white paper

7 STEPS GUIDE TO BUILDING LIFE CYCLE ASSESSMENT

or

WHY YOU NEED LCA TO BUILD SUSTAINABLY

by

One Click LCA

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Tytti Bruce-Hyrkäs (Msc.) works for Bionova Ltd, a Finnish construction Life Cycle Assessment expert company. She is one of the developers of One Click LCA, the global Whole Building Life Cycle Assessment software solution, used in over 50 countries.

She has been **personally responsible for over 100 life cycle assessments in the construction sector and is an authorized EPD verifier**. She has also conducted several studies on the topic including an upcoming scientific paper to be published in the Procedia CIRP journal as part of the the CIRP Life Cycle Engineering (LCE) conference in Copenhagen and has been advising the Finnish government on LCA-based green public procurement and regulatory development, including a carbon regulation roadmap for the construction industry.

As **Director for Customer Journey** she is responsible for One Click LCA's customer trainings and professional LCA support, as well a global training program in collaboration with several leading organizations such as *BRE* and *Green Building Councils* and *universities* all over the world. Finally, **she annually teaches Whole Building Life Cycle Assessment to hundreds of construction professionals**.

One Click LCA is the Building Life Cycle Assessment tool that allows you to calculate the environmental impacts of your building in less than one hour: just **import your BIM/Revit/gbXML, or Excel file** and the software will automatically map your data to our extensive LCA database and automate the calculations, giving you a **detailed report** that you can then submit for certification purposes or use to improve your design.

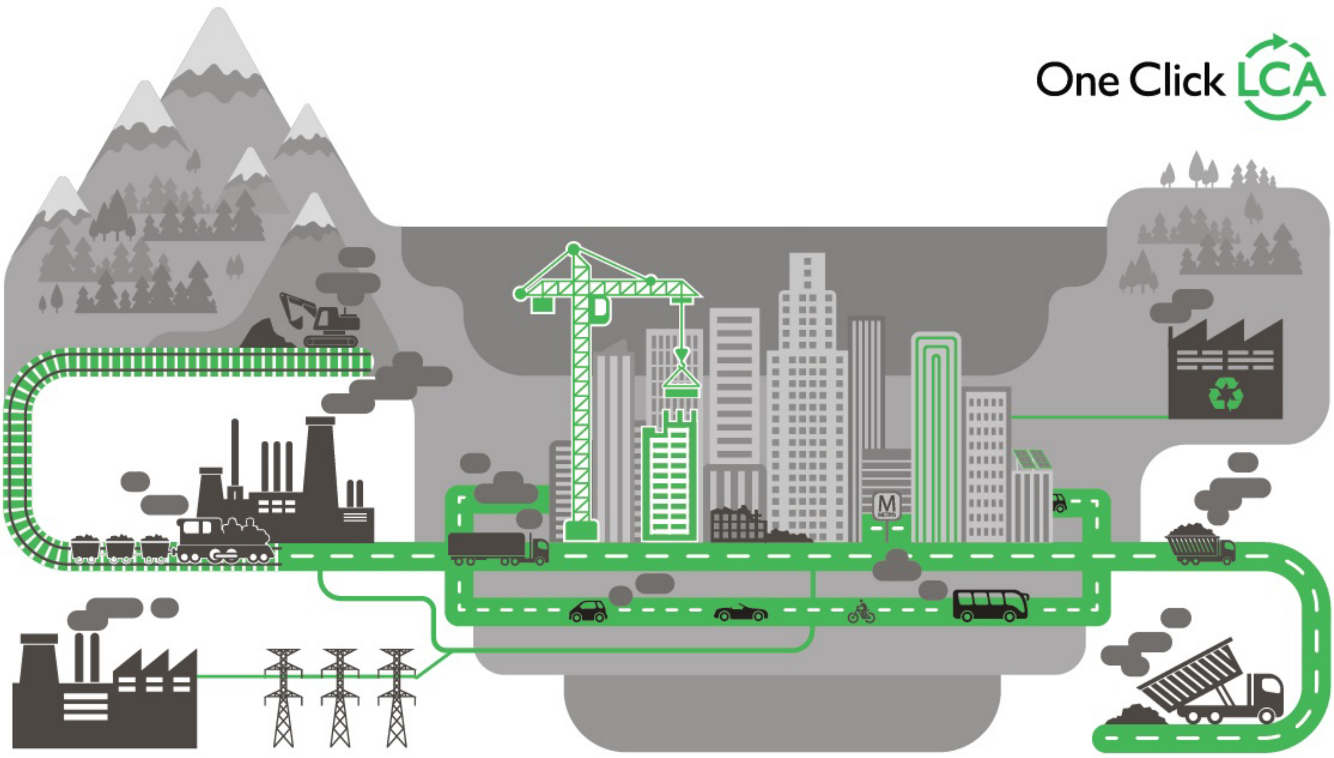
1 INTRODUCTION TO LIFE CYCLE ASSESSMENT

If you are reading this, it is likely because you know that the time to become a Life Cycle Assessment expert is now. However, you might perceive LCA as a complicated, difficult topic that cannot be easily mastered.

Hopefully, by reading our detailed guide you will learn that **calculating the Life Cycle Assessment of a building will enable you to make more informed decisions and achieve real sustainability**. You will also understand what principles Building Life Cycle Assessment is based on, and why it is important to adopt it in your workflow.

This whitepaper will guide you through the basics of LCA and help you understand:

1. Why Building Life Cycle Assessment matters
2. How is it calculated
3. What's its place in the construction industry

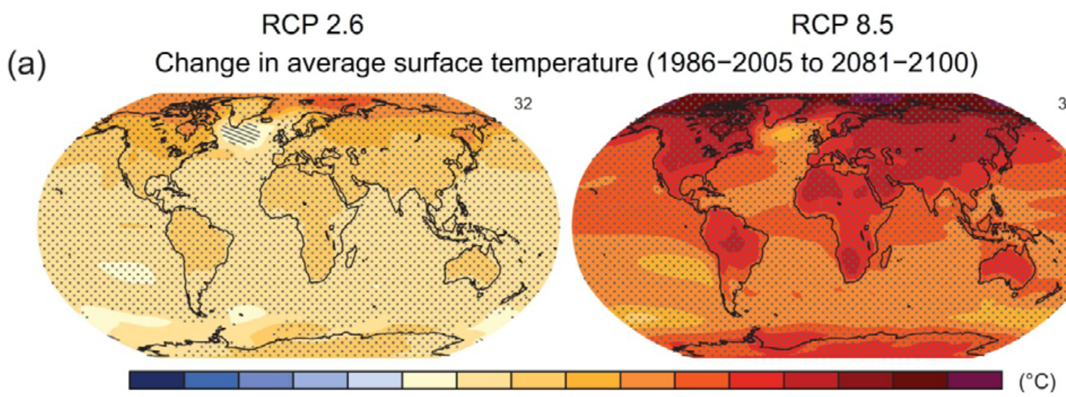


2 WHY BUILDING LIFE CYCLE ASSESSMENT MATTERS

Before jumping into buildings, let's discuss what Life Cycle Assessment means in general. The main purpose of LCA is to answer a simple question: **how sustainable is my product, service, or process?**

If you want to calculate the environmental impacts of a product, a service, or process in an accurate, reliable way, no methodology is better than LCA. This is due to two main factors: first of all, **Life Cycle Assessment is a scientific methodology, and relies on cold, hard data** rather than impressions, predictions, or marketing labels; secondly, **it analyzes the impacts over the whole existence of the product/service/process**.

To put this in even clearer terms, imagine that you are designing a building and that you have the option of knowing either how many carbon emissions it would cause to use a certain material for insulations or how many carbon emissions each element in your building would cause over the whole lifetime of the building. In the second case you might find that the material option that seemed so environmentally friendly at first is not the best way to reduce carbon emissions in your building and might actually do more harm than good.



Source: IPCC AR5

How do you compare product to know which one causes less environmental impacts?

The only way to know for sure is to look at all the steps of the process, from raw material to manufactured product, including extraction of the materials, energy consumption, manufacture, transportation, use, recycling, and final disposal or end of life.

Our buildings exist in a complex ecosystem, and when analyzing them **we should think about climate change, non-renewable resources, and the environment as a whole**.

Life-Cycle Assessment's ***strength*** lies in the fact that it takes into account also what happens before and after the final product is used by customers, and effectively measures effects over a long time of period.

The same principle applies if you need to **compare design options to find the best compromise** between costs, environmental impacts, functionality, and aesthetics. It is impossible to make an informed decision if you don't have a complete overview of your building from building site to demolition and disposal.

3 HOW DO YOU CALCULATE BUILDING LIFE CYCLE ASSESSMENT?

Life cycle stages or How to look at the whole picture

In order to understand how to calculate Building Life Cycle Assessment we need first to talk about the stages of a building's life cycle. **Buildings interfere with the environment through their whole life cycle.** Constructing a building, using it for many years and finally knocking it down will have an impact on the environment.

In order to get the full picture, the full life cycle of the building must be considered.

There are four life cycle stages:

- **the product stage** – extracting, producing materials, and transporting the materials (along with workers and vehicles) anywhere between the extraction point and the construction site.

- **the construction stage** – transporting the materials, the energy to power the construction equipment, supporting construction materials, and disposing any waste.

- **the use stage** – operational energy used to occupy a building over its lifetime (electricity, heating, etc.), maintenance, repairs, and replacement of materials.

- **the end-of-life stage** – demolition and recycling or disposal of materials.

Each of these stages involves processes that will either consume valuable resources or release pollutants/harmful substances into environment.

Environmental impacts or How to measure your building's effects on the environment

When we talk about environmental impacts and emissions, we need to clarify what exactly they are. **Emissions are substances released into the air, water, or soil, which negatively impact the environment, and humans as a result.** They often enter the environment as waste products.

The most known emissions are greenhouse gases (GHG) emissions, which contribute to global warming. **Greenhouse gases are gases that trap heat into the atmosphere, therefore contributing to warming up the planet and the rise of average temperatures across the world.**

Global warming has negative effects on ecosystems, people, and economies and, as a result, **reducing its effects has become a major concern for governments and organizations worldwide**.

In addition to greenhouse gas emissions and their warming impact in the atmosphere there are several other ways in which we can evaluate the impact of emissions on the ecosystems.

Some of the most commonly used impact categories are introduced in the table below. **These categories help us to measure the effect of some substances and gases on the environment, and to quantify the impact of human actions on the environment.**

IMPACT CATEGORY	UNIT	DESCRIPTION
Global warming potential (greenhouse gases)	$kgCO_2$ eq	Global warming potential is a relative measure of how much heat a greenhouse gas traps in the atmosphere. The global warming potential is calculated in carbon dioxide equivalents meaning that the greenhouse potential of an emission is given in relation to CO_2. Since the residence time of gases in the atmosphere is incorporated into the calculation, a time range for the assessment is defined to be 100 years.
Acidification potential	$kgSO_2$ eq	The acidification of soils and waters occurs predominantly through the transformation of air pollutants into acids, which leads to a decrease in the pH-value of rainwater and fog from 5.6 and below. Acidification potential is described as the ability of certain substances to build and release H+ions.
Eutrophication potential	$kgPO_4$-eq	Eutrophication is the enrichment of nutrients in a certain place. It can be aquatic or terrestrial. All emissions of Nitrogen and Potassium to air, water and soil and of organic matter to water are aggregated into a single measure. Nutrients may be released into the ecosystem for instance from agriculture or in waste water.
Ozone depletion potential	$kgCFC_{11}eq$	Ozone depletion potential represents a relative value that indicates the potential of a substance to destroy ozone gas as compared with the potential of chlorofluorocarbon-11 which is assigned a reference value of 1, resulting in an equilibrium state of total ozone reduction. For instance, many refrigerants contribute towards ozone depletion.
Formation of ozone of lower atmosphere	kgC_2H_4eq	Describes the effect of substances in the atmosphere to create photochemical smog. Also known as summer smog.

In addition to the environmental impact categories listed above, there are plenty of others that can be analysed. For instance, the EN standards for Building Life Cycle Assessment list a total of **24 environmental impact categories**.

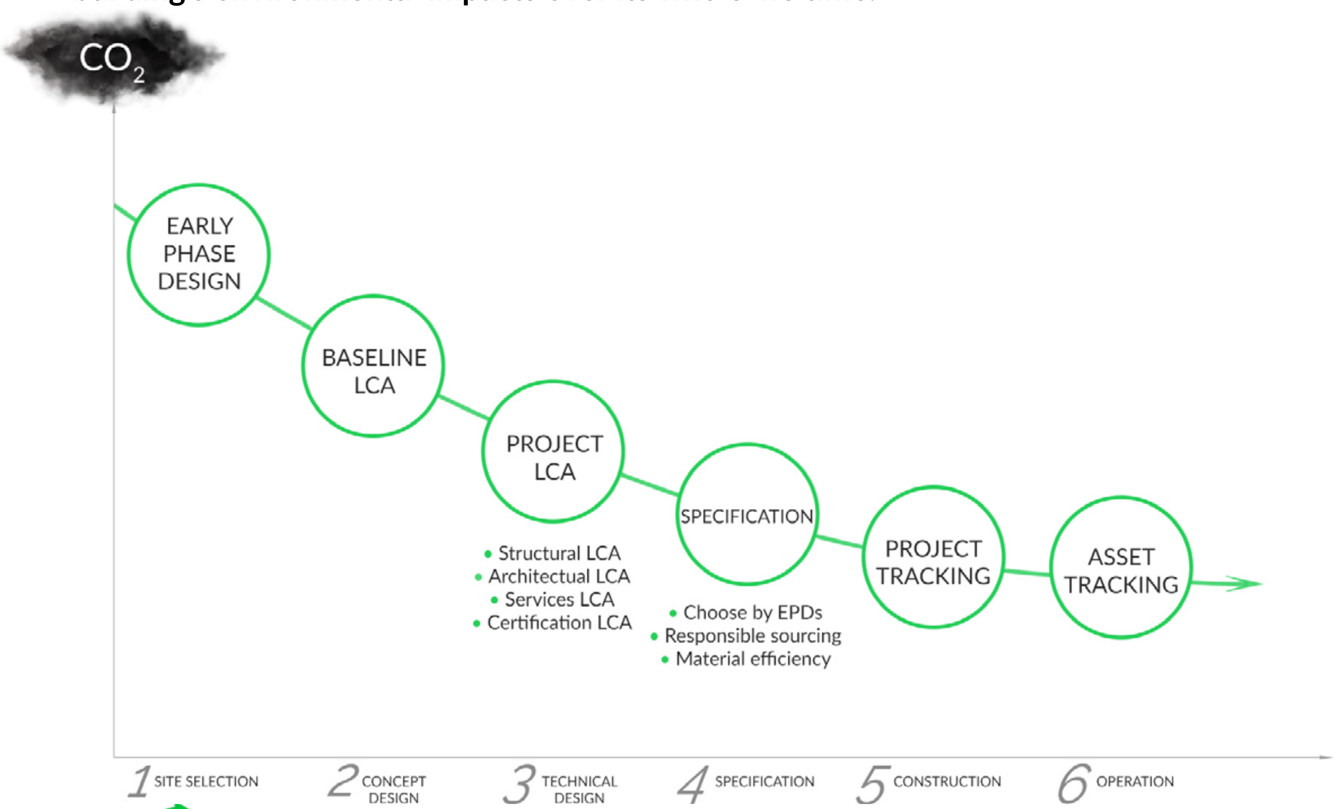
All the different **emissions are translated into environmental impacts** by multiplying them with the characterization factors that converts their effect into common unit. For example, in the case of climate change all of the emissions are converted into COe equivalents, by comparing the warming potential of different greenhouse gases to that of 1 kg of CO_2 in the atmosphere.

The ***target unit*** for the conversion is defined in the calculation standard / characterization methodology. The characterization used for buildings methodologies are defined below.

LCA IMPACT INDICATOR UNITS *Use*	**CML2012** *Europe / EN standards*	**TRACI 2.1** *North America*	**ReCiPe**
Global warming potential	**CO_2e**	CO_2e	CO_2e
Ozone depletion potential	**CFC-11-eq**	CFC-11-eq	CFC-11-eq
Acidification potential (land)	**SO_2e**	SO_2e	SO_2e
Eutrophication potential (fresh water)	**$PO_4^{3}e$**	N eq	P eq
Formation of tropospheric ozone (photochemical oxidant formation)	**C_2H_4e**	NO_xeq	kg NMVOC
Depletion of non-renewable energy resources	**MJ**	MJ	Kg oil eq

The CML method was developed by University of Leiden and is mandatory in the calculations following the European EN standards. Practically all European Life Cycle Assessment data and most of the global data follow these standards. The TRACI method was developed by U.S. Environmental Protection Agency in 2002 and is commonly used in North America.

By applying one of these methodologies you will be able to **quantify and analyze a building's environmental impacts over its whole life time**.



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4 KEY CONCEPTS OF LIFE CYCLE ASSESSMENT

We have now clarified which methods you can use to calculate Building Life Cycle Assessment and what they measure, but there are still some key concepts to go through in order to understand how to interpret the results.

Environmental impact indicators express potential, not global consequences

Each indicator describes a particular category of environmental impacts. **The impacts are expressed in quantities of a substance that has the potential to cause such impacts** – but they do not represent the actual harm (final impact, endpoint) eventually caused. For instance, global warming potential represents the amount of CO_2e gases released. But the final, global, impact can be the acceleration of polar caps' melting.

Construction LCA uses attributional approach

Attributional approach refers to the methodology in which **inputs and outputs are attributed to the analyzed building by linking and/or partitioning the emissions of the system according to a normative rule**.

In other words, it means taking into account the direct impacts the building has on the environment, assuming that building level choices do not have an impact on the system level. One example could be excluding the potential impacts of choices at the building level on the emission profile of the country level network.

Consequential LCA takes into account also system level consequences. For instance, if many buildings choose to use renewable energy this eventually causes changes in the energy network. The system-level LCA may be referred to as ***"system expansion"*** and it is more complex. This approach is well suited for political decision making.

Cradle-to-gate and cradle-to-grave

The beginning of the life cycle is often referred to as "cradle". **The analysis that takes into account the product stage is often called "cradle-to-gate"** in which gate refers to factory gate or a product ready to be shipped from the factory. **The end of the life cycle is known as "grave".** Thus, an analysis that describes the whole building life cycle is often called "cradle-to-grave".

Normalization and weighting of impacts

Construction's environmental impacts encompass a wide range of different kind of environmental impacts such as climate change, mineral extraction, ozone depletion and waste generation. Assessing such different issues in combination requires subjective judgements about their relative importance. **Normalization and weighting are methods that can be used to combine the results of different environmental impact categories into one indicator.** BRE Ecopoints is one example of normalization and weighting methodology for environmental impacts.

Normalization: Comparing different environmental impact category results to a norm to "measure them on same scale". When comparing several different impact categories **this can help to understand the significance of each result**.

Weighting: Giving each impact normalized category a different value based on its estimated importance.

Example of normalization & weighting BRE Ecopoints

Climate change
Fossil fuel depletion
Ozone depletion
Human toxicity to air
Human toxicity to water
Waste disposal
Water extraction
Acid deposition
Ecotoxicity
Eutrophication
Summer smog
Minerals extraction

Normalization & weighting to each category's percentage rating

+ / - 100 ecopoints

where 100 = annual impacts of typical UK citizen

5 LIFE CYCLE ASSESSMENT STANDARDS

The rules for the Life Cycle Assessment are defined by the standards. The most important standards for building Life Cycle Assessment are listed below. The European CEN / TC 350 standards are highlighted.

Cornerstone standards:

— ISO 14040 and ISO 14044 – fundamentals for LCA; used in all industries and in professional context, almost all the time

Construction works specific standards:

— EN 15978 – LCA standard for construction projects (European standard, basis for all EU regulations)

— ISO 21929-1 and ISO 21931-1 (hardly used LCA standards)

Environmental Product Declaration standards:

— ISO 14025 – cornerstone standard for all kinds of EDPs

— EN 15804 (EPD data) and EN 15942 (EPD format) (European standard, basis for all EU regulations)

— ISO 21930 – (hardly used EPD standard)

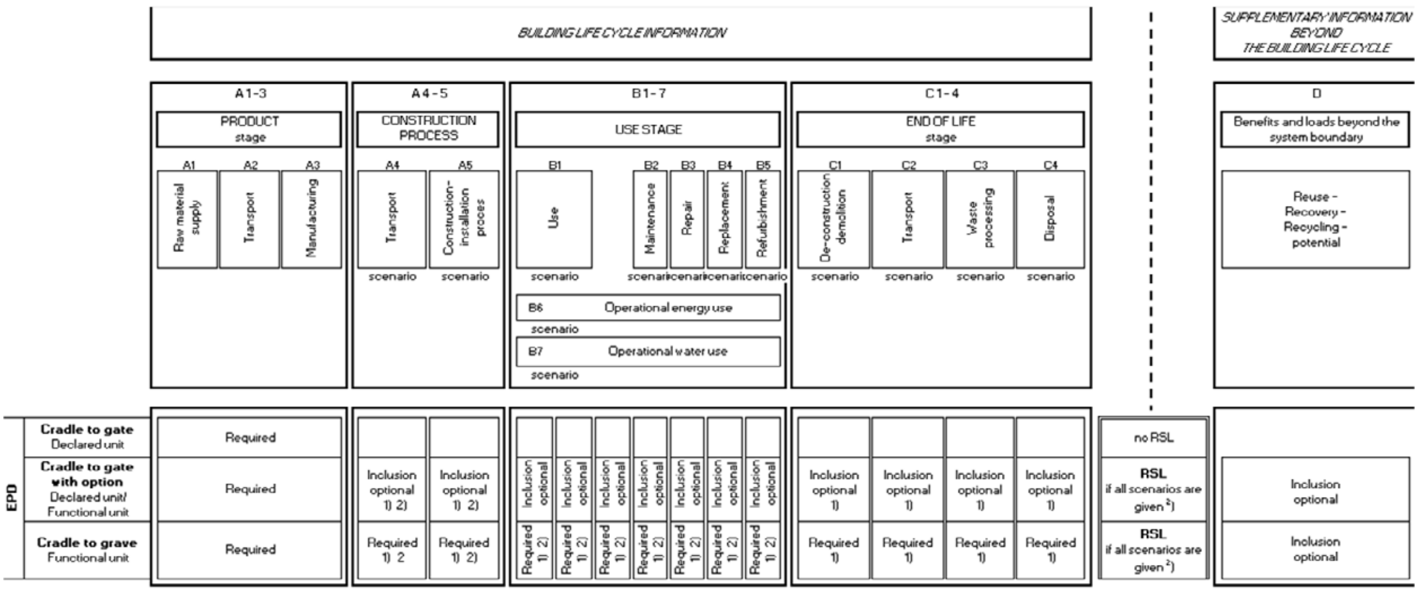
6 THE MAIN RULES FOR LIFE CYCLE ASSESSMENT FROM EN STANDARDS

Life cycle stages evaluated:

In EN standards the Life Cycle Assessment stages are defined with letters A, B and C. Letter A refers to **all processes that happen before the building is taken into use**: product manufacturing and construction process stage. Letter B covers **the use stage of the building** including material repairs, replacement and refurbishment. Stages starting with letter C cover the **end-of-life processes**.

Module D contains **the loads and benefits beyond the building life cycle**. In practice this could mean the environmental benefits resulting from choosing recycled building materials. To avoid double counting (*e.g.* counting the benefits for this building and for the building/product that uses the materials), these benefits are not considered part of the life time of the building, but can only be given as additional information.

Detailed stages are shown in the picture below.



Common principles for the analysis:

Required Service Life is set based on the property owner's requirement: materials must be replaced if they fail to perform for that lifetime.

Functional requirements must be clearly documented: comparison between designs or products is only possible for comparable performance *e.g.* similar technical or energy performance requirements.

Construction products are only comparable at the building level: no comparison without taking into account the building context. *For example*, one product might require more maintenance or replacements over the building's life-cycle, have a different kind of energy performance, or require additional other materials.

Forecasting is not allowed: you are not allowed to take into account any potential improvements that might happen in the future.

You are not allowed to calculate LCA with the use of market-based green electricity: that's not structural and it is impossible to guarantee that the future owner of the building will continue using green electricity throughout the service life of the building.

7 THE ROLE OF LIFE CYCLE ASSESSMENT IN THE CONSTRUCTION INDUSTRY

Currently, the importance for the construction industry to contribute to the global effort to cut carbon emissions is general knowledge. However, **there are some obstacles to a wider adoption of sustainable practices in the building sector**: confusion and lack of knowledge on how to achieve real sustainability, fear of increasing costs, and lack of regulations stipulating what standards must be followed.

Regarding the last point, governments and institutions worldwide are introducing sanctions, regulations, and incentives directed at promoting passive buildings, sustainable infrastructure, and a more transparent approach to manufacturing. For what concerns costs, **performing Life Cycle Costing calculations along Life Cycle Assessment represents a powerful opportunity to reduce costs in addition to environmental impacts**.

While there is still work to be done to educate architects, engineers, and consultants about the benefits of Life Cycle Assessment, the methodology is already in use in the construction sector for a plethora of goals.

Building Life Cycle Assessment can be used to identify performance gaps, compare products, make procurement decisions or improve designs, amongst others.

LCA is a transparent alternative to greenwashing and commercial eco-friendly labels. Results obtained with the LCA methodology can be **trusted**, since they are based on international standards and not susceptible to commercial pressure or vague eco-labelling.

Construction specialists use Building Life Cycle Assessment to:

- identify the building's environmental hotspots when it comes to carbon emissions and other environmental impacts
- achieve credits for Green Building rating schemes like BREEAM, LEED, DGNB, HQE, etc.
- compare design alternatives and choose the highest performing ones
- find the most sustainable materials
- evaluate building site options
- compare the environmental impacts of renovating vs. demolishing and building anew
- calculate Environmental Product Declarations for building materials
- and much more!

For many construction specialists it is very **important to have access to LCA results in a timely manner**, and traditional LCA calculations can take up to a couple of months. However, this doesn't need to be the case.

Building Life Cycle Assessment calculations can be automated with a tool that allows you to import your data and get your LCA results in a fraction of the time.

One Click LCA is the Building Life Cycle Assessment tool that allows you to calculate the environmental impacts of your building in less than one hour: just **import your BIM/Revit/gbXML, or Excel file** and the software will automatically map your data to our extensive LCA database and automate the calculations, giving you a **detailed report** that you can then submit for certification purposes or use to improve your design.

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