Sun Spaces, Monitored & Predicted Performance and Lessons to Improve Design Practice

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Study was commissioned by the Housing Association to:

- provide real data on performance in practice
- To help determine the causes of any performance gaps identified and identify remedial actions
- To use knowledge and insight to inform current and future development plans

Design intent:

- Harnessing passive and active solar gain
- Double-height sunspaces to act as thermal buffer
- Highly insulated, airtight building fabric
### Case Studies

- **Passive Stack Ventilation**
- **Airtightness 5 - 6 m³/h/m²**
- **Sunspace to the back**
- **N/S or NE/SW orientation**
- **107 – 108 m²**

#### Site A

<table>
<thead>
<tr>
<th>Code</th>
<th>Vent.</th>
<th>Site</th>
<th>Typology</th>
<th>Orientation</th>
<th>Floor area</th>
<th>Occupancy</th>
<th>Home occupied</th>
<th>Airtightness (m³/h/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS1A</td>
<td>Passive</td>
<td>A</td>
<td>Semi-detached</td>
<td>N/S</td>
<td>108 m²</td>
<td>2A, 3C</td>
<td>Evenings &amp; weekends</td>
<td>4.76</td>
</tr>
<tr>
<td>PS2A</td>
<td>Stack</td>
<td>A</td>
<td>Semi-detached</td>
<td>NE/SW</td>
<td>107 m²</td>
<td>2A, 5C</td>
<td>All day</td>
<td>5.60</td>
</tr>
<tr>
<td>ME1B</td>
<td>dMEV</td>
<td>B</td>
<td>Semi-detached</td>
<td>N/S</td>
<td>107 m²</td>
<td>2A, 2C</td>
<td>Evenings &amp; weekends</td>
<td>5.99</td>
</tr>
<tr>
<td>ME2B</td>
<td>dMEV</td>
<td>B</td>
<td>Semi-detached</td>
<td>E/W</td>
<td>88 m²</td>
<td>3A</td>
<td>Evenings &amp; weekends</td>
<td>5.42</td>
</tr>
</tbody>
</table>

- **Mechanical Extract Ventilation**
- **Airtightness 5 - 6 m³/h/m²**
- **Sunspace to the front**
- **N/S or E/W orientation**
- **88 – 107 m²**

#### Site B
Methodology

**Stage One**
- 27 Households (75% response rate)
- Design & construction drawings review
- Household survey
- Identified suitable dwellings for detailed monitoring stages

**Stage Two**
- 4 dwellings
- Ventilation performance evaluation
- Seasonal analysis
  - Indoor environmental conditions
  - Occupant diary and interviews
  - Energy consumption
- Measured airflow rates
- Status of ventilation system
- Positioning of trickle vents
- Ventilation noise levels (selected dwellings)

**Stage Three**
- 1-4 dwellings
- Fabric performance testing
- Further detailed monitoring
- Selected dwellings
- Airtightness testing
- Smoke testing
- U-value testing
- Thermography survey
- Volatile Organic Compounds
- PM2.5 and PM10
- Formaldehyde

**DATA SOURCES**
- SAP documents
- Floor plans and sections
- Site plans
- Ventilation information
- Construction information

**DATA COLLECTED**
- Occupant satisfaction with indoor environmental quality
- Occupant behaviour
- Awareness and understanding of ventilation strategies
- Understanding and use of sunspace
- Temperature, RH, CO2 levels
- Summer and winter/spring seasons
- Occupancy levels, activities and behaviour
- Occupant awareness and understanding
- Energy consumption
- Ambient conditions
Monitoring
Sunspace design

Site A

- Double glazed metal insulated frame system
- Glazed door and opening window
- Tiled floor and open joint timber decking
- Wall between building and sunspace is timber studwork faced on both sides with lightweight plasterboard.

Site B
Air supply to sunspace
Insights from the household survey

- Overall, high level of satisfaction with IAQ (93%), natural light levels (100%), indoor temperature (96%) and noise levels (96%) in the home.

- High frequency of reported window opening, particularly during the summer where 67% of households reported opening windows constantly.

- 15% of households experienced problems with overheating in the sunroom.

- 33% of households stated that they didn’t like the sunspaces (due to lack of privacy, functionality of the space / temperature control, or concerns with condensation / dampness).
Insights from the household survey

- High frequency of drying clothes indoors reported

- Clothes typically dried in:
  - Kitchen (40%)
  - Sun space (26%)
  - Living room (24%)

- 41% of households reported noticing condensation, mould or mildew on the walls or surfaces in the sunspace.
### How are the sunspaces used by the occupants?

#### Responses (summer)

- All the time (33%)
- Sitting in (33%)
- Never / don’t use (26%)
- It is too hot (15%)

- “Too hot to be used and it's at the front of the house, so not practical to sit in”
- “It's nice and quiet, a lot for sitting out”
- “Nothing now - may use it for storing garden furniture”
- “As a dining room”
- “I don't use it. Grandkids use as a small playroom but it is like a sauna”
- “Sitting in summer on windy days”

#### Responses (winter)

- All the time (15%)
- Never / don’t use (44%)
- It is too cold (26%)

- “Not really as it's too cold”
- “Kids that visit play there”
- “As a coffee room”
- “I don't use it. In the winter, the window freezes.”
- “All the time for sitting in”
- “Don't use it - too cold.”
Environmental monitoring - Spring temperatures

Temperature levels (1st-7th April) : House 1A

Temperature levels (1st-7th April) : House 1B

Temperature levels (1st-7th April) : House 2A

Temperature levels (1st-7th April) : House 2B
Environmental monitoring – summer temperatures

Temperature levels (18-22nd Aug) : House 1A
- Kitchen
- Main bedroom with sunspace
- Bedroom north facing
- Sunspace (downstairs)

Temperature levels (18-22nd Aug) : House 1B
- Kitchen
- Main bedroom (north)
- Bedroom with south sunroom
- Sunroom (downstairs)

Temperature levels (20-26th Aug) : House 1A
- Kitchen
- Living room
- Main bedroom with sunspace
- Bedroom south facing
- Sunspace (upstairs)

Temperature levels (20-26th Aug) : House 1B
- Kitchen
- Living room
- Main bedroom east sunspace
- Bedroom west facing
- Upstairs sunspace
- Downstairs sunspace

Temperature levels (20-26th Aug) : House 2A
- Kitchen
- Living room
- Main bedroom with sunroom
- Bedroom north facing
- Sunroom (upstairs)

Temperature levels (20-26th Aug) : House 2B
- Kitchen
- Living room
- Main bedroom east sunspace
- Bedroom west facing
- Upstairs sunspace
- Downstairs sunspace
Environmental monitoring – spring humidity levels

Relative humidity levels (1st-7th April) : House 1A

- Kitchen
- Boys bedroom (south facing)
- Main bed (south facing w sun room)
- Upstairs sun space

Relative humidity levels (1st-7th April) : House 1B

- Kitchen
- Bedroom (south)- with sun space
- North bedroom
- Upstairs sunroom

Relative humidity levels (1st-7th April) : House 2A

- Kitchen
- Boys bed (North facing)
- Downstairs sun space

Relative humidity levels (1st-7th April) : House 2B

- Kitchen
- Main bed- east with sun space
- Sun space (upstairs)

Relative humidity levels (1st-7th April) : House 2B

- Kitchen
- Living room
- West facing bedroom
- Sun space (downstairs)
Environmental monitoring – summer humidity levels

Relative humidity levels (18-22nd Aug) : House 1A

Relative humidity levels (20-26th Aug) : House 1B

Relative humidity levels (20-26th Aug) : House 2A

Relative humidity levels (20-26th Aug) : House 2B
Temperature differences

- Peak sunspace temp > 50°C observed in 3 homes (spring and summer)
- Some evidence of overheating, particularly in bedroom adjacent to sunspace (2A)
- Key differences observed between East and West facing sunspaces

<table>
<thead>
<tr>
<th>House No</th>
<th>Room</th>
<th>Spring (March – April)</th>
<th>Summer (August – September)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Temp (°C)</td>
<td>RH (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max  Min  Mean</td>
<td>Max  Min  Mean</td>
</tr>
<tr>
<td>PS1A</td>
<td>Downstairs sunspace (S)</td>
<td>57  4  17</td>
<td>96  7  48</td>
</tr>
<tr>
<td></td>
<td>Adjacent kitchen</td>
<td>28  18  23</td>
<td>65  28  43</td>
</tr>
<tr>
<td></td>
<td>Upstairs sunspace (S)</td>
<td>55  4  19</td>
<td>89  12  44</td>
</tr>
<tr>
<td></td>
<td>Adjacent bedroom</td>
<td>34  17  23</td>
<td>67  23  45</td>
</tr>
<tr>
<td>PS2A</td>
<td>Downstairs sunspace (SW)</td>
<td>44  7  16</td>
<td>79  13  52</td>
</tr>
<tr>
<td></td>
<td>Adjacent kitchen</td>
<td>24  13  19</td>
<td>68  24  47</td>
</tr>
<tr>
<td></td>
<td>Upstairs sunspace (SW)</td>
<td>52  7  17</td>
<td>75  14  48</td>
</tr>
<tr>
<td></td>
<td>Adjacent bedroom</td>
<td>48  17  21</td>
<td>64  14  47</td>
</tr>
<tr>
<td>ME1B</td>
<td>Downstairs sunspace (S)</td>
<td>33  7  19</td>
<td>69  14  42</td>
</tr>
<tr>
<td></td>
<td>Adjacent living room</td>
<td>26  13  20</td>
<td>58  20  40</td>
</tr>
<tr>
<td></td>
<td>Upstairs sunspace (S)</td>
<td>52  5  20</td>
<td>72  5  41</td>
</tr>
<tr>
<td></td>
<td>Adjacent bedroom</td>
<td>25  16  20</td>
<td>53  19  38</td>
</tr>
<tr>
<td>ME2B</td>
<td>Downstairs sunspace (E)</td>
<td>29  7  14</td>
<td>89  24  61</td>
</tr>
<tr>
<td></td>
<td>Adjacent living room</td>
<td>25  15  20</td>
<td>71  28  48</td>
</tr>
<tr>
<td></td>
<td>Upstairs sunspace (E)</td>
<td>39  6  16</td>
<td>88  17  59</td>
</tr>
<tr>
<td></td>
<td>Adjacent bedroom</td>
<td>26  14  20</td>
<td>66  30  50</td>
</tr>
</tbody>
</table>
Sunspace airtightness

- Airtightness tests performed in all 4 homes
- Tests performed with sunroom doors opened and closed
- Tests revealed air infiltration through the sunspaces
- The results suggest sunspaces are not that airtight in some homes and there is uncontrolled leakage
- This may have an impact on the low night time temperatures observed in these spaces

<table>
<thead>
<tr>
<th>House No.</th>
<th>Excluding sunroom</th>
<th>Including sunroom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average air permeability (m³/h/m²)</td>
<td>Average Air Changes per Hour (ACH)</td>
</tr>
<tr>
<td>PS1A</td>
<td>4.76</td>
<td>4.51</td>
</tr>
<tr>
<td>PS2A</td>
<td>5.60</td>
<td>5.31</td>
</tr>
<tr>
<td>ME1B</td>
<td>5.99</td>
<td>5.69</td>
</tr>
<tr>
<td>ME2B</td>
<td>5.42</td>
<td>5.50</td>
</tr>
</tbody>
</table>
Summary of key findings

- While the Scottish climate suggests using solar energy is not the most feasible option, results suggest sunspaces can be particularly beneficial in Spring / Autumn seasons.

- The key however is occupant understanding and interaction with the sunspace.

- As spaces unheated, may not be considered as habitable rooms, however can provide additional living space when conditions allow.

- Raises concerns regarding occupant expectations, which may result in complaints.

- This is supported by reports of overheating in sunspace.

- In theory, thermally isolated sunspaces can be used as heat collector, providing heat for adjacent rooms.

- Since sunspaces not included in main building fabric, temp & RH swings expected.

- A quarter of homes use sunspace for drying clothes—good idea providing ventilation is sufficient.

- Reports of condensation and dampness (supported by measurements). RH levels highest in East facing sunspace.

- Attributed to: i) temp swings overnight, ii) warm air escaping & condensing on cold sunspace surfaces, iii) drying clothes in sunspace (if inadequately ventilated).
**Recommendations**

- Methods to purge vent the sunspaces while maintaining security during hot spells
- Greater consideration should be given to air pathways between the sunspaces and the heated interior
- Summer shading (integral) recommended to tackle overheating
- Insulated blinds could be used to reduce back losses at night and prevent overheating during peak summer months
- To maximise preheat ventilation of air, an integrated air extract and supply system could be installed to help distribute solar gain throughout the house
- Residents should be advised that sunspace can be used to dry clothes on sunny day when vents open, however the moisture source should be removed at night
Thank you

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