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

Project number: ZA233U
Property numbers: TSB035

Author: Hastoe Housing Association

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Technology Strategy Board
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SBRI
Government challenges.
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Final Report

Project information

- **ZA reference number:** ZA233U
- **Location of property:** Attleborough, NR17
- **Lead participant details:** Hastoe Housing Association
  Marina House
  17 Marina Place
  Hampton Wick
  KT1 4BH
- **Date report issued:** 28 July 2011

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1. Project details and directory

Project Participants

Role	Organisation	Contact Details
Property Owner		
Housing association (held in trust)	Hastoe Housing Association	Address: Marina House 17 Marina Place, Hampton Wick, Surrey, KT1 4BH Tel: 020 8973 0424 Website: www.hastoe.com
Design Team		
Architect	ECD Architects	Address: Studio 3, Blue Lion Place, 237 Long Lane, London, SE1 4PU Tel: 020 7939 7528 Website: **:** www.ecda.co.uk
Contractor		
Main contractor	Roalco Ltd	Address: Ardleigh House, Dedham Road, Ardleigh, Colchester, Essex, CO7 7QA Tel: 01206 231700 Website: www.roalco.co.uk
Sub-contractor – M & E Including Solar Thermal & Air Source Heat Pump	Evergreen Ventures Ltd	Address: Unit 1, Evergreen Venture Park, Barton Road, Wisbech, PE13 4TP Tel: 01945 419090 Fax: 01945 419088
Sub-contractor – Heat Recovery Ventilation	EnviroVent Ltd	Address: EnviroVent House, Hornbeam Business Park, Harrogate, HG2 8PA Tel: 01423 859394 Fax: 01423 810910 Website: www.envirovent.com
PV installer	Solar Technologies Installations Ltd	Address: British Gas Solar, Bampton House, Bampton Court, Hursley Road, Chandlers Ford, Eastleigh, SO53 2TA Tel: 0845 0751287 Website: www.solartechnologies.co.uk
Supplier - doors	JELD-WEN UK	Address: Retford Road, Woodhouse Mill, Sheffield, South Yorkshire, S13 9WH Tel: 0114 229 3251 Fax: 0114 229 3260
Supplier - windows	Crittall Windows	Address: 28a First Avenue Bluebridge Industrial Estate, Halstead, Essex, CO9 2SX Tel: 01787 479017

		Fax: 01787 478845
Supplier - secondary glazing	Selectaglaze Ltd	Address: Campfield Road, St Albans, Hertfordshire, AL1 5HT Tel: 01727 837271 Fax: 01727 844053
Supplier - Energy Control Blinds	Heatsaver Shades UK	Address: The School, Great Elm, Frome, Somerset, BA11 3NY Tel: 01373 813429

2. Introduction

The property was chosen to be the subject of the retrofit as it was a particularly poor performer in terms of energy efficiency and thermal comfort. As a 'G' rated property, it had the high environmental impacts associated with an energy inefficient home, namely high carbon emissions. Although the cottage was a unusual property (a 1940's almshouse), it did reflect efficiency issues common to a number of properties across the UK, such as a significant lack of insulation, poor air tightness, no mains gas, and a reliance on expensive electric heating and a coal fire.

Beyond the 'eco' elements of the retrofit, the layout of the cottage also did not meet the needs of the future, older, resident. Therefore the project was an opportunity to address both the sustainability and liveability issues of the cottage. The core aim of the retrofit was to improve energy efficiency and to reduce the associated carbon emissions by over 90%, by using a mixture of proven and new techniques, materials and technologies.

3. Occupants

The cottage had been vacant for some time when it was chosen to be the subject of the retrofit. The resident chosen to move into the retrofitted cottage was living nearby and had strong family connections with the area and the property itself. Her father had worked for the local landowner (who had built the cottages) and the tenant remembers the cottage and its neighbours being built. It was an interesting dimension to the project to involve someone who had been so closely involved with the property. It was also apparent that the project was preserving buildings of local and historical significance for future generations to enjoy and benefit from.

In addition to the environmental elements of the retrofit, the tenant brought specific requirements to the project for the layout of the property, such as the need for a walk-in shower This, along with the lower predicted running costs of the property, and greater thermal comfort, has provided a greater quality of life to the tenant.

The cottage remained unoccupied during the course of the retrofit; however the tenant was close enough to the site to witness the day to day activities and to regularly be updated on how the retrofit was progressing.

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	27/01/11
Planning application submitted (if appropriate)	N/A
Planning permission granted (if appropriate)	N/A
Building Regulations application submitted (if appropriate)	29/07/10
Building Regulations approval granted (if appropriate)	11/08/10
Contract for work let / signed	26/08/10
Occupants moved out (state if they remained or property was empty)	Property was vacant
Start on site	04/10/10
Completion of retrofit	15/03/11
Occupants moved in	18/04/11
Monitoring system commissioned and operating properly	15/03/11
Building defects corrected	04/07/11
Building services and controls operating correctly	15/03/11
Official opening ceremony	15/07/11

5. Pre-retrofit property

TSB035 is one of a four property terrace built in 1948. It is a single storey, two bedroom bungalow, practically a stand-alone property, joined only by an unheated flat-roofed porch to the adjacent properties. There were no significant planning implications as it is not located in a conservation area. The property comprised of a small kitchen, living room, two bedrooms and a small bathroom. It was initially thought to be of un-insulated solid wall construction, but during the course of the retrofit it was discovered to be a mix of un-insulated solid and cavity walls. It had steel framed glazing and very little loft insulation. The property was off mains gas, with the main sources of heating being electric storage heaters and an open coal fire, which placed a great financial burden on the resident.

The cottage exhibited poor levels of energy efficiency and air tightness. When the property was initially selected it was determined to produce 327 kilograms of CO_2 per m^2, with the aim of the retrofit to reduce this by 95% to 18 kilograms of CO_2 per m^2. The actual retrofit achieved a 92% reduction in carbon emissions 26.72 kilograms of CO_2 per m^2 and, although it slightly missed the original target, the project team view this as a fantastic achievement. As part of the pre-retrofit testing the air tightness was measured at 5.28 m^3/ ($h.m^2$) 5.28 (approximately equating to eight air changes per hour).

6. Design

Our approach to energy saving and CO_2 reduction was to follow a lean-clean-green hierarchy, focusing on low-to-no maintenance solutions, to:

- Minimise heat losses from the property's thermal fabric and ventilation

- Supply residual space and water heating using replicable, low carbon technology
- Minimise lighting and appliance energy load
- Use proven, renewable energy systems

The original proposal of measures sought to find an innovative way of externally insulating without alteration to the external appearance of the property, whilst simultaneously employing advanced insulation materials to address internal cold bridging at the solid floors and window reveals. Although not in a conservation area, vacuum glazed windows and 'Brickshield' cladding were not acceptable to planners which resulted in a reduction in performance of the windows (traditional Crittall metal frames were specified (although secondary glazing and thermal blinds improved performance); and a slight reduction in internal floor area (internal insulation in lieu of external). To offset the heat and energy demand, a Daikin Altherma air source heat pump was specified, along with photovoltaic (PV) panels. A whole house heat recovery mechanical ventilation system from EnviroVent would then provide pre-warmed, filtered, fresh air by recovering almost all the heat from the returned air.

The main specification was as follows:

Thermal Insulation

- Existing solid ground floor to be covered with Aerogel Spacetherm C – 18mm chipboard with a Spacetherm blanket backing.
- 80mm Aerogel Spacetherm P dry-lining insulation to be applied to front, flank and rear internal walls with additional cavity wall insulation installed wherever possible resulting in a U-value of 0.11 W/m²K. (Note: The original specification was written in accordance with manufacturers' guidance, i.e. void between insulation and internal face of external wall. Given the risk of interstitial condensation at the perimeter of the boards, it was agreed to fix these directly to the internal face of the exposed wall with an internal void instead thereby reducing risk and also improving future adaptability by providing a zone for services).
- Loft – blown loft insulation laid at 420mm achieving a U-value of 0.1 W/m²K

Windows and Doors

- Selectaglaze secondary glazing system
- Entrance doors replaced with Jeld Wen doors with integral vacuum insulated panels and legacy vacuum glazing to vision panels

Ventilation

- EnergiVent Q humidity-responsive, filterless mechanical heat recovery ventilation with a retrofit airtightness strategy

On-site renewables

- Low profile in-line 1.05 KW photovoltaic panels that power Air Source Heat Pump
- Daikin Altherma LT air source heat pump
- Solar thermal back-up to Air Source Heat Pump providing hot water when possible

Lighting

- 90% efficient LED lighting throughout

Energy efficient appliances – A+ or better
- Cooker
- Washing machine
- Fridge-freezer

Monitoring and Controls
- Prototype Wattbox intelligent controls and user interface

Other
- Insulated Heatsaver roman blinds with sealed perimeter framing

7. Construction

In terms of procurement, the project was tendered using the JCT 2010 (with CDP) contract type. The contract structure was a main contract with direct labour covering traditional trades plus some specialist sub-contractors. In terms of sub-contractors, there was a single M&E sub-contractor with a number of other minor trades. All installers were procured via the main contractor and all specialist equipment was procured via named subcontractors. Site supervision was completed by an in-house site agent.

The role of the architect/design team was to supervise/oversee construction and sign off works, and was provided on the project by ECD Architects. Their overall view of the project was that it was relatively trouble-free with only minor defects arising post-completion. The project finished eight weeks late, however; this was largely due to the late delivery of the external doors with procurement of vacuum insulated panels causing significant delay. Otherwise the project was generally well managed and quality control was good, resulting in very impressive air-tightness results (despite the fact that for planning reasons traditional Crittall steel frame windows had to be used). ECD Architects would suggest that this success was in large part due to the diligence of the Site Agent who was particularly keen to ensure air tightness was maintained.

8. Commissioning and occupancy

Practical completion was reached on 15 March 2011, which was followed by two weeks of post-retrofit testing. The tenant formally took up residency in the property on 18 April 2011. The tenant had been involved in the project from the design stage, therefore she had excellent awareness of the aims of the retrofit and the measures that were incorporated as part of it. She also lived closed to the retrofit site and had seen the retrofit progress. A formal handover was carried out prior to move in, involving Hastoe's Regional Housing Manager and Sustainability Manager, to ensure that she was aware of the key issues relating to her new home. The only technology that the tenant comes into direct contact with is the Wattbox, to control the temperature of the home. The Wattbox is simple and intuitive to use and training was provided to the tenant on how to use it by Roalco. Roalco continue to support the tenant as she familiarises herself with how to use this technology. There have

been a couple of instances where an error message has been displayed and the tenant has been uncertain of what to do. Roalco are providing additional training with engineers from Wattbox to ensure that the tenant is comfortable with using the technology. Key Hastoe staff, including out-of-hours call out representatives, will be included on the training, to ensure that knowledge and support can provided from within Hastoe as time goes on. A short, simple, home user guide has also been produced for the property providing simple advice, tips and facts on how to use the retrofitted home. The tenant is keen to see how her energy use behaviour combined with the efficiency measures within the home will affect her electricity bills, particularly in winter. She is particularly interested in the solar meter to see how much energy the PV panels are generating.

9. Costs (Not including Decent Homes works)

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration	incl	14,250	Incl	14,250	
Design	incl		Incl	Incl	
Construction overall					
- Prelims	3,672	8,569	8,375	8,300	
- Fabric measures	20,193	Incl	14,621	Incl	
- Building services (conventional)	2,851	Incl	2,040	Incl	
- Low /zero carbon technologies	43,895	Incl	49,661	Incl	
- Consequential costs	4,407	4,407	2,500	2,500	
Occupant temporary housing	n/a	n/a	n/a	n/a	
Monitoring equipment	7,600	Incl	7,600	Incl	
Monitoring and reporting service	incl	750	Incl	750	
R&D costs (please detail)	n/a	n/a	n/a	n/a	

10. Wash-up meeting

A formal wash-up meeting was not held for the project; however, all the key project participants have remained in close contact during the period since the retrofit was completed to ensure that any issues/snags have been resolved. The key project participants have also collaborated on a number of promotional opportunities for the retrofit; an entry to the National Housing Federation 'What We Are Proud Of' Awards, a case study for Future Constructor and Architect magazine, a video on the resident experience of the retrofit for the two EST/Sustainable Homes 'How to Finance Green Homes' conferences and an entry for the Small Retrofit category of the Inside Housing Sustainability Awards 2011.

11. Doing it again

Hastoe will be replicating a number of the features from the retrofit in the upgrading of the remaining three cottages in the terrace. The cottages are in a similar condition to the pre-retrofit state of TSB035. The upgrades will include increased levels of insulation, replacement windows and the installation of PV panels and air source heat pumps. The upgrades will also incorporate the revised layout from TSB035. The improvements will be undertaken by the same consultants and contractors, therefore facilitating the direct translation of learning points from the original property to the rest of the cottages. The additional works are being carried at a cost to Hastoe of £230,000 inclusive of VAT. The improvements will not include the installation of the Wattbox technology, and this function, whilst less sophisticated, will be undertaken by a smart meter.

The key learning points from the retrofit are considered as follows:

- **Contractor skills** – although not an issue on this retrofit project, (as mentioned before the good quality control on site ensured that the project achieved excellent results), it did flag up the need for more investment and training in skills related to retrofitting techniques to enable retrofits to become more commonplace. The retrofitting of insulation and air-tightness in particular were areas where specialist knowledge/skills are required. Roalco had never been involved in a retrofit such as this before; however, the project reflected their own environmental ethos and they valued it as an opportunity to be involved and to up-skill their staff.

- **Supply of materials** – long lead-in times required for ordering and delays in delivery for some products caused significant knock-on delays to the completion of the retrofit. For example, the Jeld Wen door was specified by a number of the Retrofit for the Future projects and this seemed to exacerbate the long delays that were experienced with this product. This highlights the need for a more efficient supply chain if large-scale retrofits are to be undertaken.

- **Resident engagement** – resident involvement from the outset was key to the successful realisation of the project and for the resident to buy-in to the retrofitted property. The tenant was a key member of the project team from the start of the project and was consulted on every aspect of the design and construction, e.g. the walk-in shower was included at her request, and she made the choice of what finishes were to be included in the property, such as kitchen, carpets, and tiles. The high levels of resident engagement are being repeated immediately in the upgrades to the remaining cottages in the terrace and for future retrofit/refurbishment projects.

- **'Simple' technology** – however simple the technology is to use, steps must be taken to ensure that the resident is comfortable with how to use it. The Wattbox is the only high-tech equipment that the tenant has to use as a result of the retrofit, to control the temperature of the house. It is simple and intuitive to use; however, there have been a couple of occasions when an error message has been displayed and the tenant has been unsure of what to do. Additional support is therefore being given in this area, such

as more detailed training for the tenant and key staff, and key staff making themselves available out-of-hours.

12. Business benefits

Hastoe
Hastoe places a strong emphasis on innovation in sustainability, with protecting the climate and tackling fuel poverty as part of our key corporate objectives. Therefore our involvement in this high profile project has been an important achievement for the association, demonstrating our commitment to the well-being of our residents and environmental sustainability. Our specialism in rural areas and environmental sustainability makes us distinct from other associations, which is something that is promoted through involvement in innovative projects such as this. We have already taken steps to move it on from an exemplar project, and have made preparation to complete similar upgrades on the remaining cottages in the terrace. We are also actively assessing our stock to identify opportunities for a larger-scale retrofit.

ECD Architects
This project has used a number of innovative technologies which ECD hope to use on more mainstream projects over the next few years. Networking with specialist suppliers has also increased their skills and understanding of the technologies involved and potential opportunities. This has led to repeat work (ECD are working on the upgrade of the remainder of the terrace) and hopefully further opportunities for low-carbon retrofit and refurbishment.

Roalco – main contractor
Roalco's goals continue to be the prevention of customer fuel poverty, promote home energy efficiency and to protect the planet. Roalco staff, who gained experience on this contract, will attain their qualifications for photovoltaic and solar thermal installation during 2011. This will extend their delivery, resourced in partnership with the supply chain team selected for this project. Roalco plumbers have upgraded their pressurized cylinder certification to incorporate all aspects of sustainable technology with special emphasis in the integration of the various technologies to minimise carbon footprint. Roalco managers report significant enquiries for care home and housing retrofit projects in 2012.

13. Additional Information

Key results from the retrofit:

	Pre retrofit	**Post retrofit**
SAP rating	15	84
Energy efficiency / environmental rating	G	B
Energy/fuel spend	£900-1000	£300 (predicted)
CO_2 emissions Kg CO_2 per m^2	327	26.7 (92% reduction)
Air changes per hour	8	3
Air permeability $m^3/(h.m^2)$	5.28	1.97