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: ZA398Y1
Property number: TSB054

Author: Ridge & Partners LLP

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.
Innovative solutions.

Final Report

Project information

- **ZA reference number: ZA398Y1**
- **Location of property: Oxford, OX2**
- **Lead participant details:**

Ridge & Partners LLP
The Cowyards
Blenheim Park
Oxford Road
Woodstock
OX20 1QR

- **Date report issued: 30 November 2011**

Contents

1. Project details and directory 4
2. Introduction 7
3. Occupants 7
4. Dates 7
5. Pre-retrofit property 7
6. Design 8
7. Construction 9
8. Commissioning and occupancy 11
9. Costs 12
10. Wash-up meeting 13
11. Doing it again 14
12. Business benefits 15
13. Additional Information 15

1. Project details and directory

Role	Organisation	Contact Details
Project Leader	Ridge & Partners LLP	Address: The Cowyards Blenheim Park Oxford Road Woodstock OX20 1QR Tel:01993815000 Website: www.ridge.co.uk
Property Owner		
Local Authority	Housing Projects Oxford City Council	Address: Oxford Town Hall St Aldate's Oxford OX1 1BX Tel: 01865 252319 Website: http://www.oxford.gov.uk/PageRender/decH/HousingIndex.htm
Design Team		
Architect	Ridge & Partners LLP	Address: The Cowyards Blenheim Park Oxford Road Woodstock OX20 1QR Tel:01993815000 Tel: 01993815000 Website: www.ridge.co.uk
Engineer	Ridge & Partners LLP	
QS	Ridge & Partners LLP	wharper@ridge.co.uk

Design Team		
Monitoring and POE experts	Low Carbon Building Group, School of Architecture	Oxford Brookes University Main contact: Tel: 01865 484049 Fax: 01865 483298
Contractor		
Main contractor	Leadbitter	Address: Grange Court, Abingdon Science Park, Abingdon, OXON, OX14 3NB Tel: 01235 544500
Sub-contractor – electric	CT Walters Electrical	Address: Unit 4 Park End Works Croughton, Brackley NN13 5LX Tel: 01869 810047
Sub-contractor – heating	Oxford City Homes	
PV installer / Solar Thermal	Applied Sustainable Energy	Address: Langford Locks Kidlington Oxford OX5 1LH Tel: 0845 834 0891
Supplier – windows	Window World (Wales) Ltd	Address: Unit A5 Garth Works Taffs Well Cardiff CF15 7RN Tel: 029 2081 3066

MVHR	Vectaire	Address: Lincoln Rd, Cressex Ind Estate High Wycombe HP12 3RH Tel: 01494 522 333
External Render	Surewall Limited	Address: Unit 19, Broadmarsh Business Centre Harts Farm Way, Havant Tel: 0870 609 2057
Cavity Injection Insulation	Miller Pattison	Address: Unit 11 Stadium Way Tilehurst Reading RG30 6BX Tel: 0118 9422 390
Painting / Plastering / External Works / Carpentry	Leadbitter	

2. Introduction

A partnership developed between Ridge and Oxford Brookes University (OBU) in collaboration with Oxford City Council (OCC) to assess one of the council's houses against the government carbon reduction 2050 targets. OBU monitored the internal environment of the chosen property and interviewed the tenants before any design work was carried out, They identified issues such as cold, dark spaces that were difficult to maintain at comfortable levels and which noted a significant increase in C02 levels going from summer into the winter heating season. Ridge surveyed the existing property and identified issues such as rising damp, condensation and movement cracks within the property.

We hoped to show the benefits of a fabric first approach on reduced heat loss and energy demand / carbon footprint as well as highlighting the benefits of a whole house MVHR system to winter CO2 levels. The property was to be monitored in detail for two years to record the results.

3. Occupants

The occupants – an older couple – were the same before and after the retrofit. They were decanted to another Council House for the duration of the works, just around the corner in the same area of Oxford. There were no issues regarding this apart from the cost of the move which was a little more than originally predicted in the Phase 2 application.

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	June 2009
Planning application submitted (if appropriate)	March 2010
Planning permission granted (if appropriate)	June 2010
Building Regulations application submitted (if appropriate)	May 2010
Building Regulations approval granted (if appropriate)	August 2010
Contract for work let / signed	September 2010
Occupants moved out (state if they remained or property was empty)	September 2010
Start on site	September 2010
Completion of retrofit	December 2010
Occupants moved in	December 2010
Monitoring system commissioned and operating properly	March 2011
Building defects corrected	March 2011
Building services and controls operating correctly	Jan 2011

5. Pre-retrofit property

The two up two down Victorian end terrace is solid brick wall construction with an artificial

slate roof. It has a flat roof two storey cavity wall rear extension built in 1972 which extends as into the garden as single storey extension. This rear extension contains the kitchen on the ground floor and bathroom on the first floor. This was extended a little further in 2003 with an additional ground floor WC.

OBU carried out monitoring prior to the retrofit.

OCC chose the property from a number of potential options by interviewing prospective tenants to determine the most co-operative household that would be least inconvenienced by being moved from their home for a period during the building work.

6. Design

We applied external insulation to the end gable wall and the rear north walls leaving the decorative brickwork exposed on the front south east elevation. Insulated plasterboard was applied to all internal walls including the inside face of the front and rear external walls. The inside face of the gable wall was left as plastered masonry in order to retain some thermal mass.

The roof was proposed to be insulated in the line of the roof with a number of roof lights added to allow summer purge ventilation and create a stack effect, while an MVHR system was fitted along with Solar Thermal tubes and PV panels.

A section of an internal dividing wall was removed on the ground floor to allow natural light from the bright south side of the house to get into the middle of the house and brighten the darker north side of the property. This also provides a great line of sight through the property for the tenants and increases the sense of space and openness in what is a very small house.

The existing double glazed windows were removed and new triple glazed windows added in order to reduce the disparity in thermal performance between the windows and the walls.

The entire house was rewired with a new heating system fitted with an efficient gas boiler. Monitoring equipment was fitted to record the temperature, humidity, CO2 levels in each room as well as the performance of the MVHR, PVs, Solar Thermal and individual circuits within the house.

The original design cost plan was over budget so the scope of project was reduced slightly, mainly affecting the roof works. The roof was insulated at ceiling level with a cold ventilated roof space retained and the roof lights were omitted. A single Monodraught Sunpipe was provided at the top of the stairs. This allows ventilation and daylight to the centre of the house over the stairs.

The key differences between the retrofit as designed and as built were:

- Rotten floor boards and concrete hearths were discovered in the first floor.
- Additional timbers were required to line the structural openings to receive the new windows as voids were discovered when the existing windows were removed.
- Wet roof decking was discovered when the 1st floor extension ceiling was removed showing the existing flat roof had been leaking.
- Gaps in the existing first floor structure including timbers in the rear extension all carried into the inner leaf wall making the air tight seal around them more complicated.

The strategy was to insulate the building as tightly as possible without losing excessive floor area or ceiling height, while improving the building airtightness. The MVHR was to improve winter air quality when windows are not opened as in summer, while allowing a stack effect up the stairs with the exposed masonry allowing night time cooling in summer to reduce the risk of overheating. The PVs and Solar Thermal are used at source as there is often someone resident in the property during the day.

7. Construction

- Procurement :
  Procurement was a negotiated cost plan. Revising the scope of works to suit the client budget and grant funding
- Contract type:
  JCT Minor Works Building Contract with Contractors Design
- Contract structure:
  The contract was Site Managed by a Leadbitter Project Manager with a core of direct labour throughout the scheme covering the labour only trades such as strip out and alterations, external works, carpentry, loft insulation, painting and plastering.
- Sub-contractors:
  Circa 12 subcontractors used on the scheme
  - Electrical – CT Walters
  - Mechanical and plumbing – Oxford City Homes
  - Solar Thermal / PV – Applied Energy Sustainability
  - MVHR – Vectaire
  - Windows – Window World (Wales) Ltd
  - External Render – Surewall Limited
  - Cavity Injected Insulation – Millar Pattison
  - Floor Coverings – Station Flooring
  - Scaffolding – Allen & Foxworthy
  - Mastic Sealant – S&D Sealants
  - Flat Roof – Charterville
  - Tiled Roof – Bicester Roofing CO.
- Specialist installers:
  As above contactors schedule. Appointed by LBC, but involved in the project at an early stage to ensure advice / recommendations and relevant standards were met.
- Specialist equipment suppliers:
  The majority of subcontractors employed in the scheme were local specialists that

have a proven track record of providing a quality product within a reasonable budget. As the scheme was negotiated following an initial tendering process, the subcontractors worked alongside us, the Client's team and client.

- Site supervision:
  We employed a Project Manager to oversee all works, subcontractors and suppliers on site and to keep a diary of the works on site, both written and video. To aid the project, OCC provided their Clerk of Works to assist in overlooking the quality and specification.
- Role of architect/design team :
  The architect and designers had a key role to play once works commenced on site. The nature of retrofit schemes is to have quick answers to site queries as situations / conditions and circumstances come up on site. The requirement to be flexible on site and still maintain the overall key aspirations of the project is critical. At the start of the scheme, it was agreed to have weekly progress meetings with all key project personnel, subcontractors and designers. Once major items were resolved, we meet on a fortnightly basis.

Lessons learned

The scheme was ambitious and asked a lot from the individual contractors to work well together on a one off scheme. However, we feel the spirit at the start and throughout was a credit to all involved in the scheme. The project had its own specific problems to overcome which we believe we need to see past. All schemes nationally would have been affected by the extreme weather experienced during the last winter, which did have a knock effect of trying to complete by Christmas in particular. Working in the centre of Oxford again throws up its difficulties with regards to contractors' parking, deliveries and site setup / facilities.

The specific site area was restrictive: an end terrace property, with the side gable abutting two neighbours' gardens. The rear garden was flanked on all sides with private property to one side and the end aspects, with the third side adjacent a local community building. Space within the property was at a premium, and "just in time" deliveries were critical to not affect other trades. With so many bodies on site at potentially one time, the sequencing of works was vital to remain productive.

Ultimately this restrictive area and neighbour concerns had a bigger impact on the scheme than we'd foreseen, and therefore impact on costs and programme were incurred as a direct and indirect effect of this.

Three specific tasks that were far more onerous than we had planned were the external works, external render insulation and the air tightness works. The works externally required more hand dig than planned and we uncovered problems with the existing drainage. The thickness of the external render insulation impacted on the existing openings such as the back door and also extended the window boards internally (specifically the kitchen window over the sink is quite a reach to get to the handle). The air tightness works were very labour intensive, taping, stapling, plastering and joining. We had an operative doing nothing but these works for a far greater period than we had planned. This also impacted on each following trade whose work needed to go through the membranes, so sheathing and sealing

needed to each fitting.

We would qualify that should a scheme be rolled out with a greater number of properties for retrofit, then the above kinks and sequencing problems would be significantly negated.

8. Commissioning and occupancy

1)PV
2) MVHR
3) Gas boiler / heating installation
4) Electrical installation
5) Monitoring System

The systems were reviewed with the tenants in the form of a tutorial, and handover packs were provided to cover queries and emergency contact details for representatives of each of the key specialist trades. It is critical to the overall performance of the scheme that the correct training is provided. Having an efficient property will not count for much if the property is not run efficiently on a day to day basis.

9. Costs

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration		Incl.		Incl.	
Design		12,400.00		12,400.00	
Construction overall					
- Prelims		14,217.50		38,779.00	Extended period due to weather, and Full Supervision Provided
- Fabric measures		33,906.72		42,600.00	
- Building services (conventional)		7,850.00		10,218.00	Increase costs for Electrical contractor
- Low /zero carbon technologies - PV / SOLAR / MVHR		8,103.00		8,603.00	Increase on solar thermal cylinder and pipework
- Other - Boundary Wall Works - Triple Glazed Windows and Doors - Kitchen - GF and 1st F Bathroom - Painting & Finishes - Professional Fee's		 3,010.00 6,154.00 3,800.00 9,520.00 5,991.24 2,820.00		 8,500.00 5,400.00 3,800.00 9,520.00 5,311.00 2,820.00	Increase in boundary wall costs and hand dig as previously noted
- Consequential costs		0.00		1,500.00	Items of compensation to neighbours for inconvenience
Occupant temporary housing		5,700.00		6297.00	
Monitoring equipment		7,762.00		7,762.00	
Monitoring and reporting service		37,100.00		37,100.00	
R&D costs (please detail)		/		/	

10. Wash-up meeting

2 February 2011 – Wash up meeting incl Post construction activities.
Attendees:
Oxford City Council
Oxford Brookes
Ridge
Leadbitter

Issues discussed.

1. Remaining monitoring installations to be carried out by EST/Microwatt

2. How and where the monitored data can be viewed on line.

3. Tenants User guide (graphic manual) – proposed contents.

4. Video camera for tenants

5. Official handover with tenants

6. Post completion testing

a. Air-pressure test and thermal imaging – TSB (BSRIA)

b. Additional thermal imaging – Oxford Brookes

7. Next two years – Oxford Brookes

a. Oxford Brookes to meet with tenants to discuss future monitoring/POE

b. Weekly and monthly download of monitoring data

c. Quarterly (seasonal) comfort and satisfaction questionnaire and interview

d. Daylight factor readings quarterly (seasonal)

e. System performance assessed and adjusted when necessary

f. Quarterly reporting to TSB

4 August 2011 – Monitoring Wash up meeting with Microwatt to review monitoring data received from the property. Issues discussed included gaps in monitoring data and sensors not working.
Attendees:
Microwatt
Oxford Brookes
Ridge

11. Doing it again

What would you definitely do, not do, or do differently if you were doing it again:

1. Definitely do again
   Provide an MVHR system to insure improved internal air quality.
2. Definitely not do again
   Leave stapled membranes untapped allowing air losses or allow internal insulation to be mechanically fixed to solid masonry walls creating cold bridge – picked up in the internal thermographic images
3. Reduction of costs
   LED bulbs in the central pendant fittings, as the tenant removed them as soon as they moved in as they were 'not bright enough.'
4. Improvement of the design process
   n/a
5. Improvement of the construction process
   Start the project earlier or later in the year to avoid the winter frost which affected the external work.
6. Improvement of the commissioning and occupancy process
   Reduce the complexity of the monitoring installation and allow the tenants to record the data within the property.

What efficiency gains would you expect from a larger programme of retrofits?

- Economies of scale in procurement larger quantities of materials
- Management and training opportunities of sub-contractors and tenants
- Potential for job creation in neighbourhood through apprenticeships
- Streamline maintenance contracts / regimes across properties for MVHR other services
- Options for shared energy centre / generation / district heating etc.

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

- Finding a suite of solutions that is appropriate for all properties.
- Finding properties that can be empty for the duration of the works.
- Reducing the capital cost of the works through economies of scale / reduced complexity
- Ensuring that whatever level of insulation is installed it is continuous and the buildings are airtight.

12. Business benefits

What lessons have been learned that will benefit the participants' businesses in terms of innovation, efficiency or increased opportunities?

Increased understanding of low energy design and the complications of retrofitting, reducing heat loss and air tightness best practice as well as the holistic approach the retrofit projects. The thermograph images taken by Oxford Brookes highlighting the heat loss through but joints in insulation taught us that lapped joints are essential to limit heat loss as well as fixing points, flashing and service penetrations. The lesson learned is that testing and assessing the as-built is as important as any pre-assessment to feed back into future projects.

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

Ridge
Direct – approx 12 gained to date, for example, Oxford Colleges and private residential refurbishments.
Indirect – we have formed a sustainability team creating opportunities and developed successful marketing material.
We have presented our retrofit project at several seminars which has raised our profile in the sector.

Oxford Brookes – 5 gained.

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

Ridge: 375k estimate over next 5 years.

13. Additional Information

The project has been great success. Our first three months of monitoring data show that we are well on the way to achieving an 85% carbon reduction at the property. The tenants are the happiest in Oxford in their bright, cosy, warm, draft free, quiet house. We are seeing very stable conditions in the property as far as temperature goes; however the CO2 levels are still rising when meals are prepared. The tenants have an internal display highlighting the CO2 levels and have been encouraged to open their windows to promote air changes to disperse the CO2 if they note it rising above certain levels. In this way, they are interacting much more with their environment than before the works.