Circularity for Educators

04. An Interdisciplinary Approach to Circularity

Life Cycle Assessment

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Life cycle assessment, or *LCA, is an assessment method to determine the environmental impacts of a product or service over its whole life cycle, from cradle to grave:* that is from the time the natural resources are mined, all the way to the product's manufacturing, transportation, use, and ultimately, disposal. LCA draws its relevance from considering all steps in a building product's life cycle. Furthermore, in an LCA, a broad range of environmental impacts are considered, such as climate change, resource depletion, toxicity for humans and ecosystems, and acidification. This is in contrast with many other assessment methods, which focus only on a part of the life cycle or a single environmental aspect.

LCA can be used to compare the environmental performance of building variants, sometimes also with a limit value from legislation. But it can also be used to show the contribution of building parts, materials or life cycle phases. This can help to identify hot spots where the environmental performance may be improved.

Life cycle assessment calculation tools

There are several LCA tools for buildings available, such as *One-Click LCA, BREAAM, LEED, TOTEM or GPR Gebouw.* In the Netherlands, LCA tools for buildings use a *standardized LCA calculation method: the Bepalingsmethode Milieuprestatie Bouwwerken*, translated as determination method for environmental performance of buildings. This method describes the calculation of the *MPG, the milieuprestatie van gebouwen*, or environmental performance of buildings. The MPG is a score for the environmental performance of the building per square meter gross floor area and per year. For the MPG calculation the environmental impacts of the building materials are calculated for *11 environmental impact categories* and *combined into a single score.* The Bepalingsmethode Milieuprestatie Bouwwerken method is used in combination with a standardized LCA database for building materials and products, *the Nationale MilieuDatabase, or NMD*. In the Dutch building legislation, it is required to make an MPG calculation when applying for a building permit for dwellings or for small offices. To meet the requirements for a building permit, the *MPG must be lower than a maximum value of 1.0 for offices and 0.8 for dwellings.*

Life cycle assessment and circularity

The application of LCA can be extended for assessing the environmental performance of circular construction materials or circular projects. However, switching from a cradle-to-grave to a cradle-to-cradle model - where materials or products re-enter the loop - can be challenging. *The main challenge lies in the way environmental* *impacts of materials and products that are reused or recycled outside the scope of the building project should be attributed.* Current EN standards merit the use of reused or recycled materials, but ignore end-of-life benefits of using reusable or recyclable materials. It is clear that circular concepts can lower the environmental impacts of the building industry, but the issues around scope, allocation and service life extension, which are all important for LCA, are currently still under discussion.

Examples of life cycle assessment and circular components: The modular kitchen

So, how can a life cycle assessment be extended to show the potential environmental benefits of circular strategies like upcycling, reuse and recycling? Let's take a look at a couple of examples.

The first example is that of a modular kitchen concept. The kitchen is split into three modules: a base frame, cabinets and cabinet fronts, each with a different service life. The construction frame has a service life of 80 years, the shelves and drawers a service life of 40 years and the fronts of the cabinets a service life of 20 years. Modularity here allows for the more durable kitchen components to be reused in other kitchen projects. So, can LCA account for the environmental impacts of the reuse potential of these components?

If the LCA process tree of such a kitchen would be fully worked out for the modular kitchen, including those component cycles before and after use, it would become very big and confusing. This would not be useful for designers and decision makers. In this case, to avoid confusion, the LCA was performed for an average kitchen based on assumptions for component cycles before and after use in the project. This is done through the use of two factors: a probability factor that measures the likelihood of a life cycle to occur, and an allocation factor that measures how the environmental impact is allocated across the life cycle stages. However, in order to showcase the amounts of materials that can be reused or recycled, an additional material flow analysis was implemented. On the one hand, the LCA scores, show the impacts of the modular kitchen on the environment; on the other hand, the material flow analysis shows the amount of input and output materials that can be further used for reuse or recycling. This is reflected in the scores, with the modular kitchen on the right side of the table having the highest number of white squares, meaning it performs best in terms of circularity.

Examples of life cycle assessment and circular components: The IEBB project

In other cases, the use of indicators for circularity besides LCA scores is advocated. In the *Dutch IEBB project,* one of the activities was to develop an assessment framework for sustainable building renovation projects, which also considers circular solutions. *Three indicators were proposed: the classical LCA indicators* to show the environmental performance, which is also part of the Dutch building legislation; *the life cycle CO_2 emissions*, also known as embodied carbon; *and an indicator for circularity*. This indicator was not worked out in the project, but it was suggested to show insight in the circular material flows by presenting the input flows of reused and recycled materials, and the output flows at end of life of materials with potential for reuse, recycling or incineration for energy generation.

Epilogue

So, currently, *the tendency is to go for separate LCA and circularity indicators to provide as much transparency as possible.* The circularity indicators can be a simple material flow analysis, presenting the amounts in kilograms of material. But these indicators can also be more elaborate, with weighting for the different R-strategies, supplemented by accounting for the potential for demounting and disassembly, for which novel approaches have been developed. Even the potential for flexibility in building use can be included. And the amount of bio-based materials, often regarded as another pillar of circular building, can be displayed as well. This way, the circularity of a circular building project can be quantified and thus be compared with the environmental performance calculated with LCA, and other indicators like technical performance, cost figures and aesthetics, for a holistic discussion between stakeholders and a complete decision-making process.