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: ZA467S
Property number: TSB090

Author: Earthwise Construction

The work reported here has been funded by the Technology Strategy Board under the Small Business Research Initiative (SBRI) under the Retrofit for the Future programme. This project is one of nearly 90 projects funded under the programme. Further information on the programme can be found at: www.innovateuk.org/retrofit

Technology Strategy Board
Driving Innovation

SBRI
Government challenges.
Ideas from business.
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Final Report

Project information

- **ZA reference number:** ZA467S
- **Location of property:** Brighton, BN1
- **Lead participant details:** Earthwise Construction c/o Low Carbon Trust, Brighton Eco Centre, Brighton, BN1 3PB, 07974 122 770, www.earthwiseconstruction.org
- **Date report issued:** 21 July 2011

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1. Project details and directory

Role	Organisation	Contact Details
Lead partner	Earthwise Construction	Address: c/o Low Carbon Trust, Brighton Eco Centre, Brighton, BN1 3PB Tel: 07974 122 770 www.earthwiseconstruction.org
Registered Social Landlord	Two Piers Housing Co-operative	Address: c/o 14 Oriental Place, Brighton, East Sussex BN1 2LJ Tel: 01273 328 108 Website: www.twopiers.coop
Architect	BBM Sustainable Design	Address: Unit 16, Star Gallery, Lewes BN7 1YJ Tel: 01273 480533 Website: www.bbm-architects.co.uk
Main contractor	Earthwise Construction	As above
Subcontractor – electric	A C Electric	Address: 130 Central Avenue, Telscombe Cliffs, Peacehaven, East Sussex BN10 7NE Tel: 01273 575 334
Subcontractor - heating	Sun Trader	Address: 39 Dane Vale, Brighton BN1 5ED Tel: 01273 550 225 Website: www.suntrader.co.uk
Solar thermal installer	Sun Trader	As above
Supplier - windows	Nordan	Address: Maitland Road, Lion Barn Business Park, Needham Market, Ipswich IP6 8NZ Tel: 01449 722 922 Website: www.nordan.co.uk
Supplier - windows	Ecomerchant	Address: Unit 5, The Cobden Centre, Folly Brook Road, Emersons Green, Bristol BS16 7FQ Tel: 01795 530 130 Website: www.ecomerchant.co.uk
Supplier - MVHR	Green Building Store	Address: Heath House Mill, Heath House Lane, Golcar, Huddersfield HD7 4JW Tel: 01484 461 705 Email: info@greenbuildingstore.co.uk Website: www.greenbuildingstore.co.uk

2. Introduction

The project came about after hearing a presentation at Ecobuild 2009. Earthwise Construction and BBM Sustainable Design formed a consortium to develop a project and then set about recruiting a registered social landlord partner. We received funding for two phase 1 projects and this project received funding for phase 2. The other feasibility project was ZA466N.

The aim for the project was for a realistic, replicable and robust 'whole house' solution to retrofitting solid wall Victorian housing in Brighton demonstrating deep cuts in CO_2 emissions. The house chosen was typical of housing stock in the city and along the south coast. The project aimed to transform a hard to treat, hard to heat 'F' rated 19th century property into energy efficient 'B' rated 21st century house by dramatically reducing space and water heating demand, and electrical consumption. The project also aimed to use established market ready 'off the shelf' technologies that when combined offer the best carbon return per £ spent and when used together are more that the sum of their parts, demonstrating wide scale replicability.

3. Occupants

The property was fully occupied (except one bedroom as outlined above which was used for storage) during the project. All the residents moved out for a 3 week window in October 2010 whilst the most invasive works were undertaken; internal wall insulation in front bedrooms and living room, ground floor insulation, Vrogum double glazed sashes installed in the front bay windows, condensing gas boiler, solar thermal system and insulated hot water tank installed.

The new resident was selected through the housing co-operative structure and prospective tenants were interviewed.

When the residents moved back in they operated the house as before, but it had been fully insulated. Therefore it was much warmer, at around 23°C. An operating manual for the house has been provided, it is anticipated that people will gradually learn how to operate in a more energy efficient way, use less energy and reduce their bills. The average bills for the house before the retrofit were around £1,500.

Please state the make-up of occupants before and after the retrofit:

Age band	Number before retrofit	Number after retrofit
Under 5 years		
5-16 years		
17-21 years		
22-50 years	6	6
51-65 years		
Over 65 years		
Please state if (yes/no):	**Before retrofit**	**After retrofit**
Married couple / partners	No	No
Couple / partners with children	No	No
Any disabled persons	No	No

4. Dates

Event	Date
Presentation at Ecobuild 2009	4 March 2009
Recruitment of Two Piers Housing Co-operative	May 2009
Phase 1 funding awarded & phase 1 start date	1 August 2009
Phase 1 ends	30 November 2009
Planning application submitted	22 December 2009
Phase 2 funding awarded & phase 2 start date	29 January 2010
Planning permission granted	25 February 2010
Contract for work signed	18 July 2010
Front windows planning application submitted	21 June 2010
Building Regulations application submitted	16 August 2010
Front windows planning application granted	16 August 2010
Work commenced onsite	23 August 2010
House opened to public as part of Eco Open Houses 2010	12 September 2010
Residents move out for 3 week period	October 2010
MVHR commissioned	12 January 2011
Completion of retrofit	31 January 2011
Building defects corrected	1 March 2011
Building services and controls operating correctly	1 March 2011
Building Regulations approval granted (signoff)	1 March 2011
Monitoring system commissioned and operating properly	21 March 2011
Air Pressure Test by BSRIA	21 March 2011
Thermography	27 March 2011
Phase 2 ends	1 April 2011
Official opening by local MP	5 September 2011
House opened to public as part of Eco Open Houses 2011	11 September 2011

5. Pre-retrofit property

Please provide a brief description of the pre-retrofit property

Large detached Victorian property on the outskirts of Brighton & Hove, typical of housing stock in the city. Falls in a conservation area of Brighton & Hove so planning permission required for external works. Large but compact building form with extensive architectural detailing on front street facing elevation. Solid wall construction with no insulation. Solid concrete ground bearing slab built in 1983, possibly with some insulation. Large roof area and loft space with 100mm of insulation. Generally good levels of fabric maintenance - no issues with integrity of roof. Six bedrooms, several bathrooms and a large open plan kitchen and living room, with doubling up of appliances. Existing boiler system was 'heavy', unresponsive, poorly maintained and was over 25 years old.

Two Piers Housing Co-operative had 4 potential properties in Brighton. We visited them all and looked at SAP reports that had been commissioned as a review their housing stock in 2005. The property had a SAP rating of 33 (energy band F), the worst of the four and was the most typical of housing stock in the city. Therefore it was chosen for the direct impact of the project and replicability in other typical housing stock.

6. Design

Please provide a brief description of the retrofit as originally proposed

3 pronged approach of whole house measures designed with the strategy to reduce heat loss by: upgrading the external building fabric, providing energy efficient systems for space and water heating and improved efficiency with electrical systems. The 3 prongs are outlined below:

Upgrading the external building fabric:

- External wall insulation: 120mm of internal insulation (IWI) on the front elevation, with 120mm external insulation (EWI) on the side and rear elevations
- Ground floor insulation: 120mm of insulation over the ground floor slab
- Roof insulation: 200mm of insulation between and over the joists
- Improved glazing: new double glazed Vrogum vertical sliding sash windows for the front elevation and aluminium clad triple glazed Nordan casement windows for the side and rear elevations
- Increased airtightness: continuous airtight plane on and between all external elements to reduce drafts and achieve 3 ach/hr

Providing energy efficient systems for space and water heating:

- Condensing gas boiler: 90%+ efficient new Vaillant EcoTEC gas boiler
- Hot water tank: 376 litre highly insulated twin coil storage for hot water generated by the solar thermal array or the condensing gas boiler
- Solar thermal array: 4 x Thermomax DF 100 evacuated tube solar thermal arrays on the east facing roof (60 tubes)
- Mechanical Ventilation with Heat Recovery: 94% efficient Paul Novus (F) 300 DC unit

Improved efficiency with electrical systems:

- Appliances: A++ rated fridge
- Low energy lighting: fitting of compact fluorescent lighting through
- Induction hob to replace existing gas hob

If the proposals for the retrofit changed please explain these changes and the background that led to the change:

The project delivered all aspects of the design except the induction hob, which was not installed for financial saving towards the end of the project. When this change was modelled using the SAP extension sheet the predicted annual CO_2 emissions were actually reduced by 1kg/m^2/yr! This was due to the CO_2 conversion factors for mains electricity and mains gas being 0.422 and 0.194 kgCO_2/kWh.

Key differences between the retrofit as designed and as built:

There wasn't any need to modify the design apart from insulating the external wall in the adjacent garage. During winter, after the rest of the walls had been insulated, the bedroom that was connected to the garage started to show damp problems, so we insulated this element using the same EWI treatment to solve the problem. We also discovered asbestos

in two locations and had it removed by a specialist company.

There were other minor changes, e.g. we used 2 x 60mm of Kingspan Kooltherm K7 when externally insulating the walls, instead of 1 x 120mm. Kingspan's website stated that 120mm depth boards were a standard product, but this was not actually the case, except in very large volumes. The additional fixings and installation of the insulation in two layers added expense to this aspect of the project.

7. Construction

- **Procurement** – the lead partner was the Contractor (Earthwise Construction) who undertook the work
- **Contract type** – bespoke letter between Contractor (lead partner) and Registered Social Landlord (Two Piers Housing Co-operative)
- **Contract structure** – main contractor with direct labour covering most trades plus some specialist subcontractors
- **Subcontractors** – plumbing: gas & solar thermal, electrics, painting & decorating, rendering: acrylic render on external wall insulation system, monitoring equipment & pulsed meters, MVHR company commissioned the system after installation by main contractor
- **Specialist installers** – as above
- **Specialist equipment suppliers** – MVHR: Green Building Store, Solar Thermal: Sun Trader, Monitoring Equipment: EST
- **Site supervision** – Contractor managing works with weekly inspections from Architect and regular inspections from Local Authority Building Control
- **Role of architect/design team** – submission of two planning applications and building control drawings, supervision of construction to resolve any onsite issues. To reduce costs details were resolved onsite.

Lessons learned

One problem was with the conservation officer regarding the windows on the front elevation. In effect the planning / conservation process delayed the start date of the project from March to August which meant that the polymer render was applied in late Autumn / early Winter. The Wetherby 3 coat system with its final 1mm finish coat would seem to be a very costly measure. Two lessons here are leaving adequate time to address planning permission consents and examining alternative cheaper render finishes for external wall insulation.

Another potential issue could be the exasperation of existing damp problems in the house, and the effect that additional insulation could have on them. Once all the insulation had been installed, one of the bedrooms showed increasing damp, probably due to the larger differences in surface temperature between the insulated and uninsulated elements. Due to financial constraints, it was not possible to insulate adjacent outside walls in unheated areas, i.e. the attached garage. In other projects this could provide potential problems for a housing provider, where they may have to invest in additional internal damp proofing measures.

It would be interesting to know the effect of the air tightness layer to the front wall of the property, as it was a technically difficult and time consuming to install, involving 4 bay windows.

8. Commissioning and occupancy

What commissioning was carried out, what problems were discovered and how these were addressed?

Solar thermal and gas boiler commissioned – no problems

MVHR commissioned – there is an ongoing issue that some residents state that the air supplied by the MVHR system is too cold during the night. Green Building Store (the supplier) sent three data loggers to monitor the system. One was installed in the supply air feed from the MVHR unit, another in the supply duct to a room and the last in the room on a shelf. We monitored 3 rooms over a 3 week period in February / March and are now in the process of analysing the data. We hope to resolve the issue before the next heating season. The MVHR unit has been turned off during spring and summer.

The handover process

No formal handover as residents remained in situ. The contractor wrote a house pack, which was circulated to the residents. Some technologies explained directly by commissioning agent during process, e.g. MVHR.

9. Costs

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration		£5,500		£7,500	
Design		£18,000		£18,000	
Construction overall					
- Prelims	£8,200	£7,200	£8,500	£7,200	
- Fabric measures - ground floor	£7,500	£5,000	£7,500	£7,150	
- Fabric measures - walls	£14,300	£28,900	£21,950	£21,650	
- Fabric measures - windows	£24,500	£9,800	£21,500	£8,800	
- Fabric measures - roof	£3,000	£4,800	£7,200	£4,800	
- Building services (Gas boiler, hot water tank & MVHR)	£11,500	£4,000	£11,500	£4,000	
- Low /zero carbon technologies - solar thermal	£3,500		£5,850		
- Appliances	£2,000		£1,700		
- Plumbing - including moving soil pipe	£3,000		£3,500		
Monitoring equipment	£5,800		£3,700		
Total	£101,300	£65,200	£110,900	£61,100	

The initial budget for the project was £166.5K, with match funding of £16.5k from Two Piers in addition to the £150K TSB funding. Due to loss of the Low Carbon Buildings grant for solar thermal, asbestos removal and other costs Two Piers Housing Co-operative provided an additional £6k of funding, to raise their contribution to £22.5k.

10. Wash-up meeting

Regular meetings with residents and architects held throughout project, but no wash up meeting held.

11. Doing it again

Definitely do again:
External wall insulation was an easy and effective way of insulating the property and provided much less problems that internal insulation on the front street facing façade. If there had not been so many architectural features on the front of the property and the property was not in a conservation area then the budget for this component would have been significantly reduced and eliminated the thermal bridge where the two insulation systems cross over. The cost of reinstating the existing architectural detail was prohibitively expensive at around £15,000.

Definitely not do again:
Working with the residents in situ was a big challenge for the contractor and householders. For example cleaning up at the end of each day was time consuming and consistently doing it to a level that is satisfactory to people in their own home was difficult. In terms of progress, the most progress was made in the three weeks in October 2010 that the residents were decanted. A shorter build time in a vacant house would resolve this issue.

Reduction of costs (what might you leave out and how would you make things cheaper?)
Whole house ventilation with heat recovery was expensive and at the moment is not delivering a level of thermal comfort that is acceptable to the residents. We are in the process of resolving this, but an alternative ventilation strategy, e.g. only in kitchen and bathrooms might be more appropriate.

Improvement of the design process (better informed design decisions, more professional input, etc.)
Many of members of the professional team in phase 1 did not provide value for money in the sense that their services could easily be undertaken by either the main contractor or a subcontractor. These include: Quantity Surveyor, Mechanical & Electrical Engineer, CDM Coordinator and formal academic partner for monitoring and evaluation.

Improvement of the construction process (reduce timescale, smooth operation, etc.)
Longer lead time to resolve complex planning and conservation issues, e.g. issue of windows impacting on start date as outlined above.

Improvement of the commissioning and occupancy process
Provision of cheap affordable local housing to decant residents to during the build process.

What efficiency gains would you expect from a larger programme of retrofits?
Cheaper materials due to volume, e.g. thicker insulation depths as standard, e.g. 120mm instead of 2 x 60mm. Continuity of process as teams move between properties and increased skills and knowledge. Less thermal bridging but dealing with elements in volume, e.g. EWI in terraces. Volume of materials enabling Reduced design costs due to replicability of design and the introduction of a pattern book of robust details.

What, in your view, would be key to making replication at this scale successful?
The provision of affordable local houses to cheaply decant tenants to during the retrofit process to minimalise disruption. Training for subcontractors and residents on how to get the optimum performance from their retrofitted home. Negotiation of substantial discounts due to volume of materials ordered. Enhanced 'green deal' to enable investment in highly energy efficient components and insulated elements.

12. Business benefits

The experience of Retrofit for the Future has provided us with real learning in the delivery of low energy refurbishment to a high standard. This project was an opportunity to include all of the elements we advise clients to include, but usually are value engineered due to cost constraint. We would like to thank the Technology Strategy Board for this opportunity.

How many business leads and opportunities has the project helped stimulated for participants?

Three business leads in the last two months for Earthwise Construction, including a potential Passivhaus standard retrofit in Brighton, a low energy refurbishment in Brighton and a project to retrofit 450 houses in Suffolk including 8 to EnerPHit (Passivhaus) standard. We would be providing consultancy and project management expertise in the later.

What value of retrofit business do you expect as a result of the project over the next 5 years?

£2 million. Assuming 4 x £100k retrofits, 2 for the main contractor and 2 for the architect. This is a conservative estimate.