Universität Stuttgart
[1] Instute for Acoustics and Building Physics

Fraunhofer IBP
[2] Institute for Building Physics

Karlsruher Institut für Technologie
[3] Building Lifecycle Management

Step-by-step implementation of BIM-LCA

A case study analysis associating defined construction phases with their respective environmental impacts

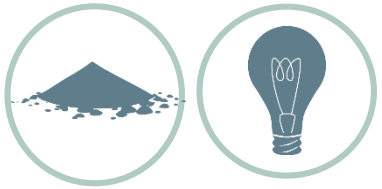
R. Di Bari [1] ; O. Jorgji [2]; R. Horn [1]; J. Gantner [2] and S. Ebertshäuser [3]

SBE2019 Conference
Graz, 11-13.09.2019

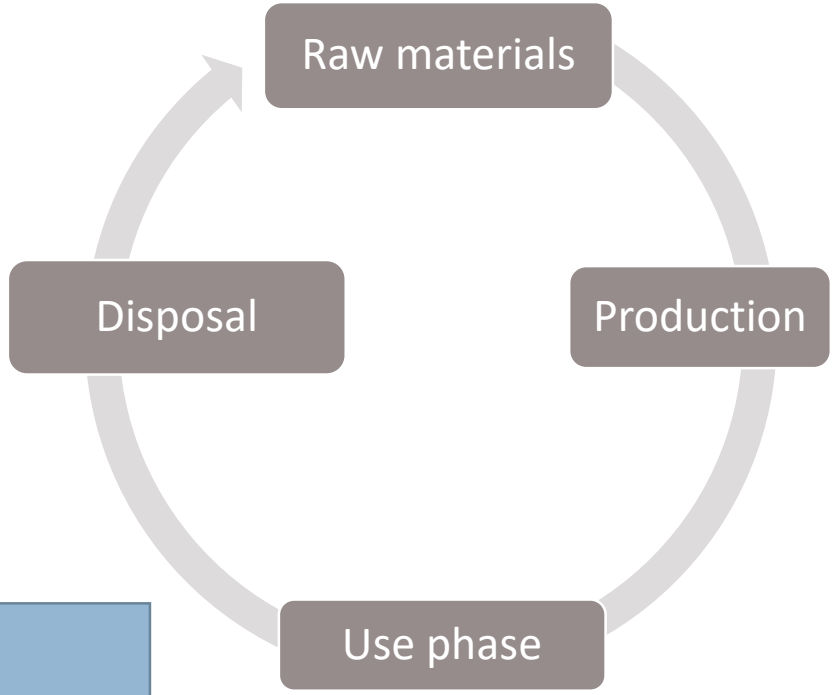
Introduction

BIM-LCA Traditional approach

BIM



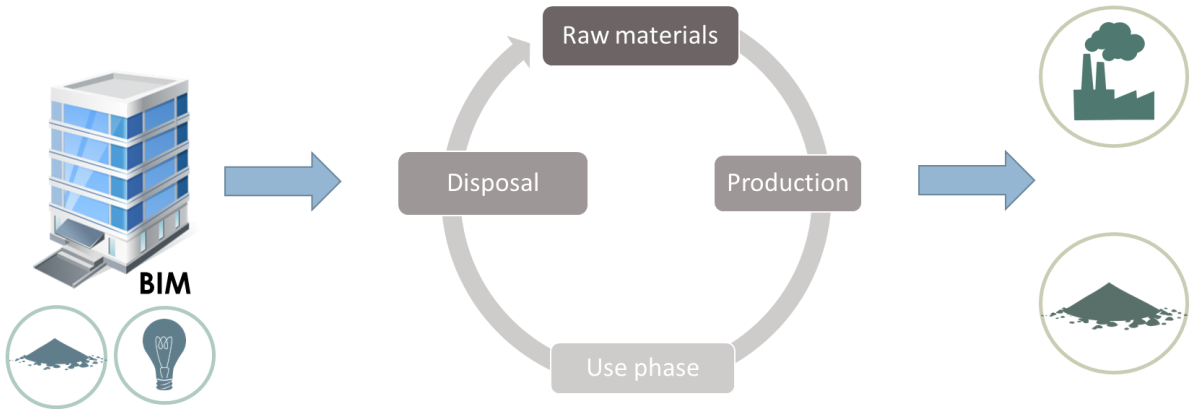
- Geometry
- Materials
- Processes



- Environmental values for **building evaluation** (certification)

Motivation

Early planning phases approach



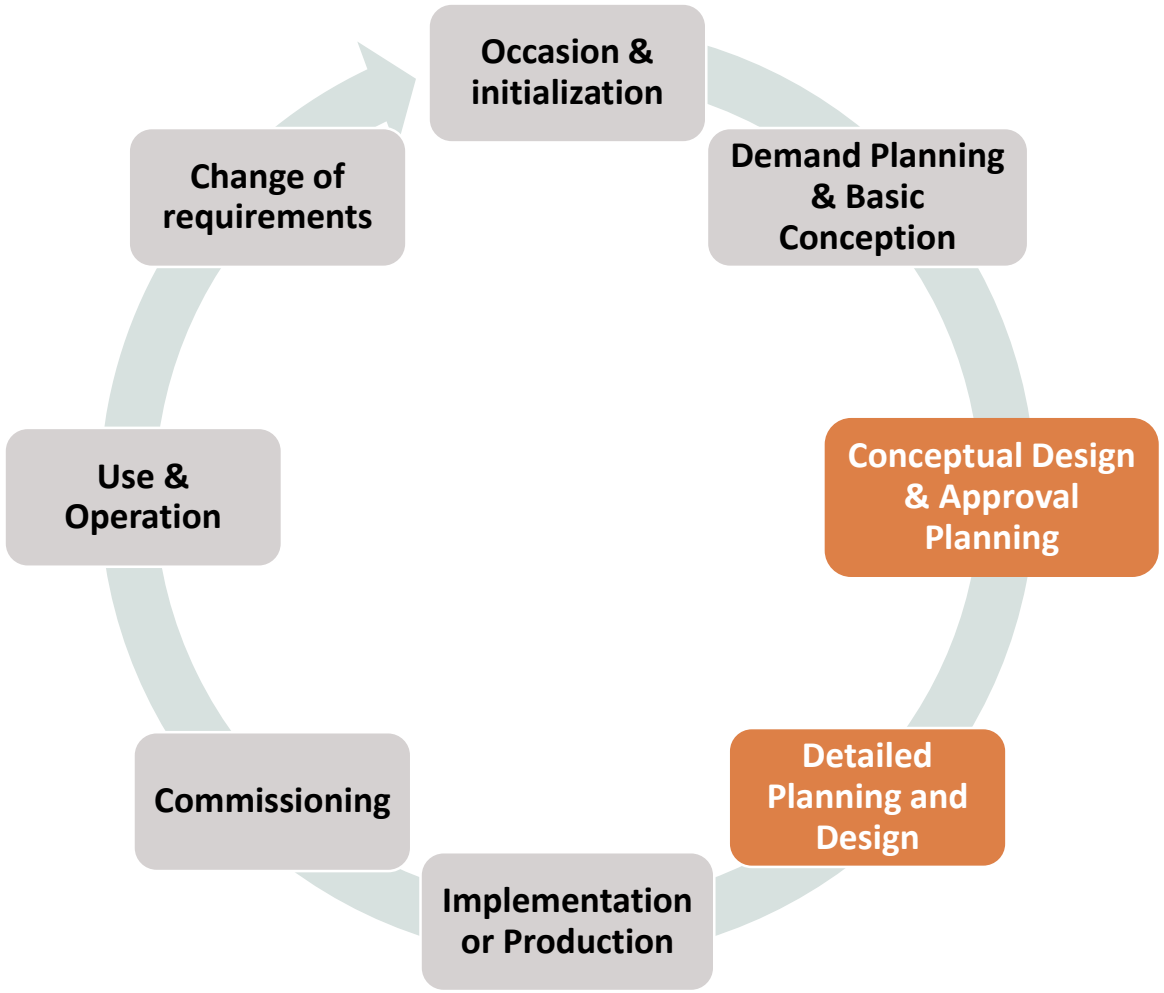
- Tool availability for LCA on building components
- BIM can realize an integrated design starting from early stages
  - Up to 40% elimination of unbudgeted change and 80% reduction in cost estimation time with almost 7% reduction in project time

Source: CIFE Technical Reports (2007)

State of art

Early planning phases approach

- LCA-BIM implementation, by technical point of view, within range (IFC format)
- Impact evaluation during early decision making more debated.
  - Previous analyses as basis for environmental information. (Antón and Díaz, 2014)
  - Problem with result accuracy (transport distances measurement), or evaluation of EoL and refurbishment (Galic et at. 2014)
  - Most of application are intended only from the **early design phases**.

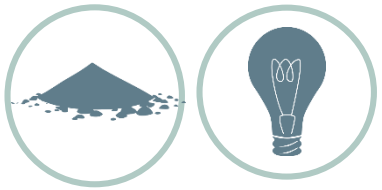


Source: K. Rexroth et at. (2018), adapted

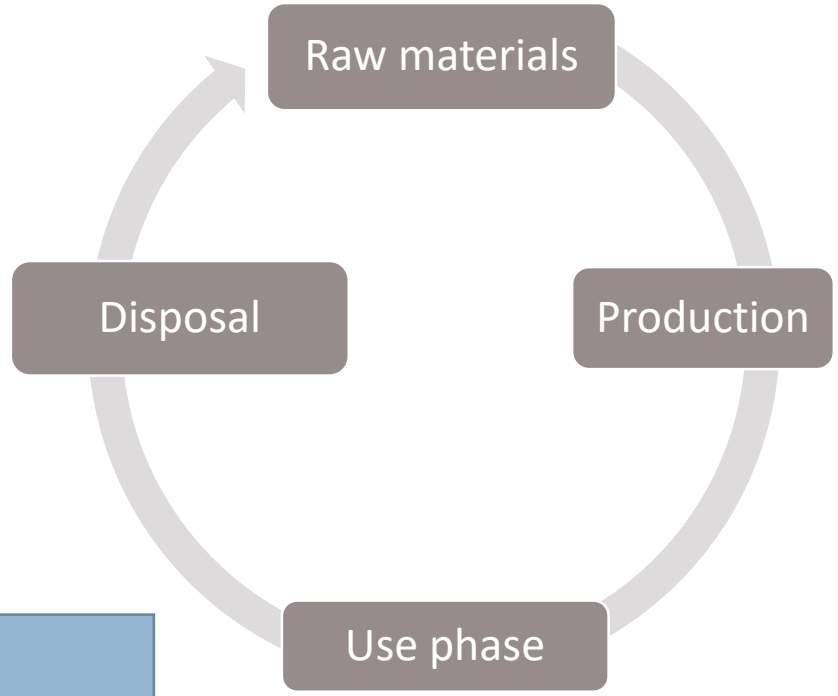
Research purpose

Early planning phases approach

BIM



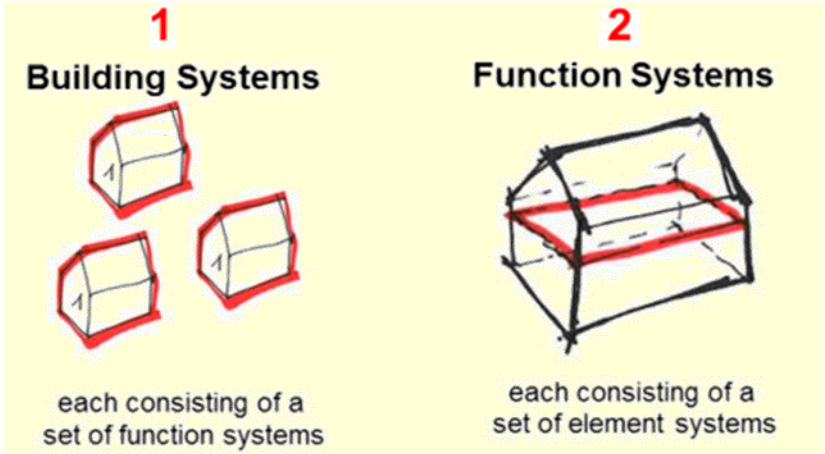
- Shape
- Building type
- Construction type
- Energy standard



- Environmental values **for decision making**

Method

Building fragmentation and full automation



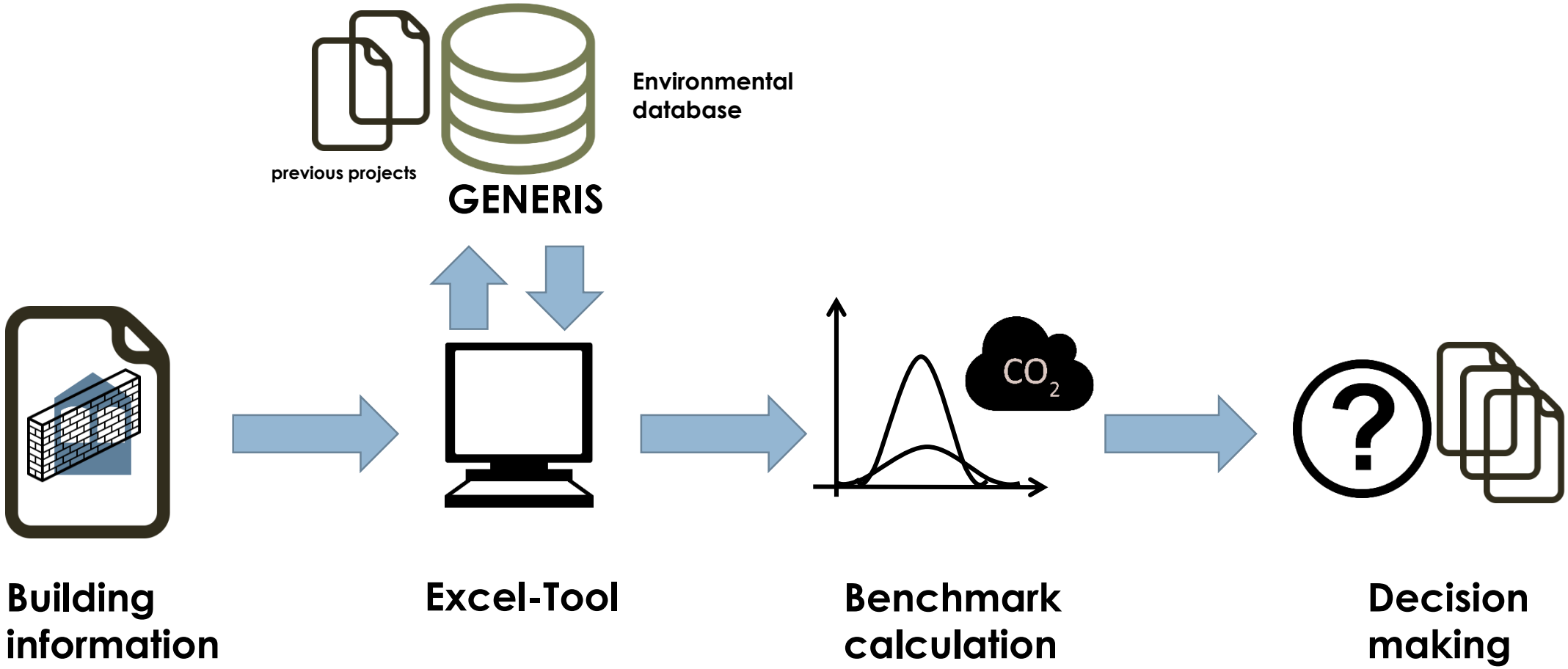
Source: K. Rexroth et at. (2018), adapted

1. *"Step-by-step"*-fragmentation of the information
2. reduction to most detailed value
3. conversion depending on its characteristic (descriptive, quantitative, and Boolean)

→ FULL AUTOMATION

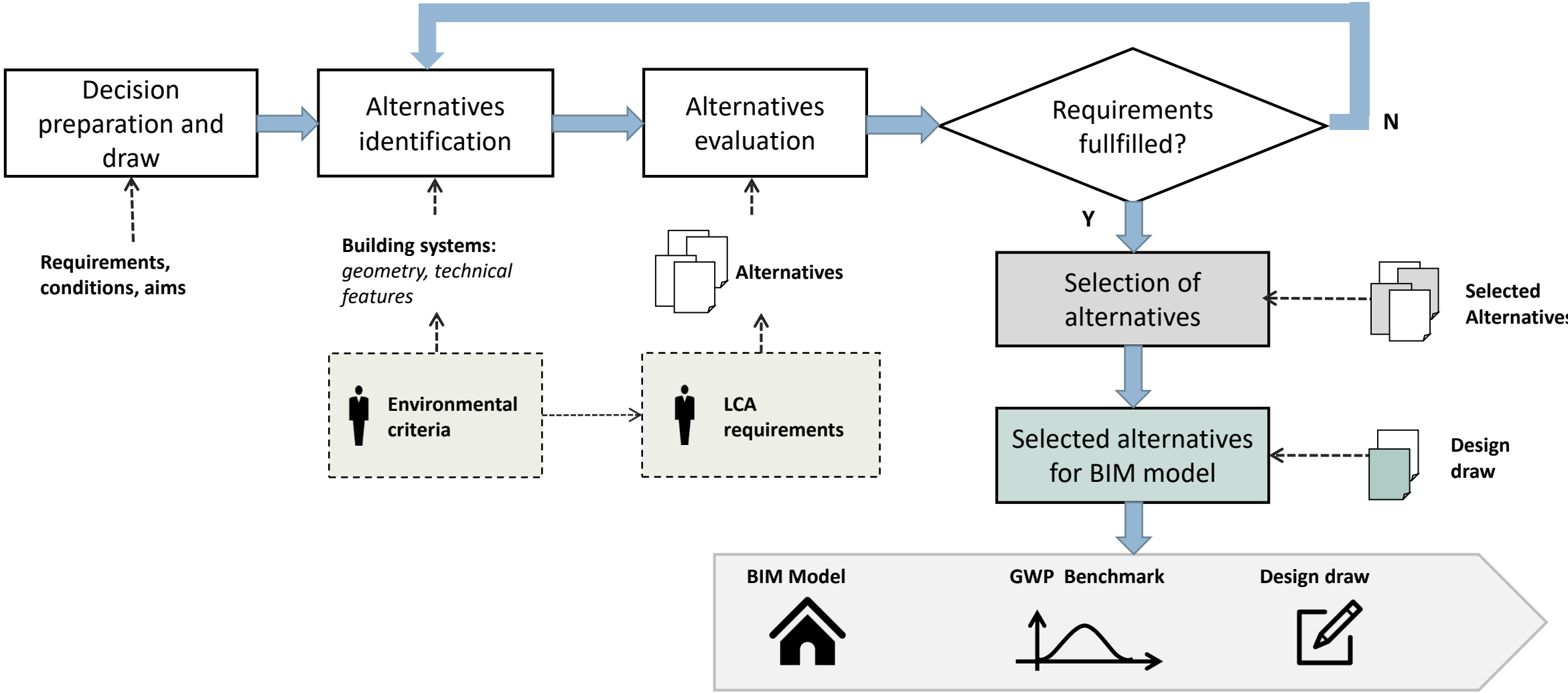
Method

Environmental benchmarks



Case study

Early planning phases



Results

First phase: Building system

Building system	Info	Reference	Example
General information	Building Type	Use type	Multi- apartment building - Fixed
	Energy standard	EnEV, KfW, Passive house, Plus energy building	KfW55 – Fixed
	Installation standard	Low/high	Variable
	Construction type	Massive/Light	Variable
	Net surface		**707,4 m²**

Table 1: Building system alternatives

GWP [kg CO2 eq./m²y]	Massive Building /Low installation standard	Light Building/ Low installation standard	Light Building/ High installation standard
Production CG 400+300 + EoL CG 300 + CG 400	5,59	1,26	1,26
Use phase KfW55	22,94	22,94	22,94
Total	***28,53***	***23,2***	***23,2***
	DGNB Reference value [NWO15(V16)]		***53,11***

Table 2: Results (*Source: Generis*)

- Relevance of construction type (massive/light)
- Low relevance of installation standards
- Difference between GENERIS Benchmarks and reference value of DGNB certification system → Lack of information

Results

Second phase: Function system

Functional system – Cost group [DIN 276]	Example	Amount [26]	GWP [kg CO2 eq./m²]
Basement – CG320	Basement with overlying insulation – Fixed	294,4 m²	148,55
External walls – CG330	1) Wood Walls 2) Wood fibers	776,8 m²	3,38 17,96
Ceiling – CG350	Wood ceiling with structural beams- Fixed	588,8 m²	-19,60
Roof - CG360	Slope Roof- Fixed	294,4 m²	139,10
Installation set – CG400	1) KfW55: with ***Underfloor heating***, 2) KfW55:with ***District heating station.***	707,4m²	56,73 28,78

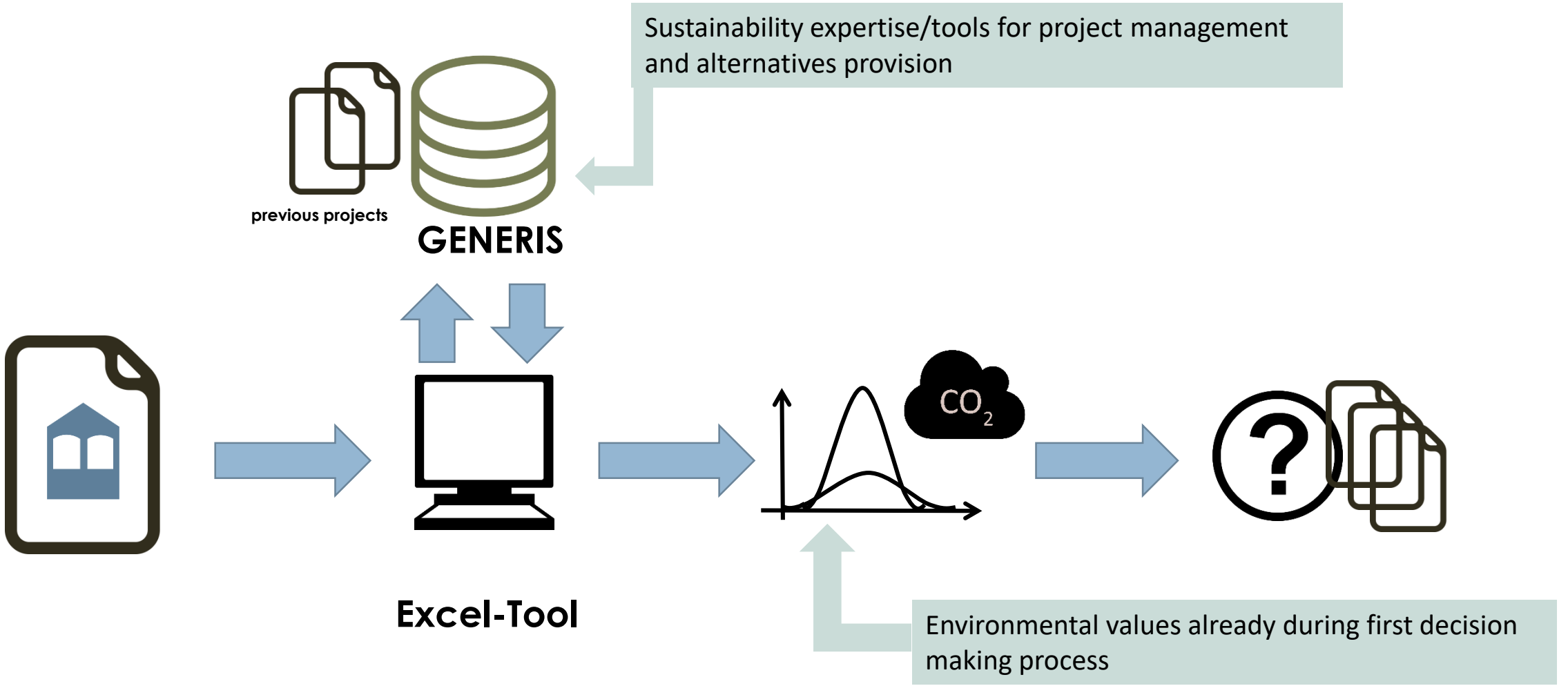
Table 1: Function systems alternatives

GWP [kg CO2 eq./m²y]	Wood walls/ underfloor heating	Wood walls/ district heating	Wood fibers walls/ district heating
Production + EoL CG 400+300	**3,28**	**2,72**	**3,04**
DGNB Reference value [NWO15(V16) Construction] [26]			**3,98**

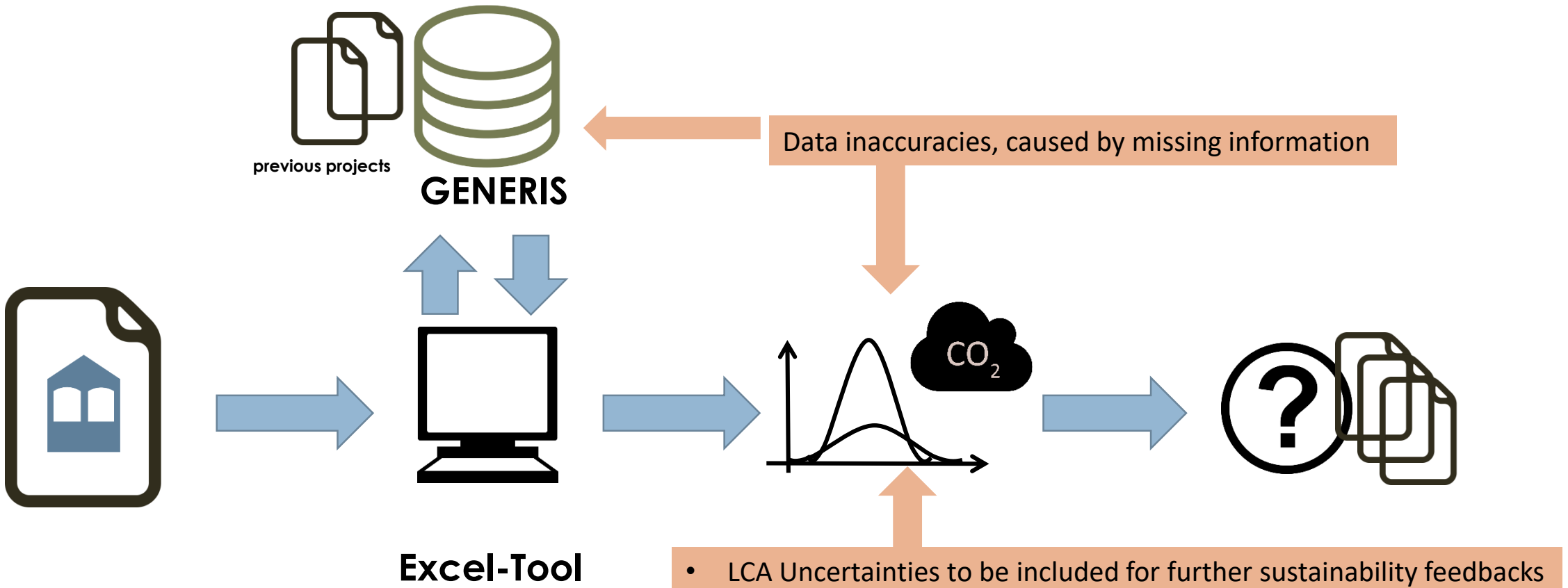
Table 2: Results (*Source: Generis*)

- Installation sets more relevant.
- The calculated benchmarks with good accuracy (comparison with NWO15 - reference value of DGNB certification system)
- Lack of comprehensibility regarding energy consumption, specific installations and auxiliary energy, any further information → Use phase results not enhanced.

Discussion

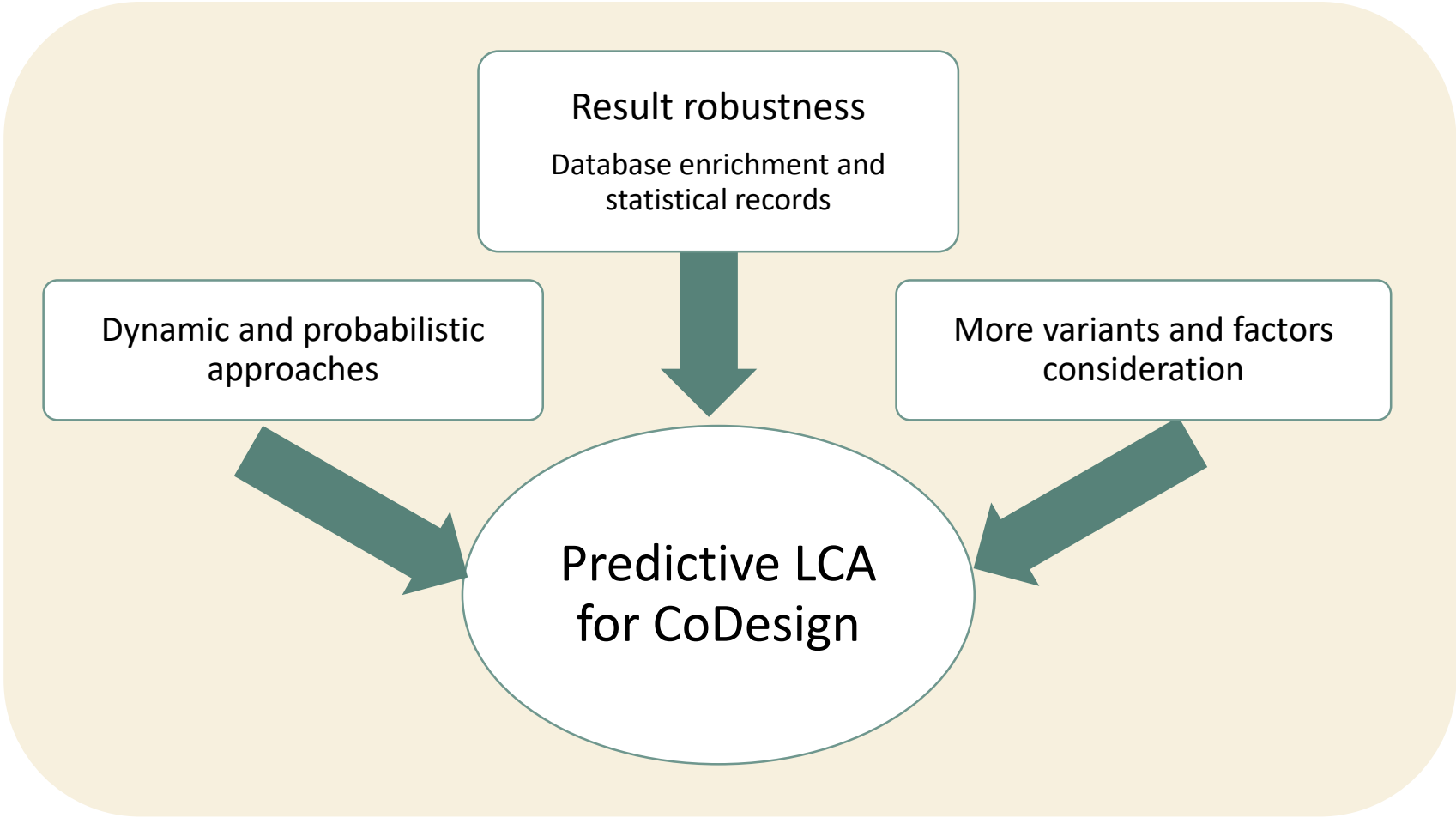

Sustainability expertise/tools for project management and alternatives provision
previous projects
GENERIS
CO2
Excel-Tool
Environmental values already during first decision making process

Discussion


previous projects
GENERIS
Data inaccuracies, caused by missing information
CO_2
Excel-Tool
• LCA Uncertainties to be included for further sustainability feedbacks and the value robustness.
• Final environmental impacts not depicted by a single trustworthy value, but by a range of values

Outlooks

New framework for predictive LCA



Universität Stuttgart

IntCDC

German Excellence Cluster for Integrative Computational Design and Construction for Architecture

Thank you for the attention!

Roberta Di Bari
Sustainable Construction
Department Life Cycle Engineering (GaBi)

Institute for Acoustics und Building Physics (IABP)

roberta.di-bari@iabp.uni-stuttgart.de
http://www.iabp.uni-stuttgart.de/gabi

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