ETH zürich

SBE19 Graz

SUSTAINABLE BUILT ENVIRONMENT D-A-CH CONFERENCE 2019

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In Cooerpation with:

Consistent BIM-led LCA during the entire building design process

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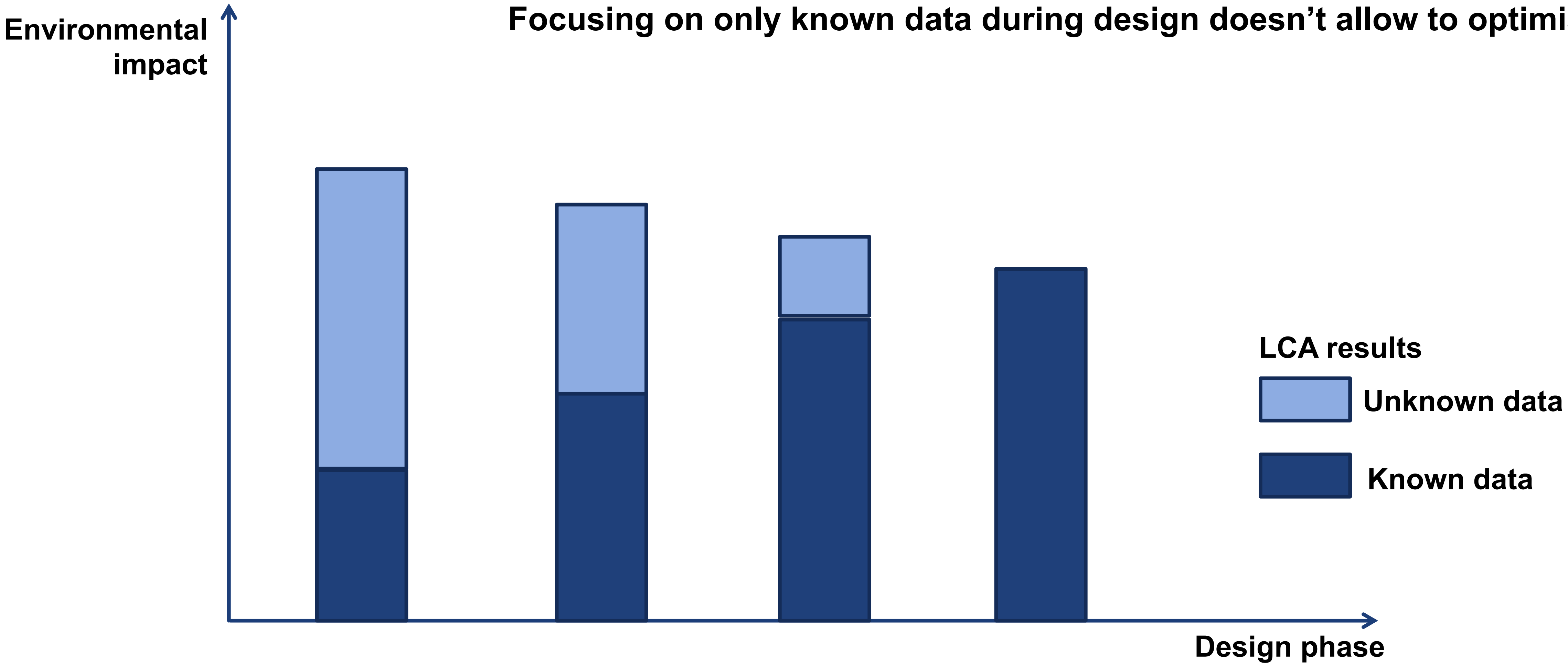
Introduction

- Life Cycle Assessment (LCA) is a suitable method for holistic evaluation of the environmental performance of buildings
- Most time for LCA of buildings is spent on gathering the necessary information
- Building Information Modelling (BIM) can provide the necessary input and speed up the process

Early design	Detailed design	LOD	Tools	Ref.
	●	–	Revit, Navisworks, Excel, API	[12]
●		200	Revit, GBS, ATHENA Impact Estimator, Excel	[7]
●		–	Dprofiler, CostLab, eQUEST, SimaPro, ATHENA EcoCalculator, Excel	[13]
●		–	Revit, Dynamo, Excel	[14]
●		–	Revit, Excel	[11]
	●	–	Revit, Excel, SIMIEN, SimaPro 7.3	[16]
●		–	Grasshopper, Rhinoceros	[17]
	●	–	Revit, Excel, SIMIEN, SimaPro 7.3	[18]
	●	–	BIM tool (N/S), Excel	[19]
●		–	Revit, Ecotect, IESVE, Excel, Athena Impact Estimator	[20]
●		–	Revit, Athena Impact Estimator, Excel	[21]
	●	300	Revit, Korea LCI database	[9]
●		–	Grasshopper, Design Builder, DIVA, Ladybug,Galapagos, Octopus,Rhinoceros	[22]
	●	–	Revit, Revit DB link, MS Access, Athena Impact Estimator, Excel, Visual Studio	[23]
●		–	Revit, Tally, GBS	[24]
●		–	Revit, Revit API, External db	[25]
●		–	Revit, Insight	[26]
	●	–	Revit, Ecotect, Excel	[27]
●		200	Revit, Dynamo, Excel	[8]
	●	–	Revit, Power Pivot, FME, Google Maps API	[28]
	●	–	Revit, Dynamo, MySQL, Grasshopper, Slingshot, Archsim, Octopus,EnergyPlus	[29]
●		–	Revit, Excel	[30]
●		–	ArchiCAD, Excel	[31]
	●	300	Revit, Excel, Glondon BIM5D, eBALANCE, Designbuilder,	[10]

Risk

Focusing on only known data during design doesn't allow to optimise



Problem

- Current BIM-LCA approaches are defined for a specific design stage / Level of Development (LOD) and do not allow for consistent feedback from early to detailed design stages

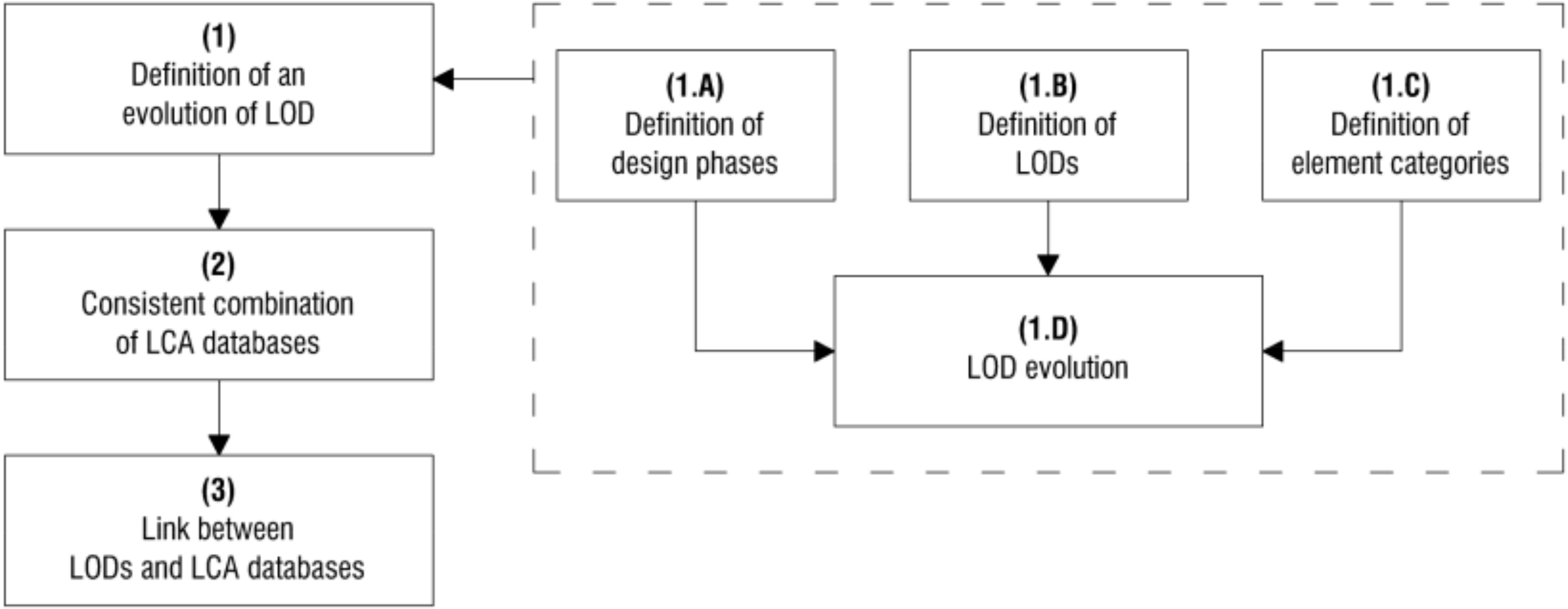
- Only assessing the defined components misses a large share of the impact

Goal

Develop a framework to

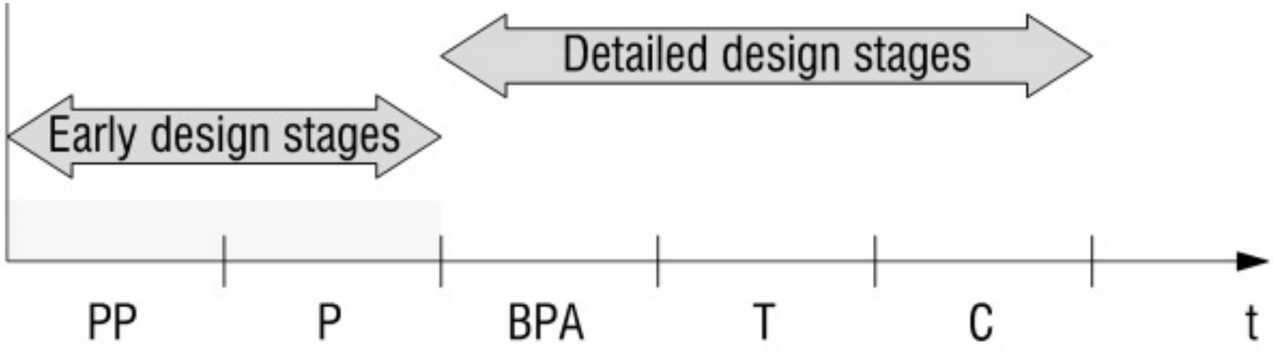
- use LCA as a consistent decision-making tool during all phases of the design process.
- consider the available information in the BIM model with as much accuracy as possible in each design stage.

Method

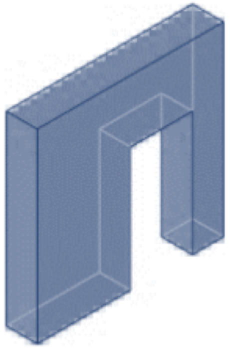
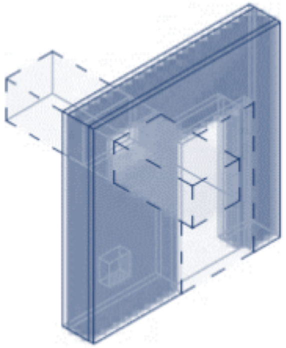
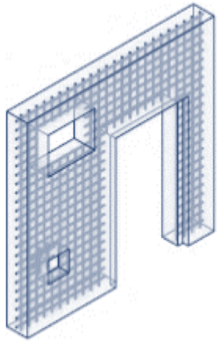

(1)
Definition of an
evolution of LOD
(2)
Consistent combination
of LCA databases
(3)
Link between
LODs and LCA databases
(1.A)
Definition of
design phases
(1.B)
Definition of
LODs
(1.C)
Definition of
element categories
(1.D)
LOD evolution

1A Design stages

1. Project Planning (PP)
2. Project (P)
3. Building Permit Application (BPA)
4. Tendering (T)
5. Construction (C)



1B LODs

Pre-LOD	LOD 100	LOD 200	LOD 300	LOD 400
$m^2_{\text{floor area}}$				

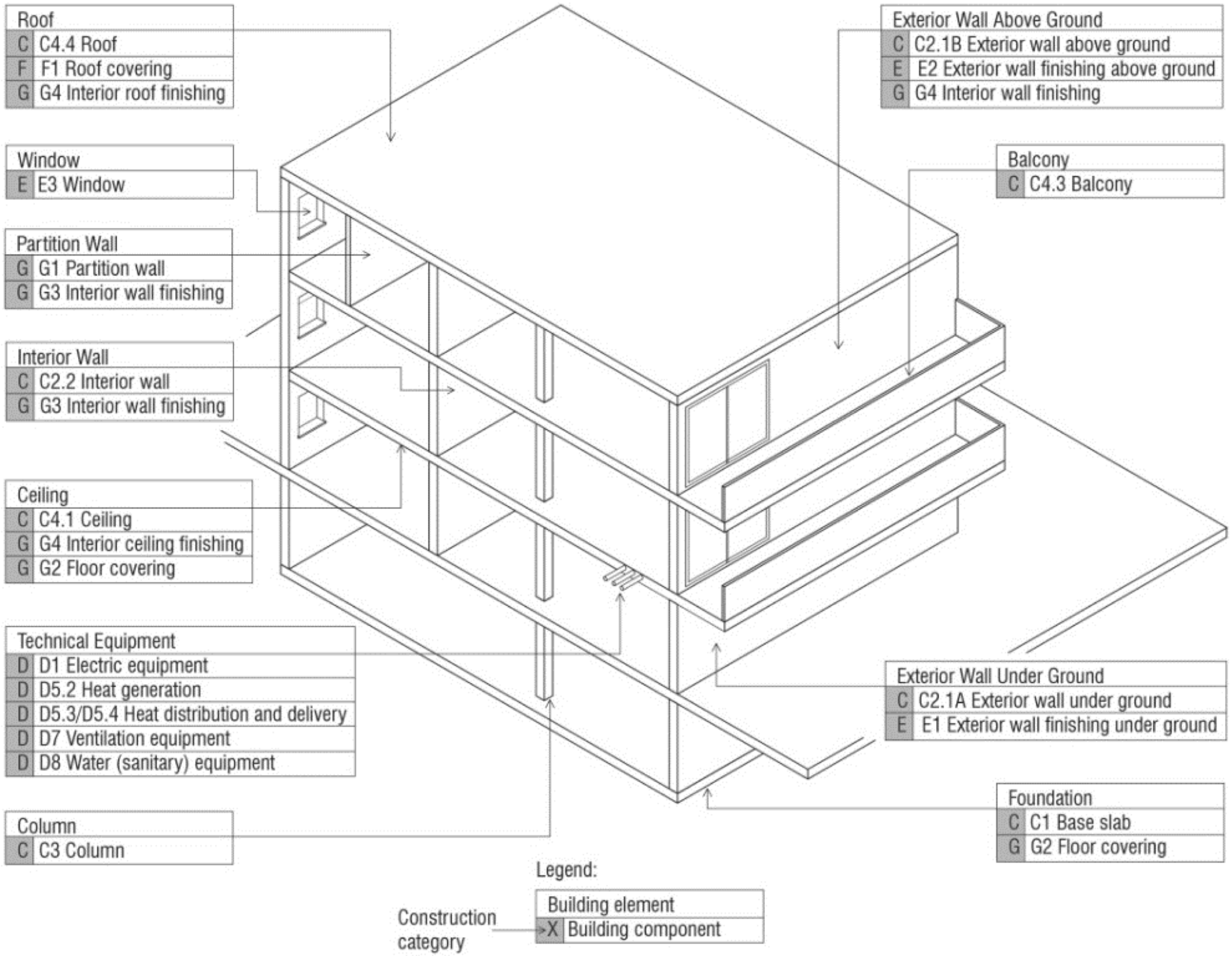
1C Element categories

Construction categories

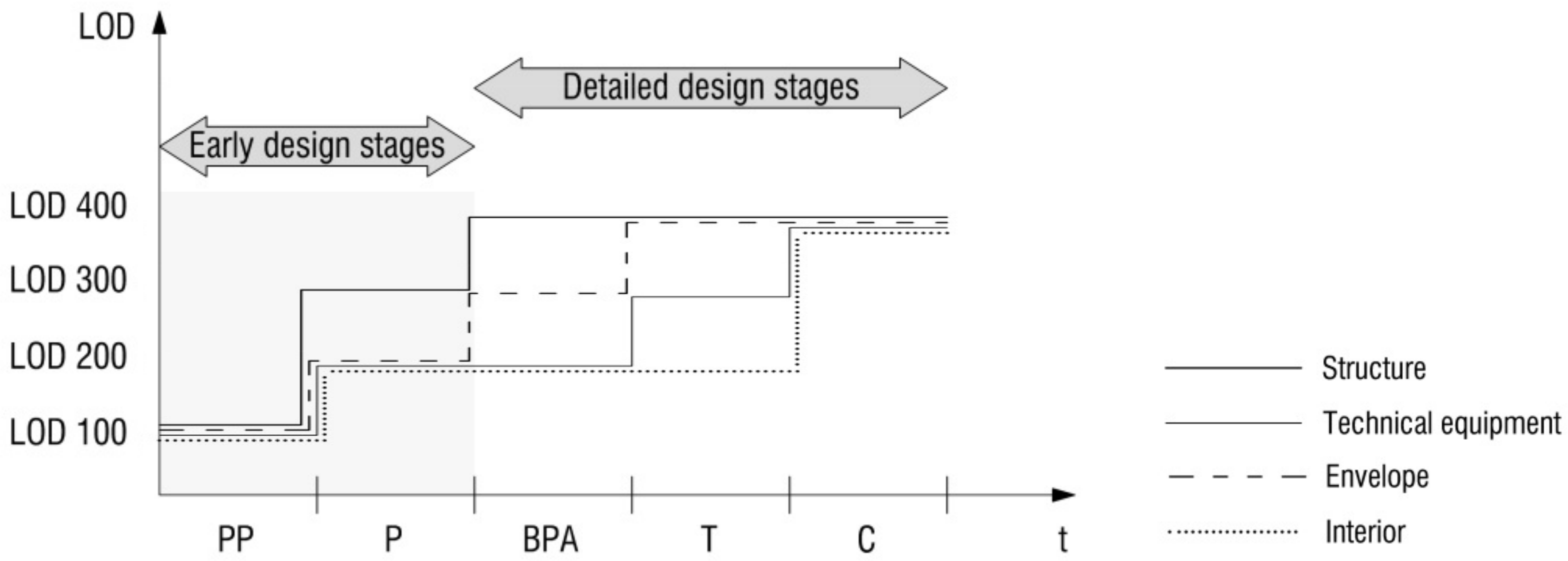
1. Structure (C)
2. Envelope (E+F)
3. Interior (G)
4. Technical equipment (D)

Architectural elements

1. Base plate / foundation
2. Exterior wall under ground
3. Exterior wall above ground
4. Window
5. Interior wall
6. Partition wall
7. Column
8. Ceiling
9. Balcony
10. Roof
11. Technical equipment*



1D LOD evolution



2 LCA databases

- Per material*: KBOB list “Ökobilanzdaten im Baubereich 2009/1:2016” (https://www.kbob.admin.ch/kbob/de/home/publikationen/nachhaltiges-bauen/oekobilanzdaten_baubereich.html)

- Per component*: Bauteilkatalog (http://www.bauteilkatalog.ch/ch/de/Bauteilkatalog.asp)

- Per m^2 of building*: F. Wyss, R. Frischknecht, K. Pfäffli, V. John, Zielwert Gesamtumweltbelastung Gebäude - Machbarkeitsstudie, 2014.

*background data based on Ecoinvent 2.2

3 Link between LOD and database

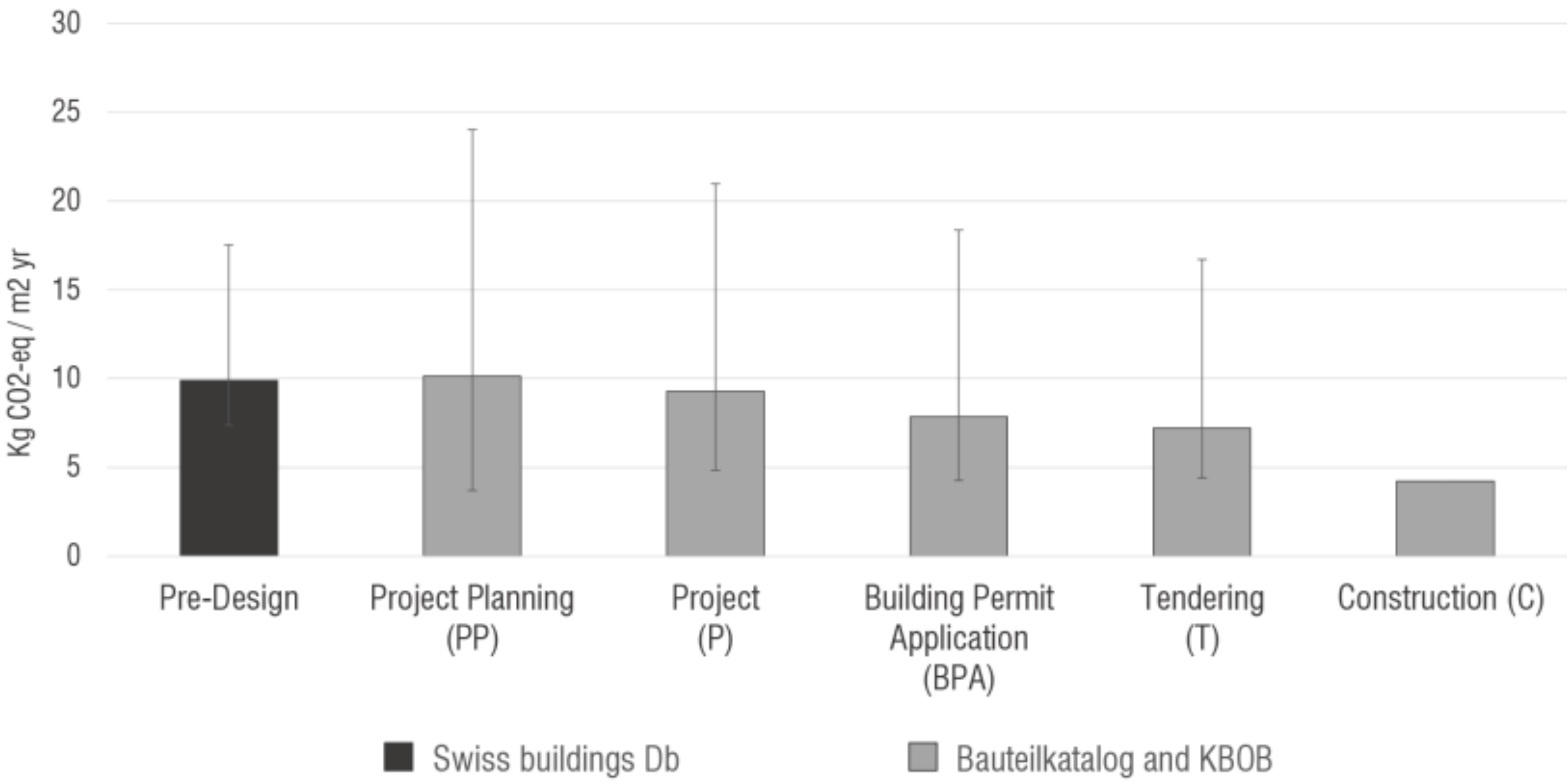
LOD	Database	Use of Database
Pre	Swiss Buildings Database	Average value at building level
100	Bauteilkatalog	Average value at building element level
200	Bauteilkatalog	Average value at building component level
300	Bauteilkatalog	Specific value at building component level
400	KBOB	Specific value at material level

BAUTEILKATALOG			KBOB	LOD 400	LOD 300	LOD 200	LOD 100
Construction categories	Building components	Constructive solutions	Materials				
C. Structure	Load-bearing wall	Wooden frame construction	Hard wood	GWP	GWP	GWPaverage GWPmin GWPmax	GWPaverage GWPmin GWPmax
			Wood fibre insulation board	GWP			
			...	GWP			
		Concreete frame construction	Concreete	GWP	GWP		
			Reinforcement steel	GWP			
				GWP			
		...	...	GWP	GWP		
E. Envelope	Exterior wall cladding	Wooden cladding	Pine wood	GWP	GWP	GWPaverage GWPmin GWPmax	
			Larch wood	GWP			
			...	GWP			
		plasterboard plastered, wooden substructure	Plaster	GWP	GWP		
			Hard wood	GWP			
				GWP			
		...	...	GWP	GWP		
G. Finishing	Interior wall finishing	Gypsum finishing	Gypsum	GWP	GWP	GWPaverage GWPmin GWPmax	
			Paint	GWP			
			...	GWP			
		Wooden finishing	Wood	GWP	GWP		
			Paint	GWP			
			...	GWP			
		...	...	GWP	GWP		

Case study

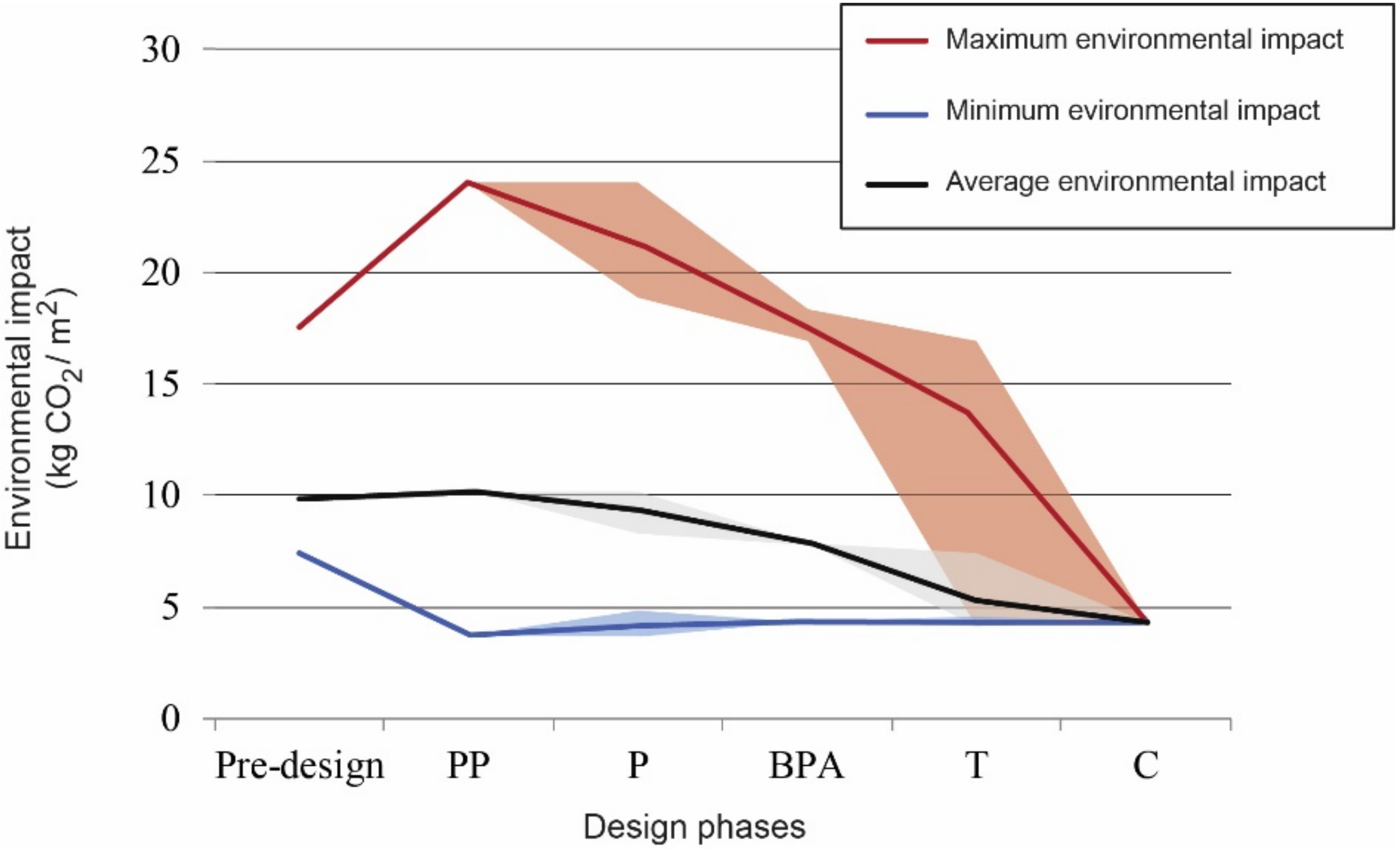
Architectural element	Area [m²]
1. Base plate / foundation	228.0
2. Exterior wall under ground	183.0
3. Exterior wall above ground	723.5
4. Window	200.7
5. Interior wall	1368.1
6. Partition wall	391.4
7. Column	0
8. Ceiling	1140.0
9. Balcony	90.0
10. Roof	228.0
11. Technical equipment	912.0*

Results for embodied Global Warming Potential



Sensitivity towards LOD evolution

Building components	Design phases				
	PP	P	BPA	T	C
Structure	100	300	400	400	400
Envelope	100	**200/ 300**	300	400	400
Technical equipment	100	200	**200/ 300**	**300/ 400**	400
Interior	100	200	200	**200/ 300**	400



Conclusions and future developments

- Mixing various LOD and LCA databases works (identical background data)
- Low sensitivity towards LOD choices
- Forecast of the final environmental impact
- LCA for decision support (always as accurate as possible)

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- Mixing various LOD and LCA databases works (identical background data)
- Low sensitivity towards LOD choices
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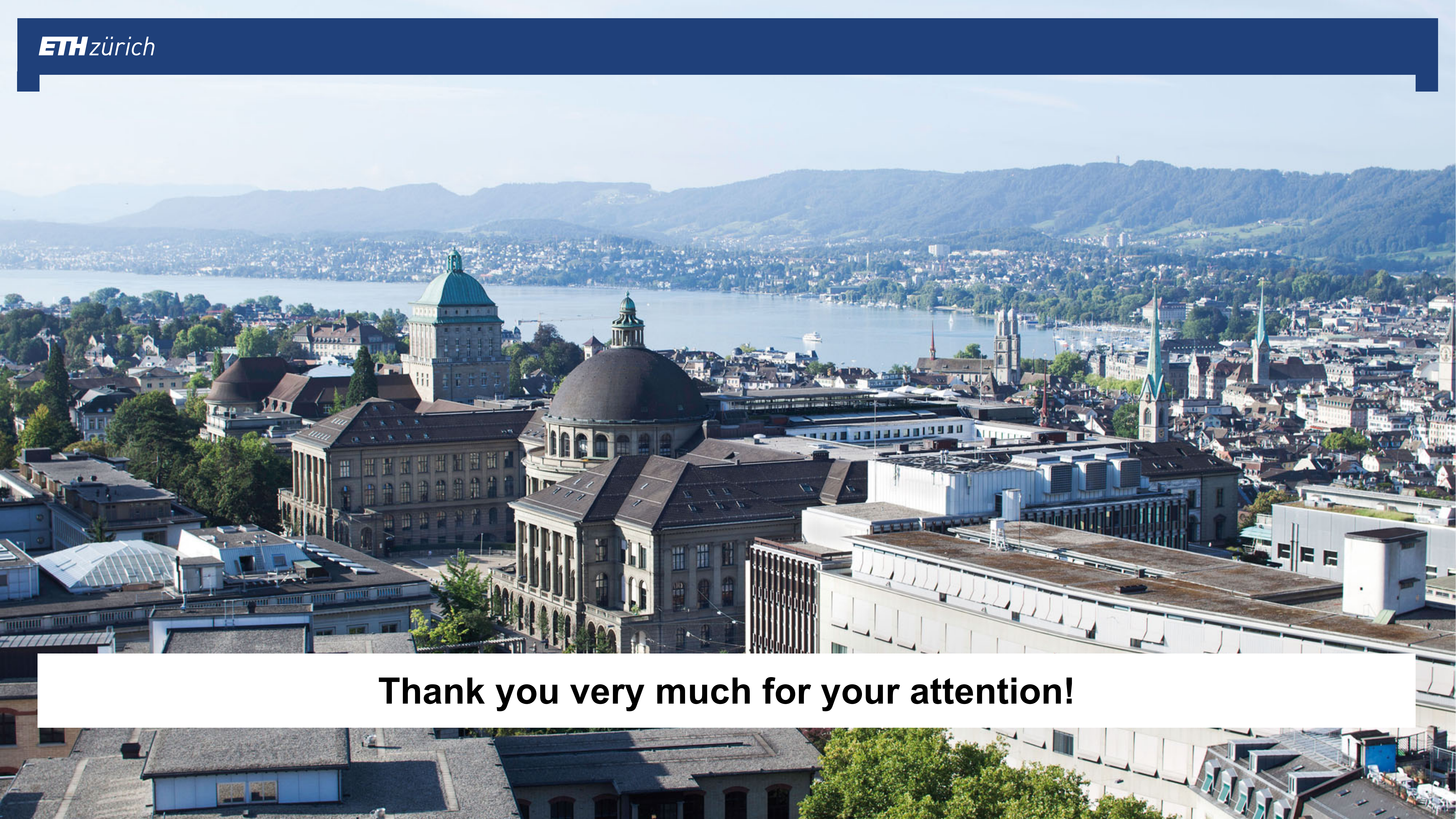
- Integration of operational environmental impact
- Framework developed for Swiss context -> transfer to other countries
- Implementation as tool for BIM software



Thank you very much for your attention!