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: ZA213Y
Property number: TSB061

Author – Isos Housing Ltd.

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Technology Strategy Board
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SBRI
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Final Report

Project information

- **ZA reference number:** ZA213Y
- **Location of property:** Tyne and Wear, NE29
- **Lead participant details:** Isos Housing
  5 Gosforth Park Avenue
  Gosforth Business Park
  Newcastle upon Tyne
  NE12 8EG
- **Date report issued:** October 2011

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1. Project details and directory

Role	Name & Position	Organisation	Contact Details
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Contractor			
Main contractor		EnviroHomes Ltd	Address: Blyth CEC Ridley St, Blyth. NE24 3AG. Tel: 01670 542 857 Website: www. envirohomes.co.uk
PV installer		John N Dunn Group	Address: John N Dunn Group Phoenix House Kingfisher Way Silverlink Business Park Wallsend Tyne & Wear NE28 9NX T: 0191 2952900 Email: info@sol2o.co.uk

2. Introduction

The properties in our ownership meet Decent Homes Standards (DHS). We aim to invest in, and continuously improve, our housing stock to ensure that it can meet the highest possible energy efficiency standards. The Retrofit for the Future competition was an excellent opportunity to work with 'Green technology pioneers' to help find a solution to some of the challenges we encounter.

The two storey property at the heart of the Retrofit Project had solid brick walls, no roof or wall insulation, timber framed single glazed windows, domestic hot water provided by the mains system in a water storage tank, radiators without TRVs or sophisticated controls and a roof that was traditionally slated and insulated well below current recommended standards. The main heating source was via a Baxi Bermuda gas back boiler, secondary gas fire and radiators were off the mains gas supply. The property is situated in North Tyneside, Tyne & Wear. It is located in the Riverside ward which ranks among the most deprived 5% in the country. This type of property is typical of those built in this period. Whilst gas is available, which is the cheapest form of heating, the design of the dwelling means it is considerably less efficient than more modern house types, resulting in some tenants experiencing fuel poverty due to the inefficiencies of the house design. To summarise, the property was 'hard and expensive to heat'.

This type of building is common, particularly across the North East. Isos has 564 similar properties within its portfolio. We wanted to find a solution to the 'hard to heat problem' and if successful it would provide excellent opportunities for replication.

Ultimately we hope the project will act as a catalyst for the 'retrofit market' and an opportunity to showcase radical exemplar solutions for people living in social housing. This will assist in raising awareness of the technologies available, inevitably increase market demand and thus make these solutions more affordable. By improving energy efficiency we can reduce fuel poverty and improve the health and well being of tenants.

3. Occupants

The occupants were initially the same before and after the retrofit (a mother and daughter). The original tenant moved back to the property in December 2010.

The original tenant moved from the property in May 2011 to a home elsewhere in the region (for reasons unrelated to the retrofit project).

During the decant period, some of the occupants property was put in storage (e.g. white goods).

There were no great challenges encountered when decanting the tenants. Isos ensured that they had a choice of suitable alternative accommodation i.e. within the locality and in close proximity to family, friends, schools etc. It was a priority that the tenant's social and family networks were not disrupted.

When the property became void in May 2011, several problems with the boiler/air source heat pump were identified along with the PV and solar thermal panels. Further work had to be undertaken by EnviroHomes; this was completed on 29 July 2011.

A new tenant was selected using the local Choice Based Lettings (CBL) scheme. Before they accepted the tenancy, the prospective tenant was fully informed of the details of the retrofit project and our aims and objectives.

The tenancy of the new tenant started in August 2011.

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	8 June 2009
Planning application submitted (if appropriate)	-
Planning permission granted (if appropriate)	-
Building Regulations application submitted (if appropriate)	-
Building Regulations approval granted (if appropriate)	-
Contract for work let / signed	May 2010
Occupants moved out (state if they remained or property was empty)	30 June 2010
Start on site	July 2010
Completion of retrofit	29 July 2011
Occupants moved in	December 2010/ August 2011
Monitoring system commissioned and operating properly	29 July 2011
Building defects corrected	Zero defects.
Building services and controls operating correctly	29 July 2011
Other key dates? (please add more lines as necessary)	=

5. Pre-retrofit property

The property is an Edwardian two bedroom end terrace house. The house is of solid wall brick construction, the thickness of the bricks being 275mm. There was no insulation on the walls. The insulation in the roof had been upgraded over the years to be 150mm thick quilt. The windows had been replaced shortly before the retrofit began as part of a planned maintenance programme (double glazed UPVC). The total floor area of the property is approximately 70m^2. The house is on the main gas network and had a gas combi-boiler installed which provided both the domestic hot water and the central heating. Heating distribution was by standard panel radiators. A two storey rear extension had been added, estimated to have been in the 1980s. This housed a utility room on the ground floor and bathroom on the first floor.

6. Design

The design was a ‘fabric first’ approach. The idea was to make the building envelope as efficient as possible before any heating, renewable technology and controls were added. As the property was of brick construction, located ‘directly onto the street’ and an end terrace, external insulation was not feasible. Many of the ‘traditional’ forms of internal insulation were also prohibitive for use because of the amount of internal floor space that would be lost. Aerogel materials were originally considered as they have a very good insulation in a relatively thin layer. However, the cost of the Aerogel became prohibitive. 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. This proved to be a more cost effective solution and also thermally more efficient that using the Aerogel. After further investigation, it was decided that Vacupor would be used on the interior of the walls and also in the ground floor. Vacupor panels were laid directly over the existing floor and then a ‘floating floor’ placed over the top. This gave an overall reduction in head height of 40mm – however this could be easily accommodated in this Edwardian property.

To give protection to the Vacupor wall panels, a 50mm timber stud frame was placed in front of them. The stud then had plaster board fixed over it and was then skimmed. This gave a ‘service void’ for electrical wiring etc. In addition, in the future, pictures, light shelving and furniture can be fitted without the insulation being compromised. Although this method did add to the thickness of the wall, the overall thickness for the u value required was still considerably less than for a PIR based solution.

Originally the windows were to be replaced with timber triple glazed units. However, just before the project began new plastic windows were fitted. They were not replaced again (to save cost). However, In’Flector blinds were fitted to ‘up rate’ the u-value of the windows. In’Flector blinds can be reversed to keep heat in the property during the winter months and stop heat entering during the summer. They are a relatively new concept and have just been given third party accreditation.

Heating was provided by a new unit to the UK - a Daalderop Combinair. This is basically a ‘siamesed’ air source heat pump and combination gas boiler. The majority of the heating load is taken by the heat pump. In cold periods, this is ‘topped up’ by the gas boiler. All the domestic hot water is provided by the gas boiler but augmented by the use of solar thermal technology. Originally the new domestic hot water tank was to be placed adjacent to the boiler. However, space constraints meant that the tank had to be located on the first floor. This means that the distance from the tank to the boiler is not ideal and there will be some unnecessary heat loss between the two, despite the pipe work being lagged. The tank and solar thermal cylinder are located in the cupboard in the second bedroom which reduces the level of available storage space.

Solar PV panels with a designed load of 1.0kWp were fitted to the roof. The house faces south east so is not ideal in orientation. However, the roof has a good pitch at 30 degrees and there is no over shading of the panels.

Ventilation is provided by mechanical ventilation with heat recovery. The unit is located in the loft and extracts from the bathroom and the kitchen. It also incorporates the extract over the cooker. This is a standard feature for this Itho (now Daaldrop) equipment.

Originally the exterior doors were to be proprietary insulated composite doors. However ‘good’ doors were on long lead times and the project team were not sure of their performance. EnviroHomes developed timber doors that were filled with vacuum insulation panels that give a theoretical u-value well below 1.0 W/m^2K (EnviroHomes are now developing these for sale).

7. Construction

From the outset Isos, EnviroHomes and Northumbria University used a ‘partnership approach’ to the retrofit project. As each company would be guaranteed of the work, a traditional JCT contract was not signed.

- Procurement – EnviroHomes took the lead on construction and were also designer for the project.
- Contract type – As discussed, above there was no formal JCT contract between the organisations.
- Contract structure – EnviroHomes’ core business is the manufacture of modular buildings. However, the sister company to EnviroHomes is a traditional contracting company. Therefore the actual construction was completed totally by Roland Hill Ltd. 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 also registered under MCS for installation of solar thermal panels so this was also undertaken. Regular meetings were held, between Isos and EnviroHomes and in turn EnviroHomes and Roland Hill Ltd. In addition to the work being undertaken for the Retrofit project, there were some minor works that were not covered by the competition funding - for example, removal and refitting of kitchens, up-grading of bathrooms etc. This was originally going to be undertaken by Isos but was actually completed by EnviroHomes (with funding from Isos).
- Sub-contractors – the only specialist work that was sub-contracted was the installation and commissioning of the solar PV panels.
- Specialist installers – The only specialist installer required was for the solar PV installation. This was so that the system met the full criteria of the MCS accreditation. This company was directly employed and instructed by EnviroHomes.
- Specialist equipment suppliers:
    - Vacuum Insulation Panels. This was procured by EnviroHomes Ltd directly from Porextherm and imported from Germany. On investigation, this is the only VIP that could be found to be readily available with third party accreditation that would be accepted by the local building control. There are others available but they were either without accreditation or the support from the manufacturer not to the required standard, usually because they were not a UK supplier. The application of the panels was uncomplicated and the manufacturer did not need to visit the site for any specific training.
    - Solar thermal panels. These were supplied from Sundwell Solar (manufactured in the UK). EnviroHomes have used these in the past and found them to be very reliable and excellent in their performance. Based on our experience, they appear to outperform other more common panels.
- Site supervision – Site supervision was by EnviroHomes. 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. Isos surveyors and the Retrofit Project Manager also visited the site at regular intervals.
- Role of design team – The design team and the contractor were ‘one and the same’

(EnviroHomes). Designers and engineers visited site at regular intervals – at least twice weekly. This ensured work was interpreted and undertaken as envisaged. Any installation challenges were discussed on site with the trades directly before work on that particular element had commenced. There was also close liaison with other suppliers. This was especially true with the Vacupor vacuum insulation panels. This close supervisory approach meant that the correct material was specified and ordered in the most efficient manner. Early involvement with the supplier mitigated any possible problems with delivery with it being on a 3-4 week lead time.

8. Commissioning and occupancy

Few challenges were encountered when setting to work, testing and commissioning the equipment. There were no major problems with the equipment itself, although there was an original plan to have all the commissioning carried out within a block.

Commissioning the monitoring equipment proved to be the most challenging part of the project as it was designed specifically for the property. Whilst the controls were commissioned quickly to allow the tenant to move in, the monitoring side was more problematic.

There were challenges with getting the instruments to 'talk to' the data collection equipment. Due to technical difficulties encountered by EnviroHomes and their subcontractors, the remote monitoring and data collection outlined in our proposals was not possible. Data is successfully transmitted and collected, but only on a USB stick within the property.

Before the original tenant returned to the retrofitted property, they viewed it on a number of occasions to have the design rationale and principles explained to them. During this time Isos and EnviroHomes took on board any specific comments they had, and involved them as much as possible in decision making. Before the tenant moved back in, a training / appreciation session of approximately 2 hours was held with them. This discussed 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

For the first few weeks the tenant was left getting used to the house and the equipment and control systems. Manuals and instructions for all the systems and controls were left in the house. After this initial settling in period, a further top up training session was undertaken. The biggest challenge for the tenant was understanding the concept of the new heating system. This had to be explained on a number of occasions. The amount of information displayed on the touch screen control panel caused confusion, e.g. the temperature in every room is displayed and there is no thermostat 'dial' on the wall to use. The tenant expected, early on, that the temperature in all the rooms should be the same. There was a considerable amount of education required to explain the concept of zonal heating. By displaying less information, it is felt that this issue would not have arisen.

The original tenant in this property fully embraced the house and all the systems within it. Key to this success was their involvement and inclusion in the final design/installation

process.

The original tenant moved from the property in May 2011 to a home elsewhere in the region (for reasons unrelated to the retrofit project).

When the property became void, several problems with the boiler were identified along with the interaction between the control panel and the PV and solar thermal systems. Further work had to be undertaken by EnviroHomes; this was completed on 29 July 2011.

The new tenant was selected using the local Choice Based Lettings (CBL) scheme. Before they accepted the tenancy, the prospective tenant was fully informed of the details of the retrofit project and our aims and objectives by the area Housing Officer.

The tenancy started in August 2011 and the tenants were trained by EnviroHomes on using the heating system (in the prescence of Isos staff). Further training on how to use the system was needed (a second session). Again, the touch screen control panel is a big departure from the traditional type of controls so initially the tenant struggled to control temperatures in each room and to obtain hot water. It was discovered that frequent ‘breakdowns’ of the system reported by the tenant were caused by confusion and lack of understanding of the controls, rather than equipment or design failure.

9. Costs

Item Stage>	Design stage		Post-construction		See Numbered Notes Below
	Materials	Labour	Material	Labour	
Management and administration	N/A	10000	N/A	8000	
Design	N/A	10000	N/A	8000	
Construction overall					
- Prelims	4000	4000	2274	1875	
- Fabric measures					
o Floor insulation	5000	1510	5937	3643	
o Wall insulation	10000	7670	9709	7327	
o Windows & Doors	9197	3500	3605	3374	(1)
o Roof	1900	500	1478	1009	(2)
- Building services (conventional)	10500	4000	16529	14889	(3)
- Low /zero carbon technologies	2500	3000	2325	4018	
o Solar thermal	6500	0	7618		(4)
o Solar PV					
- Other	18,610.57				(7)
- Consequential costs					
o Window				1280	(5)
Alterations				1385	(5)
o Kitchen				1288	(5)
Installation				1123	(5)
o Bathroom				2531	(5)
Installation					
o Tiling					
o Decoration					
Occupant temporary housing					
Monitoring equipment	9500	N/A	11193	N/A	(6)
Monitoring and reporting service					

Please note all costs above exclude VAT.

(1) This portion of the project is lower because of not fitting new windows but fitting Inflector Blinds.
(2) More work was carried out in the loft than estimated.
(3) Because of the way some of the costs in this section were booked, it is felt that in reality they should have been in the design, management and preliminaries sections.
(4) This was a complete sub-contract order which was a fixed sum with no break down of costs.
(5) These items were covered as extras not originally budgeted for by EnviroHomes.
(6) Because the controls and monitoring system was bespoke this took longer to finish than was expected.
(7) Costs associated with decanting the original tenant, plus costs regarding moving them back in. £7,200 of this figure is the fee charged by Northumbria University for their assistance with the project.

10. Wash-up meeting

Following completion of the build stage of the project, Isos met with Northumbria University staff to discuss what we had learned and to outline what we would do better next time. In addition, meetings were held on site at the property with EnviroHomes to discuss the outcomes of the project.

This final report discusses the positives/negatives of the scheme and the important lessons that have been learned for the future. Clearly the project has been a success – the only real disappointment was the performance of the Daaldrop Combinair (see below).

Also, in future, the control panel for the heating /hot water will be made more simple to use. This is more likely to lead to behaviour change by the tenant, accompanied with cost and energy savings.

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 an excellent way of making the house very well insulated without losing large amounts of the internal floor area. In the floors, it meant that the existing floor could remain untouched and gave good thermal results again. The room height was reduced slightly, but this was of little consequence as the style of the building (Edwardian) meant the property already had very high ceilings. The In'Flector blinds are an excellent way of reducing the u-values of window openings and greatly enhance the energy efficiency of the home (both in summer and winter).

2. **Definitely not do again –**

   The Daaldrop Combinar boiler/air source heat pump is providing sufficient hot water but insufficient heat to the radiators. This is likely to cause problems for the tenants in the winter months. It is also extremely expensive to run.

   In addition, problems have been encountered when maintaining the boiler/air source heat pump (Daaldrop Combinair). It is not manufactured or widely distributed in the UK and spare parts for repairs are not readily available.

   The health and wellbeing of the tenants are paramount. Due to persistent, intermittent breakdowns of the system (as well as the high running cost), a decision has been taken to remove the Daaldrop Combinair and replace it with a Potterton gas combination boiler. As well as being extremely energy efficient, the boilers are reliable and easy to install and maintain, plus Potterton provide excellent customer service.

   Even though the Daaldrop Combinair will be removed, the property will still remain one of the most energy efficient in the region due to the extensive insulation of the building fabric, plus the presence of solar thermal and PV technologies.

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. On reflection, the original and new tenant could have been consulted more extensively to avoid the confusion over the complexity of the

heating controls. More research could have been conducted with tenants (and the Isos Housing Management Team) to discover and discuss attitudes towards the use of central heating and behaviour change.

5. **Improvement of the construction process** – time was lost by not having space to store materials on site – apart from actually in the house. This lead to problems with scheduling labour and the construction period being extended far longer than was intended.

6. **Improvement of the commissioning and occupancy process** – integration of the technologies together, especially with the bespoke control and monitoring system, was not perfect. However, it is felt that over time this would become more 'slick' when a greater number of renewable technologies are installed as routine in housing association properties. In addition to educating residents on how to use heating controls, more time should be taken in future to ensure that tenants fully understand the principle of how a heating system operates.

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 time was required to measure the house accurately to ensure the correct amount of panels was delivered so there was no wastage. If a large scale project was undertaken (e.g. retrofitting 50+ homes), costs would be far less due to the benefit of large economies of scale.

Key to making larger projects run more efficiently would be closer coordination between designers and tenants. This would involve both overview and detailed briefing sessions and management of their expectations of the work to be carried out.

As discussed earlier, it is recommended that in future tenants should have far more involvement in the design of the control panel. It has proven to be a complex and confusing system that successive tenants have found very difficult to operate. Behaviour change is key to using renewable technologies and this was made more difficult by the use of the bespoke touch screen controls.

It is clear that the project has been useful in demonstrating the effectiveness of different types of green technology. However, it is not cost effective. The project cost totalled over £150,000 and the property concerned is only valued at approximately £75,000!

12. Business benefits

The main lessons learned are how important it is to take a whole house approach to retrofitting a property and to more carefully consider the use of particular renewable technologies before they are installed.

The project has shown that education and the promotion of behaviour change to tenants are essential when installing and utilising renewable technologies. Spending significant time to ensure tenants are familiar with heating controls is essential. A considerable amount of time was invested in tenant liaison for this project. It is unlikely that this time could be spent with every tenant if this project was to be rolled out over a larger number of properties (due to the time and associated financial costs involved). In addition, the tenant who originally 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.

Business opportunities are perhaps based around the Vacupor insulation. Since the completion of the project, EnviroHomes have been approached by the German company who manufacture the Vacupor insulation. They are now the UK importers of the product. This has already led to increased turnover for the company, which is predicted to rise significantly over the coming months and years.

The project has been very useful in demonstrating what works and what doesn't. For example, solar thermal is definitely a technology we (Isos) will consider rolling out across our stock. It is relatively simple to install, inexpensive in comparison with other renewable technologies and user friendly. Importantly, solar thermal is efficient and provides 'free' hot water for tenants, which reduces fuel poverty.

The In'Flector blinds have also been effective in insulating the building and also providing radiated heat. We (Isos) will certainly consider their use in hard to heat dwellings.

Isos is committed to improving the sustainability of its stock and the communities in which it operates. The TSB Retrofit project has provided a welcome opportunity to road test new technologies and innovative methods of construction. It has also revealed housing and project management challenges that we (Isos) will be able to easily overcome in the future, e.g. education and training of tenants and training required for heating engineers.