Fuel Poverty Research Network (FPRN)

Research at the University of Salford's Energy House

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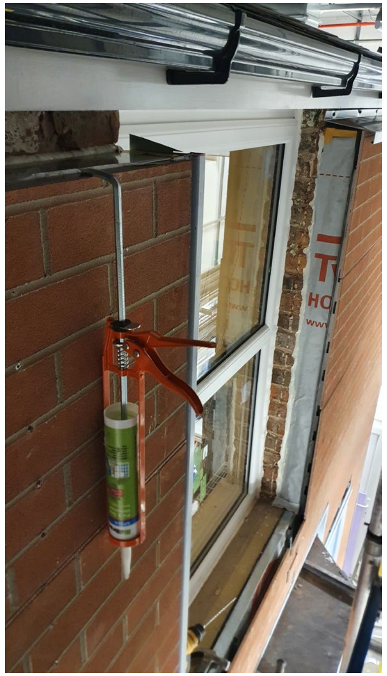
University of Salford Energy House 1 Test Facility

- Salford Energy House (Energy House 1)
  - Replica of a pre-1920 end-terrace built using reclaimed materials and construction methods of its time
  - Over 200 permanent sensors monitoring energy and environmental conditions
  - Additional ~150 sensors installed for DEEP
  - Central heating system can be fed by either a boiler or air source heat pump
  - Automation of openings, appliance use, domestic hot water
  - Adjoining dwelling enables conditions in neighbour to be simulated
- Environmental chamber
  - Temperature range of -12°C to 30°C
  - Simulate wind, rain, and solar radiation
  - **Provides a repeatable test environment**

DEEP Retrofit Project

- DESNZ Demonstrationn of Energy Efficiency Potential (DEEP) Project
  - Collaboration with Leeds Beckett University and Loughborough University
- Energy House 1 provided a detailed **case study** investigating solid wall fabric retrofit thermal performance and its interaction with space heating systems
- Test aims:
  - Compare differences between piecemeal and whole house approaches to solid wall retrofit
  - Identify unintended consequences of fabric retrofit focusing on the risk of surface condensation and mould growth at junctions between elements
- Methodology:
  - Full fabric retrofit of the Salford Energy House following both approaches to fabric retrofit
  - Fabric thermal performance measurements throughout the retrofit process



Energy House DEEP Piecemeal Fabric Retrofit Programme

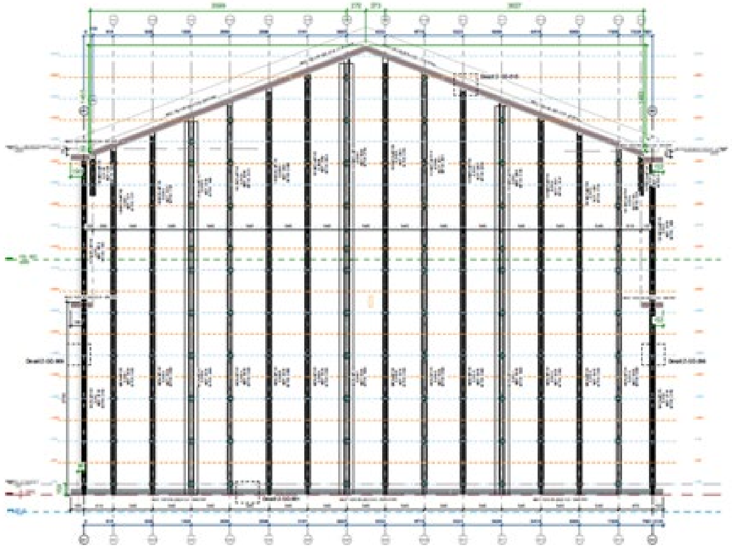
<table>
<tr><th>Test stage\Retrofit</th><th>Roof</th><th>Openings</th><th>Ground floor</th><th>External walls</th><th>Whole house approach measures</th></tr>
<tr><td>Stage 1 - baseline</td><td>Cold roof - 100 mm mineral wool</td><td rowspan="2">'E' rated uPVC double glazing and doors</td><td rowspan="3">Suspended timber - uninsulated</td><td rowspan="4">225 mm brick with 12.5 mm wet plaster</td><td rowspan="5">Junctions untreated</td></tr>
<tr><td>Stage 2 - roof</td><td rowspan="4">Additional 170 mm mineral wool. Total 270 mm mineral wool</td></tr>
<tr><td>Stage 3 - openings</td><td rowspan="3">'A' rated uPVC double glazing and GRP doors</td></tr>
<tr><td>Stage 4 - ground floor</td><td rowspan="2">150 mm mineral wool between joists + vapour barrier</td></tr>
<tr><td>Stage 5 - EWI [piecemeal approach full retrofit]</td><td>102 mm mineral wool external wall insulation (EWI)</td></tr>
</table>

- Simulation of the piecemeal full fabric retrofit process
- Fabric thermal performance measurements at each test stage

Energy House DEEP Piecemeal Retrofit Measures

- Conventional retrofit materials
- Specified to meet Approved Document Part L1b
- Installation intended to simulate 'typical' practice

Energy House DEEP Piecemeal Approach to EWI



Energy House DEEP Whole House Approach Retrofit

<table>
<tr><th></th><th>Test stage\Retrofit</th><th>Roof</th><th>Openings</th><th>Ground floor</th><th>External walls</th><th>Whole house approach measures</th></tr>
<tr><td rowspan="5">Piecemeal retrofit approach retrofit</td><td>Stage 1 - baseline</td><td>Cold roof - 100 mm mineral wool</td><td rowspan="2">'E' rated uPVC double glazing and doors</td><td rowspan="3">Suspended timber - uninsulated</td><td rowspan="4">225 mm brick with 12.5 mm wet plaster</td><td rowspan="5">Junctions untreated</td></tr>
<tr><td>Stage 2 - roof</td><td rowspan="8">Additional 170 mm mineral wool. Total 270 mm mineral wool</td></tr>
<tr><td>Stage 3 - openings</td><td rowspan="7">'A' rated uPVC double glazing and GRP doors</td></tr>
<tr><td>Stage 4 - ground floor</td><td rowspan="6">150 mm mineral wool between joists + vapour barrier</td></tr>
<tr><td>Stage 5 - EWI [piecemeal approach full retrofit]</td><td rowspan="5">102 mm mineral wool external wall insulation (EWI)</td></tr>
<tr><td rowspan="4">Whole house approach measures</td><td>Stage 6a - EWI below DPC</td><td>EWI below DPC</td></tr>
<tr><td>Stage 6b - Bay window</td><td>Bay window roof, mullions, and sill externally insulated</td></tr>
<tr><td>Stage 6c - Extend eaves</td><td>Eaves extended to link loft insulation with EWI</td></tr>
<tr><td>Stage 6d - openings into EWI [whole house approach full retrofit]</td><td>Openings moved inline with EWI</td></tr>
</table>

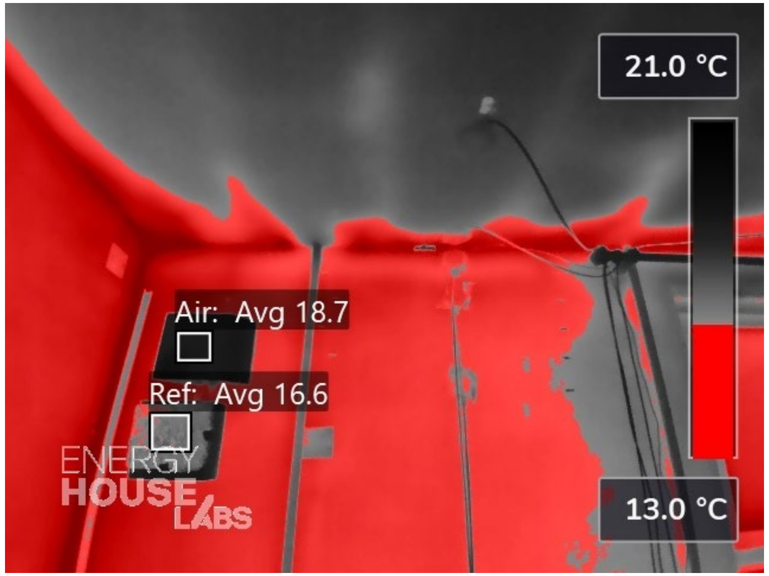
Conversion from piecemeal full retrofit to whole house approach full retrofit

Energy House DEEP Whole House Approach Measures

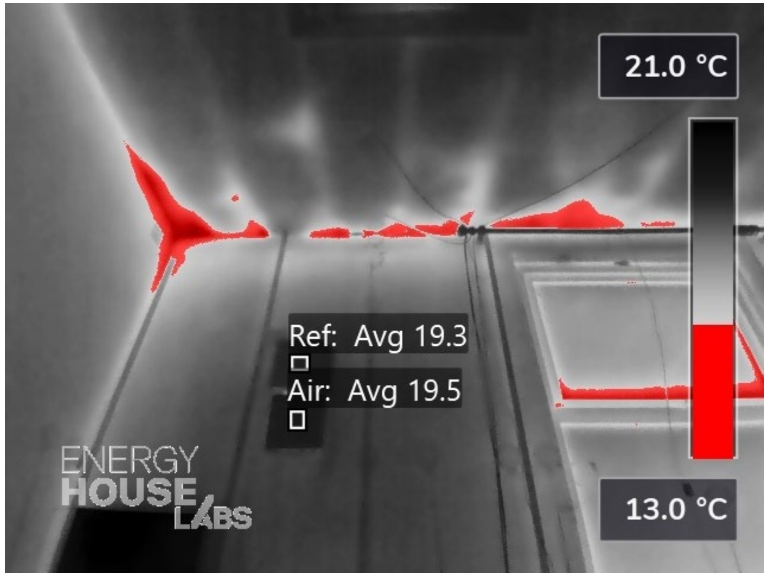
- EWI extended below DPC level
- Bay window roof, mullions, and sill insulated
- Eaves extended to link loft insulation and EWI
- Openings moved within the EWI

Energy House DEEP Surface Condensation and Mould Risk

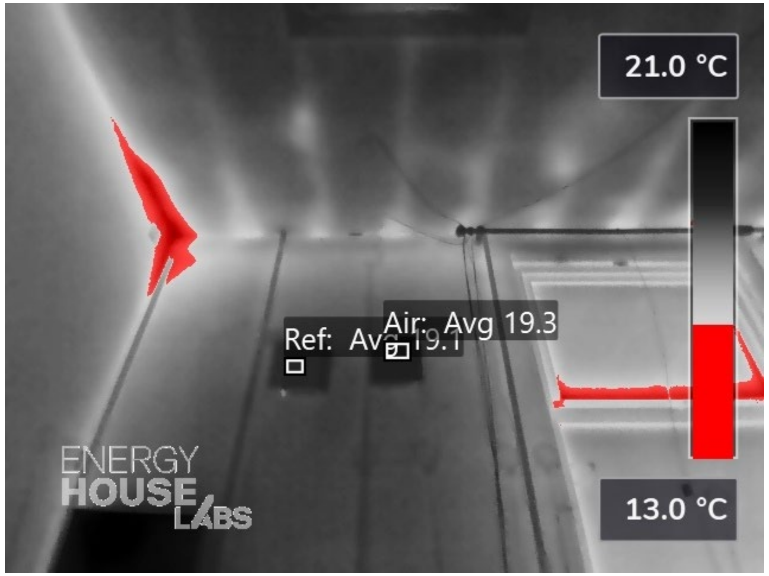
- Pre-existing risk locations on front elevation:
  - External wall surfaces
  - Corner, eaves, and gable junctions
- EWI removed risk across wall surface and corner
- Extending eaves to link loft insulation with EWI removed risk at most eaves locations
- Residual risk at eaves/gable interface at verge due to difficulty installing insulation



Stage 2 – Loft retrofit



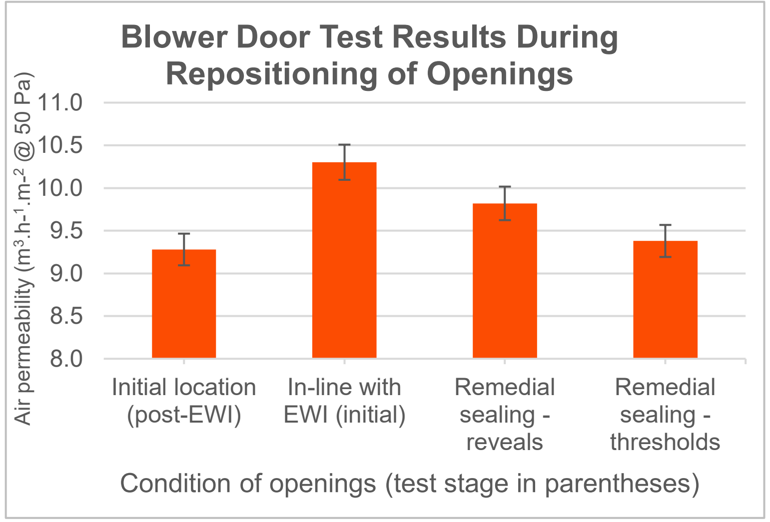
Stage 5 – EWI retrofit

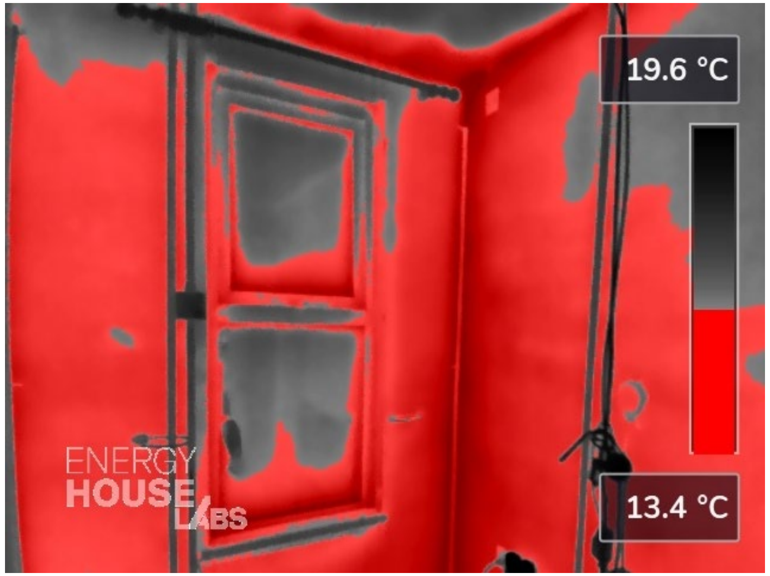


Stage 6c – Eaves extended

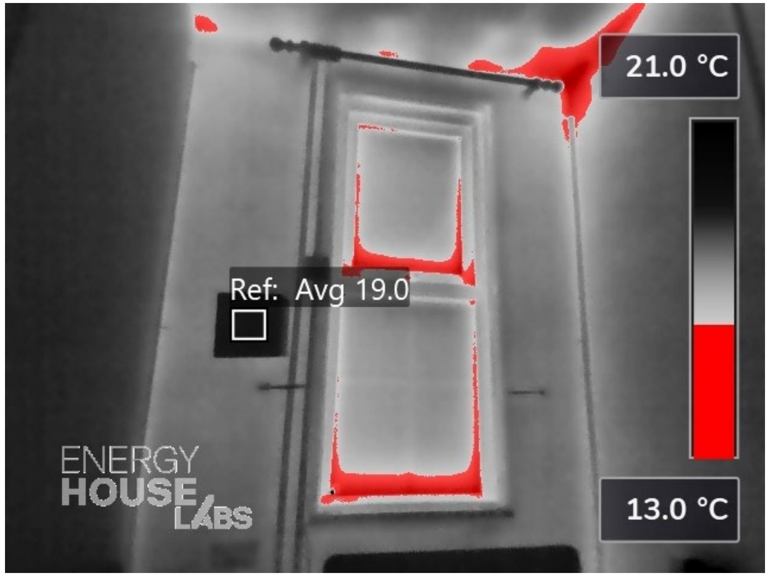
Energy House DEEP Surface Condensation and Mould Risk

- Pre-existing risk locations on rear elevation:
  - External wall surface and junctions similar to front elevation
  - Window jamb and sill
- EWI + eaves extension had similar impact on both elevations
- EWI reduced risk around window reveals, notably on jambs
- Repositioning openings increased risk at some locations
- Work to reposition openings initially reduced airtightness
- Remedial sealing was required around reveals and thresholds

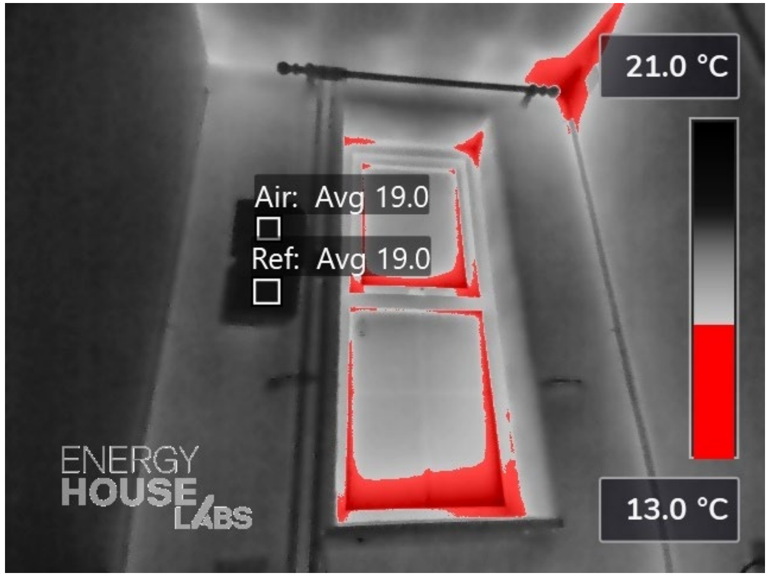




Stage 3 – 'A' rated glazing

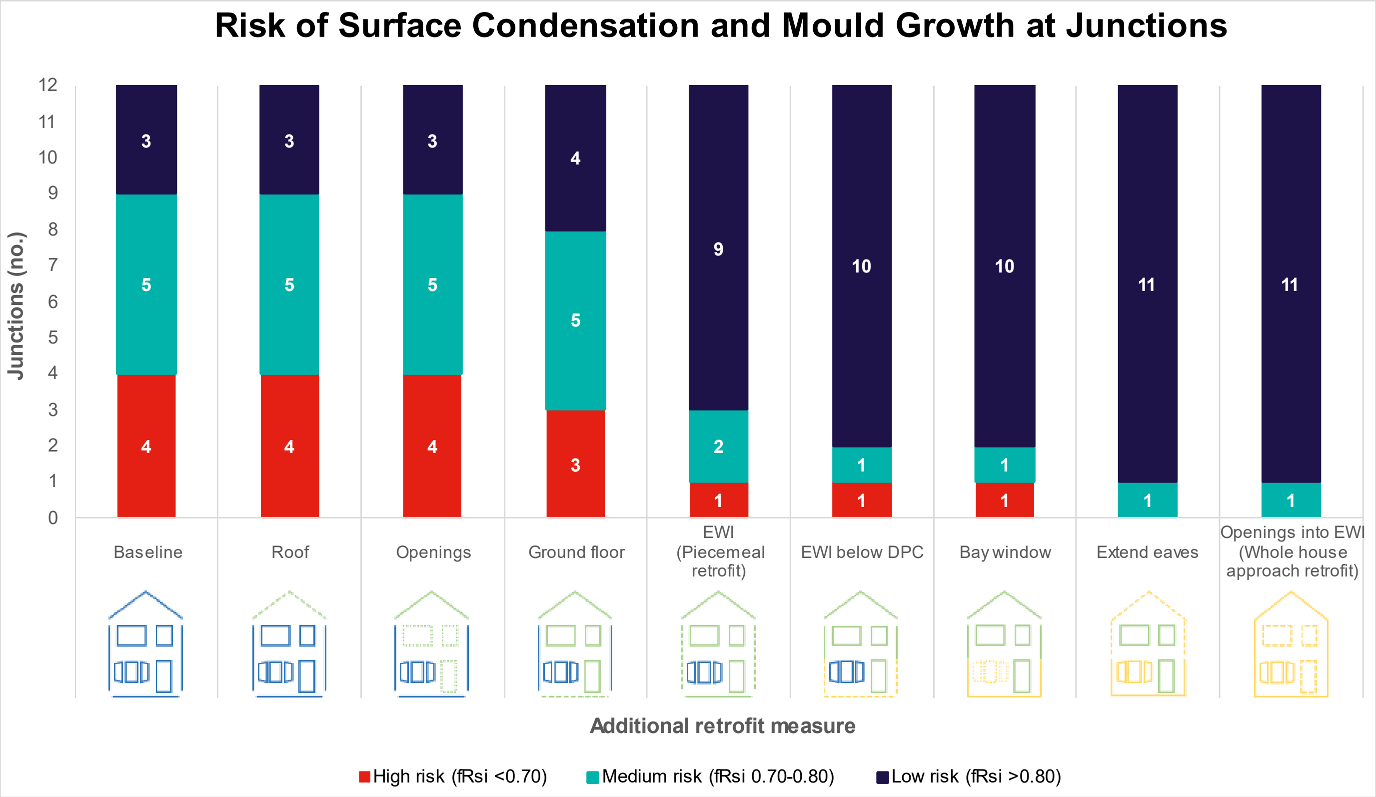


Stage 6c – EWI + eaves extended



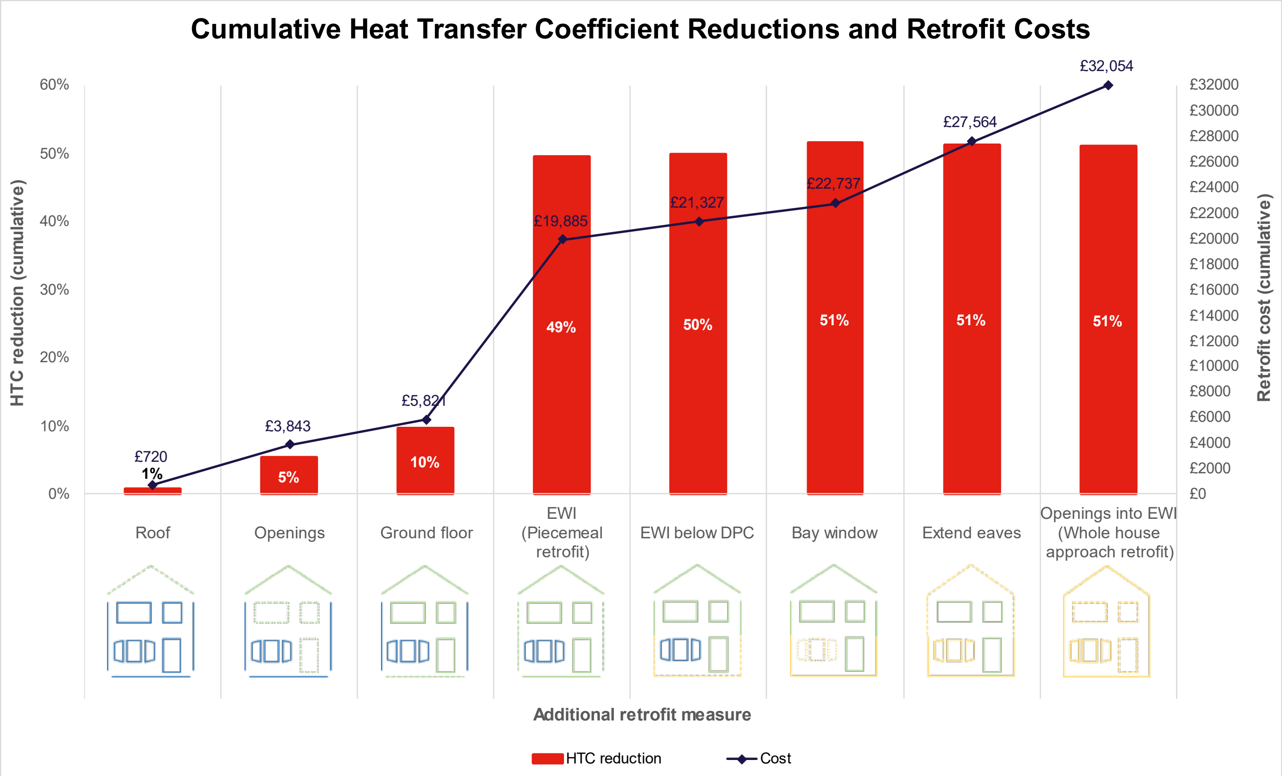
Stage 6c – Openings into EWI

Energy House DEEP Surface Condensation & Mould Growth Risk



- 9 baseline junctions considered a risk of surface condensation or mould growth
- 3 junctions remained a risk following piecemeal retrofit risk
- 1 junction remained a (medium) risk following whole house approach retrofit
- **Not all whole house measures were required** (e.g. repositioning of openings)

Energy House DEEP Retrofit Fabric Heat Loss and Cost



- Piecemeal approach full retrofit resulted in a 49% HTC reduction from baseline
- Whole house approach retrofit resulted in a 51% HTC reduction from baseline
  - Whole house approach measures increased cost of retrofit by ~50%
  - Some whole house measures could be considered unnecessary
  - **Whole house measures many not significantly reduce space heating energy bills**
- EWI resulted in a 44% HTC reduction from previous stage
  - Most effective HTC reduction measure, but also most costly
  - Most effective measure at removing risks at junctions

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Energy House DEEP Fabric Testing Summary

- The whole house approach retrofit resulted in a lower risk of surface condensation and mould growth than the piecemeal retrofit
  - The fabric retrofit work required to minimise the risk of surface condensation cannot be financed through paybacks in space heating energy savings
    - Alternative funding models may be required
  - Some whole house measures were not required and added unnecessary cost to the retrofit
    - Survey tools that identify junctions that that require treatment will help specifiers decide which measures are appropriate and provide quality assurance of retrofits
- Existing piecemeal retrofits can be converted to whole house approach retrofits
  - Care needs to be taken not to damage existing thermal and airtightness barriers

Nesta – Boiler Flow Temperature

Salford Energy House Boiler Flow Temperature Testing

Initial Report

October 2022

University of Salford: David Farmer, Grant Henshaw, Ben Roberts, Professor Richard Fitton, Professor Will Swan

Heating consultant: Richard Burrows – Mid Wales Plumbing & Heating Supplies Limited

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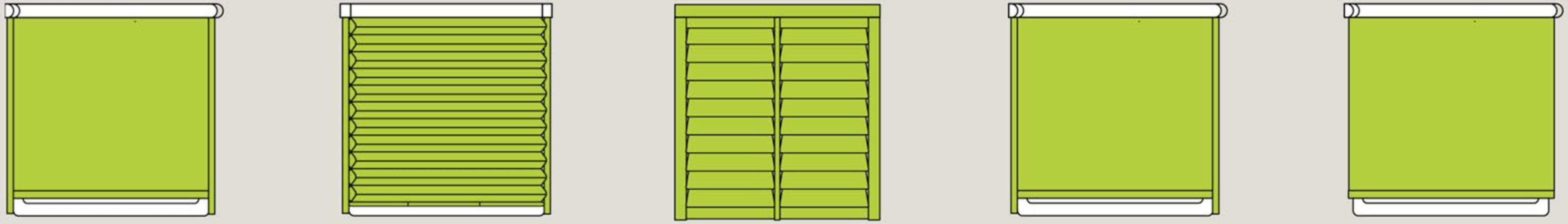
https://www.nesta.org.uk/report/salford-energy-house-boiler-flow-temperature-testing-initial-report-october-2022/

Nesta – Boiler Flow Temperature

Season	Flow temp. (°C)	Change in gas use		Change in boiler efficiency (% points)		Living room cycle temp. (°C)	Heat-up time (mins)	
		70 °C baseline	80 °C baseline	70 °C baseline	80 °C baseline		AM	PM
Winter	80	+5%	-	-1	-	21.0	23	24
Winter	70.2	-	-5%	-	+1	20.7	30	31
Winter	60.8	-7%	-12%	+4	+5	20.3	37	41
Winter	55.1	-12%	-16%	+5	+6	20.0	56	59
Winter	48.2	-19%	-23%	+5	+6	19.6	-	157
Shoulder	70.4	-	-	-	-	20.8	22	20
Shoulder	55.7	-13%	-	+3	-	20.4	20	21

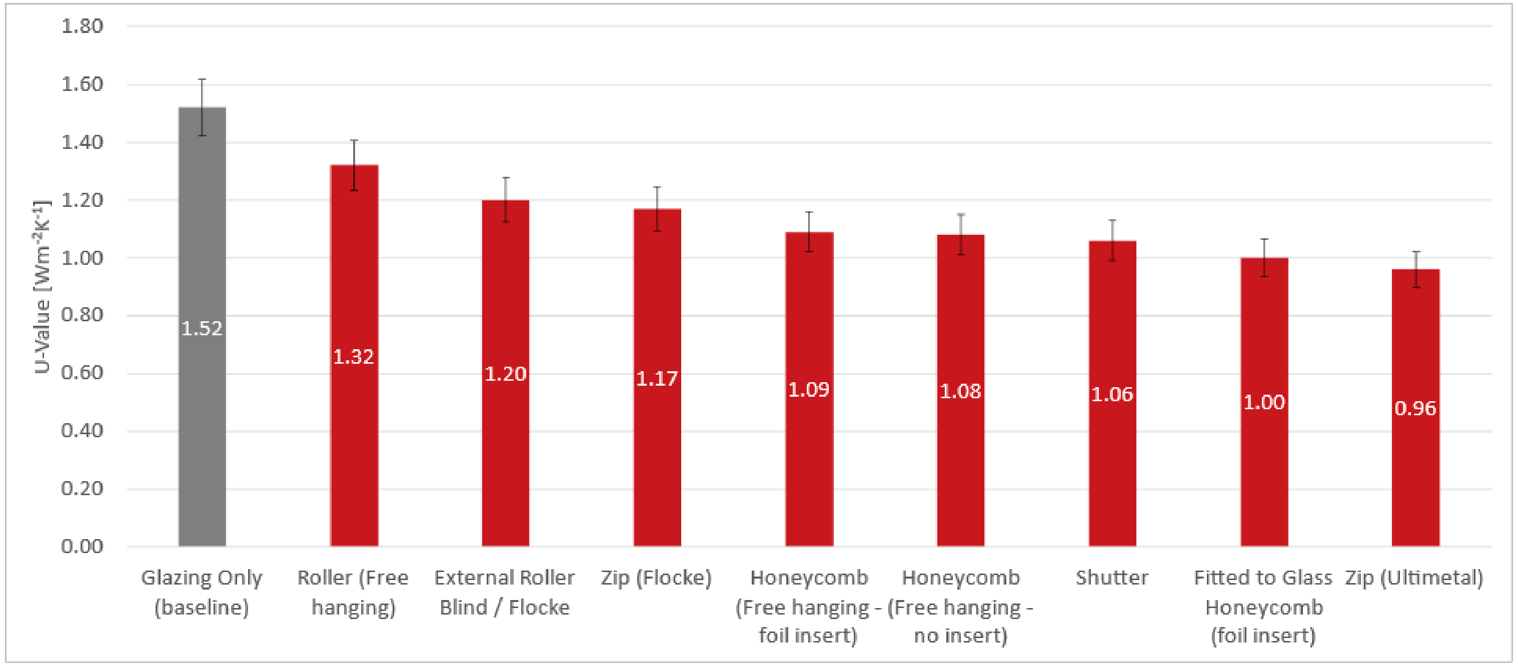
- **Important** to note that gas central heating systems are typically designed for flow temperatures of 70 °C and reducing low temperature can:
  - Increase heat-up times
  - Impact thermal comfort
  - Resulting in failure to achieve set-point in cold conditions.
- Weather compensation control automate this process and can reduce space heating energy use and maintain set-points IF installed and commissioned correctly.

BBSA – Window Blind Testing



Roller blind with zipped side channels	Honeycomb blackout blind in framed bead / perfect fit system	Internal plantation shutter	Roller blind with side channels	Standard roller blinds
heat loss reduction, up to	**heat loss reduction, up to**	**heat loss reduction, up to**	**heat loss reduction, up to**	**heat loss reduction, up to**
33%	**32%**	**28%**	**22%**	**13%**

BBSA – Window Blind Testing



- Up to 37% reduction in centre pane U-value
  - Baseline of no window covering
  - 27% reduction from free hanging roller blind
- Generally, systems which were more airtight performed better
- Reduction in energy use will depend on glazing area and proportion of time spent with blinds closed

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