Integrated Life Cycle Assessment : Benchmarks and Uncertainty

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Overview

- Assessment perspective
- Reference values
- Benchmarks
- Uncertainty and validation
- Influence of service life assumptions

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LC xx applications

Type of application	**Need of benchmarks**
LCA isolated	Compare alternatives
LCC isolated	Targets Compare with experience values
Sustainability rating based on LCA and LCC	Several benchmarks
Integrated **LCA + LCC + Energy + Risk**	**Related benchmarks – validation** **Scalalable benchmarks**
Energy efficiency path (SIA) Embodied + Operation + Mobility	Targets and Budget
Multi-assessment based on Building information Model	Automatic scaleable reference system

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Why Benchmarks ?

What are the basic principles for the development of benchmarks ?

How to select and qualify reference buildings for the establishment of benchmarks ?

How to establish interrelated and consistent benchmarks when dealing with the development and use of a system of indicators ?

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Types of benchmarks

Limit value – the lowest acceptable value of an evaluation scale

Reference value – the present state of the art – an average or median value

Best practise – values that have been reached (measured) in experimental or demonstration projects

Target value – the upper limit of the scale – the highest theoretically possible level – when exceeded a bonus can be granted

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LCA benchmark calculation

General conditions for the LCA calculation	
Period of observation	50 years
Life cycle stages	Construction Operation (energy demand) Renovation End of life
Database	Ökobau.dat, Germany
Energy demand calculation	German Standard DIN 18599
Service life of building components	„Guideline for Sustainable Building 2001“ and VDI 2067
Reference units	m² net floor area (NFA)

2011 research project launched by BMVBS to provide benchmarks for sustainability assessment systems exclusively for multi-family buildings with 6 – 100 housing units

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Reference buildings

Type	stories	Accomodation Units	Size	Gross Floor Area	Energy demand level			Material				Technical equipment			
	n.	n.	S/M/L	m²	ENEV 2009	Real	Lowest	Mineral Bricks	Concrete	Wood-frame	MassiveTimber	Real	Heating system		
													f/g	w	hp	dh
DECK-ACCESS																
Deck-access	3+c	18	M	2005	x	x	x	x		x		w	x			
Deck-access	5+c	12	M	1988	x	x	x	x				dh	x	x		
Deck-access	3+c	9	S	1514	x			x	x				x	x	x	
TOWER																
Tower	6+c	11	M	1661	x	x	x		x			g	x			
Tower	4+a+c	14	M	1685	x	x	x	x				g	x	x	x	
APARTMENT BUILDING																
2-Apartm./st.	3+a	7	S	970	x	x	x	x			x	g	x			
2-Apartm./st.	3+a+c	24	L	3311	x	x	x	x				g	x			
2-Apartm./st.	5+c	31	L	5357	x	x	x	x				dh				x
2-Apartm./st.	7+c	34	L	4840	x		x		x	x			x			
3-Apartm./st.	4+a+c	13	M	2333			x	x								x
3-Apartm./st.	4+a+c	50	L	7292			x	x								x
4-Apartm./st.	4	13	S	2028	x		x						x			x

Stories: c: Cellar; a: Attic. Buildings size: S, M, L: small (7units/3 floors), medium (35/4), large (60/5).
ENEV: German Energy Conservation Regulations.
Heating system: f/g: Fossil/Gas; w: Wood; dh: District Heating; hp: Heat Pump.

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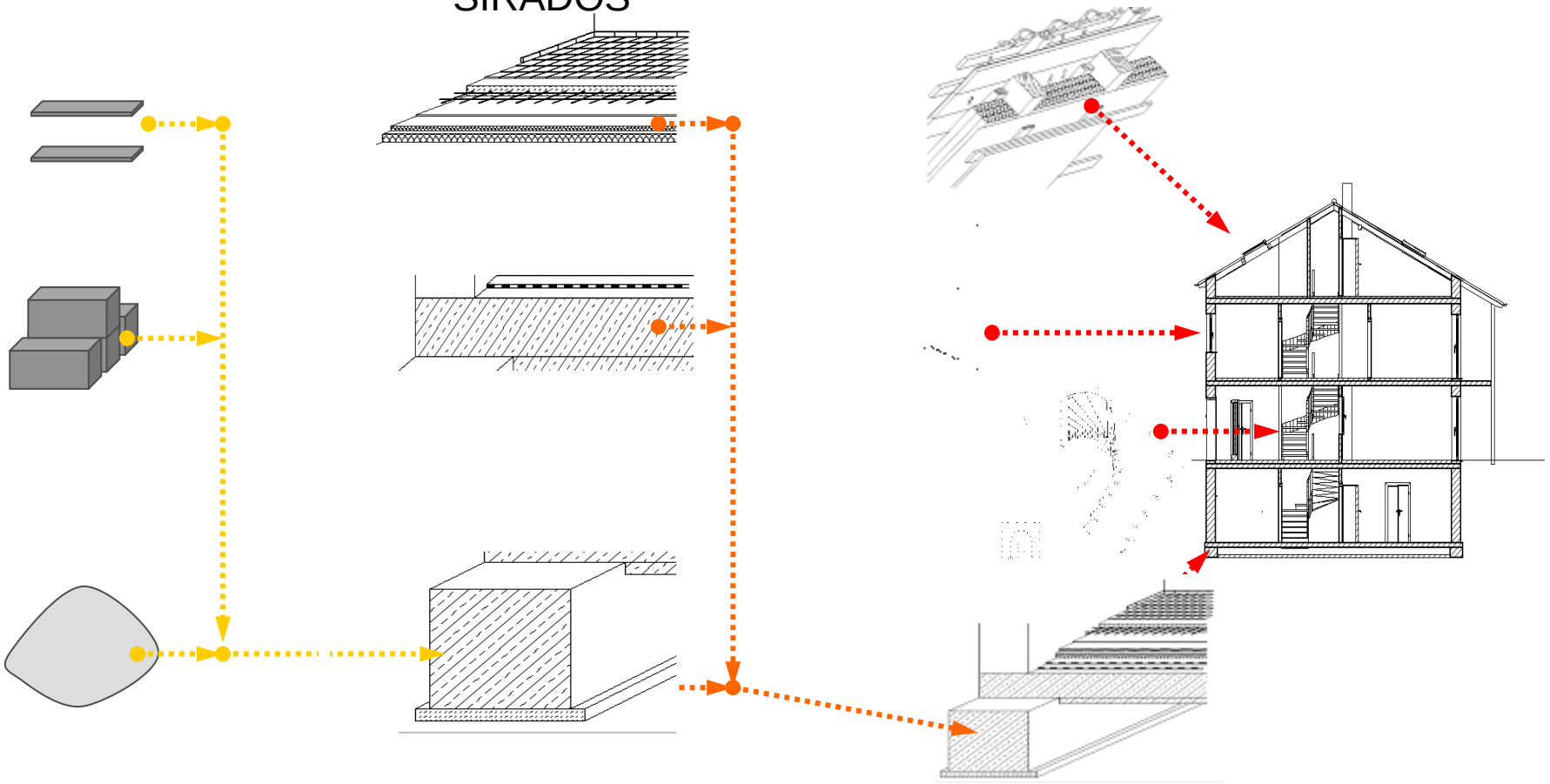
Element method (Legep)

Ökobau.dat

Element catalogue
SIRADOS



Material → Building product → Element → Building

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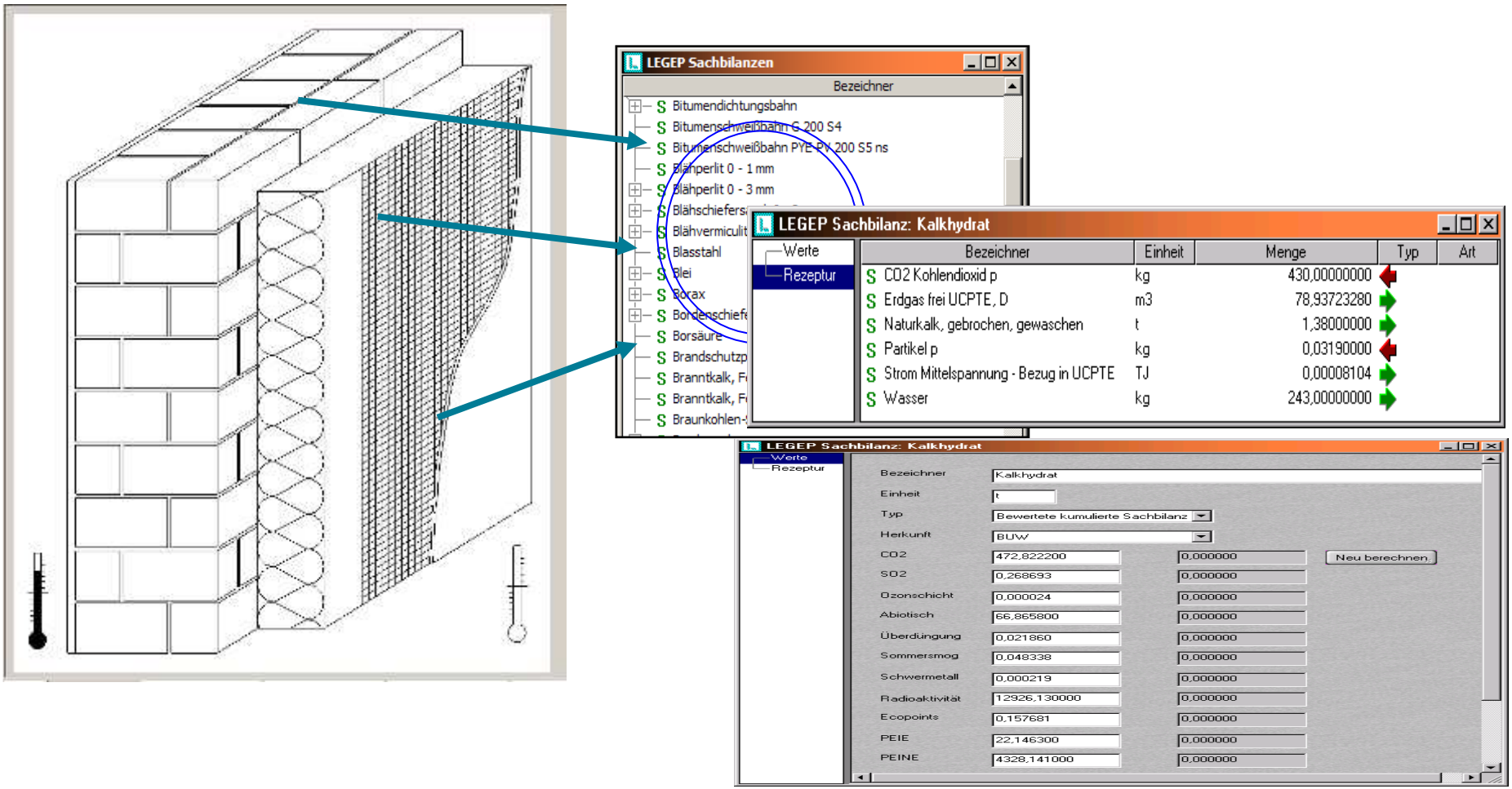
Element catalogue



LCA: CO2, SO2, PEI /pro m²

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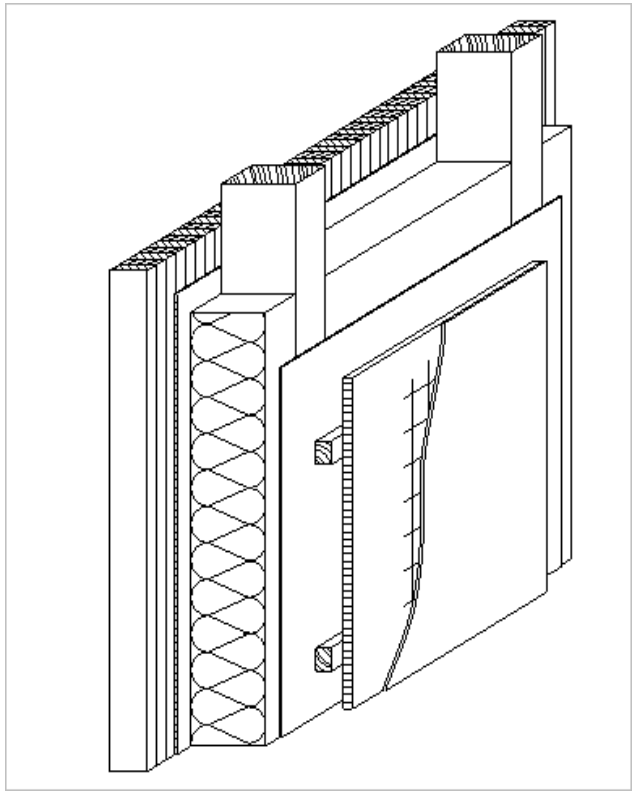
Consecutive elements



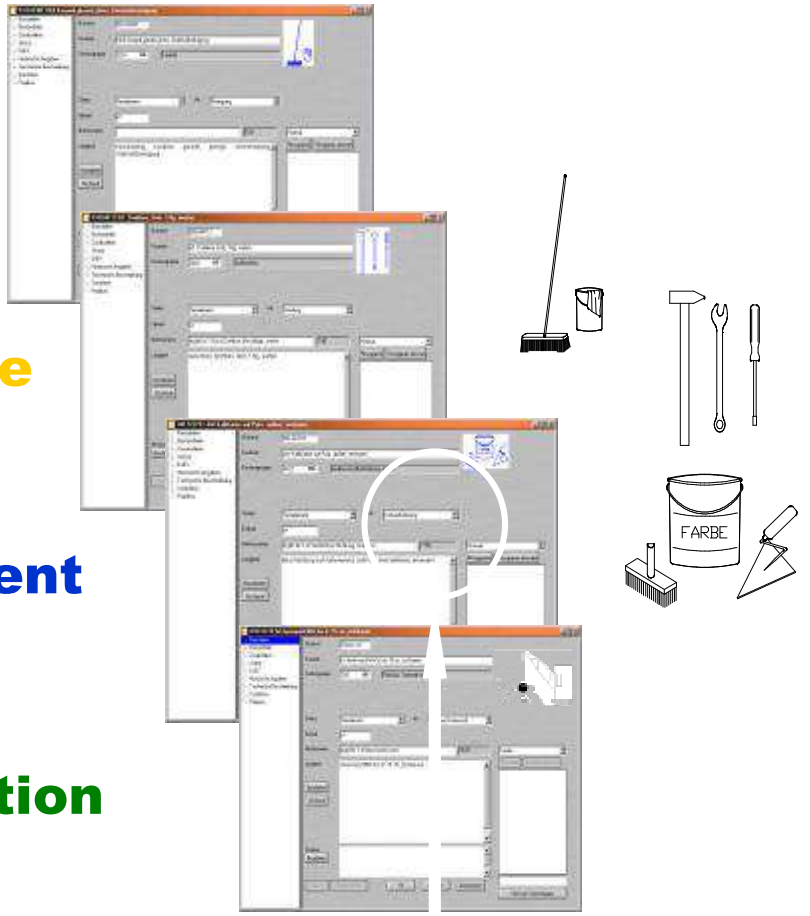
(Operation)

Cleaning

Maintenance

Refurbishment

Deconstruction



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Benchmarks Life Cycle Costs

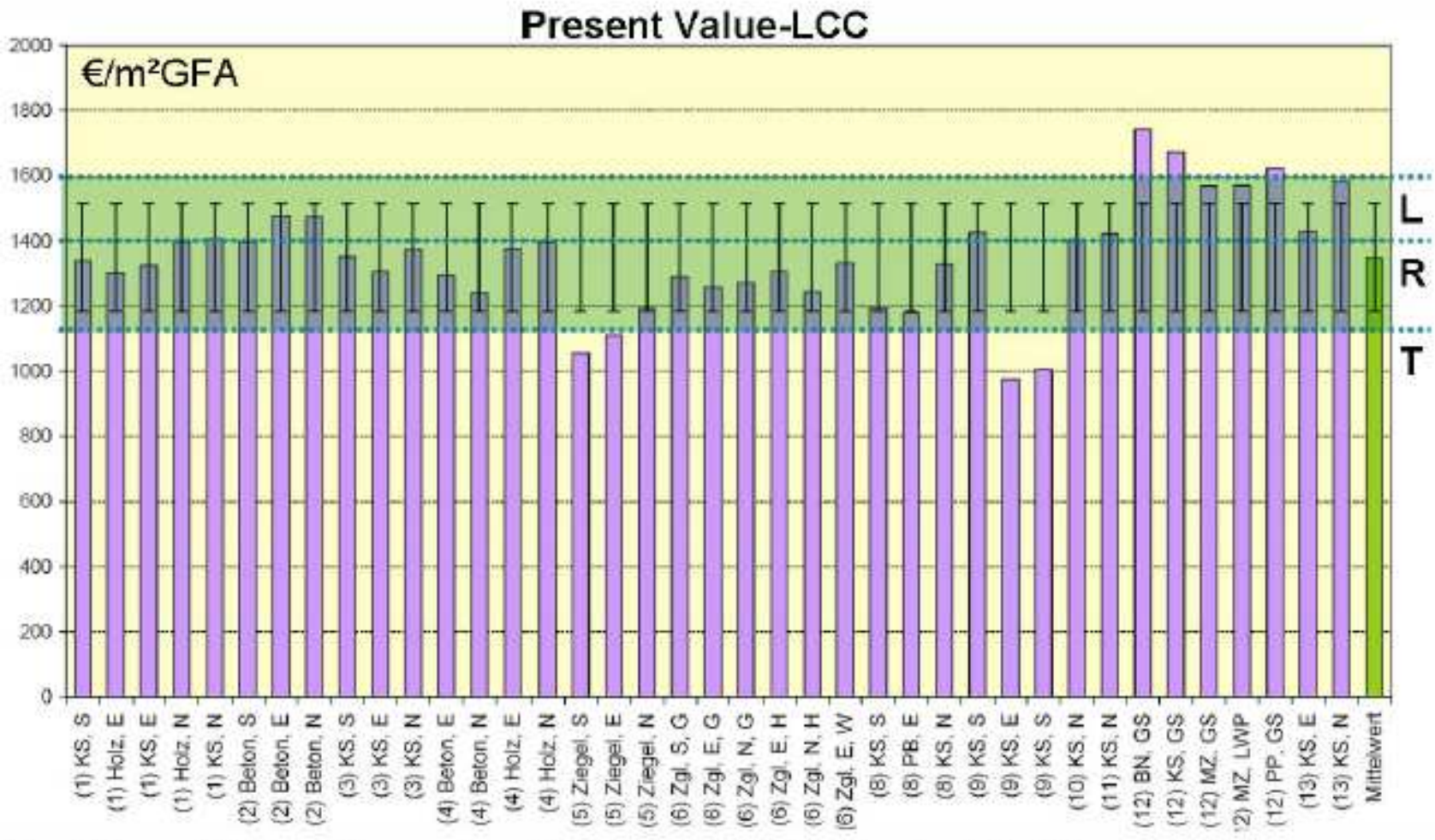

Fig. 2 Present Value of the analysed buildings, €/m² GFA (standard deviation: ±168,58 €)

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Benchmarks LCA Primary Energy non renew.

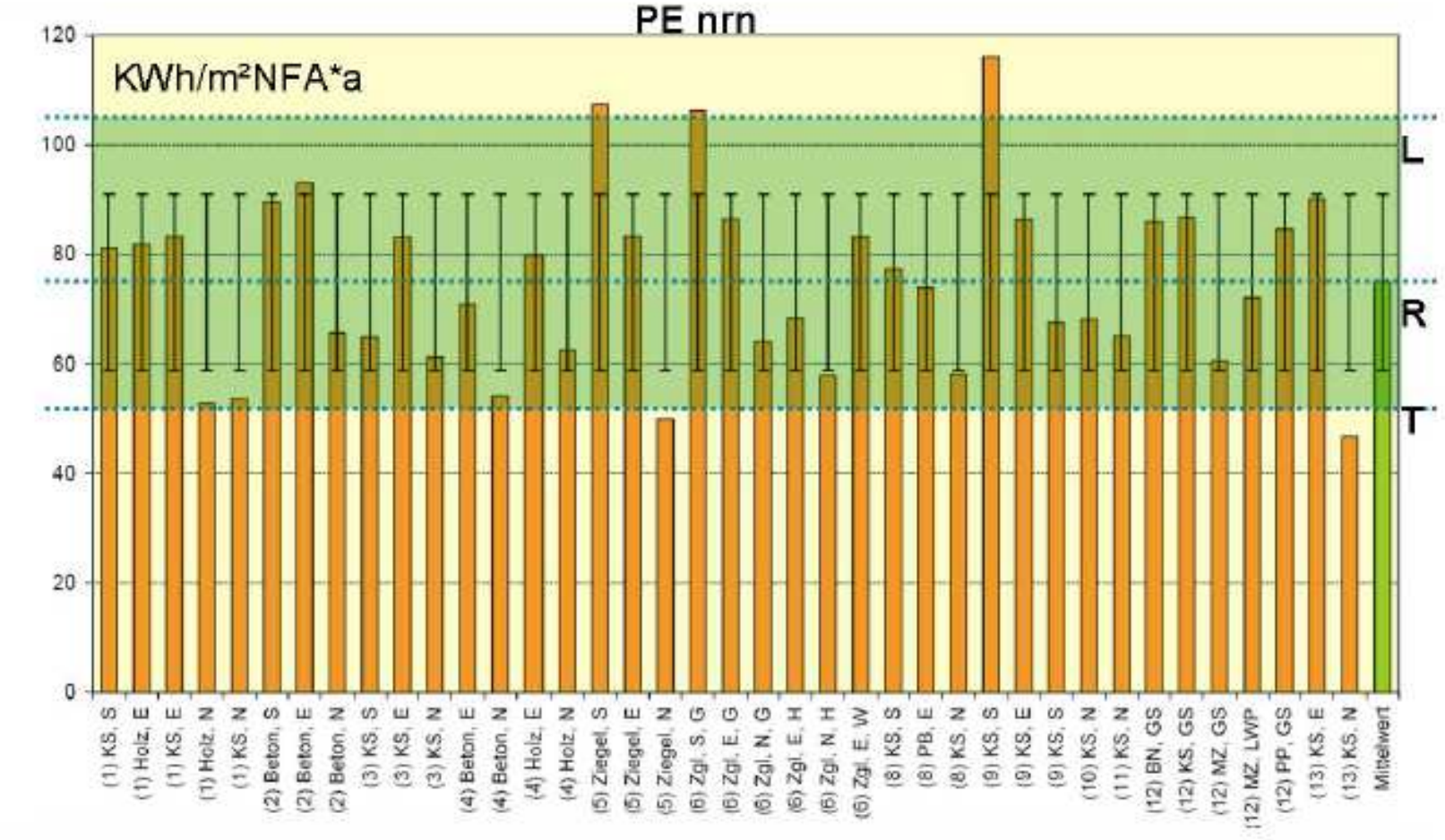

Fig. 4 Primary Energy non-renewable corridor (standard deviation: ±16,215)

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Benchmarks LCA - Global Warming Potential

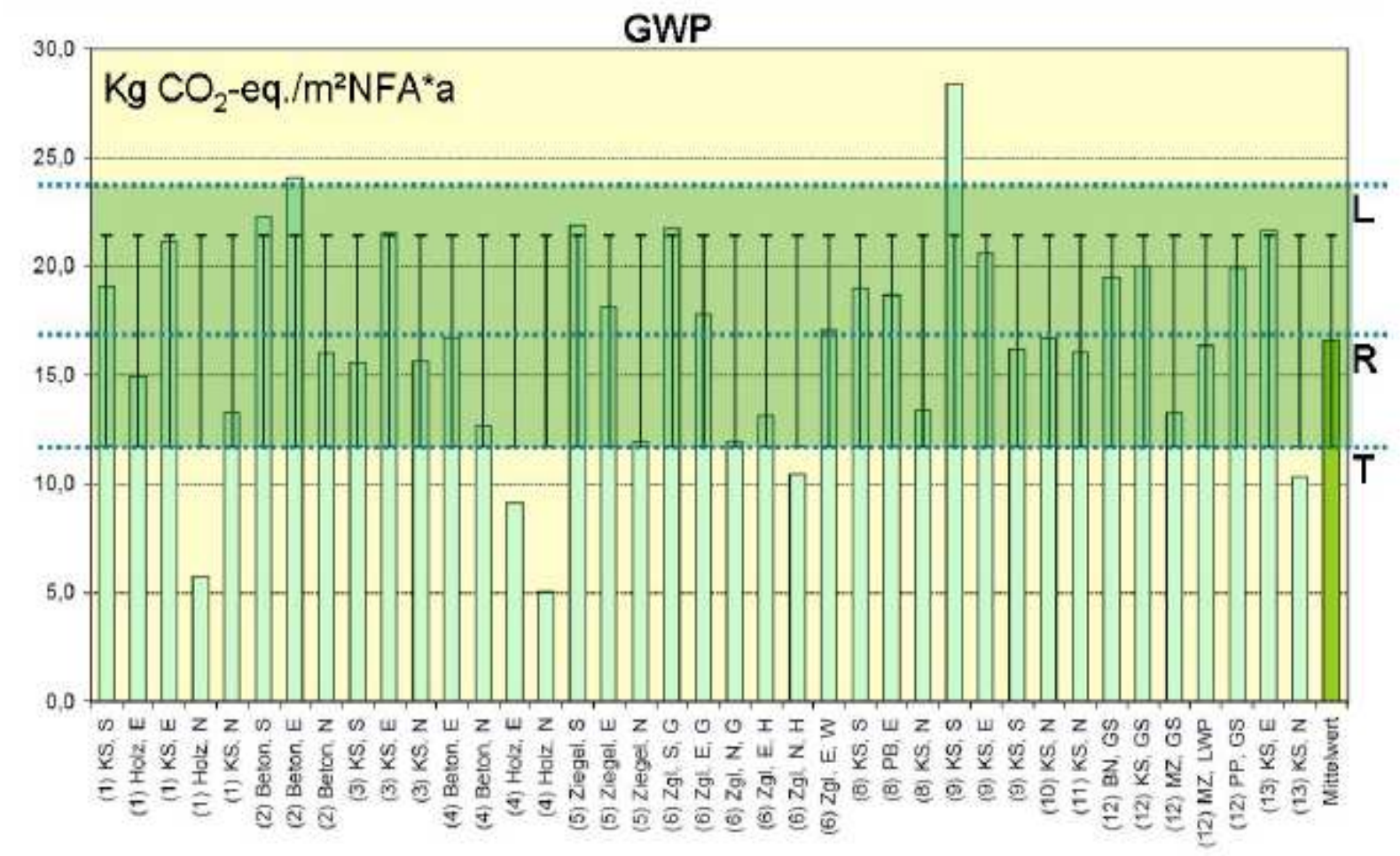

Fig. 3 Global Warming Potential corridor (standard deviation: ±4,899)

LCA all benchmarks results

Indicator	Unit	Limit value	Reference value	Target value
Global Warming Potential (GWP)	kg CO_2-equ./m² Net Floor Area (NFA) and Year	**23.8**	**17.0**	**11.9**
Ozone Depletion Potential (ODP)	kg R_{11}-equ./ m² NFA*a	**0.0000020**	**0.0000010**	**0.00000070**
Photochemical Ozone Creation Potential (POCP)	kg C_2H_4-equ./ m² NFA*a	**0.014**	**0.010**	**0.007**
Acidification Potential, (AP)	kg SO_2-equ. / m² NFA*a	**0.070**	**0.050**	**0.035**
Nutrification Potential (NP)	kg PO_4-equ. / m² NFA*a	**0.007**	**0.005**	**0.0035**
Primary Energy non-renewable	kWh PE nrn/ m² NFA*a	**105.0**	**75.0**	**52.5**
Primary Energy renewable	kWh PE rn/ m² NFA*a	**35.0**	**25.0**	**17.5**
Total Primary Energy	kWh PE total/ m² NFA*a	**140.0**	**100.0**	**70.0**
Percentage Primary Energy renewable	%	**5**	**8**	**20**

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Reliability test with real buildings

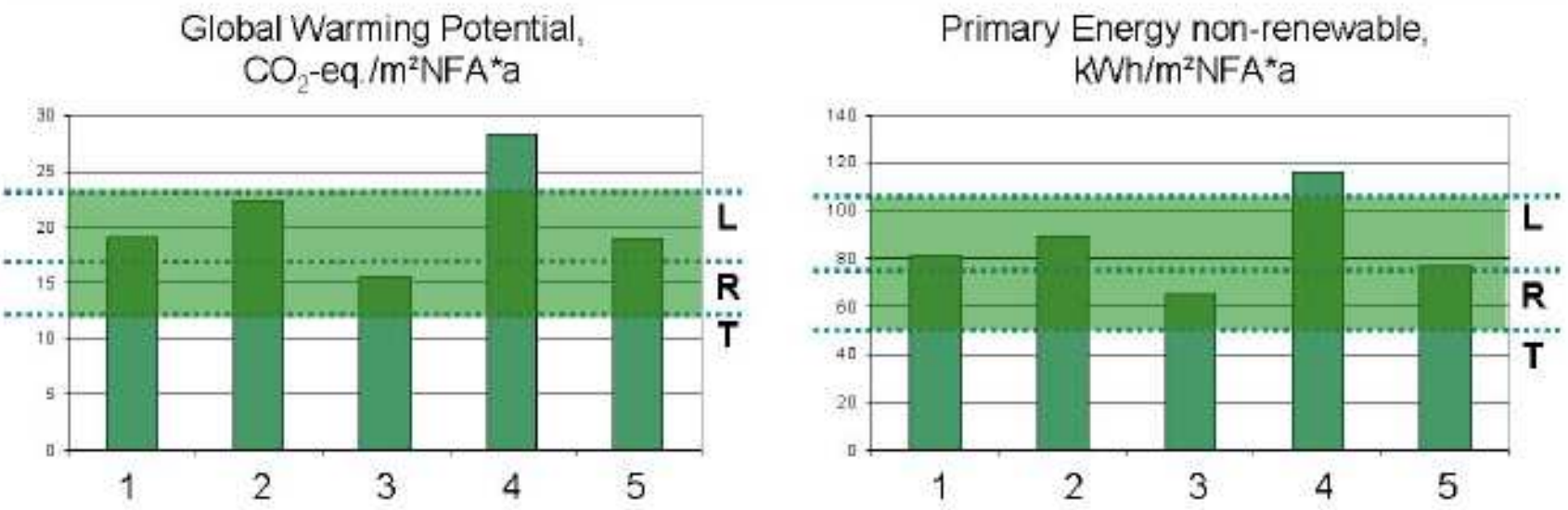

Fig. 5 Reliability Test of the GWP and PE nrn values-corridors, through the analysis of 5 real buildings.

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Benchmarks and Uncertainty

Decomposition approach :

Parameter uncertainty	mainly inventory
Model uncertainty	mainly building description
Scenario uncertainty	mainly scenario assumptions

Proxy approach :

Interval of Benchmarks	proxy for total uncertainty

Conclusion :

values outside standard deviation are significant (+/-)

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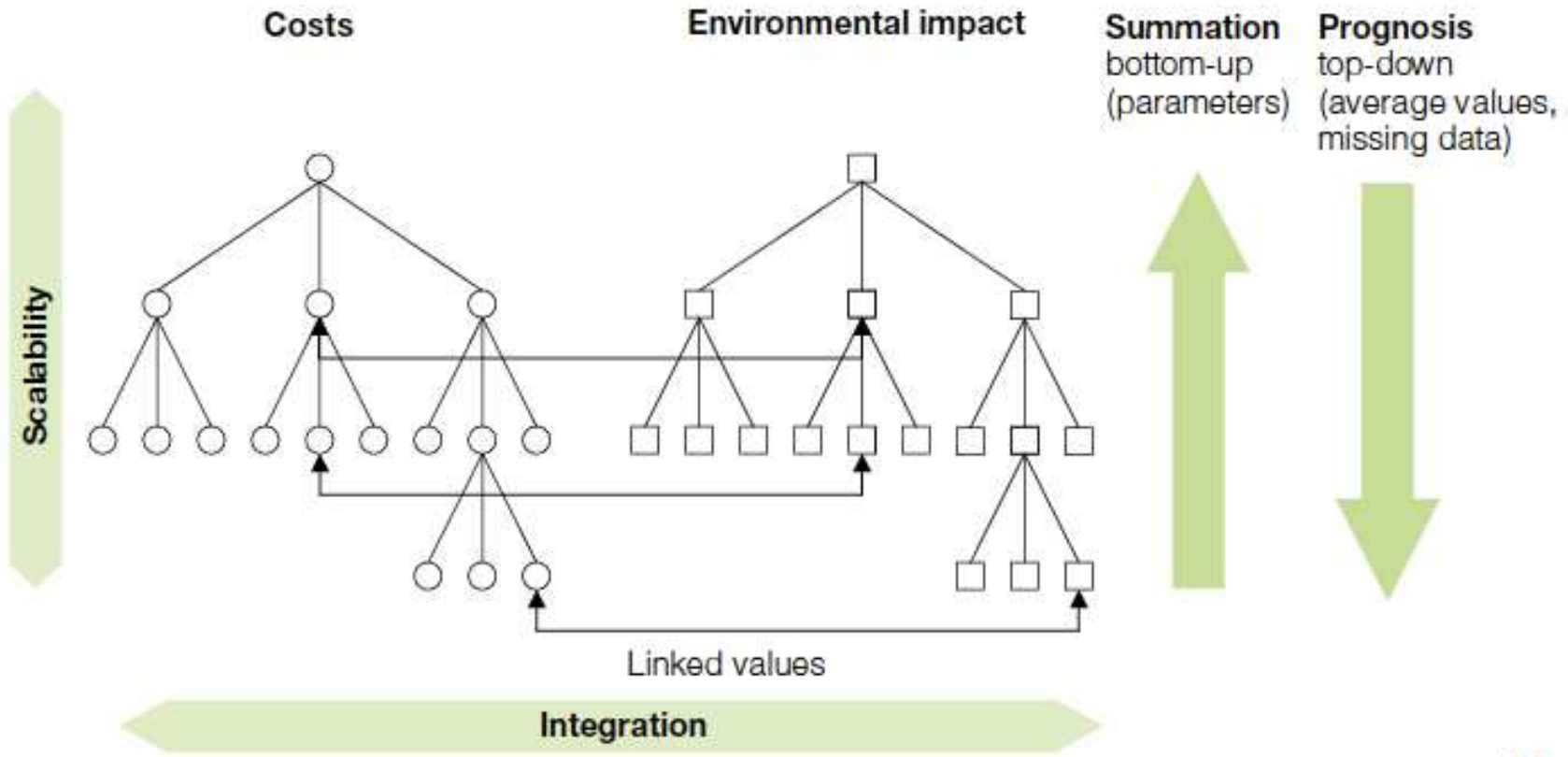
Scalability (top down and bottom up)



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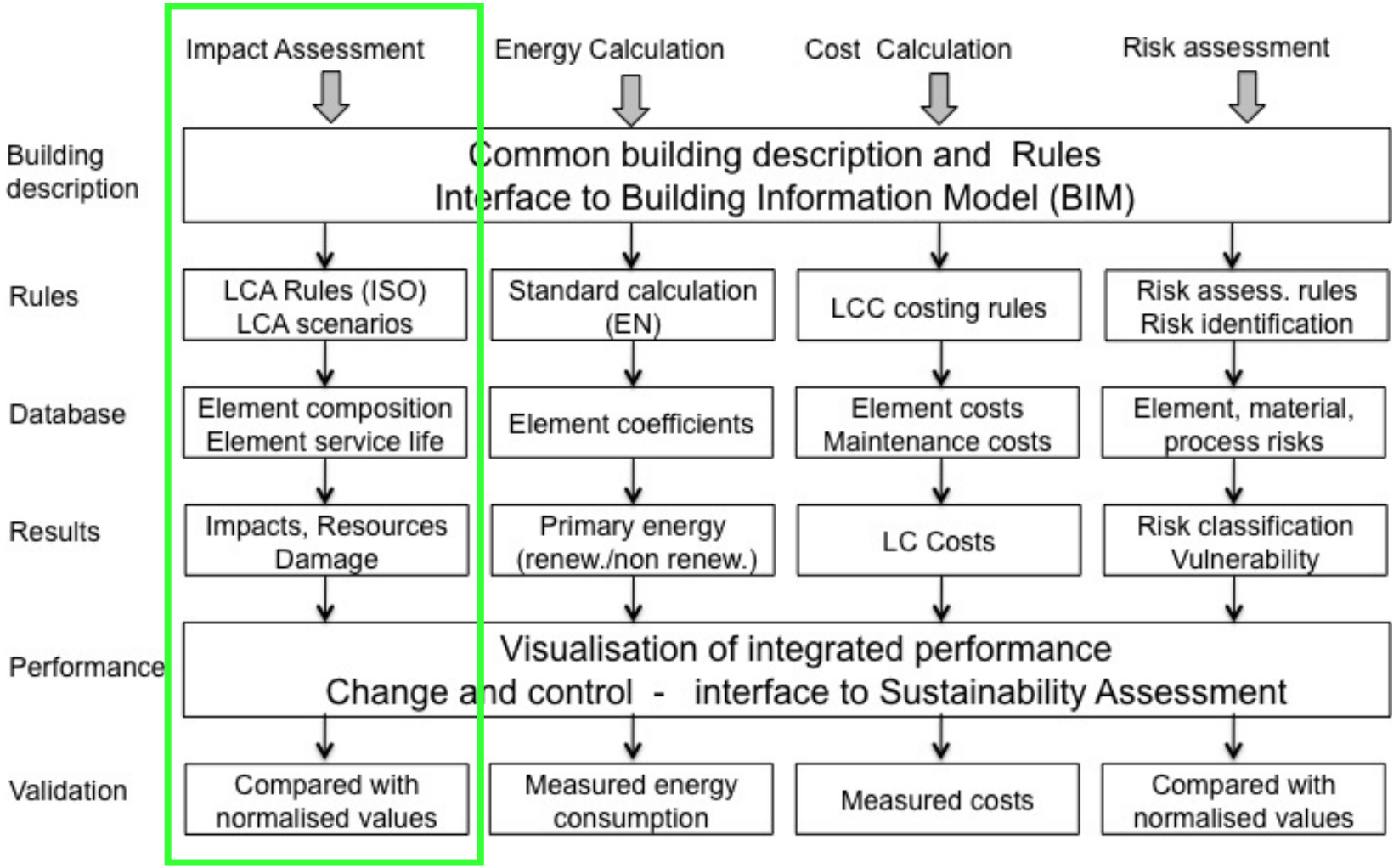
Integrated LCA



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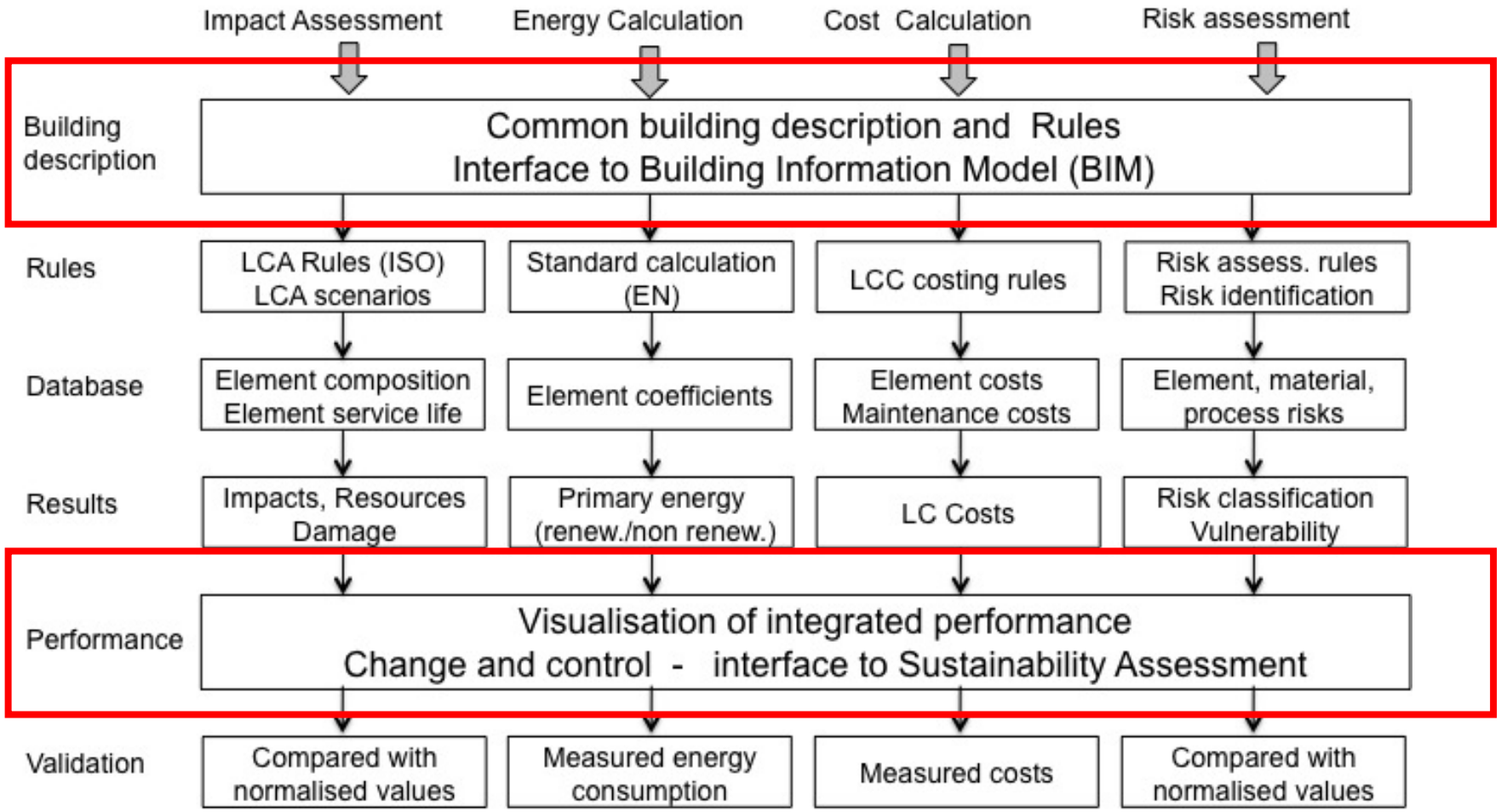
Integration



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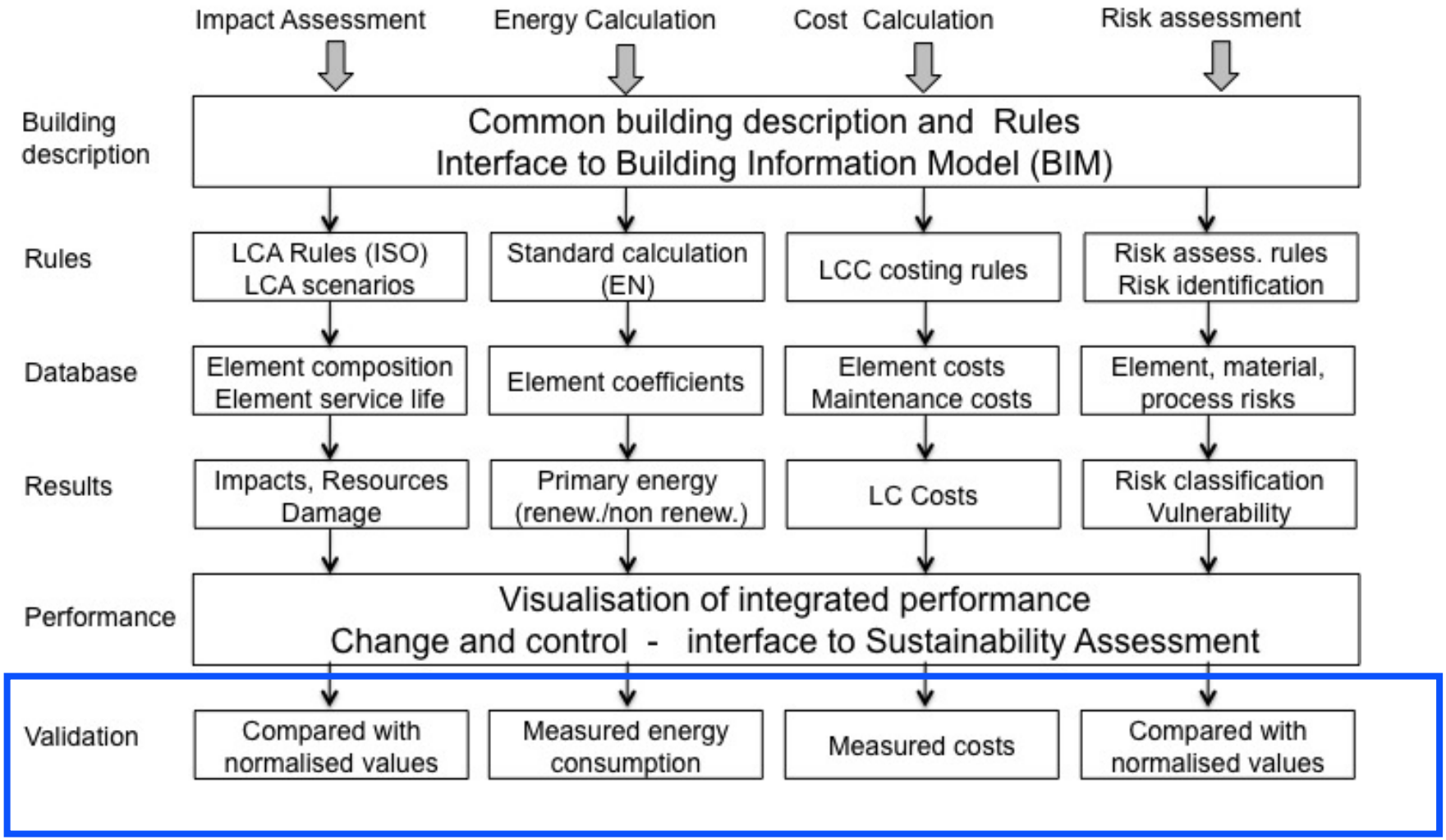
Validation



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Reference service life assumptions

The reference service life assumptions are influenced by :

Very high uncertainty (life time > 100 years)

Relation between operation and construction impact

Importance of building and component durability

Type of impact

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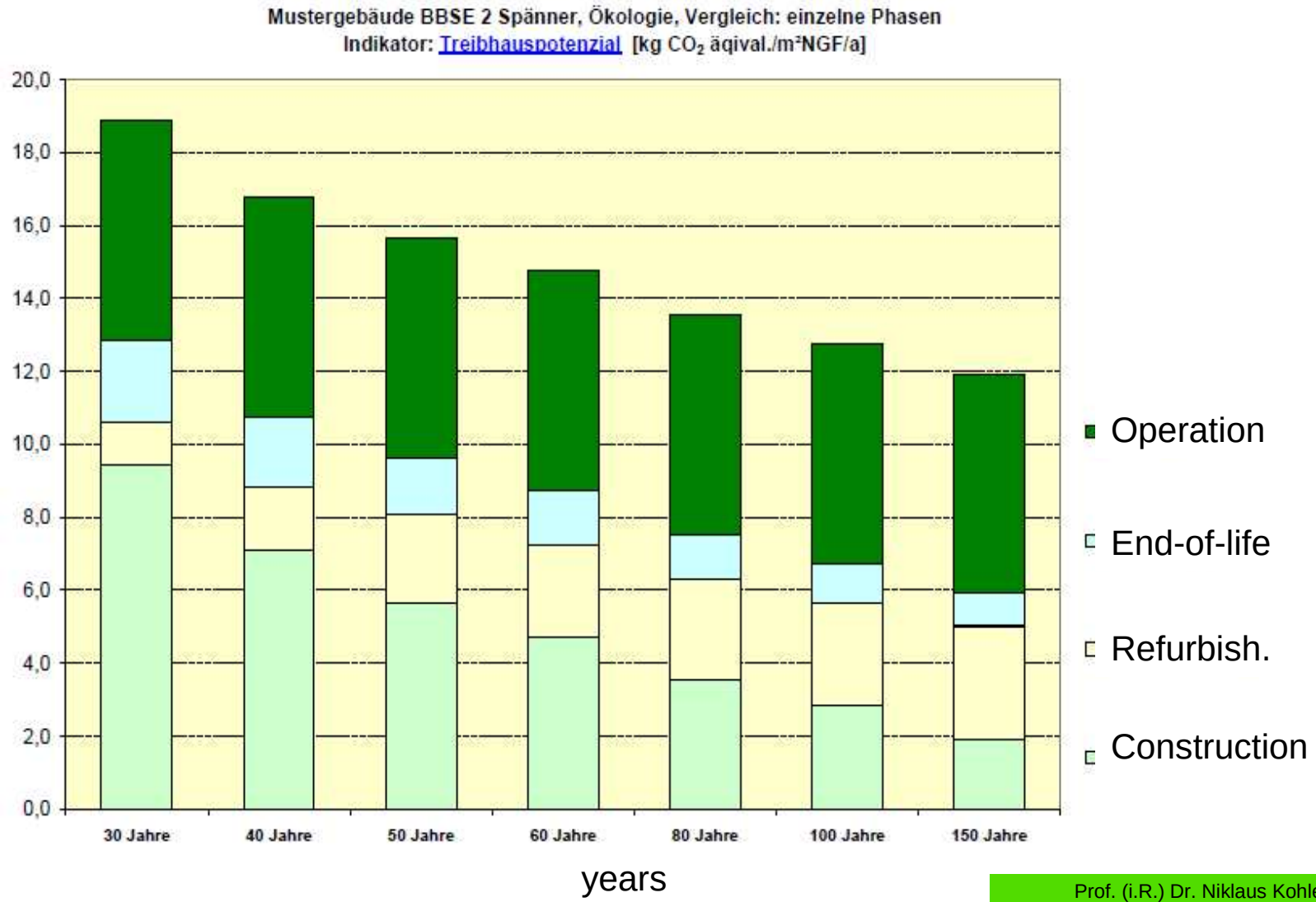
LCA – GWP (kgCO_2/m²NGFa depending on RSL



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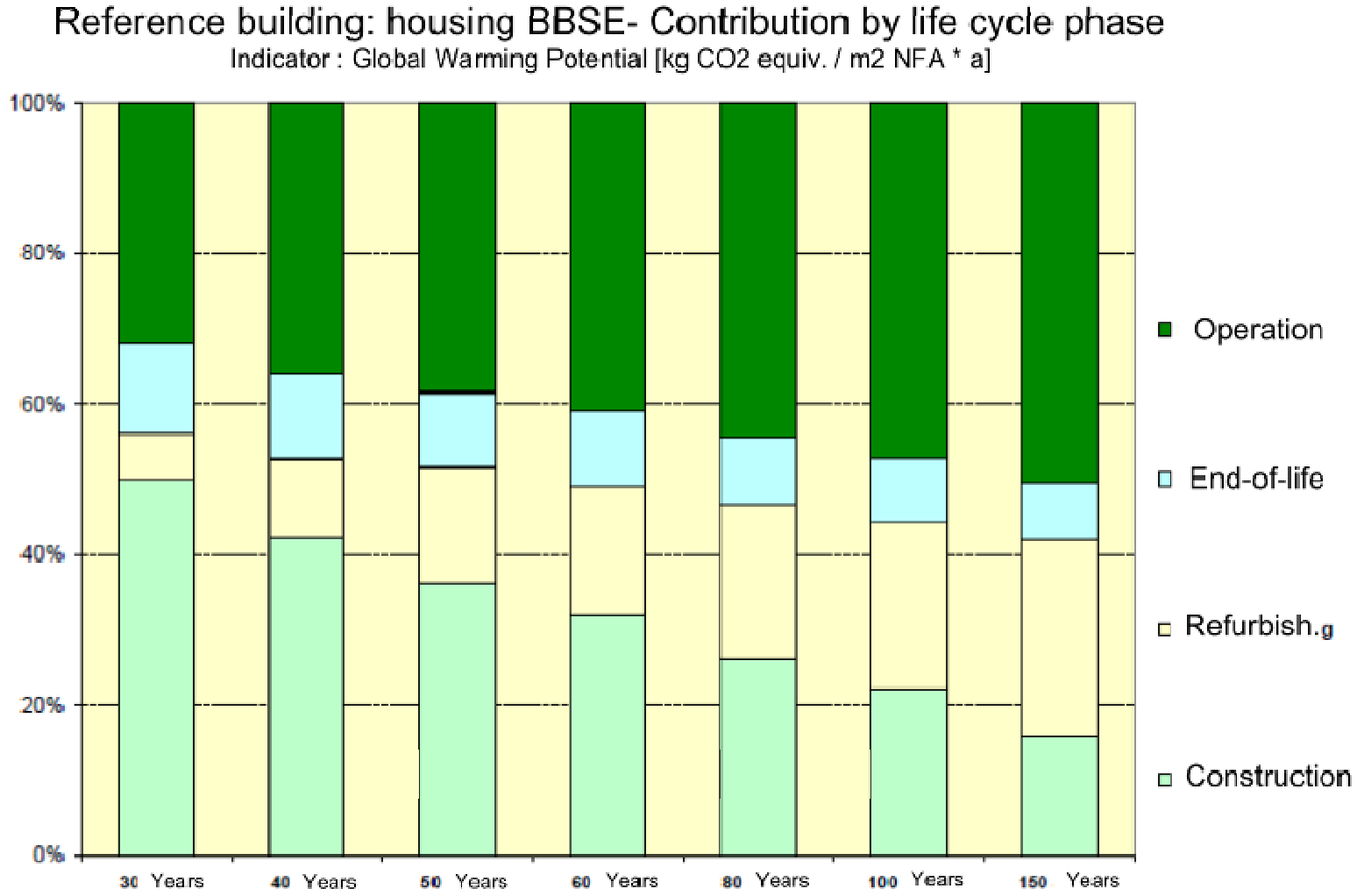
GWP depending reference service life



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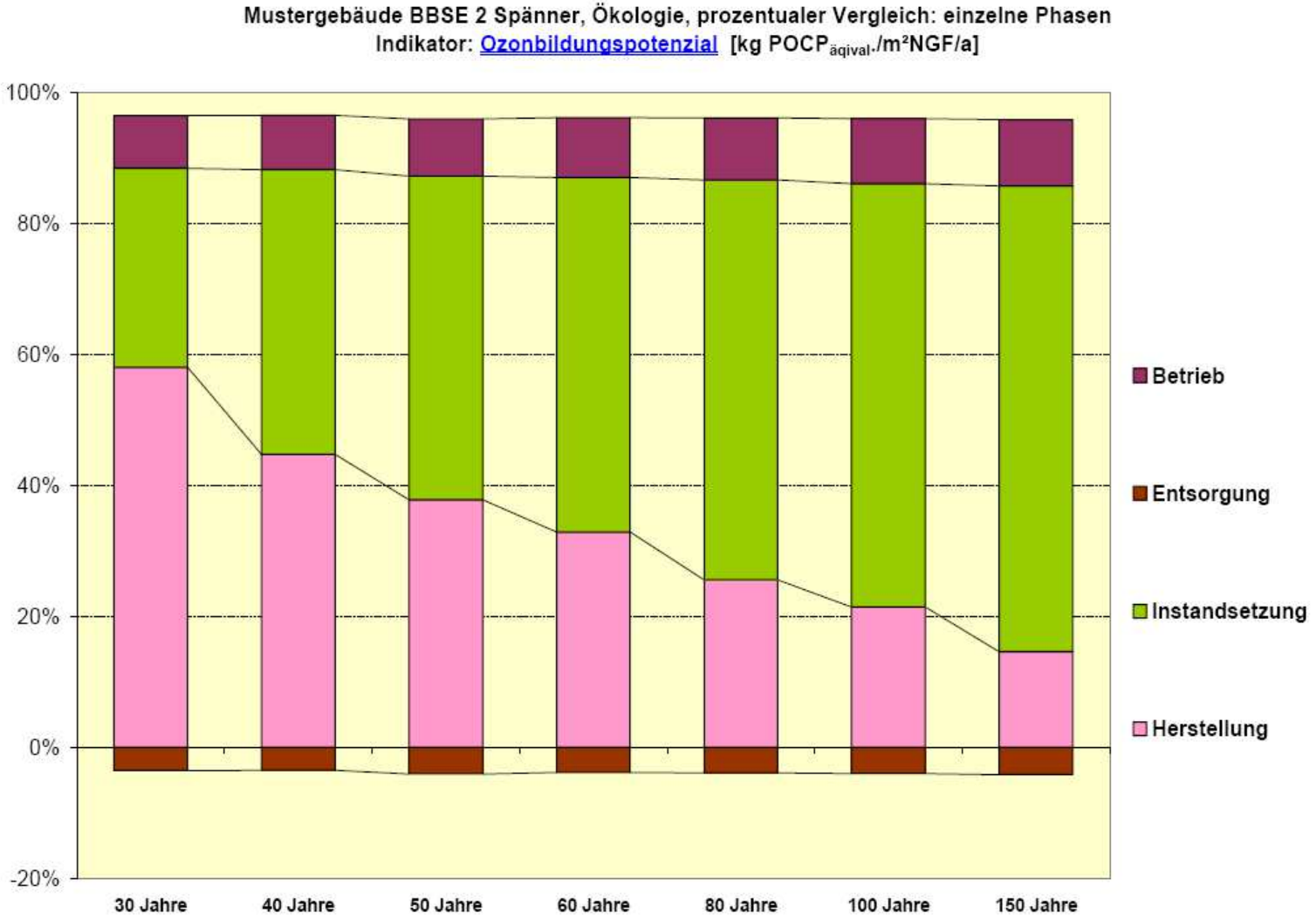
LCA – POCP depending on RSL (in %)



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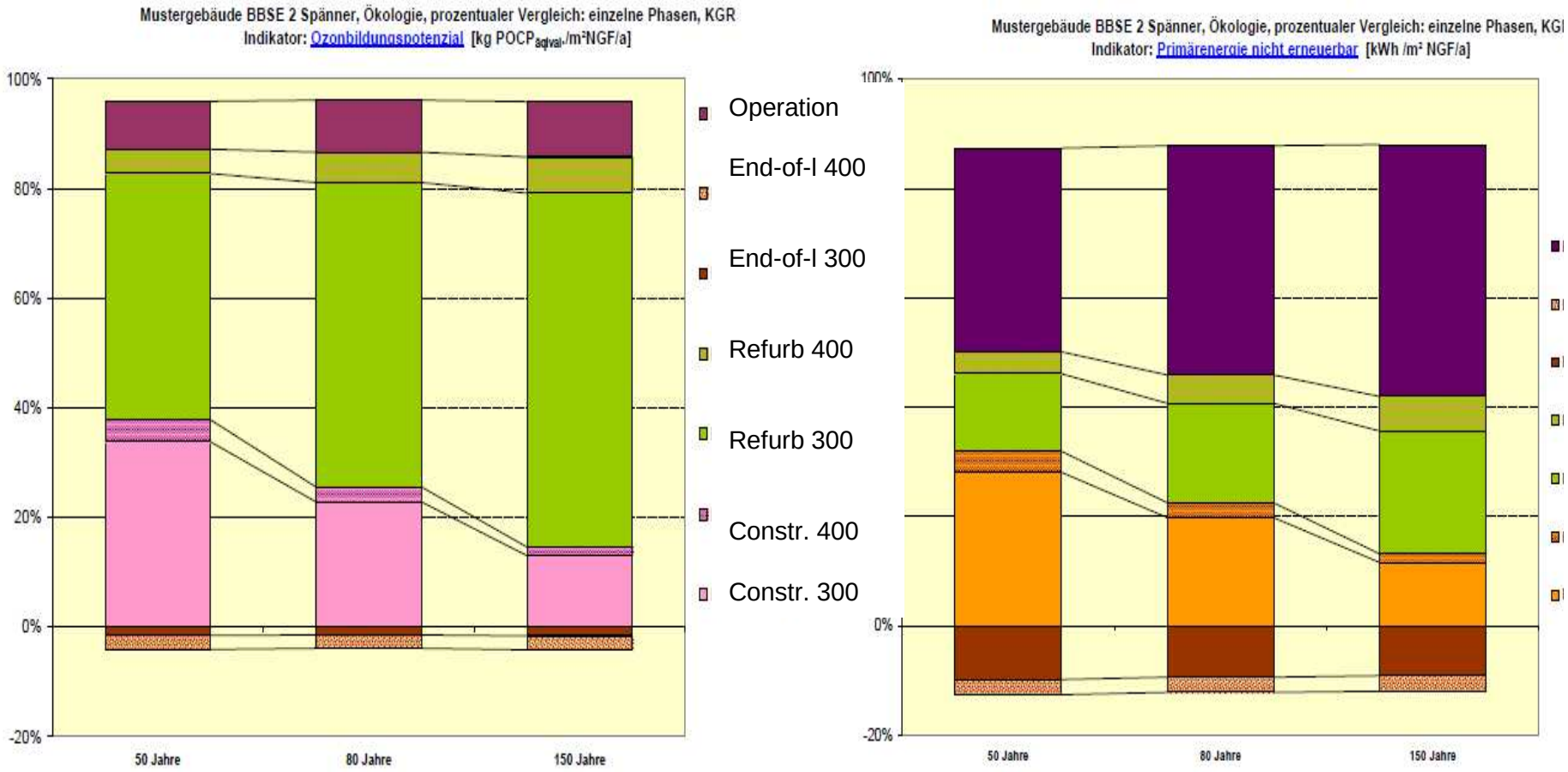
Benchmarks POCP and PE n.r. and RSL



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Conclusions concerning the choice of RSL

The calculation rules could favour non-durable solutions

A longer RSL priorizes the operation part, a shorter period the construction part

A prolongation from RSL 50 years to 100 or 150 years reduces the impact of a log lasting bearing structure up to 50 %

Possibly all components with significantly longer service life than the RSL could receive a bonus

The whole life time of a building could be divided into shorter periods with transition conditions

Durability as a central objective of sustainability is not well taken into account by present methods

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General Conclusions

- Benchmarks of different level will be more and more necessary
- Reference buildings are a possible approach
- A common and scalable building description is necessary
- Integrated LCA allows to establish consistent benchmarks
- Benchmark corridor can be used as a proxy for uncertainty
- There is lack of data from reference buildings
- The consequences of the choice of RSL are not well dominated

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