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: ZA218B
Property number: TSB086

Author: Camco

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

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SBRI Government challenges. Ideas from business. Innovative solutions.

Final Report

Project information

- **ZA reference number:** ZA218B
- **Location of property:** EH22, Edinburgh
- **Lead participant details:**

  Castle Rock Edinvar
  1 Hay Ave,
  Edinburgh,
  EH16 4RW
  Tel: 0131 657 0688
  Website: www.castlerockedinvar.co.uk

- **Date report issued:** 10th November 2011

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1. Project details and directory

Project team

Role	Name & Position	Organisation	Contact Details
Property Owner			
Registered Social Landlord		Castle Rock Edinvar	1 Hay Avenue, Edinburgh, EH16 4RW Tel: 0131 657 0688 Website: www.castlerockedinvar.co.uk
Design Team			
System Design		TB Mackay	
Project Consultant		Camco	The Workstation, 15 Paternoster Row, Sheffield. S1 2BX. 0114 221 0374
Contractor			
Main contractor		TB Mackay	
Monitoring contractor		Parity Projects	www@parityprojects.com

2. Introduction

This is an ambitious project that involved a comprehensive package of retrofit measures at a property to deliver substantial energy and carbon savings, in line with government aspirations of an 80% carbon reduction. To achieve such substantial savings a whole-house refurbishment approach was adopted. This involved measures to reduce energy demand, incorporating low carbon technologies and working with occupants.

Work was carried out to test and consider a range of technologies and measures applicable to properties similar in nature to many others within Castle Rock Edinvar's portfolio and across Scotland. The selected property was previously heated by means of a gas fired back-boiler resulting in high energy bills, high CO_2 emissions and restricted comfort and utility for the tenant.

3. Occupants

The occupant was the same before and after the retrofit.

The sole occupant of the property is a retired lady in her sixties. The tenant did not occupy the property for a period of 4 weeks during the retrofit. Alternative accommodation was provided by a relative and the occupant's possessions were placed into storage. Although no issues were reported in respect of decanting, the arrangement did place a time pressure on the contractors to complete the retrofit work to a strict deadline.

4. Dates

Timeline of key dates:

Event	Date
Project start date (when was the first proposal discussed or agreed)	July 2009
Contract for work let / signed	18/08/2009
Occupants moved out	11/03/2010
Start on site	15/03/2010
Completion of retrofit	09/04/2010
Occupants moved in	09/04/2010
Monitoring system commissioned and operating	May 2010
Building defects corrected	End April 2010
Building services and controls operating correctly	End April 2010

5. Pre-retrofit property

The property selected is a west facing, two bed semi-detached bungalow. Built pre-1919, it is of traditional brick construction, comprising of cavity brick walls with a roughcast external finish. The property has a pitched and slated roof, drained to ground level by way of cast iron gutters and downpipes. Heating was previously provided by a gas back boiler and radiator system. The property was double glazed to both front and rear of the building and had 270mm insulation within the attic space.

The pre-retrofit property had a SAP 2005 rating of 49, putting it in band E. Air permeability was measured at 27.83 $m^3/hr/m^2$. This is considered to be very poor and does not achieve the required air permeability of 10 $m^3/hr/m^2$ as specified in the SAP calculations. This was improved to 9.55 $m^3/hr/m^2$ after the retrofit.

The property was selected as one of 434 ex Lothian Coal Company properties of similar age and build which Castle Rock Edinvar own within the area, where there is potential for replicating the retrofit design. CRE have a total housing stock of over 5,000 homes which vary in type and age.

6. Design

The following measures were proposed for the retrofit:

Energy Efficiency Measures; Increased roof insulation, retrofit underfloor heating system combined with insulation, "A" rated sash and case sustainable windows, mechanical ventilation with heat recovery (MVHR), sealing of the fabric to greatly reduce air infiltration, low energy lighting throughout and consideration of measures to reduce appliance consumption such as "A" rated goods and occupant literature pack with information about ways to save energy.

Low Carbon Technology; An air to water heat pump (external to the property) to supply water at approx 45°C and provide space heating in conjunction with an underfloor heating system to replace the existing heating system. The underfloor panels are an innovative approach to retrofit as the panel integrates additional insulation, low temperature distribution, reduces air movement through existing exposed floor boards and can be simply fitted to a wide range of homes with minimum disruption.

Another air to water heat pump (latent heat recovery unit) installed in the roof space to provide hot water and make use of the higher air temperatures in the unheated attic from solar gains, heat loss from below and heat produced by the MVHR unit. At the time of our application, we were unaware of this technology being installed anywhere else in the UK.

Renewable Energy; A roof mounted solar collector integrated into the hot water systems using a combined thermal store. The single thermal store will utilise heat from the latent recovery heat pump and solar collector.

The proposed solar collector, heat pumps, MVHR unit, thermal store and controls are all manufactured by Stiebel Eltron.

No changes were made to the initial retrofit design upon installation.

Post-installation, an acoustic fence was installed around the external ASHP in response to complaints from a neighbour about the noise of the fan in this unit. A timer was also installed to switch both the internal and external ASHPs off at night to reduce noise for both the occupant and neighbour.

7. Construction

Procurement
The project was procured by Castle Rock Edinvar through a partnering arrangement with TB Mackay, who were an approved supplier to CRE at the time. TB Mackay were appointed as the main contractor to carry out the retrofit work based on their availability and related experience.

The system consisting of the solar collector, heat pumps, MVHR unit, thermal store and controls was designed by the supplier Stiebel Eltron, who sourced the most appropriate equipment from the range of products they manufacture.

Other aspects of the retrofit, such as the refurbishment of the bathroom and kitchen, were procured through Castle Rock Edinvar's procurement framework using existing preferred suppliers.

Contract type
Minor Works Building Contract (Scotland).

Contract structure and specialist installers
TB Mackay was appointed as the main contractor, with sub-contractors employed to carry out specialist tasks.

Sub-contractors were employed by TB Mackay for work to the exterior of the property, which included roof, chimney and rendering work.

Specialist equipment including the low carbon and renewable energy system was supplied by the manufacturer Stiebel Eltron, who also designed the system.

The provision and installation of the monitoring equipment was subcontracted by CRE to Parity Projects, a specialist in this area. TB Mackay also provided support to Parity Projects on installation of the monitoring equipment.

The thermal imaging and air tightness testing was provided under the TSB programme (by BSRIA).

Site supervision
TB Mackay provided a project supervisor to coordinate the various trades, with responsibility for the overall site. A site foreman, also from TB Mackay, directed the builders and joiners. Support was also provided by a technical engineer from Stiebel Eltron, who visited the site from Germany to provide assistance installing the low carbon and renewable energy system.

8. Commissioning and occupancy

Commissioning
Commissioning of the installed retrofit technologies was carried out by TB Mackay, with support provided by Stiebel Eltron, the equipment manufacturer and system designer.

The monitoring equipment was tested and commissioned by Parity Projects. Following the initial installation, Parity found that a number of data streams were not working correctly. A second visit was arranged and these items were corrected. It was also subsequently found that the meter installed to record the energy consumed by the external ASHP was connected to a circuit that was not used. This problem was overcome by reconnecting the meter into the correct circuit, although some data was lost.

Following analysis of the year one monitoring data by Camco, several anomalies were identified which required investigation. A site audit of the monitoring system was carried out by Parity Projects. Remedial actions were carried out to correct discrepancies in the data being recorded by the monitoring system and data provided to Camco for analysis.

One issue remains outstanding, this being a ~15% gap between the total electricity usage and the sum of the various meters installed, which could not be accounted for during the audit of the monitoring system. Parity Projects recommend that this be investigated further by a qualified electrician.

Occupancy
A decision was taken not to provide the occupant with excessive documentation on the retrofit and equipment installed. Instead, it was thought more appropriate to provide continual training which included repeat visits to demonstrate how to optimise use of the new equipment.

The low carbon and renewable energy system was also designed with the occupant in mind, for example, automatic controls were included where possible to minimise the input required. Checklists were also provided so problems could be overcome. For example, clear instructions were given on what to do if there wasn’t enough space heat. A contact telephone number was also provided so the tenant could contact TB Mackay. Instructions were given on what information to relay and how this could be found, so problems could be diagnosed and overcome remotely where possible.

9. Costs

Design stage budget

The following table was submitted with the original "Retrofit for the Future" application:

Works	Materials	Labour	Sub-total
Ground Works / Building Works	235.00	445.00	680.00
Heating	11,235.01	2,565.00	13,800.01
Hot Water	4,809.01	1,170.00	5,979.01
Ventilation	2,124.56	600.00	2,724.56
Joinery	5,938.69	3,990.00	9,928.69
Electrical	1,282.75	1,270.00	2,552.75
Windows & Doors	3,000.00	2,000.00	5,000.00
Roof works	250.00	150.00	400.00
Technical & Supervision	500.00	220.00	720.00
Rainwater harvesting	500.00	220.00	720.00
Camco technical		34,662.50	34,662.50
Decant of resident		3,500.00	3,500.00
Contingency for additional work		10,000.00	10,000.00
Maintenance and insurance		1,178.00	1,178.00
Travel & subsistence		1,200.00	1,200.00
Total	**29,875.02**	**63,170.50**	**93,045.52**
TOTAL INCL. VAT (17.5%)	**35,103.15**	**74,225.34**	**109,328.49**

In addition, CRE committed to contribute £15,000 toward work costs and to supervise and manage the contract at zero cost, at an approximate saving to the project of £7,500.

Final costs

The following cost breakdown was provided following completion of the project.

TB MacKay Cost Breakdown	TSB Costs	CRE Costs
Main Contract and Maintenance Costs	48,383.03	
Decoration Costs		2,106.00
Decoration for Bathroom		370.50
TV aerial		67.60
Harling		6,945.00
Chimney		475.00
Insulate and Sheet 3 cupboards	930.00	
Vents to 2 chimneys	180.00	
Insulation to Kitchen lofts	70.00	
Protection Cage for ASHP	650.00	
Extra cost for A Rated Windows	2,064.00	
New Boundary Fence		956.24
New Wiring in Kitchen		510.00
New Electrical Sockets		811.37
Extra for new Draught Skirting	720.00	
Handrail in loft and insulate door	449.25	
Thermal Pipework for MVRU	1,239.05	
Core holes for MVRU	195.00	
Extra for laminate	175.00	
Final Thermal Image	620.00	

Installation of monitoring eqp	650.00	
Wiring for monitoring eqp	1,125.60	
Bathroom flooring		269.38
Kitchen flooring		379.23
New kitchen light and loft light	104.35	
Kitchen		3,070.00
Bathroom		2,750.00
Extra for ASHP base	240.00	
Lifting Equipment	167.70	
Extra flooring over adjoining property	400.00	
Extra Timbers	240.00	
DVDs	397.00	
Monitoring	6801.52	
Camco technical	34,662.50	
Total	**99,451.01**	**18,710.32**
TOTAL INCL. VAT (17.5%)	**116,854.93**	**21,984.63**

10. Doing it again

Problems

Construction

- Installation of the monitoring equipment after the other retrofit measures were completed compromised the internal finish of the property achieved by TB Mackay and their subcontractors. This problem was attributed to poor communication between the main contractor (TB Mackay) and the monitoring specialist (Parity Projects), and time/cost constraints preventing a site visit by the monitoring team prior to installation.
- Completing the retrofit, which involved renovation of the entire property, was challenging in a four week timeframe. The pressure on TB Mackay and their subcontractors to complete the work on time was amplified since the occupant had been decanted from the property and her belongings placed in storage, with associated inconvenience and costs.
- Other than the low carbon domestic hot water system (solar thermal unit and internal ASHP), the other retrofit technologies were considered complex to install.
- Following installation of the external ASHP, the neighbour to the property raised concerns about the noise from this unit. Noise measurements had to be conducted and an acoustic fence installed to resolve this issue. Challenges were also faced in finding a suitable product to use in construction of the acoustic fence. This problem was partially attributed to a lack of contact with the neighbour prior to the retrofit.
- The internal ASHP was also known to create noise and was purposefully sited away from the adjoining property at one side of the attic. Following installation, the occupant complained that it could be heard and so a timer was installed to turn this unit off at night.
- The installation of new windows as part of the retrofit was a particular challenge.
- One of the major overall challenges for TB Mackay was anticipating and sourcing the materials required for installation of the retrofit technologies, several of which were new to the company. Specific examples include the ducting for the heat recovery unit and a suitable product to use as an acoustic fence for the external ASHP. Delays and problems were encountered sourcing materials from various suppliers and this reduced the time available for materials inspection before installation.

Other

- Several anomalies were identified in the year one monitoring data which required investigation and a site audit of the monitoring system.
- The installed monitoring system allows monitoring data to be accessed remotely via a web-based portal. The current system generates periodic reports (available in MS Excel format) to record new data captured by the monitoring equipment. These individual datasets have to be collated to create a complete dataset for analysis over a longer period, for example, year one performance analysis. Collating the individual datasets is time consuming and this work has to be repeated if there are any anomalies in the data that have to be corrected.
- Time could be saved if the monitoring data was made available as a complete dataset which was updated when new readings were uploaded periodically from site.
- The occupier has reported that at times the input air from the MVHR feels cold. This is probably a simple draught effect. This has apparently led to the occupier turning off the

MVHR at times. However the occupier does report that the completed property is comfortable. It would seem that this problem with the MVHR is a relatively small issue.

Good Points

- TB Mackay had freedom to utilise their skills and design the retrofit from the start of the project, rather than being dictated to. The company cite this as a major positive since it allowed them to demonstrate their expertise in this area, from the concept stages to completion of the project.
- TB Mackay was impressed by the low carbon domestic hot water system, which comprised of a solar thermal unit and internal ASHP. This system was considered to be very adaptable and could be integrated into other properties.
- Parity Projects refer to the quality of the workmanship and co-operation provided by TB Mackay as a positive aspect of the project, in particular TB Mackay's responsiveness to resolve issues that arose with the monitoring system, including attending a site audit of the monitoring system.

Lessons learned

Construction

- Where a monitoring system is to be installed, this should be integrated into the overall work so as not to compromise the finish of any work to the interior of the property. This would involve liaison between the main contractor and monitoring specialist at an early stage of the project and ideally include a site visit by the monitoring specialist at an early stage.
- Installation of novel retrofit technologies can be complex and this should be allowed for in project planning. With experience it is hoped that the complexity of installing this equipment can be reduced.
- An acoustic fence can be used to reduce the noise from external ASHPs and TB Mackay developed their knowledge of suitable products to achieve noise reductions and where they can be sourced.
- Liaison with the neighbours to retrofit properties should be carried out wherever possible and at an early stage in the project, with a focus on raising awareness of any external appliances to be installed and their likely impacts. This will allow any issues (e.g. noise, visual) to be identified and resolved at an early stage and the need for corrective action avoided where possible.
- Timers can be used as an effective solution to reduce the noise associated with ASHPs, whereby these units are switched off during the night.
- Additional time should be allowed to identify, source and inspect the materials required for the installation of technologies new to a contractor. This will be reduced as a company gains experience and identifies suitable suppliers.

Other

- Thorough analysis of the monitoring data at an early stage of the project would allow anomalies to be identified and corrective action taken early, potentially saving time later in the project and avoiding the need for additional site visits and corrective action. This would also ensure data for long periods is not lost, which can occur if problems go undetected.

- Specifications for monitoring systems should include the functionality to provide a complete dataset including all data captured since installation of the system, which is periodically updated with new readings.
- Parity Projects acknowledge that more time should have been allowed for commissioning of the monitoring system. As a result, Parity has developed a more comprehensive commissioning process which involves revisiting the site when all aspects of the installation are working correctly to carry out the commissioning process.
- Parity Projects recognise the benefits of being involved at the design stage of the project, which would have provided a better understanding of the system to be installed. This is likely to aid the monitoring strategy developed for future projects and result in a more comprehensive monitoring of energy use.

11. Business benefits

Lessons learned in terms of innovation, efficiency or increased opportunities
The retrofit project allowed TB Mackay to develop its skills base and experience, particularly in relation to installing low carbon and renewable energy technologies. As part of the agreement between the two companies, staff from TB Mackay (equipment installer and project supervisor) received one week's training by Stiebel Eltron in Germany. This led to TB Mackay becoming an approved UK contractor for Stiebel Eltron, facilitating them to carry out this and other installations of Stiebel Eltron technology.

Parity Projects has developed experience of managing the installation of monitoring and metering equipment, from this and other projects in the Retrofit for the Future programme. This has allowed the company to develop comprehensive monitoring systems and web applications to convey the results.

Business leads and opportunities
The project acted as a starting point for TB Mackay to expand its business in this area and the company now actively looks to undertake retrofit and renewable energy installation projects.

As a direct result of the retrofit, Castle Rock Edinvar became aware of TB Mackay's ability to design systems. This led to TB Mackay working for Castle Rock Edinvar on a subsequent project to replace an existing district heating scheme with a new system. Located in East Lothian, the project supplied 28 flats within a sheltered housing complex through a district heating system. This featured a solar thermal buffer that fed into the main system to provide backup.

Parity Projects has a wide ranging portfolio in the domestic retrofit sector offering advice to private home owners, strategic stock assessments to social and private landlords, energy reduction system design and consultancy as well as building monitoring. Parity's involvement in this and other high profile Retrofit for the Future projects has resulted in a considerable number of leads and a number of projects across this sector range, in particular the building monitoring business has definitely benefitted from the high profile Retrofit for the Future projects.

Value of the retrofit business over the next 5 years

Castle Rock Edinvar has a provisional budget of £100k for retrofit work to its housing stock over the next 5 years.