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:** ZA241K
**Property number:** TSB062

**Author:** Roland Hill Ltd

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
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SBRI
Government challenges.
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Innovative solutions.

# Final Report

**ZA Reference Number:** ZA241K

**Location of property:** Whitehaven, CA28

**Lead participant details:**

Roland Hill Ltd
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**Date report issued:** August 2011

## Contents

1. Project details and directory ..... 4
2. Introduction ..... 5
3. Occupants ..... 6
4. Dates ..... 6
5. Pre-retrofit property ..... 7
6. Design ..... 8
7. Construction ..... 10
8. Commissioning and occupancy ..... 12
9. Costs ..... 13
10. Wash-up meeting ..... 15
11. Doing it again ..... 15
12. Business benefits ..... 16

## 1. Project details and directory

| Role | Organisation | Contact Details |
|---|---|---|
| Lead Partner | Roland Hill Ltd | Brayton Domain<br>Aspatria<br>Wigton<br>Cumbria<br>CA7 2BD<br>Website:<br>www.rolandhills.co.uk |
| Housing Authority | Home Group | The Copeland Centre<br>Catherine Street<br>Whitehaven<br>CA28 7SJ<br>Website:<br>www.homegroup.org.uk |
| Architect / Engineer | EnviroHomes Ltd | Brayton Domain<br>Aspatria<br>Wigton<br>Cumbria<br>CA7 2BD<br>Website:<br>www.envirohomes.co.uk |
| QS | Roland Hill Ltd | As above |
| Main contractor, directly carried out the following activities:<br>• Building<br>• Electrical<br>• Heating inc solar<br>• Plumbing<br>• All joinery<br>• Roofing | Roland Hill Ltd | As above |
| PV installer | CBJ Electrical Ltd | CBJ Electrical Services<br>Warwick Mill<br>Warwick Bridge<br>Carlisle<br>CA4 8RR<br>Website:<br>www.cbjconsultants.co.uk |

## 2. Introduction

The dwelling is located on a housing estate in West Cumbria. The estate has started to undergo major refurbishment in the last few years. The houses are in areas of social deprivation which were once vibrant communities. The area once had major industrial and mining complexes close by, which have now all gone. Creating exemplar properties in the area would encourage further regeneration in the area. It would also give a positive focus to the estate. Home Group owns in excess of 11,000 properties throughout the region and this scheme will be used as a pilot for future regeneration schemes.

The approach with the property has been a fabric first approach. The challenge is to upgrade the existing fabric and achieve deep cuts of about 60% in $CO_2$ emissions through fabric measures first. We wanted to demonstrate that this approach was best carried out with external insulation to the property. This is possible because the property still has its original cement render over the original brick cavity wall construction. The innovation for this property was the use of Vacuum Insulation Panels applied externally to the property. These should give excellent u-values with reduced thickness compared to the use of traditional insulants. Again, this was an aspiration because the adjoining property is privately owned so we did not want an excessive wall thickness change at the juction of the two properties. The proposed technologies for further reductions can also be easily scaled up and replicated in different areas of the region and the country.

The property also suffered from a first floor ‘bridge bathroom’, built in the 1970s. Residents do not like these so they are being removed. This property was chosen to demonstrate an off-site, highly insulated, modular solution to this replacement – provided by EnviroHomes Ltd. This was lifted into position, complete with fitted bathroom and kitchen, and connected to the house in an afternoon. Finally, the project team wanted to show that an older house can be bought very much up to, and well beyond, Decent Homes standards on an estate that has experienced social problems and does not have a good reputation within the town. The property, it is hoped, will be a lighthouse for the estate and attract good and positive comments from the occupiers and all the resident around it.

## 3. Occupants

This particular property was chosen as it was un-occupied and had been for a considerable time.

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

| Age band | Number before retrofit | Number after retrofit |
|---|---|---|
| Under 5 years | Property void | 0 |
| 5-16 years | Property void | 0 |
| 17-21 years | Property void | 1 |
| 22-50 years | Property void | 2 |
| 51-65 years | Property void | 0 |
| Over 65 years | Property void | 0 |
| **Please state if (yes/no):** | **Before retrofit** | **After retrofit** |
| Married couple / partners | Property void | Yes |
| Couple / partners with children | Property void | Yes |
| Any disabled persons | Property void | No |

## 4. Dates

| Event | Date |
|---|---|
| Project start date (when was the first proposal discussed or agreed) | 10/2/10 |
| Planning application submitted (if appropriate) | Not Required – permitted development |
| Planning permission granted (if appropriate) | |
| Building Regulations application submitted (if appropriate) | 12/7/10 |
| Building Regulations approval granted (if appropriate) | 4/9/10 |
| Contract for work let / signed | 15/9/10 |
| Occupants moved out | Void Property |
| Start on site | 18/10/10 |
| Completion of retrofit | 21/5/11 |
| Occupants moved in | 12/6/11 |
| Monitoring system commissioned and operating properly | 19/5/11 |
| Building defects corrected | 21/5/11 |
| Building services and controls operating correctly | 2/6/11 |

## 5. Pre-retrofit property

The property is ‘typical’ 1930s 3 bedroom semi-detached house. At the start of the retrofit the property was unoccupied and was one of a number of properties on the estate that were due for either refitting or demolition. This particular property was adjoined to an owner occupier and could therefore not be demolished. As can be seen from the pictures below the property was also joined by a ‘bridge bathroom’ to the next pair of semi-detached houses. Most of the semis on this estate are joined in this way. This was a way of giving the house separate bathrooms in the 1970s when they were erected. The next 4-5 blocks of houses were demolished during this retrofit project.

The property is brick built with a cavity, approx. 50mm wide, which is uninsulated. Home Group has not had good experience with insulated cavities in Cumbria. This is partly due to the exposed nature of a lot of their houses – this house being only ½ mile away from the Irish Sea. The exterior of the house still had its original cement render and this was in poor condition, it was cracked in a number of places and hollow for a considerable portion of the exterior.

The original house was approx. 70m$^2$ between the two floors. The first floor had three bedrooms and Home Group were keen not to reduce this number by keeping the bathroom upstairs in the existing building perimeter.

The roof of the property still had the original tiles. These have suffered greatly over the years from the, now demolished, chemical works nearby that over the years produced considerable pollution.

There was an unheated under stairs cupboard / coal house that was accessible from outside the property only. In the past this had led to cold spots within the property. In the bedrooms the ceilings are partly within the slope of the roof. This section of the rooms was completely uninsulated and had led to considerable heat loss and condensation problems.

The property had no utilities connected to it at the start of the project and was therefore not monitored. It was picked so that it could be shown as a lighthouse project for the rest of the estate and Home Group NW. Comparing the condition of the property at the start of the project with that at the end.

## 6. Design

The basis of this design has always been a fabric first approach. The idea was to make the building envelope as efficient as possible before any heating elements and controls were added. Because the property was rendered, with the render in a poor state of repair, it was decided to externally insulate as the render had to be replaced anyway. Because the property is adjacent to an owner occupier it was further decided to limit the aesthetic intrusion as much as possible at the junction of the two properties. Therefore the concept of Vacupor Vacuum Insulation Panels was considered. This is a material that has been used very little in the UK but that has great potential. It was decided to use the material not only on the exterior of the house but also in the ground floor. For the exterior application the supplier recommended that their Vacupor PS product was used. This is a vacuum panel that is sandwiched between two layers of 10mm polystyrene. This allows the material to be adhered to the brick work of the house and then also polymer rendered to give a strong external finish. This gave an external finish to the house that was not dissimilar to that before work started – only with a cleaner finish!!

During the construction the only item that appeared that was not known about was a public sewer that ran through the rear garden of the property. This happened to also run directly under where the pocket foundations for the modular extension were to be positioned. Because the extension is modular, it was relatively easy to have this redesigned and the position of the supports were altered to accommodate the drains.

From the point of view of the energy saving designs there were only three minor areas that were altered. These are described below.

1. MVHR versus passive ventilation. The project originally was designed with passive ventilation. However this had to be altered to an MVHR unit because of technical and planning issues with the passive system. The bathroom and kitchen are in the ground floor extension which meant that the ducting would have to go from these locations vertically up to close to the ridge line. This meant that ducting was difficult to support effectively outside. It also raised concerns about aesthetics and planning consents –

which were not required with the scheme as originally designed.

2. Portions of the three bedrooms were within the slope of the main roof due to the height of the ceilings. The amount of insulation in this slope had to be reduced slightly over what was planned initially. Therefore within this area the target u-value was not met. This was because the thickness of the insulation required would have impinged on the internal window reveals in each of the bedrooms. However the total area of this part of the roof is approx. 10% of the total roof area so it was felt that making it more aesthetically pleasing within the property was preferable.
3. Originally it was planned to fit cavity wall insulation to the property. However this was not carried out and the cavity remains unfilled. This was because of three fold concerns:
    a. Primarily the RSL has had a history of major problems with cavity insulation to the point where they do not fit it on any of their properties and have removed if from a number of them
    b. On inspection there was a considerable amount of debris at the base of the cavity which led to concerns over breaching of the cavity.
    c. The property adjacent to the one in question is privately owned. None of the companies contact could guarantee that there would be no problems internally next door due to a possible varying of thermal performance of their wall. This was due to the ‘overblow’ of material from ‘our’ property to the privately owned one.
4. Originally the exterior doors were to be proprietary insulated composite doors. However ‘good’ doors were on long lead times and did not have low u-values. Timber doors were developed that were filled with vacuum insulation panels to give a theoretical u-value well below 1.0 $W/m^2K$. We are now developing these as a product for sale.

## 7. Construction

For the contract from the TSB in this project, Roland Hill Ltd was the lead, designer and contractor. Therefore the approach to the procurement etc. was not in a standard method or route.

- **Procurement** – It was always understood from the outset of the project, between the RSL and Roland Hill that Hill would act as principle contractor and designer for the project.
- **Contract type** – This house was a void at commencement of the project with no utilities connected, kitchen removed etc. Therefore there were a number of items of work that were required to be carried out which were not covered by the Retrofit for the Future competition. These works were covered under a JCT Minor Works contract with Contractors Design.
- **Contract structure** – One of the main benefits of this project is that Roland Hill directly employ all the trades used on this project with the exception of specialist installers – see below. The company is registered under MCS for installation of solar thermal panels so this was also undertaken. Regular meetings were held between the RSL and Roland Hill Ltd. In addition to the work being carried out under the Retrofit for the Future project, progress was also monitored on the work outside the project. This included, for example, reinstallation of all the utilities, replacement of the roof, fencing and walling etc.
- **Subcontractors** – the only specialist work that was subcontracted was the installation and commissioning of the solar PV panels. Because of the general extensive works that were required to the house this meant that more than one trip to the site was required by the subcontractor to install and commission. Their work was hampered, for example, by not having an electrical supply to the property which meant that commissioning could not be completed.
- **Specialist installers** – The only specialist installer required was for the solar PV installation to ensure that the system met the full criteria of the MCS accreditation. This company was directly employed and instructed by Roland Hill.
- **Specialist equipment suppliers** – specialist equipment provided was as below:
    - Vacuum Insulation Panels. These were procured from EnviroHomes Ltd which is the importer of VIP's from Porextherm in Germany. On investigation, this was the only VIP on sale in the UK with third party accreditation that would be accepted by the local building control. In addition it was the only VIP that was available in the UK that could be used on the exterior of the building and be directly rendered onto. There are others available but these have to be imported by the user. It had been originally planned for the supplier to be on site all the time that the external wall insulation was being fitted. However the application of the panels was so straight forward that after a short time it was felt that they were no longer required.
    - Solar thermal panels. These were supplied from Sundwell Solar (manufactured in the UK). Roland Hill has used these in the past and found them to be very reliable and excellent in their performance. In their experience they appear to outperform other more common panels.

- **Site supervision** – Site supervision was again by Roland Hill direct labour. Because of the closeness of the site to the head office of the company the supervision was carried out by visiting inspection at least once a day.
- **Role of design team** – The design team and the contractor were one and the same company. Therefore the designers were retained on the project for its duration. Designers and engineers visited site at regular intervals – at least twice weekly. This ensured that work was interpreted and carried out as envisaged. It made sure that any installation issues could be discussed on site with the trades directly before work on that particular element had commenced. There was however close liaison with other suppliers. This was especially true with EnviroHomes which supplied the Vacupor Vacuum Insulation Panels. This close approach meant that the correct material was specified and ordered in the correct manner. Early involvement with the supplier mitigated any possible problems with the insulation with it being on a 3-4 week lead time.

## 8. Commissioning and occupancy

Setting to work, testing and commissioning of the equipment went smoothly overall. There were no major problems with the equipment itself. The only hold up in this process was waiting for the utilities to be reinstalled and completed. There was an original plan to have all the commissioning carried out within approximately three days as a block. This was not achieved however mainly due to the considerable wait to have the gas supply reinstalled. This alone meant that final commissioning and handover of the house – fully tested – was delayed by approximately four weeks.

All test and commissioning data was recorded and held on file as a reference for the future.

Occupancy in this project was very straightforward. A new tenant was identified well before the house had reached completion and commissioning had taken place. Therefore they were shown round the property on a number of occasions to have the design rationale and principles explained to them. During this time we took on board any specific comments they had and involved them as much as possible. For example, the house was painted to colours specified by the tenant. Before the tenant moved into the property a training / appreciation session of approx. 2 hours was held with them. This went through the following systems:

1. Boiler
2. Solar thermal panels
3. Solar PV panels
4. Extraction systems
5. Low energy lighting
6. Controls and monitoring system
7. Instrument positions and what they read
8. Limitations of any equipment or systems

The tenants moved in immediately after this initial training. For the first couple of weeks or so they were left to ‘getting used to’ the house and the equipment and control systems. Manuals and instructions etc. of all the systems and controls had been left in the house. After this initial settling in period a further ‘top up’ training session was carried out. This followed a similar agenda to the first session but left out material where the tenant felt that they were fully conversant with a particular system.

After about four weeks of being in the house the tenants went through the first of the post occupancy evaluations. This involved a face to face interview and also explanation of how the on-going evaluation would be conducted.

So far the tenants in this property have fully embraced the house and all the systems within it. They are showing others from the estate around the property on an impromptu basis and are proud to be involved in the whole process. Key to this has been the involvement they felt during the final stages of the retrofit and prior to them moving in.

## 9. Costs

| Item Stage> | Design stage | | Post-construction | | See Numbered Notes Below |
|---|---|---|---|---|---|
| | Materials | Labour | Material | Labour | |
| Management and administration | N/A | 7000 | N/A | 8924 | (1) |
| Design | N/A | 5500 | N/A | 4697 | (2) |
| Construction overall | | | | | |
| - Prelims | 1690 | 300 | 1720 | 526 | (1) |
| - Fabric measures | | | | | |
| o Floor insulation | 2700 | 2950 | 2766 | 3123 | (3) |
| o Wall insulation | 8832 | 9754 | 8725 | 11524 | (4) |
| o Windows & Doors | 5000 | 2276 | 3260 | 4983 | (5) |
| o Roof | 980 | 1564 | 712 | 1354 | |
| - Building services (conventional) | 8195 | 4410 | 8623 | 4527 | (6) |
| - Low /zero carbon technologies | 3240 | 1936 | 1684 | 975 | (7) |
| o Solar thermal | 8580 | 0 | 6276 | 0 | (8) |
| o Solar PV | | | | | |
| - Other | | | | | |
| o Decoration | 420 | 1350 | 493 | 1362 | |
| - Consequential costs | | | | | (9) |
| o Demolition | 120 | 3120 | 187 | 2943 | |
| o Openings | 3780 | 400 | 3527 | 412 | |
| o M&E | 700 | 1410 | 777 | 1269 | |
| o Kitchen / Bathroom | 850 | 2295 | 451 | 1837 | |
| o 2nd Fix / Decoration | 1300 | 2810 | 1456 | 2341 | |
| o Utility Supplies | 3100 | 1400 | 2546 | 927 | |
| o Extension | 5245 | 7872 | 6135 | 5236 | |
| o Externals | 3290 | 5920 | 4625 | 7346 | |
| Occupant temporary housing | N/A | N/A | N/A | N/A | |
| Monitoring equipment | 12595 | N/A | 9357 | N/A | (10) |
| Monitoring and reporting service | N/A | 37921 | N/A | 34921 | (11) |
| R&D costs (please detail) | N/A | N/A | N/A | N/A | |

Please note all costs above exclude VAT. This has been done because under HMRC rules there will be a mixture of 5 & 20% VAT. Leaving them excluding VAT keeps them on a 'level playing field'.

(1) The project overran the original timescales for a number of reasons and his meant that the overall costs for this were over that originally budgeted.
(2) It was estimated there would be more work to do on designs after contract award than was required in reality.
(3) Working with the specialist supplier (EnviroHomes Ltd) meant that costs were accurate in this area. The slight overrun on labour was attributed to the breaking up of the existing floor structure.
(4) Working with the specialist supplier (EnviroHomes Ltd) meant that costs were accurate in this area. The overrun on labour was attributed to the amount of learning and practice required for applying the external insulation. It is felt that for the next project carried out using Vacupor insulation the labour portion would drop to the budgeted figure. This is based on a measured time for applying the insulation towards the end of the process – which was far faster than at the start.
(5) Originally it was planned to buy the new triple glazed windows required for the project but these were eventually made in-house. This accounted for the differences between the budgeted and actual labour and material splits. Extended delivery times quoted from the original manufacturers necessitated the final manufacture of the units within our own joinery shop and this was another reason that the project overran on time.
(6) Changes in specification from the design period to the actual installation caused differences in the costs in this area.
(7) Significantly more competitive quotes were received for the equipment. In addition Roland Hill became MCS accredited and the labour portion of this element was brought in-house.
(8) This element was subcontracted. The reduction in cost was due to the falling cost of PV systems that has occurred over the months of the project.
(9) None of these costs are covered by the TSB project but by Home Group. These covered items that were required to bring the house up to Decent Homes and habitable standards. The majority of this was predicted before the project commenced.
(10) For this project we developed our own monitoring and control system. This went through more of the design and prototyping in phase 1 of the competition than was originally thought. Therefore the cost associated with this to complete to running stage was less than was predicted.
(11) Most of this cost was for POE for Oxford Brooke University. The reduction in cost was because a co-heating test was originally planned but this was not carried out because the house was not completed until spring time.

## 10. Wash-up meeting

No wash up meeting was carried out – mainly due to the complications of aligning diaries

## 11. Doing it again

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

1. **Definitely do again** – the use of the Vacupor Vacuum Insulation, in both the walls and floors, was a good way to prevent making house appear very different next to its un-modified 'twin'. This gave excellent thermal results whilst leaving the house with the same traditional architectural look. In the floors it greatly reduced the amount of material needed to be carted off site and tipped and gave good thermal results again. The use of the off-site constructed extension reduced the amount of time required on site for this particular element of the retrofit.
2. **Definitely not do again** – because of the orientation of the property, the addition of the solar PV panels did not have the effect that might have been hoped and they did not really give the return that would have been expected for the capital outlay.
3. **Reduction of costs** – in a house that was not particularly treated with air tightness membranes, the use of the mechanical ventilation was marginal.
4. **Improvement of the design process** – the design process was not too problematic as the house was not in a habitable state prior to being chosen for the project. In a habitable situation more time would have to have been taken deciding on what would be kept of the original house and what would be redone.
5. **Improvement of the construction process** – time was lost on site by not having everything to hand or not having definite delivery dates for equipment. This led to problems with scheduling labour and the construction period being extended longer than was intended. For fast turnaround on construction projects, possibly nothing should be started until all the equipment and components were available.
6. **Improvement of the commissioning and occupancy process** – integration of all the technologies together, especially with the bespoke control and monitoring system, was not perfect. However it is felt that this would become more 'slick' the larger number of retrofits were carried out including all these technologies.

Significant efficiency gains could be made with the Vacupor vacuum insulation if a large number of similar properties could be tackled in one project. Here, considerable time was required to measure the house accurately to have the panels constructed. With similar houses one could be measured and then spot checks carried out on each of the other houses to check for regularity. All other areas would benefit from larger project sizes including all the renewables etc. In addition, management costs per house would significantly reduce for larger properties as would all the other preliminaries.

Key to making a larger project run more efficiently would be close coordination between designers and the early involvement of the tenants. This would involve both overview and

detailed briefing session and management of their expectations of the work to be carried out.

One of the main lessons learnt is how important it is to look at a whole project solution and how the integration of differing technologies can affect the final outcome.

Another key element is the time spent with tenants on training and familiarisation – for this project a considerable amount of time was invested in them and it is felt unlikely that this time could be spent with every tenant if this was being rolled out over a larger number of properties. In addition, the tenant who moved into this house was very amenable and enthusiastic about the project, wanting it to work. In reality, unfortunately, not every tenant would be this enthusiastic.

Other lessons learnt are around the Vacupor insulation which would take considerably less time to fit than was required on this project. In fact it was easier to fit than was originally predicted.

## 12. Business benefits

The profile of Roland Hill Ltd, and evidence of its capabilities, has been significantly raised in the regional area in which it operates through this project.

EnviroHomes Ltd, the supplier of the Vacupor, has seen a significant upturn in the number of retrofit enquiries for its product which has led to increased sales of the product.

Roland Hill is forecasting to receive approx. £10m of retrofit business over the next five years.

EnviroHomes is estimating an total increase in sales of approx. 300% over the next five years, equating to a total increase in sales of approx. £6.5m