The Embodied Carbon of Building Services Systems in Houses

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Background

- New Zealand has committed to achieving net zero greenhouse gas (GHG) emissions by 2050
- The Building and Construction accounts for around 20% of New Zealand’s carbon emissions through the energy and materials used in buildings.
- The Ministry of Business Innovation and Employment has developed draft methodologies to calculate embodied carbon, for consultation in 2024
- The only compulsory reporting on services is on HVAC

<table>
<thead>
<tr>
<th>Building System</th>
<th>Mandatory: must be included in the assessment</th>
<th>Voluntary: may be reported independently within the assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building services</td>
<td>- HVAC equipment</td>
<td>- Water, drainage, electrical services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Other building systems such as fire and security systems</td>
</tr>
</tbody>
</table>
Current Embodied Carbon Tools

- Tend to focus on building
  - Groundwork
  - Structure
  - External Envelope
  - Non-structural internal elements

- Vary between an element and a complete building focus

- Services tools are rare and focus on components
Current progress

Most advanced and comprehensive:

Bullen L. and Dowdell D., (2023) BRANZ Study Report SR479 *Embodied carbon of New Zealand office and residential building services*

- Reference Buildings for Standalone houses, Medium Density Housing, Apartments and four Office Buildings
- Suite of internationally available Environmental Product Declarations (EPD) and equivalents BRANZ tools and recognised databases
- System quantities from Beca (offices) and Ortus International Ltd (residential)
- Over a 50 year Life Cycle
This work

Clearcut® - long-established cost estimating software with a major extension to also encompass a range of carbon assessments

• Reference Building for Standalone house 150m²
• Suite of internationally available EPD’s and equivalents BRANZ tools and recognised databases
• Electrical quantities “as supplied” by an electrical contractor
• Plumbing quantities from architectural layouts and system schematic
• Over a 50 year Life Cycle
Results - BRANZ

Residential Carbon Footprint by Services Type

- DH 1
- DH 2
- MDH
- AP
- AP-building

Key:
- HVAC
- Electrical
- Plumbing
Table 4. Comparison of residential building embodied carbon footprints and services carbon footprints.

<table>
<thead>
<tr>
<th>Residential typology</th>
<th>Embodied carbon footprint – dwelling</th>
<th>Embodied carbon footprint – services</th>
<th>Total embodied carbon footprint – dwelling and services</th>
<th>Services contribution to total carbon footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand-alone house⁷</td>
<td>254</td>
<td>43</td>
<td>297</td>
<td>17%</td>
</tr>
<tr>
<td>MDH</td>
<td>296</td>
<td>58</td>
<td>354</td>
<td>16%</td>
</tr>
<tr>
<td>Apartment⁸</td>
<td>605</td>
<td>150</td>
<td>755</td>
<td>20%</td>
</tr>
</tbody>
</table>
Unitec comparisons

- Differences
  - Extent of plumbing service included (valves fixtures and fittings)
  - Quantities used in each service
Unitec comparisons

- Differences
- Replacement cycles
Lessons learned EPDs

- Not all systems are equal
- PEP: EPD comparisons
Lessons learned

- Search engines in EPD databases use manufacturers’ data and references which makes interrogation very hard.
Lessons learned

• System “families” do not always make sense

- Heating, ventilation and air conditioning equipment
  - Ventilation and/or Heating and/or Air Conditioning and/or Hot Water Heating
  - Heating and/or air conditioning and/or hot water heating
- Hot water heating
  - Individual storage water heaters
    - Heat pump water heater
    - gas water heater
    - solar water heater
  - electric water heater
Lessons learned

• Functional units are usually per kg, but other components made of similar materials rarely have weights published.

  E.g. PVC pipe and PVC fittings

• Manufacturers make pragmatic simplifications in some of their calculations E.g. socket outlets and switches use the same EPD
Lessons learned

- Official EPD databases should be used rather than manufacturer’s websites

### Environmental Information

#### Potential environmental impact

<table>
<thead>
<tr>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
<th>TOTAL</th>
<th>Co-efficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.22E+00</td>
<td>1.96E-01</td>
<td>1.17E-01</td>
<td>0.00E+00</td>
<td>1.41E-02</td>
<td>0.00E+00</td>
<td>1.47E-02</td>
<td>0.00E+00</td>
<td>2.57E+00</td>
<td>0.28</td>
</tr>
</tbody>
</table>

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<th>D</th>
<th>TOTAL</th>
<th>Co-efficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.50E-01</td>
<td>3.92E-02</td>
<td>2.34E-02</td>
<td>0.00E+00</td>
<td>2.82E-03</td>
<td>0.00E+00</td>
<td>2.80E-03</td>
<td>0.00E+00</td>
<td>5.18E-01</td>
<td>0.28</td>
</tr>
</tbody>
</table>
For the future

- Services systems should be included in embodied carbon calculations
- Agree Functional Units for complete services systems
- Grow the ANZ database
- Services system data need development so that small practitioners can apply them easily and reliably.
For the Future

• Beware components targeted to reduce operational efficiency because of their high consumption
• Encourage more use of CIBSE TM65, support its use via engineering student projects