Technology Strategy Board
Driving Innovation

Retrofit for the Future

Project final report

Cover note

This report was prepared by the collaborative project team for this Retrofit for the Future project, to provide fuller context on their experiences and the particulars of their retrofit's specification, construction and occupation.

The authors were encouraged to include honest, transparent and constructive comment, garnered from multiple perspectives across their team. All views are taken to be an accurate account from the time.

There may have been further modifications to the property after this report was produced. It is therefore possible that a small minority of statements will no longer be valid.

Although minor modifications have been made to this report by the Technology Strategy Board, these were only to ensure the privacy of individuals, including the residents, and compliance with the Data Protection Act.

This report may contain links to other websites, such as for project partners or the retrofit project. The Technology Strategy Board is not responsible for the content of those websites.

This report has already proven to be a valuable source of information for the technical and cost analysis reports published by the Technology Strategy Board which are available at: www.retrofitanalysis.org

Retrofit for the Future Project Final Report

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Property number: TSB096

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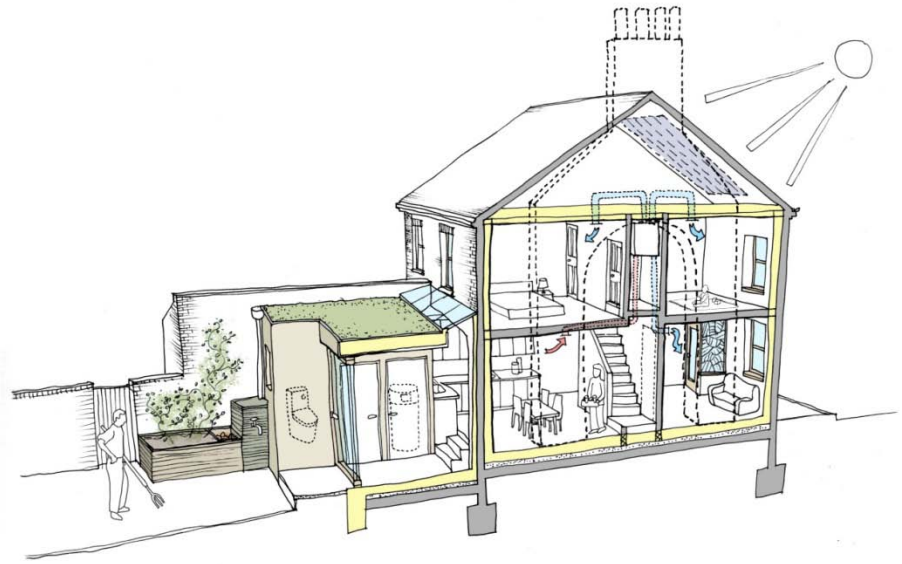

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Sanctuary Group
at ANNE THORNE ARCHITECTS LLP
McBAINS COOPER
KING SHAW ASSOCIATES
Seddon G&J Seddon Limited

SBRI Government challenges. Ideas from business. Innovative solutions.

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Final Report

Project information

- **ZA reference number:** ZA114U
- **Location of property:** Stoke-On-Trent, ST1
- **Lead participant details:** Sanctuary Housing Group
- **Date report issued:** 15 August 2010

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1. Project details and directory

Role	Name & Position	Organisation	Contact Details
Property Owner			
Housing Association		Sanctuary Group	Sanctuary Group 20 Ketley Park Road Ketley Telford TF1 5BF 01782 203458 www.sanctuary-group.co.uk
Design Team			
Architect		Anne Thorne Architects LLP	7 Temple Yard London E2 6QD 020 7729 6268 www.annethornearchitects.co.uk
Mechanical & Electrical Engineer		King Shaw Associates	The Stables Priston Mill Bath BA2 9EQ 0845 519 4371 www.kingshaw.co.uk
QS		McBains Cooper	Blackfriars House, St Mary's Parsonage, Manchester, M3 2JA 0161 278 0404 www.mcbainscooper.com
Monitoring		Building Sciences Ltd.	Edmunds House, 40 The Green, South Bar Street Banbury, Oxon OX16 9AE 07814 027184 www.buildingsciences.co.uk
Contractor			
Main contractor		Seddon Construction Ltd	PO Box 13, 55 Duke Street, Fenton Stoke-on-Trent ST4 3NN 01782598000 enquiries@seddon.co.uk www.seddon.co.uk

Sub-contractor – electric	SV Electrics and SV Security Systems	Vinewood House, 1 Waters Edge Business Park, Campbell Road, Stoke-on-Trent, Staffordshire ST4 4DB
Supplier - windows	EcoPassiv Triple-Glazed Green Building Store	Heath House Mill, Heath House Lane, Golcar, Huddersfield HD7 4JW 01484 461705 info@greenbuildingstore.co.uk www.greenbuildingstore.co.uk
Supplier - Air Tight Membranes & Tapes	Intello Membrane & Proclima Tapes Ecological Building Systems UK Ltd.	17, City Business Centre, Lower Road, London SE16 2XB, UK 05600 758025 info@ecologicalbuildingsystems.com www.ecologicalbuildingsystems.com
Supplier - MVHR Unit	Maico Ventilation UK Ltd.	Unit 9, Victory Park, Trident Close, Medway City Estate, Rochester, Kent, ME2 4ER, UK Telephone: +44 (0) 1634 716712 Fax: +44 (0) 1634 716912 Website: www.maicoventilation.co.uk
Supplier – Solar Hot Water System	Rotex Heating System Ltd	Unit 7, Lodge Road, Kingswood, Bristol, BS15 1TA Tel +44 (0)117 961 1698, www.rotex.co.uk

2. Introduction

A whole house approach to the retrofit was achieved through detailed application of Passivhaus principles to the refurbishment of an 19th century terrace house, which prioritises insulation of the fabric, achieving good air tightness with minimal space heating requirement, and whole house heat recovery ventilation. The aim is to make the house easy to inhabit with a low carbon footprint.

The existing building has been carefully surveyed, and proposed fabric and services have been analysed using the Passive House Planning Package, which allows designers to test assumptions thoroughly, and a free exchange of ideas between architect, service engineer and contractor has allowed proposed design details to be well integrated, and assessed for practicality.

3. Occupants

The occupants are new tenants that moved into the property that had been an empty void property that the housing association had just acquired.

The new occupants were selected from the priority housing list and had confirmed that they were willing to commit to the 2 year monitoring period and involvement in the project to ensure that they would be fully on board with the retrofit project.

The new occupants are a middle-aged couple from the area.
The occupants appear to very technically minded and interested in the properties and new systems for solar hot water and heat recovery ventilation system within the house.

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	17/06/2009
Planning application submitted (if appropriate)	22/03/2010
Planning permission granted (if appropriate)	18/06/2010
Building Regulations application submitted (if appropriate)	11/08/2010
Building Regulations approval granted (if appropriate)	15/09/2010
Contract for work let / signed	27/09/2010
Occupants moved out (state if they remained or property was empty)	Void Property
Start on site	27/09/2010
Original Programme Date for Completion	20/12/2010
Actual Completion Date of retrofit	25/02/2011
Occupants moved in	04/03/2011
Monitoring system commissioned and operating properly	25/02/2011
Building defects corrected	25/08/2011
Building services and controls operating correctly	25/02/2011

5. Pre-Retrofit Property

This is a small single Victorian terrace house in Hanley, Stoke on Trent. It receives very little passive solar radiation, and is therefore a cold feeling house. PHPP confirms lack of passive solar gain.

The house has a front living room, rear kitchen and dining room, a small bathroom extension on the ground floor, and two bedrooms upstairs. The total internal floor area of the house is 64sqm.

It shares with large numbers of houses:

- 225mm solid brick walls (originally detailed around sash windows)
- A decorative brick front elevation shared with remaining houses in the terrace
- Pitched tiled roof with front slope facing southwest
- A rear extension reducing daylight into rear room of the main house, and increasing external envelope
- A large part of the external envelope is party walls shared with neighbours
- Heavily ventilated chimney stacks passing through rooms and roof space
- High levels of air permeability, resulting in draughty and cold internal environment in winter
- Inefficient heaters providing inadequate space and water heating, resulting in high energy bills to resident

All this is typical of houses across the country of this period, and the solutions outlined in this proposal, tailored for the specific house orientation and layout, would be suitable.

The terrace is part of the Hanley renewal area, a pathfinder scheme for Stoke on Trent. This terrace has been designated for refurbishment as part of an ongoing refurbishment programme. The house is typical of housing stock not only in Hanley, but the wider area of Stoke-on-Trent which is predominantly in private ownership.

6. Design

Passive measures incorporated to reduce the base load of the building comprising super insulation and highly airtight construction. The building envelope is to be insulated internally, as external insulation is not acceptable on the front elevation and a new solid floor with insulation laid, reducing thermal bridging. Internal insulation impacts on space standards, but chimney breasts are to be removed to reduce air filtration, which creates more space, and an internal draught lobby to the front door was also shown in the original design. Potential thermal bridges between roof/wall and floor, and adjoining houses were carefully detailed.

Sheepswool insulation and wood-fibre insulation, which absorbs and releases moisture, has low embodied energy and can be laid directly against the solid brickwork, are to be used. Detailing for air tightness was carefully considered.

A Passivhaus certified MVHR unit with associated ductwork was to be installed, and a combined Gas-Solar Unit that it will prioritise solar thermal over the gas boiler to make the most efficient use of solar water.

Design Changes

1. As the design progressed, the M&E engineer wanted to allow for the installation of a small wet heating system to be fed from the Gas/Solar unit, as it was not felt that the MVHR unit could provide sufficient heat to the house during the colder winter months.

2. During the strip out of the property, a small cellar was discovered under the old solid floor of the front room so had to be filled on site. Had we previously known it was there, we may have detailed the new insulated floor slab differently so as to reduce the amount of concrete that was poured into this void.

3. The MVHR unit was chosen as it was a Passivhaus Certified unit, and we felt that for a project of this high specification and energy reduction requirements, we wanted kit that we knew would perform as claimed. Therefore, we wanted guaranteed performance on the heat exchanger efficiency, fan power, noise and filter specification that a certified unit would give us, particularly as this was the first project for which we had specified such a unit.

4. As the project was in construction, the draught lobby was excluded from the design as it was felt that this would take up too much space in the front room that would prevent a flexible layout of furniture in this small house.

5. The original design insulated the entire length of the party walls with 60mm wood fibre insulation. This was omitted for cost reasons during the negotiated tender. A 600mm return was retained on the four corners of the party walls.

Whilst this did not adversely affect the energy monitoring and heat demand in PHPP, it has however not upgraded the sound insulation between neighbours that would have been a beneficial bonus of insulating these walls.

The terraces in this street have a particularly thin party wall to one side, and the tenant has since noted that they can hear their neighbours clock ticking through the wall.

6. A wet lime plaster finish to the internal wood fibre insulation was revised to plasterboard on battens. This was to remove the additional drying out period that a wet plaster system on these walls would require. It also allowed a service zone for cabling and pipe work and removed the need to chase into the wood fibre board, as well as allowing for future cabling works to be carried out without chipping into plaster.

7. Construction

Procurement:	Negotiated Tender with Framework Contractor
Contract Type:	JCT IC with Bill of Quantities
Contract Structure:	Management Contractor
Subcontractors:	M&E Subcontractors Carpenters
Specialist Equipment:	No specialist installers were required, as all the solar thermal and MVHR kit were installed by the M&E subcontractors, and the air-tight detailing and triple-glazed windows were installed by the site team.
Specialist Equipment:	Triple-Glazed, Solar Thermal Gas Unit, MVHR Unit, sheepswool insulation, wood-fibre insulation and airtight tapes and membranes were not on standard supply framework of the Housing Association.
Site Supervision:	Clerk of Works regularly on site employed directly by Sanctuary Housing, as with all refurbishment works.
Role of Architect:	Monthly site visits to oversee construction and client site meetings. Constant email and telephone contact to handle day-to-day queries regarding retrofit works from contractor.

Lessons Learnt On Site:

Airtightness: The airtightness requirements and attention to detail were a vast learning curve on site, and something that was certainly over and above the standard refurbishment brief. Being present at the air tests helped the contractor and carpenters understand the connection between air-tightness and heat loss, as did the importance stressed on the continuous insulation details.

Particular areas that were surprise paths of airflow when a mid-construction air test was carried out were as follows:

- Socket back-boxes (would ensure that they were plastered behind before installing next time, or use air-tight back-boxes to save chasing out such a large hole).
- Electrical oval conduits (standard spec used and plastered in, but created air path we didn't consider through plastered wall that we considered airtight).
- Patched plaster work to party wall (design team thought that patching to original plaster would create airtight finish to party wall, but not found to be the case, so entire wall was re-skimmed – the party wall was a large contributor to air leakage which was a great surprise to us, as we were concentrating our main efforts on the external walls).
- Joist ends supported on Party Wall (a lot of attention to detailing was given to the Joists that were supported the external wall to the front wall – air-tight tapes and sealant detail. However, the final air-test showed air paths through the party wall where the joists to the rear first floor room spanned from one party wall to the other).

Airtight detailing – Cable Penetrations: The contractor found that the specialist tapes used for sealing cable penetrations from the loft space into the first floor were designed for different shaped

cables, so when the UK flat cables were pushed through round holes, it wasn't a tight fit and let air through, so required additional sealing.

Service Runs: Running services through the first floor allowed cabling to sockets and switches on the first floor to be run up to the outlet and down the outlets on the ground floor, minimising the number of penetrations to the roof membrane.

MVHR Duct Runs: Flexible ducting from Maico Ventilation had been specified for the MVHR ducting to the different rooms, as it had been assumed by the design team that this would be easier to manipulate and route on site.

However, in reality the pipe work was difficult to bend around tight corners or even at 90 degrees, and the M&E installer would have found it much easier with rigid spiral bound ductwork specified to fit more exactly.

MVHR Outlets: The specification of the air supply outlets was also changed during construction. Instead of routing ductwork in the loft space and having to insulate it to bring it to a ceiling mounted outlet to both bedrooms, we utilised the ceiling void above the stairs to bring the ductwork below the airtight membrane and insulated loft space to a wall outlet located close to the ceiling – a far simpler solution.

Demolishing Chimney Stacks: The internal stacks were removed for two main reasons: firstly to remove potential air path; secondly to increase floor space that would be reduced due to internal insulation. The works involved on site were however quite involved structurally, and required a steel beam to support the stack at roof level that was not being removed as it was a shared stack (as many are) with the neighbours.

There were also issues of poor pointing in the existing stack letting water into the void where the chimney breast once was, so there was an additional cost to render the chimney stack to make it water tight which was an additional cost.

8. Commissioning and Handover

Commissioning

Commissioning was required to the combined Rotex GasSolar unit and the whole house MVHR ventilation unit.

The commissioning was carried out by the M&E sub-contractor. In addition to their normal commissioning process, they completed the Passivhaus Planning Package MVHR commissioning sheet to ensure that the system had been balanced correctly.

Handover

The occupants were invited to site team meetings during the construction process so that they were involved in the retrofit works and fully understood each of the measures that were being applied to the house.

This included visits to site to see the insulation being put in place, the solar panels on the roof, air-tight membranes, and the MVHR unit.

On handover, the contractor ensured that the M&E subcontractor was present to explain how the MVHR and solar thermal unit had been programmed.

Occupant Feedback at Wash-Up Meeting (10 June 2011)

Solar Thermal Unit: The occupants think this system works very well, and just carries on in the background. They do not feel that they need to touch or adjust programming. They are impressed with the simple panel on the unit that tells you how much solar energy the unit has been using and are surprised that panels appear to deliver heat even when cloudy.

MVHR Unit: The MVHR unit is simple to use, but the control panel took some understanding initially. They've not had to change the filter yet. It would have been better to provide a simple explanation sheet to accompany the manual and initial explanation. The boost is a little noisy, but the tenants don't use it much. The holiday setting is very useful.

Heating: The occupants like a warm house – 23-24 degrees Celsius! They are switching the radiators on manually if needed when cold, otherwise the MVHR runs in the background. It is unclear which system takes precedence. Design Team need to communicate and understand this better themselves.

The bathroom can be cold, and upstairs is generally cooler than downstairs.

9. Costs

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration		£4,037		£5,000	
Design		£26,330		£6,497	
Construction overall					
- Prelims				£12,515	
- Fabric measures			£18,610	£30,562	
- Building services (conventional)			£3,400	£2,100	
- Low /zero carbon technologies			£13,000	£1,200	Solar Heating and Ventilation
- Other			£1,440	£800	
- Consequential costs			£600 £6,522 £1,200	£600 £14,150 £200	Damp Proofing Extension works Basement fill
Occupant temporary housing					
Monitoring equipment	£6,200				
Monitoring and reporting service		£9180			
R&D costs (please detail)					
(add more rows if there are other items)					

10. Wash-up meeting

A Wash-Up Meeting was held on 10th June to review the project. The participants were the Construction Manager, Senior Development Officer and Clerk of Works from Sanctuary Housing, the Site Manager from Seddon, and the Project Architect and a colleague from Anne Thorne Architects. The two tenants also attended the meeting.

The meeting was a very useful opportunity to talk to the occupants about their time in the house so far, and for them to give direct feedback to the project team. Below is a summary of issues discussed at the meeting that are not covered elsewhere in this report.

Use of MVHR:
The occupants found the MVHR system simple to use and had no issues with the sound of the unit when on 'normal' mode; however, the unit was noisy when on boost setting. The holiday mode setting they found very useful.

Cold Bathroom:
The bathroom could be cold, and this needs to be remedied by the Design Team, as the M&E engineer did not locate a radiator in the bathroom, but was relying on the MVHR system to heat to the room. However, this was a clear under-design, so will be rectified.

Solar Thermal:
The Rotex unit works well for the occupants and functions 'in the background'.

Thermal Comfort:
The occupants like to keep their house at 23/24°C, but upstairs they are finding it is cooler than this. This is several degrees higher than the design temperature of 21 degrees. It is hoped that we can give the occupants feedback on the monitoring data to advise them on energy use for their house.

Draught Free:
The occupants are not experiencing any draughts, and say that the house pulls back the heat very quickly if the front door is open or open windows closed.

Overheating:
The house can get hot quickly during sunny weather, but they find that the rooflights in the kitchen are a great way to get rid of heat very quickly and cool the house.

11. Doing it again

What would we definitely do again?

Attention to airtightness, as the benefits to occupants' thermal comfort and heating bill in terms of possible energy savings are now clearly understood

Consider air testing as part of standard refurb works: write targets into contracts and incentivise good results and best practice

If triple glazing comes down in price, then the housing association could see that being added to their standard refurbishment specification

Why not combine airtightness with sound insulation to party walls?

Consistent Design team was important to following through the design

The clerk of works is a great fan of the heat recovery system as it will reduce condensation issues and there is no reliance on the human element, but there are concerns over the additional cost of this item of kit. It is seen as more for new builds than refurbs at present with fundraising available.

Fabric approach (insulation and airtightness) rather than renewable approach seen as the way to go by all, so insulation using hygroscopic materials to external walls seen as important in dealing with existing buildings.

What would we definitely not do again?

The windows were on a long lead in period as they were coming from Poland. Looking for a UK manufactured window with a shorted lead-in period would be a preference on future projects.

Reduction of costs?

Woodfibre insulation and sheepswool were simple to work with, but costs were expensive. A lower U-value could be targeted in future retrofits to reduce costs.

There are now combined MVHR and gas solar systems on the market in Europe, which sound attractive, and may be a simpler solution in terms of installation, user operation and space given up in existing houses.

Improvement of the design process

Clerk of works: next time, have more involvement with M&E on site regarding radiator locations, socket locations etc. They should have more involvement with the design, and we should have understood the system better.

Improvement of the construction process

Pre-contract negotiations could have been easier - trying to get the budget to meet scheme requirements

Open tender rather than negotiated could have kept costs down.

Schedule of works, not bill of quantities may have been simpler

Add airtight clause to contract

Improvement of the commissioning and occupancy process

Providing the occupants with a simple one-page summary of the airtightness, MVHR, and solar system in their house was always intended but not executed in time for them moving in. We intend to provide this in the near future.

What efficiency gains would you expect from a larger programme of retrofits, eg: 50 homes of similar age and design in a similar neighbourhood?

Doing a street of them would be more economic for time and scale and easier to manage. The site team could move from one house to the next, making the most effective use of labour costs, and gaining direct benefit from the learning curve of site operatives over airtight details and thermal bridge & bypass free insulation installation.

Increased buying power with suppliers if at scale.

May also allow for external insulation to terraces to be carried out on street scale.

Would remove the need for thermal insulation to party walls if at terrace level – however, need for sound insulation for these properties to the party walls would still be required.

What, in your view, would be key to making replication at this scale successful?

Occupants currently get the cost savings of the energy improvement works, not the housing association, so payback is going the wrong way. Rent increases would be required to make it pay to cover evidenced reduced fuel bill costs so the occupants were not out of pocket.

Income for current refurbishment project is grants and rent at present, which would not cover additional cost**.** Evidence is needed from the monitoring of the houses before decisions can be made on what measures can be cost effectively replicated, because as mentioned above, future funding can only be based on evidenced cost savings from energy bills at present.

12. Business benefits

The Retrofit for the **F**uture project has given all involved a great opportunity to grapple with the realities of subjecting a standard refurbishment process to a deeper fabric upgrade and services installation.

The chosen house was a particularly challenging due to it**s** small size, existing condition, and poor fabric condition.

There is has been great interest in the project, and several articles published on the retrofit project. An open day held at the completion of the project was well attended.

In terms of business leads and opportunities, there has been more interest in the private market in terms of house retrofit projects for design team members.

The social housing sector has been subject to spending cuts that have impacted on the allocated costs of the standard house refurbishment that are being pressured for cost reductions. Therefore the reality of implementing additional retrofit measures at present must be done at no additional cost to the standard refurbishment works.