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: ZA366J
Property number: TSB023 / TSB022

Author:
Hockerton Housing Project

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: ZA366J**
- **Location of property: Newark, Nottinghamshire NG24**
- **Lead participant details:**

Newark and Sherwood Homes Limited
Kelham Hall, Kelham
Newark On Trent
Notts NG23 5QX
www.nshomes.co.uk

- **Date report issued:**

Contents

1. Project details and directory 4
2. Introduction 5
4. Dates 7
5. Pre-retrofit properties 7
6. Design 8
7. Construction 10
8. Commissioning and occupancy 12
9. Costs 13
10. Wash-up meeting 14
11. Doing it again 14

1. Project details and directory

Role	Organisation	Contact Details
Project Lead		
Project Manager & Energy Consultant	Hockerton Housing Project Trading Limited	Address: The Watershed, Gables Drive, Hockerton, Southwell, Notts NG25 0QU Tel: 01636 816902 Email: hhp@hockerton.demon.co.uk Website: www.hockertonhousingproject.org.uk
Property Owner		
RSL	Newark and Sherwood Homes Limited	Address: Farrar Close, Brunel Drive, Newark On Trent, Notts NG24 2EG Tel: 01636 655561Website: www.nshomes.co.uk
Design Team		
Architect & Designer	Hockerton Housing Project Trading Limited	Address: The Watershed, Gables Drive, Hockerton, Southwell, Notts NG25 0QU Tel: 01636 816902 Email: hhp@hockerton.demon.co.uk Website: www.hockertonhousingproject.org.uk
Contractor		
Main contractor	Hockerton Housing Project Trading Limited	Address: The Watershed, Gables Drive, Hockerton, Southwell, Notts NG25 0QU Tel: 01636 816902 Email: hhp@hockerton.demon.co.uk Website: www.hockertonhousingproject.org.uk
Sub-contractor – electric	K H Electrical	Address: 65 Leeway Road, Southwell, Notts NG25 0BZ Tel: 01636 816144
Supplier – MVHR	EnviroVent Limited	Address: EnviroVent House, Hornbeam Business Park, Harrogate HG2 8PA Tel: 01423 810810 Email: MHickford@envirovent.com Website: www.envirovent.com
Supplier - windows	Yorkshire Window Co. Ltd	Address: Hellaby Industrial Estate, Hellaby, Rotherham, South Yorkshire S66 8HN Tel: 01709 540982 Email: info@yorkshirewindows.com Website: www.yorkshirewindows.com

2. Introduction

Hockerton Housing Project (HHP) was keen to demonstrate that our passive solar, high mass design principles that have been demonstrated successfully in many new-build properties could also be applied in a retrofit context.

Through a strong relationship with Newark and Sherwood District Council (NSDC), HHP contacted Newark and Sherwood Homes Limited (NSH) the Registered Social Landlord for the NSDC owned housing stock. A number of hard to treat house types from the NSH stock were considered as potential for the retrofit project, and in the end the Wimpey No Fines solid walled archetype was selected, for a number of reasons:

1. Solid walled properties are a particularly challenging house type for energy efficiency retrofit;
2. NSH had a significant number of Wimpey No Fines properties in their portfolio, and there are over 300,000 Wimpey No Fines houses in the UK;
3. One estate of Wimpey No Fines properties in Newark is an area of high social deprivation, and we were keen to deliver an exemplar retrofit project on such an estate;
4. HHP believed they could retrofit two properties within the available budget, and the estate had a large number of detached pairs of Wimpey No Fines that were still in NSH ownership. In addition, the retrofit approach taken lent itself to detached units (or detached pair in this instance).

HHP believed that through the implementation of their high mass, passive solar design, using predominantly existing technology and construction skills, a retrofit solution to deliver the aspirational energy use and emissions reductions in the order of 80% was achievable for this archetype.

3. Occupants

Two adjoining properties (a detached pair) were retrofitted. TSB022 was a void property at the commencement of the project; voids where the adjoining property was still in the NSH stock were targeted for the project, as it was far less complex to only have to approach one set of tenants to request participation in the retrofit project. It was hoped that properties with a southerly rear aspect would be retrofitted, as the intention was to build a sunspace to the rear of the properties to harvest passive solar energy. TSB022 and TSB023 have an easterly rear aspect, but were selected on the basis that:

1. We were keen to commence the retrofit project in spring 2010 so the work would be completed by autumn 2010 and would enable maximum monitoring period, including two heating seasons;
2. If properties with a southerly rear aspect had been used and the design proved successful, we would be open to challenge that it wouldn't work for other aspects, so an easterly rear aspect was more challenging, but if successful will give the design greater credibility.

The second property – TSB023 – was occupied by a retired couple who have lived there for a number of years. They were approached by NSH to see if they were prepared to have their home retrofitted, and expressed strong interest, so a meeting was convened with HHP to further discuss the proposed design, the likely benefits for them as residents, which were summarised in a Tenant's Benefits document, as well as a bespoke tour of Hockerton Housing Project, so they could see how the design principles worked in practice, albeit in a new build and differing archetype. Mr & Mrs Morton agreed to take part and, due to the invasive nature of the retrofit, were re-housed in a flat in the town centre for the duration of the build phase, but were regular visitors to site to inspect progress. They were also consulted on some of the more aesthetic exterior & interior re-designs of the house.

Following completion of the retrofit, the empty property was advertised through normal channels for NSH properties, but prospective tenants were asked to write a short statement of why they felt they would make good tenants for the retrofitted property; some details of the unusual nature of the property were included in the advertisement. A small number of applications were received, about half a dozen, and four applicants were short-listed for a short interview with NSH & HHP. This was to enable the tenants to find out more about the property and the implications of living there (such as the requirement for energy use monitoring and having to participate in annual occupancy evaluations & questionnaires) and NSH & HHP to assess the most appropriate tenants for the property, based on family unit size and lifestyle.

4. Dates

The dates below refer to both properties except where explicitly stated.

Event	Date
Project start date (when was the first proposal discussed or agreed)	May 2009
Planning exemption application submitted	29th March 2010
Planning exemption granted	9th April 2010
Contract for work let / signed	12th March 2010
Occupants moved out – Number 30; number 28 was void	26th March 2010
Start on site	29th March 2010
Completion of retrofit	1st Oct 2010
Occupants moved in	TSB022 – 5th Nov 2010 TSB023 - 4th Oct 2010
Monitoring system commissioned and operating properly	Nov 2010
Building defects corrected	N/A
Building services and controls operating correctly	1st Oct 2010 (on-going issues with MVHR)

5. Pre-retrofit properties

The pre-retrofit properties were a detached pair of semis, of solid wall construction (Wimpey no-fines concrete). They had all cost-effective energy efficiency measures applied – double-glazed throughout, gas condensing boilers, and recommended level of loft insulation (250mm). The only key difference between the properties was that TSB023 (the occupied property) had a modern kitchen and bathroom installed; TSB022 was due for kitchen and bathroom refit as it had just become void. The ground floor was solid concrete cast directly on the earth below.

The houses were both 3-bed semis over 2 storeys, each storey being 42m^2, giving a total floor area of 84m^2. Both houses had large rear gardens and good-sized front gardens, with gates and pathways to the side, giving access to the rear garden from the front, as well as access to the external side (kitchen) doorway.

The internal ground floor configuration of the properties was slightly different. Both houses had a front door opening directly into the hallway that led through to a separate kitchen to the rear, which contained the gas-condensing boiler. Off the hallway, TSB022 had access to a front sitting room; a rear separate dining room was accessed through the kitchen. TSB033had a single sitting/dining room off the hallway.

In both houses the first floor was accessed via a staircase from the hallway, directly inside the front door. At the top of the stairs and to the rear was a bathroom/WC; from the landing

the 3 bedrooms were accessed; 2 double bedrooms, one front and rear, and one single bedroom at the front above the stairs/front door. The airing cupboard containing the hot water cylinder was also located off the landing.

Both houses had a gas fire to chimney in the sitting room, and ventilation via airbricks in all rooms except kitchen and bathroom, which had electric extract fans.

No monitoring was carried out prior to the retrofit, but energy use data was available for TSB023 for the preceding two years, which showed that average annual electricity use (for lights, appliances and cooking) was 3,202kWh, and average annual gas use (for heating and hot water only) was 12,493kWh. The tenants were quite frugal in their energy use, and kept the property at quite a low temperature; during a pre-retrofit visit during the day, a thermometer in the kitchen was reading 15°C. This wasn't due to choice; the houses were very difficult to keep warm once the central heating was off, so to maintain a reasonable internal temperature throughout the day would have meant significantly higher energy use and cost.

6. Design

The key principles of the retrofit design were to turn the existing high mass walls and floor from a negative to positive energy element, through a combination of high levels of external insulation and passive solar design. The mass of the walls and floor would then act as a heat source, building up an energy store through spring, summer and autumn as they absorb excess energy from passive solar gain, and giving this out gradually through winter as internal air temperatures fall.

Passive solar design aspects include:

1. Re-sizing and positioning of openings to reduce heat loss and increase passive gains;
2. Addition of a porch to the front door and a 1.5 storey sunspace across the rear of the house, both to act as buffer zones between the internal and external environments, and the sunspace to harvest passive solar energy.

The addition of a sunspace to the rear of the properties also enabled the incorporation of a downstairs shower room/WC to improve the Lifetime Homes rating.

In order to introduce the levels of wall insulation required, 250mm, a new external brick skin was constructed, creating a 250mm cavity between it and the original 250mm thick solid wall, which was fully filled with insulation (Knauff Dritherm 32). This approach, rather than external cladding, was taken for the following reasons:

1. There are no proven solutions for mechanically fixing 250mm of external wall insulation;
2. The brick skin provides far greater longevity for the properties than an external insulation and render solution;

3. The existing roof had a deep overhang (almost 250mm) which meant the addition of a new external brick skin and large cavity would not require significant structural roof work – two additional rows of tiles had to be added and guttering was then attached directly to the external skin;
4. The brick skin is more aesthetically pleasing than a render finish.

In order to build up the new external brick skin, the existing bay windows to the front of the properties were removed. These bays were timber framed and tile hung, with no insulation at all, and therefore a significant source of heat loss. Constructing the new external skin around the existing bays would have been extremely complex, so the decision was taken to flatten the front aspect of the properties.

To remove heat loss through the floor, and to enable the mass of the floor to be beneficial (as a heat store), necessitated the excavation of the existing floor and sub-soil, right down to the base of the original footings. A 250mm layer of insulation was then added (Polystyrene) and a concrete slab then cast on the insulation, incorporating 50mm of edge insulation to avoid cold bridging between the floor slab and wall.

The chimneybreast was removed from the properties to reduce heat loss. It was removed right up through the upper floor and loft space, and the chimneystack was also then removed. The party wall (where the chimneybreast was located) was then insulated on both floors, continuously through the internal floor, and up into the loft space. This has two benefits:

1. It reduces heat transfer from the property up through the party wall and out into the loft space;
2. It provides sound insulation between the adjoining properties. As triple glazing was also introduced as a part of the retrofit, the houses would have far less external sound penetration, and therefore sound from the adjoining property would be more noticeable.

Loft insulation was topped up to 500mm (Knauff Earthwool), and the loft hatch sealed shut to prevent residents from storing possessions on top of the insulation and therefore negating its benefit. Additional storage space was introduced with the addition of the porch and sunspace to compensate for the loss of a loft space.

All windows and doors were replaced with triple-glazed PVCu (Eurocell Logik) units from Yorkshire Windows, with soft low-e coating and krypton filled, delivering a U-value of 0.8. The Porch and Sunspace windows and doors were double-glazed units from Yorkshire Windows. PVCu units were used instead of timber for the following reasons:

1. Lower maintenance for the RSL;
2. In keeping with the openings on the rest of the estate;
3. Lower cost.

A mechanical ventilation with heat recovery (MVHR) system from EnviroVent was installed. This extracted from the kitchen/diner, first floor bathroom and sunspace WC/shower room, and provided fresh air into the three first-floor bedrooms. Originally the MVHR solution was

designed in conjunction with EnviroVent to be modified so that when the house was below a pre-defined demand temperature, if available, warmer air would be imported from the sunspace rather than the external intake vent on the roof, to automatically harvest the passive solar energy accumulating in the sunspace. However, this design modification was ultimately not implemented by EnviroVent.

Hot water is provided via the HHP designed "Hotsi" indirect system incorporating a large volume (250 litres) super insulated temperature efficient thermal store; heating for the store is provided via an electric immersion. Since the water in the cylinder (store) isn't used directly, it need not be heated to 60°C, and instead is maintained at around 45°C, which still delivers sufficient temperature hot water at the point of use, at around 38-40°C. This system requires far less energy to provide hot water; in-use monitoring of the systems at Hockerton Housing Project has shown average daily energy use for hot water of around 4kWh, compared to UK average of 11kWh. The electric immersion is on a 7-day electric timer.

Due to the high levels of insulation, air tightness and passive solar design, there was minimal predicted heating demand, and as a result the gas central heating system was removed and replaced by two 2kW electric heaters – one in the sitting room and one in the dining room – and two 700W electric towel rails – one in the first floor bathroom and one in the sunspace WC/shower room. All heaters are on 7-day digital electric timers and have built-in thermostats.

Rather than install on-site renewables, a £1,500 investment per property was made in a local community owned wind turbine to offset onsite electrical consumption. This decision was made for the following reasons:

- The same financial investment in a large-scale offsite wind turbine would fund around 5 times the generation capacity from on site PV array;
- The orientation of the properties was not appropriate for a PV array;
- The investment in the community wind turbine should be repaid after 20 years;
- The offsite community wind turbine has no maintenance costs for the RSL;
- There was concern about potential vandalism/theft of on-site renewables.

7. Construction

HHP provided design and build for the retrofit, so there was no separate main contractor engaged for the build phase.

The build phase had to be carried out in compliance with Construction Design and Management Regulations, which was a requirement due to the client being an RSL. This necessitated a much higher level of project management and administration than had been factored into the project costing, which had a significant impact on the profitability of the project. NSH provided a CDM co-ordinator for the project, as HHP did not have anyone suitably qualified to perform this role.

HHP were the main contractor for the build phase. Additional specialist installers and sub-contractors were engaged as appropriate:

- A Gas Safe registered heating engineer was engaged to de-commission and remove the gas central heating system;
- An NICEIC registered electrician was engaged to fully re-wire the properties, install and commission all power, lighting and heating circuits , appliances and a new consumer unit; additional sub-meters were also installed for 8 individual circuits:
    - Downstairs ring;
    - Upstairs ring;
    - Kitchen ring;
    - Sunspace ring;
    - Lighting;
    - Heating;
    - Immersion heater;
    - MVHR;
- Two independent sub-contractors for general building & decorating;
- Two independent sub-contractors for bricklaying;
- EnviroVent provided supply and fit services for the MVHR system;
- Yorkshire Windows provided supply and fit services for the windows and doors.

Most of the build phase went to plan, although with some overrun on both budget and timeframes, for the following reasons:

- Once the actual properties for the retrofit had been identified (the precise properties were not known during the design phase), it was decided to fully re-wire and replace kitchens and bathrooms in both properties, and re-decorate throughout;
- One of the properties had been previously underpinned due to subsidence damage caused by a collapsed drain to the rear of the property. As excavation was carried out for the internal floor replacement and new external skin foundations, and the original footings and foundations were exposed, it became apparent that the underpinning was not adequate, so further underpinning to the original external walls of both properties was necessary;
- Side paths and ramps were requested to enable wheelchair access to both properties;
- Some of the windows and doors (for the sunspace and main entrance) were not delivered to specification and/or were not satisfactory for accessibility, so had to be re-specified, which caused additional cost and time delay;
- Electrical costs were far higher than the client was prepared to pay. This was as a result of HHP engaging a small and independent electrical contractor that has been used in the past and delivers high-quality and reliable work, but does not perform whole house re-wires of the scale/volume that the client would normally expect, and therefore cannot deliver the much lower unit costs that would be expected. *[As part of the rewire additions included the fitting of meters to the separate circuits in both houses,[as detailed elsewhere] additional separate circuits for water heating, space heating, porch lighting sunspace lighting, power, timers, heaters, rooflight switching, outside lighting and additional sockets over and above the typical refit*]. This led to

HHP having to fund some of the costs of the electrical work, which further impacted the project margin.

8. Commissioning and occupancy

The installing electrician carried out electrical commissioning; further commissioning tests for heating and hot water systems and the sub-circuit monitoring were carried out by HHP for a couple of weeks following completion of the retrofit and prior to re-occupancy.

EnviroVent engineers commissioned and tested the MVHR systems. Although initially these seemed to work fine, during the subsequent autumn, winter and spring (2010/11) a significant number of issues arose with the systems, including malfunctioning and complete breakdown. The original units were replaced twice, and finally replaced with a new model during the summer of 2011.

Following post retrofit air-pressure testing of the properties, it was discovered that there was an ill-fitting window in the bathroom of TSB033, causing unacceptable air leakage issues, so this was resolved by HHP.

To minimise energy use in the houses post-retrofit, it was vital that residents understood the design principles that had been incorporated, and how their occupancy could help maximise energy saving, whilst not impacting on their lifestyle. To educate the occupants, HHP carried out a walkthrough of the properties, pointing out all the features and how to best use the house to minimise energy use. In addition, a user guide was produced and provided for the residents of each house.

9. Costs

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration		£20,000		£25,000	
Design					
Construction overall					
- Sub-contractors		£51,000		£59,000	
- Fabric measures	£60,000		£52,000	£30,000	
- Building services (conventional)					
- Low /zero carbon technologies	£3,000		£3,000		
- Travel	£1,000			£3,000	
- Contingency	£5,000				
Occupant temporary housing					
Monitoring equipment	£8,000		£4,900		
Monitoring and reporting service					
R&D costs (please detail)					
Additional items (funded by NSH)			£10,000	£16,000	New partition walls Asbestos removal Electrical re-wire Sunspace shower room Bathroom refit Kitchen refit Carpeting Side paths Internal doors Staircase panels & rails

10. Wash-up meeting

A wash-up meeting was not held.

11. Doing it again

HHP operates a small consultancy business that tends to undertake small-scale bespoke projects; our strategy is not to develop into an organisation delivering large-scale retrofit build projects, although we would potentially undertake design and/or consultancy roles for large-scale retrofit.

Were we to undertake similar projects again, it would most likely be a bespoke project for private homeowner(s), and as such not under CDM regulations. Whilst we appreciate CDM regulations are appropriate and necessary on large-scale construction projects, we don't believe it added any value to our retrofit project; it was merely an administrative overhead that resulted in significant and unexpected additional cost. As a result we would probably avoid projects necessitating compliance with CDM, or be sure to factor in the additional costs, but on the scale of a project such as this retrofit, this would probably make us uncompetitive as a prime contractor.

Our experience with the MVHR systems and associated problems would make us examine their operating parameters more closely, to ensure they are viable for UK winter conditions; a system that switches to extract only at temperatures of 5°C or lower does not seem practical for UK climatic conditions, but this may be an unfortunate and unique feature of the units we installed.

We generally found suppliers very slow to respond to communications, needing a significant amount of management time simply to get a quote. This both surprised and frustrated us, particularly given the economic climate and general state of the building industry during the summer of 2010, when we would have expected businesses to be falling over themselves to gain business. As a result, we'd certainly engage suppliers earlier in the design process, and manage them more closely.

We were however very pleased with how the general build phase progressed and with the finished product, as were the client. We would certainly engage again small independent sub-contractors with which we had previous experience. We believe this added significantly to the overall quality of the final product, which is vital in energy-efficient retrofit, as quality and longevity of solution are key to long-term success.

We believe our solution for this house type can be successful at scale, and early monitoring results seem to support this view. The relative simplicity of the design, and complete lack of dependence on relatively new and unproven technology (MVHR systems aside), but rather only requiring proven methods, products and skills already widely available in the construction industry, is a particular strength in our view. Delivery at scale by a major construction firm would significantly reduce overall cost, but we are unable to accurately

predict this. Build quality is critical to retrofit work, and whether this can be maintained on a large scale and at a competitive price point is questionable.

12. Business benefits

The Retrofit for the Future completion was a great opportunity for HHP to demonstrate our energy efficiency design principles in practice and in a retrofit context, and has provided the opportunity to disseminate this to a wide audience.

As of yet the project has not stimulated any business leads or opportunities, but it did provide the opportunity for us to engage with a number of other businesses in the energy efficiency and retrofit sector, which may lead to future opportunities.

It is too early to say what impact this will have on our business over the next 5 years, but we expect the retrofit market to develop and grow significantly in that timeframe, and this project will give us a high-profile exemplar demonstration project from which to promote our services. We are confident that the homes will perform well, delivering significant energy and emissions reductions, and most importantly, significant fuel cost savings for the tenants.