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

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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
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)
Space-Time-Indicator (STI) framework

- Raw materials
- Level 3: Building materials
- Level 2: Sub-elements
- Level 1: Building elements
- Building clusters

Spatial Resolutions
- Life cycle inventory: Materials, processes
- Other indicators: Financial, Social, Circularity, Criticality, etc.
- Environmental indicators: GWP, PM, EP, Land-use, etc.

Temporal Resolutions
- Per activity (at stock level)
- A: Sum across whole life cycle (WLC)
- B: Per life cycle stage (LCS)
- C: Per life cycle module (LCM)
- D: By point in time (yearly)
- E: By point in time (..., hourly)
STI Nexus and SLiCE model for HD LCI/LCIA data

Spatial attributes (keys)
Hierarchical building information modelling (element-method)

<table>
<thead>
<tr>
<th>[...]</th>
<th>Building</th>
<th>Element</th>
<th>Worksection</th>
<th>Construction material/product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bldg A</td>
<td>Elem A</td>
<td>Wsec A</td>
<td>MatC A</td>
<td>[...]</td>
</tr>
<tr>
<td>Bldg A</td>
<td>Elem A</td>
<td>Wsec B</td>
<td>MatC A</td>
<td>[...]</td>
</tr>
<tr>
<td>Bldg A</td>
<td>Elem A</td>
<td>Wsec B</td>
<td>MatC C</td>
<td>[...]</td>
</tr>
<tr>
<td>Bldg A</td>
<td>Elem B</td>
<td>Wsec C</td>
<td>MatC D</td>
<td>[...]</td>
</tr>
<tr>
<td>Bldg A</td>
<td>Elem B</td>
<td>Wsec A</td>
<td>MatC A</td>
<td>[...]</td>
</tr>
<tr>
<td>Bldg A</td>
<td>Elem B</td>
<td>Wsec A</td>
<td>MatC B</td>
<td>[...]</td>
</tr>
</tbody>
</table>

Temporal attributes (keys)
Building life cycle stages/modules and point in time

<table>
<thead>
<tr>
<th>[...]</th>
<th>Life cycle stage</th>
<th>Life cycle module</th>
<th>Nested module</th>
<th>Point in time (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Production</td>
<td>A1</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>Production</td>
<td>A2</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>Production</td>
<td>A3</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>Use phase</td>
<td>B6</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>Use phase</td>
<td>B6</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Use phase</td>
<td>B6</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>Use phase</td>
<td>B4</td>
<td>A1</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>Use phase</td>
<td>B4</td>
<td>A2</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>Use phase</td>
<td>B4</td>
<td>A3</td>
<td>15</td>
</tr>
</tbody>
</table>

Indicator attributes (values)
LCI amounts and LCIA results

<table>
<thead>
<tr>
<th>[...]</th>
<th>Material amount</th>
<th>Energy amount</th>
<th>Indicator GWP</th>
<th>Indicator PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>xx kg</td>
<td>xx kgCO2e</td>
<td>xx kgPM2,5e</td>
<td>xx kgPM2,5e</td>
<td>[...]</td>
</tr>
<tr>
<td>yy kWh</td>
<td>yy kgCO2e</td>
<td>yy kgPM2,5e</td>
<td>yy kgPM2,5e</td>
<td>[...]</td>
</tr>
<tr>
<td>zz kg</td>
<td>zz kgCO2e</td>
<td>zz kgPM2,5e</td>
<td>zz kgPM2,5e</td>
<td>[...]</td>
</tr>
</tbody>
</table>

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
↓
Hotspots analysis
Materials
Life cycle stages
Carbon profile (e.g.)

Building stock modelling
Year n
Upscaling archetype results to stock level (country/region/EU)

Evolution over time
- Stock composition
- Carbon reduction

Low carbon solutions
- Efficiency increases
- Bio-based materials
- Circular approaches

Analysis baseline year
- WLC baseline in 2020 from original archetypes

Scenario analysis building stock development
- WLC business-as-usual / current policies
- Reduction scenarios to meet climate targets

Policyrelevant (EU, MS)
Translation (en) Scenario analysis Stakeholder involvement Metropolitan scale Building model Regional scale Building model Macro-scale Micro-scale Data processing and model validation
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)
“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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