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: ZA237K
Property number: TSB002 / TSB004

Author: Encraft

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.
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Innovative solutions.

Final Report

Project information

- **ZA reference number:** ZA237K
- **Location of property:** Beausale, CV35
- **Lead participant details:** Encraft, Perseus House, 3 Chapel Court, Holly Walk, Leamington Spa CV3 24YS www.encraft.co.uk
- **Date report issued:** 2 November 2011

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1. Project details and directory

Role	Organisation	Contact Details
Project Manager and Energy Consultant	Encraft	Address: Perseus House, 3 Chapel Court, Holly Walk, Leamington Spa, CV32 4YS Website: www.encraft.co.uk
Warwick District Council	Warwick District Council	Address: Property Services, PO Box 1710, Riverside House, Milverton Hill, Leamington Spa Website: www.warwickdc.gov.uk
Main contractor	Kinetics	Address: Curdworth House, Kingsbury Road, Minworth, Sutton Coldfield, B76 9EE Tel: 08458 722128 Website: www.kineticsgroup.co.uk
Subcontractor - Windows	Bowater Windows	Address: Water Orton Lane, Minworth, Sutton Coldfield, B76 9BW Website: www.bowaterbuildingproducts.com
Subcontractor – External Wall Insulation	Transcast	Address: Blythe Valley Park, Central Boulevard, B90 8AG Website: www.transcast.org.uk
Subcontractor – Monitoring and controls	WattBox	Address: The Technocentre, Coventry University Technology Park, Puma Way, Coventry, CV1 2TT Webiste: www.wattbox.com

2. Introduction

The key aim of this project was to develop a whole house retrofit kit to ensure that energy demands and carbon dioxide impacts are addressed as a whole and disruption to tenants is minimised. ZA237K delivers a non-invasive renovation package with four distinct modules:

1. Non-invasive insulation module
2. Extremely low carbon heating module
3. Combined solar module
4. Lighting, appliances and control module

Each module could be installed as a standalone project but together they form a whole house solution that delivers deep cuts in both carbon emissions and primary energy consumption. The modules were carefully designed following a detailed cost benefit analysis of all potential measures to improve energy efficiency. The focus is on delivering a rural solution that takes advantage of the space available and reinforces links in a local wood fuel supply chain.

We are deliberately applying an identical retrofit to the two identical houses so we can specifically study the influence of different human behaviour patterns on the carbon emissions of the house.

3. Occupants

Both homes had the same tenants before and after the works. The unique innovation in our solution is the non-invasive nature of the chosen package of works. One of the barriers to retrofitting social housing is the need to decant tenants while work is carried out. The modules in our solution were selected so that tenants could remain in their homes throughout the renovation project. The added benefit of this approach is that there can be no hidden costs since there is no need to re-home tenants or spend money on the type of redecoration work that is otherwise required for some of the more invasive retrofit options.

Make-up of occupants before and after the retrofit:

TSB002

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

TSB004

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

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	26/03/2010
Planning application submitted (if appropriate)	N/A
Planning permission granted (if appropriate)	N/A
Building Regulations application submitted (if appropriate)	N/A
Building Regulations approval granted (if appropriate)	N/A
Contract for work let / signed	15/07/2010
Occupants moved out (state if they remained or property was empty)	Occupants remained
Start on site	19/07/2010
Completion of retrofit	16/09/2010
Occupants moved in	N/A
Monitoring system commissioned and operating properly	15/08/2010
Building defects corrected	15/11/2010
Building services and controls operating correctly	15/08/2010
Wattbox heating control replaced with traditional timeclock at TSB002 (Wattbox remains but only acting as a hub for the monitoring systems)	January 2011

5. Pre-retrofit property

The two houses are 1950s semi-detached properties. They are of the same design and layout with a total heated floor area of around 80.5sqm, split over two storeys plus a further 11sqm unheated space in single storey outbuildings attached at the rear.

The properties are in a rural setting in Warwickshire and were selected as typical examples of the rural house type so that our solution would automatically be replicable. The properties are owned by Warwick District Council who estimate that around 9% of their own housing stock is comprised of similar houses in similar settings (around 500 households). Across the UK, rural properties comprise around 20% of the total social housing stock (around 860,000 households). They are notoriously hard to treat and expensive to heat since they are often off the gas network and tend to be poorly insulated, often with solid brick walls. Warwick District Council is interested in replicating our retrofit kit and we'll promote our solution to other social housing providers who have a high proportion of rural homes.

The properties have filled cavity walls but we noticed that bricks bridge the cavity gap at regular intervals and the width of the gap is only around 20mm, so they are only slightly better than a solid wall. The windows were recently replaced and the loft insulation topped up, so both lofts and windows meet current Building Regulation standards. We assumed there was no insulation in the solid ground floors or the small sections of sloping roof in the first floor rooms. The homes are heated electrically: One by night storage heaters and one by a direct acting electric boiler. Electric immersion provides water heating in both homes but secondary heating is different in each: One has electric fires and the other open fires.

6. Design

ZA237K delivers a non-invasive renovation package with four distinct modules designed and implemented on both houses:

1. Non-invasive insulation module - this includes external wall insulation (120mm phenolic foam to achieve a target u-value of 0.1Wm/^{2}K) and new triple glazed windows (target u-value 0.9W/m^{2}K) and composite doors (target u-value 1.2W/m^{2}K)
2. Extremely low carbon heating module - this includes a wood pellet boiler (Windhager Biowin) with 150kg integral hopper for manual feed
3. Combined solar module - this includes both solar thermal (Baxi Solarflo flat panel collectors 2 x 2.02 sqm with associated dual coil hot water cylinder and a mixer shower) and a 1.48kWp solar photovoltaic system
4. Lighting, appliances and control module - this includes low energy light bulbs for all light fittings (vouchers provided to tenants who made their own selections from a range) and new appliances to include all white goods (see list below). The control element of this module will include a V-Phase unit for regulating the incoming electricity supply and a Wattbox for the control of space and water heating.

There were no major differences between the retrofit as designed and as built. The one difference of note is that the pellet boilers that have been installed are manually fed into a 150kg integral hopper, rather than automatically fed from an external pellet store as was originally proposed. This change in design came about partly as a result of feedback from the tenants (they were not keen to have a large plastic pellet store taking up space in the garden). But also because predicted pellet consumption was estimated to be around 1.5 tonnes per year and the smallest external pellet store we could find held 1.5 tonnes. It is not advisable to store pellets for more than a few months in a container such as this due to the degradation in fuel quality. Therefore, a 1.5 tonne pellet store would only work for a building which consumes more than 4 tonnes of pellets per year. Instead, an outside storage unit was provided for storing bagged pellets. This unit is much smaller than the 1.5 tonne store originally proposed so was more acceptable to the tenants.

White goods installed:

TSB002	**TSB004**
1 x Bosch WAS32460 Washing Machine	1 x Hotpoint Washer (WMD962G)
1 x Bosch WTE84308 Tumble Dryer	1 x Hotpoint Dryer (AQCF852BU)
1 x Bosch KTR16A21GB Fridge	1 x Bosch Fridge (KTR18P20GB)
1 x Bosch GSB26N11GB Freezer	1 x Bosch Freezer (GSD14A20GB)
1 x Bosch HBN331SOB Cooker	1 x Bosch Cooker (HCE54212OB)
1 x Bosch PIE611T114E Hob	
1 Set Of Free Of Charge Cooking Pans (to work with the induction hob)	

7. Construction

- **Procurement** – with a framework partner
- **Contract type** – standard JCT
- **Contract structure** – main contract with direct labour covering most trades plus some sub-contractors
- **Sub-contractors** – 3 (windows, cladding and monitoring)
- **Specialist installers** – as listed above for sub-contractors, engaged via a main contractor
- **Specialist equipment suppliers** – Wattbox and V-Phase, direct from manufacturer
- **Site supervision** – visiting inspections from project managers at Kinetics and Encraft
- **Role of design team** – retained to supervise/oversee construction

Lessons learnt:

Difficulties were experienced in relation to the tenants throughout the construction and post construction "snagging" phases. This is mostly due to the fact that tenants were not decanted. It was the express wish of the tenants that they should not be decanted (indeed they only agreed to be involved with the project on that basis) but the amount of work that was carried out in the end was perhaps too intensive and certainly more invasive than first thought. Each module of our retrofit kit would not be too invasive if implemented individually. But when packaged together as a whole house retrofit, the impact is arguably so great that it requires tenants to be decanted. A balance must be found whereby the number of people and the length of time onsite govern whether tenants are decanted or not.

It is well understood that certain tenants simply cannot be decanted. One way around this could be to implement the retrofit kit over a number of years as part of a planned maintenance programme. The only problem with this approach is that it could bypass the benefits of taking a whole house approach and measures could be poorly selected as they have not been considered holistically.

Perhaps if tenants were preselected on the basis of their willingness to engage and personal interest in sustainable technologies then many of the difficulties we experienced would not have arisen. In any case, because such a large amount of work must be implemented it is advisable that a formal contract is drawn up with the tenant's explicit agreement in order to set their expectations. The contract should be detailed enough to be used as a reference in case of snagging.

The scale of the project in financial terms did not warrant a continual site presence (e.g. from a site based project manager) but this was certainly needed from a tenant liaison point of view. Tenants overheard conversations and discussions between site operatives about problems arising onsite and, as a result, sometimes formed misconceptions as to the reason or scale of the problem. For example, a number of solutions were discussed for the re-routing of the soil pipe at TSB002 but in the end there was only one practical solution given the work that had already been completed. Although the most practical solution was agreed by site operatives, the tenant preferred one of the other solutions which had been discussed which had turned out not to be practical on closer inspection. This and similar instances

caused stress for both for the tenant and for the site operatives.

One further example of this has emerged during post construction whereby one tenant has lost confidence in the Wattbox heating controller. In this case the tenant overheard conversations during the time Wattbox was fitted and during subsequent visits to fine tune the settings on the heating control. At the time Wattbox was a near to market product, effectively still a prototype which was bound to need fine tuning for it to work properly. Evidence from subsequent data monitoring indicates that the Wattbox was working as intended because room temperatures remained warm and comfortable but despite this, the tenant reported to feeling out of control and in the end requested a traditional timeclock (which was fitted in January 2011 at TSB002). The Wattbox at TSB004 remains in control of the heating and at both houses Wattbox remains in situ serving as the hub for the data acquisition systems. It will still be interesting to compare the performance of the two houses now that only one has heating controlled by Wattbox.

Overall it seems that the way in which whole house retrofit projects are presented to tenants requires careful thought and planning and preferably a dedicated tenant liaison officer. It may well be easier and therefore cheaper to apply whole house retrofits whilst properties are vacant.

It was initially thought that the scale of the project in financial terms did not warrant a full programme of works or a full and detailed specification of works. However, experience has shown that timescales and problems arising onsite could have been reduced if more time had been spent on forward planning before and during the work onsite. This would have avoided various problems that were encountered such as the scaffold being readjusted a number of times because it was not designed with all measures and the requirements of each contractor in mind. Similarly the rooflines were not extended sufficiently and had to be readjusted and items were often not delivered to site at the most opportune moment because they had not been ordered in time.

8. Commissioning and occupancy

Encraft provided a written specification which explained all of the technologies that would be installed during the retrofit. This was given to the tenants before work commenced and the tenants signed against this specification to give their consent to proceed with the works described. However, it was later observed that the tenants struggled to understand much of the technical information that was provided in this document and due to their lack of experience with building projects were not aware of the impact each of the measures proposed would likely have on their homes and lives.

Windhager, Wattbox and Kinetics provided onsite training and support for the tenants so that they could better understand the new systems which had been installed and learn how to use them. Windhager left detailed technical information about the boiler which is stored in a secure place next to the boiler. Each contractor acted in this way on behalf of the systems they installed. It was agreed that a more holistic approach to the handover process would be more effective but the financial constraints of this project did not warrant the expenditure. A whole house handover and education day would certainly be recommended if this level of retrofit is replicated to multiple properties in future. Such a scheme would need to be developed with the involvement of all members of the design team and all subcontractors but should be the responsibility of the property owner (in this case Warwick District Council) to disseminate. Indeed the property owner should ideally remain as the first and single point of contact for tenants in all matters arising.

Wattbox is a new innovative product and as such had no support infrastructure. However Wattbox are on call should any problems arise with their equipment and tenants were able to contact Wattbox directly with any concerns arising. This meant that any time there was a problem with the heating, Wattbox were called out. Indeed they were the first to be called even though the problem wasn't always with the Wattbox and this has caused them undue costs. Unfortunately there was no way to avoid this because it was impossible to rule out Wattbox as nobody outside of the company knew enough about how the equipment worked. Concerns have been voiced by the property owners (Warwick District Council) as to how ongoing support for the Wattbox will be provided given that Wattbox are not in a position to offer emergency call out support in line with Warwick DC's standard service agreement with their tenants. In response to the concerns raised, Wattbox have offered to train someone at Warwick DC and provide documentation detailing steps that can be taken in case of failure.

Educating tenants to ensure they use their new systems efficiently is certainly a necessary element of any sustainable retrofit, but one that can be quite difficult to achieve if tenants are not technically minded. For example, one tenant indicated that they did not really understand what central heating was (they thought that all central heating systems were only ever fuelled by natural gas) and the tenant who had the Wattbox replaced with a traditional heating controller was subsequently found to have switched their electric immersion water heater onto continual heating and thus for a time they were not benefiting from their solar thermal system at all (we have subsequently helped to better inform the tenant on this issue).

9. Costs

Unfortunately a detailed final account is not available because the main contractor, Kinetics Group, went into administration shortly after the wash-up meeting and we have subsequently not been able to get hold of the required information. Kinetics charged for their work as quoted with only a few minor variations but it is suspected that the true cost of their involvement was greater than the amounts they originally quoted and subsequently charged.

Where this project became more expensive than expected was in the time taken up with tenant liaison and resolving snagging issues. If a dedicated tenant liaison officer had been provided by the property owner and a formal contract drawn up before work started onsite to set tenant's expectations with regard to finishing and redecoration requirements, although this would have required budget set aside for these elements during the design and planning stage it may have avoided the significant extra costs that were borne by the team in order to try and resolve the snagging issues at the end of the project.

Costs stated in the table below do not include VAT and are quoted as a total for both houses.

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration	N/A	Included in design fee	N/a	circa £40,000	Excessive (and ongoing) due to tenant liaison requirements
Design	N/A	£19,775	N/A	N/A	Phase 1 costs
Construction overall	N/A	N/A	£140,364		
- Prelims	N/A	N/A	£4,582		
- Fabric measures	N/A	N/A	£51,922		External wall insulation + windows + all prep work
- Building services (conventional)	N/A	N/A	£9,194		Lighting, appliances and extract fans
- Low /zero carbon technologies	N/A	N/A	£58,901		Biomass boilers + solar thermal + solar PV + all prep work
- Consequential costs	N/A	N/A	£3,130		Mostly cleaning and moving tenant's belongings etc
Occupant temporary housing	N/A	N/A	N/A	N/A	Tenants remained in their homes throughout

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Monitoring equipment			£12,634		Provided by Wattbox
Monitoring and reporting service	N/A	N/A	N/A	N/A	Included in the equipment costs
R&D costs (please detail)	N/A	N/A	N/A	N/A	

10. Wash-up meeting

A wash-up meeting was held on 13 May 2011 with representatives of Encraft, Warwick District Council, Kinetics, Bowater Building Products and Wattbox.

During the meeting we talked about and agreed responses to the questions posed in this report.

11. Doing it again

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

Definitely do again
External wall insulation – because it is a low-maintenance solution with a long lifetime and seems to have the greatest impact on lowering energy bills in hard to treat properties

Definitely not do again
Implementing such a large programme of works in such a short timeframe without first decanting the tenants. If the programme of works could be spread over time by splitting it into modules then tenants could perhaps stay in the home.

Stop the external wall insulation above ground – this leaves a massive thermal bridge at the junction between the ground floor and the wall. In future we will always recommend that external wall insulation is continued below ground.

Reduction of costs
Reducing the thickness of the external wall insulation to suit the existing roof structure in order to minimise extra work required to extend rooflines.

Appliances are not usually provided by social landlords due to the ongoing maintenance requirements and legal problems associated with ‘gifting’ and therefore are likely to be left out of future social housing retrofit projects.

Overall we believe it should be possible to achieve a 60% cost reduction for a solution that achieves 80% of what we achieved.

Improvement of the design process (better informed design decisions, more professional input, etc.)
Use PHPP rather than SAP to inform design decisions. A follow on retrofit project has required the use of PHPP and it has proven to be a more useful tool for decision making, in part because it forces you to pay attention to details which are all too easy to miss in a SAP calculation alone.

More consideration and attention paid to thermal bridging and air tightness

Improvement of the construction process (reduce timescale, smooth operation, etc.)
Provide a site manager.

Provide a full and detailed specification of works.

Provide a full programme of works (this was requested but never produced by the main contractor).

Agree a formal contract with the tenants (if they are to remain in the house during the construction phase) which sets their expectations and helps them to understand and accommodate the construction process and to serve as a reference for any snagging (our project timescales were greatly extended during the snagging phase as disputes were difficult to settle without tenant liaison support or a formal contract in place).

Better quality assurance
Improvement of the commissioning and occupancy process.

More comprehensive and appropriately pitched/disseminated training and education for the tenants.

Dedicated tenant liaison officer

12. Business benefits

Wattbox
Wattbox has launched their entire business off the back of this and other TSB Retrofit for the Future projects. They have had many new business leads and at the time of the wash-up meeting stated that they were 12 months away from commercial production of the Wattbox heating controller. The building performance monitoring and evaluation services were initially offered by Wattbox as an add-on to their heating controller but that aspect has now evolved into a major part of their business and they have gone on to secure further funding from the TSB in this aspect.

Bowater
This project was the first installation of Bowater's 'Smart Sash' windows and the system has now officially been released. They are currently supplying these windows for a retrofit project with Birmingham City Council and 320 properties. They have also secured a £500k project to supply to the Central London Housing Management Group.

Kinetics
Kinetics had lots of interest from people wanting to learn about their experiences with this project and they delivered numerous presentations etc. They had received no direct business leads at the time of this report. Kinetics Group has since gone into administration.

Structherm has had "plenty" of leads for properties requiring external wall insulation.

Windhager is waiting for the Renewable Heat Incentive.

Warwick District Council
Warwick District Council has no plans to roll out this level of retrofit on their stock due to a lack of funding but they continue to upgrade properties in line with their planned maintenance programme. They have been installing solar PV in order to benefit from the Feed in Tariff and are hopeful that the Green Deal will provide the funding they need to implement a more comprehensive retrofit programme in future.

Encraft
Encraft continue to be involved with a number of retrofit projects, both in the public and private sectors. As was the case before the Retrofit for the Future competition, we are often asked to conduct feasibility studies and designs for retrofitting homes, schools, offices, community centres and other buildings. Our most interesting project which came about as direct a result of our involvement with Retrofit for the Future is an ongoing project with Orbit Heart of England Housing Association where we are leading the design and co-ordination of the retrofit of two adjoining semi-detached Wimpey no-fines houses. One will be brought up to Passivhaus EnerPHIT standard, while the other will have an 'affordable' retrofit with a budget of £40k. This project alone has generated an income of around £25k this year. We expect the value of our retrofit business to be in the region of £250k - £1m, totalled over the next 5 years.