ETH zürich

Dual environmental benchmarks for buildings

LCA Forum

June 18th 2019

hollberg@ibi.baug.ethz.ch

Institute of Construction & Infrastructure Management
Chair for Sustainable Construction
Dept. of Civil, Environmental & Geomatic Engineering

IEA EBC ANNEX 72
Assessing Life Cycle Related
Environmental Impacts Caused by Buildings

”Top-down or bottom-up?” – How environmental benchmarks can support the design process

Building and Environment 153 (2019) 148–157

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Top-down or bottom-up? – How environmental benchmarks can support the design process

Alexander Hollberg[a,*], Thomas Lützkendorf[b], Guillaume Habert[a]

[a] Institute of Construction and Infrastructure Management, Chair of Sustainable Construction, Swiss Federal Institute of Technology (ETH Zurich), Stefano Franscini Platz 5, 8093, Zurich, Switzerland
[b] Centre for Real Estate, Department of Economics, Karlsruhe Institute of Technology (KIT), 76128, Karlsruhe, Germany

ARTICLE INFO

Keywords:
Life cycle assessment
Benchmarks
Greenhouse gas emissions
Climate targets
Environmental design

ABSTRACT

Buildings are responsible for a large share of greenhouse gas (GHG) emissions. The use of Life Cycle Assessment (LCA) during the design phase can help to improve the environmental performance of buildings. However, designers and clients find it difficult to set environmental performance targets and interpret the results obtained through LCA in order to improve the building design. Therefore, reference values or benchmarks are needed. Current available LCA-based benchmarks have mostly been developed for certification systems on whole building level and do not provide design guidance on material or element level. To close this gap, this paper introduces an alternative approach that supports the design process by providing guidance and encouraging to improve the environmental performance. The aim of this approach is to support exploiting the optimization potential particularly regarding the embodied GHG emissions related to the manufacturing of construction products and to the construction, maintenance and demolition of the building. The concept consists in combining top-down benchmarks per capita derived from the capacity of the global eco system with bottom-up reference values for building components that are defined based on a statistical best-in-class approach (top 5%) using the market share of different construction products. Benchmarks for GHG emissions for new residential buildings in Switzerland are discussed. The results of applying the dual benchmark approach to a case study show that it can facilitate the use of LCA-based tools for design support and promote the optimization of the building-related environmental performance.

https://doi.org/10.1016/j.buildenv.2019.02.026

Environment-related questions during the design process

"The building is responsible for a Global Warming Potential of 1'002'500 kg CO_2-equivalent over the next 50 years"

Environment-related questions during the design process

1. Is the building climate-friendly?

2. How can the environmental performance of the building be improved through the choice of materials and construction principles?

Top-down benchmarks

1 t CO_2-e per capita and year

Top-down benchmarks

1 t CO_2-e per capita and year

↓

36% attributed to housing

Top-down benchmarks

1 t CO_2-e per capita and year

↓

36% attributed to housing

↓

360 kg CO_2-e per capita and year

Top-down benchmarks

1 t CO_2-e per capita and year

↓

36% attributed to housing

↓

360 kg CO_2-e per capita and year

↓

SIA 2040 scenarios

Top-down benchmarks

1 t CO_2-e per capita and year

↓

36% attributed to housing

↓

360 kg CO_2-e per capita and year

↓

SIA 2040 scenarios

↙

Embodied 270 kg CO_2-e/(c·a)

Top-down benchmarks

1 t CO_2-e per capita and year

↓

36% attributed to housing

↓

360 kg CO_2-e per capita and year

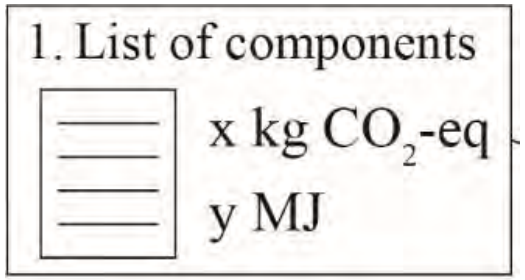
↓

SIA 2040 scenarios

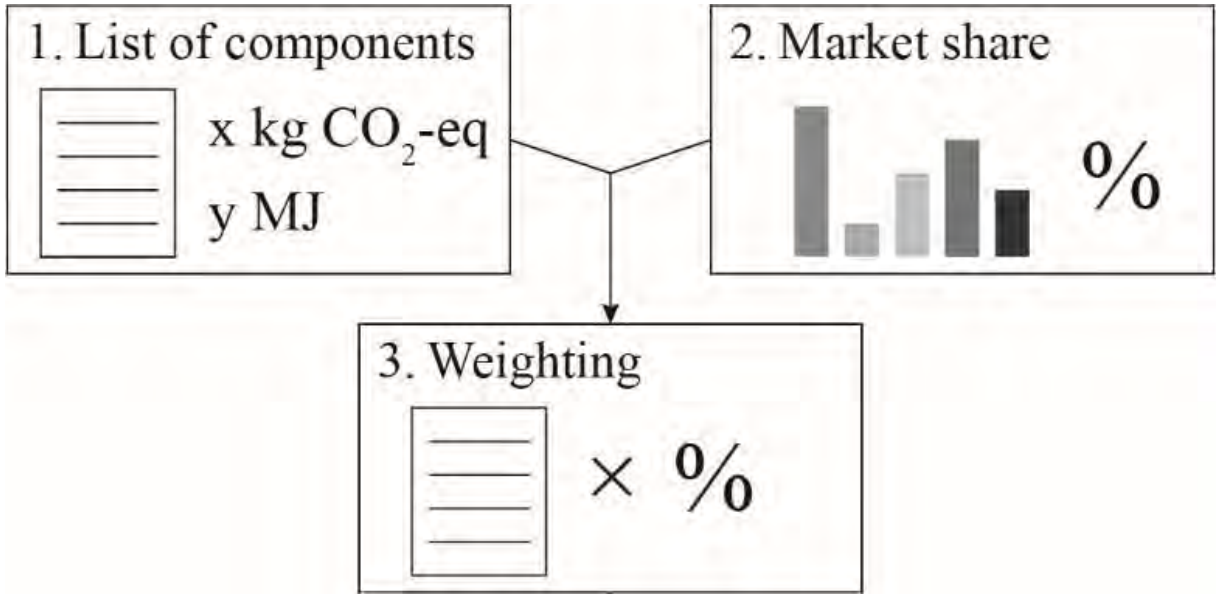
↙ ↘

Embodied 270 kg CO_2-e/(c·a) Operational 90 kg CO_2-e/(c·a)

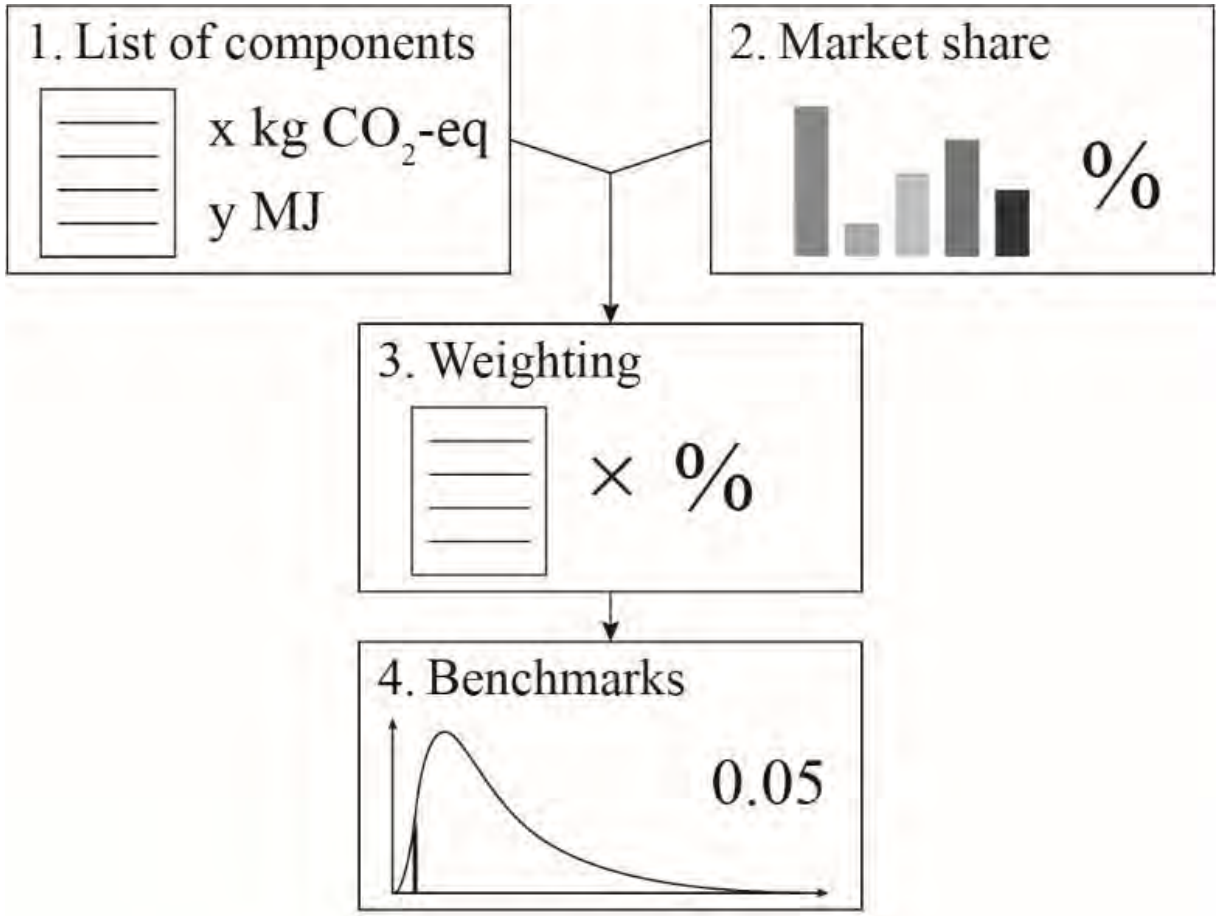
Bottom-up benchmarks



Bottom-up benchmarks



Bottom-up benchmarks



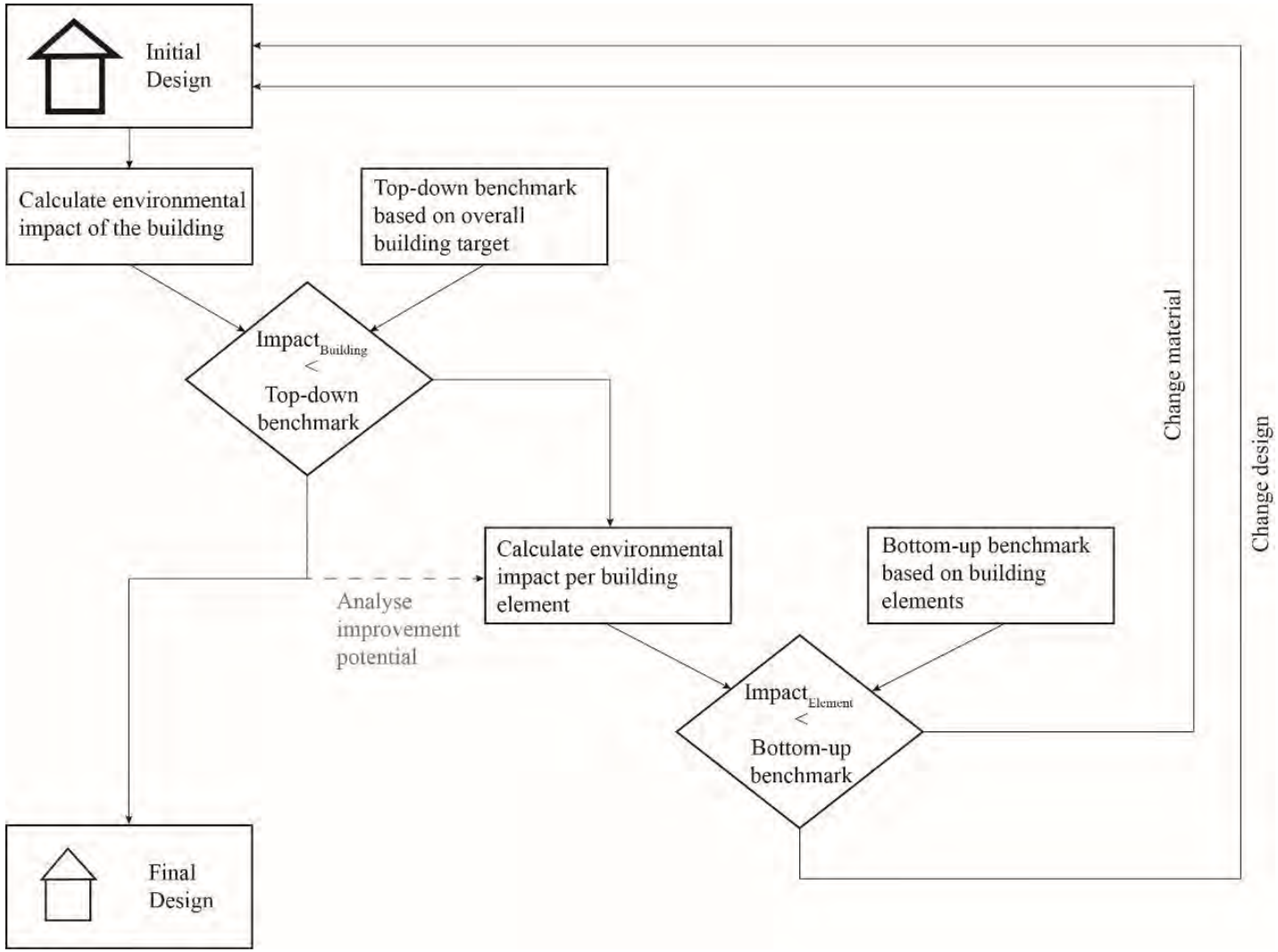
Bottom-up benchmarks

Minimum, maximum, weighted mean and target values (0.05 quantile) for GWP for the building elements.

Building element	Sample size	Reference unit	GWP [kg CO_2-e/(unit·a)]			
			Min.	W. mean	Max.	Target (0.05)
1. Base slab	80	$m^2_{element}$	1.32	2.23	2.82	1.87
2. Exterior walls underground	3	$m^2_{element}$	3.52	3.72	3.87	3.35
3. Exterior walls aboveground	404	$m^2_{element}$	0.82	2.11	3.82	1.37
4. Windows	16	$m^2_{element}$	1.49	3.16	5.57	1.85
5. Interior walls	35	$m^2_{element}$	0.59	1.28	4.46	0.82
6. Partition walls	30	$m^2_{element}$	0.58	1.05	3.97	0.83
7. Columns	7	piece	1.29	6.04	11.76	1.91
8. Ceilings	1260	$m^2_{element}$	0.66	2.24	4.69	1.37
9. Balconies	4	$m^2_{element}$	1.2	1.48	1.76	1.13
10. Roof	273	$m^2_{element}$	0.79	4.05	7.71	2.32
11. Technical equipment[a]	29	m^2_{AE}	1.18	–	3.36	1.18*

[a] Due to a small number of solutions in the building component catalogue, no benchmark is calculated, but the minimum is used. The target value is the sum of minimum values for electric equipment, heat generation, heat distribution and delivery, ventilation equipment and water (sanitary) equipment of residential buildings.

Application to a case study



Case study results

Top-down benchmark

	GWP [kg CO_2-e/a]
Embodied	4860
Operation	1620
Total	**6480**

Case study results

Top-down benchmark

	GWP [kg CO_2-e/a]
Embodied	4860
Operation	1620
Total	**6480**

Actual building

	GWP [kg CO_2-e/a]
Embodied	5518
Operation	2073
Total	**7591**

Case study results

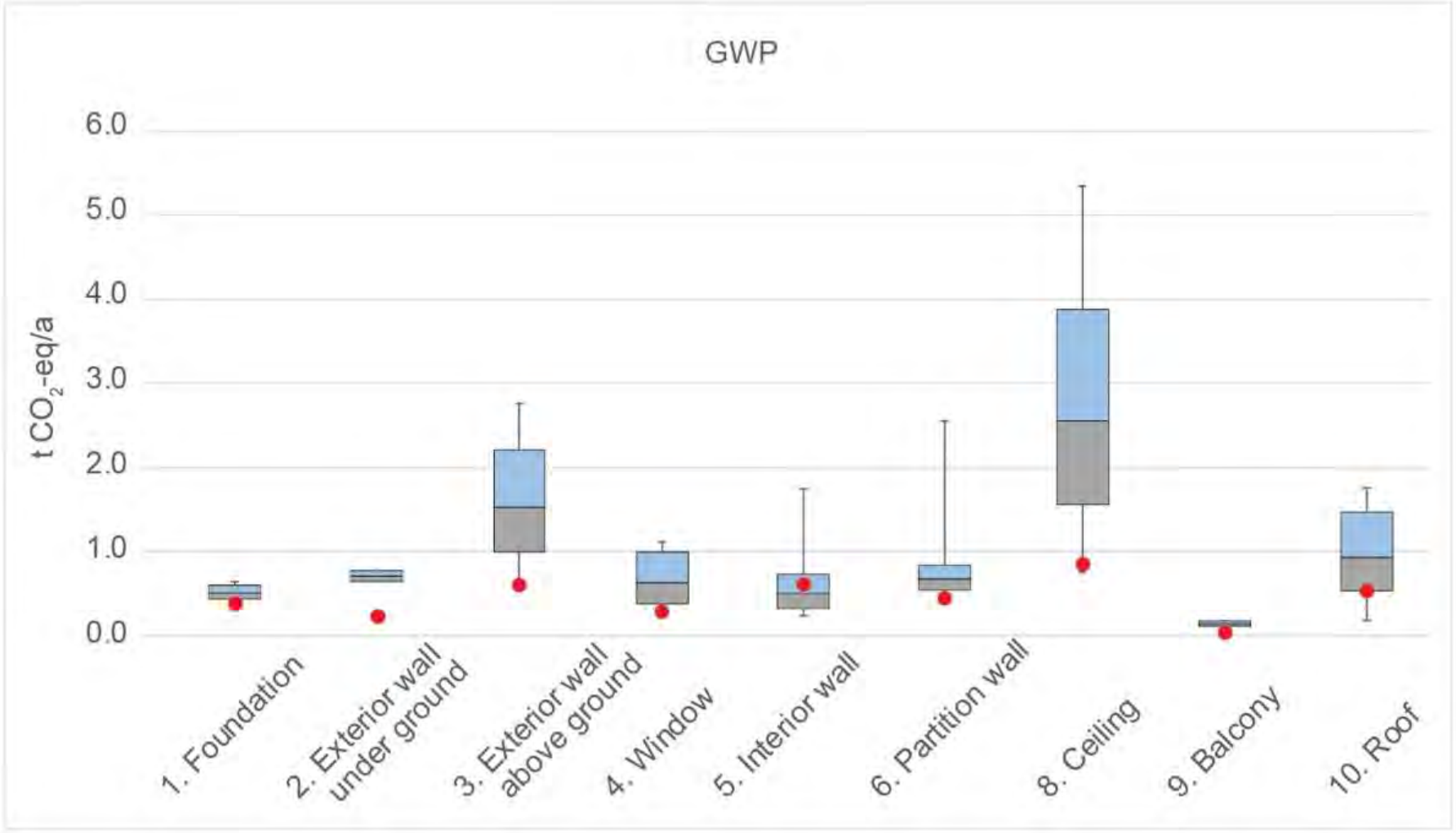
Top-down benchmark

	GWP [kg CO_2-e/a]
Embodied	4860
Operation	1620
Total	**6480**

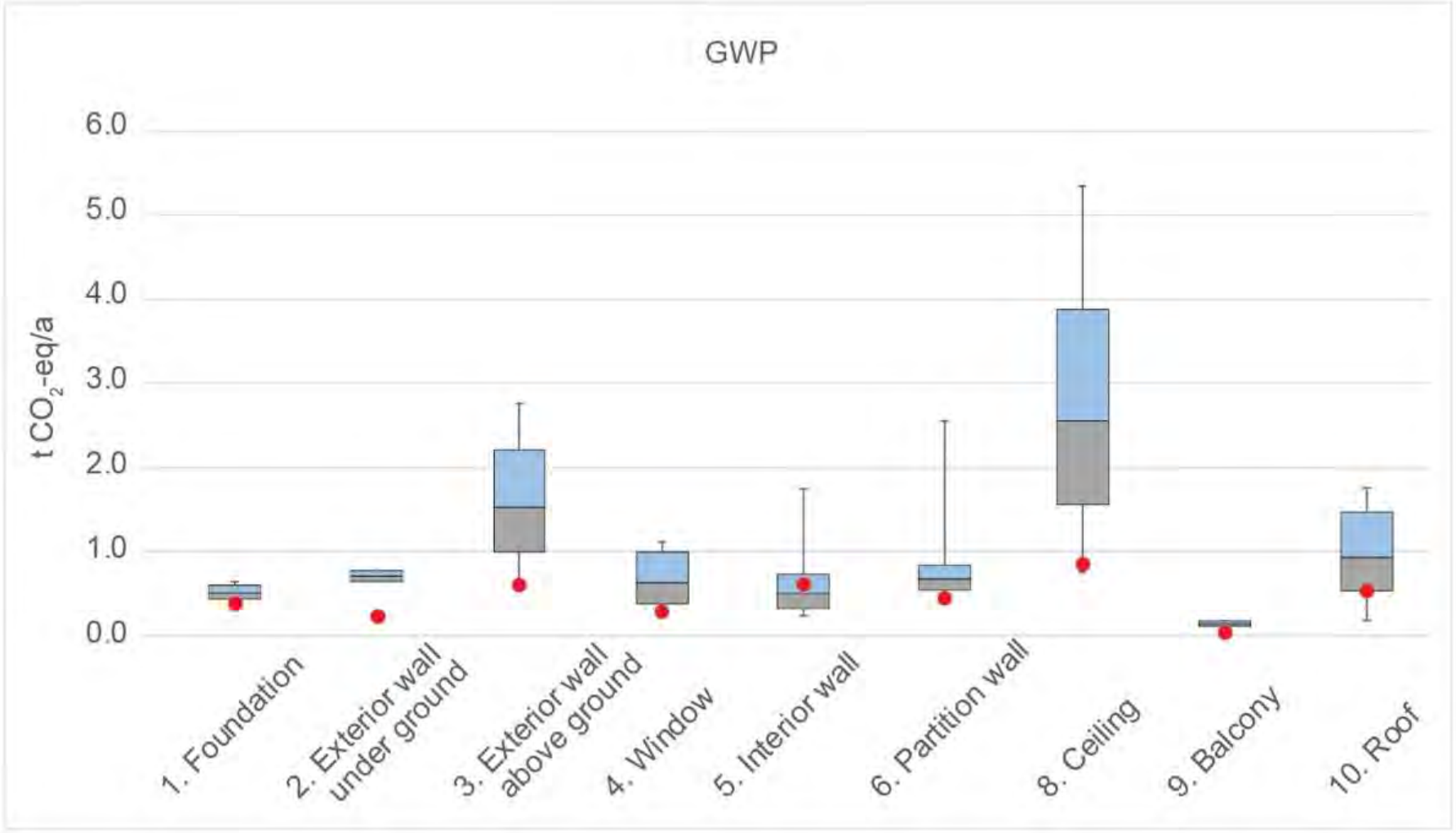
Actual building

		GWP [kg CO_2-e/a]
Embodied		5518
Operation		2073
Total	**+15%**	**7591**

Potential to improve construction/material selection



Potential to improve construction/material selection



-4%

Potential to improve construction/material selection

Sufficiency!

Remarks

- Component catalogue limited to typical constructions
- Application to other nations/regions possible
- Extension to other indicators (What is the top-down target? – Planetary boundaries, carrying capacity, …)
- Integration into LCA tools for buildings

Thank you very much for your attention!