Towards BIM-integrated, resource–efficient building services

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Resource efficient construction

‘Makes best use of materials, water and energy over the lifecycle of built assets to minimise embodied and operational carbon’ [and other environmental impacts] (WRAP)
Why embodied carbon?

Based on Ibn-Mohammed et al (2013)

- Initial embodied emissions: 2-3 years
- Operational emissions: 40-60 years
- Recurring embodied emissions
- End of life embodied emissions
Why building services?

Initial embodied carbon - average of 30 London office buildings

- Superstructure: 39.8%
- Substructure: 16.2%
- Vertical envelope: 17.0%
- Building services: 14.7%
- Other: 12.3%

CIBSE (2014)
Why building services?

![Diagram showing the percentage distribution of costs and embodied carbon for different categories, including initial embodied carbon, recurring embodied carbon, capital costs, and lifetime costs. The data is from AECOM (2014).](image)

- Initial embodied carbon: 15% building services, 85% other building elements
- Recurring embodied carbon: 60% building services, 40% other building elements
- Capital costs: 35% building services, 65% other building elements
- Lifetime costs: 50% building services, 50% other building elements
Some challenges

Design choices

Gaps in tools

Gaps in data sources and calculation methods

Policy  Practice  Markets  Industry attitudes
Gaps in data sources & calculation methods

- LCA databases mainly focus on raw materials
- Too few Environmental Product Declarations (EPDs)
- Methods needed to predict embodied carbon of composite MEP components
### Gaps in LCA-based tools for buildings

<table>
<thead>
<tr>
<th>Complexity level</th>
<th>Methods</th>
<th>Examples</th>
<th>Comment</th>
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<tbody>
<tr>
<td>1 – Product comparison</td>
<td>Quantitative, full LCA</td>
<td>GaBi, Simapro</td>
<td>Accurate, too complex for lay use. Data lacking on building services.</td>
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<tr>
<td>2 – Whole building decision support</td>
<td>Quantitative, simplified LCA</td>
<td>Ecoccalculator, Etool, Rapiere</td>
<td>More user friendly. May include building services but still face data gap.</td>
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<td>3 – Building environmental assessment</td>
<td>Mixed - quantitative &amp; qualitative</td>
<td>BREEAM, LEED</td>
<td>Mixed methods unreliable for lifetime impacts. Building services often not included in LCA if used</td>
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</tbody>
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Based on Cabeza et al (2014)

All LCA tools depend on available data sources!
Why BIM?

- Material and component quantities
- Operational carbon data and calculation methods
- Embodied carbon data and calculation methods
- Costs
- BIM design tool
- Sustainable choice of building components and systems
Case study of fan-coil units

- Horizontal, ducted, water-side fan coil units are widely used in HVAC systems of various types in UK offices.
- A composite component with 5 main raw materials.
- Selection typically based on operational performance and cost, not embodied or whole-life carbon, as data lacking.
- Hypothesis to test: Could a parametric method predict embodied carbon of a generic class of component?

BSRIA, 2013
Results

- Embodied carbon rises with mass and total cooling capacity
Results

- Relative embodied carbon & mass falls slightly as total cooling capacity rises
Results

- Mass rises with total cooling capacity, by manufacturer
Results

- Relative mass falls as total cooling capacity rises

![Graph showing the relationship between mass and total cooling capacity](image-url)
Conclusions

- Embodied carbon and mass of FCUs rise absolutely / fall relatively with total cooling capacity
- If variations in mass between manufacturers can be explained, embodied carbon can be predicted
- Variations in gauge of steel casing explain 30% of the mass variation between manufacturers A and C
- Whole life carbon impacts of FCUs depend on additional calculations and assumptions
- *Parametric methods can predict embodied carbon of generic, composite MEP components*
- *Adding embodied carbon to BIM can help choose resource-efficient components and systems*
The way forward

Refine data sources and calculation methods

Refine tools

Design choices

Influence policy, practice and industry attitudes
Any questions?

References

- BSRIA (2013) The illustrated guide to mechanical cooling
- CIBSE (2014) TM56, Resource efficiency of building services