs are typically used to assess the environmental impact of a production process (ELCA), although other domains, such as lifecycle costing, are also possible. A lifecycle cost analysis, also known as an LCC or LCCA, follows a similar framework, albeit in the context of the total financial cost of an asset or investment throughout its service life. In the manufacturing space, this means a comprehensive analysis of the total cost of producing a final product or an intermediary one. It goes beyond the relatively simple first-cost analysis to evaluate the long-term costs and financial risks. Typical outputs of an LCCA report include the total cost of the investment in a given product, the return on investment, total cost of ownership (TCO) and the payback period.

To summarise, ELCAs and LCCAs answer different questions: one determines environmental impact and the other determines the total cost of ownership. However, by combining the two frameworks, manufacturers can build a strong business case for environmental and economic sustainability. This is particularly relevant when evaluating the effectiveness of new production methods, such as WAAM.

The key steps of a lifecycle assessment

The two most widely recognised standards governing LCAs are ISO 14040, which covers the principles and frameworks, and ISO 14044, which covers the requirements and guidelines. To validate the authenticity and accuracy of an LCA report, it must be reviewed by a neutral third party. Performing an LCA spans several key phases, which broadly cover the following areas:

The first stage concerns the goal and scope of the assessment. The main criteria to define is the part of the product lifecycles to be analysed, typically cradle-to-gate or cradle-to-grave. For a comprehensive report into the sustainability of WAAM as a production method, manufacturers should typically focus on the latter. In WAAM, this begins with the extraction of raw materials, such as crude gasses and ores. The next, and typically the broadest, stage is manufacturing itself, which includes transport, the refinement of raw materials, wire metal production, finishing, and

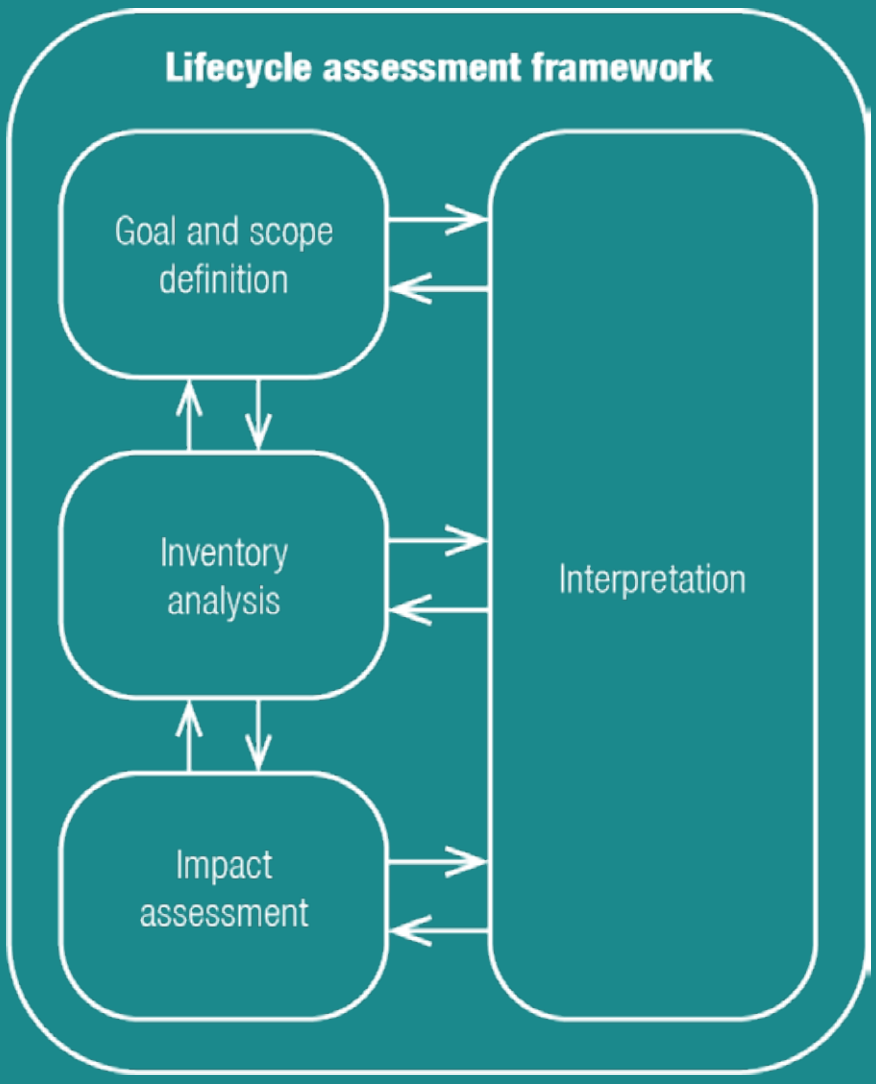

Figure 1: LCA structure according to ISO 14040

assembly of a final product. Next is the fuel or energy consumption of the finished product during use. Finally, a cradle-to-grave LCA will assess the recycling and disposal of the product at the end of its life. In the case of intermediary parts or materials, the end-of-life analysis may be consolidated into an LCA report for the final product.

The next stage is to perform an inventory analysis. This gives a comprehensive description of the materials and energy required within the production system. The lifecycle inventory (LCI) must be thoroughly documented with the accurate collection, aggregation, and validation of data. Furthermore, data must be related to unit processes and functional units to obtain a complete picture into the elementary inputs and outputs of a given production model.

The next stage is to use the information collected for the inventory analysis to create an impact analysis. The lifecycle impact assessment (LCIA) serves to evaluate the potential impact of a product and its constituent production processes on the environment and human health. Both the ISO 14040 and 14044 standards require the selection of impact categories and a thorough classification and characterisation of those impacts. Optionally, the LCIA may also incorporate the normalisation, grouping, and weighting of results under one or more lifecycle phases. Over time, many different impact assessment methods have been developed. Selecting an appropriate IAM is an important decision and one that will significantly influence the results.

The fourth and final stage is the interpretation of the LCA. This involves compiling the report and, optionally, handing it over to a neutral third party for validation and publication. This report can be presented in the form of diagrams providing visibility into the environmental performance of WAAM as compared to conventional manufacturing processes.

Carrying out a lifecycle cost analysis follows a similar process to that described above, albeit from a financial perspective. Another key difference is that an LCCA report is purely an internal document, which manufacturers can use to determine the cost advantage, if any, of adopting WAAM production processes. Furthermore, the findings from an LCA environmental report can also help to better quantify the total cost savings of adopting WAAM. After all, when it comes to environmental sustainability, the gap between what is better for the environment and what is better from a business and financial perspective is steadily closing.

What can manufacturers do with the results?

Consumers and government regulators are demanding greater accountability and attention to corporate social responsibility (CSR) and environmental sustainability. Another important reason for adopting the LCA principles and framework is the transition towards a circular economy. An LCA can also show the relations of different partners within a value chain. Manufacturing firms, particularly given their often-complex global supply chains, are under increasing scrutiny. As such, it can be highly advantageous for manufacturers to measure and communicate the environmental and social impacts of their products and services. Performing an LCA is not only a legal necessity in the case of existing manufacturing operations, but also a reliable tool for identifying new opportunities across increasingly complex supply chains and shared responsibility models. ■