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

Dr Gráinne McGill
Researcher, Mackintosh Environmental Architecture Research Unit,
Glasgow School of Art

Context

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 $m^3/h/m^2$
- Sunspace to the back
- N/S or NE/SW orientation
- 107 – 108 m^2

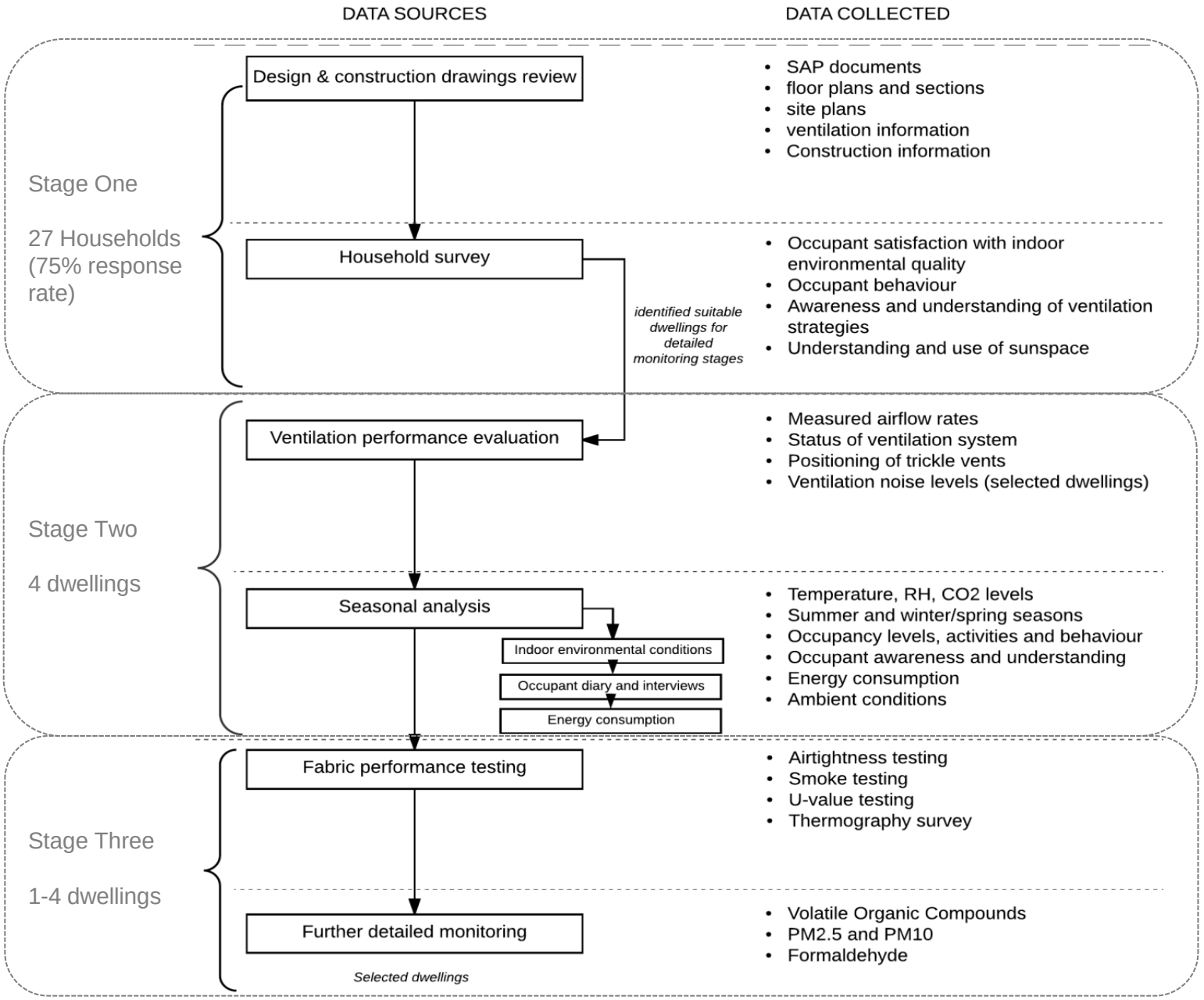
Site A

- Mechanical Extract Ventilation
- Airtightness 5 - 6 $m^3/h/m^2$
- Sunspace to the front
- N/S or E/W orientation
- 88 – 107 m^2

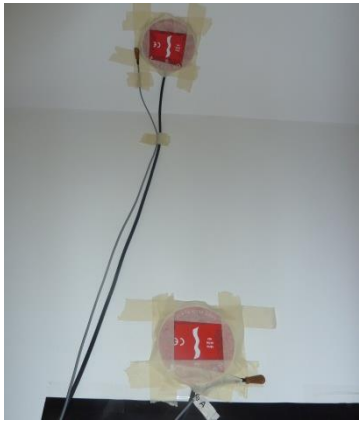
Site B

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

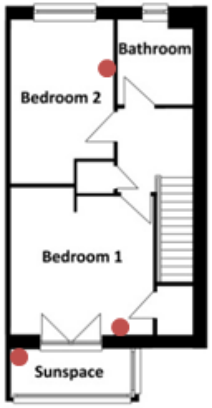
Methodology

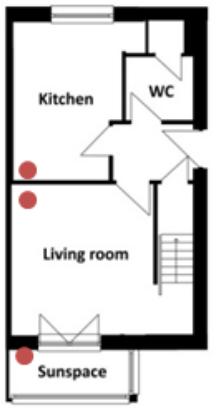


Monitoring

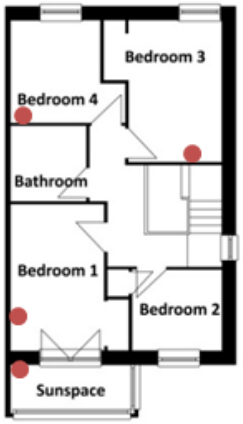


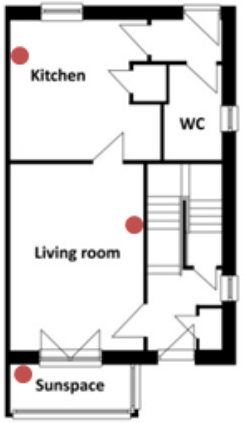
Floor plans



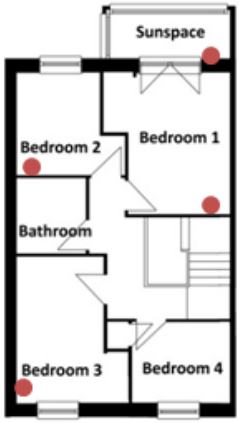


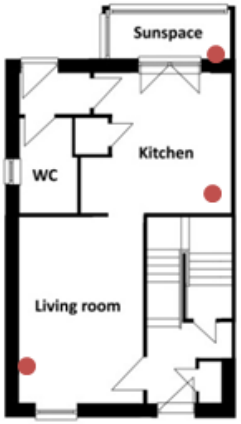
ME1B



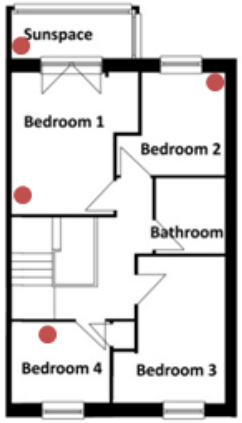


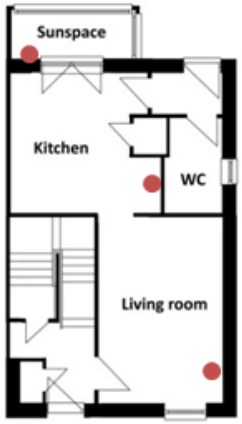
ME2B





PS1A





PS2A

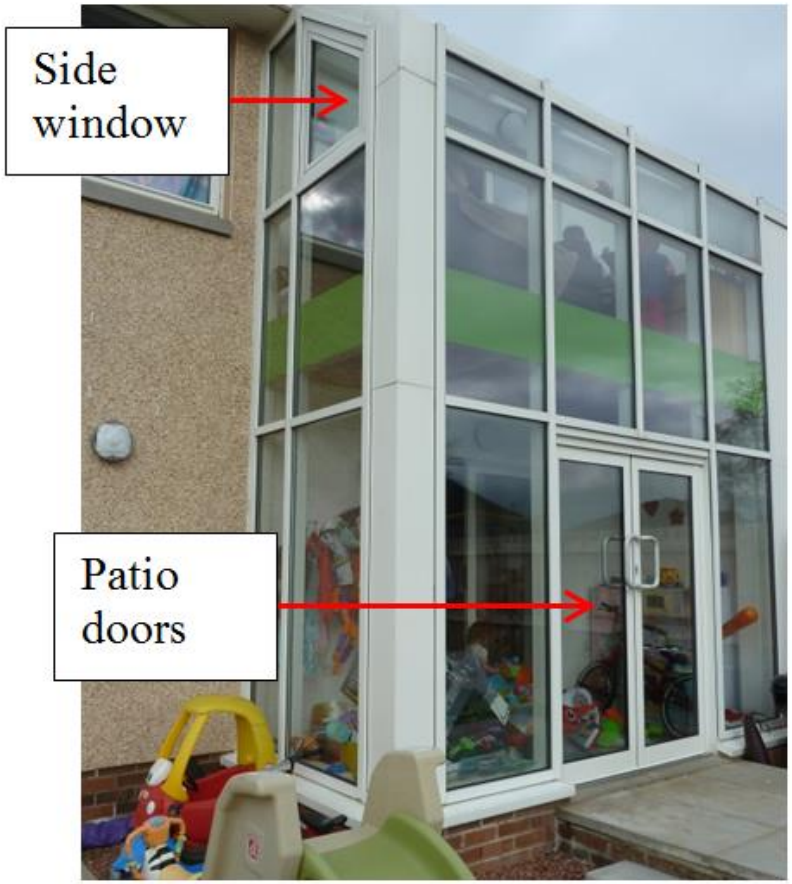
Sunspace design

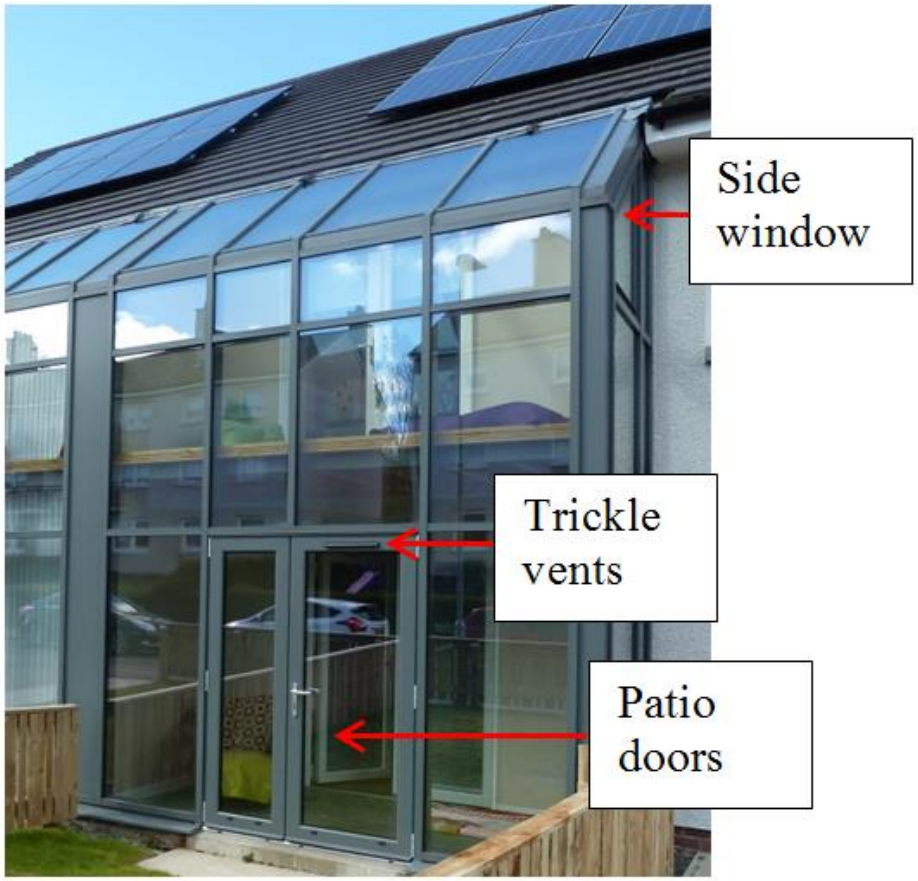
Site A

Site B

- 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.

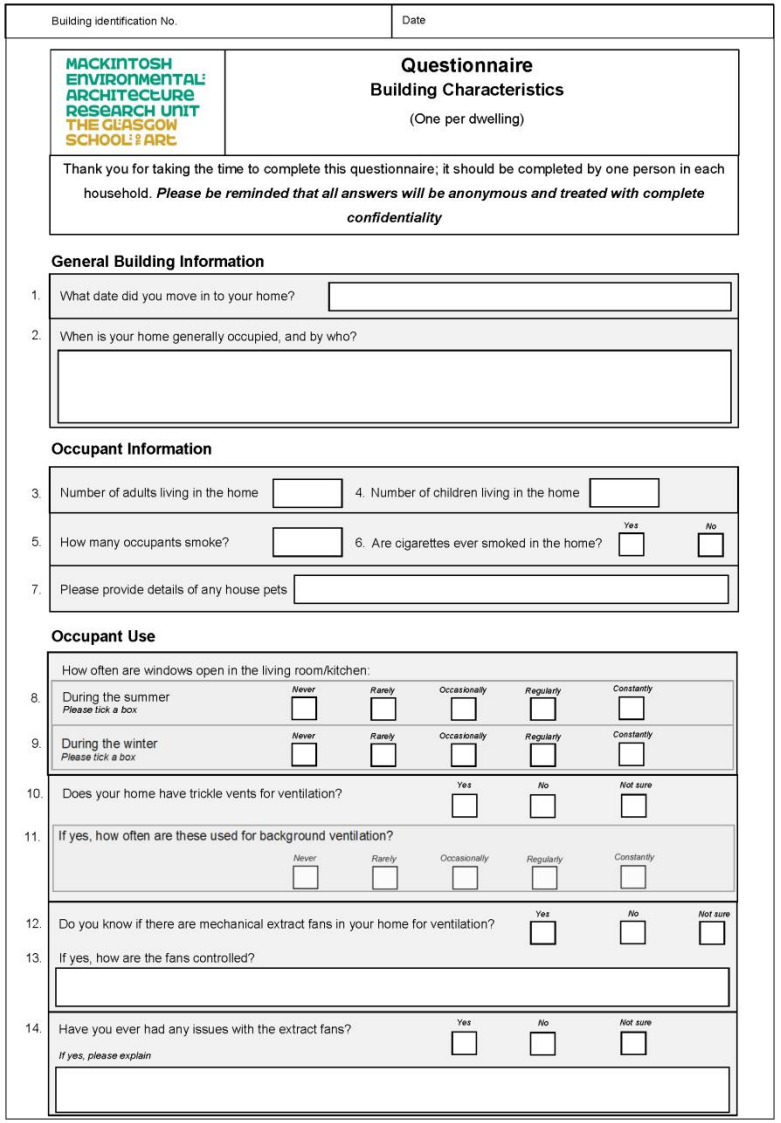
Air supply to sunspace





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)



Building identification No. | Date

MACKINTOSH ENVIRONMENTAL ARCHITECTURE RESEARCH UNIT THE GLASGOW SCHOOL OF ART

Questionnaire
Building Characteristics
(One per dwelling)

Thank you for taking the time to complete this questionnaire; it should be completed by one person in each household. ***Please be reminded that all answers will be anonymous and treated with complete confidentiality***

General Building Information

1. What date did you move in to your home?
2. When is your home generally occupied, and by who?

Occupant Information

3. Number of adults living in the home
4. Number of children living in the home
5. How many occupants smoke?
6. Are cigarettes ever smoked in the home? Yes / No
7. Please provide details of any house pets

Occupant Use

How often are windows open in the living room/kitchen:

8. During the summer *Please tick a box* — Never / Rarely / Occasionally / Regularly / Constantly
9. During the winter *Please tick a box* — Never / Rarely / Occasionally / Regularly / Constantly
10. Does your home have trickle vents for ventilation? Yes / No / Not sure
11. If yes, how often are these used for background ventilation? Never / Rarely / Occasionally / Regularly / Constantly
12. Do you know if there are mechanical extract fans in your home for ventilation? Yes / No / Not sure
13. If yes, how are the fans controlled?
14. Have you ever had any issues with the extract fans? Yes / No / Not sure
    If yes, please explain

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"

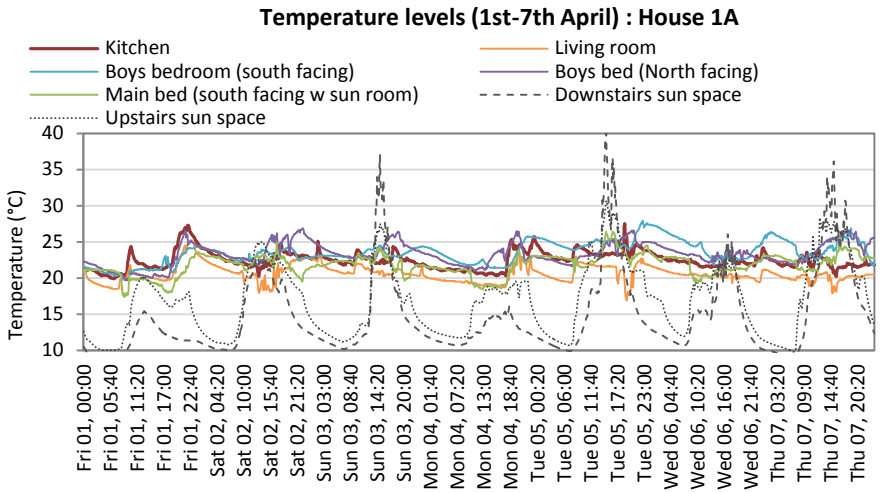
"As a coffee room"

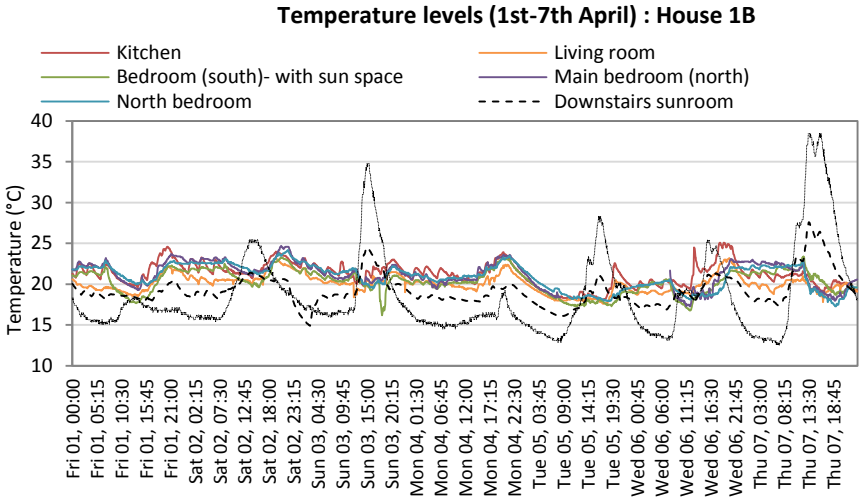
"I don't use it. In the winter, the window freezes."

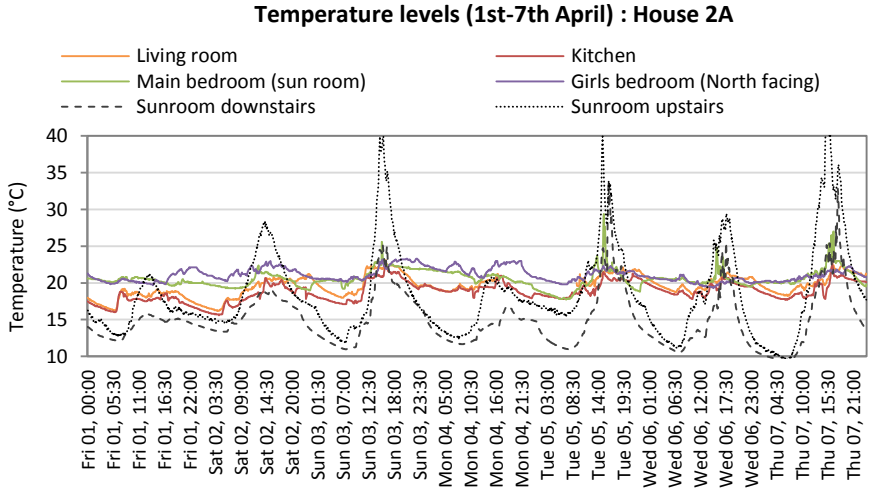
"All the time for sitting in"

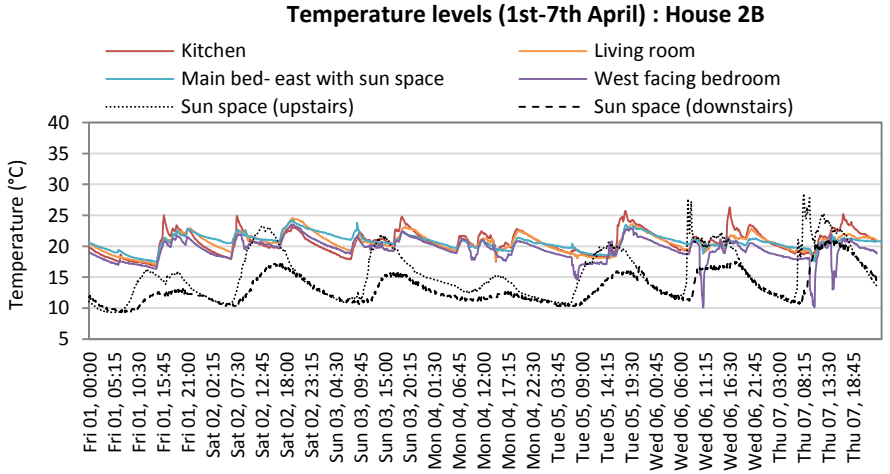
"Don't use it - too cold."

Environmental monitoring - Spring temperatures

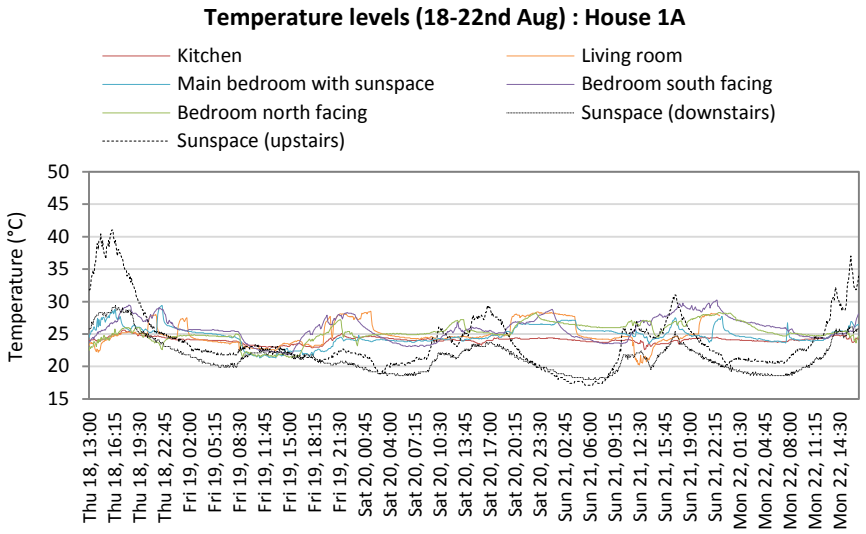


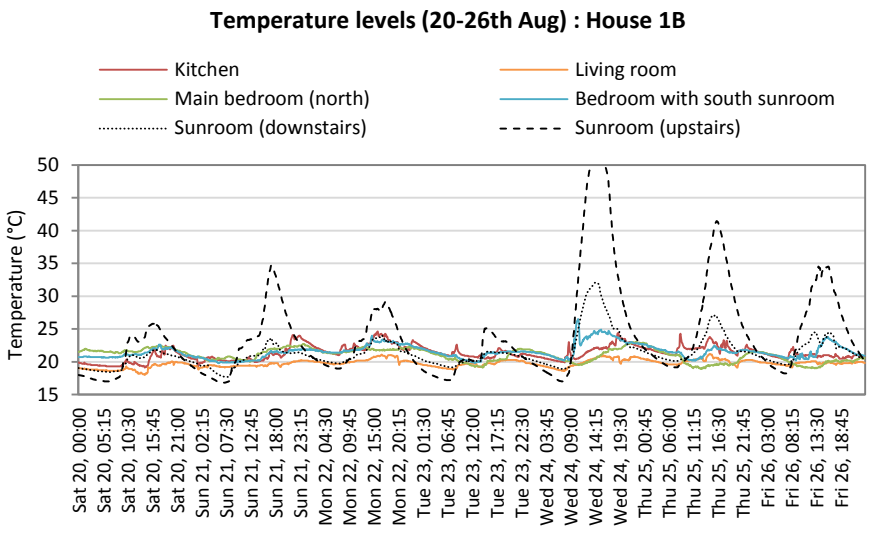


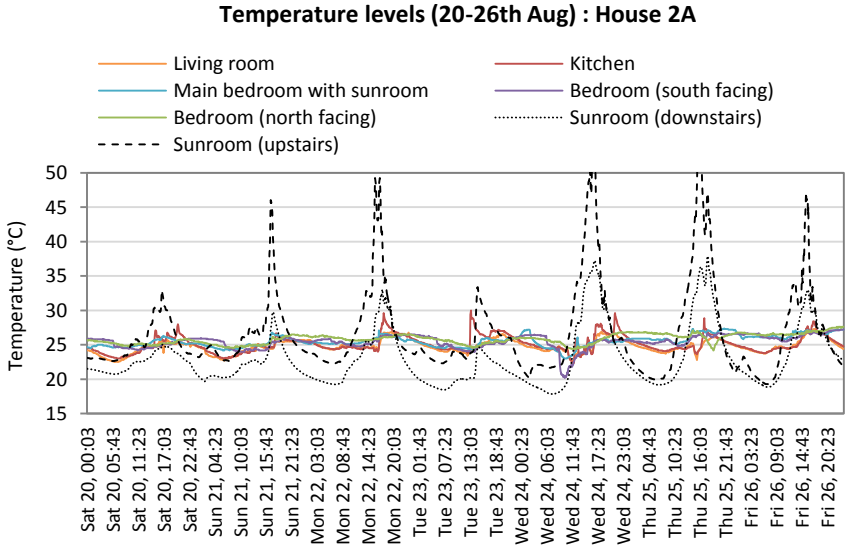


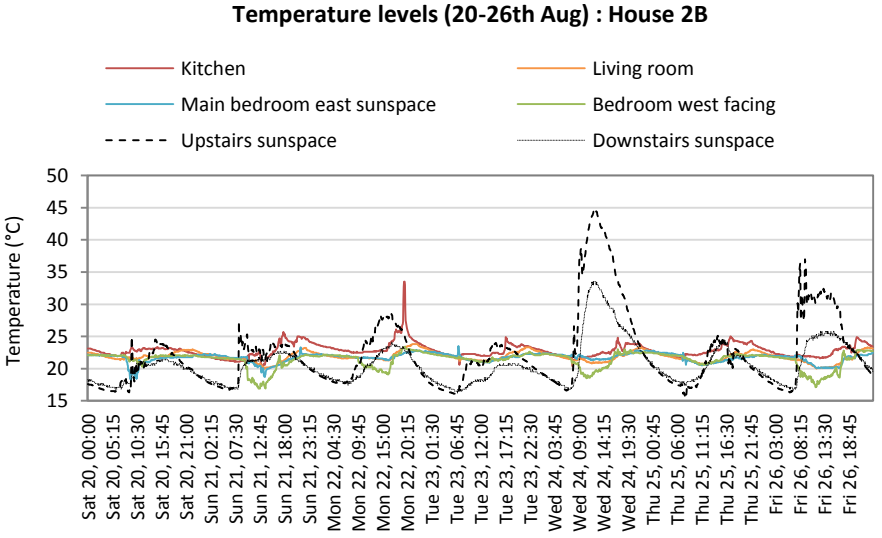


Environmental monitoring – summer temperatures

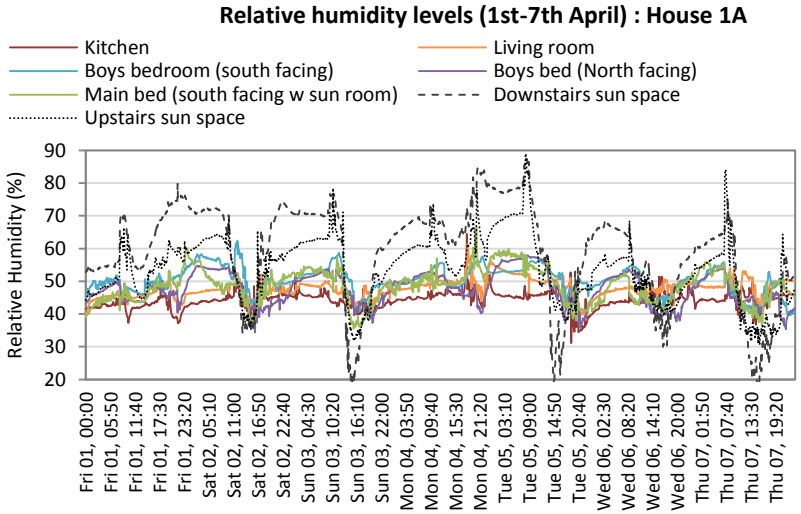


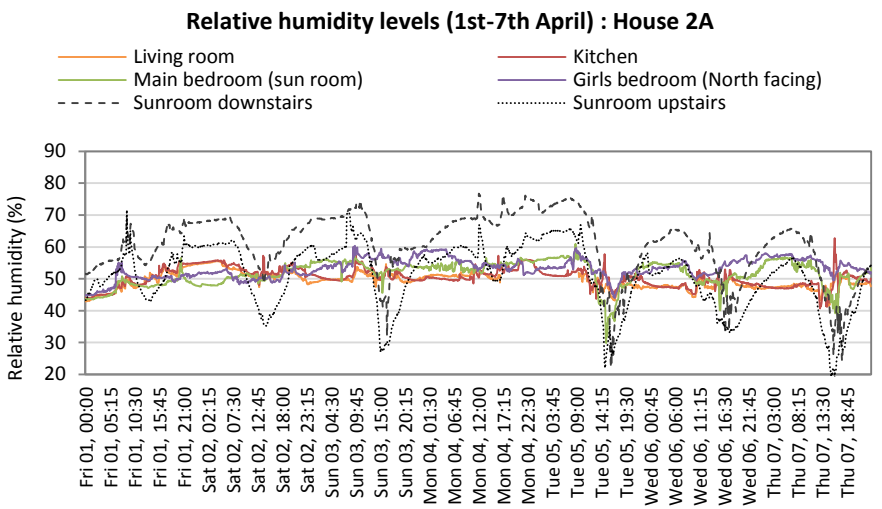


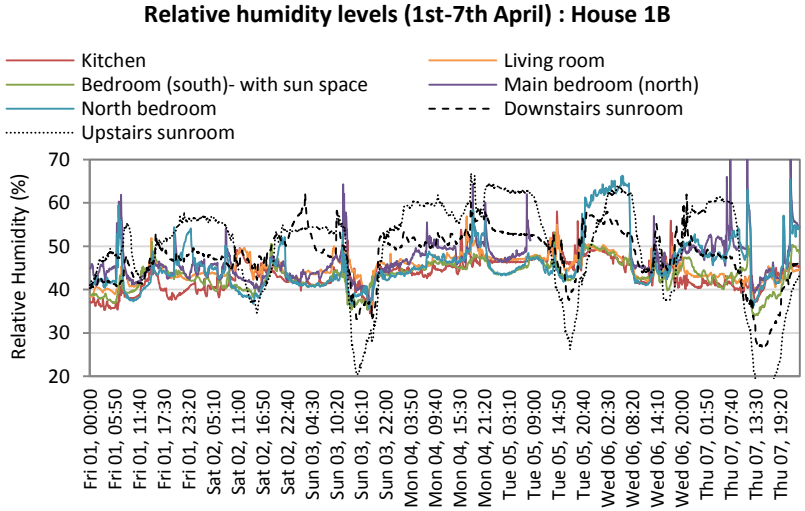


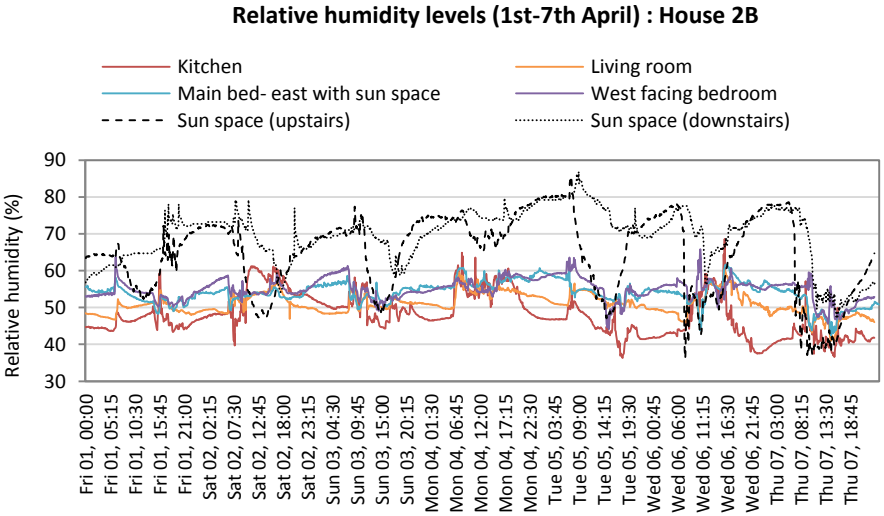


Environmental monitoring – spring humidity levels

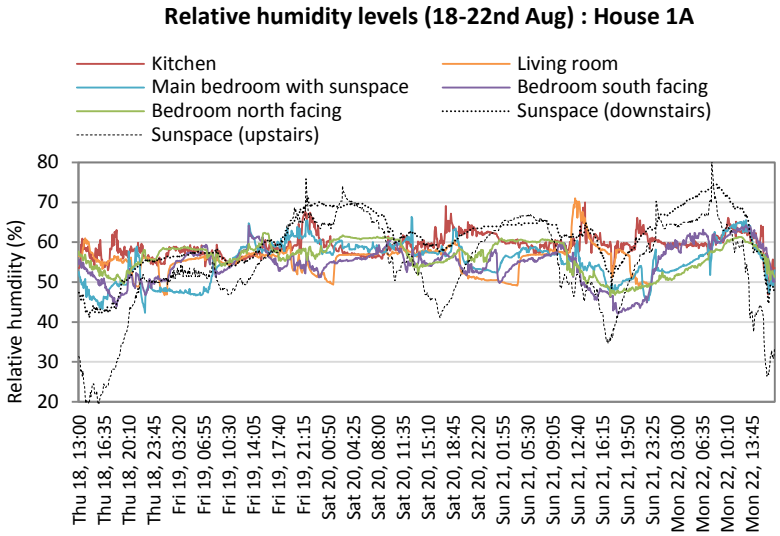


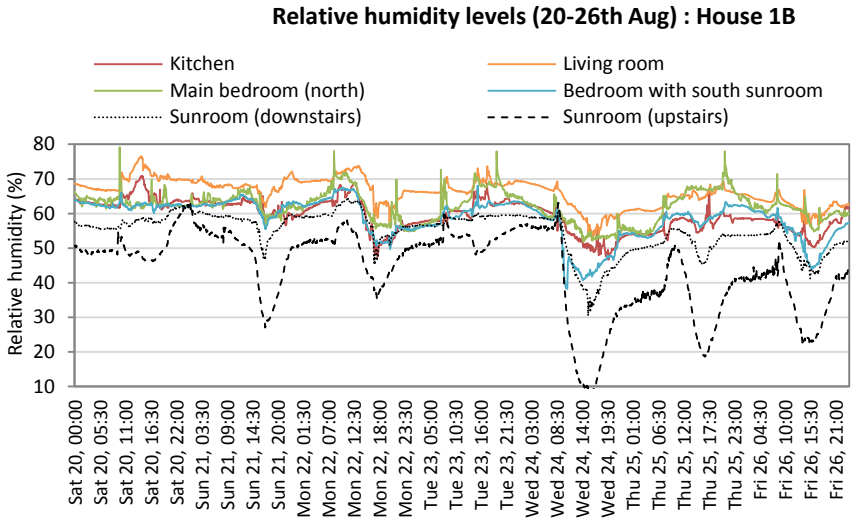


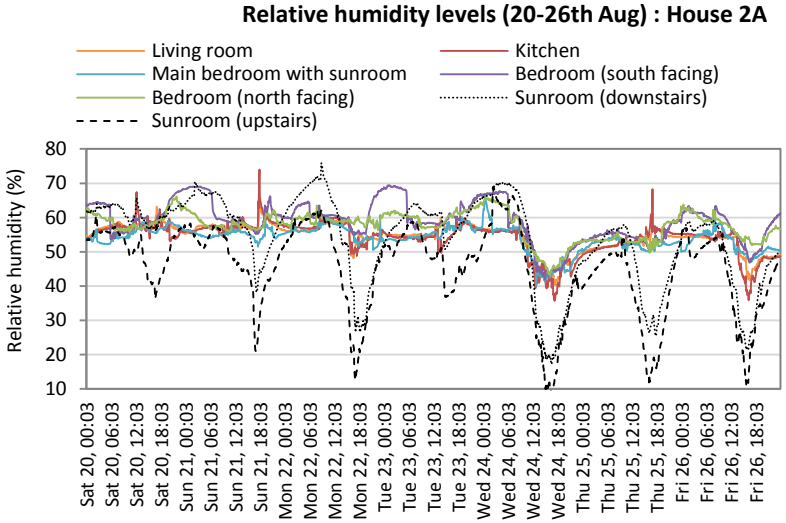


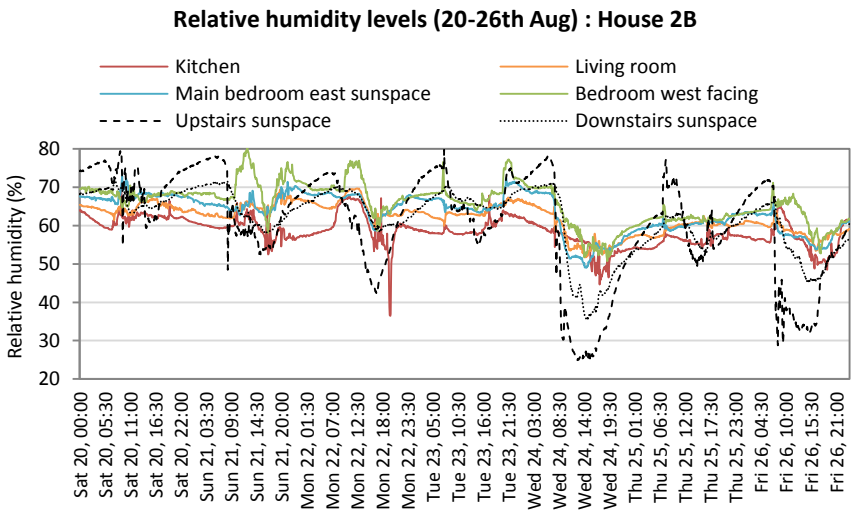


Environmental monitoring – summer humidity levels









Temperature differences

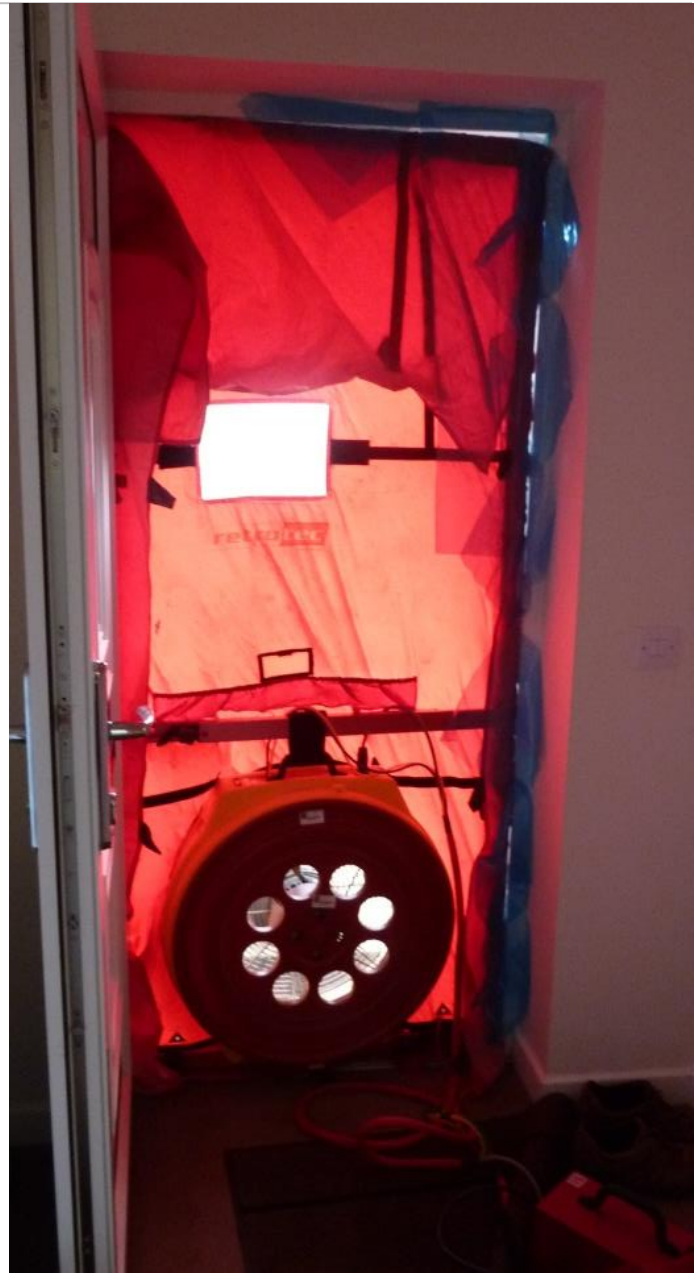
- Peak sunspace temp > 50°C observed in 3 homes (spring and summer)
- Some evidence of overheating, particularly in bedroom adjacent to sunspace (2A)
- Key differences observed between East and West facing sunspaces

		Spring (March – April)						**Summer (August – September)**					
		Temp (°C)			RH (%)			Temp (°C)			RH (%)		
House No	Room	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
PS1A	Downstairs sunspace (S)	57	4	17	96	7	48	41	15	23	84	26	58
	Adjacent kitchen	28	18	23	65	28	43	26	21	24	70	43	58
	Upstairs sunspace (S)	55	4	19	89	12	44	52	14	22	87	10	56
	Adjacent bedroom	34	17	23	67	23	45	31	21	25	68	34	55
PS2A	Downstairs sunspace (SW)	44	7	16	79	13	52	44	16	23	79	12	55
	Adjacent kitchen	24	13	19	68	24	47	31	22	25	74	36	55
	Upstairs sunspace (SW)	52	7	17	75	14	48	62	16	26	72	8	47
	Adjacent bedroom	48	17	21	64	14	47	32	23	26	68	40	55
ME1B	Downstairs sunspace (S)	33	7	19	69	14	42	33	17	22	69	31	55
	Adjacent living room	26	13	20	58	20	40	23	18	20	79	52	65
	Upstairs sunspace (S)	52	5	20	72	5	41	53	15	24	69	9	45
	Adjacent bedroom	25	16	20	53	19	38	27	19	22	75	38	57
ME2B	Downstairs sunspace (E)	29	7	14	89	24	61	34	16	21	80	35	61
	Adjacent living room	25	15	20	71	28	48	25	20	22	72	40	61
	Upstairs sunspace (E)	39	6	16	88	17	59	45	15	22	86	22	60
	Adjacent bedroom	26	14	20	66	30	50	25	18	22	74	44	62

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

	Excluding sunroom		**Including sunroom**	
House No.	Average air permeability (m3/h/m2)	Average Air Changes per Hour (ACH)	Average air permeability (m3/h/m2)	Average Air Changes per Hour (ACH)
PS1A	4.76	4.51	11.0	10.4
PS2A	5.60	5.31	14.5	13.7
ME1B	5.99	5.69	8.0	7.6
ME2B	5.42	5.50	7.1	7.2



Summary of key findings

- While the Scottish climate suggests using suns energy not 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

Dr Gráinne McGill

Mackintosh Environmental Architecture Research Unit (MEARU)

Glasgow School of Art

g.mcgill@gsa.ac.uk