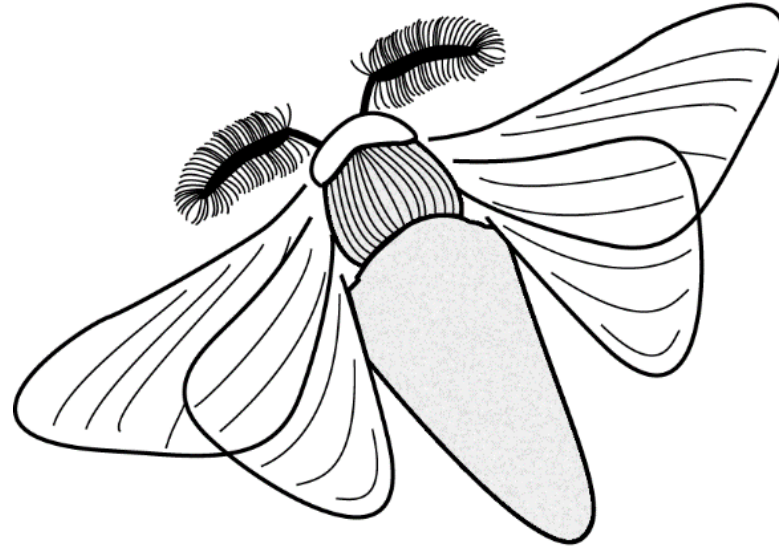


# BOMBYX



A design-integrated parametric tool for real-time Life Cycle Assessment

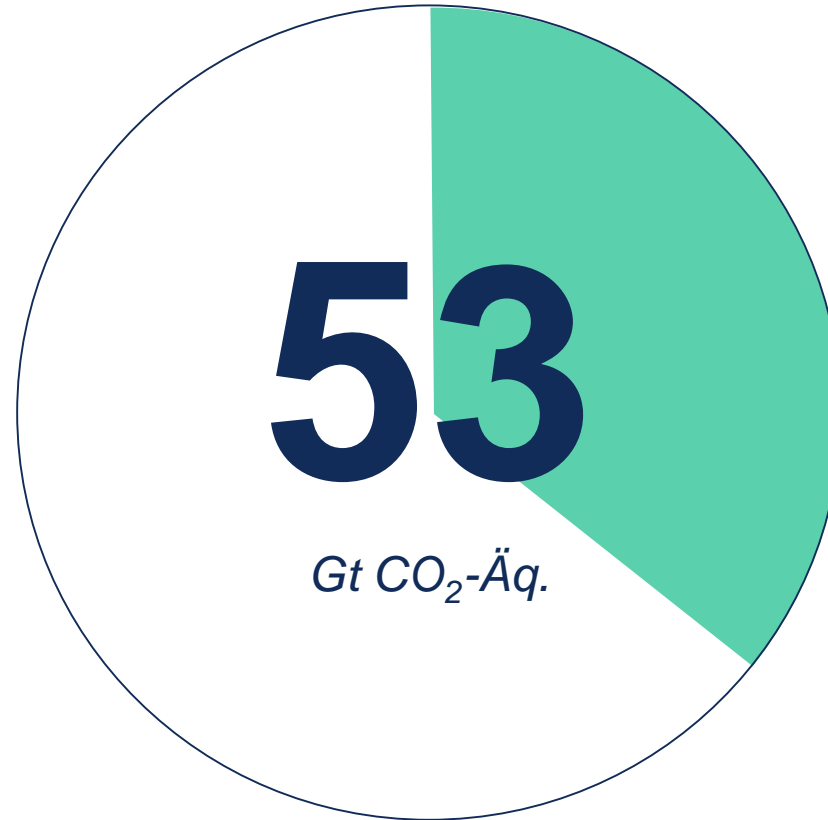
# Motivation

**53**  
Gt CO<sub>2</sub>-Äq.



Global greenhouse (GHG) emissions 2012  
<https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE>

# Motivation

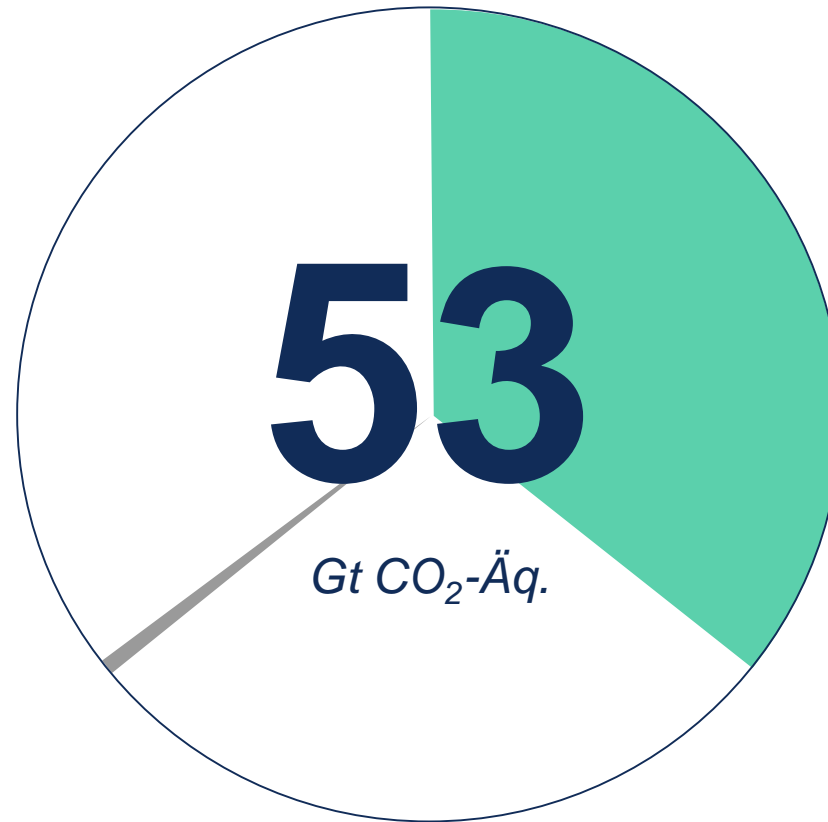


Built Environment

UNEP SBCI, 2009, Buildings and Climate Change Summary for Decision-Makers

# Motivation

Aviation

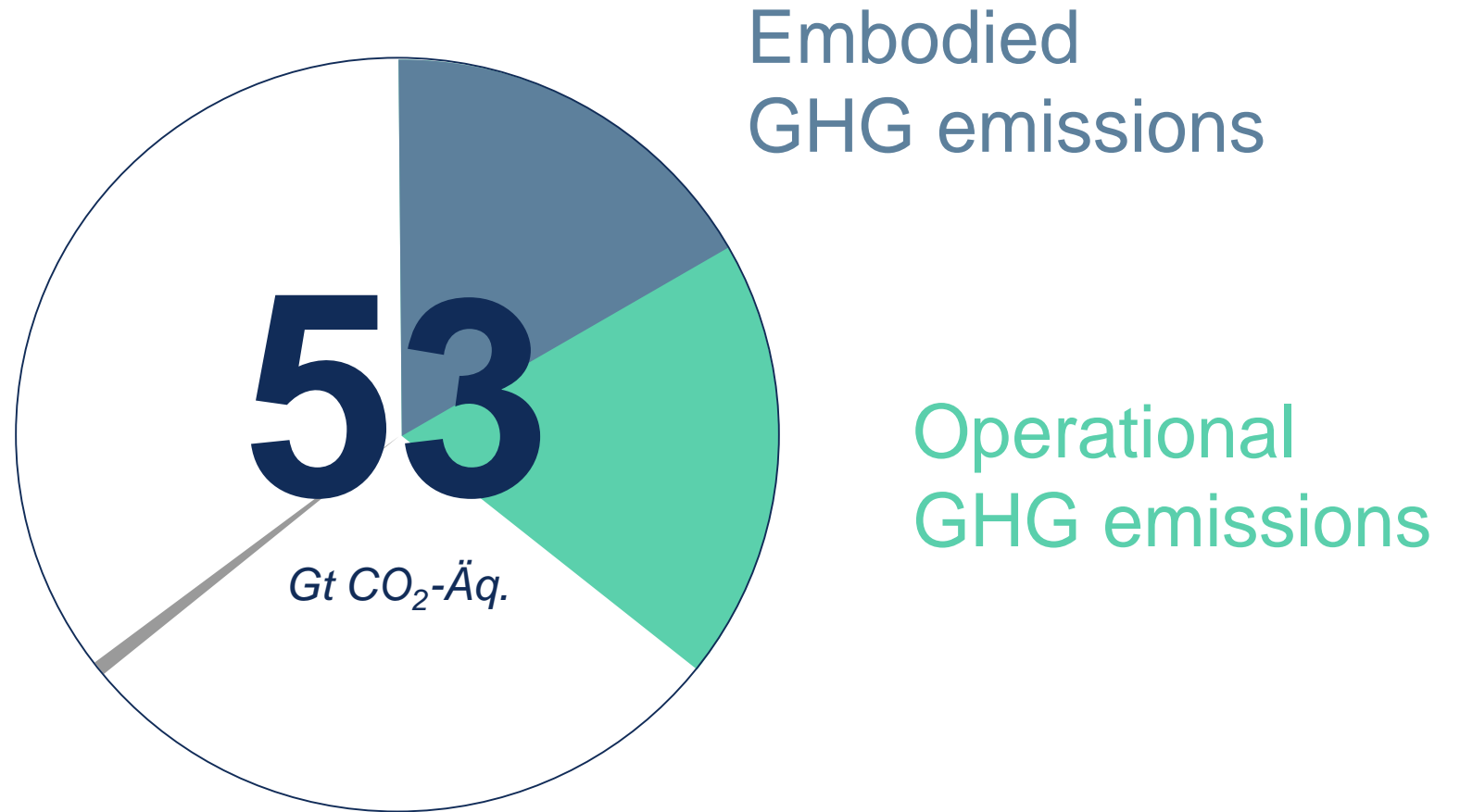


Built Environment

<http://www.atag.org/facts-and-figures.html>

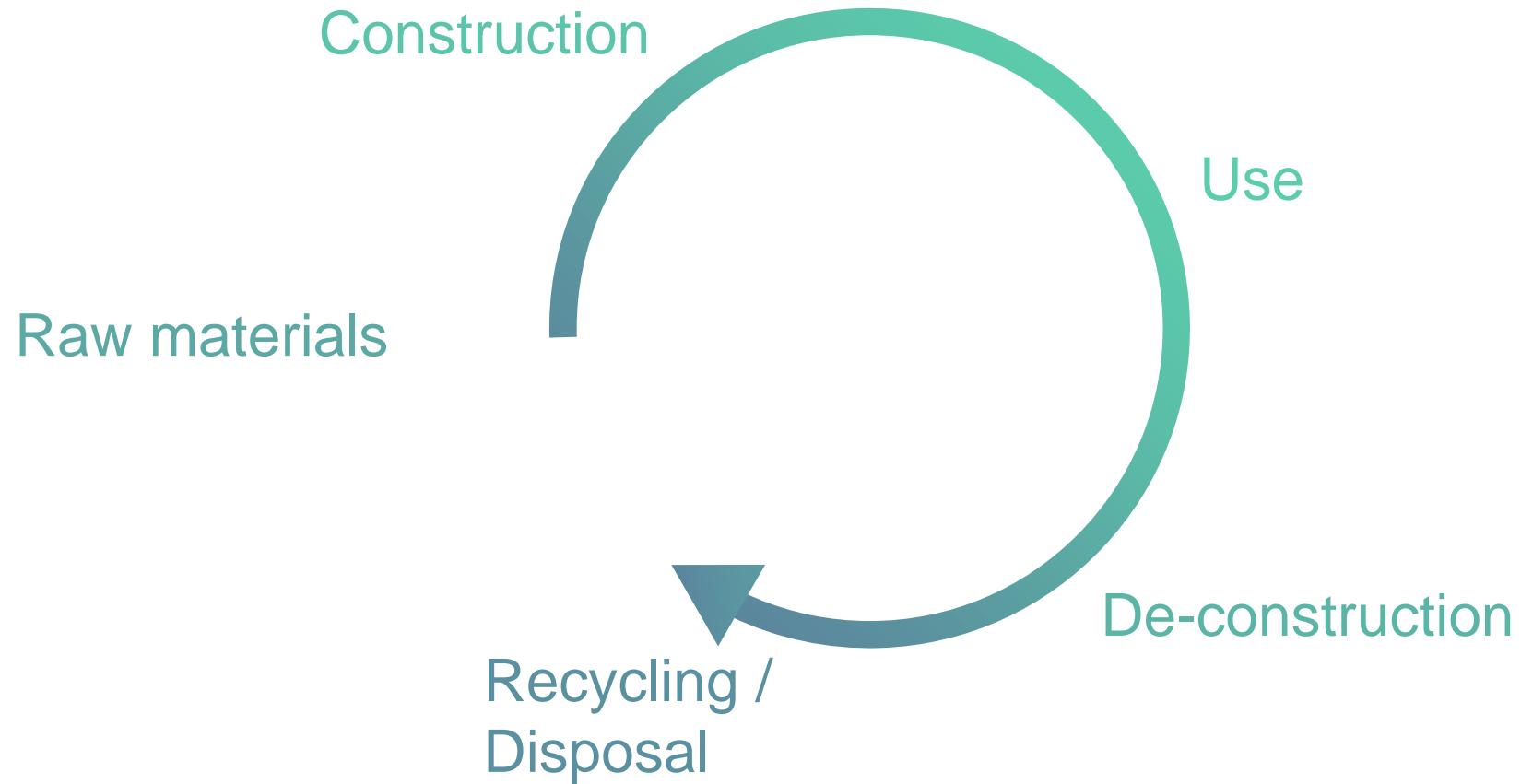
# Motivation

Aviation



UNEP SBCI, 2009, Buildings and Climate Change Summary for Decision-Makers

# Life cycle perspective

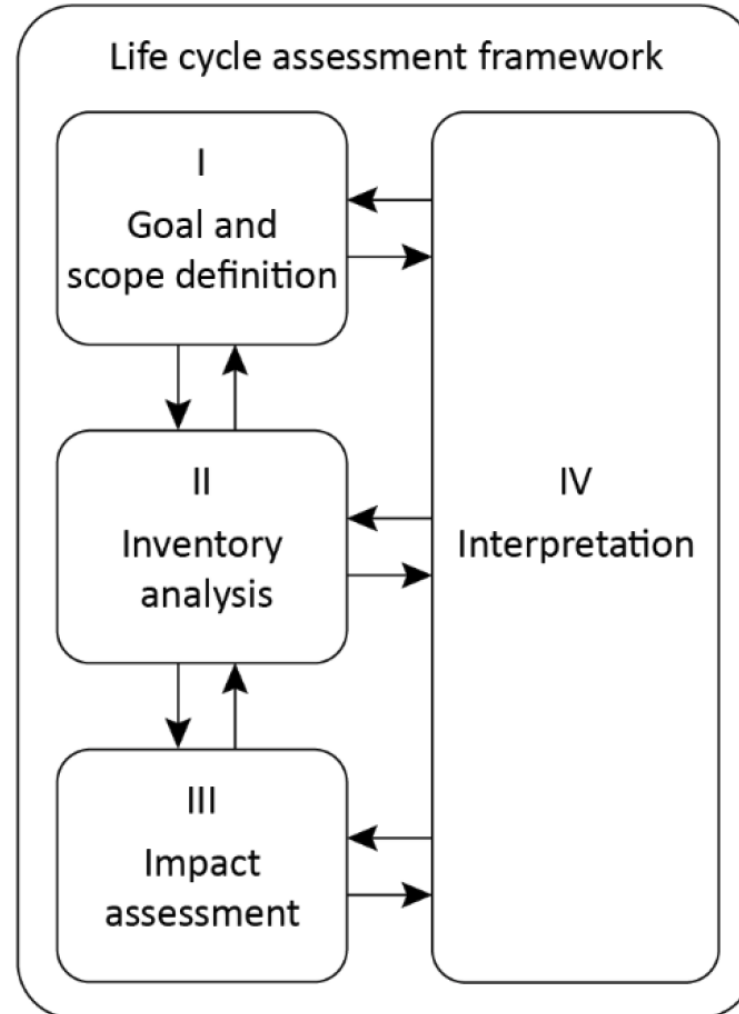


# Life Cycle Assessment

Product			Construction		Use Stage							End of Life				Benefits and loads beyond the system boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal	Re-use, recovery and recycling potential

Life cycle modules (based on EN 15978:2012, p.21)

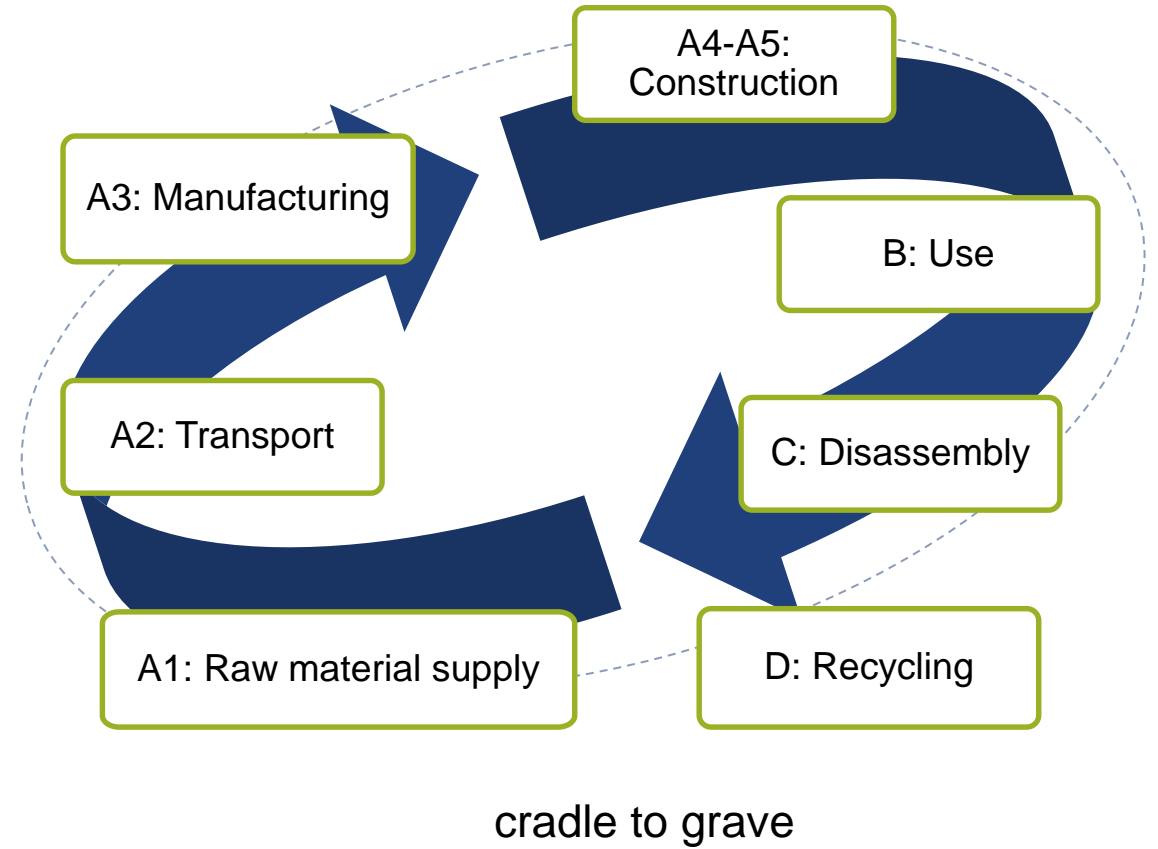
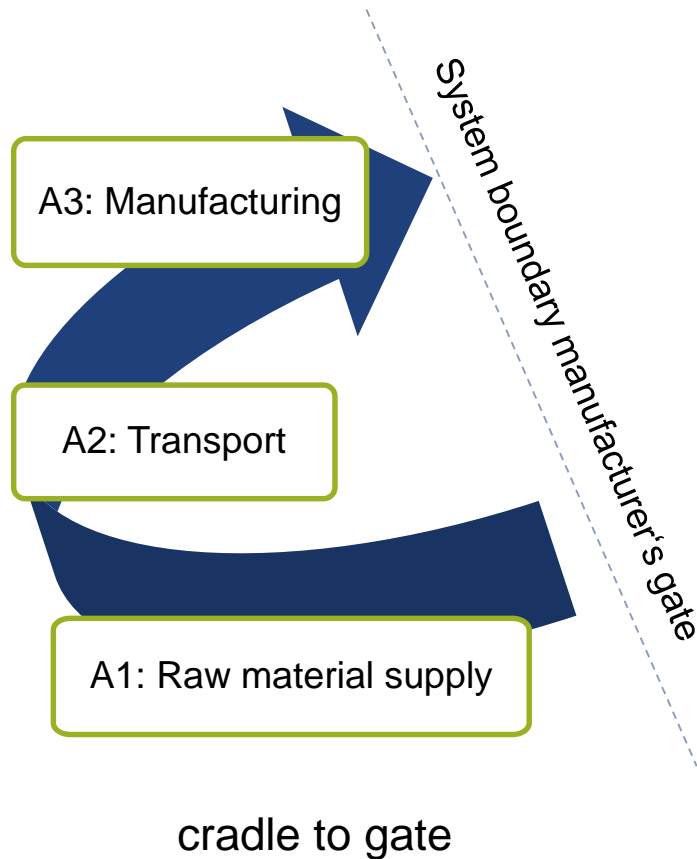
# Life Cycle Assessment



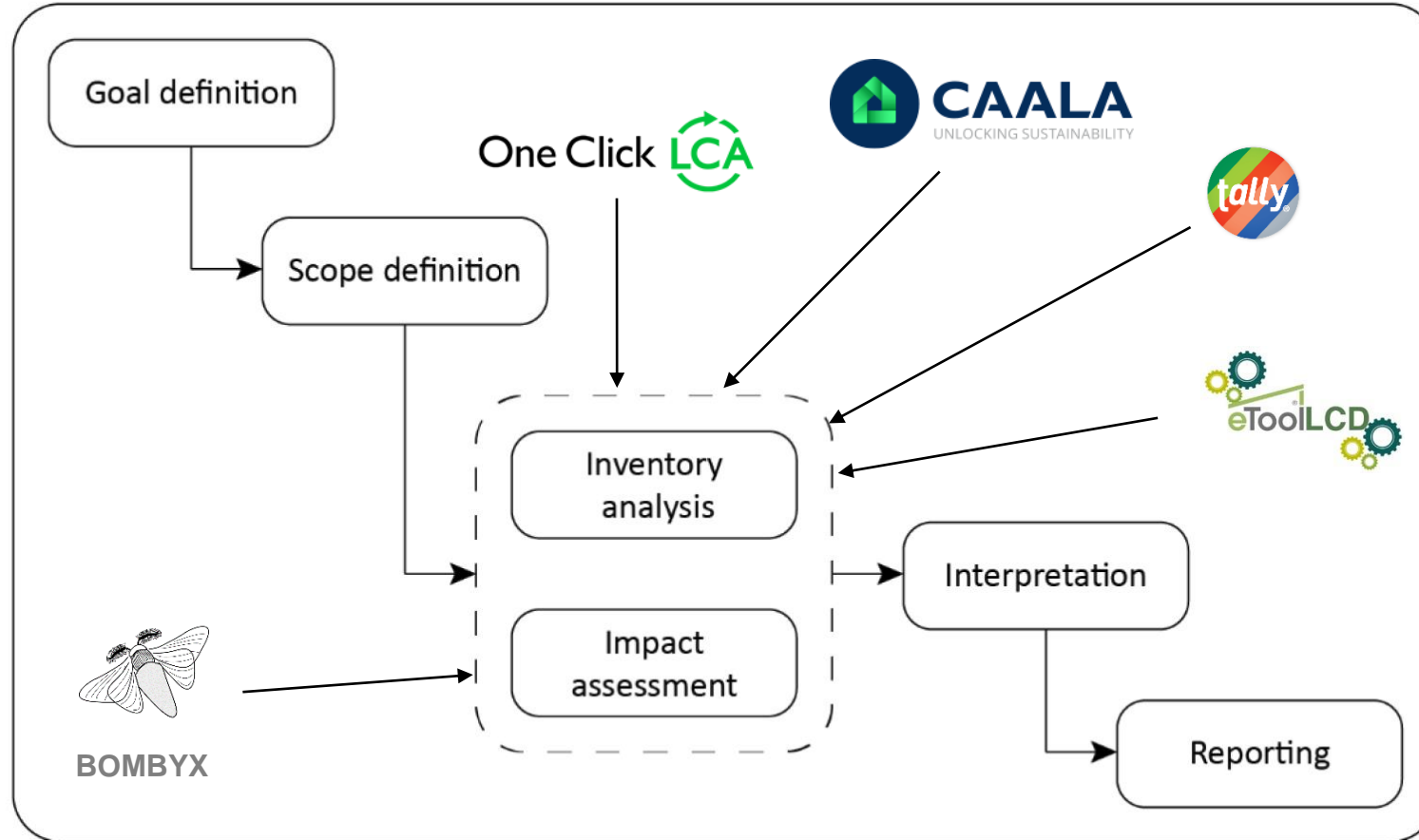
Stages of LCA  
ISO 14040:2009, p.16)



# Life Cycle Assessment



# Life Cycle Assessment



# LCA data

## Materials / Processes

- Ecoinvent
- GaBi
- ELCD
- USLCI
- Quartz

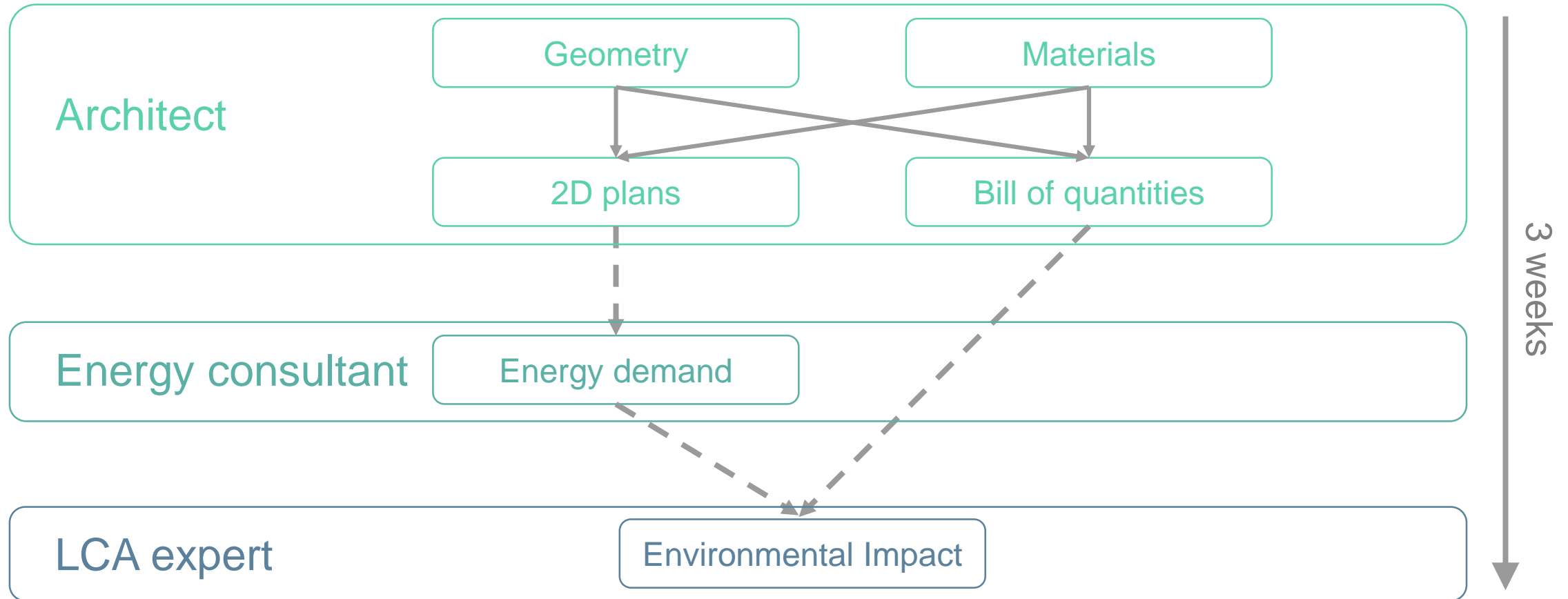
## Building materials:

- Spain: ITEC
- Germany (&Denmark):  
Ökobau.dat
- Switzerland: KBOB
- EPD database

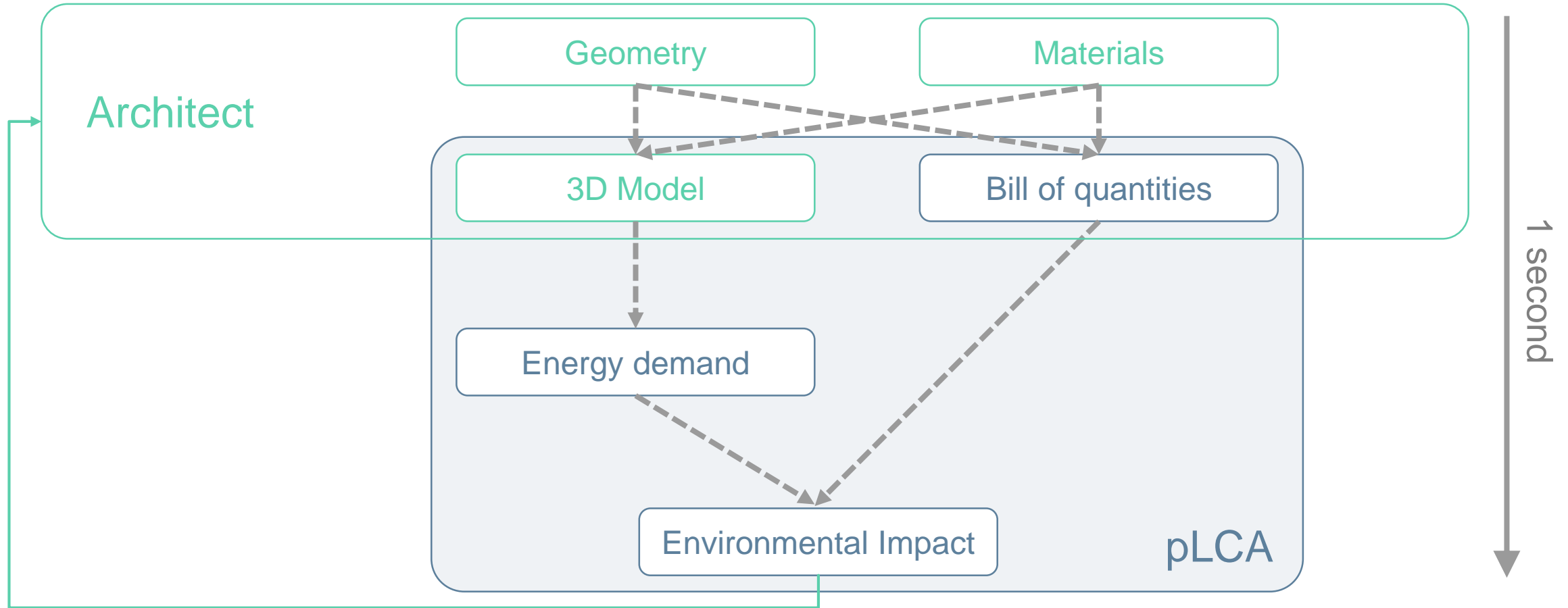
## Components

- Bauteilkatalog

# Process of LCA in architectural practice today

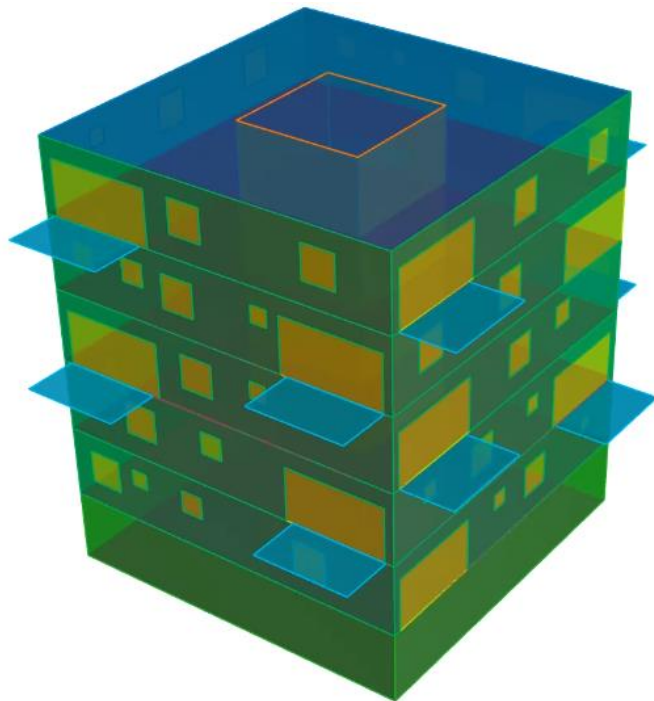


# Parametric LCA

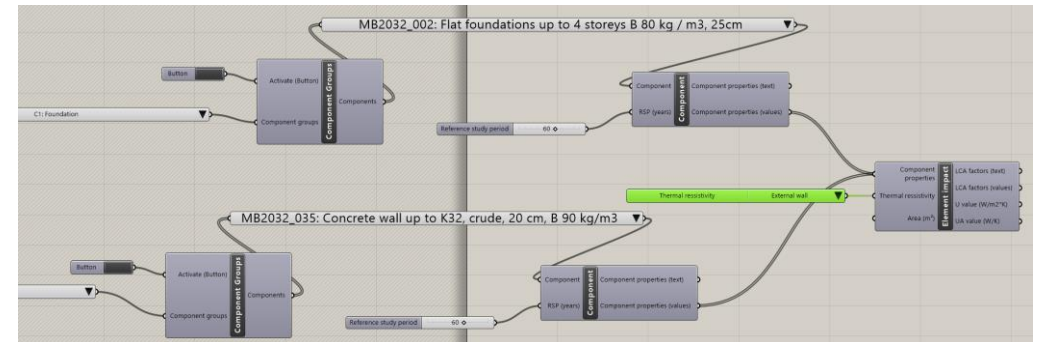


# Bombyx...

- is a parametric LCA tool for application in early design stages
- includes simplified LCA method
- is based on Rhino 3D modelling software and grasshopper



Name	C...	L...	C...
<b>Layer 01</b>	✓		
Balconies	🔦	📁	🟦
Ceilings	🔦	📁	🟨
Columns	🔦	📁	🟥
Exterior walls above ground	🔦	📁	🟩
Exterior walls under ground	🔦	📁	🟩
Flat roofs	🔦	📁	🟩
Interior walls	🔦	📁	🟨
Partition walls	🔦	📁	🟨
Pitched roofs	🔦	📁	🟪
Slabs	🔦	📁	🟪
Windows	🔦	📁	🟩



# Tool Structure

Version 1 (2018-2019)

Version 2 (2020)

Bottom – up

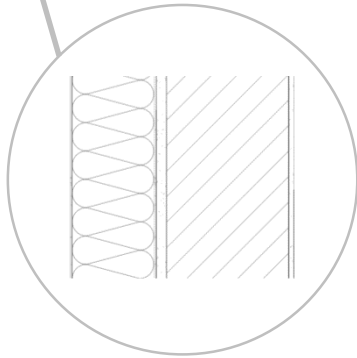
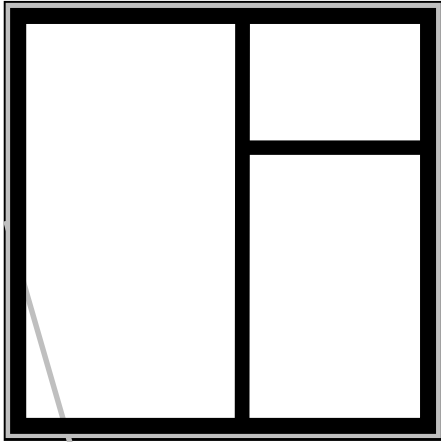
Top – down

Material – component – element – building

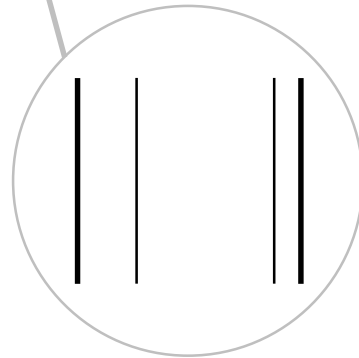
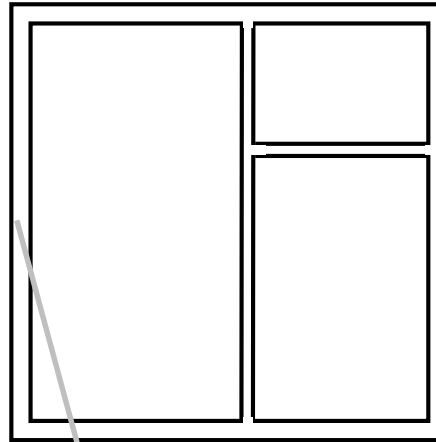
Building characteristics – average impact  
of the element – building impact

# Structure of building elements

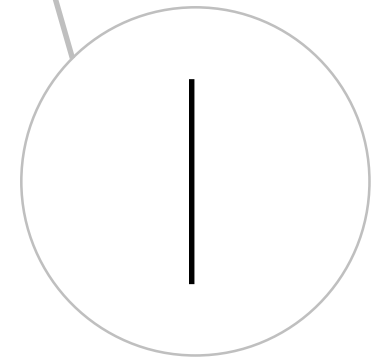
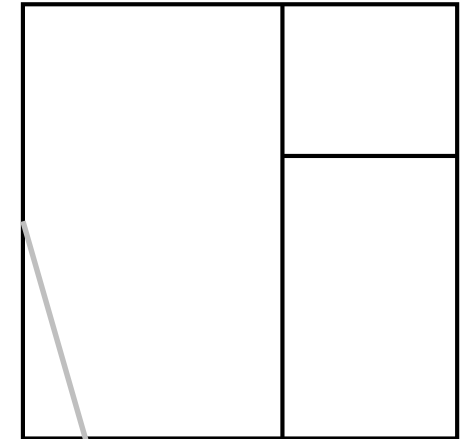
Material level



Component level

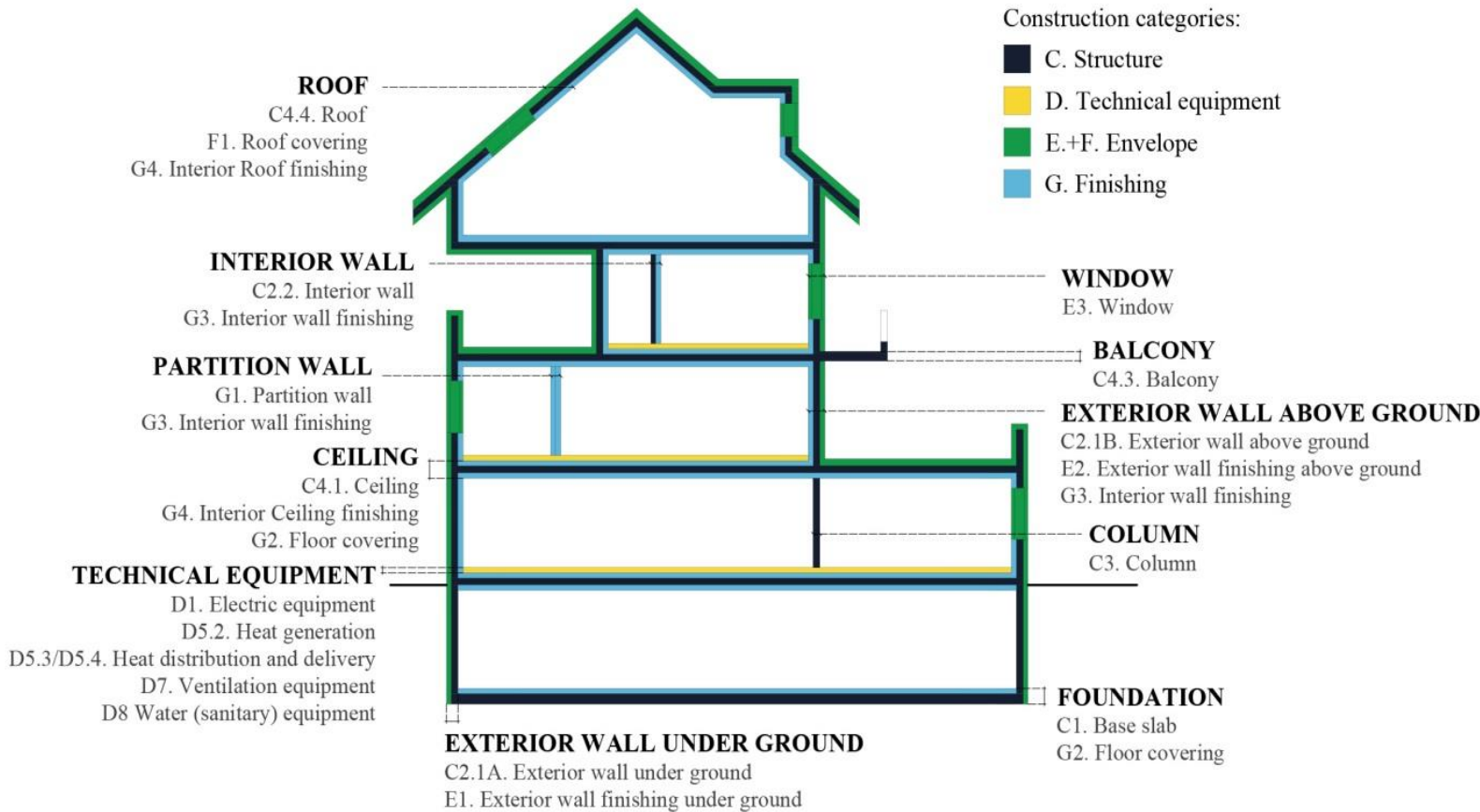


Element level



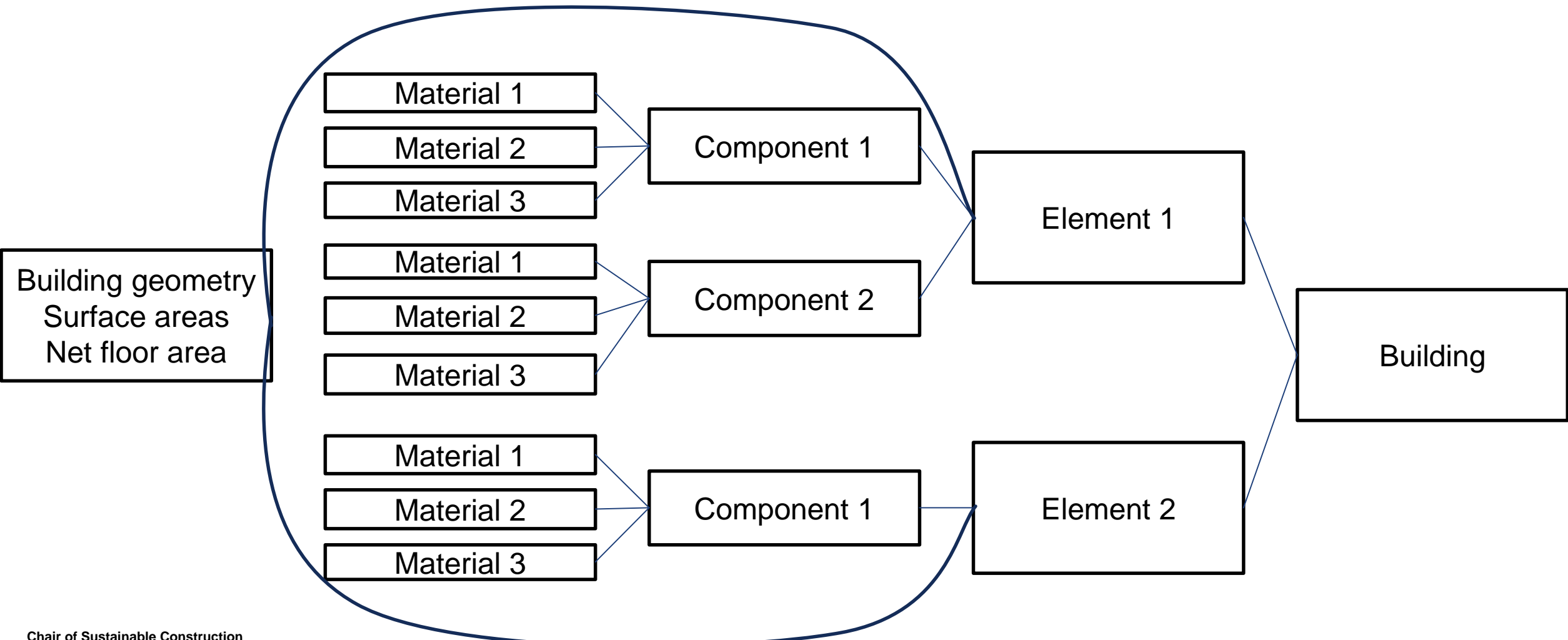


# Structure of building elements

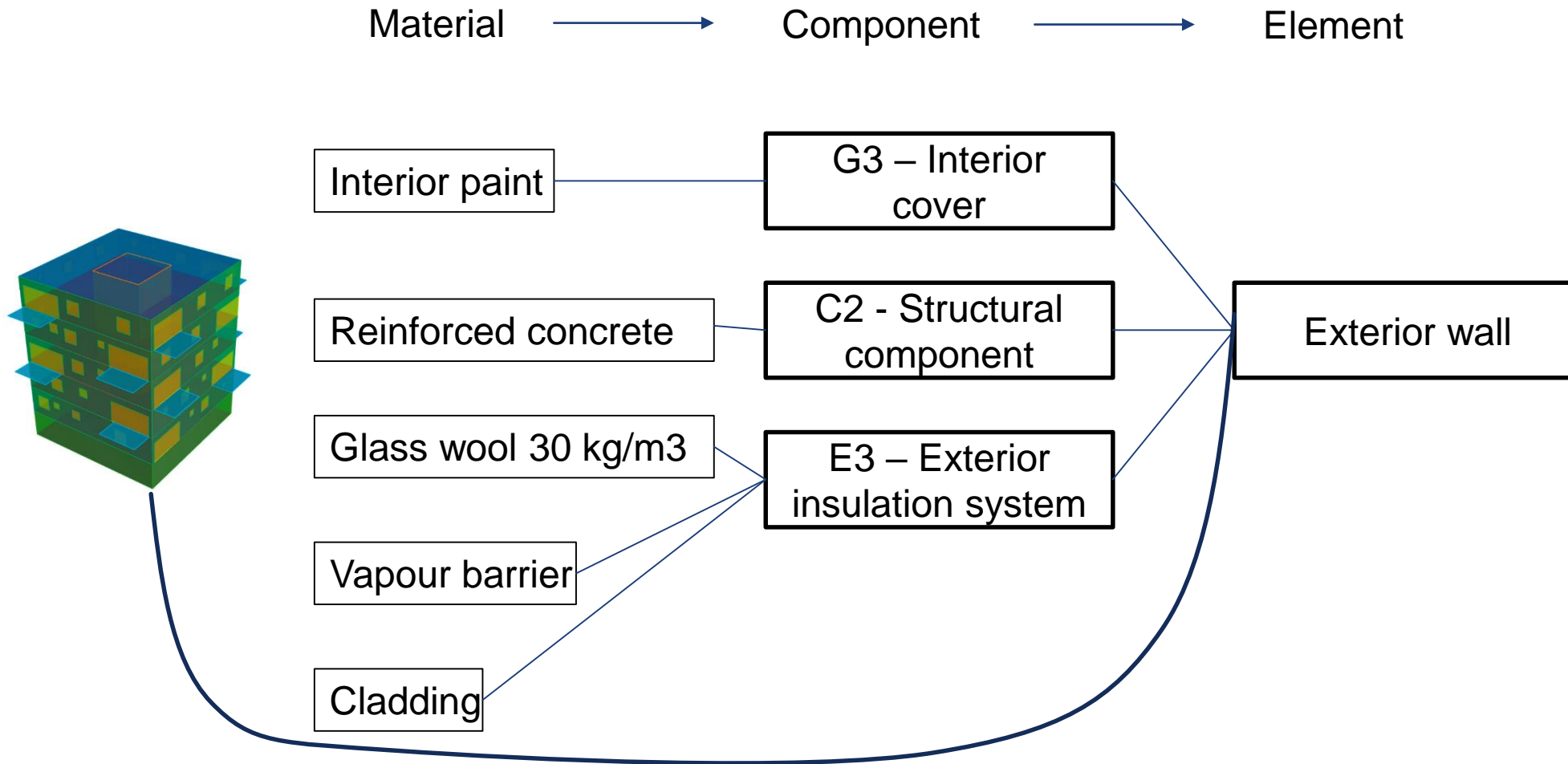


Architectural element	BKP-H Component
1. Foundation	C1 Base slab, foundation
	G2 Floor covering
2. Exterior wall under ground	C2.1A Exterior wall under ground
	E1 Exterior wall finishing under ground
3. Exterior wall above ground	C2.1B Exterior wall above ground
	E2 Exterior wall finishing above ground
	G3 Interior wall finishing
4. Window	E3 Window
5. Interior wall	C2.2 Interior wall
	G3 Interior wall finishing
6. Partition wall	G1 Partition wall
	G3 Interior wall finishing
7. Column	C3 Column
8. Ceiling	C4.1 Ceiling
	G2 Floor covering
	G4 Interior ceiling/roof finishing
9. Balcony	C4.3 Balcony
10. Roof	C4.4 Roof
	F1 Roof covering
	G4 Interior ceiling/roof finishing
11. Technical equipment	D1 Electric equipment D5.2 Heat generation D5.3 / D5.4 Heat distribution and delivery D7 Ventilation equipment D8 Water (sanitary) equipment

# Steps

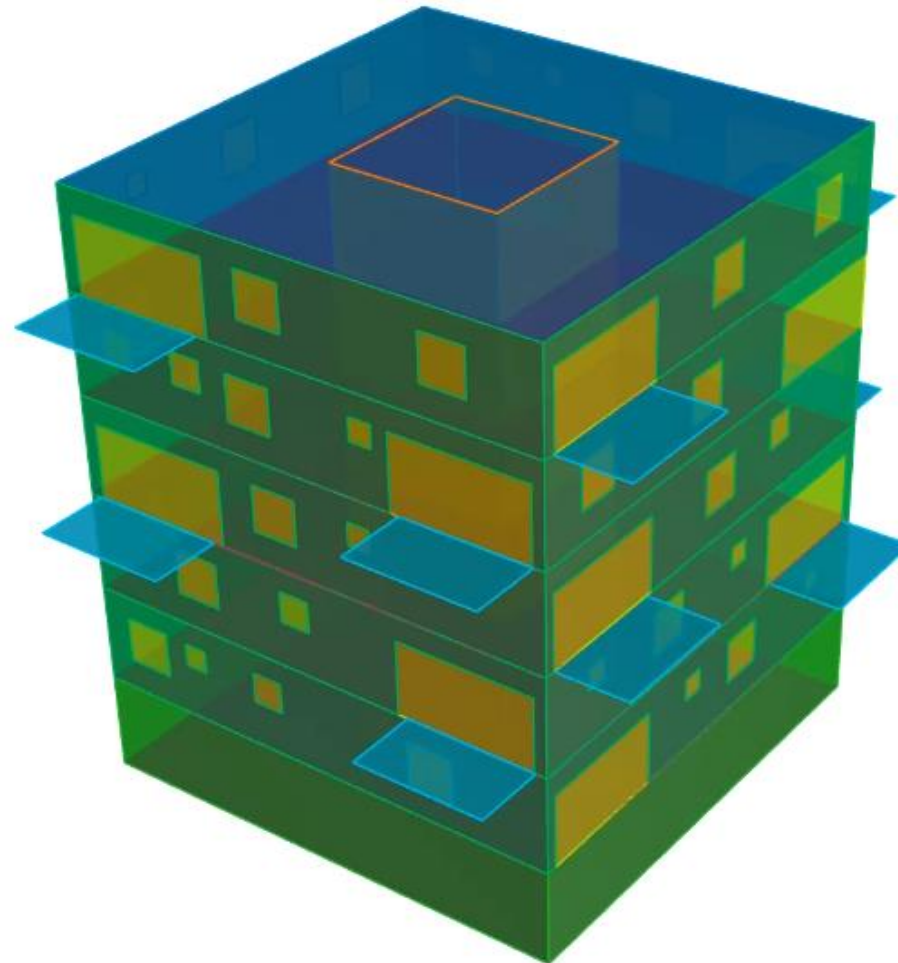


# Example exterior wall



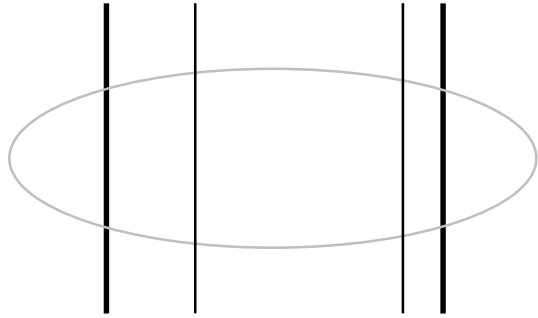
# Geometry

- Geometry is created in Rhino or imported from CAD/BIM tool
- Each element is drawn on one layer
- Each layer is assigned a material combination



Name	C...	L...	C...
<b>Layer 01</b>	✓		■
Balconies	💡	🔒	■
Ceilings	💡	🔒	■
Columns	💡	🔒	■
Exterior walls above ground	💡	🔒	■
Exterior walls under ground	💡	🔒	■
Flat roofs	💡	🔒	■
Interior walls	💡	🔒	■
Partition walls	💡	🔒	■
Pitched roofs	💡	🔒	■
Slabs	💡	🔒	■
Windows	💡	🔒	■

# Element



E2.2  
MB2032\_04  
External thermal  
insulation system

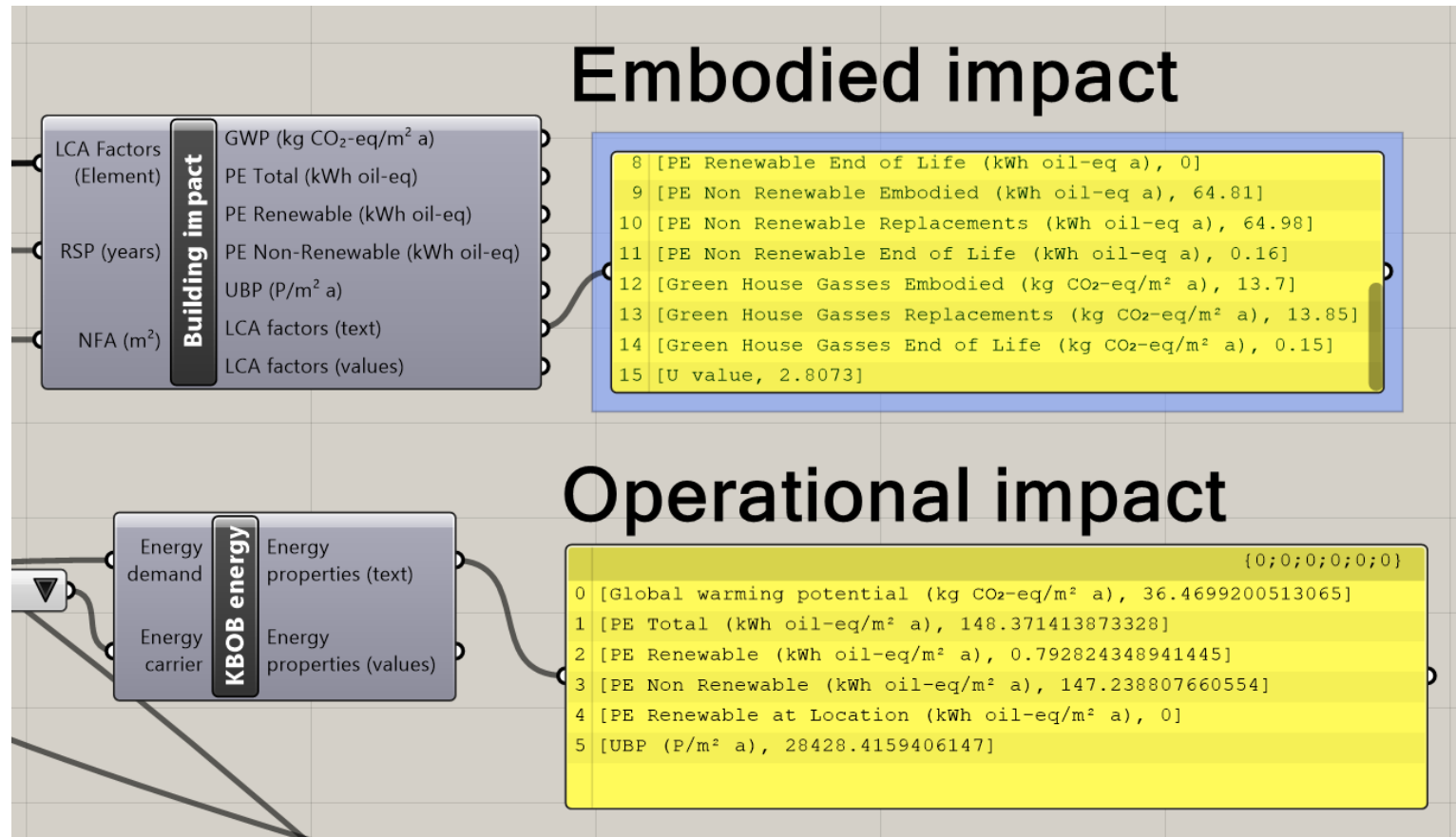
C2.1B  
MB2032\_036  
Reinforced  
concrete, 20 cm,  
B 105 kg/m<sup>3</sup>

G3  
MB2032\_125  
Rendering, paint

<http://www.bauteilkatalog.ch/ch/de/21.asp?lng=DE&navid=5>

# Embodied vs Operational

- SIA 380/1 quasi-static energy analysis



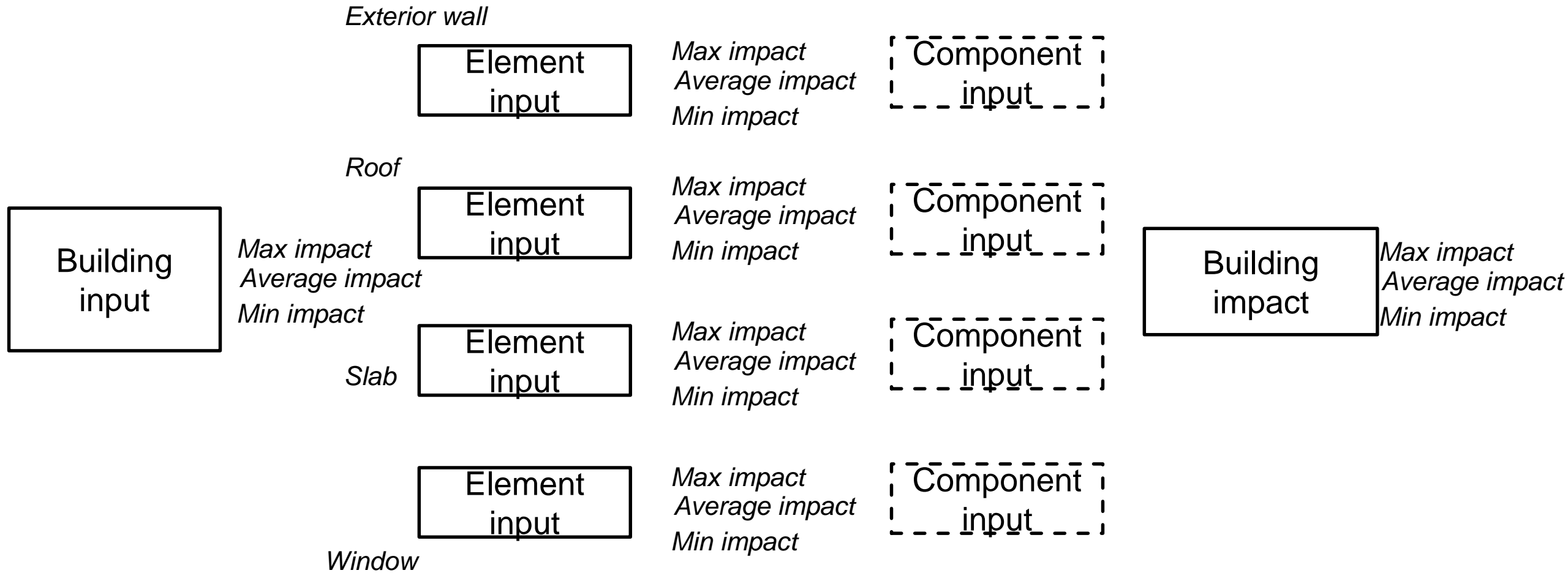
# Advantages and disadvantages

- Full assessment
- Easy to use
- Swiss database with big selection of materials
- Requires knowledge of all the materials or the components

# Version 2



# Version 2



# Version 2 – building input

Structural material

Concrete

- Concrete
- Wood
- Brick
- Steel

Building size

Small

- Small
- Mid-size
- Highrise

Building usage

Residential single family

- Residential single family
- Residential multi family
- Office

Energy preference

Standard

- Standard
- Above average
- Passive house

# Database

- Material level - KBOB
- Component level – Bauteilkatalog, EcoKomposit

# Material level

## Details for material: 10.004 - Polystyrene expands (EPS)(15 kg/m<sup>3</sup>)

---

**English name:** Polystyrene expands (EPS)(15 kg/m<sup>3</sup>)

**German name:** Polystyrol expandiert (EPS)(15 kg/m<sup>3</sup>)

**French name:** Polystyrène expansé (EPS)(15 kg/m<sup>3</sup>)

**KBOB ID:** 10.004

**Density:** 15.00 kg/m<sup>3</sup>

**Reference unit:** kg

**Disposal ID:** 91.028

**Disposal:** Entsorgung, Gebäude, EPS-Isolation flammgeschützt, in Beseitigung

**UBP'13 embodied:** 3610.00

**UBP'13 EoL:** 1570.00

**Primary energy total embodied:** 30.00 kWh oil-eq

**Primary energy total EoL:** 0.14 kWh oil-eq

**Primary energy renewable embodied:** 0.36 kWh oil-eq

**Primary energy renewable EoL:** 0.00 kWh oil-eq

**Primary energy non renewable embodied:** 29.70 kWh oil-eq

**Primary energy non renewable EoL:** 0.13 kWh oil-eq

**Global warming potential embodied:** 4.46 kg CO<sub>2</sub>-eq

**Global warming potential EoL:** 3.19 kg CO<sub>2</sub>-eq

**Thermal conductivity:** 0.04 (W/m\*K)

[Edit material](#)

[Back to List](#)

## Component:

F1.2 / Compact roof foam glass, U = 0.2

**Component code:** F1.2

**Sort code:** MB2032\_016

**Category (English):** Flat roof

**Category (German):** Flachdach

**Category (French):** Translation missing.

**Category text (English):** Compact roof foam glass, U = 0.2

**Category text (German):** Flachdach, Kompaktdach, Schaumglas, U = 0.2

**Category text (French):** Translation missing.

**Short description (German):** Translation missing.

**Reference service life (years):** 20

**Component cost:** -

**Building size - small:** Yes

**Building size - mid-size:** Yes

**Building size - highrise:** Yes

**Building usage - single:** Yes

**Building usage - multi:** Yes

**Building usage - office:** Yes

**Building energy - standard:** Yes

**Building energy - above average:** No

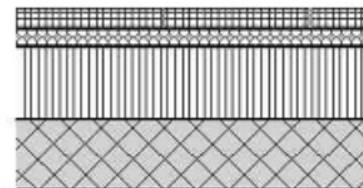
**Building energy - passive house:** No

**Struct material - concrete:** Yes

**Struct material - wood:** No

**Struct material - brick:** No

**Struct material - steel:** No



# Component level

Layers:

Material	Thickness (m)	Thermal conductivity (W/m*K)	Percent (%)	Min thickness (m)	Max thickness (m)	Increment (m)	Layer
02.007 - Cement stone	0.060	0.700	100.00	0.060	0.250	0.010	1
03.011 - Broken gravel	0.050	2.000	100.00	0.020	0.150	0.010	2
09.008 - Polyethylene fleece (PE)	0.001	0.420	100.00	0.001	0.003	0.001	3
09.003 - Geomembrane bituminous	0.001	0.017	100.00	0.001	0.003	0.001	4
09.003 - Geomembrane bituminous	0.001	0.017	100.00	0.001	0.003	0.001	6
09.003 - Geomembrane bituminous	0.003	0.017	100.00	0.001	0.003	0.001	7
10.007 - Foam glass(110 kg/m3)	0.200	0.045	100.00	0.100	0.300	0.010	5
01.002 - Building construction concrete (without reinforcement)	0.020	1.800	100.00	0.160	0.280	0.020	8

Save values

# Summary

- Simplified LCA calculation tool based on different LOD
- Swiss database of materials and predefined components
- Geometry is taken from 3D model

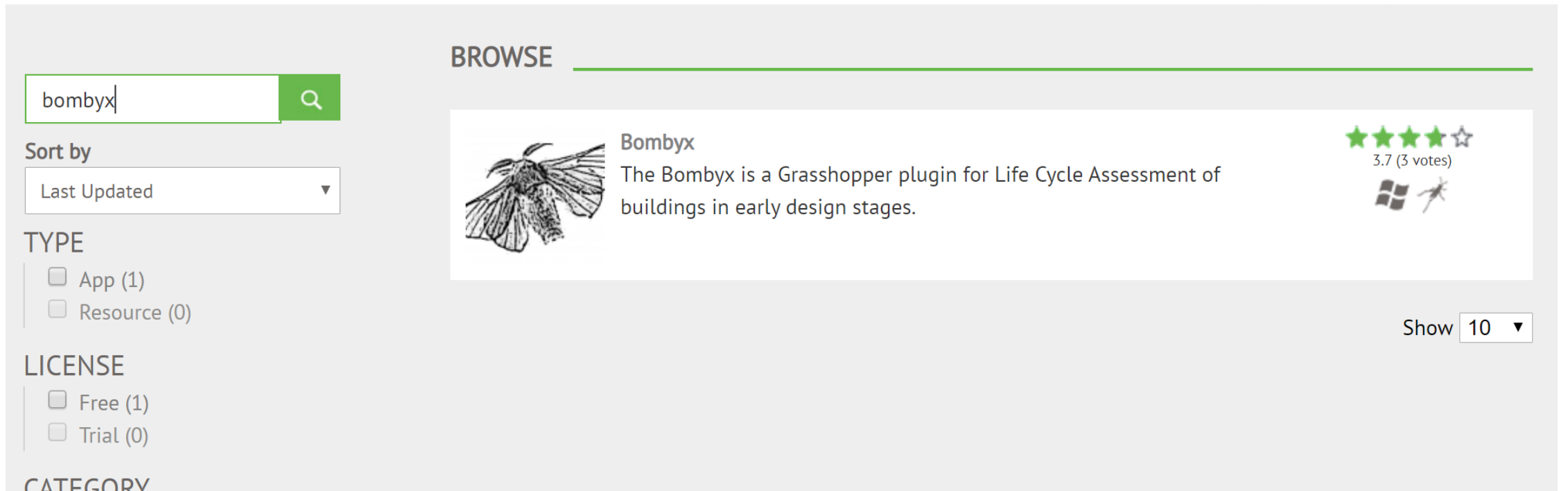
# Downloading the plugin

<https://www.food4rhino.com/>

The screenshot shows the food4Rhino website interface. At the top left is the logo for 'food4Rhino' with the tagline 'Apps for Rhino and Grasshopper'. To the right are navigation tabs for 'APPS', 'EVENTS', and 'SUPPORT', with 'APPS' highlighted. Further right is the user name 'Alina\_Galimshina | Logout'. Below the navigation is a search bar with the placeholder text 'What are you looking for?' and a green 'Search' button. Below the search bar is a social media banner featuring the Instagram logo, a rhino icon, and several hashtags: '#rhino3d', '#digitalfabrication', '#grasshopper3d', and '#computationaldesign'. The banner also includes the text 'mcneel.europe'. Below the banner is a section titled 'SPONSORED APPS' which displays six app cards with their respective logos and names: EasyJewels3D ver 2, Mindesk RT VR AR, ShapeDiver, Pufferfish, XNurbs Rhino..., and Lands Design.



# Downloading the plugin



The screenshot shows a web interface for browsing software plugins. On the left, there is a search bar containing the text 'bombyx' and a search icon. Below the search bar, there are filter sections for 'Sort by' (set to 'Last Updated'), 'TYPE' (with options for 'App (1)' and 'Resource (0)'), 'LICENSE' (with options for 'Free (1)' and 'Trial (0)'), and 'CATEGORY'. The main content area is titled 'BROWSE' and features a search result for 'Bombyx'. The result includes a small image of a moth, the title 'Bombyx', a description: 'The Bombyx is a Grasshopper plugin for Life Cycle Assessment of buildings in early design stages.', a rating of 3.7 (3 votes) shown as four green stars and one grey star, and icons for Windows and Grasshopper. At the bottom right of the interface, there is a 'Show 10' dropdown menu.

# Downloading the plugin

## BOMBYX (by ETHZ\_SC)



The goal of Bombyx is to allow for simplified whole building Life Cycle Assessment (LCA) of buildings during design.

The current WIP version focusses on the assessment of embodied impacts using the Swiss LCA database for building materials.

In the future, further national databases will be integrated. Furthermore, the assessment of the operational phase will be integrated.

Internet access is needed to access the database.

**Category:** Architecture

**License:** Free

[Download](#)

Your vote: 5  
3.7 (3 votes)

**Downloads:**

593

[Website](#)[Support Email](#)[License](#)

# Downloading the plugin

C:\User\AppData\Roaming\Grasshopper\Libraries

Unzip the folder → Start Rhino and grasshopper

Lets practice!

**Thank you!**

**Alina Galimshina**

**Email: [galimshina@ibi.baug.ethz.ch](mailto:galimshina@ibi.baug.ethz.ch)**

Chair of Sustainable Construction

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<https://sc.ibi.ethz.ch/en/>

[www.ethz.ch/en.html](http://www.ethz.ch/en.html)

