

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

Evaluating applicability through a comparative approach

Katarina Slavkovic, Emilie Nault, Thomas Jusselme, Marilynne Andersen

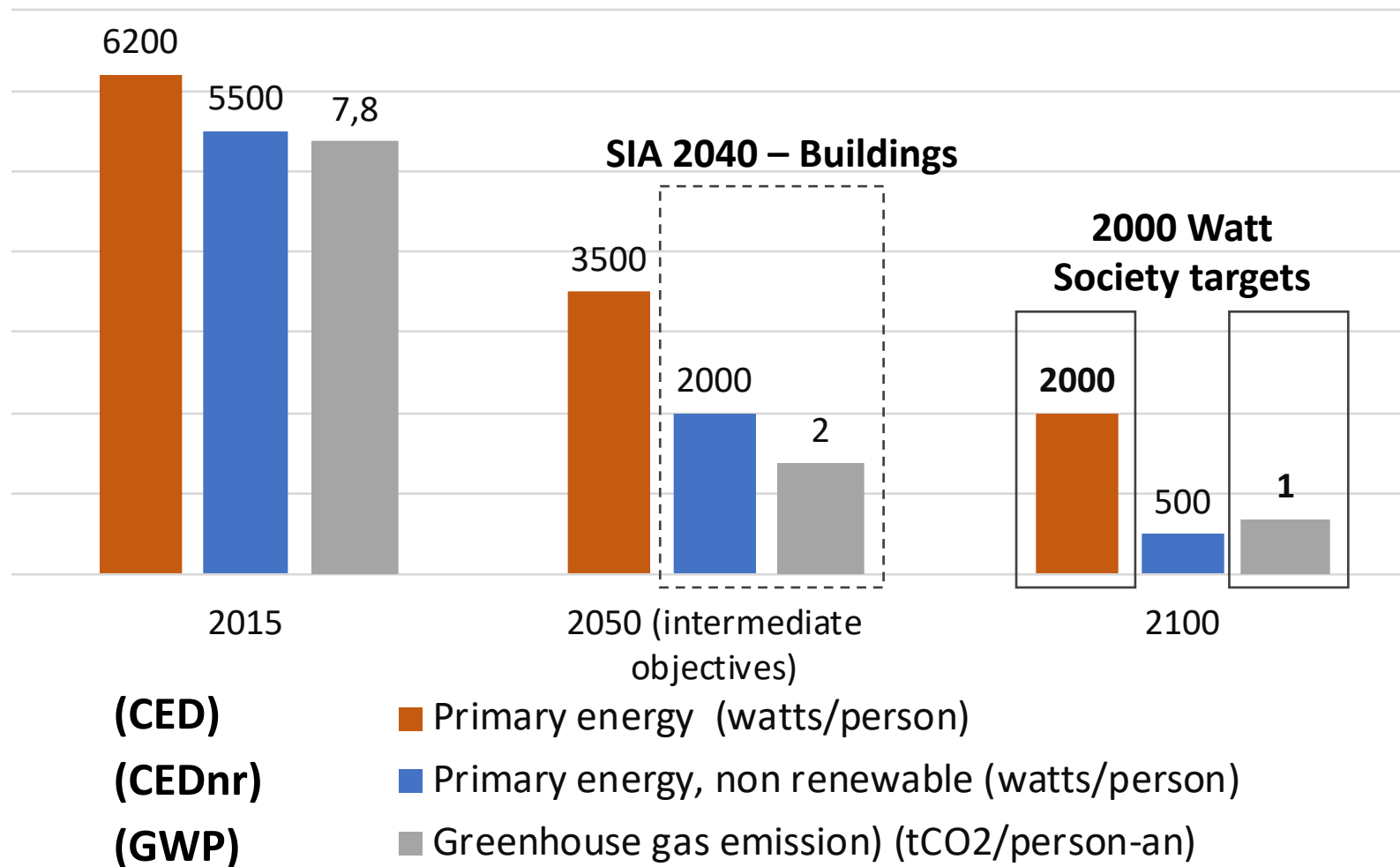
Building 2050 group | Smart Living Lab | EPFL

Sustainable Built Environment SBE conference

Graz University of Technology | September 13, 2019



Context | Environmental objectives



Context | Carbon objectives

Construction

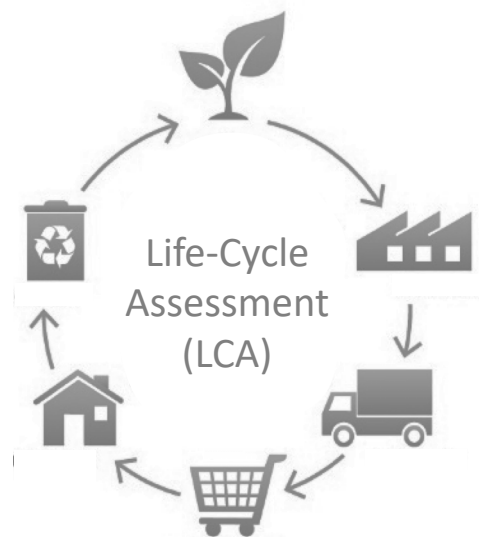
Impacts that relate to construction, replacement and disposal

Operation

HVAC, DHW, lighting, appliances etc.

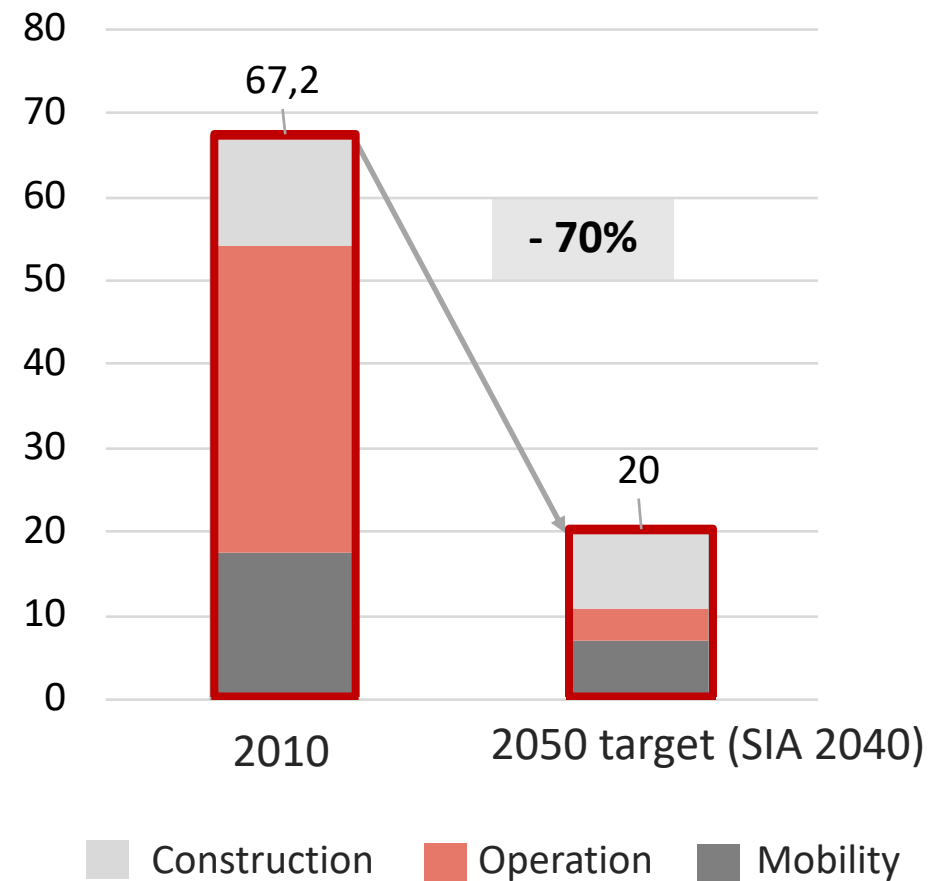
Mobility

Location-dependent everyday mobility



Buildings in Switzerland

GWP (kgCO₂/m²-an)



Context | Early planning



Photo credits: Yves Marchon / Beauregard Films

Photo: Yves Marchon / Beauregard Films

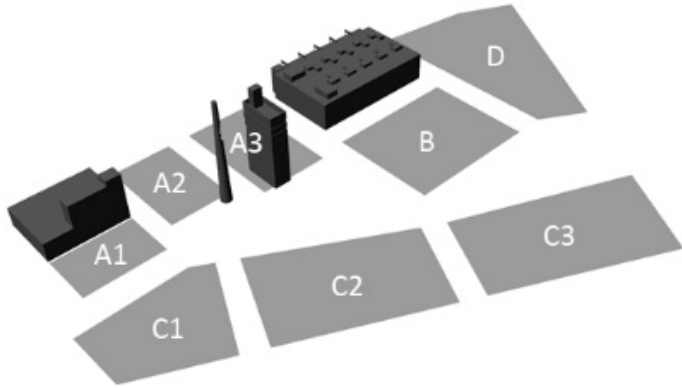
Research question

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

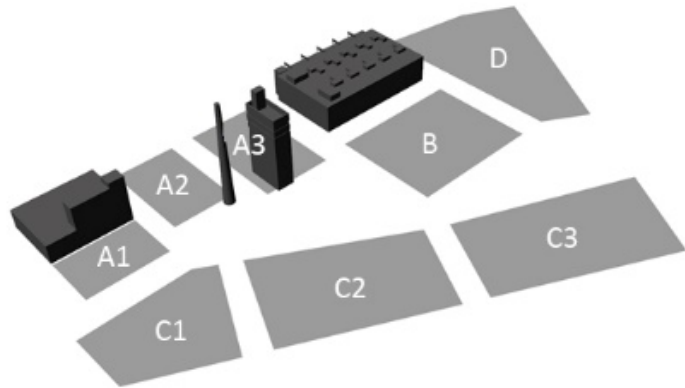


Zones on the blueFactory site,
as defined according to the SETUP
project analysis

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



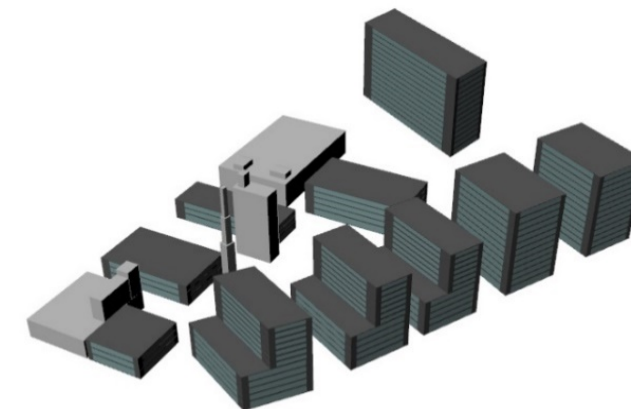
Zones on the blueFactory site,
as defined according to the SETUP
project analysis

Variable parameters

1	BS	Building shape (typology)	
2	BD	1 BS	Building shape (typology):
3	BH		1 N-S (Point-Bar N-S aligned)
4	CONT		1 E-W (Point-Bar E-W aligned)
5	WWR		
6	WIN		L (L Shaped)
7	FRA		
8	U		U (U Shaped)
9	PV		O (Courtyard)
10	HVAC		
11	VENT	2 FRA	Frame quality:
12	HOREL		1 Wood/alu
13	VEREL		2 Alu
14	INS		3 PVC
15	COVS		4 Wood
16	COVW	3 U	Thermal transmittance (U-value, W/m2K):
17	BAL		1 U value 0.1
			2 U value 0.2
			3 U value 0.3

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

FIL ROUGE POUR LA CONSTRUCTION DURABLE

Sméo

CRÉER NOUVEAU PROJET
MES PROJETS
PARTAGER PROJETS
PRIX DES ÉNERGIES

Philosophie Sméo
Documentation
Liens

Contact
Préf. utilisateur
Logout

FR
DE

DONNÉES GÉNÉRALES | CIBLES FINANCIÈRES | ANALYSER PROJET | RÉSULTAT DÉTAILLÉ

ÉNERGIE GRISE

SURFACES NON CHAUFFÉES*

SURFACE TOTALE DE RADIER [m²]

PERIMETRE TOTAL DE RADIER [m]

NOMBRE MOYEN DE NIVEAUX [-]

LES CONSTRUCTIONS SONT MAJORITAIREMENT

LES CONSTRUCTIONS EN SOUS-SOL SE TROUVENT MAJORITAIREMENT SOUS L'EMPRISE DES BÂTIMENTS

SURFACES CHAUFFÉES*

	MODE CONSTRUCTIF 1	MODE CONSTRUCTIF 2	MODE CONSTRUCTIF 3
PART DES SP REALISEE SELON (%)	<input type="text" value="100"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
FAÇADES*	<input type="text" value="Ventilée (BA 18cm)"/>	<input type="text"/>	<input type="text"/>
	<input type="text" value="Uta (0.11 W/m².K)"/>	<input type="text"/>	<input type="text"/>
DALLE INFERIEURE*	<input type="text" value="XPS + BA 30cm +"/>	<input type="text"/>	<input type="text"/>
	<input type="text" value="Uta contre non ch"/>	<input type="text"/>	<input type="text"/>
DALLES D'ETAGE COURANT*	<input type="text" value="BA 26cm + EPS 3"/>	<input type="text"/>	<input type="text"/>

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

<https://www.smeo.ch/>

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

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DONNÉES GÉNÉRALES | CIBLES FINANCIÈRES | ANALYSER PROJET | RÉSULTAT DÉTAILLÉ

ÉNERGIE GRISE

SURFACES NON CHAUFFÉES*

SURFACE TOTALE DE RADIER [m²] 1740

PERIMETRE TOTAL DE RADIER [m] 212

NOMBRE MOYEN DE NIVEAUX [-] 1

LES CONSTRUCTIONS SONT MAJORITAIREMENT enterrées

LES CONSTRUCTIONS EN SOUS-SOL SE TROUVENT MAJORITAIREMENT SOUS L'EMPRISE DES BÂTIMENTS Oui

SURFACES CHAUFFÉES*

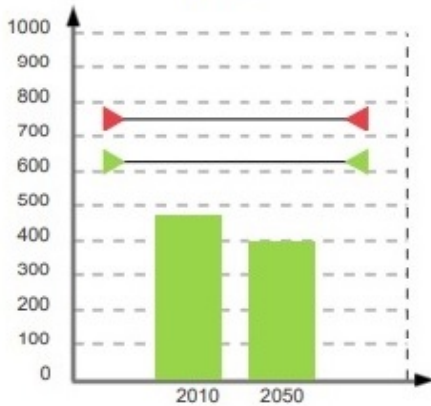
	MODE CONSTRUCTIF 1	MODE CONSTRUCTIF 2	MODE CONSTRUCTIF 3
PART DES SP REALISEE SELON (%)	100	0	0
FAÇADES*	Ventilée (BA 18cm)		
	Uta (0.11 W/m².K)		
DALLE INFERIEURE*	XPS + BA 30cm +		
	Uta contre non ch		
DALLES D'ETAGE COURANT*	BA 26cm + EPS 3		

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

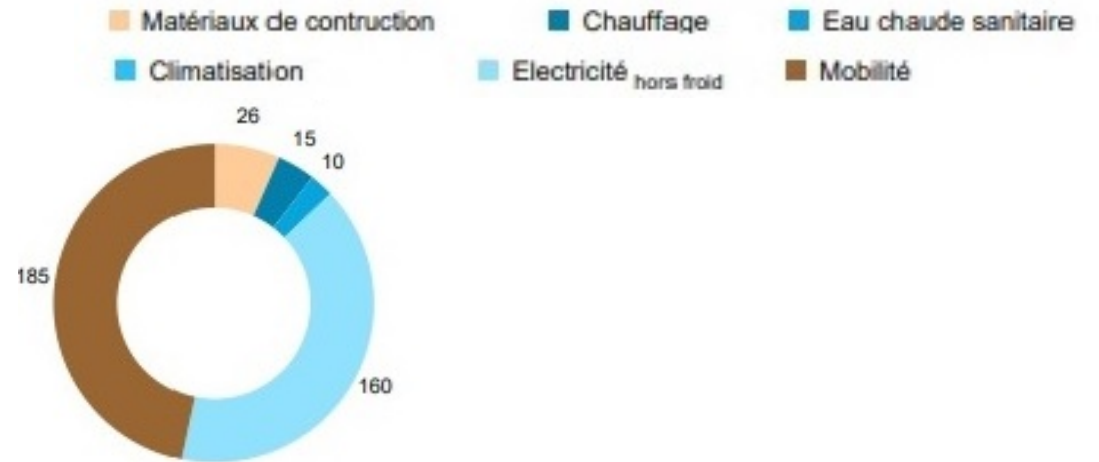
<https://www.smeo.ch/>

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

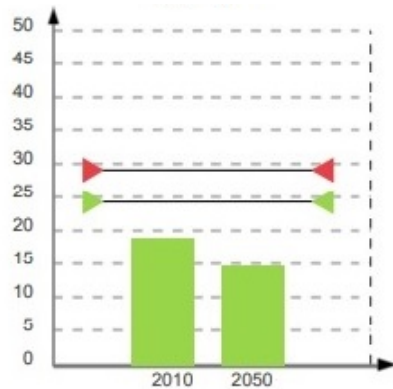
NRE [MJ/m²a]



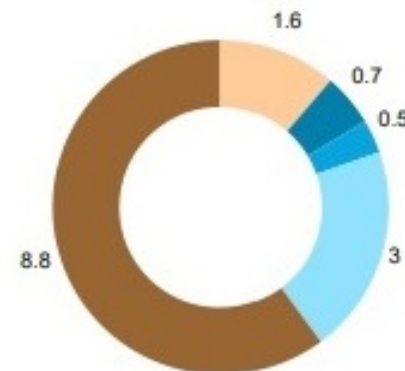
NRE*	
Énergie primaire non renouvelable [MJ/m ² an]	
CONSTRUCTION	26 ●
EXPLOITATION	185 ●
MOBILITÉ	185 ●
TOTAL	396 ●



GWP [kg_{eq}CO₂/m²a]



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/>

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



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

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

The screenshot displays the 'Rechenhilfe II' interface for building data entry. The top navigation bar includes 'Rechenhilfe II', 'Areal', 'Gebäude', 'Energie', 'Mobilität', 'Cockpit', and 'Speichern'. The main section is titled 'Gebäude' and contains the following input fields:

- Gebäudenname:** A text input field containing 'Gebäude 1'.
- Notizen:** A text input field containing 'Notizen'.
- Gebäudestrategie:** A dropdown menu set to 'Neubau'.

Below these fields are two buttons: 'Werte aus einem anderen Gebäude kopieren' and 'Gebäude und Zonen löschen'. The next section is 'Angaben Gebäude', which includes a dropdown for 'Phase nach SIA 112' with a warning message: 'Bitte Phase nach SIA 112 wählen. Es muss ein Rechnungsverfahren ausgewählt werden.' The 'Indikatoren' section shows three red boxes for 'Primärenergie gesamt', 'Primärenergie nicht-erneuerbar', and 'Treibhausgasemissionen', all with the value '0.0' and a 'Wert wird benötigt!' warning. A blue box at the bottom provides a note about energy calculation: 'Berechnung Graue Energie aus GEPAMOD. Stellt den Beitrag der Primärenergie und Treibhausgasemissionen aus Gebäudeelementen dar, welche laufend erneuert werden.' The final section is 'Zonen des Gebäudes' with a note: 'Um Zonen zu erfassen oder zu editieren, muss eine Phase nach SIA 112 ausgewählt sein.' The footer contains navigation links: '← Zurück', '↑ Vorheriges Gebäude', and '↓ Nächstes Gebäude'.

Screenshot of interface. Example of Input fields in Buildings section

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

Rechenhilfe II Areal Gebäude Energie Mobilität Cockpit Speichern ⚙️ ⓘ

Gebäude

Gebäudenname

Notizen

Gebäudestrategie

▼ Projekt- und Richtwerte anzeigen

Angaben Gebäude

Die Angaben müssen sich auf den **Sollzustand** des Gebäudes beziehen.

Phase nach SIA 112

Es muss ein Rechnungsverfahren ausgewählt werden.

Indikatoren

	Primärenergie gesamt	Primärenergie nicht-erneuerbar	Treibhausgasemissionen
Projektwerte Erstellung	<input type="text" value="0,0 kWh/m²"/>	<input type="text" value="0,0 kWh/m²"/>	<input type="text" value="0,0 kg/m²"/>
	Wert wird benötigt!	Wert wird benötigt!	Wert wird benötigt!

Berechnung Graue Energie aus GEPAMOD. Stellt den Beitrag der Primärenergie und Treibhausgasemissionen aus Gebäudeelementen dar, welche laufend erneuert werden.

Zonen des Gebäudes

Um Zonen zu erfassen oder zu editieren, muss eine Phase nach SIA 112 ausgewählt sein.

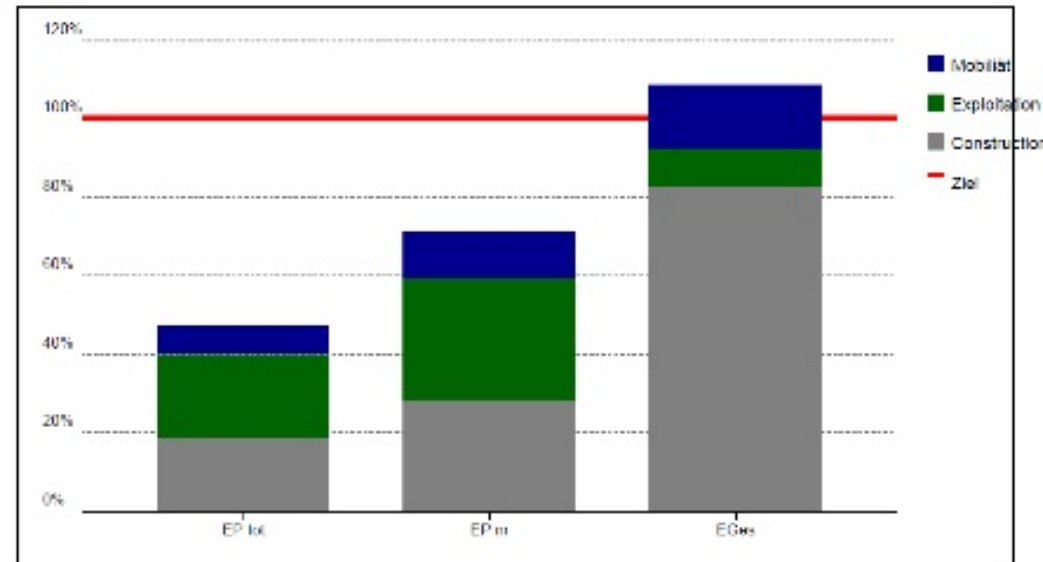
Areal (Areal in Entwicklung) / Übersicht / Gebäude: Gebäude 1

Screenshot of interface.
Example of Input fields
in Buildings section

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

Valeur cible

	EP _{tot}	EP _{ex}	EGes	Justificatif quantitatif
Valeurs cibles	271 kWh/m ²	155 kWh/m ²	19.5 kg/m ²	
Indice	127 kWh/m ²	110 kWh/m ²	21.1 kg/m ²	
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

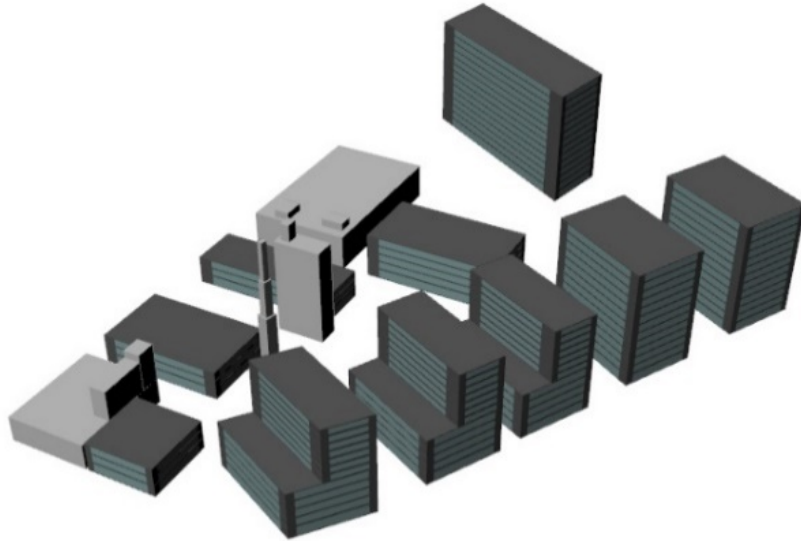
Comparability of tools

	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.
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Comparability of tools

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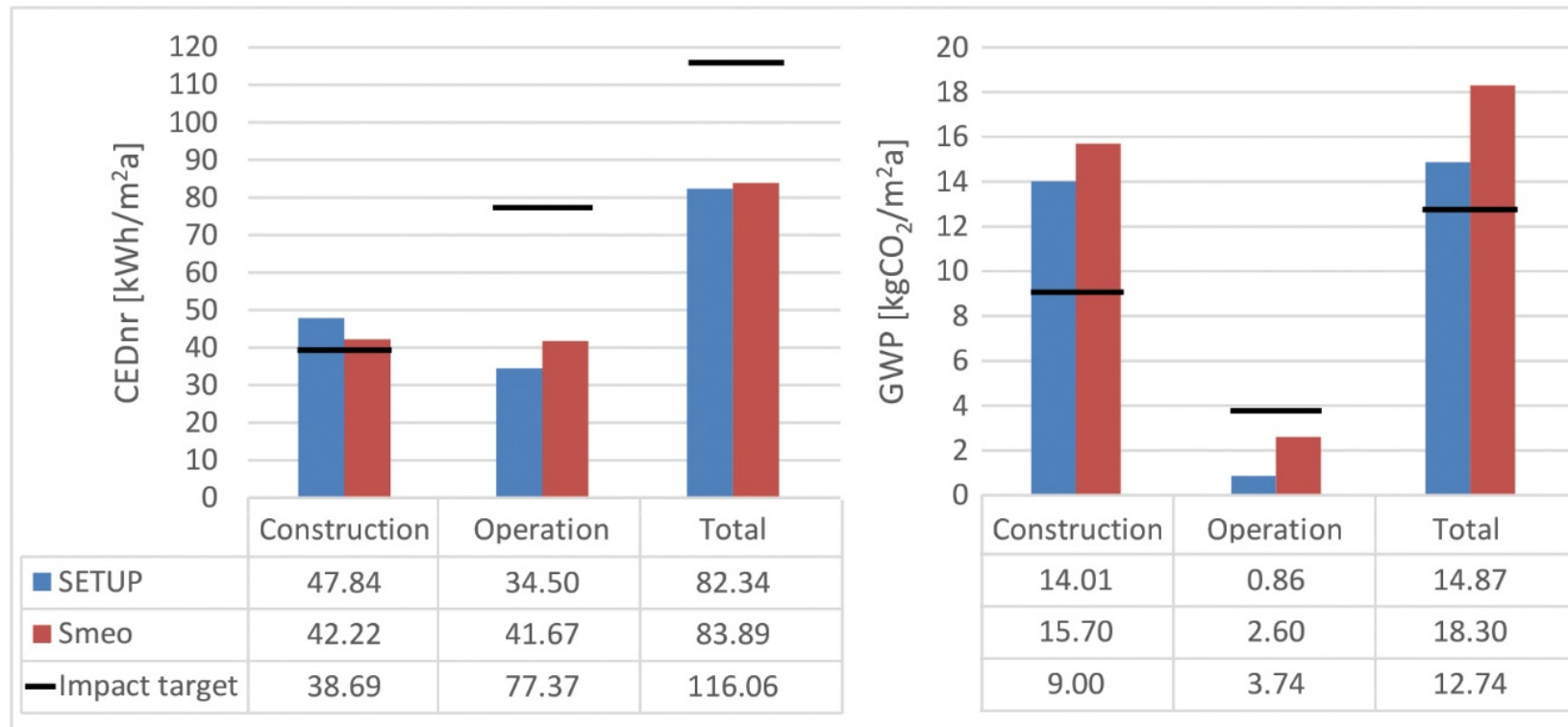
Comparability of tools | Case study



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/m ² K
Frame type (U-value)	Wood, U-value: 1.3 W/m ² K
Thermal transmittance (U value of external walls and roof)	0.1 W/m ² K
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



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

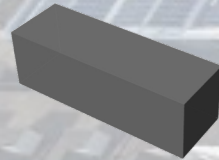
Application in early planning

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

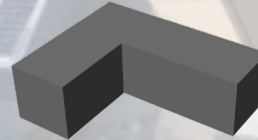
I N-S



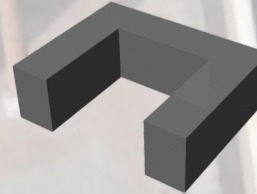
I E-O



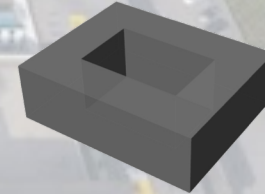
L



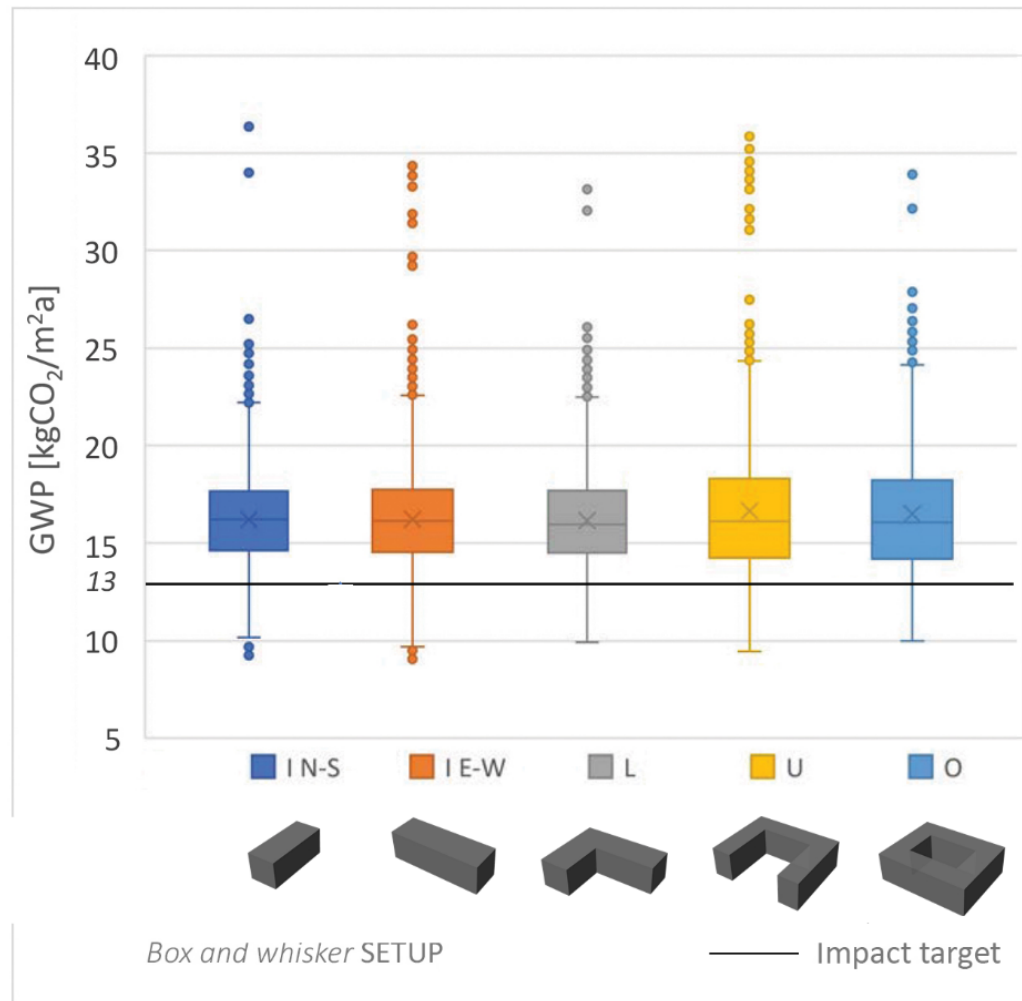
U



O



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

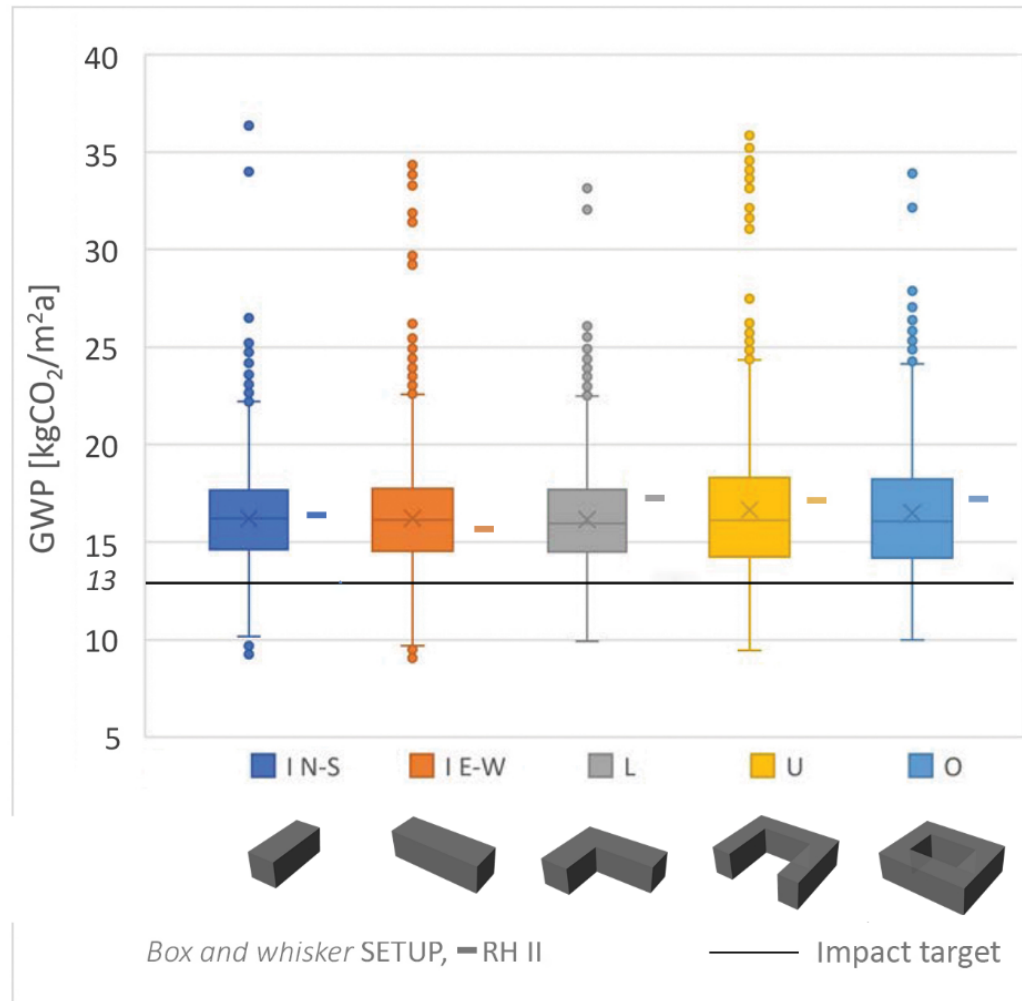


Figure 6. Site-level GWP impacts of master plan alternatives composed of buildings with uniform shape

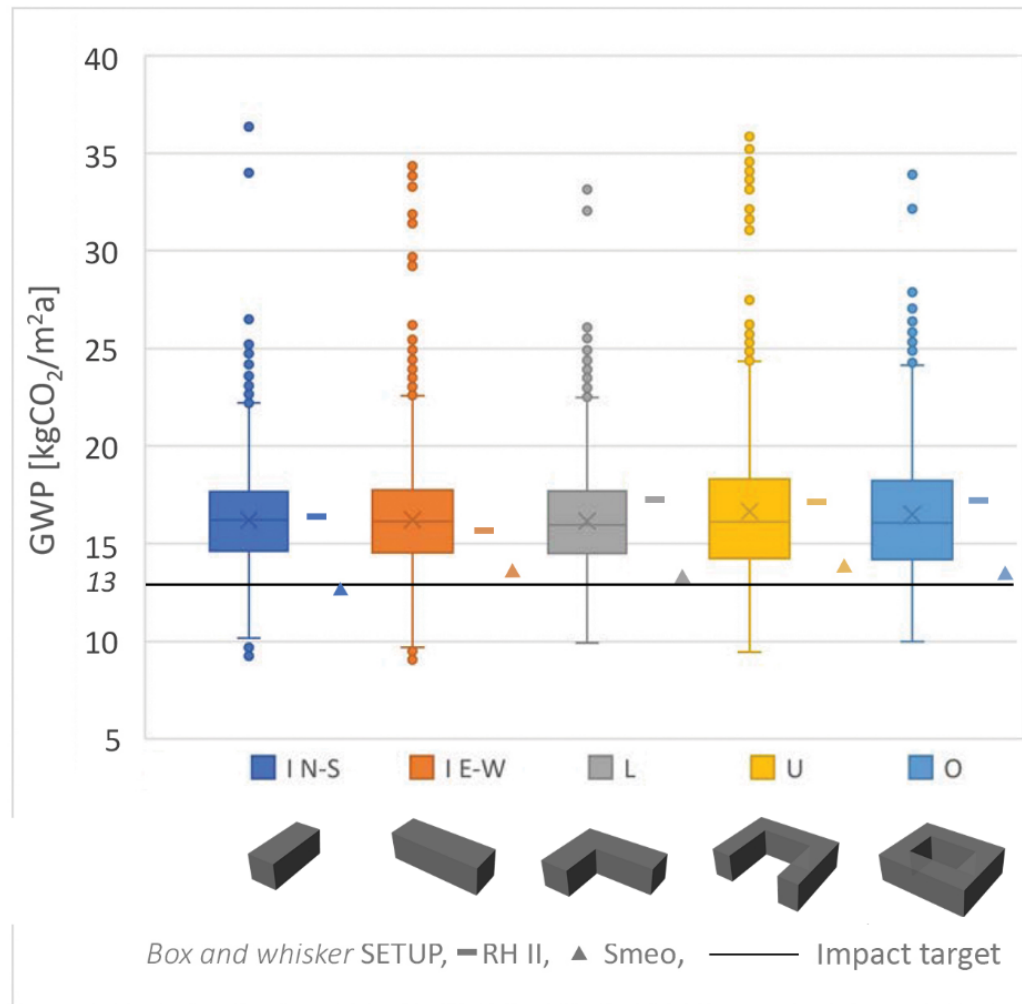
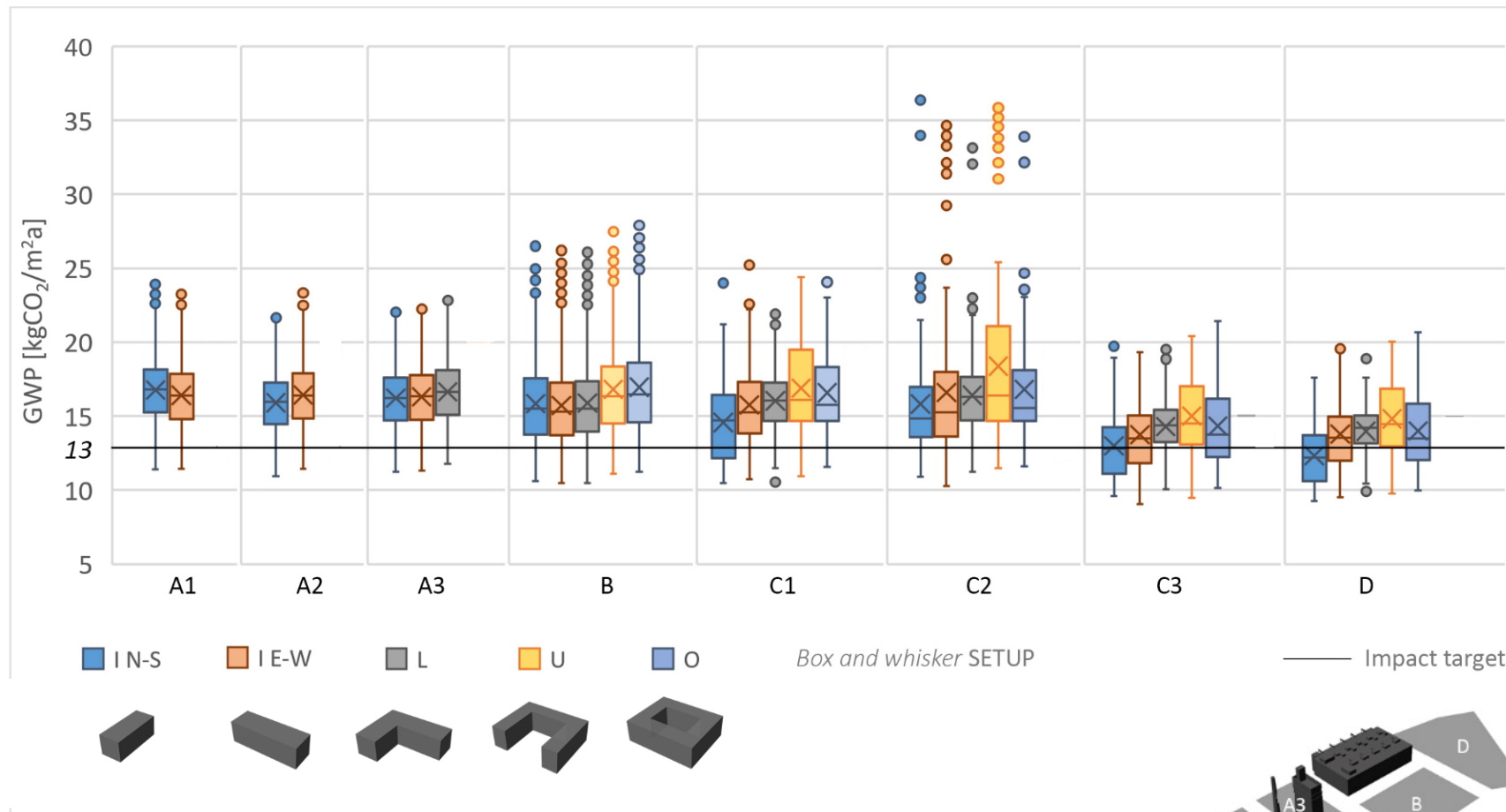
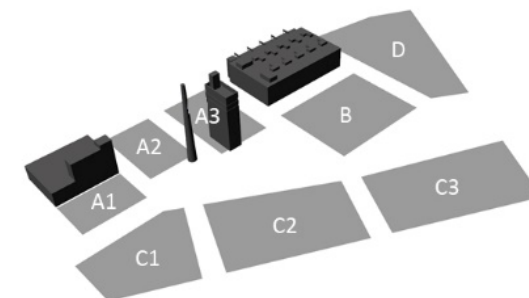


Figure 6. Site-level GWP impacts of master plan alternatives composed of buildings with uniform shape

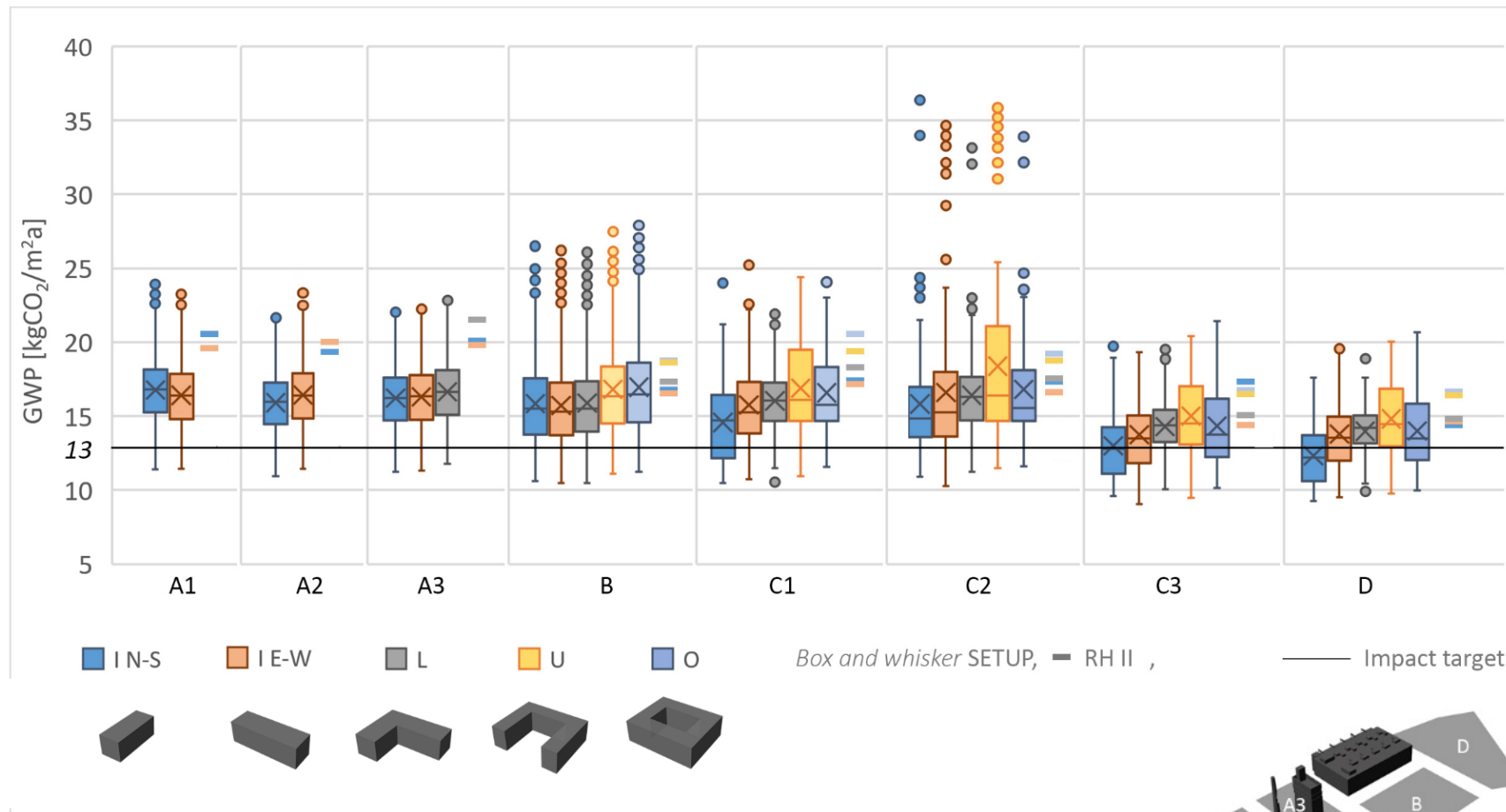
Answer to the design question | Results | SETUP



Plot-level GWP impacts of project alternatives with variable shapes

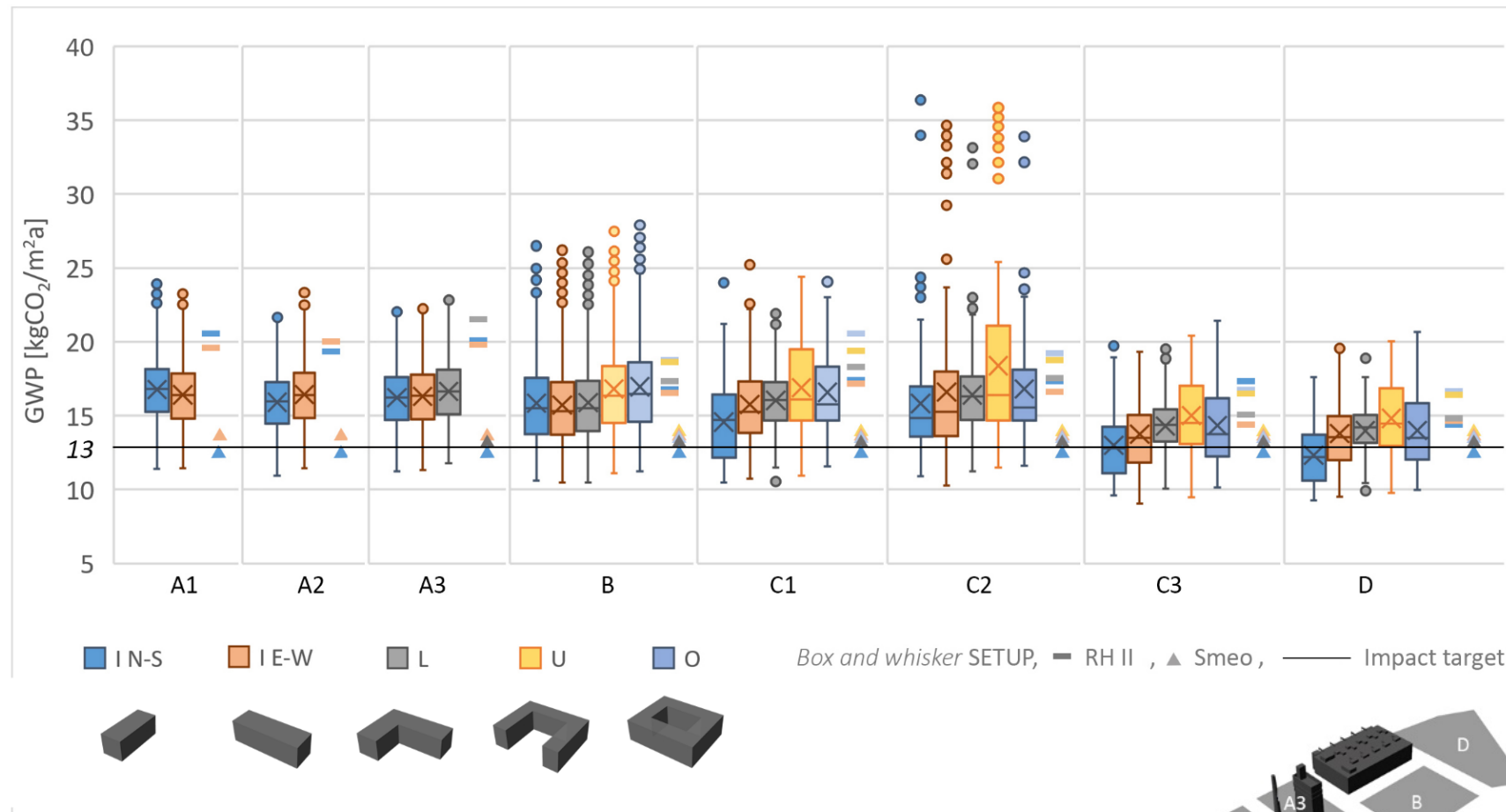


Answer to the design question | Results | SETUP | RH II

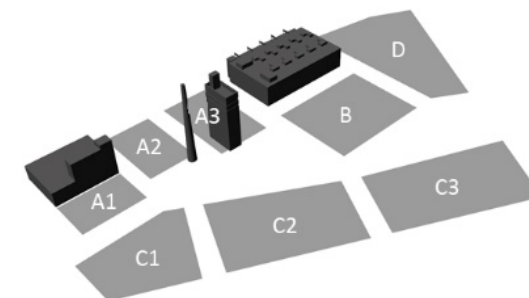


Plot-level GWP impacts of project alternatives with variable shapes

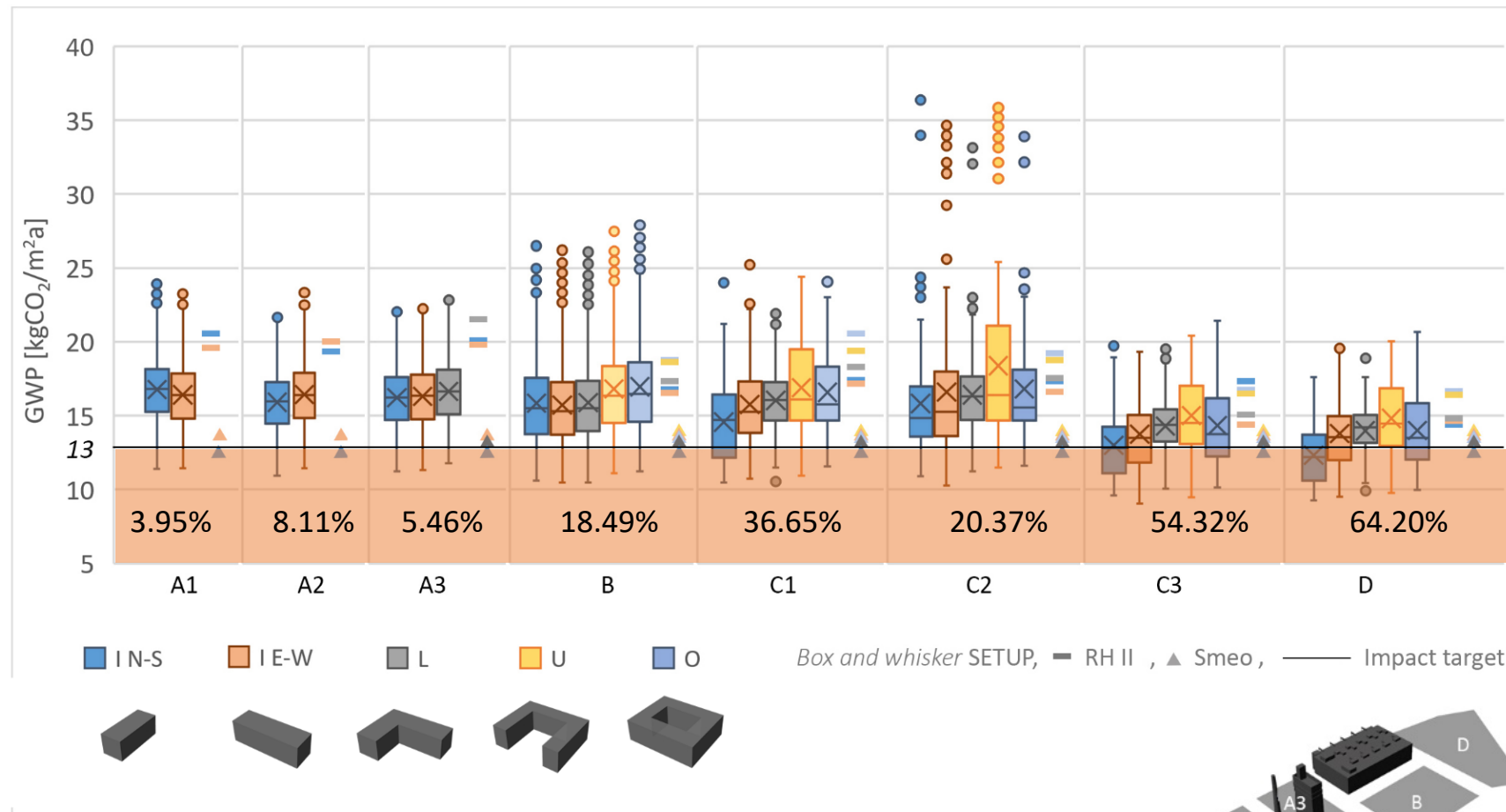
Answer to the design question | Results | SETUP | RH II | Smeo



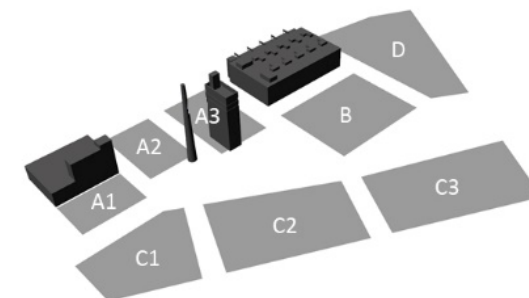
Plot-level GWP impacts of project alternatives with variable shapes



Answer to the design question | Results | Feasibility



Plot-level GWP impacts of project alternatives with variable shapes



Questions?

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building2050

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