Think outside the box: ‘Churn’ and the Environmental Impact of Office Fit-Out Retrofit

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Buildings and energy

- 30 million buildings (domestic and non-domestic) in the UK
- 87% of UK’s national building stock that will exist in 2050 has already been built
- Energy is required throughout the life-cycle of buildings: 30-40% of the global energy
- 1.8 million non-domestic; consume long-life energy intensive materials and are responsible for 18% of the country’s total CO₂ emissions
Challenges

- Reduce resource consumption
- Reduce greenhouse gases
- Climate Change

- Retain and reuse existing buildings
- Focus on Operational Energy (OE)
- UK & EU strategies development
- UK 2050 target
- Retrofit procedures & Recurring Embodied Energy (REE) under-reported
Study aim

Explore the embodied energy due to office interiors’ retrofit activities associated with the ‘Make Good’ process as a result of ‘Churn’ in commercial settings

- **Part 1** - REE due to retrofit interior fit-outs, including Fixtures, Fittings & Furniture (FFF/’churn’ items), compared to an office building’s initial embodied energy and operational energy over various lifespans

- **Part 2** - REE and carbon footprint of four floor finishes over 50 years
Office buildings and life-cycle energy

Operational Energy (OE)

- The largest component of life-cycle energy
- Size and type of the building
- Open plan ‘Typical’ and ‘Good Practice’ consume 0.85 GJ/m²/y and 0.47 GJ/m²/y

Embodied Energy (EE)

- Prefabrication, construction, transportation and administration
- Direct energy is used to support these processes
- Indirect energy or Initial Embodied Energy (IEE)
- Source & type of building materials
Office buildings and life-cycle energy

Recurring Embodied Energy (REE)

- Due to maintenance and refurbishment
- Depends on material durability, maintenance, installed systems & the building lifespan
- Modelled based on replacement rates of building components

Expected Lifespan (years)

EU and American buildings **50-70**
Services **15-20**
Fittings and spatial divisions **5-10**
Workstations and furniture **<5**
Embodied energy in office buildings

**Office fit-out** - internal finishes, fixtures, fittings and furniture

**Retrofit** – replacement of fit-out elements and equipment

‘Replacement frequency’

Previous studies: Recurring embodied energy is always larger than the initial embodied energy with office buildings having a refurbishment cycle of 25-30 years and services and finishes having much shorter cycles

How about the replacement of ‘churn’ items and their effect?
‘Churn’ and the ‘Make Good’ process

Fit-out ‘Churn rate’ – The number of times an item is replaced over a facility’s life (25% for institutions, 44% for services, 45% for office headquarters facilities)

A high annual churn rate of 30% of building occupants is normal in the UK

‘Make Good’

Wasted EE repetitions and increased REE values
### Building element ‘churn rates’

**Previous assumptions (40 years of building life)**

<table>
<thead>
<tr>
<th>Building element</th>
<th>Churn rate (%)</th>
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</thead>
<tbody>
<tr>
<td>Upper floors</td>
<td>0</td>
</tr>
<tr>
<td>External walls</td>
<td>10</td>
</tr>
<tr>
<td>Internal walls</td>
<td>10</td>
</tr>
<tr>
<td>Columns</td>
<td>0</td>
</tr>
<tr>
<td>Substructure</td>
<td>0</td>
</tr>
<tr>
<td>Floor finishes</td>
<td>200</td>
</tr>
<tr>
<td>Wall finishes</td>
<td>400</td>
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<table>
<thead>
<tr>
<th>Building element</th>
<th>Churn rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling finishes</td>
<td>100</td>
</tr>
<tr>
<td>Fixtures, fittings and furniture</td>
<td>560</td>
</tr>
<tr>
<td>Electrical</td>
<td>20</td>
</tr>
<tr>
<td>Air-conditioning</td>
<td>20</td>
</tr>
<tr>
<td>Fire protection</td>
<td>20</td>
</tr>
<tr>
<td>Plumbing</td>
<td>20</td>
</tr>
<tr>
<td>Other</td>
<td>20</td>
</tr>
</tbody>
</table>

*Fittings, fixtures and furniture have the highest ‘churn rate’ among all elements*
Study method and steps

Life Cycle Assessment (LCA)

Part 1

Review of the study by Yohanis and Norton (20)
Review of the study by Treloar et.al (16)
Operational Energy values for 'Typical' and 'Good Practice' offices (13) extrapolated over 25, 50, 60, 70 and 100 years
Operational Energy related CO₂e emissions (27) extrapolated over 25, 50, 60, 70 and 100 years

P-LCA
I/O-LCA & Literature
Embodied Energy of the office building & services
Embodied Energy of FFF

Part 2

Selected floor finishes

BEES Software P-LCA

Embodied Energy of floor finishes over 50 years
Embodied Carbon of floor finishes over 50 years

'Churn rates' applied & extrapolated over 25, 50, 60, 70 & 100 years
Part 1 - Study concept

A UK notional office building

- Open-plan (716.7 m²)
- IIE 10.5 GJ/m²
- Additional 10% construction factor (non-FFF IEE of 11.55 GJ/m²)

‘Churn’ items

- 10.9 m²/desk → 50 desks
- 2 medium-sized meeting rooms fully enclosed
- 3 small-sized group-work tables divided with panels

<table>
<thead>
<tr>
<th>Element</th>
<th>Quantity</th>
<th>Aver. IEE (GJ/item)</th>
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</thead>
<tbody>
<tr>
<td>Workstation</td>
<td>50</td>
<td>6.14</td>
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<tr>
<td>Desk/table</td>
<td>50</td>
<td>2.7</td>
</tr>
<tr>
<td>Reception hutch</td>
<td>3</td>
<td>7.6</td>
</tr>
<tr>
<td>Pedestal table</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Conference table</td>
<td>2</td>
<td>6.5</td>
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<tr>
<td>Credenza</td>
<td>3</td>
<td>3.8</td>
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<tr>
<td>Cupboards</td>
<td>1</td>
<td>2.8</td>
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<tr>
<td>Drawers</td>
<td>52</td>
<td>2.1</td>
</tr>
<tr>
<td>Shelving</td>
<td>10</td>
<td>3.2</td>
</tr>
<tr>
<td>Desk-chairs</td>
<td>79</td>
<td>1.6</td>
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<tr>
<td>Pull-up chairs</td>
<td>55</td>
<td>0.48</td>
</tr>
<tr>
<td>Partition (m²)</td>
<td>93.6</td>
<td>2.74</td>
</tr>
<tr>
<td>‘Compactus’</td>
<td>2</td>
<td>19.6</td>
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</tbody>
</table>
Part 2 - Selected floor coverings

Synthetic carpet (11 years)
- Durable & resilient
- Non-renewable petroleum products/recycled material
- Mainly landfilled

Wool carpet (25 years)
- Natural/renewable/durable
- Sheep wool
- Landfilled

Natural Cork Tiles ‘NCT’ (50 years)
- Oak tree bark
- Natural/renewable/resilient/biodegradable
- Landfilled/compostable

Vinyl Composite Tiles ‘VCT’ (40 years)
- Limestone with a polyvinyl chloride (PVC) binder
- Landfilled/incinerated/recycled
Part 1 - FFF LCA Results & discussion

- IEE was 11.55 GJ/m² (literature: 4-12 GJ/m²)
- ‘Churn’ items REE was 5.32, 10.64, 12.77, 14.89 and 21.28 (GJ/m²) respectively
- Over 60 years ‘churn’ items REE was very close to the IEE (13.07 GJ/m²), while over 100 years was 1.62 times this value
- Their REE ranged between 26 and 49% of the building’s total EE
The ‘churn’ items REE was almost half the operational energy of a ‘Good Practice’ office and accounted for \( \frac{1}{4} \) of that of a ‘Typical’ office.

Total embodied energy values were close to the OE values of a ‘Good Practice’ office.
Part 2 - BEES Analysis Results & discussion

- Wool carpet was the most energy and carbon intensive followed by nylon carpet
- Natural Cork Tiles & Vinyl Composite Tiles have low embodied energy & carbon values
- Floor finishes REE over 716.7m² < ‘churn’ items REE
- Wool carpet CO₂e appeared to account for 25% and 14.3% of a ‘Good Practice’ and ‘Typical’ office respectively

Blue-Embodied energy
Red-Embodied Carbon
REE of fittings, fixtures and furniture holds a significant % of the total embodied energy of an office building

The ‘churn’ items’ REE is more important in the case of ‘Good Practice’ buildings

Interior finishes and services have been considered in a number of studies, while they have a much lesser REE effect compared to ‘churn’ items, due to the ‘Make Good’ process

Wool & nylon carpet EE intensity similarity cannot be assumed regarding CO₂e results
Conclusions and Recommendations

- Quantify the impact of fit-out choices & their frequency
- Up to which extent these impede sustainable fit-out
- Investigate the social, financial, fashion & functional drives of the quick cycle fit-out
- Designers, FMs, practitioners & owners need to rethink design choices considering the ‘Make Good’
- Design for shorter cycles/use natural, local, renewable, reusable & recyclable materials/of lower energy intensities & carbon content and not of unnecessary longevity
- Designers, FMs & practitioners need to be educated
Thank you!