CONSTRUCTION BLUEPRINT

Module 15

Tools for Circular Economy

Digitalisation in Construction

24 partners 12 countries

Date of Event

*Author/ **Institute***

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Technological University of the Shannon: Midlands Midwest
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To equip the learner with the basic knowledge and skills required to understand and know how digital tools and models can support the reduction of the environmental impact of buildings.

Tools for Circular Economy | Objectives

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1. Identify existing BIM and Digital tools on the market used to assist with sustainable and healthy construction
2. Outline how BIM use in the construction industry, can help to contribute towards reducing waste, carbon emissions and produce more energy efficient building stock.
3. Identify and outline the implications and benefits of using BIM and other digital tools to construct and renovate sustainable healthy buildings
4. Identify and outline how BIM can support Life Cycle Assessment (LCA) of buildings to calculate their overall environmental impact.
5. Identify and outline how BIM can support the Life Cycle Costing (LCC) of buildings to calculate the cost over the building's entire life cycle.
6. Demonstrate using BIM and digital tools, an outline of a strategy on how to achieve low-risk, high-impact sustainable healthy renovation works using suitable materials and products

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Topic 1 – Sustainable construction

Topic 2 – BIM checks for LCA

Topic 3 – BIM checks for LCC

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1. Sustainable construction

Sustainable construction

This section will Summarise the EU Green Deal and Circular Economy Principles, Waste and Recycling.

Explain how to determine sustainable, low embodied energy, recycled and reused products and materials.

Introduce different brands and discuss the phrase "fit for purpose".

Outline benefits of Lean Construction.

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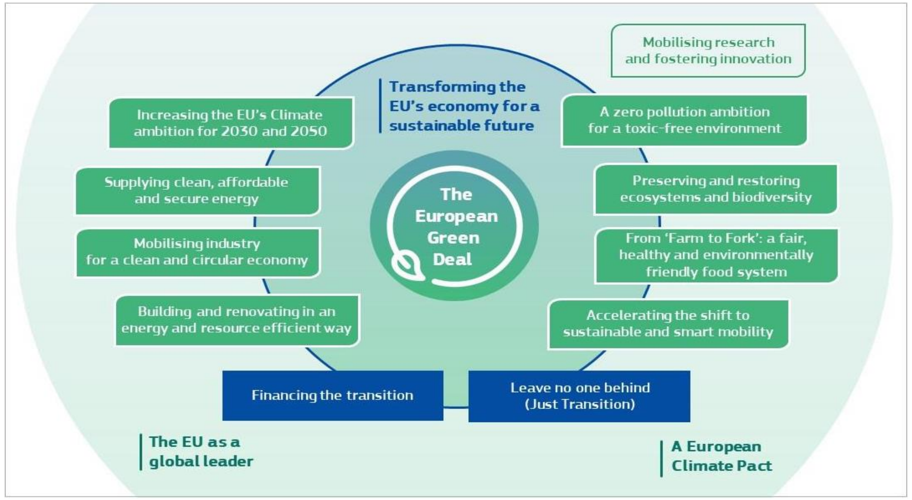
EU Green Deal

The deal commits the EU to achieve zero carbon emissions by 2050, with a 50% - 55% cut in emissions by 2030 (compared with 1990 levels)

- Energy – promotion and integration of renewable energy sources
- Buildings - focus on renovating existing buildings to improve energy efficiency
- decarbonisation of energy-intensive industries
- sustainable products policy targeting resource-intensive industries
- Transport – measures to support cleaner, greener and alternative transport, to achieve a 90% reduction of emissions from the sector

Making Europe climate-Neutral

- pledges to help companies to become world leaders in clean products and green technologies
- improving the well-being of people.
- protecting our natural habitat which will be good for people, planet and economy
- Pollution – launch of a new zero pollution plan in 2021 covering air, water, and soil, in order to better monitor, report, prevent and remedy pollution
- Agriculture/fisheries – measures to support biodiversity, reduce the use of harmful chemicals, improve food processing, packaging and waste.
- Just transition: No one will be left behind



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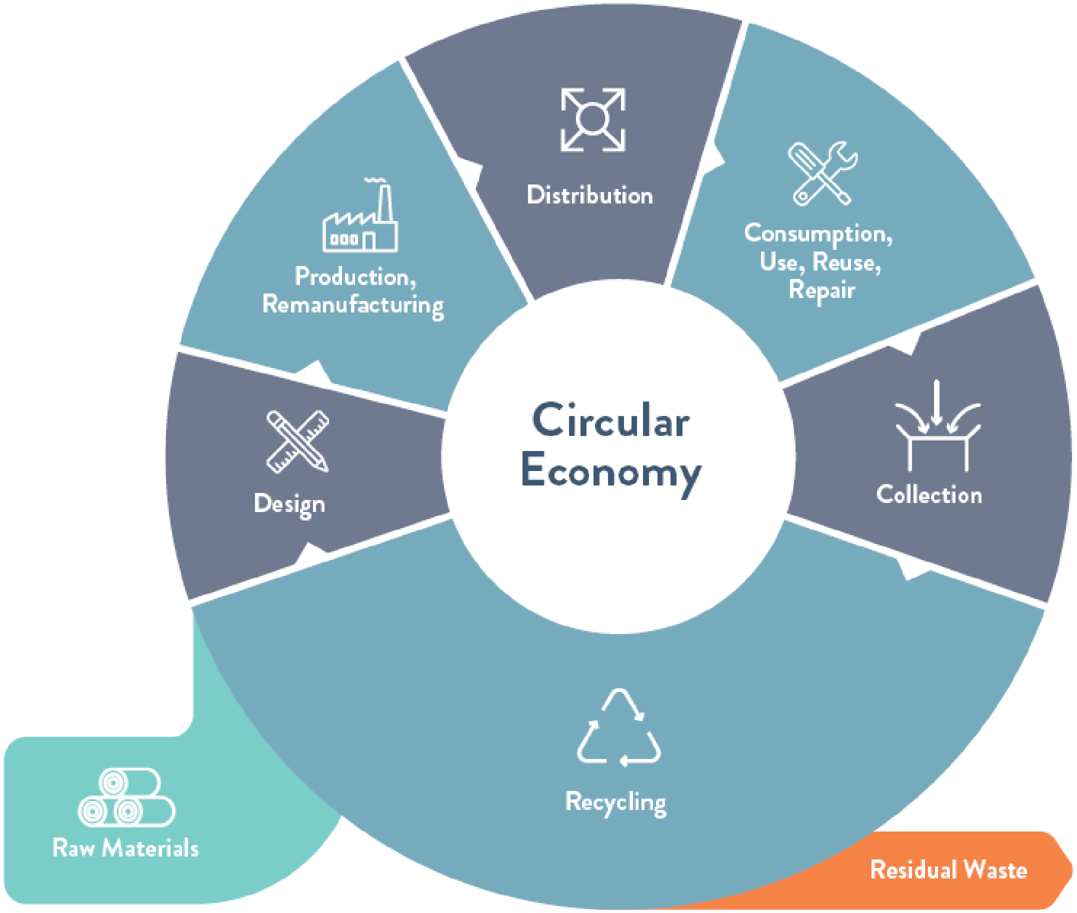
Circular Economy

Raw material extraction and material processing as responsible for 90% of biodiversity loss and water stress.
A new EU circular economy strategy was published in March 2020, which aims to:

Make sustainable products, services and business models the norm and transform consumption patterns so that no waste is produced in the first place.



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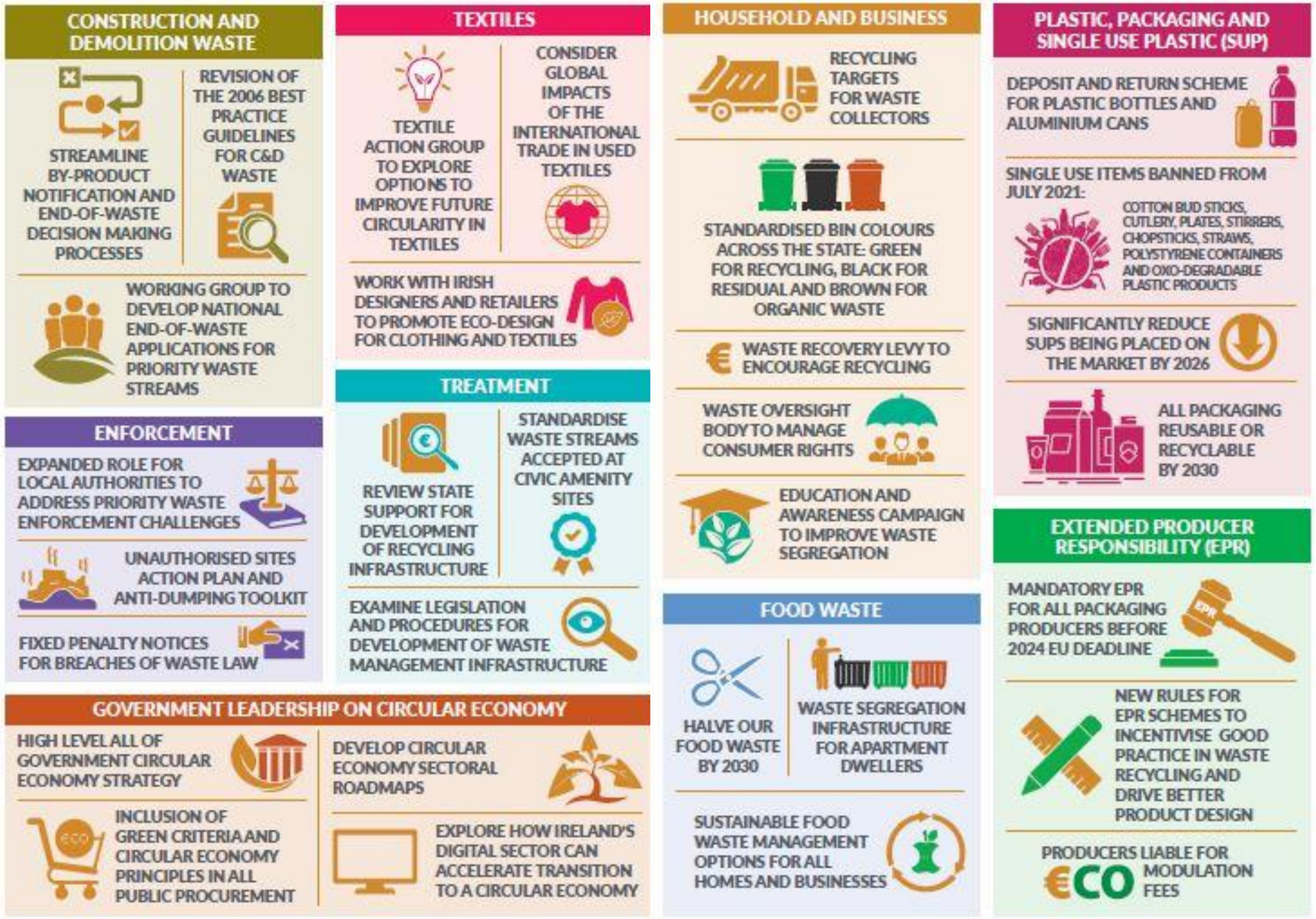
Waste and Recycling



Today, the global economy is only 8.6% circular

Take* Make *Waste is a tradition of the linear economy

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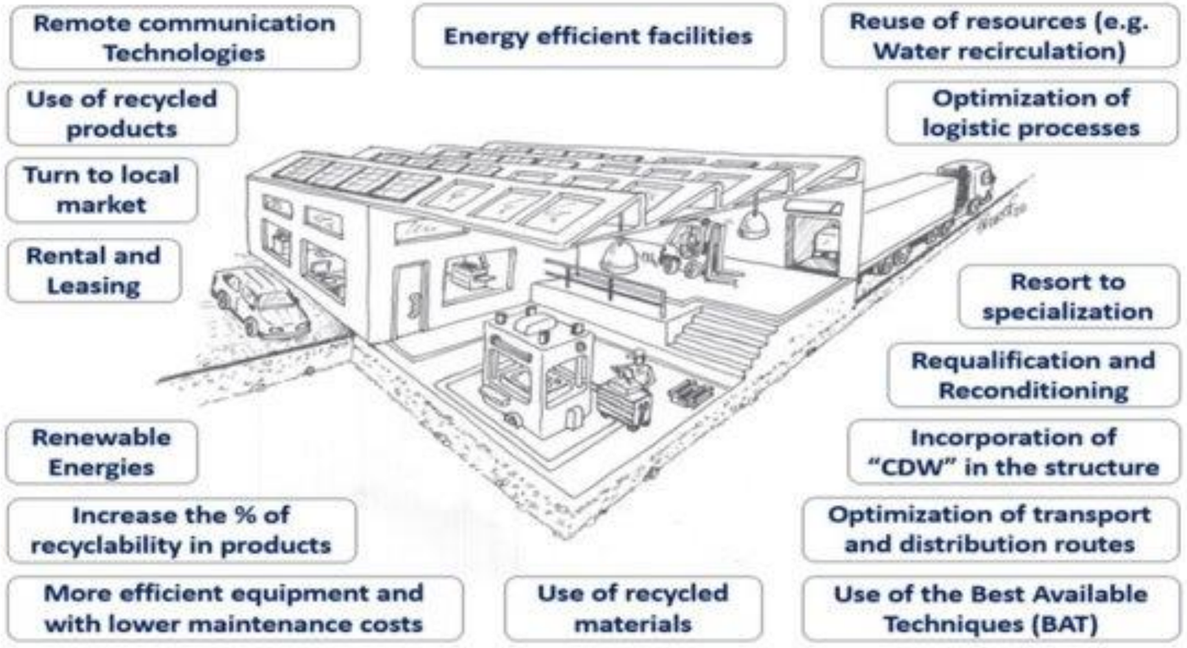
Circular Waste and Recycling in Construction

Reduce waste and deliver high-quality waste management: facilitate the future circular use of building elements, components and parts, with a focus on producing less waste and on the potential for the reuse, or high-quality recycling of major building elements following deconstruction. This includes efforts along the value chain to promote:

- the reuse or recycling of resources where most of the value is retained and recovered at the end of a building’s or it’s equipment's life span
- the component design and the use of different construction methods to influence the recovery for reuse or recycling to avoid down-cycling.



Sustainable construction

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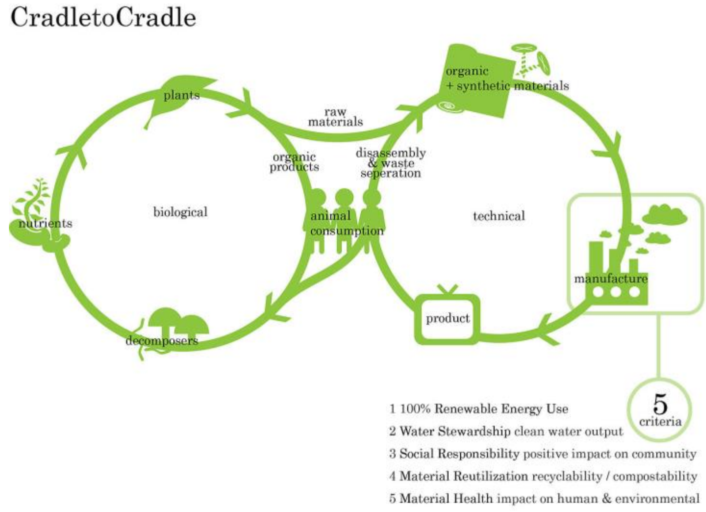
Other concepts of circular deep renovation solutions include:

The **DRIVE0** project, based on developing circular deep renovation solutions both in terms of innovative technical solutions, innovative construction processes, combined with process optimization and digitalization (with BIM as a main carrier)

https://www.drive0.eu/

https://youtu.be/viRjVTNhTmA



Cradle to Cradle (C2C) sees waste as an eternal resource and doing the right thing from the beginning. It is about making community and product development function in the same way as a healthy ecological system where all resources are used effectively, and in a cyclical way (as opposed to the current linear system that can be better described as a Cradle to Grave system).

https://www.youtube.com/watch?time_continue=17&v

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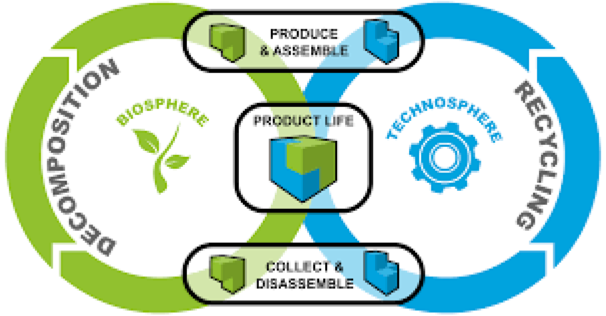
Prioritise Reducing And Reusing Materials Before Recycling Them.

THE HOME PERFORMANCE INDEX (HPI)©
Know that your house is a home.



For buildings built to the NZEB standard embodied impacts can represent **50%** of the total life cycle carbon. **Environmental Product Declarations (EPD)** are the building blocks for assessing the embodied environmental impacts of buildings.

Ecolabelling is a voluntary method of environmental performance certification and labelling that is practised around the world. An ecolabel identifies products or services proven to be environmentally preferable within a specific category

The European standard **EN 15804** is the basis for the common EPD approach by all ECO Platform members.

CERTIFIED 40-49 points | SILVER 50-59 points | GOLD 60-79 points | PLATINUM 80+ points

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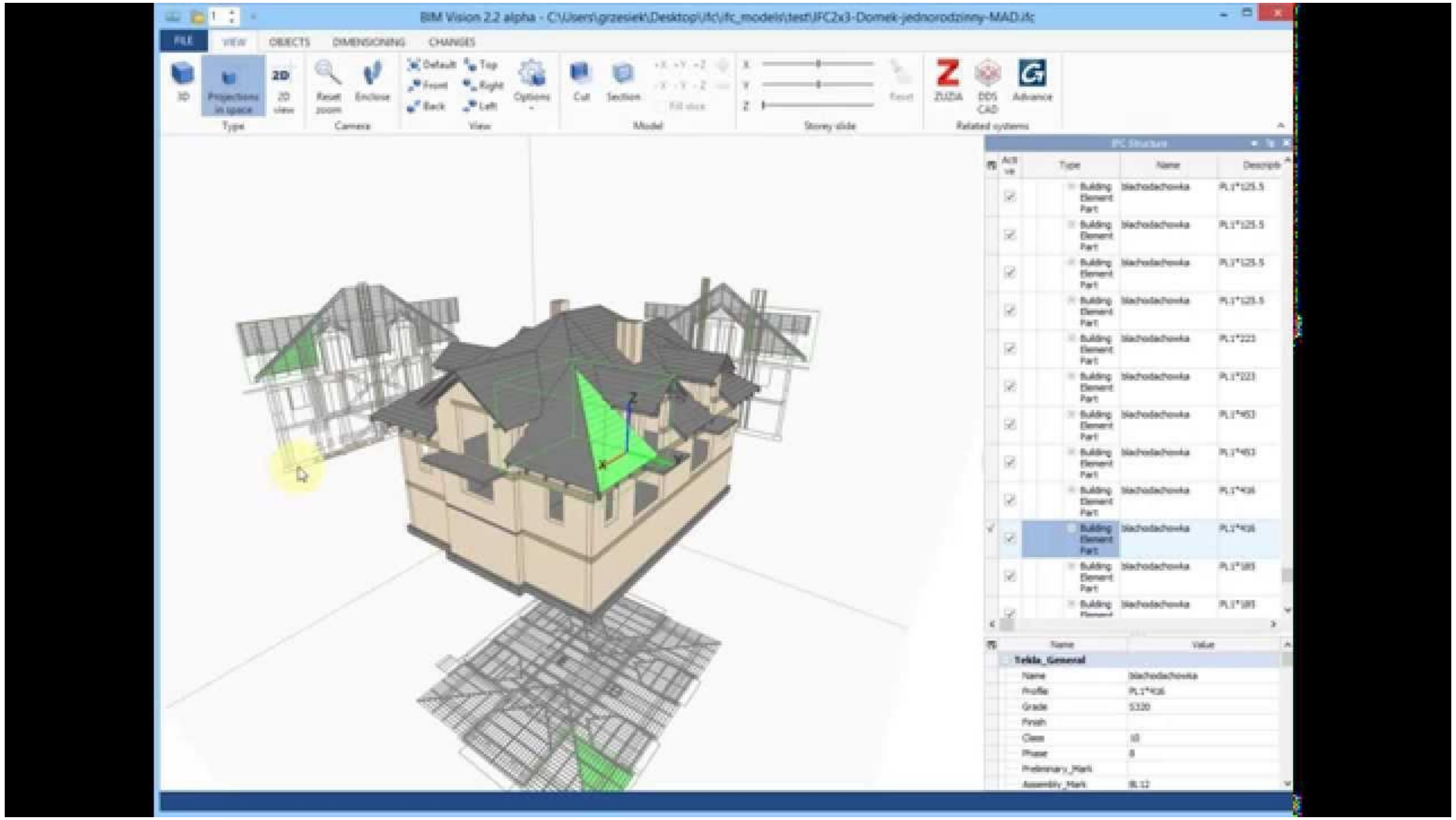
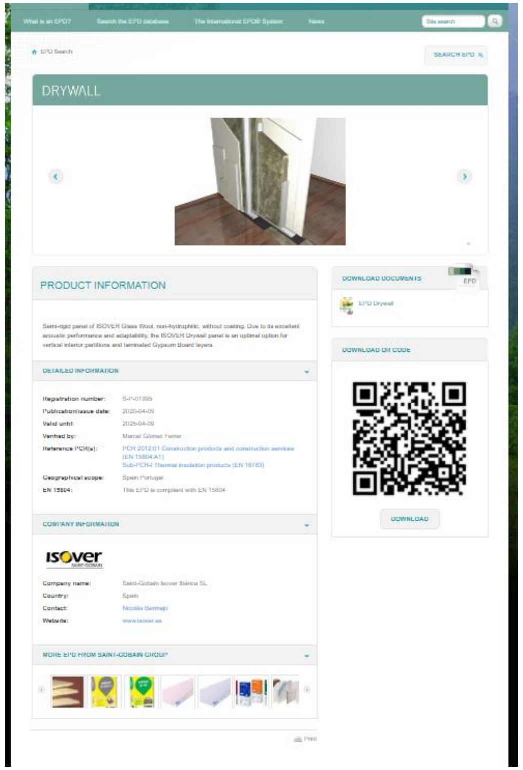
BIM For Embodied Carbon Footprinting

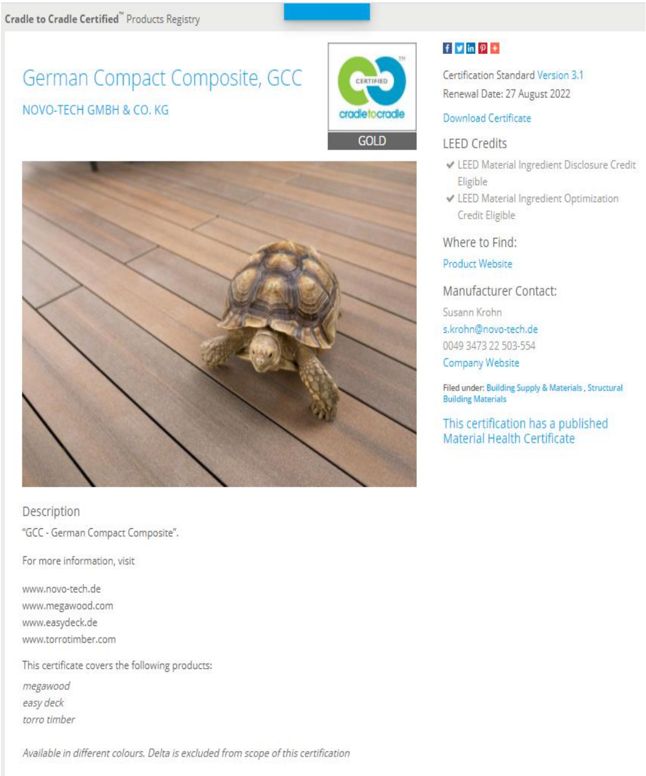
Numerous studies have shown the opportunity of using BIM for life-cycle assessment (LCA) and life-cycle costing (LCC).

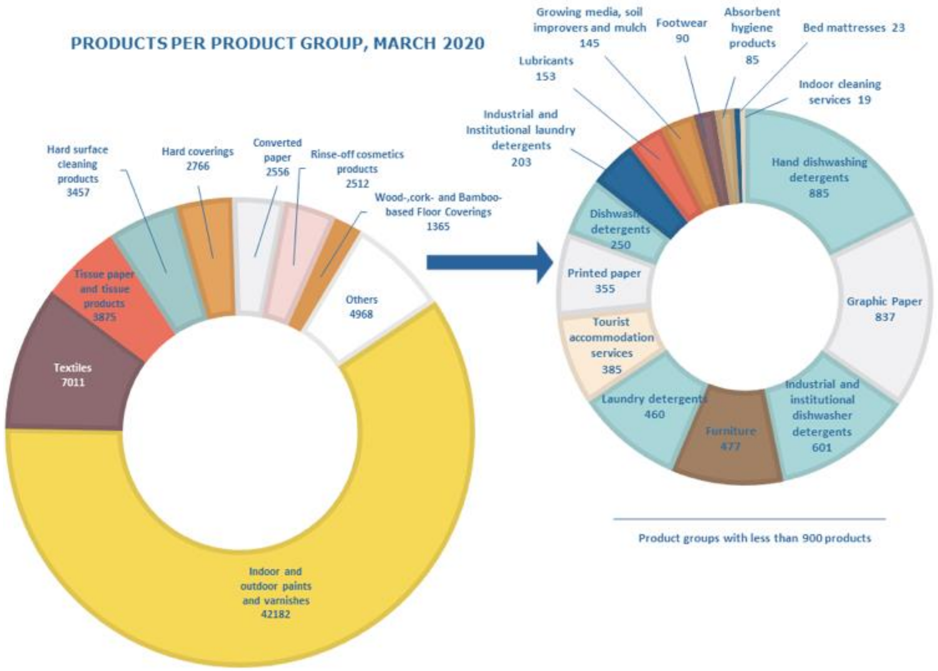
BIM models can capture information, about the intended products and/or suppliers for these same products.



ECO label examples







Sustainable construction

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When designing and constructing NZEBs:

- **don’t underestimate the environmental impact of the building envelope.**
- **Account for embodied energy and embodied carbon of the building envelope**

- Embodied energy
  - Total primary energy required to produce a material

More energy efficient buildings

More substantial proportional contribution of the building envelope to the CO_2 emissions

Embodied energy – info:

Material	MJ/kg	Material	MJ/kg	Materijal	MJ/kg	Material	MJ/kg
Steel	20.1	Reinforced concrete	1.9	Air dried wood	0.5	Clay tiles	6.5
Aluminum	155	Brick	2.5	Cement mortar (1:3)	1.33	Straw bales	0.91

Source: https://en.wikipedia.org/wiki/Embodied_energy

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Lean Construction

- The Lean Movement is gaining popularity in the construction world it's about cutting out waste and increasing value-added activities.
- Lean construction is a way of realising projects by maximising value and minimising costs; during construction, project maintenance, design, planning, and handover using specific techniques.
- Basically, save on time, effort and a waste of materials.

Benefits include removing waste from the process to reduce risk, improve safety, shorten schedules, and improve communication.

Waste as defined by Lean include:

- **Overproduction**
- **Waiting**
- **Unnecessary transportation or conveyance**
- **Over processing or incorrect processing**
- **Excess inventory**
- **Unnecessary movement**
- **Defects**
- **Unused employee creativity**

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Key choices about building design to reduce impacts

Construction:

- Construction products (recycled materials such as aggregates from construction and demolition waste)
- Transportation of aggregates to production sites by rail or shipping
- Environmental management of construction and demolition waste

Construction and use of buildings in the EU:

- Uses approx. half of all materials extracted
- Consumes 40% of energy
- Consumes 1/3 of water
- Generates 1/3 of all waste

Sustainable Specifications

Sourcing products certified as sustainable

Ecolabeling is a voluntary scheme, where producers, importers and retailers apply for the label for their products. It promotes the circular economy, influencing manufacturers to produce goods that

- Promote green innovation and sustainable industries
- Generate less waste and CO_2 when they are made and used
- Use energy, water and raw materials more wisely
- Last longer and are easier to repair
- Are easier to recycle
- Use less operational energy

Around 40,000 products and services hold the EU Ecolabel, It is a reliable label that identifies products and services with a reduced environmental impact.

EU Ecolabel
www.ecolabel.eu

The quality of ecolabels can vary – procurers should choose 'Type 1' ecolabels i.e. **verified by a third party and awarded on the basis of life cycle costs**.

The internet can be used to access supplier specifications and manufacturer instructions, http://www.ecolabelindex.com/ecolabels/

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To Summarise

1. Prioritise building re-use
2. Carry out whole life carbon analysis of building elements.
3. Prioritise ethical and responsible sourcing of all materials
4. Prioritise low embodied carbon and healthy materials
5. Minimise materials with high embodied energy impacts
6. Target Zero construction waste diverted to landfill
7. Promote use of local natural materials
8. Consider modular off-site construction systems
9. Detailing to be Long life and robust
10. Design building for disassembly and the circular economy
11. Offset remaining carbon emissions through recognised schemes

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2. BIM checks for LCA

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Life Cycle Assessment stages

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Life Cycle Assessment

There are four life cycle stages:

- **The Product Stage**
- **The Construction Stage**
- **The Use Stage**
- **The End-of-life Stage**

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- 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:
  1. Life Cycle Assessment is **a scientific methodology,** and relies on cold, hard data rather than impressions, predictions, or marketing labels;
  2. Life Cycle Assessment analyses **the impacts over the whole existence** of the product/service/process.

What exactly are we calculating?

- 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.

What exactly are we calculating?

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- 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 following slides.

- 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

What impacts are measured?

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Exploitation of fossil resources

acidification

kgSO2 eq

Exploitation of mineral resources

eutrofication

kgPO4-eq

What impacts are measured?

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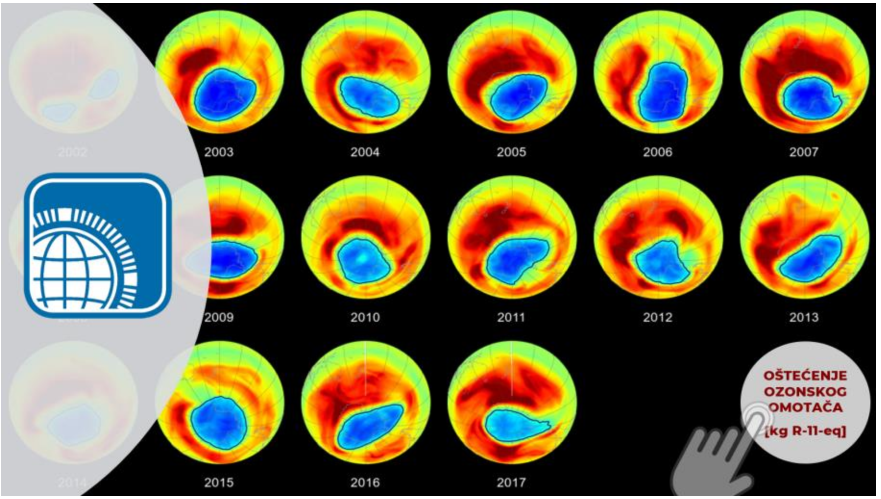
Global warming

kgCO2 eq

formation of photochemical smog

kgC2H4eq



Ozone depletion

kgCFC11eq

Source: BusGoCircular Project

How are they calculated?

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- In addition to the environmental impact categories listed in the previous slides, 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 CO2 in the atmosphere.

LCA standards

- The rules for the Life Cycle Assessment are defined by 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)

LCA- obstacles and opportunities

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- It is important for the construction industry to contribute to the global effort to cut carbon emissions.

- However, there are some **obstacles** in place preventing 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.**

- Governments and institutions worldwide are introducing sanctions, regulations, and incentives directed at promoting passive/net zero buildings, sustainable infrastructure, and a more transparent approach to manufacturing.

- Performing **Life Cycle Costing calculations along with Life Cycle Assessment represents a powerful opportunity to reduce costs in addition to environmental impacts.**

LCA calculation principles

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https://youtu.be/r0ucT1KRiO4

Tools for LCA

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- For many construction specialists it is important to get access to LCA results in a timely manner. Traditional LCA calculations can take up to a couple of months.

- **Building Life Cycle Assessment calculations can be automated with software tools** that allow you to import your data and get your LCA results in a fraction of the time.

- These tools such as OneClick LCA allow you **to import your BIM/ Revit/gbXML, or Excel file and the software will automatically map your data to a LCA database and automate the calculations**, giving you a detailed report that you can then submit for certification purposes and use to order suitable materials and products.

LCA calculation: OneClick LCA

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Demo!

LCA calculation using BIM data

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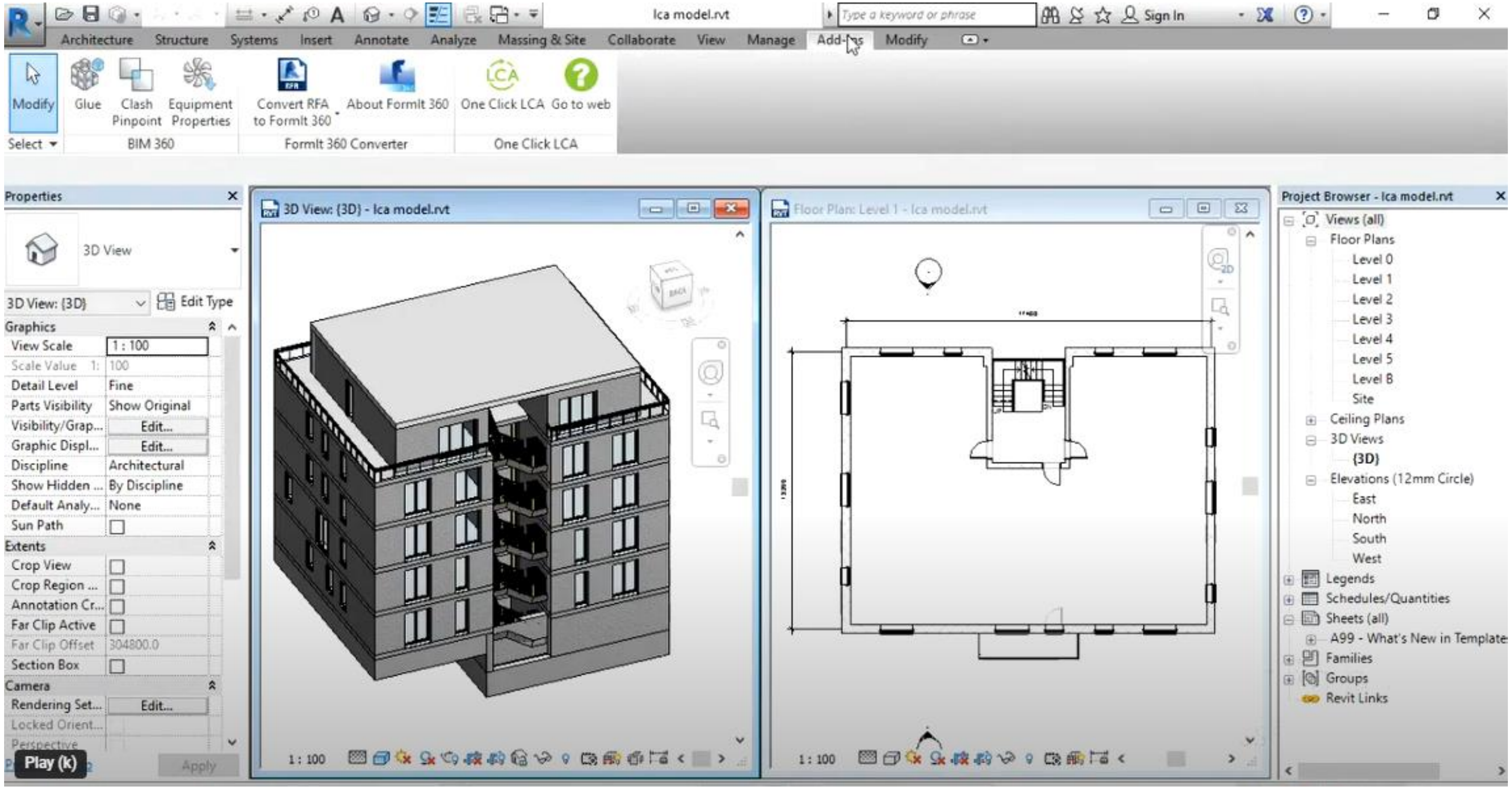

https://youtu.be/UIJryuxFIrY

3. BIM checks for LCC

LCC calculation: methods

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- While manual methods of calculations are still defined in relevant standards they are no longer being used in the production of LCC estimates.
- **Most examples of LCC are now calculated and presented in computer software.**

- There are two categories of computer-based LCC programs, which can be described as glass box or black box systems.
  - A **glass box** computer-based LCC program is characterised by the visibility of the process, such that each step in the LCC process can be seen by the operator. Conversely, a **black box** computer-based LCC program is characterised by the input of data and the output of results with each step in the process being invisible to the operator.
  - The most common glass box systems are based on **spreadsheets** and are developed within an organisation for their specific needs and on specific projects. Black box systems are usually propriety software bought from a software company.

Source: SCSI Guide to LCC

LCC calculation: spreadsheet

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Demo!

LCC and BIM

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- A Building Information Modelling/Management (BIM) approach to construction procurement is becoming increasingly popular as a collaborative set of procedures and associated processes that assist design and construction professions in conceiving, designing, constructing and operating the built environment.

- Although **5D BIM (Cost Modelling**) is currently being used by Quantity Surveyors, BIM is not extensively used in the application of LCC and there has been limited research in this area to date.

- 5D automated measurement can still be utilised in 5D application, but currently it is recommended to **export these quantities to MS Excel and then carry out the LCC estimate.**

Source: SCSI Guide to LCC

Learn more!

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The following section provides links to a number of videos, workbooks and solutions to get started on carrying out LCC estimates. They will allow the user to develop the building blocks of proficiency in LCC calculations and start applying them to an LCC estimate.

Life Cycle Costing in Excel 1 – Video

LCC Excel Template - 1

LCC Excel Solution - 1

Life Cycle Costing in Excel 2 – Video

LCC Excel Template - 2

LCC Excel Solution - 2

1 Life Cycle Costing Exercise 1 - Video

LCC Excel Template - 1

LCC Excel Solution - 1

2 Life Cycle Costing Exercise 2 - Video

LCC Excel Template - 2

LCC Excel Solution - 2

3 Life Cycle Costing Exercise 3 - Video

LCC Excel Template - 3

LCC Excel Solution - 3

4 Life Cycle Costing Exercise 4 - Video

LCC Excel Template - 4

LCC Excel Solution - 4

The exercises shown in these 4 videos, outline a number of scenarios where the calculations demonstrated in the previous videos (left) are used in some simple LCC models.

Source: SCSI Guide to LCC

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- Building Life Cycle Costing is often calculated alongside a building LCA.
- Similarly, to Building LCA, the earlier in the design process you calculate a building LCC, the more savings you can achieve. In both cases, you can compare design alternatives to find out which is better over the whole life cycle of the building.
- LCC provides metrics on costs and savings over the whole lifetime of the building. When paired with LCA, it can help design buildings that are more sustainable both from an environmental and financial perspective.

LCC calculation: software

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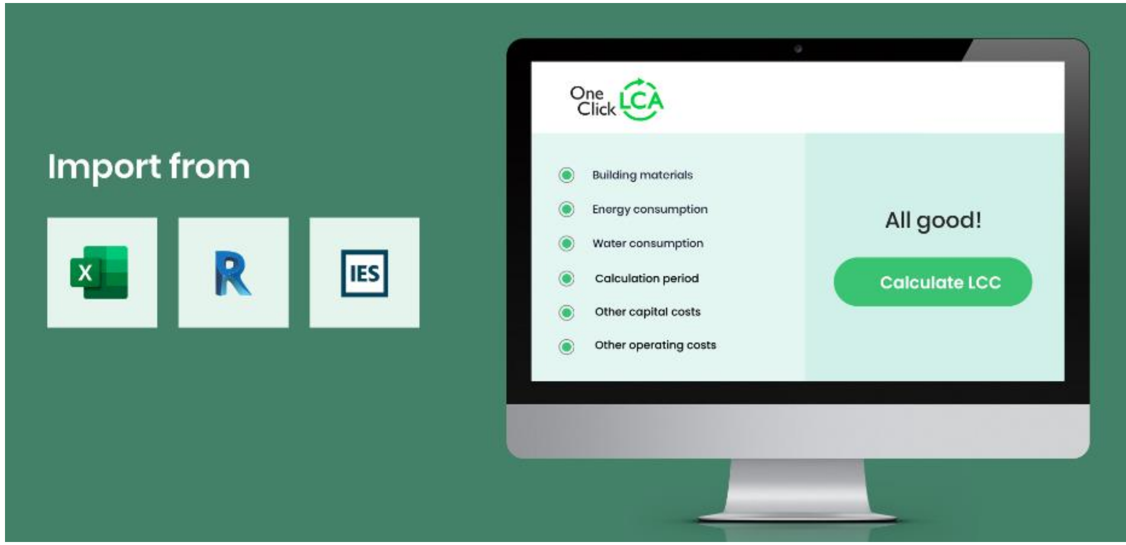
Softwares such as OneClick LCA can also be used to calculate LCC alongside LCA.

- ➢ Import all your building materials and quantities from Excel, BIM, or energy models. If you have already calculated your LCA, the materials can be used for LCC calculations.
- ➢ Operation and maintenance costs are automatically generated based on your location.
- ➢ Replacements are calculated based on the service life of your construction materials.
- ➢ All other costs can be added manually. You can edit the figures if you have project specific information.



LCC calculation using BIM data

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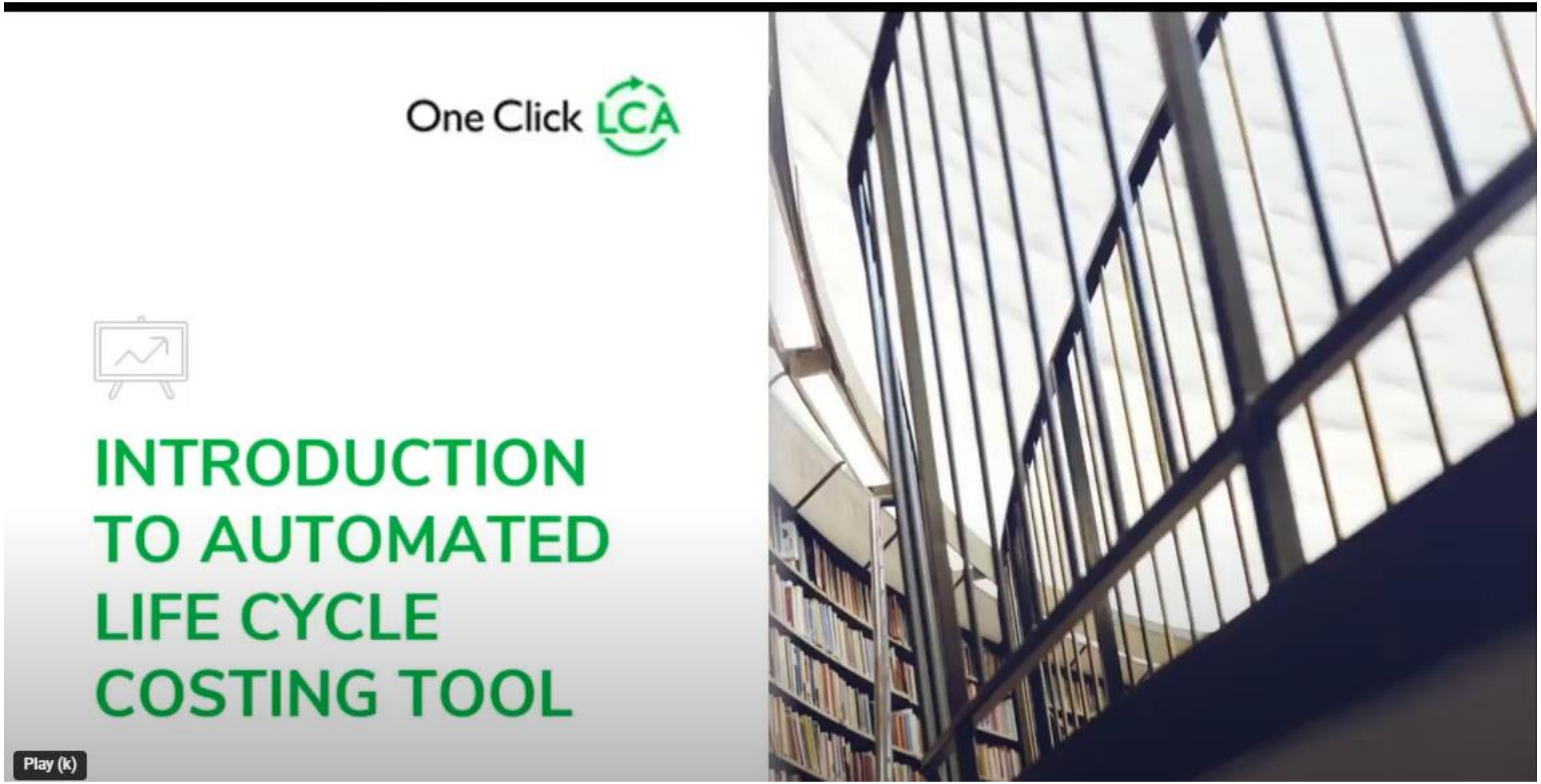

https://youtu.be/cGU3sYi_xeI

Assessment

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QUIZ!

Thank You

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