SLiCE - An open model for scalable high-definition life cycle assessment of buildings

Vienna 2023 openmod Workshop @IIASA
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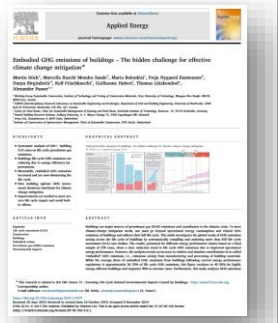
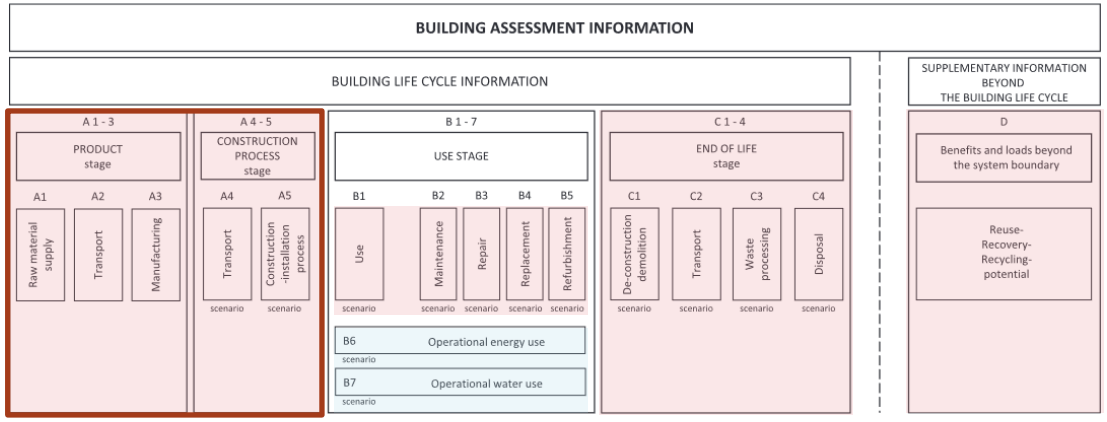
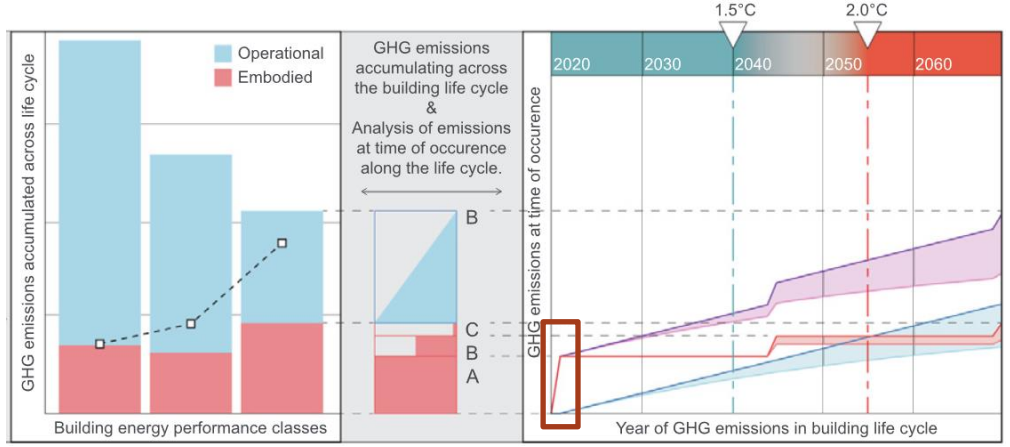
Embodied GHG emissions: The hidden challenge



- Environmental impacts related to resources and energy flows in/out of buildings (LCA)
  - CED, GHG, AP, LU, etc.
- Spatial: Hierarchical inventory modelling
  Buildings > Elements > Work sections > Materials
- Temporal: Building assessment life cycle information model (EN15804, EN15978)

- Embodied GHG emissions are increasing
- More than 50% building life cycle emissions
- Upfront emissions vs. mitigation timeframe
- Break-even only after >35 years in-use





Röck M, Ruschi Mendes Saade M, Balouktsi M, Nygaard Rasmussen F, Birgisdottir H, Frischknecht R, Habert G, Lützkendorf T, Passer A. Embodied GHG Emissions of Buildings – The Hidden Challenge for Effective Climate Change Mitigation. Applied Energy, 2020. https://doi.org/10.1016/j.apenergy.2019.114107

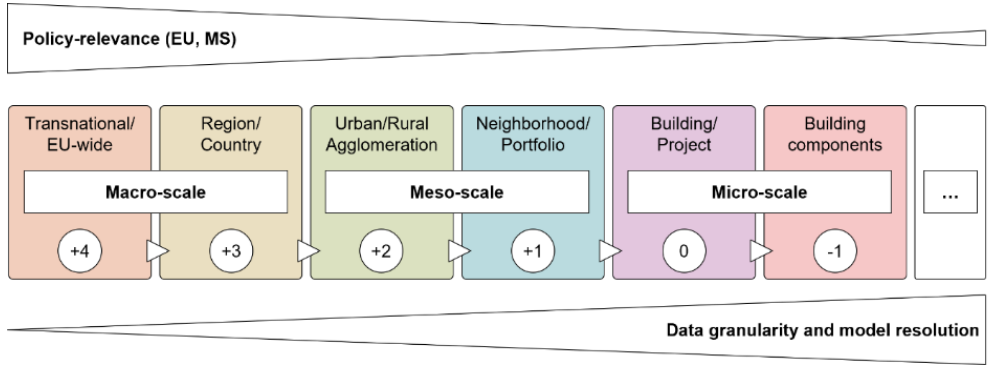
At macro-scale: Trade-offs in resolution & scope

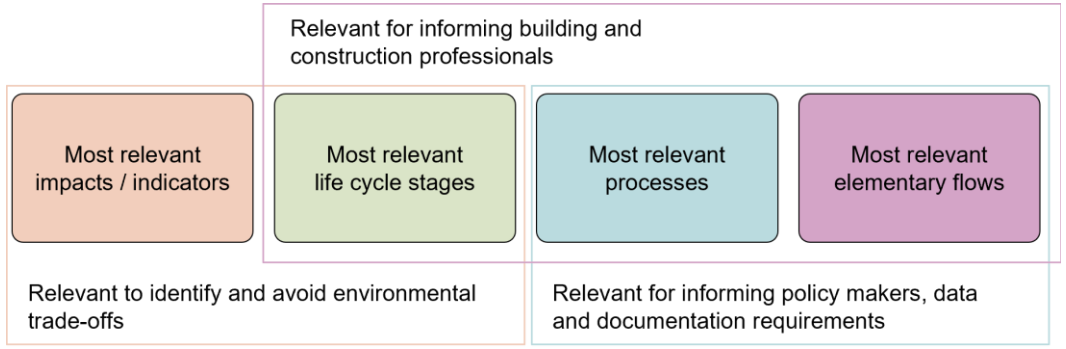
Problem A:
High policy-relevance (macro-scale) but trade-offs due to low data and model resolution

→ Risk of missing relevant effects, trade-offs

Problem B:
Macro-scale building life cycle studies apply incomplete indicator sets (only GHG, no LCA)

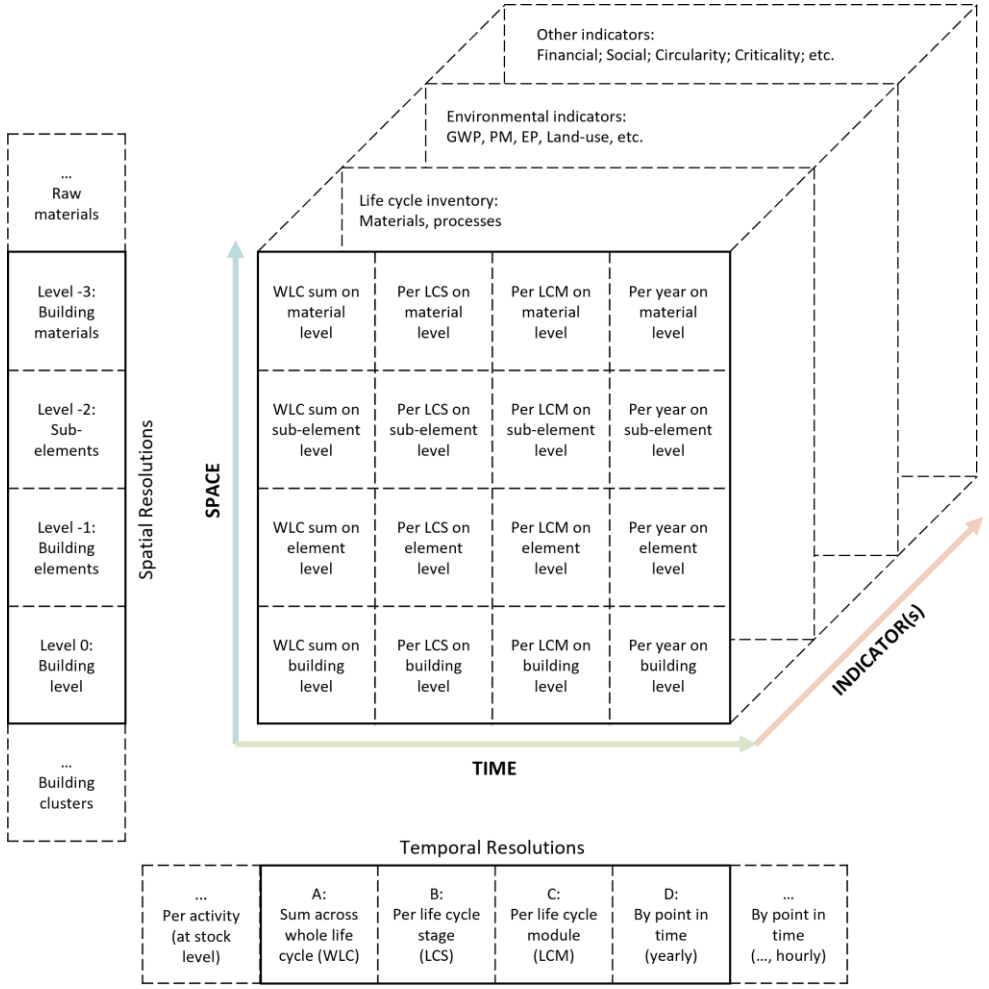
→ Risk of burden-shifting (impacts, life cycle stages)





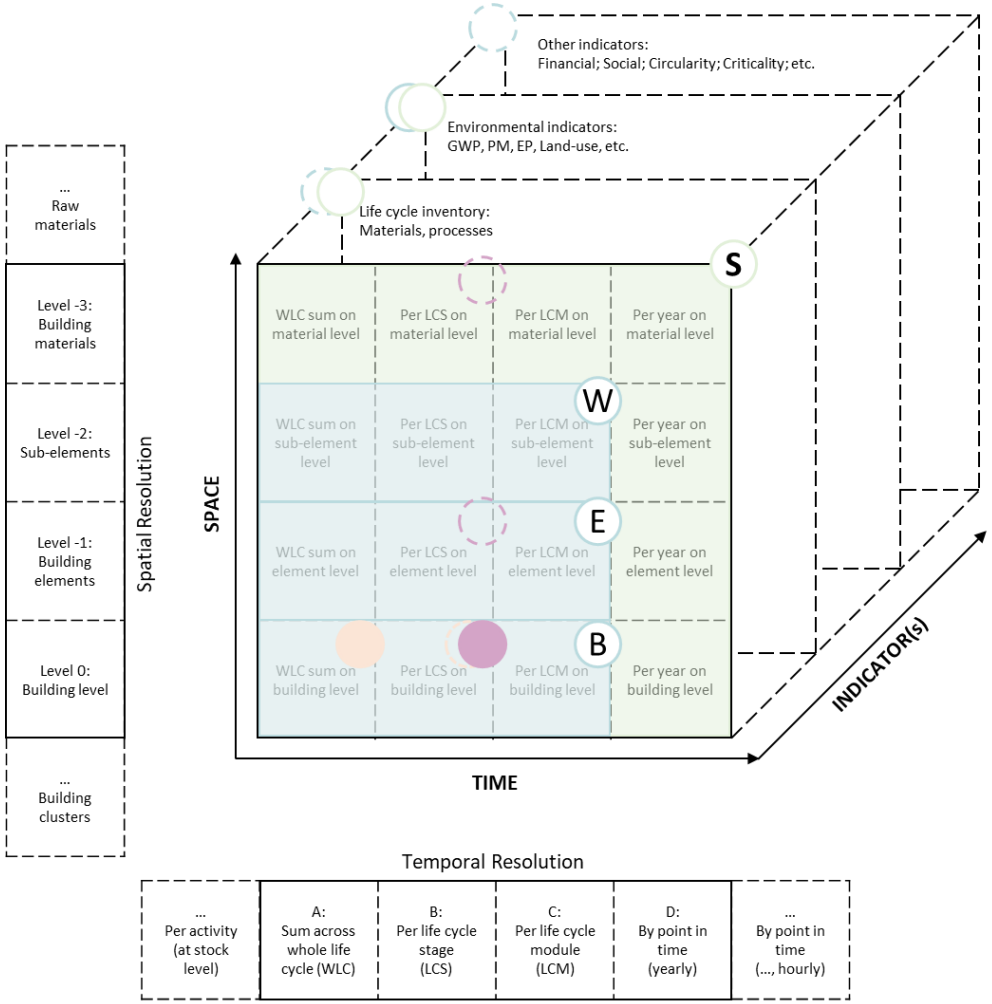
Röck M, Baldereschi E, Verellen E, Passer A, Sala S, Allacker K. Environmental Modelling of Building Stocks – An Integrated Review of Life Cycle-Based Assessment Models to Support EU Policy Making. Renewable and Sustainable Energy Reviews, 2021. https://doi.org/10.1016/j.rser.2021.111550

Space-Time-Indicator (STI) framework



Röck M, Passer A, and Allacker K. SLiCE – An Open Building Data Model for Scaling High-Definition Life Cycle Engineering and Environmental Hotspot Analysis. (Forthcoming), 2023. www.martinroeck.com

STI Nexus and SLiCE model for HD LCI/LCIA data



WLC meta-analyses

- Röck et al. 2020
- Röck et al. 2022

Building LCA models

- MMG+_KULeuven LCA model
- SLiCE building LCA model

Spatial attributes (keys)

Hierarchical building information modelling (element-method)

[...]	Building	Element	Worksection	Construction material/product	[...]
-	Bldg A	Elem A	Wsec A	MatC A	-
-	Bldg A	Elem A	Wsec A	MatC B	-
-	Bldg A	Elem A	Wsec B	MatC A	-
-	Bldg A	Elem A	Wsec B	MatC C	-
-	Bldg A	Elem B	Wsec C	MatC D	-
-	Bldg A	Elem B	Wsec C	MatC E	-
-	Bldg A	Elem B	Wsec A	MatC A	-
-	Bldg A	Elem B	Wsec A	MatC B	-
-	[...]	[...]	[...]	[...]	-

Temporal attributes (keys)

Building life cycle stages/modules and point in time

[...]	Life cycle stage	Life cycle module	Nested module	Point in time (year)	[...]
-	A - Production	A1	-	0	-
-	A - Production	A2	-	0	-
-	A - Production	A3	-	0	-
-	B - Use phase	B6	-	1	-
-	B - Use phase	B6	-	2	-
-	B - Use phase	B6	-	3	-
-	B - Use phase	B4	A1	15	-
-	B - Use phase	B4	A2	15	-
-	B - Use phase	B4	A3	15	-
-	[...]	[...]	[...]	[...]	-

Indicator attributes (values)

LCI amounts and LCIA results

[...]	Material amount	Energy amount	Indicator GWP	Indicator PM	[...]
-	xx kg	-	xx kgCO2e	xx kgPM2,5e	-
-	-	yy kWh	yy kgCO2e	yy kgPM2,5e	-
-	zz kg	zz kWh	zz kgCO2e	zz kgPM2,5e	-
-	[...]	[...]	[...]	[...]	-

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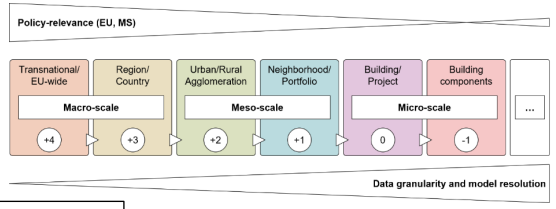
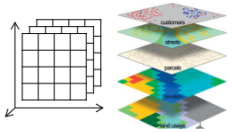
SLiCE for EU building stock scenarios



SLiCE building data for high-definition building stock modelling at macro-scale

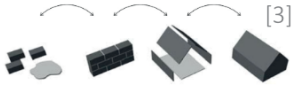
Building stock data - characterization and activities

- Definition of representative building archetypes from regional averages
- Building stock activities [m²] (operation, renov., demol., new construction)

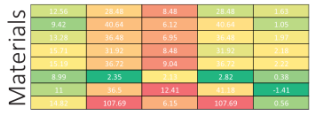


SLiCE building data

Hierarchical LCA model [3]



Hotspots analysis

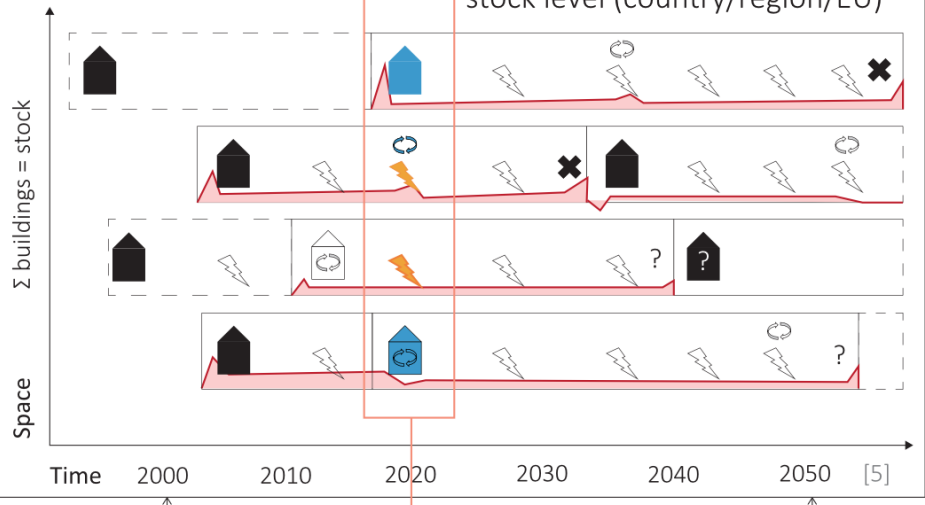


Carbon profile (e.g.) [4]

Building stock modelling

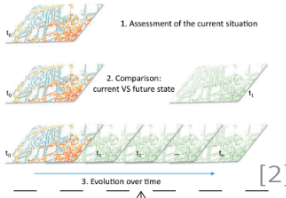
Year n

Upscaling archetype results to stock level (country/region/EU)



Evolution over time

- Stock composition
- Carbon reduction



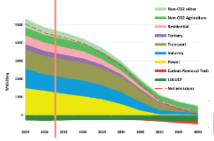
[2]

Low carbon solutions

- Efficiency increases
- Bio-based materials
- Circular approaches

Analysis baseline year

- WLC baseline in 2020 from original archetypes



[1]

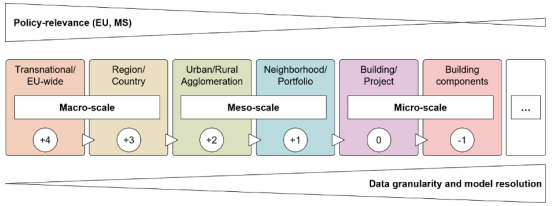
Scenario analysis building stock development

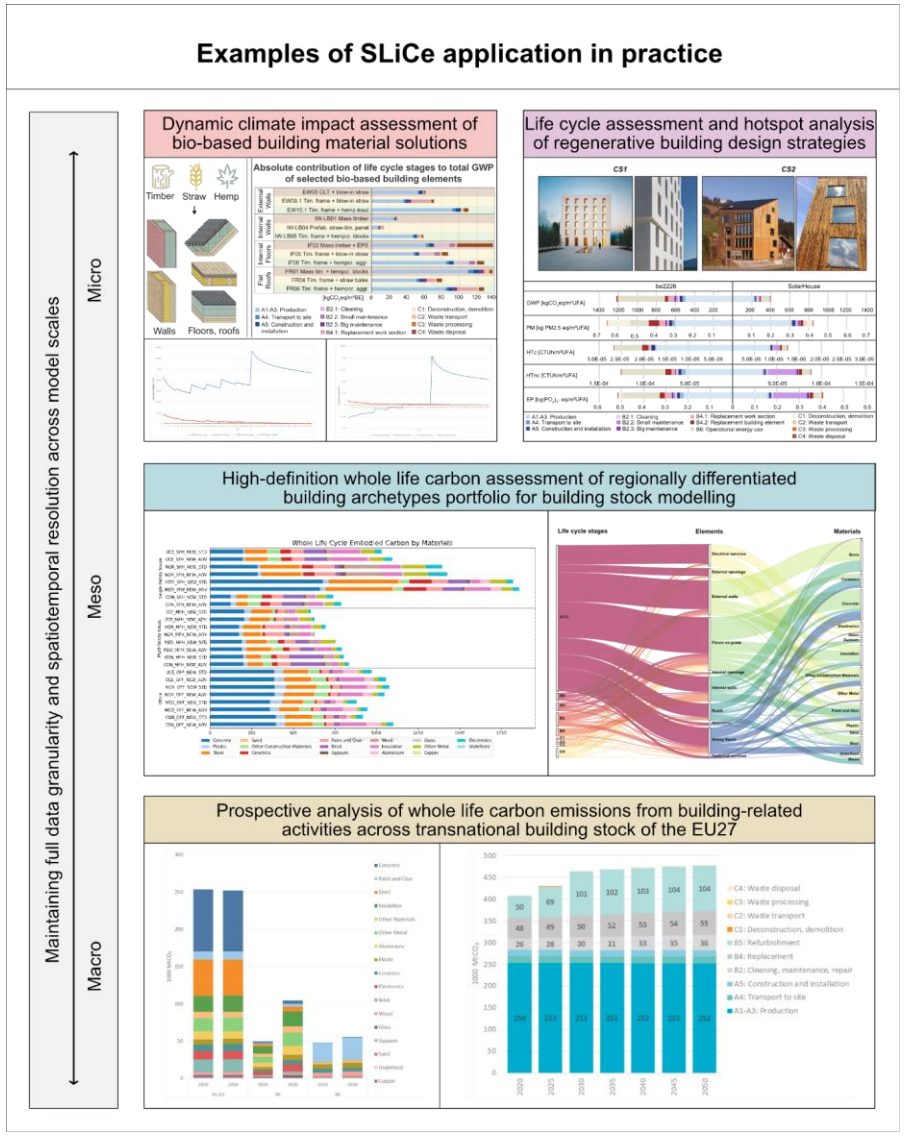
- WLC business-as-usual / current policies
- Reduction scenarios to meet climate targets

European Commission

Röck M. Building Data Models for Scalable High-Definition Life Cycle Assessment. KU Leuven, 2023 (Forthcoming). www.martinroeck.com

Application samples & next steps





- Elaboration of EU building stock model
  - Archetypes per Member State
  - Carbon reductions and removals
  - Dynamic impact characterization
  - Stock turnover model (w/ IIASA)
- Goal to make open scenario model tool
- Elaboration of open SLiCE ecosystem
  - Hotspot analysis (.ipynb)
  - Visualization (.ipynb)
  - Machine learning (.ipynb)
- Links with other models
  - Brightway (dynamic LCA)
  - Energy system models (buildings)
  - Material flow analysis (ODYM)

Röck M and Allacker K. SLiCE Building LCA Model - Implementation for High-Definition Life Cycle Assessment of Buildings across Spatiotemporal Scales. (Forthcoming), 2023. www.martinroeck.com

KU LEUVEN

TU Graz

"Our task is to make trouble, to stir up potent response to devastating events, as well as to settle troubled waters and rebuild quiet places."

-

Donna J. Haraway

Thank you.

Let's catch up!

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