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: ZA313T
Property number: TSB110

Author: UK CEED

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

- **Project Number:** ZA313T
- **Location of property:** Peterborough, PE3
- **Lead Organisation:**

  UK Centre for Economic & Environmental Development (UK CEED)
  Eco Innovation Centre
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1. Project details and directory

Role	Organisation	Contact Details
Lead Organisation	UK CEED	Address: Eco Innovation Centre, Peterscourt, City Road, Peterborough, PE1 1SA Tel: 01733 311644 Website: www.ukceed.org
Housing Association	Axiom Housing Association	
Architect	Waterland Associates	Address: Waterland House, 81 West Street, Oundle, Peterborough, PE8 4EJ Tel: 01832 270123 Website: www.waterland.co.uk
Services Engineer	Cunnington Clark	Address: 35 Priestgate, Peterborough, PE1 1JL Tel: 01733 898010 Email: Website: www.cunningtonclark.com
Consultants/CDM-C/Party Wall	Davis Langdon	Address: Clarence House, Minerva Business Park, Lynchwood, Peterborough, PE2 6FT Tel: 01733 362000 Email: Website: www.davislangdon.com
Specification Consultant	GreenSpec	Address: 91 Oakleigh Drive, Orton Longueville, Peterborough, PE2 7AR Tel: 01733 238148 Website: www.greenspec.co.uk
Main contractor	F. E. Peacock Construction Ltd	Address: Larkfleet House, Southfields Business Park, Falcon Way, Bourne, PE10 0FF Tel: 01778 391520 Email: Website: www.fepeacock.co.uk

2. Introduction

As a team of building industry consultants our approach was to develop and assess a pallette/menu of potential interventions that could be applied to any and all projects regardless of location, orientation, size or construction. The principal challenge of our approach was to develop a replicable methodology for the assessment of the most suitable intervention for any given building type and validate this through applying the approach at a local Registered Social Landlord (RSL) property, selected after review with the leading RSLs in Peterborough to represent a large-scale property retrofit challenge to showcase local innovative solutions.

3. Occupants

The property is a family home with the principal tenants being a late middle aged couple, with adult children and grandchildren. Some of the adult children reside sporadically with the principal residents and the grandchildren regularly spend the night at the premises. The tenants will be the same after the retrofit is complete.

The retrofit was to be carried out with the tenants remaining in the property as we wanted to demonstrate that such projects could be undertaken with minimal disruption to tenants and with no associated temporary re-housing costs.

During the project though it became clear that to complete the internal work the tenants would need to move out of the premises for around two weeks. Luckily a friend of the tenants was happy to accommodate the residents whilst the work was completed. The main concern from the tenant on moving out was the contents of the property and how this would be kept safe and secure. Agreement was made with the tenant and the Housing Association to put the belongings into storage whilst the work was completed.

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

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

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	18 March 2009 (phase 1) 18 February 2010 (phase 2)
Planning application submitted	19 March 2010
Planning permission granted	9 June 2010
Building Regulations application submitted	February 2011
Building Regulations approval granted	29 July 2011
Contract for work let / signed	February 22 2011
Occupants moved out	Remained in the property
Start on site	13 September 2010
Completion of retrofit	6 May 2011
Occupants moved in	N/A
Monitoring system commissioned and operating properly	26 July 2011
Building defects corrected	15 July 2011
Building services and controls operating correctly	6 May 2011

5. Pre-retrofit property

The property is a 1970s/80s masonry construction, two storey, three bedroom, 76m^2 end terrace house. The property has trench fill foundations, a concrete ground bearing floor, a timber joist first floor, a trussed rafter roof space and a concrete tiled roof. There is a cavity wall construction with brick outer leaf, concrete block inner and additional tile hanging to first floor to 3 elevations, the house is plastered internally and has low-mid performance double glazed PVCu windows.

During the project team's discussions with Axiom Housing Association, we decided that we wanted to retrofit a property that was common and typical of the housing stock in Peterborough. We settled on the 1970's terrace and chose TSB110 as the tenant was happy to participate in the project.

6. Design

The original proposal for the Retrofit project for TSB110 was to create a new envelope around the existing building by externally insulating to achieve higher u-values for both the external walls and roof. Some 200mm of rigid insulation board was to be added to the whole of the front and side elevations, while the rear was to have 100mm of external insulation. The rear, which is south facing, was originally proposed to have a solar capture wall in addition to the 100mm. The idea for the external insulation was to minimise the impact to the internal faces of the wall and thus minimising the impact to the occupants.

The overall air tightness of the property was to be improved and the aim was to achieve Passivhaus new build standard in the core fabric elements. Air management is through a heat exchange unit situated in the roof void and was planned to utilise the solar capture wall to pre-heat air in the winter before circulating around the property. This was later designed out at the pre-construction stage due to the budget cost and difficulties in quantifying the energy savings through SAP modelling. In the removal of this, the external insulation was increased to 200mm to match the other elevations. Air ducts are incorporated into the wall insulation to pre-heat air entering the heat exchange unit in the loft; retaining some of the initial solar passive principles.

The roof was planned to be stripped of tiling, the trussed rafters strengthened, the roof externally insulated then retiled. However the fasteners needed for this proposal proved elusive and the final solution included a cut timber roof over the top of the trussed rafters. The insulation was changed from a high decrement vapour open insulation to a low k value insulation vapour closed, so vapour open roof was replaced with vapour closed construction. Heat recovered from below the roof tiles is mixed with tempered fresh air in the loft space to feed the heat exchange unit and reduce the need to heat fresh air to the dwelling.

Finally, renewable energy was proposed to provide water heating, with solar photovoltaic panels installed to reduce the amount used from the national grid.

With the exception of the solar capture wall the overall design principles remained the same through the build, however there were certain details that were altered in order to achieve the design.

7. Construction

Procurement
The project was announced through UK CEED's EnviroCluster initiative inviting companies with relevant expertise to come forward, trying where possible to use local companies and expertise.

Contract type
The contract was a JCT Intermediate form of Contract, 2005 Edition, Revision 2 2009, incorporating Davis Langdon Standard Agreements.

Contract structure
There was one main contract between Davis Langdon and FE Peacock as the construction company. FE Peacock then used subcontractors for some of the specialised pieces of work.

Sub-contractors
The following sub-contractors were used by the main contractor:

- Windows – Jeld-Wen
- Joinery – Belmont Joinery
- Electrical – SNG
- Plastering – Howards
- Render – Skill
- Mechanical – Nigel Smith

Specialist installers
Solar thermal, mechanical, electrical installations for the heat recovery, PV, battery backup and water saving devices - they were all engaged by the main contractor.

Specialist equipment suppliers
PV and solar thermal were selected based on performance and best price.

Site supervision
The site agent managed the site. The project architect and housing provider also provided inspections.

Role of architect/design team
Work with other consultants to develop design to construction stage, review, monitor and comment on design development post-contract, review works on site, production of as built design information.

Following a successful wash-up meeting where the project was openly and honestly discussed at length the following lessons learnt were highlighted:

- A structural engineer should have been part of the project team from the start. This

would have meant they were involved in the design and costing for the roof which may have highlighted the roofing issue earlier.

- Research should have been completed on what conservatory roofs were suitable/practical as triple glaze caused numerous problems. Though the company we decided to use did originally state they could provide these.

- The design and build process were separate, this should have been progressed together and included the building contractor from the start.

- Design team should have been managed with clear delineation between professional designers and potential suppliers early on. Meetings were often talking shops rather than progress makers and the design often stalled due to uncertainty over roles and duties.

- The design process lacked focus on the project aims with areas of investigation possibly feeding potential to leverage in products rather than achieving project aims.

- Computer modelling completed in isolation and results not fed back to inform the design processes all the way through.

- Air test value was unrealistic and not achievable due to two main problems – external front/back doors and staircase. Achieving the targets would have meant that these items needed replacing.

- Understanding the practical implications of using new products. E.g. difficulty in finding installers (especially on untested/unproven products).

- Project/update meetings were not regular enough and lack of movement with the project between these – nothing seemed to happen for some time.

- Research should have been completed on the render we decided to use, including who had used it before and who could do the render work for us, as this caused delays with companies not wanting to use the product. Information on how the finished render would look and that there was a possibility of it being patchy would have been useful to know for programme timescales as having to stain the render once dried caused additional delays.

- The delay in ordering of the windows affected the budget as by the time orders were placed costs had increased.

- Suppliers should not have been part of the main team moving the project forward as this resulted in them trying to sell products into the project rather than the design team dictating what the actual requirements were. This resulted in certain partners not being happy when their products were not used.

- Communication between the design team and other project partners could have been

improved.

- Regular progress reports circulated to the wider project team would have been useful.

- Calculations of the budget needed to be communicated and discussed as this became very isolated to one partner.

- The tenant should have had a single point of contact to avoid confusion for the tenant and delivery team. This led to a number of issues regarding communication with the tenant.

- Too much information was provided to the tenant at times and what information was provided was sometimes not explained properly.

- Client should have been made aware from the start that delays would be expected on this project due to new products and it being a pilot project.

- A formal contract with the tenant would be a good idea to explain everything and include 'what if' scenarios.

- The Housing Association have a contract they use when refitting properties – this is something we could have modified and used.

- Completion would have been within 6 months but issues with the roof and windows caused delays.

- Delay in the starting of the construction meant that work ran into the winter months which caused delays due to the weather, especially the exceptionally cold, snowy winter in 2010/11.

- Due to a lack of understanding of what products/materials were to be used the initial costings were not realistic and were underestimated.

- There was a significant uplift in prices for materials from when costing was originally completed to when they were finally ordered.

- The VAT rise had not been taken into account and caused problems with the budget.

- Final total costs for the retrofit were not within the budget of £150,000 – a number of partners incurred additional costs, these are included in the report to show an actual budget for the project.

- Inability to obtain competitively priced / free of charge products from suppliers in exchange for publicity due to the number of retrofit projects being carried out with which suppliers were already affiliated. Advanced purchasing or even just consideration that this was likely to happen could have reduced the impact on the

budget.

- Building contractor should have allowed float within their programme to allow for potential delays and should have communicated 'worst-case' dates to the tenant rather than unrealistic targets.

- Tenants expectations should have been managed better - not promising things unless we could definitely deliver them.

- Fees not included in original budget put pressure on the construction budget and should have been defined and included from day one.

- We could have removed the u-value requirements from the porch and conservatory and focused on the main building only; this would mitigate the requirement for the triple glazed roof which caused delays to completion.

- The tenant vacating the property whilst major internal works undertaken was beneficial to the programme. This allowed the team to complete the internal work in one go and keep to a tight timeframe.

- Team was able to value engineer scheme to meet budget and still achieve sustainability requirements - e.g. omitting the solar collector wall.

- Housing Association has already seen the benefits of some of the designs used in the retrofit and are looking into the possibility of completing certain aspects to other properties.

In summary, a large proportion of the lessons learnt on the project originated during the pre-construction stage. Several of the problems which arose during construction could have been avoided through better coordination of the design team, budget and supply partners upfront. Further research into the practicality and availability of new products could have also been undertaken prior to works commencing on site. This would have mitigated several of the delays incurred and the requirement for additional design work.

8. Commissioning and occupancy

Please explain what commissioning was carried out, what problems were discovered and how these were addressed.

Testing was carried out on the PV systems and MVHR unit by the installers of the technologies (sub-contracted by the contractor) and then commissioned by the building contractor.

No problems were identified during commissioning as the technologies were not bespoke to this project and are commonly installed. The only action required following the commissioning work was to balance the air vents to the MVHR unit.

Please provide full details of the handover process and explain how you have made the occupants aware of the retrofit measures.

A full handover and demonstration to the client inducted the Axiom Housing Association and the tenant in the use of the installed technologies to ensure that the property achieves its ultimate efficiency. The handover was also used to educate the tenant on how lifestyle changes can affect the performance of the house and ultimately lead to higher-than-necessary utility bills. This included information on when to heat the house, how to use energy more efficiently (do not heat the house with the windows open, only boil what water is needed, turn off lights when not being used etc.).

The building contractor provided a demonstration which contained the following items:

- Operation and use of the MVHR
- Operation and use of the solar thermal system
- Operation and use of PV lighting and the battery back up system
- Operation of the windows and when to open them
- Operation of the attic drying space
- Guidance on possible lifestyle changes to gain the best performance and energy savings
- Notification of what the smart meters measure and how to ensure they work efficiently (i.e. not covering them).

9. Costs

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Substructure & Roof					
Existing floor	3,410.00		3,410.02		
Attic Platform	994.00		1,102.97		
Clothes Area	1,061.00		998.45		
Insulation	11,799.00		14,766.15		
Air/wind tightness	488.00		488.00		
membranes	3,902.00		6,425.00		
Roof structure		2,959.00		2,959.00	
Labour					
External Walls					
Raise Gable End	910.00		910.00		
Insulation	6,197.00		11,528.51		
Render	2,342.00		2,224.90		
Air tightness membrane	861.00		1,762.34		
Labour		1,788.00		1,788.00	
Windows and Doors					
New windows	8,410.00		8,410.00		
Labour		247.00		234.65	
Sunspace and Porch					
Sunspace construction	13,756.00		0		
Porch	7,146.00		6,431.40		
Labour		0		0	
Internal Walls					
Insulation and air tightness membrane	575.00		575.00		
Labour		1,780.00		1780.00	
Finishes					
Decoration	3,169.00		3,169.00		
Labour		0		0	
Fixtures & Fittings					
Light tube	602.00		602.00		
Sundries	454.00		454.00		
Labour		0		0	
Services					
Photovoltaic	8,500.00		4,250.00		
Whole house MV system	2,500.00		2,500.00		
Solar hot water	6,000.00		3,000.00		
LED lighting	1,500.00		1,500.00		
Labour		0		0	
Drainage					
Below ground drainage	784.00		705.60		
Labour		0		0	
Preliminaries					
Scaffolding	1,559.00		0		
General	11,650.00		14,658.33		

Labour		0		0	
Management, administration and design	22,450.00		25,450.00		
Occupant temporary housing	0	0	0	0	
Monitoring equipment	2450.00		2,500.00		
Monitoring and reporting service	0	0	0	0	
R&D costs (please detail)	0	0	0	0	
VAT @ 20%	24,693.80	0	24,916.66	0	
Additional Items Replacement Kitchen Replacement Flooring Additional Decoration Goodwill & Electricity Costs Energy Efficient White Goods	 0 0 0 0 0	 0 0 0 0 0	 2,526 1,224 2,379.6 150 500	 N/A N/A N/A N/A N/A	The cost of these additional items was not covered by the project but by Axiom and a donation from the local Co-Op (for the white goods). Prices have been included here to show the true budget which extends beyond the funding provided by the TSB.

10. Wash-up meeting

A wash-up meeting was held with the majority of the partners involved in the project. The meeting took place at the Eco Innovation Centre on the 16 June 2011 with attendees from:

- UK CEED
- Axiom Housing Association
- Waterland Associates
- Davis Langdon
- Cunnington Clark
- FE Peacocks
- Anglian Water
- Peterborough City Council

The outcomes of the retrofit work discussed at the wash-up meeting are discussed in Section 7.

11. Doing it again

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

1. Definitely do again

We would definitely insist that the tenant vacated the property for a period of time to allow the most intrusive works to be undertaken. This allowed the contractor to complete the more intrusive works on programme, with minimal disruption to the tenant.

We would also look to benefit from the use of the contractor's supply chain partner again, if possible, as this allowed competitive rates to be obtained on certain products.

2. Definitely not do again

We would not include the sun spaces in the area required to meet the air tightness targets. This would have allowed us to reduce the specification on the sun spaces to double-glazed windows and roofs, thus mitigating the design issues incurred in relation to the structural support for triple glazed roofs. The air-tightness measurements could then be taken from the external envelope of the dwelling.

Involving all supply chain partners in the initial project team meetings resulted in conflicts between the designers and suppliers in terms of the specification and prolonged the design process. We would not repeat this structure. Separating the two elements into 'design' and 'supplier' meetings would have resulted in an approach that was more focused on 'delivery' than team members effectively 'selling' their products. This would be our approach if we were to carry out another retrofit project.

In future, we would not move the project forward without input from a structural engineer, given the level to which this retrofit was carried out. Several of the design issues we experienced, and the associated delays to progress, were as a result of no input from a structural perspective during the initial design stages.

3. Reduction of costs

Omitting the solar collector wall as a value engineering exercise did not hinder the environmental performance of the building and allowed us to significantly reduce the costs. Conducting a 'value management' exercise once the initial design had been drawn up to identify other areas where costs could be reduced without affecting the quality or performance of the building could have resulted in further cost reductions.

Focusing on the primary external envelope of the dwelling for meeting the air tightness targets rather than including the sun spaces would have allowed us to reduce the glazing specification in these areas which would have potentially resulted in a reduction in costs.

Managing the tenant's expectations better would have allowed us to better define costs from the outset, making sure all 'extras' were accounted for from day one. 'Signing-off' all of the extras (decoration, landscaping, payment for use of utilities) from the outset would have mitigated the opportunity for the tenant to request additional items.

4. **Improvement of the design process**

Although the contractor was on board fairly early in the process, harnessing some of their own building knowledge could have improved the design process. For example, the products specified to insulate the roof were, in the contractor's opinion, unsuitable. An alternative product was sourced but this resulted in programme implications.

As highlighted above, input from a structural engineer from day one would have provided a more holistic approach to the design process and mitigated the issues associated with the design of the main roof and roofs to the sun spaces.

5. **Improvement of the construction process**

Float could have been built into the programme to allow for any unforeseen delays, particularly given the number of new technologies being incorporated on the scheme.

Better coordination of the procurement process i.e. identifying and ordering long lead-in items well in advance would have allowed for smoother sequencing of the works, and a reduced overall timescale.

The operations on site would have been a lot smoother had issues with the roof construction not been encountered and the overall timescale for the project would have been reduced significantly.

6. **Improvement of the commissioning and occupancy process**

The delays incurred on site had a knock-on effect to the relationship with the in-situ tenant. Promises were being made to the tenant in terms of timescales for completion that could not be delivered. Delays to construction projects are common, particularly those where new technologies and products are being used, and it would have been beneficial for the contractor to have built some float into their programme to account for this. Better communication with the tenant and management of their expectations from the outset could have prevented the difficulties that ensued. The tenant should be made aware from the start about environmental meters and monitors being installed as well as any technologies that require tenant input.

What efficiency gains would you expect from a larger programme of retrofits, eg: 50 homes of similar age and design in a similar neighbourhood?

Economies of scale would apply here, i.e. the solar equipment, ventilation units and other construction materials would have been cheaper if purchased in bulk. Some technologies, such as solar thermal heating, could also be shared across numerous properties, resulting in a saving.

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

Renovation of empty properties would significantly increase the speed of retrofit works, and would negate impacts on tenants living in the property, particularly as works were internal as

well as external. As our project focused on an end-terrace property, scale-up would ideally need to take place across all properties in the terrace due to visual impact. This is not always possible (for example, in the terrace we used, one of the properties in the middle was privately-owned).

12. Business benefits

Axiom Housing Association
Axiom Housing Association have already seen the benefits of some of the designs used in the retrofit and are looking into the possibility of completing certain aspects to other properties (notably the render).

Cunnington Clark
We do not see any clear increase in potential for retrofitting domestic scale projects as a result of this, but the experience has been invaluable in testing the waters in energy efficient retrofit innovations that will feed into our wider range of projects. Contacts within the team have lead to an increase in opportunities, but not firm orders.

Davis Langdon
The project enhanced our own knowledge - we have learnt a lot in relation to renewable technologies and the implications of installing these technologies into existing properties, in terms of 'what works' and 'what doesn't', from a manageability, cost and operation point of view. Our knowledge in relation to the products available has also been enhanced.

We have been able to use our experience of the retrofit project to advise our other clients in relation to retrofitting to enhance sustainability which has added value to our service offering.

We are able to use our experience of this project as a marketing tool when targeting new clients.

UK CEED
The project has been very useful for us as it has demonstrated that our EnviroCluster network here in Peterborough is effective, and that it included the wide range of skills and expertise necessary to complete this project. The house now also forms an important part of Peterborough, which is home to the UK's Environment Capital, as it is another project for the city which showcases the latest environmental technologies. The project has raised our profile within the local business community and we expect to engage with more businesses as a result. We will also actively pursue future innovation projects to support the innovative businesses in Peterborough.