BIM-integrated LCA - model analysis and implementation for practice

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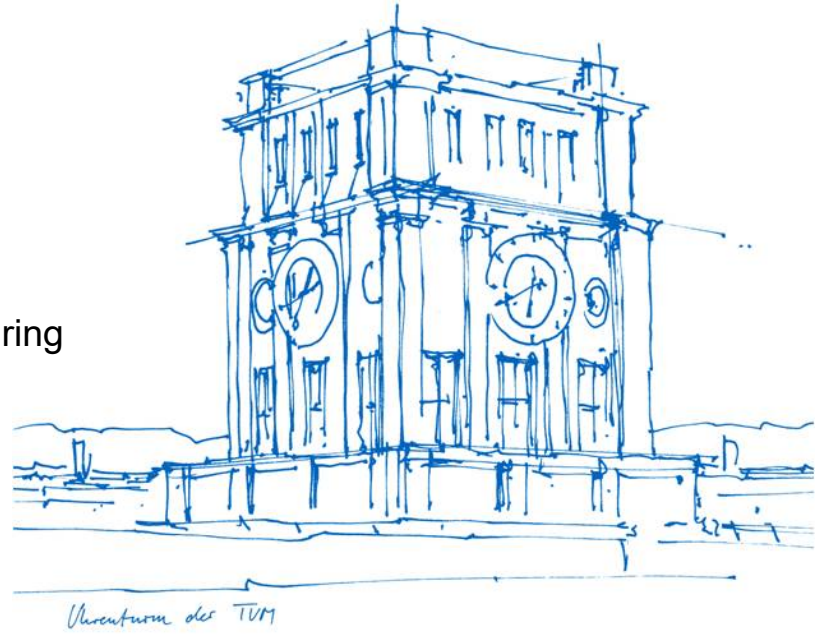


Agenda

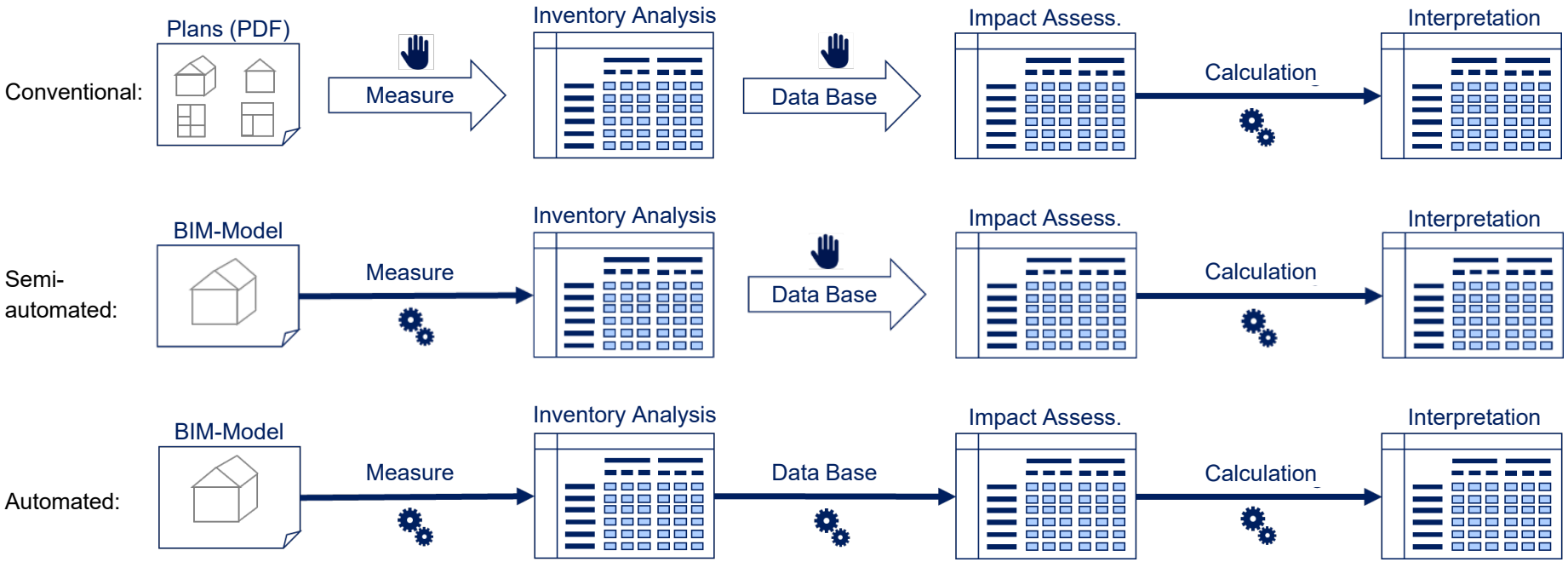
1. Introduction

2. Model analysis
   a. Procedure
   b. Model catalogue
   c. Evaluation of results
   d. Findings and recommendations

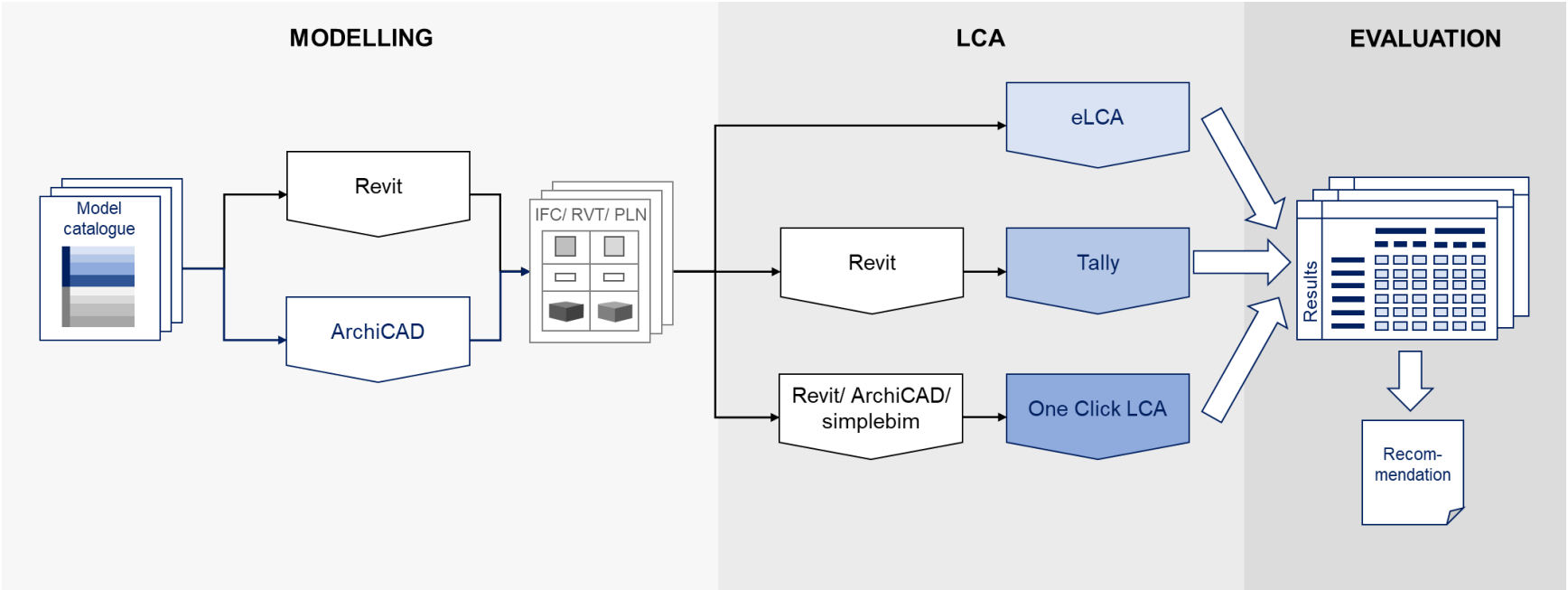
3. Improved workflow
   a. Prototypical implementation
   b. Evaluation

4. Outlook

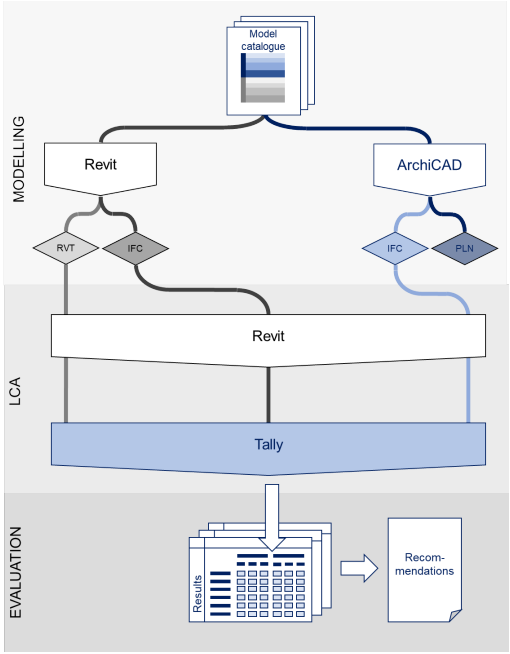
1. Procedure of the model analysis of BIM-integrated LCA

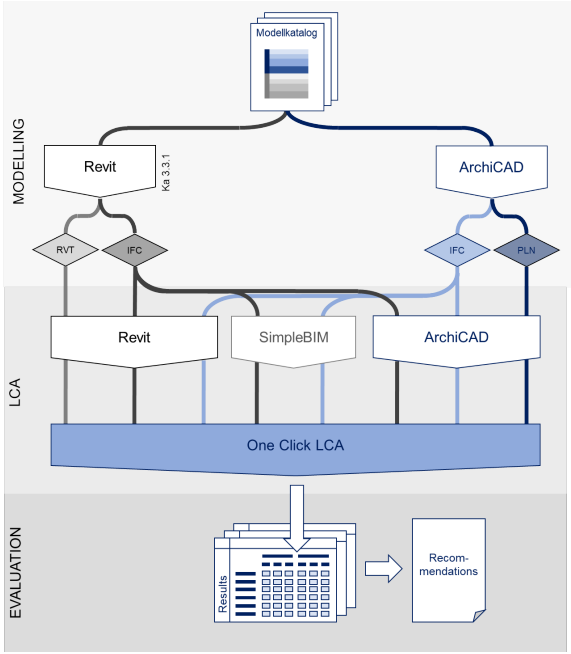


2.a Procedure of the model analysis of BIM-integrated LCA



2.a Flow of data with Tally and One Click LCA





2.b Model catalog for Case studies of the model analysis

		Modellgroup	Model	
Form	F1	Ground floor	angular	F1e
			round	F1r
	F2	Multistory	suspended ceiling	F2z
			galery with cloumns	F2g
	F3	Sloping walls	outside inclined straight wall	F3ag
			outside inclined round wall	F3ar
			inclined inside straight wall	F3ig
			inside inclined round wall	F3ir
	F4	Roof	saddle roof	F4s
			saddle roof with corner	F4e
			hip roof	F4z
			pent roof	F4p

		Modellgroup	Model	
Material	M1	Monolithic	reinforced concrete	M1s
			brick wall	M1m
			timber	M1h
	M2	Multi-layer	reinforced concrete + EPS	M2s
			brick wall + XPS	M2m
	M3	Construction	mullion-transom facade	M3p
			wood frame construction	M3h
	M4	Windows/ doors	wood frame	M4h
			aluminium frame	M4a
			plastic doors	M4k
	M5	Roof	warm roof (flat)	M5s
			brick covering (saddle roof)	M5z
			sheet metal cover (pent roof)	M5b

2.c Evaluation – comparison of results and error analysis

Ergebnisse Total

LCA-Tool		eLCA	Tally			OneClickLCA							
LCA-Plug-In		-	Revit			Revit			SimpleBIM		ArchiCAD		
BIM-Zeichensoftware		-	Revit	Revit	ArchiCAD	Revit	Revit	ArchiCAD	Revit	ArchiCAD	Revit	ArchiCAD	ArchiCAD
Datenaustauschformat		-	rvt	IFC	IFC	rvt	IFC	IFC	IFC	IFC	IFC	IFC	PLN
GWP	[kg CO_2-Äq.]	4,45E+04	4,70E+04	4,74E+04	4,64E+04	2,35E+04	2,35E+04	2,29E+04	2,04E+04	2,36E+04	2,35E+04	2,37E+04	2,37E+04
ODP	[kg R11-Äq.]	4,59E-07	2,87E-04	2,87E-04	2,81E-04	2,42E-07	2,42E-07	2,36E-07	2,11E-07	2,43E-07	2,42E-07	2,44E-07	2,44E-07
POCP	[kg C_2H_4-Äq.]	3,89E+00	3,07E+03	3,13E+03	3,07E+03	2,05E+00	2,05E+00	2,00E+00	1,79E+00	2,06E+00	2,05E+00	2,07E+00	2,07E+00
AP	[kg SO_2-Äq.]	7,73E+01	2,24E+02	2,26E+02	2,21E+02	4,08E+01	4,08E+01	3,98E+01	3,55E+01	4,10E+01	4,08E+01	4,11E+01	4,11E+01
EP	[kg PO_4^{3-}-Äq.]	1,21E+01	8,09E+00	8,25E+00	8,08E+00	6,39E+00	6,39E+00	6,22E+00	5,56E+00	6,41E+00	6,39E+00	6,44E+00	6,44E+00
PET	[MJ]	2,16E+05	3,04E+05	3,09E+05	3,03E+05	1,14E+05	1,14E+05	1,11E+05	9,91E+04	1,14E+05	1,14E+05	1,15E+05	1,15E+05
PENRT	[MJ]	1,95E+05	2,99E+05	3,04E+05	2,98E+05								
PERT	[MJ]	2,12E+04	4,22E+03	4,31E+03	4,22E+03								

Modellgruppe	Modellgruppenvariante	LCA-Tool	Datenursprung	LCA-Variante	Unterschied in den Wandflächen (ArchiCAD-Revit)	Unterschied in der Mengenerfassung bei dem IFC-:port (Revit)	Fehlen der Construction-Phase (Abweichung um durchschnittlich ~14%)	Fehlende Bauteile	FehlerXY	Zusätzliche Nutzungsphase (B1-B5)	Fehlende Nutzungsphase A4	Zusätzliches Bauteil (Deckenöffnung)
F3	ag	eLCA		eLCA_F3ag								
F3	ag	Tally	_revit	Tally_F3ag								
F3	ag	Tally	_revit_ifc	Tally_F3ag_revit_ifc								
F3	ag	Tally	_archicad_ifc	Tally_F3ag_archicad_ifc								
F3	ag	OneClickLCA	_archicad_pln_archicad	OneClickLCA_F3ag_archicad_pln_archicad								
F3	ag	OneClickLCA	_archicad_ifc_archicad	OneClickLCA_F3ag_archicad_ifc_archicad								
F3	ag	OneClickLCA	_archicad_ifc_revit	OneClickLCA_F3ag_archicad_ifc_revit								
F3	ag	OneClickLCA	_archicad_ifc_simplebim	OneClickLCA_F3ag_archicad_ifc_simplebim								
F3	ag	OneClickLCA	_revit_rvt_revit	OneClickLCA_F3ag_revit_rvt_revit								
F3	ag	OneClickLCA	_revit_ifc_archicad	OneClickLCA_F3ag_revit_ifc_archicad								
F3	ag	OneClickLCA	_revit_ifc_revit	OneClickLCA_F3ag_revit_ifc_revit								
F3	ag	OneClickLCA	_revit_ifc_simplebim	OneClickLCA_F3ag_revit_ifc_simplebim								
F3	ar	eLCA		eLCA_F3ar								
F3	ar	Tally	_revit	Tally_F3ar_revit								

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2.c Comparison of the results of the model analysis

LCA-Software	Tally			One Click LCA							
LCA-Plug-In	revit	revit	revit	revit	revit	revit	simplebim	simplebim	archicad	archicad	archicad
File-Format	RVT	IFC	IFC	RVT	IFC	IFC	IFC	IFC	IFC	IFC	PLN
BIM-Software	revit	revit	archicad	revit	revit	archicad	revit	archicad	revit	archicad	archicad
F1e	●	●	●	●	●	●	●	●	●	●	●
F1r	●	●	●	●	●	●	◆	◆	●	●	●
F2z	●	●	●	●	●	●	●	●	●	●	●
F2g	●	◆	●	●	●	●	●	●	■	●	●
F3ag	●	●	●	●	●	◆	■	●	●	●	●
F3ar	●	■	■	●	■	■	■	■	●	●	●
F3ig	●	●	■	●	■	■	■	◆	●	●	●
F3ir	●	●	■	●	■	■	■	■	●	●	●
F4s	●	■	■	●	●	■	●	●	●	●	●
F4e	●	■	■	●	●	■	●	◆	◆	●	●
F4z	●	■	■	●	●	■	●	●	◆	●	●
F4p	●	■	■	●	●	■	●	◆	●	◆	●
M1s	●	●	●	●	●	●	●	●	●	●	●
M1m	●	●	●	●	●	●	●	●	●	●	●
M1h	●	●	●	●	●	●	●	●	●	●	●
M2s	●	●	●	●	●	●	●	●	●	●	●
M2m	●	■	●	●	■	●	■	◆	■	●	●
M3p	●	■	■	■	●	●	●	■	●	●	●
M3h	●	◆	■	●	●	■	◆	◆	●	■	●
M4h	●	◆	■	●	■	■	■	■	●	◆	●
M4a	●	■	■	●	■	■	■	■	◆	●	■
M4k	●	■	■	●	■	■	■	■	■	●	●
M5s	●	●	●	●	●	◆	●	◆	●	●	●
M5z	●	■	■	●	■	■	◆	◆	■	■	●
M5b	●	■	■	●	■	■	◆	◆	■	■	●

●	25	11	11	24	16	10	13	10	17	20	24
◆	0	3	0	0	0	2	4	9	3	2	0
■	0	11	14	1	9	13	8	6	5	3	1

●	◆	■
11	0	0
9	2	0
11	0	0
9	1	1
9	1	1
5	0	6
6	1	4
6	0	5
8	0	3
6	2	3
7	1	3
6	2	3
11	0	0
11	0	0
11	0	0
11	0	0
6	1	4
7	0	4
5	3	3
4	2	5
3	1	7
4	0	7
9	2	0
3	2	6
3	2	6

181	
	23
	71

Legend: ● correct result
◆ slight deviation
■ strong deviation

2.d Findings and recommendations of model analysis

Work process:

- Semi-automatic working process better, as transparent and subsequent adjustment possible (with regard to layer thickness, composite content, exchange cycles and end-of-life scenarios)

Data format and quality:

- "Open BIM" very error-prone internal files more complete in LCA calculation
- Revit has the most interfaces to LCA programs
- LCA calculation only as accurate as the quality when creating the BIM model
- Unique naming of the components according to the component

2.d Findings and recommendations of model analysis

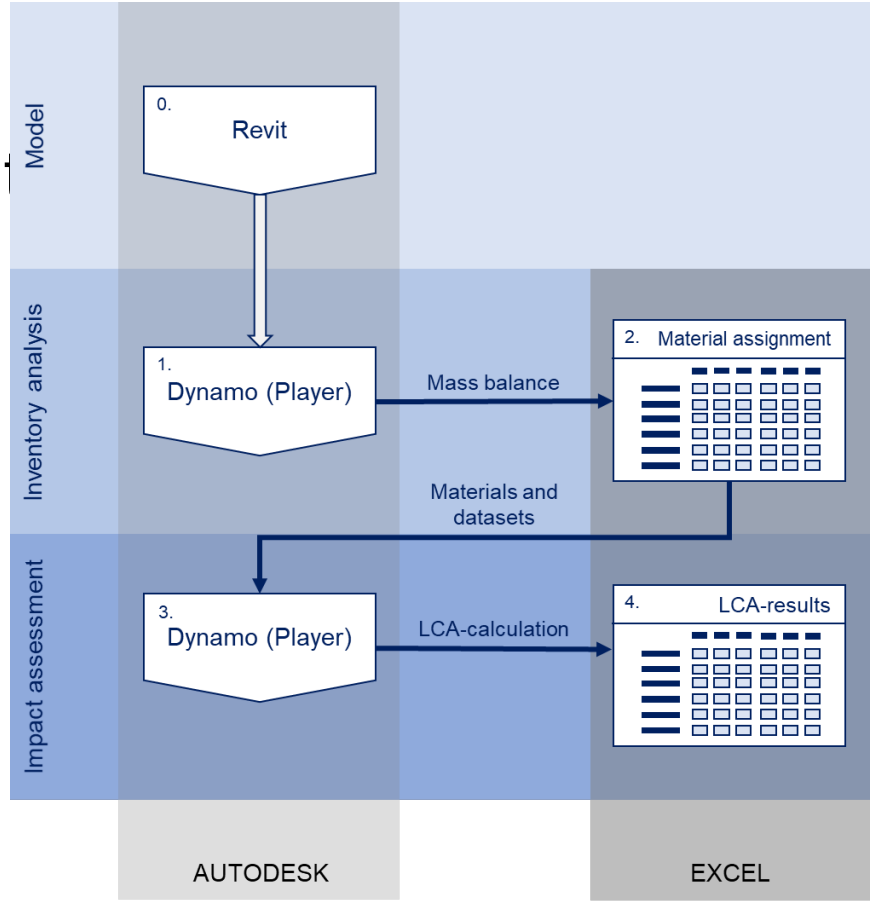
Tally:

- No external data records can be integrated
- No individual assignment of end-of-life scenarios
- Optimized only for Revit models and exclusively LEED-compliant calculation

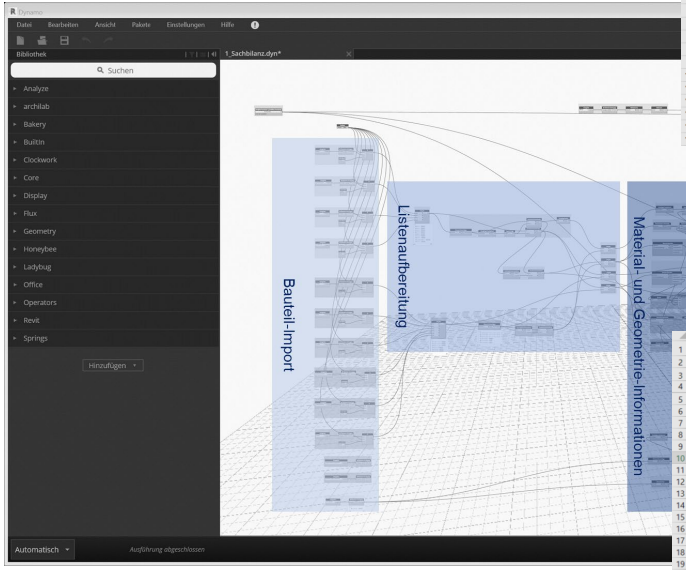
One Click LCA:

- No imaging of composite materials possible
- Incorrect material assignment of data records
- No transparent and comprehensible representation of the component-specific materials
- No individual assignment of end-of-life

3.a Improved workflow wi
a prototypical implementation



3.a Prototypical implementation



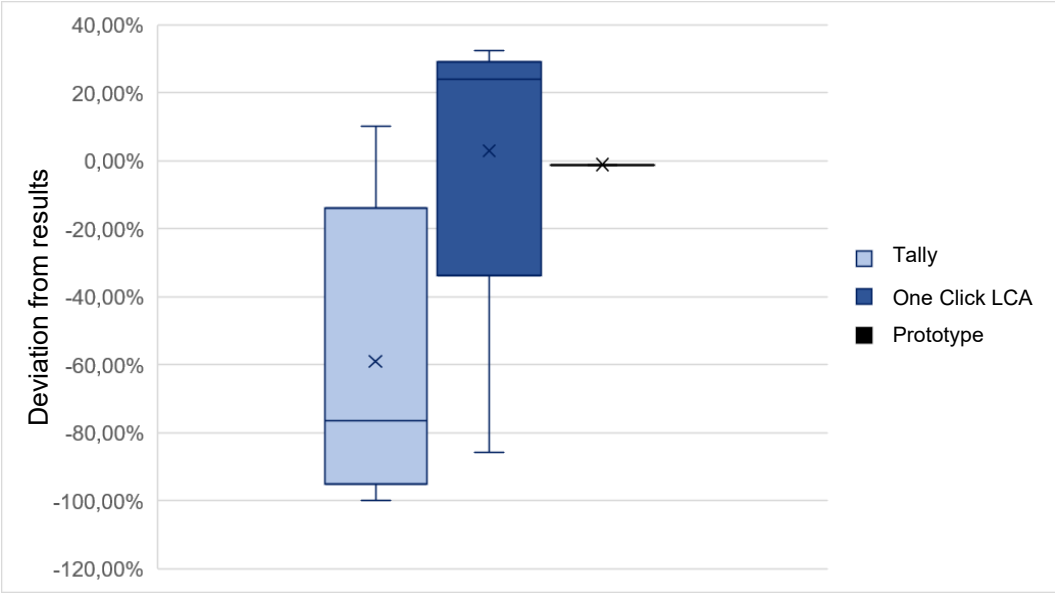
2. MATERIALZUORDNUNG

Prüf	Einbauort	Material	Dichte	Lebensdauer	Kompositanteil	Komposit-Mat.	Kategorie 1	Kategorie 2	Kategorie 3	LCA-Material
26	[]	[]	[kg/m³]	[a]	[%]	[]	[]	[]	[]	[]
	Basiswand	Stahlbeton - Sichtbeton (2)	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbeton C20/25
	Basiswand	End-of-Life-Szenario - Stahlbeton - Sichtbeton (2)	2407,31	50	98%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttaufbereitung
	Basiswand	Stahlbeton - Ortbeton	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbeton C20/25
	Basiswand	End-of-Life-Szenario - Stahlbeton - Ortbeton	2407,31	50	98%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttaufbereitung
	Basiswand	Wärmedämmung - hart	50	50	100%		Dämmstoffe	Mineralwolle	Mineralwolle	Mineralwolle (Fassaden-Dämmung)
	Basiswand	End-of-Life-Szenario - Wärmedämmung - hart	50	50	100%		End of Life	Generisch	Bauschutt	Bauschutt-Deponierung
	Basiswand	Stahlbeton - C20/25	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbeton C20/25

3. BAUTEILÜBERPRÜFUNG

Prüf	Einbauort	Bauteil	Material	Fläche	char. Länge	Volumen	Stück	Dichte	Lebensdauer	Kompositanteil	Komposit-Mat.	Kategorie 1	Kategorie 2	Kategorie 3	LCA-Mater
30	[]	[]	[]	[m²]	[m]	[m³]	[]	[kg/m³]	[a]	[%]	[]	[]	[]	[]	[]
	Basiswand	STB 30.0 - Sichtbeton 2	Stahlbeton - Sichtbeton (2)	28,00	0,30	8,40	1	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbe
	Basiswand	STB 30.0 - Sichtbeton 2	End-of-Life-Szenario - Stal	28,00	0,30	8,40	1	2407,31	50	98%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttau
	Basiswand	STB 25.0 WD 12.0	Stahlbeton - Ortbeton	28,81	0,25	7,18	1	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbe
	Basiswand	STB 25.0 WD 12.0	End-of-Life-Szenario - Stal	28,81	0,25	7,18	1	2407,31	50	98%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttau
	Basiswand	STB 25.0 WD 12.0	Wärmedämmung - hart	28,71	0,12	3,44	1	50	50	100%	0%	Dämmstoffe	Mineralwolle	Mineralwolle	Mineralwolle
	Basiswand	STB 25.0 WD 12.0	End-of-Life-Szenario - Wa	28,71	0,12	3,44	1	50	50	100%	0%	End of Life	Generisch	Bauschutt	Bauschutt-D
	Basiswand	STB 30.0	Stahlbeton - C20/25	113,82	0,30	34,12	4	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbe
	Basiswand	STB 30.0	End-of-Life-Szenario - Stal	113,82	0,30	34,12	4	2407,31	50	98%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttau
	Geschossdecke	STB 20.0	Stahlbeton - C20/25	111,83	0,20	22,37	1	2407,31	50	98%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbe
	Geschossdecke	STB 20.0	End-of-Life-Szenario - Stal	111,83	0,20	22,37	1	2407,31	50	98%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttau
	Basisdach	Titanzink - Eindeckung	Vorgabe - Dach	180,13	0,15	27,02	1	2407,31	50	100%	KM1	Mineralische Baustoffe	Mörtel und Beton	Beton	Transportbe
	Basisdach	Titanzink - Eindeckung	End-of-Life-Szenario - Vor	180,13	0,15	27,02	1	2407,31	50	100%	KM1e	End of Life	Generisch	Bauschutt	Bauschuttau
	Basisdach	Titanzink - Eindeckung	Metall - Titanzink	180,13	0,03	5,40	1	652	50	100%	0%	Metalle	Zink	Zinkbleche	NedZink NC

3.b Evaluation of the prototype



	Tally	OneClickLCA	Prototype
Minimalwert	-99,91%	-100,00%	-1,13%
Erstes Quartil	-90,58%	-59,83%	-1,13%
Median	-76,49%	21,13%	-1,13%
Drittes Quartil	-38,13%	25,30%	-1,13%
Maximalwert	10,09%	32,35%	-1,13%

3.b Evaluation of improved workflow

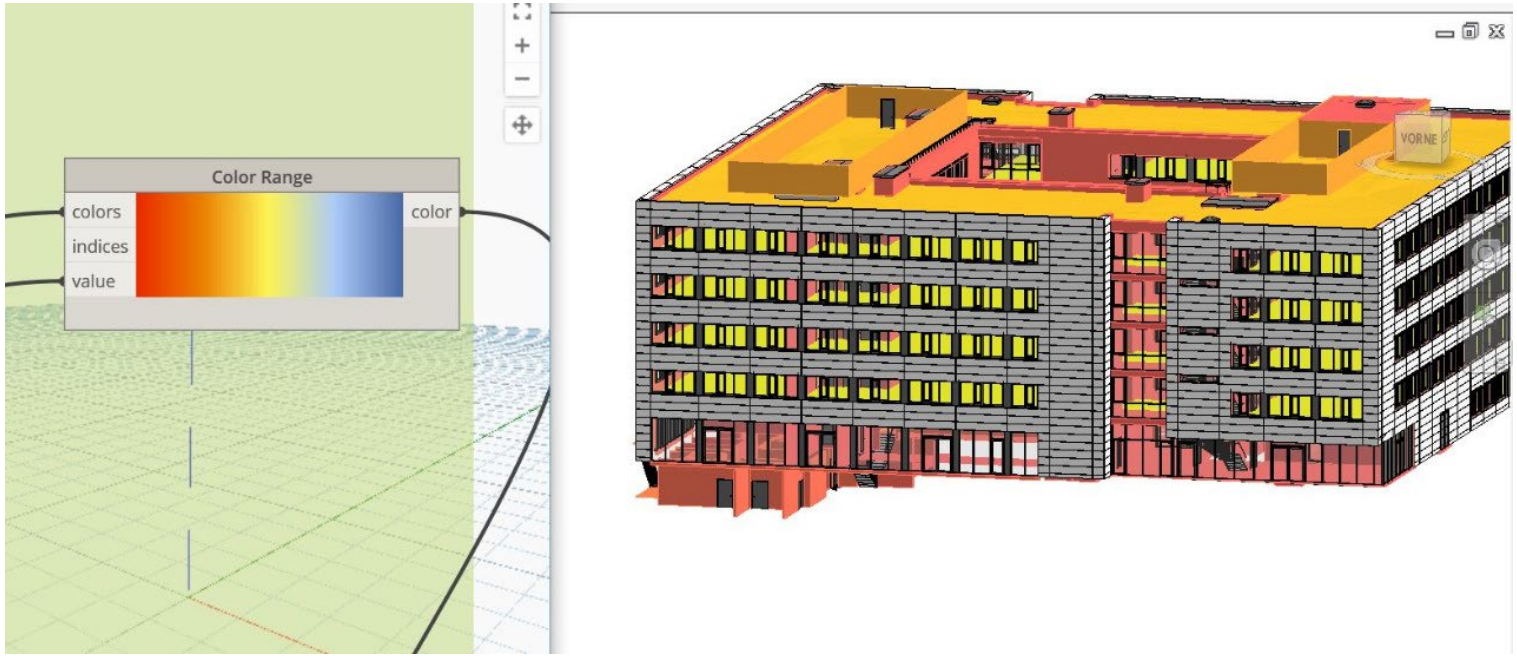
Prototype:

- Correct and transparent calculation of results (DGNB-compliant)
- Automated, component-specific life cycle inventory of materials
- Necessary error correction: subsequent, transparent adjustments of components and materials (with regard to layer thicknesses, composite proportions, exchange cycles, end-of-life scenarios, EPDs and data sets)

But:

- CPU-intensive programming
- Incorrect recording of individual component groups (stairs, windows and doors, facade elements, beams and supports)

4. Visualisation of comp. specific results with colour coding



Thanks for your attention

Kasimir Forth

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