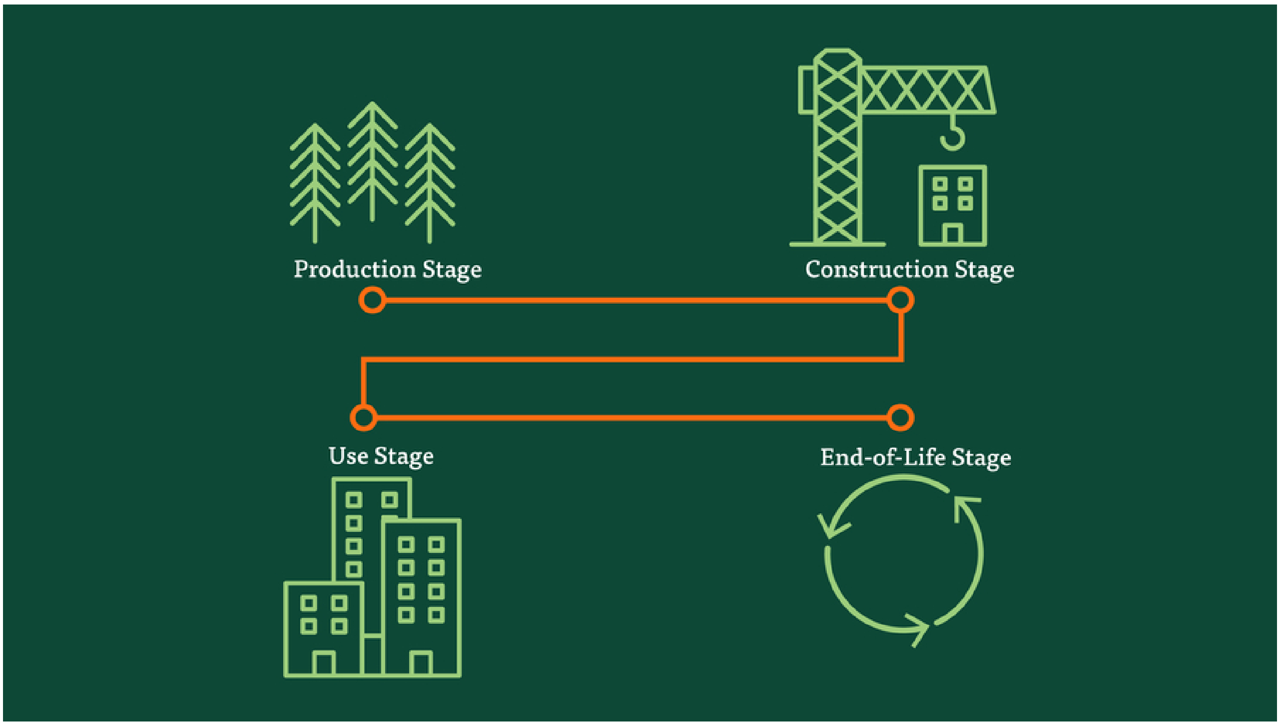
Expert Tips

Introduction to Whole Building Life Cycle Assessment: The Basics

A summary of life cycle stages and considerations for choosing tools and performing whole building life cycle assessments.



Life cycle assessment (LCA) is a systematic way of compiling and analyzing all the inputs, outputs, and potential environmental impacts of a product or system over its lifetime, from initial extraction of raw materials through manufacture, distribution, use, and final disposal. In the context of buildings, LCA can be used to evaluate a single product—like a 2×4, an engineered wood beam, or a mass timber floor panel. It can also be used to analyze an entire building system by compiling data from all the individual building components. This is referred to as Whole Building Life Cycle Assessment (WBLCA) to differentiate it from assessments focused on individual products or building components.

WBLCA has emerged as an effective way to measure embodied carbon and other environmental impact measures associated with buildings at a holistic level.

Because variables such as material choice, structural layout, design optimization, and many other factors combine to determine the lifetime carbon impact of a building, it's important to perform WBLCAs early enough in the project planning phase to help inform these decisions.

Life Cycle Stages

Life cycle assessment is governed by several international standards, notably ISO 14040 and 14044. Additionally, ISO 21930, which provides the framework and requirements for environmental product declarations (EPDs) for construction products and services, defines the following four stages of the life cycle:

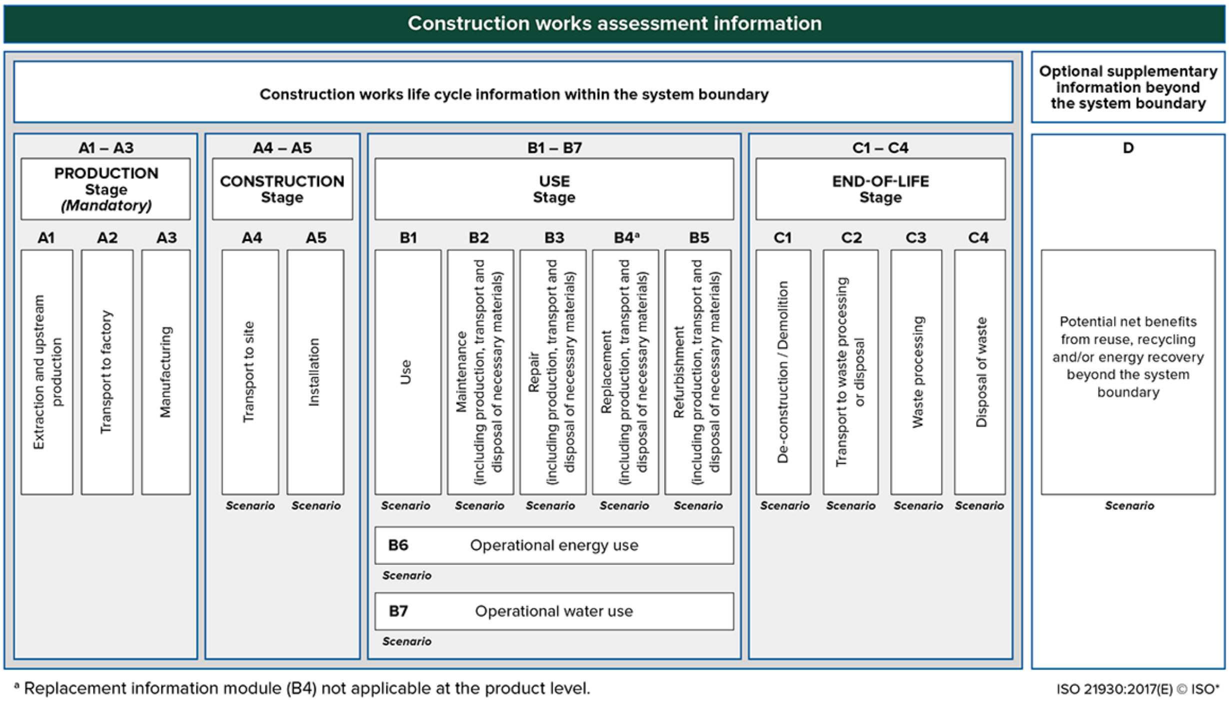
- **Production Stage: Modules A1-A3**
  A1 starts with raw material extraction or harvest; A2 is the transportation of those raw materials to the factory or mill; and A3 is manufacturing of the product itself. Together, these modules are often referred to as "cradle-to-gate."
- **Construction Stage: Modules A4-A5**
  A4 is transportation of the product to the construction site; A5 is installation and/or the construction process.
- **Use Stage: Modules B1-B7**
  These modules include maintenance, repair, replacement, and refurbishment, as well as operational water and energy use for the duration of the building's life.
- **End-of-Life Stage: Modules C1-C4**
  C1 includes deconstruction and/or demolition; C2 is transportation of waste to the disposal or processing site; C3 is waste processing; and C4 is the final disposal of that waste.

Modules A1 through C4 define the system boundary that fully represent the life cycle of the building; this is often referred to as "cradle-to-grave."

There is an additional module, beyond the system boundary:

- **Module D** is optional, supplementary information that is not part of the life cycle of the system; it is outside the system boundary. ISO 21930 states, "Module D information aims at transparency for the resulting potential environmental benefits from reused products, recycled materials, secondary fuels and/or recovered energy leaving a product system and being used in a subsequent product system."

The separation of Module D from the life cycle is important to ensure that "double counting" does not occur. Consider a wood panel from an existing building that will be reused in a new building. The carbon stored in that panel at the end of the first building's life leaves the system boundary as a carbon emission. This allows it to enter the system boundary of the second building as a carbon reduction. For more on biogenic carbon accounting, see our article on this topic, here.



Common four life cycle stages and their information modules for construction products and construction works and the optional supplementary module D

Defining the Scope

When performing a WBLCA, it is important to define the scope of the system, which may vary depending on the goal(s) of the assessment. A structural engineer may wish to evaluate the structural system and therefore may choose to only include structural elements. Architects may wish to include things like finishes and furniture. It is common to include all elements of the building system that are relevant to overall building performance—including structural elements, building envelope, finishes needed to meet fire and acoustical requirements, and components of the assembly required for acceptable vibration performance. This is especially important when performing comparative WBLCA studies, where alternative design schemes and different materials will be evaluated against each other. In these cases, it is important to consider the “functional equivalency” of the various design alternatives. All options should include the full bill of materials necessary to meet equivalent performance criteria. Consideration should also be given to the functionality of the space, including grid spacing and ceiling height. The concept of functional equivalency is discussed further in a separate article, while additional considerations regarding the scope of an LCA are outlined in a paper and companion worksheet.

Environmental Impacts

For developers and design teams seeking to make their projects more sustainable, WBLCA can be used to evaluate a variety of environmental impacts, including global warming potential (GWP), acidification, eutrophication, ozone depletion, smog, and fossil fuel consumption. With the growing emphasis on reducing carbon emissions, many designers are specifically focused on measuring, and reducing, those impacts. Furthermore, while great strides have been made in reducing operational carbon emissions—those emissions associated with the operation and use of buildings—designers have more recently expanded their focus to include embodied carbon, which is the carbon impact of the building materials themselves and construction process. For WBLCA where the goal is measuring the embodied carbon impact, it is appropriate to exclude some of the “use” modules from the analysis, typically B1, B6, and B7. B2 through B5 are related to maintenance, repair, replacement, and refurbishment, so should be included in the analysis as appropriate for the defined lifespan of the building.

WBLCA Software Tools

There are several commercially available software tools that designers can use to perform WBLCAs throughout the design and construction process to measure and potentially reduce the environmental impacts associated with the building. A description and comparison of these tools can be found here. It is important to note that these tools use different modeling techniques and background datasets, and make different assumptions, which means results from different software programs will never be identical. Therefore, when reviewing results, it is important to know which tool was used and understand the underlying assumptions. Likewise, when performing comparative WBLCA, it is important to use the same tool and assumptions to ensure a valid comparison of results.

While there are many considerations to building design, designers can use WBLCA tools as a scientific way of measuring, reporting, and reducing the embodied carbon impact of their building. This is a valuable service they can provide to clients looking to increase the environmental sustainability of their portfolio and differentiate their buildings in the market—and an important step toward mitigating the impact of new construction.

Additional Resources

Hall, E. S., Think Wood. (n.d.) *How to Calculate the Wood Carbon Footprint of a Building.*

International Organization for Standardization. (2006). *ISO 14040:2006 Environmental management – Life cycle assessment – Principles and framework.*

International Organization for Standardization. (2006). *ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines.*

International Organization for Standardization. (2017). *ISO 21930:2017 Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services.*

KL&A Engineers and Builders, Adolfson & Peterson. (2021, July). *Platte Fifteen Life Cycle Assessment.*

