Life-Cycle Assessment as a decision-support tool for early phases of urban planning

Evaluating applicability through a comparative approach

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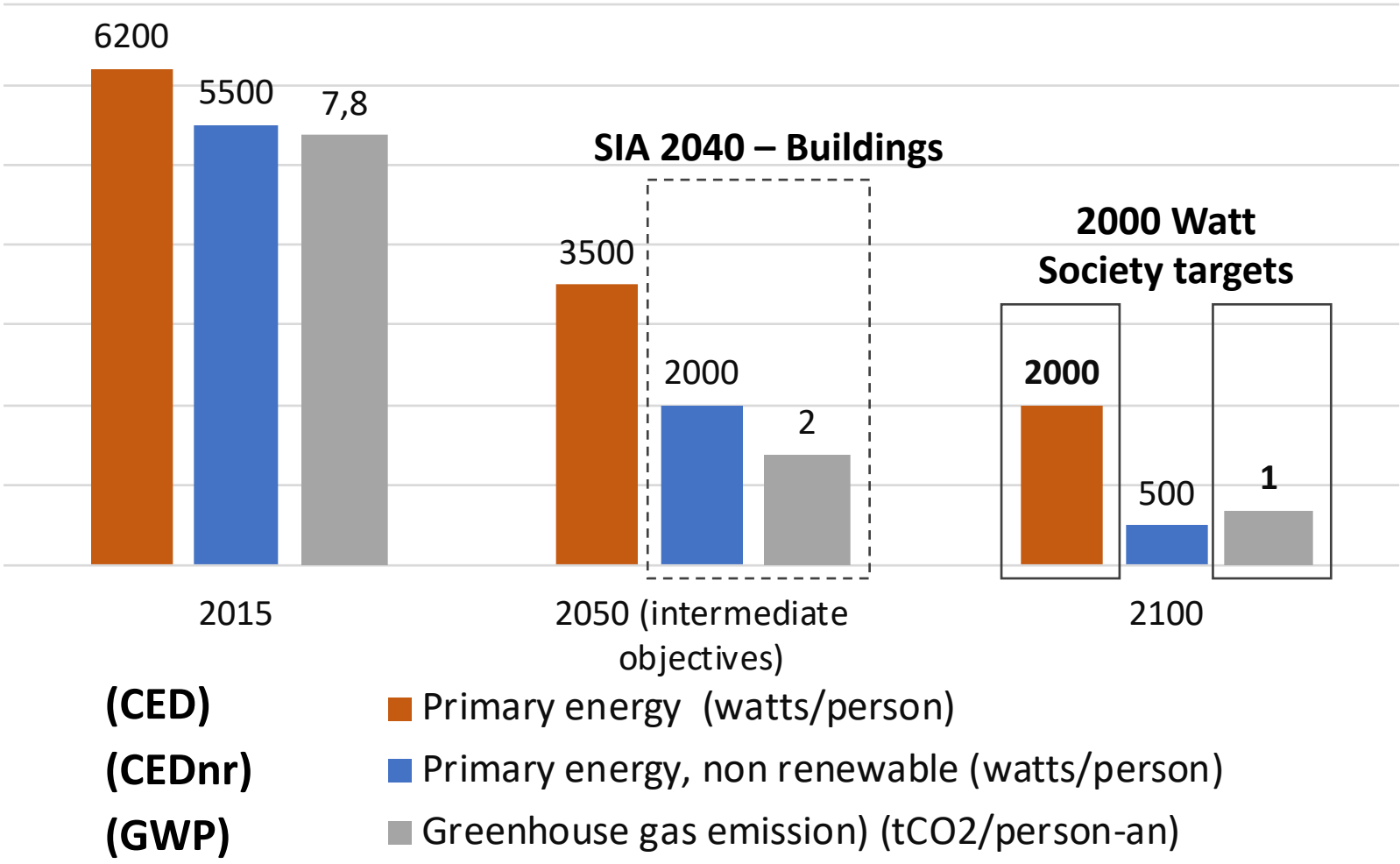
Building 2050 group | Smart Living Lab | EPFL

Sustainable Built Environment SBE conference

Graz University of Technology | September 13, 2019

Context | Environmental objectives



Context | Carbon objectives

Construction

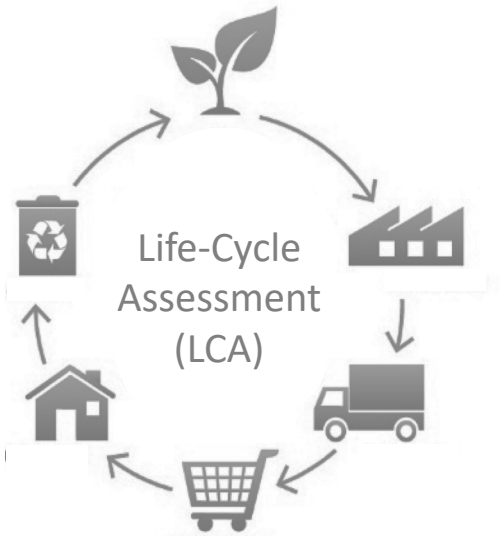
Impacts that relate to construction, replacement and disposal

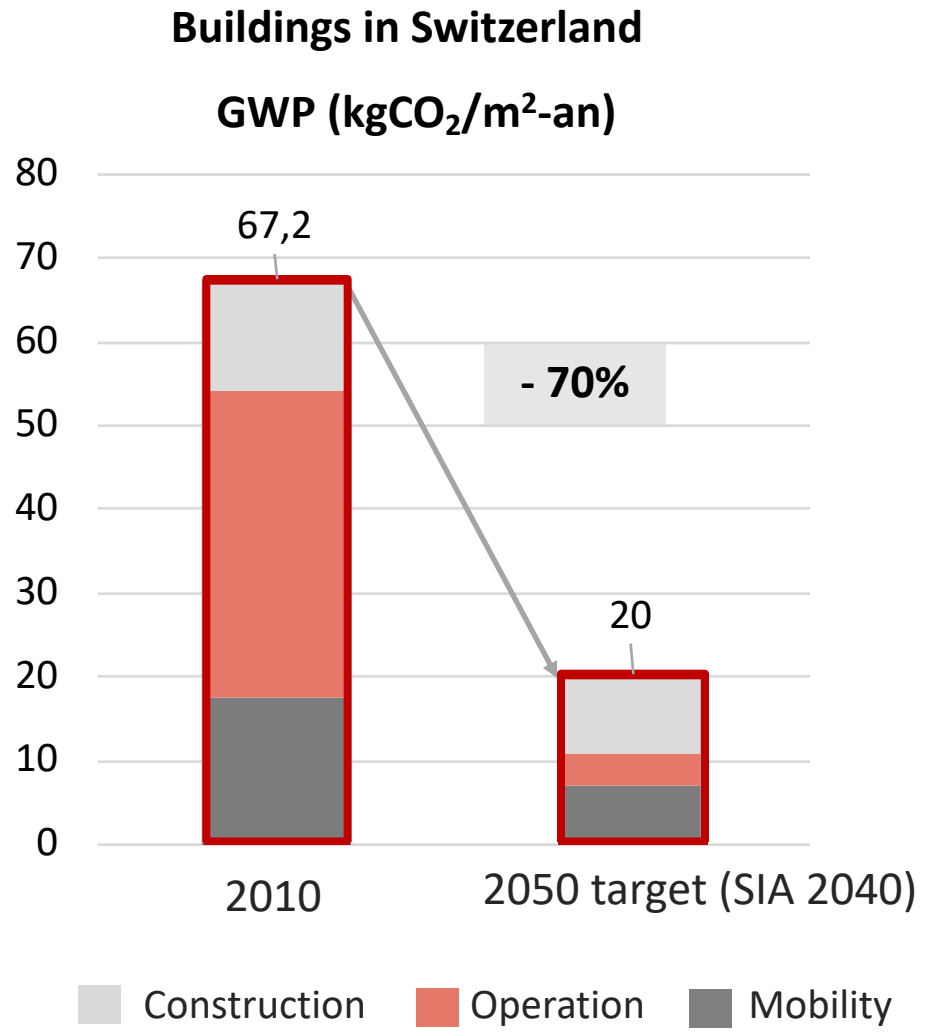
Operation

HVAC, DHW, lighting, appliances etc.

Mobility

Location-dependent everyday mobility





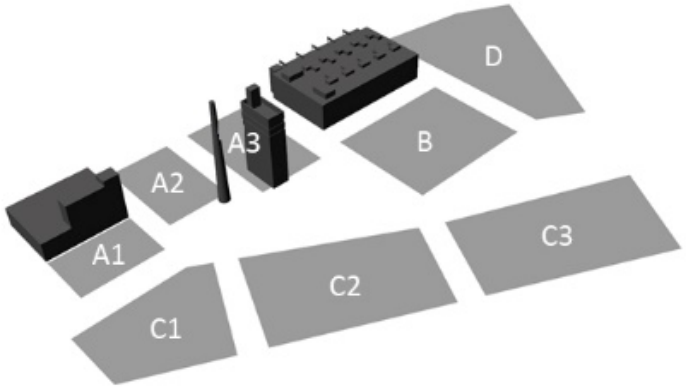
Context | Early planning

Research question

Are the tools able to guide project stakeholders in making informed decisions during the early-design stage of urban-scale projects?

Specific Environmentally-conscious Targets for Urban Planning (SETUP)

LCA-based tools | SETUP

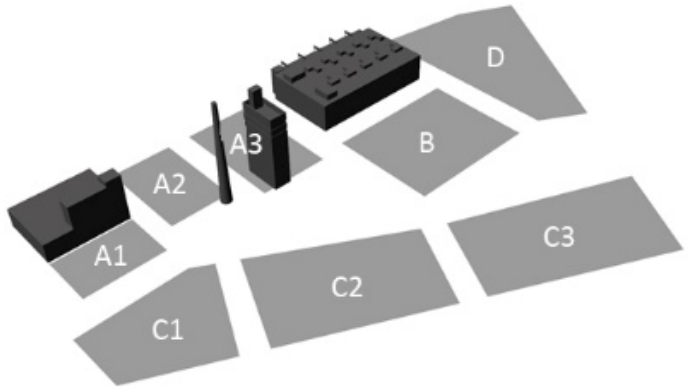


Zones on the blueFactory site,
as defined according to the SETUP
project analysis

Variable parameters

1	BS	Building shape (typology)
2	BD	Building depth (m)
3	BH	Building height (floors)
4	CONT	Built context
5	WWR	Window-to-wall ratio
6	WIN	Glazing type
7	FRA	Frame type
8	U	Thermal transmittance
9	PV	PV-to-roof surface ratio
10	HVAC	Heating and domestic hot water system
11	VENT	Ventilation
12	HOREL	Construction of horizontal elements
13	VEREL	Construction of vertical elements
14	INS	Insulation type
15	COVS	Covering slab material
16	COVW	Covering material of external walls
17	BAL	Balcony (apartment buildings only)

LCA-based tools | SETUP



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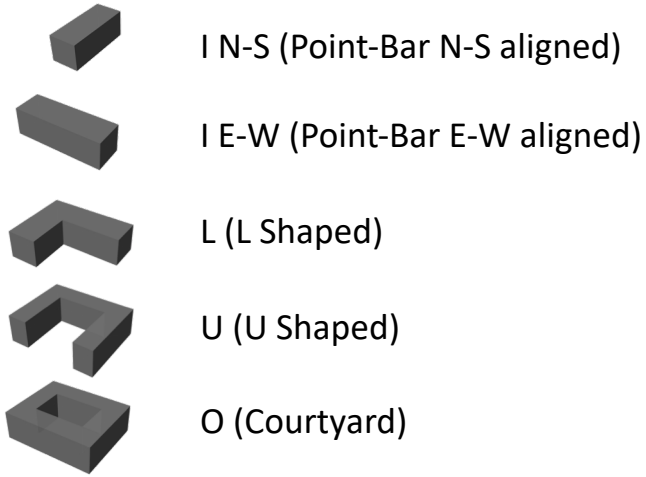
17	BAL	

1 BS Building shape (typology):



I N-S (Point-Bar N-S aligned)

I E-W (Point-Bar E-W aligned)

L (L Shaped)

U (U Shaped)

O (Courtyard)

2 FRA Frame quality:

1 Wood/alu
2 Alu
3 PVC
4 Wood

3 U Thermal transmittance (U-value, W/m2K):

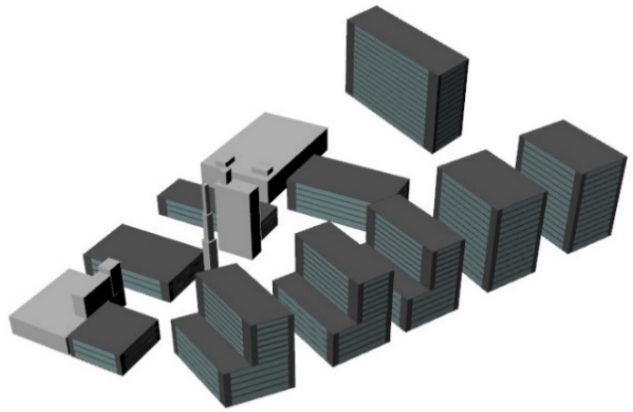
1 U value	0.1
2 U value	0.2
3 U value	0.3

LCA-based tools | SETUP

Emilie Nault, Building 2050

Parameter selection

	A1	A2	A3	B	C1	C2	C3	D
Building shape								
Select building shapes	Info	Info	Info	Info	Info	Info	Info	Info
Office								
I N-S	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
I E-W	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
L			FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
U				FALSE	FALSE	FALSE	FALSE	FALSE
O				FALSE	FALSE	FALSE	FALSE	FALSE
Apartment								
I N-S					FALSE	FALSE	FALSE	
I E-W					TRUE	TRUE	TRUE	
L					FALSE	FALSE	FALSE	
U					FALSE	FALSE	FALSE	
O					FALSE	FALSE	FALSE	



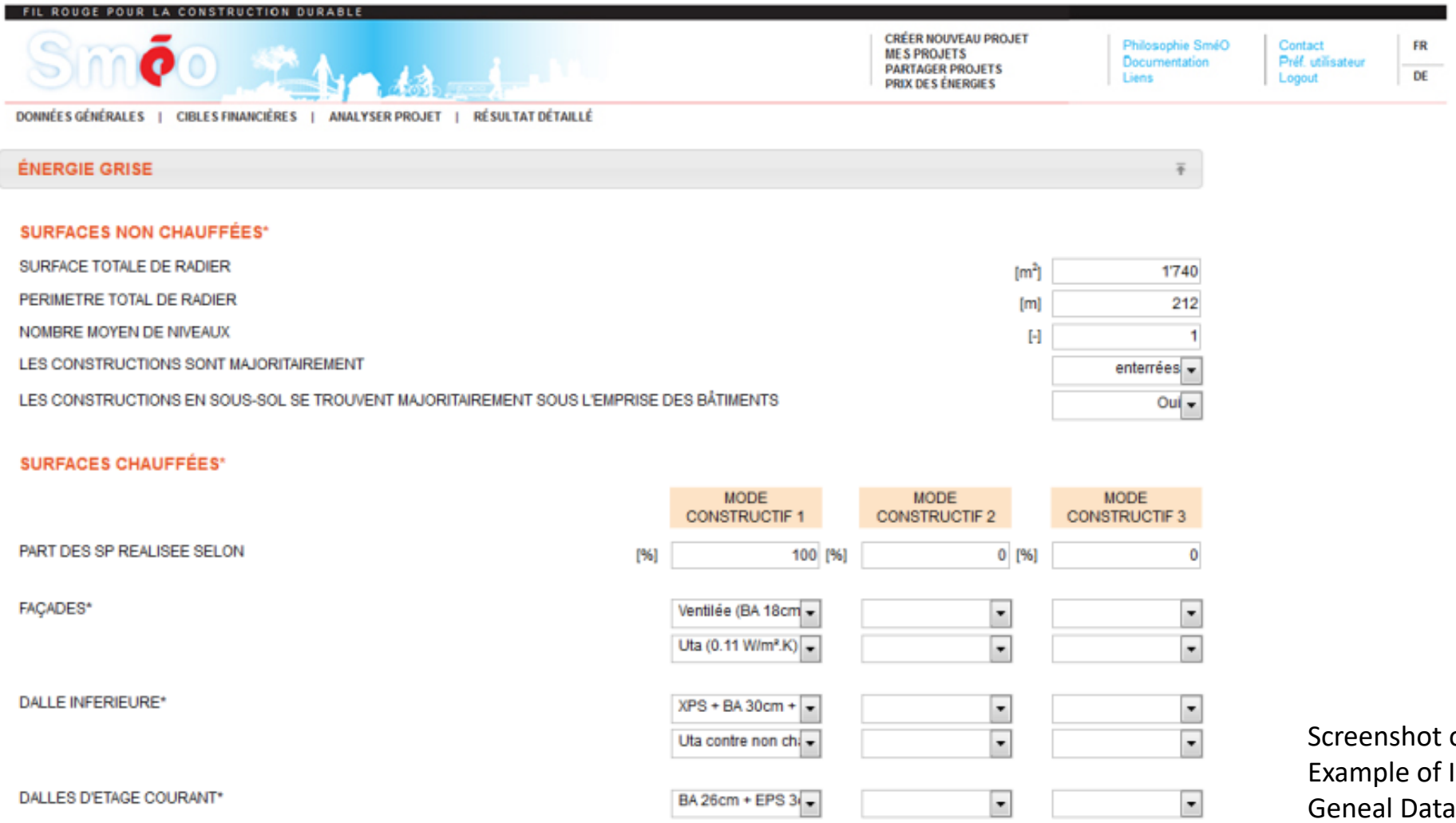
Hypothetical project

LCA-based tools | Smeo Fil rouge pour la construction durable

Are the tools able to guide project stakeholders in making informed decisions during the early-design stage of urban-scale projects?

https://www.smeo.ch/

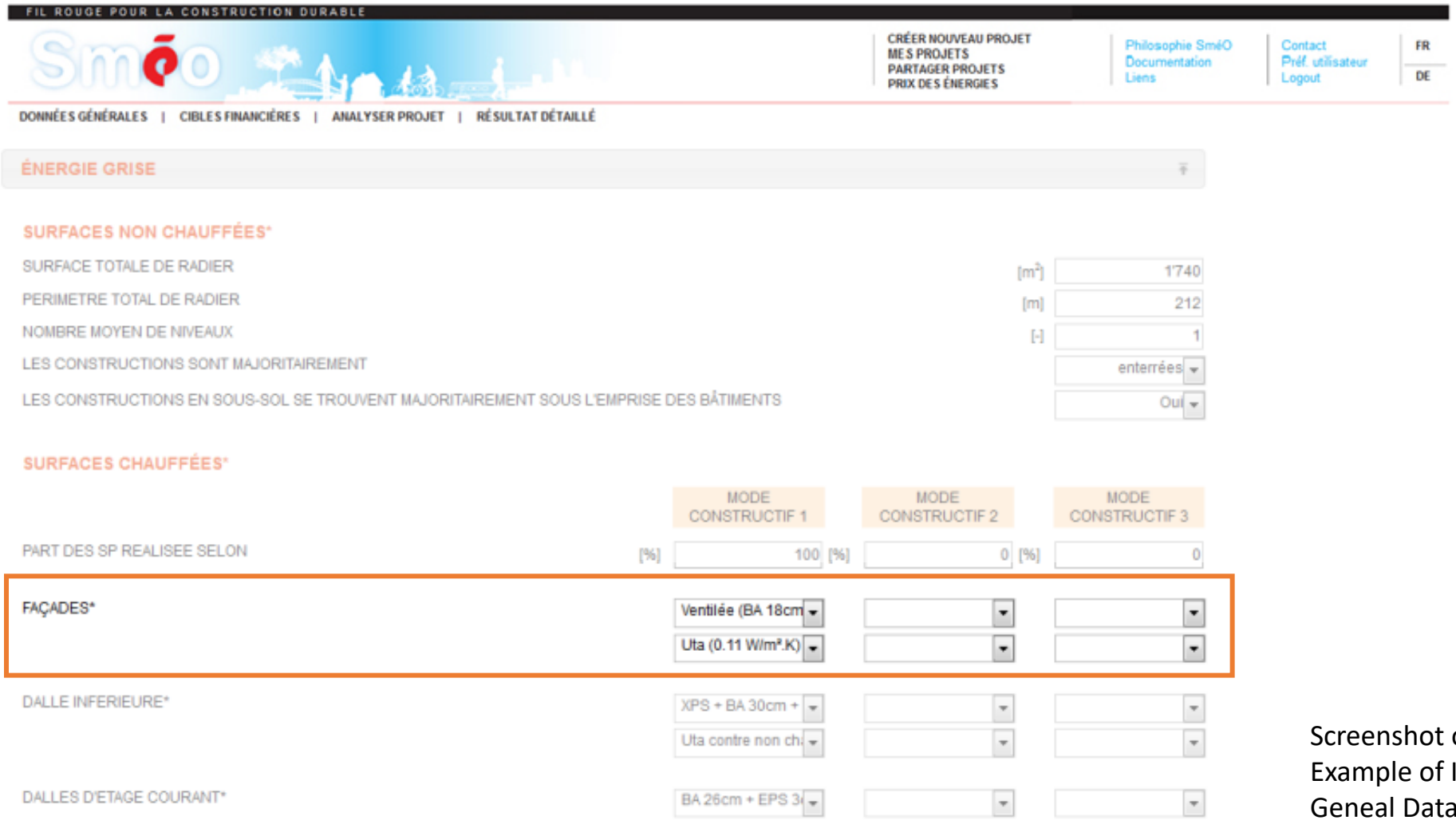
LCA-based tools | Smeo Fil rouge pour la construction durable



Screenshot of interface.
Example of Input fields in Geneal Data section

https://www.smeo.ch/

LCA-based tools | Smeo Fil rouge pour la construction durable



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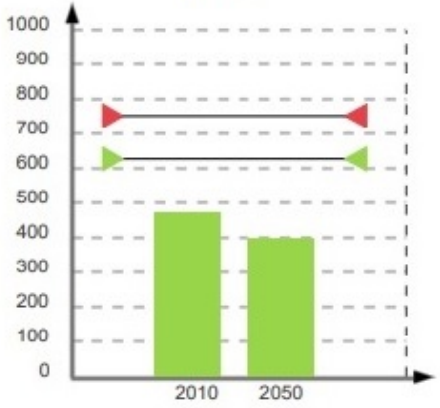
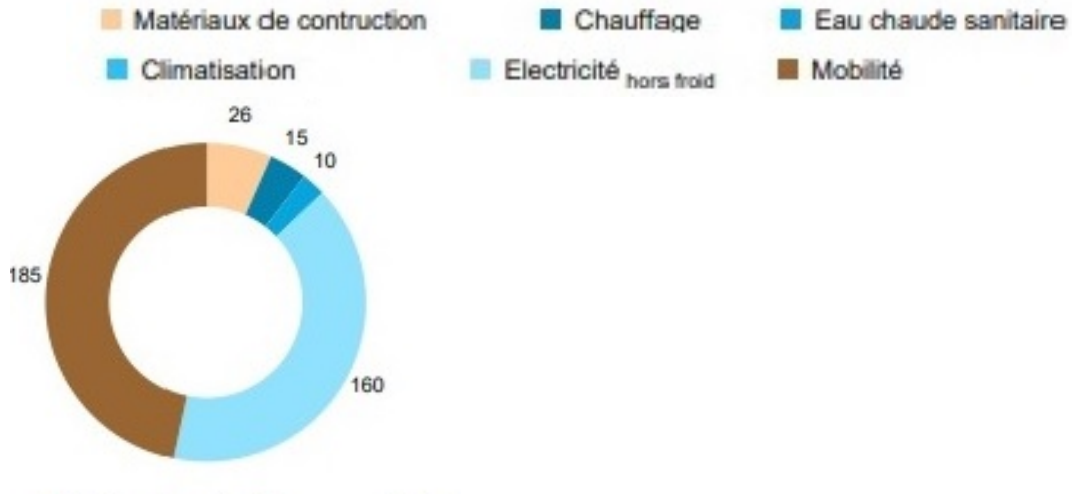
LCA-based tools | Smeo Fil rouge pour la construction durable

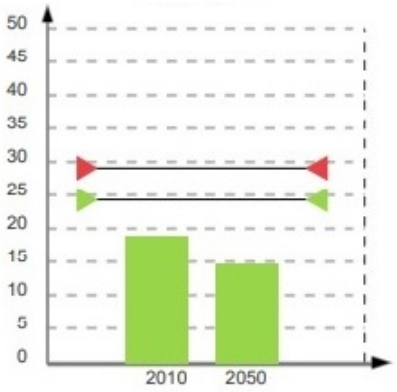
NRE [MJ/m²a]



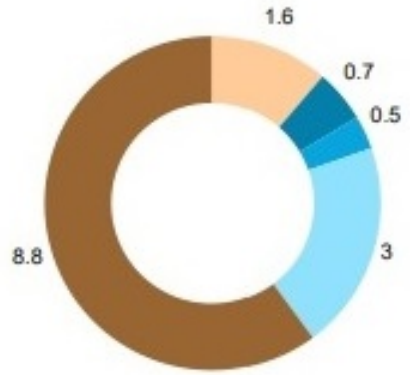
NRE*	Énergie primaire non renouvelable [MJ/m² an]
CONSTRUCTION	26
EXPLOITATION	185
MOBILITÉ	185
TOTAL	396



GWP [$kg_{eq}CO_2/m^2a$]



GWP*	Gaz à effet de serre [kg_{eq} CO_2/m^2 an]
CONSTRUCTION	1.6
EXPLOITATION	4.2
MOBILITÉ	8.8
TOTAL	14.6



Charts in the Detailed Results section

https://www.smeo.ch/

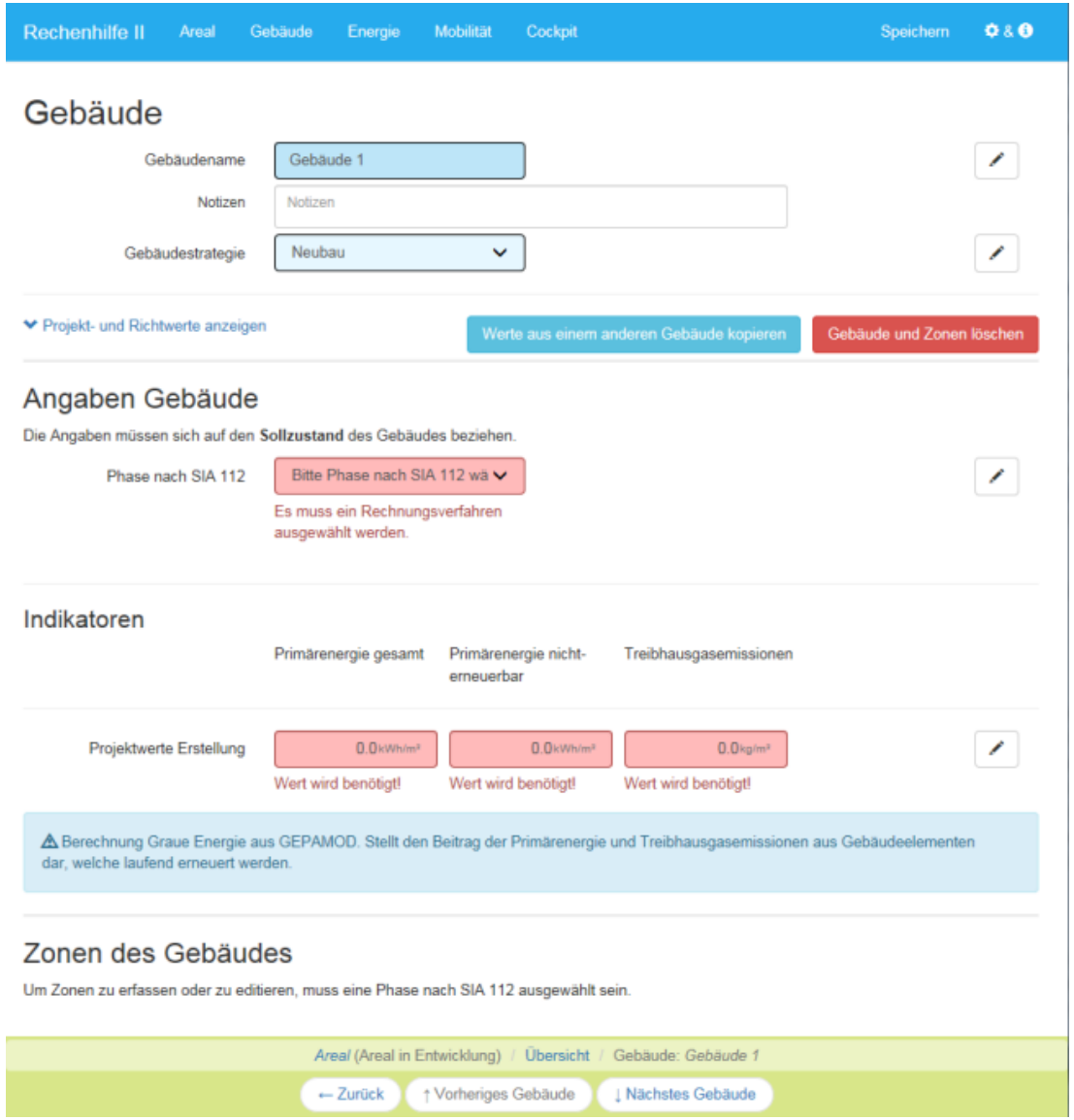
LCA-based tools | Rechenhilfe II für 2000-Watt-Areale

Are the tools able to guide project stakeholders in making informed decisions during the early-design stage of urban-scale projects?

2000 Watt Areal

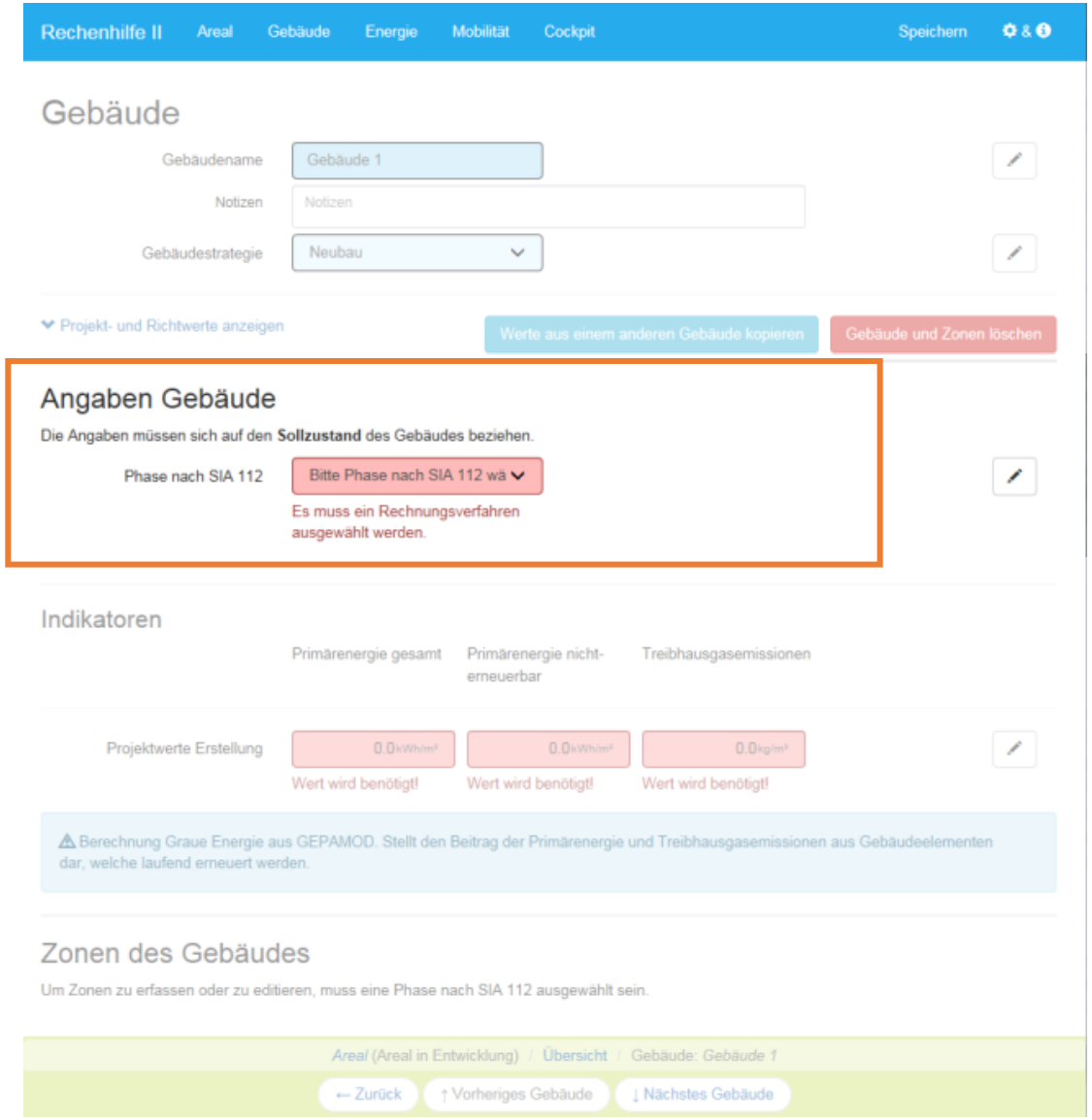
https://www.local-energy.swiss/fr/profibereich/profi-instrumente/2000-watt-areal

LCA-based tools | Rechenhilfe II für 2000-Watt-Areale



Screenshot of interface.
Example of Input fields
in Buildings section

LCA-based tools | Rechenhilfe II für 2000-Watt-Areale

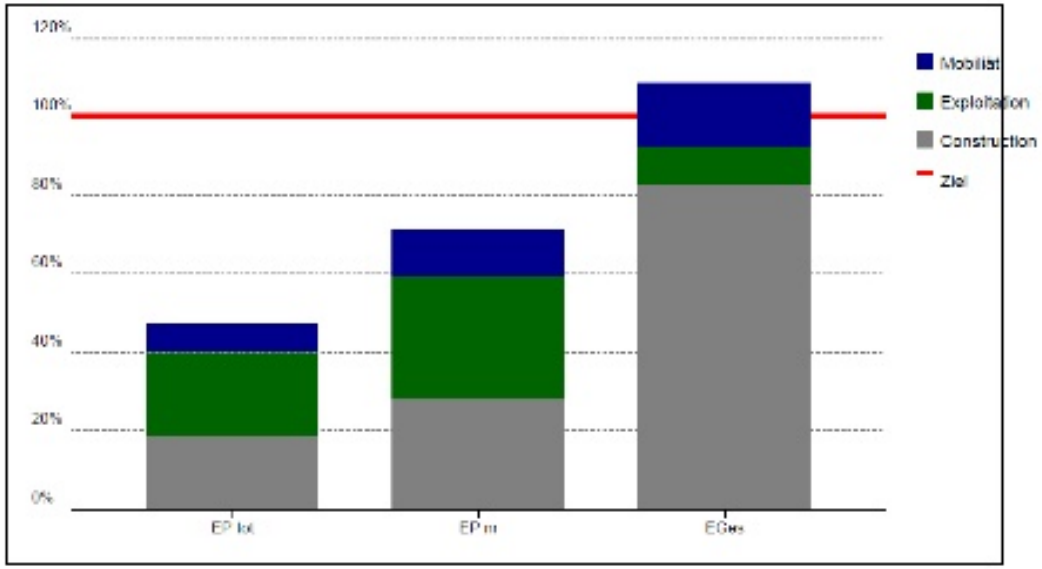


Screenshot of interface.
Example of Input fields
in Buildings section

LCA-based tools | Rechenhilfe II für 2000-Watt-Areale

Valeur cible

	EP_{ren}	EP_{n-ren}	EGes	Justificatif quantitatif
Valeurs cibles	271 kWh/m²	155 kWh/m²	19.5 kg/m²	
Indice	127 kWh/m²	110 kWh/m²	21.1 kg/m²	
Taux de satisfaction	47.1 %	70.8 %	108.6 %	
Justificatif exploitation	**Satisfait**	**Satisfait**	**Non satisfait**	**Non satisfait**



www.local-energy.swis

Comparability of tools

	SETUP (prototype)	Smeo	RH II
Origin	EPFL Fribourg, Switzerland, 2019	City of Lausanne and Canton of Vaud, Switzerland (www.smeo.ch), 2009	Federal office of Energy OFEN, Zurich, Switzerland (www.local-energy.swiss), 2018
Data source	CEN EN 15978, KBOB 2009/1:2016, SIA 380/1:2016, etc.	SIA 112, KBOB 2009/1:2012, SIA 380/1:2009, etc.	SIA 112, KBOB 2009/1:2014, etc.
Required user's knowledge	No prior knowledge	Basic knowledge	Expert knowledge
Accessibility	Conditional access (project stakeholders)	Free access (registration needed)	Free access (registration needed)
Entry format	Spreadsheet	Input fields and dropdown lists	Input fields and dropdown lists
Level (scale)	District-, plot- and component-levels	District-level	District- and building-levels
Default settings	Default settings	Default settings partly available	Default settings partly available
Life cycle phases	According to CEN EN 15978: Product (A1-3), Use (B6), End-of-life (C1-4)	According to SIA 112 project phase; project planning construction and use phases	According to SIA 112 project phase, but also dependant of system boundaries of external software

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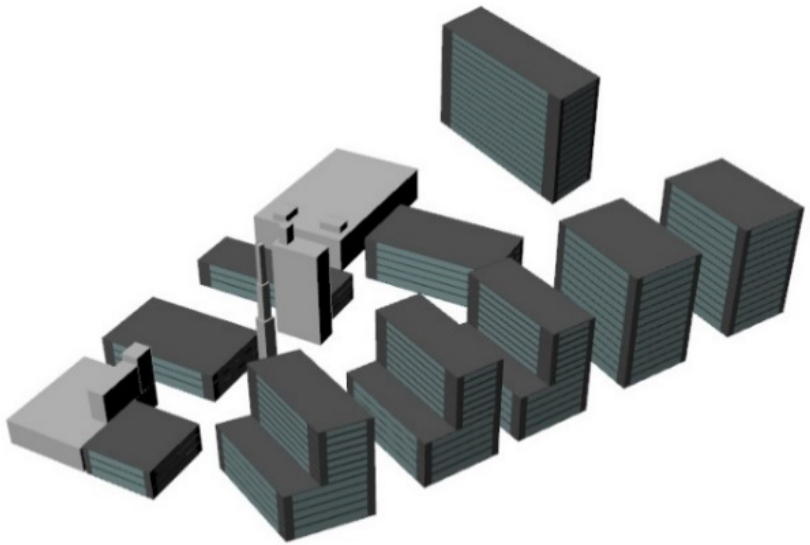
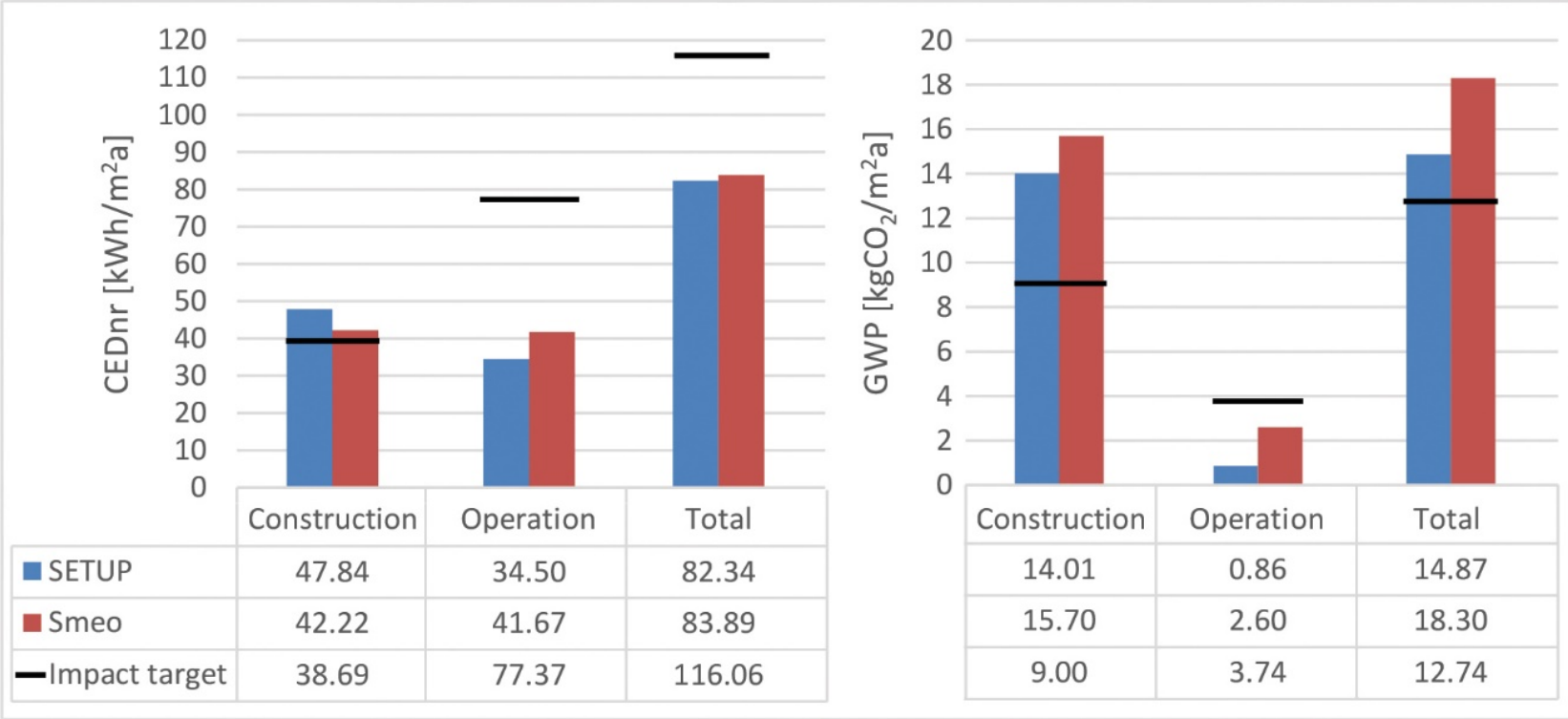
Comparability of tools | Case study



Urban massing volumes of the hypothetical project (blueFactory site case study) in the advanced planning phase.

Parameter	Building-scale
Building shape (typology)	Rectangle floorplan, I N-S
Building depth (m)	18-30m
Building height (nbr floors)	3-15 floors
Built context	Medium-high density
Window-to-wall ratio (opening ratio; all orientations; frame included)	Offices: 0.65 Apartments 0.5
Glazing type (U-value, excluding frame)	Triple glazing, U-value: 0.5 W/m2K
Frame type (U-value)	Wood, U-value: 1.3 W/m2K
Thermal transmittance (U value of external walls and roof)	0.1 W/m2K
PV ratio (PV-to-roof surface ratio)	0.9
HVAC system	Heat Pump, COP: 2.43
Horizontal elements (construction of roof and interior floors)	Dalle béton [E0 B01] [code catalogueconstruction.ch]
Vertical elements (construction of external walls)	Paroi béton apparent [W W04] [code catalogueconstruction.ch]
Insulation type	Polystyrene
Covering slab material	Linoleum
Covering material of external walls	Cement panels [1 cm]
Balcony	no

Comparability of tools | Case study



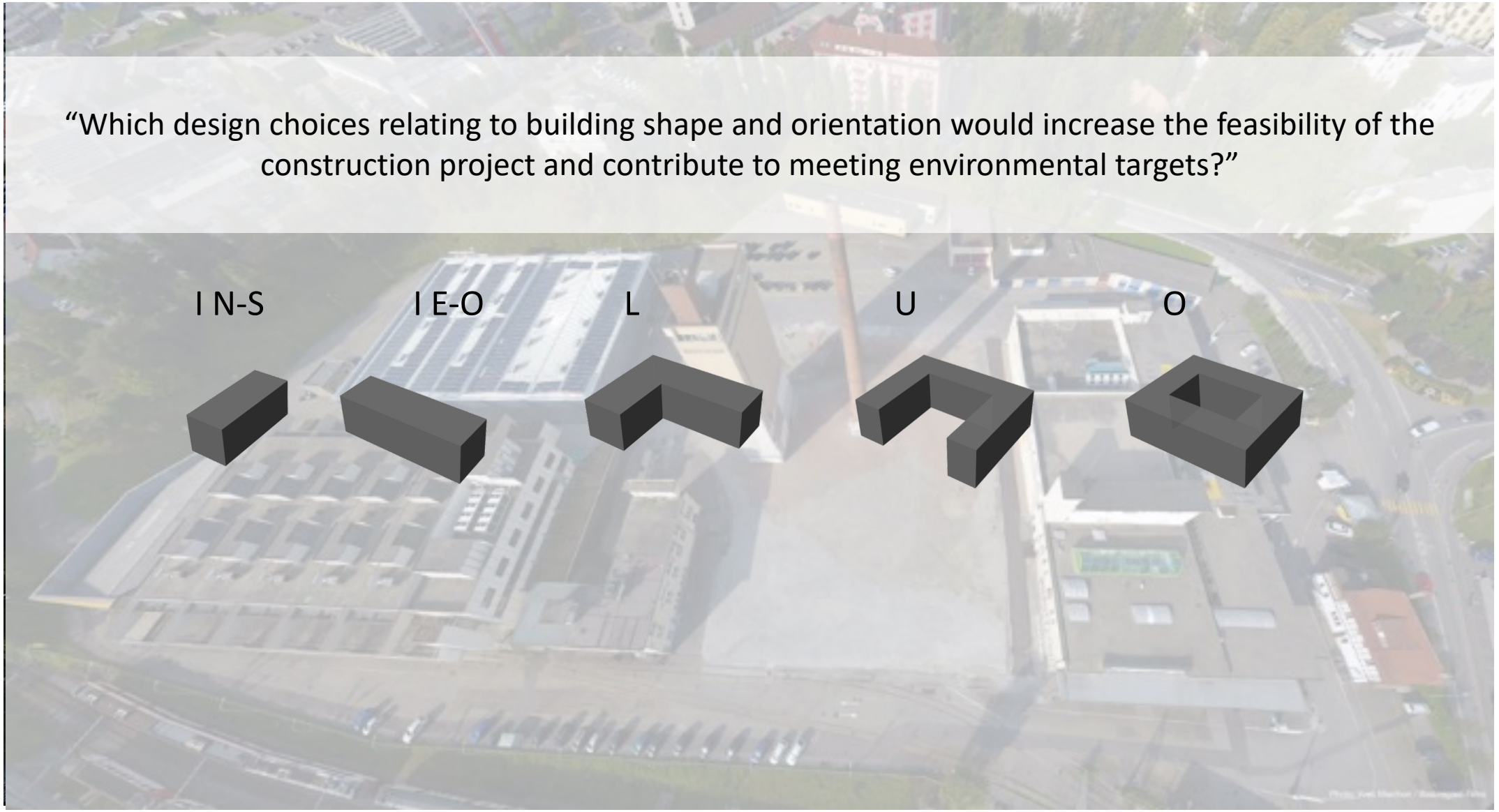
	Construction	Operation	Total
SETUP	47.84	34.50	82.34
Smeo	42.22	41.67	83.89
Impact target	38.69	77.37	116.06

Construction	Operation	Total
14.01	0.86	14.87
15.70	2.60	18.30
9.00	3.74	12.74

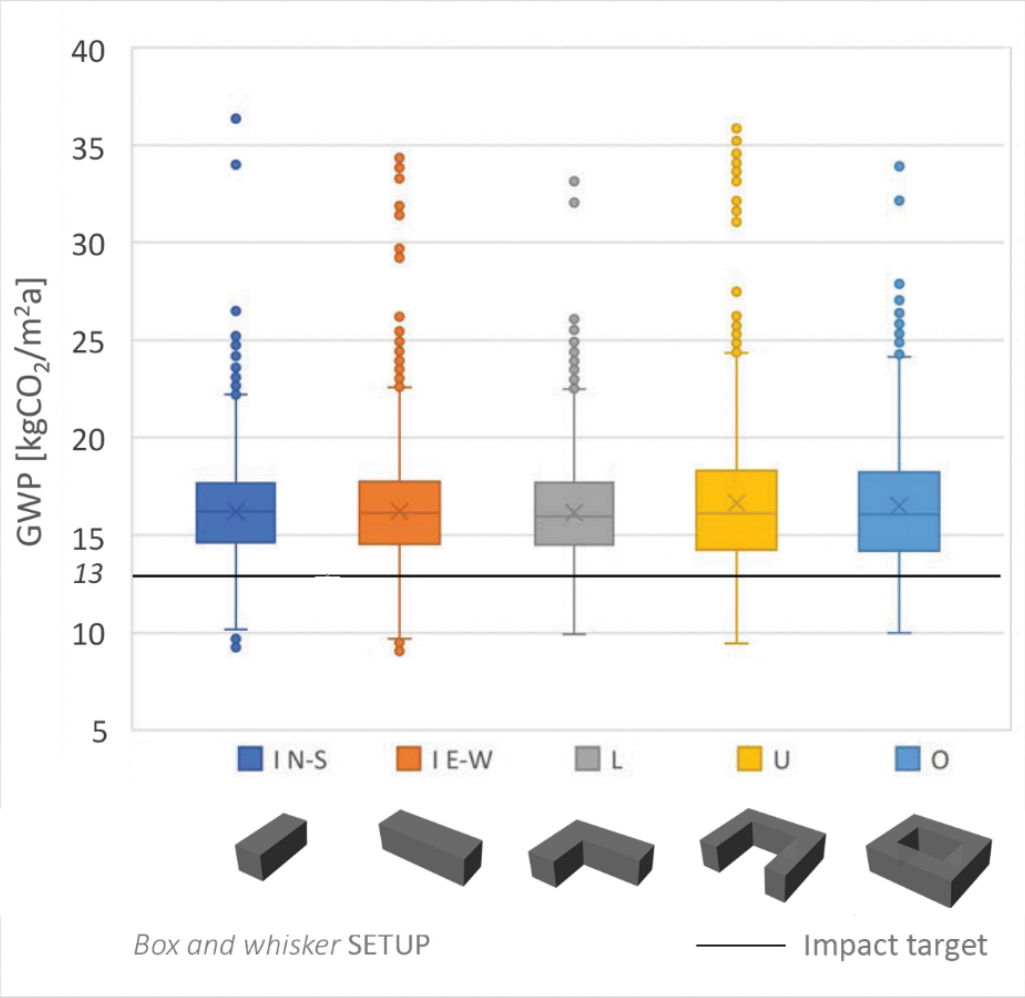
Results in terms of CEDnr (left) and GWP (right) impacts computed with SETUP and Smeo, compared to environmental targets defined by SIA 2040

Application in early planning

"Which design choices relating to building shape and orientation would increase the feasibility of the construction project and contribute to meeting environmental targets?"



Application in early planning | Results| SETUP



Site-level GWP impacts of master plan alternatives composed of buildings with uniform shape

Application in early planning | Results | SETUP | RH II

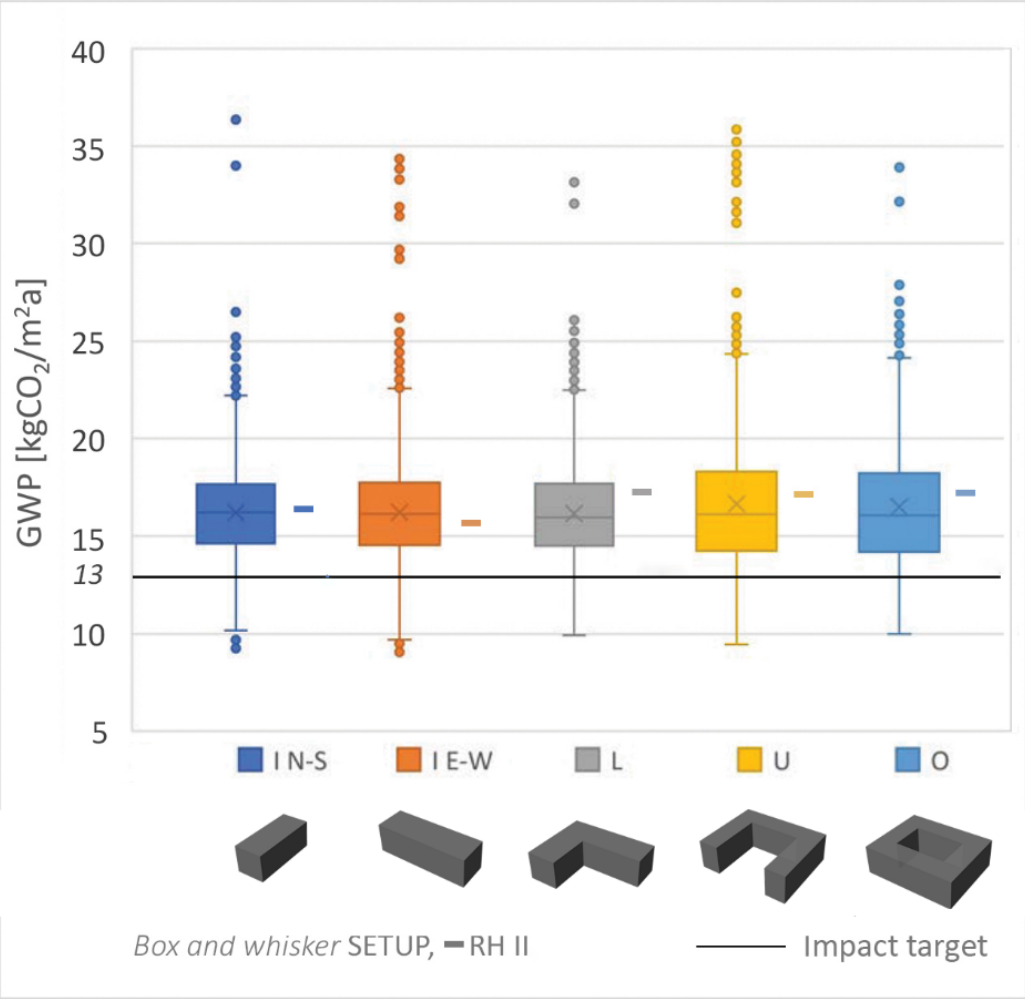


Figure 6. Site-level GWP impacts of master plan alternatives composed of buildings with uniform shape

Application in early planning | Results | SETUP | RH II | Smeo

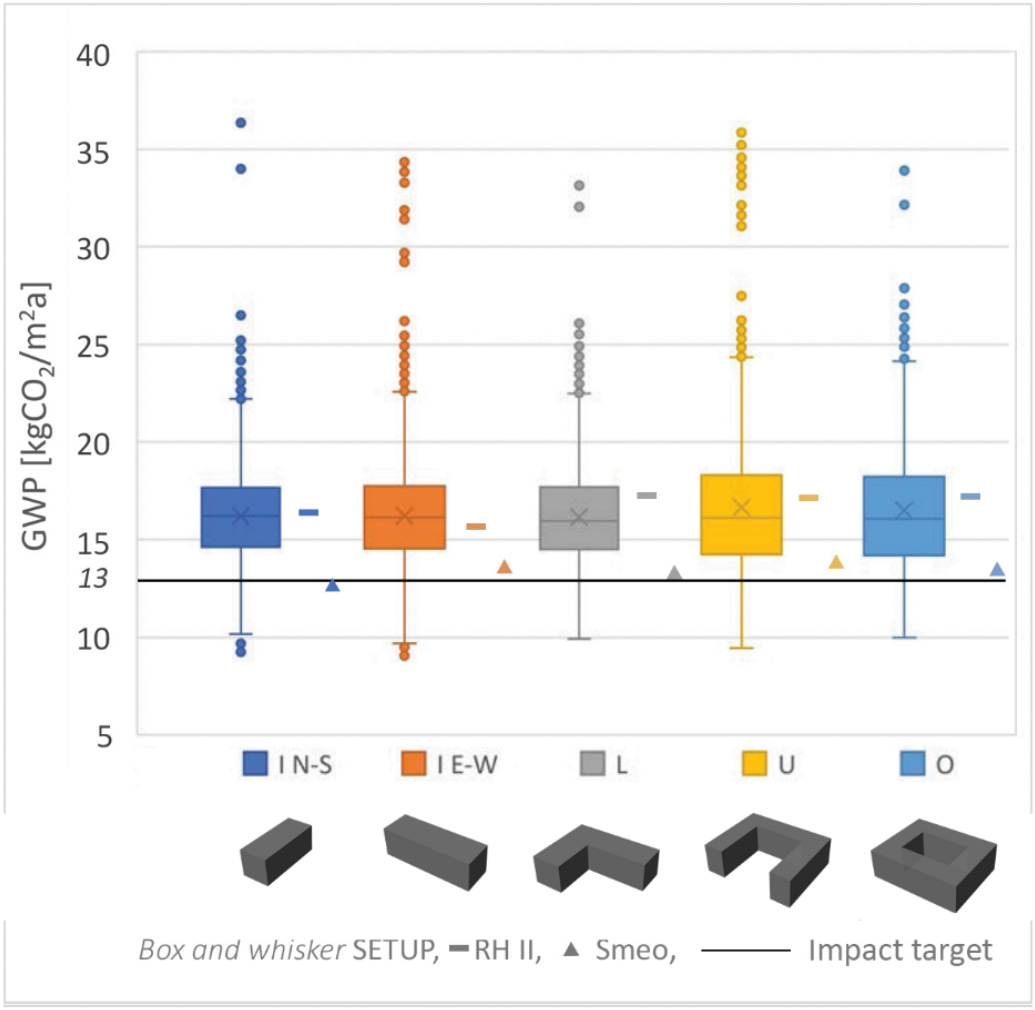
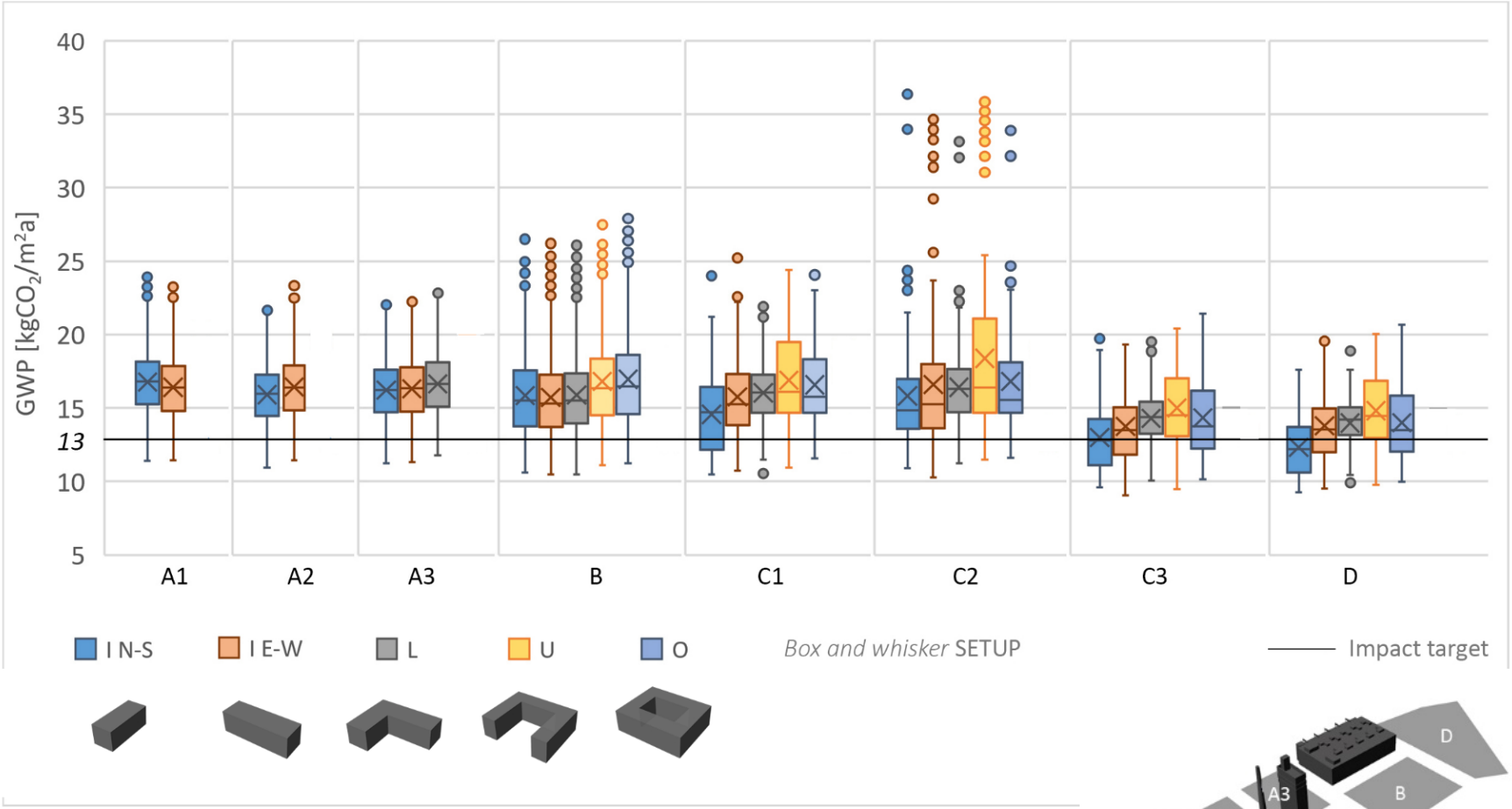
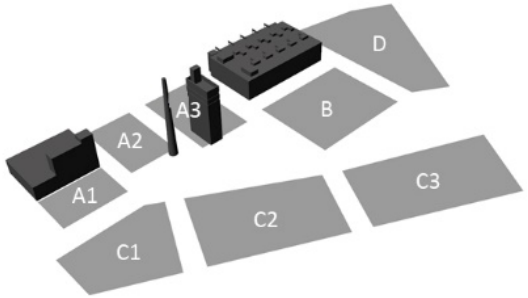


Figure 6. Site-level GWP impacts of master plan alternatives composed of buildings with uniform shape

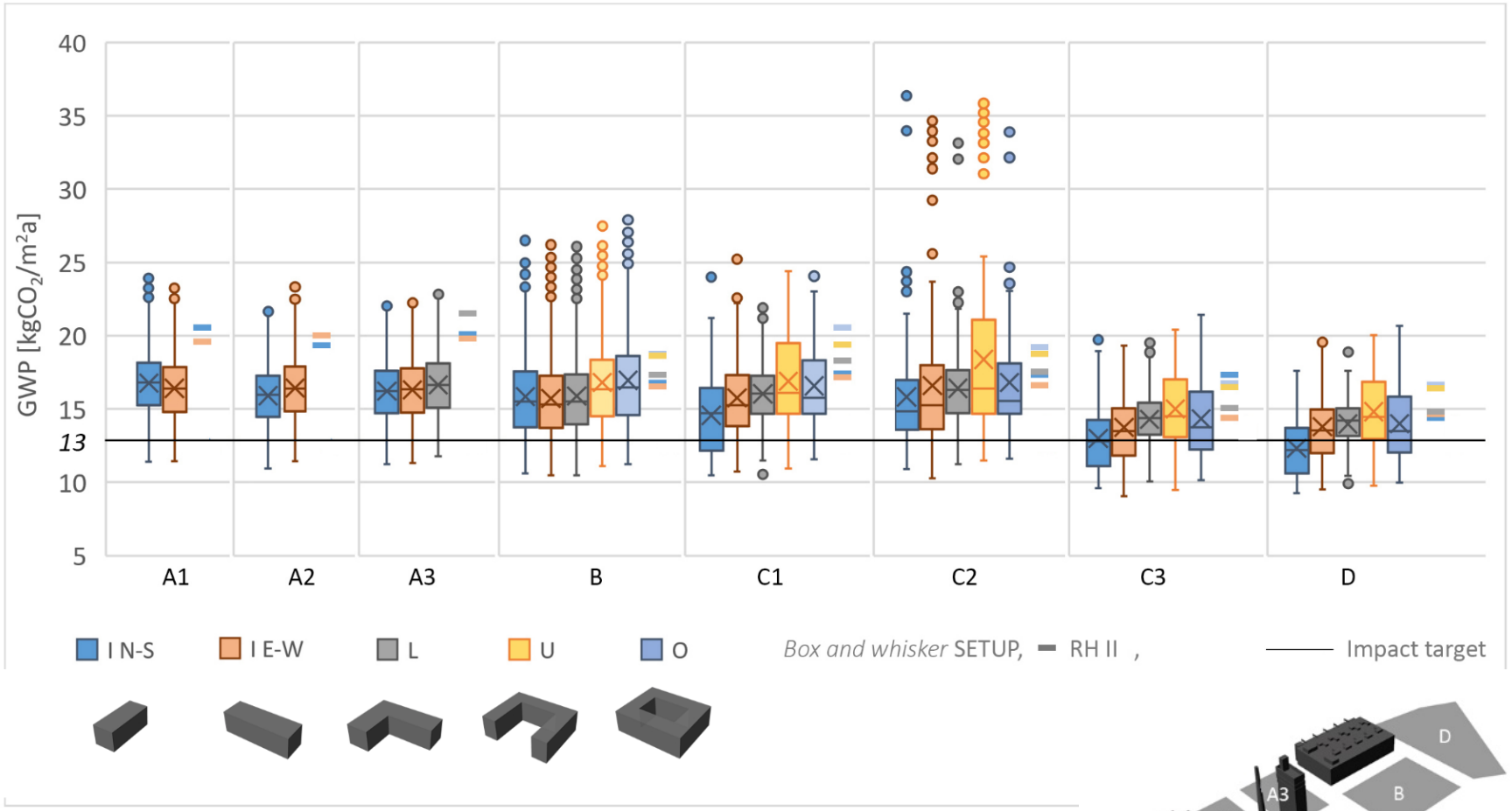
Answer to the design question | Results | SETUP



Plot-level GWP impacts of project alternatives with variable shapes



Answer to the design question | Results | SETUP | RH II



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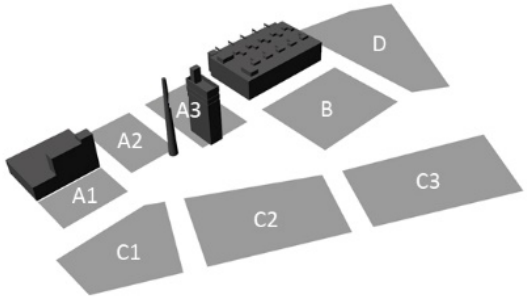
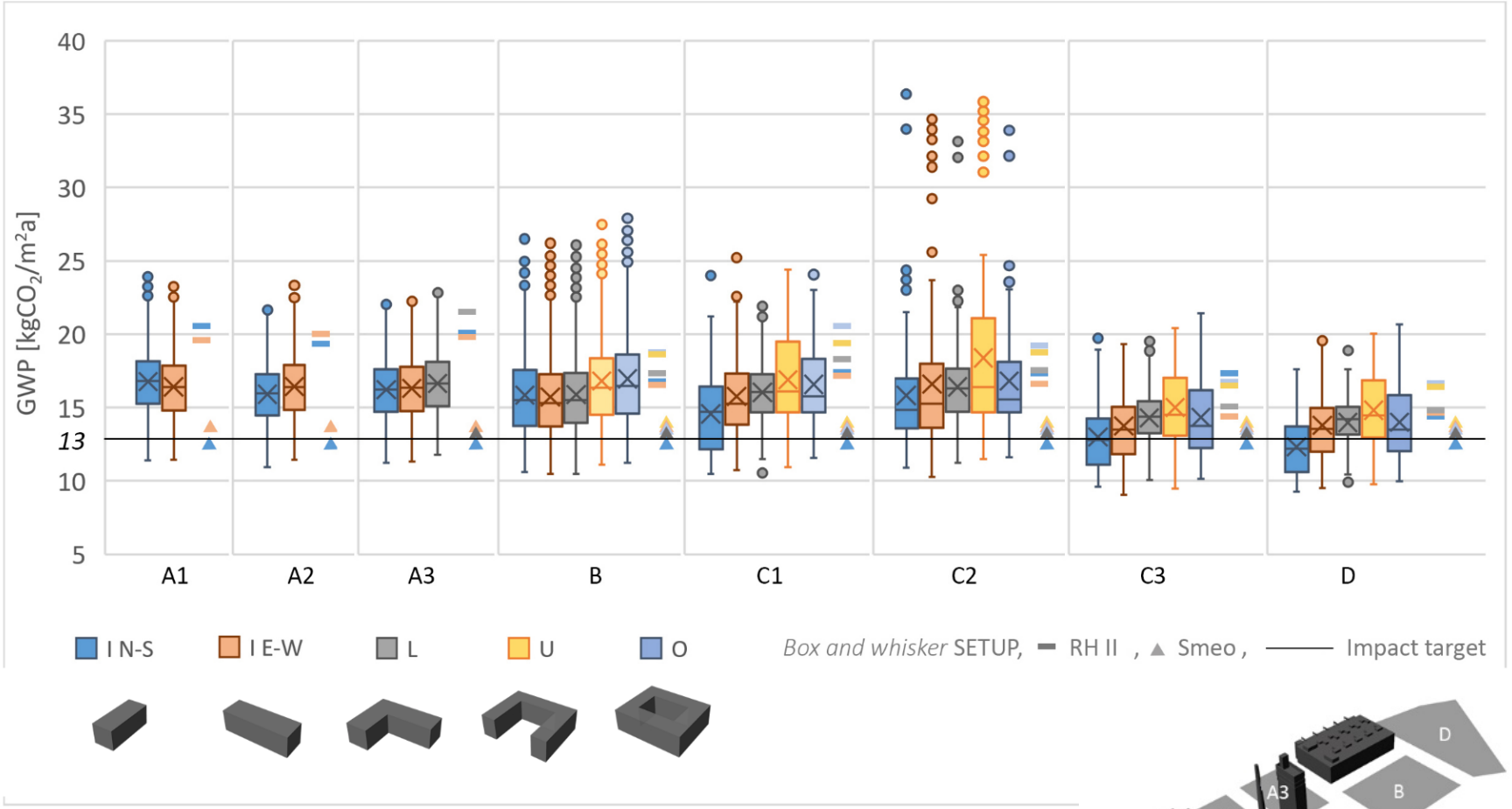


Answer to the design question | Results | SETUP | RH II |Smeo



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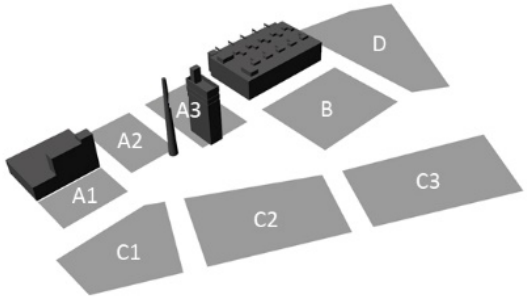
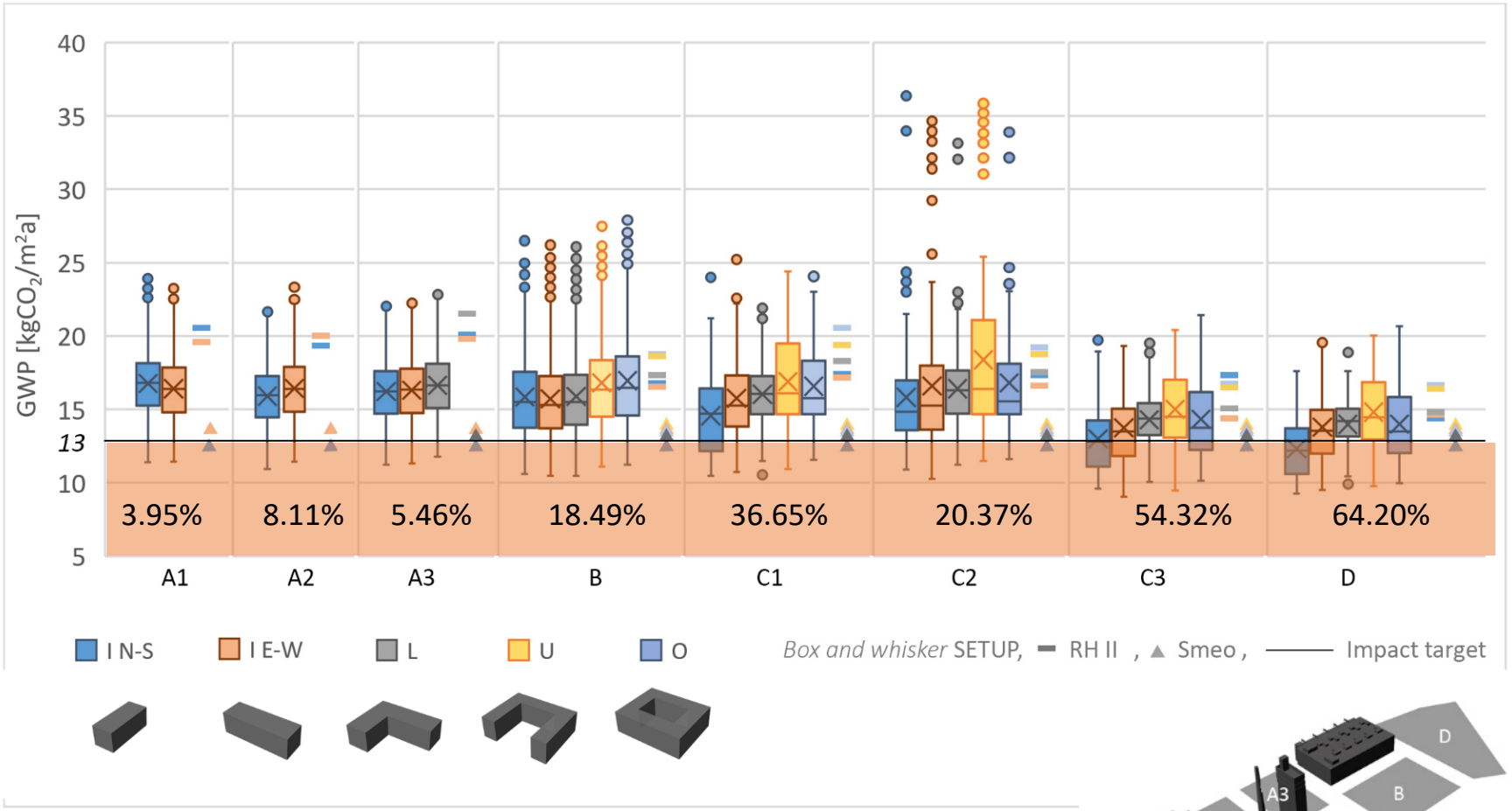
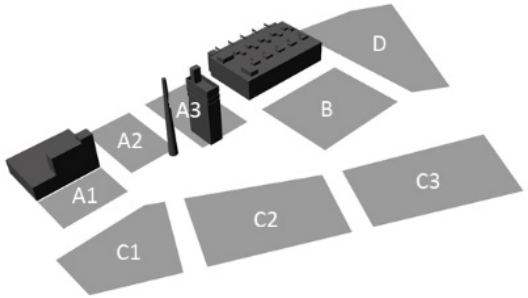


Answer to the design question | Results | Feasibility



Plot-level GWP impacts of project alternatives with variable shapes



Questions?

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Graz University of Technology | 13 September 2019