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: ZA146G
Property number: TSB026

Author: Victory Housing Trust

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Technology Strategy Board
Driving Innovation

SBRI
Government challenges.
Ideas from business.
Innovative solutions.

Final Report

Project information

- **ZA reference number:** ZA146G
- **Location of property:** NR12, Norfolk
- **Lead participant details:** Victory Housing Trust, Tom Moore House, Cromer Road, North Walsham, Norfolk, NR28 0NB
- **Date report issued:** 15th March 2011

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1. Project details and directory

Role	Organisation	Contact Details
Employers Agent	Victory Housing Trust	Address: Tom Moore House Cromer Road North Walsham Norfolk NR28 0NB Tel: 01692 502 416 Website: www.victoryhousing.co.uk
Architects	PRP Architects	Address:10 Lindsey Street London EC1A 9HP Tel: 020 7653 1200 / 0845 634 3614 Website: www.prparchitects.co.uk/
Engineer	Gawn Associates	
CDM Coordinator	Bottone Associates	
Main contractor	Hill Partnerships	Address: The Power House, Gunpowder Mill, Powdermill Lane, Waltham Abbey, Essex, EN9 1BN Tel: 0208 527 1400
PV installer	Viridian Solar	
Supplier - windows	Janex	
GSHP Installer	Econic	

2. Introduction

At the outset our aim was to analyse the technical feasibility and economic viability of reducing carbon dioxide emissions from a rural solid wall Victorian terraced house which currently has a solid fuel heating system, by 80%. Our objective was to undertake this analysis utilising the skills of the expert consultants and contractor in our team, whilst engaging our internal operation and management teams and suppliers of innovative construction materials and technologies to develop a whole house solution which is appropriate for this house type and ultimately economically replicable in rural locations around the UK. Another important objective was to develop a solution which can be implemented whilst residents are in occupation, even though the property under consideration is currently vacant; as we recognise the majority of homes will be occupied and circumstances will not typically allow residents to be relocated for the duration of the works

We recognise that the application of whole house solutions to the UK's housing stock could damage the character and heritage of our cities, towns and villages. Our strategy has therefore been to develop a solution that retains all of the existing external architectural character of the house, and replicate internal features where they exist and would be concealed by the insulation proposals.

The rural coastal location of the house and the fact that it currently uses solid fuel has allowed us to consider other fuel types as part of our objectives to propose alternative energy solutions for rural houses.

Our approach has been to maximise energy efficiency measures to reduce the reliance on technologies but our overall approach to material and technology specification has been to propose solutions that are simple to install and operate, cost effective and have minimal maintenance requirements and consequential running costs.

3. Occupants

New occupants moved into the property following the retrofit.

The make-up of occupants before and after the retrofit:

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

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed) Initial project meeting with Hills/VHT.	03.02.10
Planning application submitted (if appropriate)	N.A
Planning permission granted (if appropriate)	N.A
Building Regulations application submitted (if appropriate)	Building Notice submitted 17.03.10
Building Regulations approval granted (if appropriate)	Acknowledged 24.03.10
Contract for work let / signed	12.04.10
Occupants moved out (state if they remained or property was empty)	Property empty
Start on site	04.05.10
Completion of retrofit	22.07.10
Occupants moved in	02.08.10
Monitoring system commissioned and operating properly	N/A - MicroWatt
Building defects corrected	01.06.11
Building services and controls operating correctly	22.07.10
Programmed start date (delayed by Spacetherm availability - see above)	12.04.10
Programmed completion date (delayed by Spacetherm availability - see above)	07.06.10

5. Pre-retrofit property

The house is a 2 bed 3 person mid terrace property in a coastal hamlet in Norfolk. It was built in 1900. The brick bonding and wall thickness indicated that it was of solid wall construction; however, during the construction phase, it was discovered to be of cavity wall construction (440mm thick). Although the property has some relatively unique layout characteristics, it is a dwelling type which prevails throughout England.

The property sits in a terrace of 5 properties that fronts directly onto the dunes, with the beach and North Sea beyond. The exposed location of the building has led to the use of very substantial building practices which include 440mm thick brick / cavity / brick walls, with projecting brick reveal; large tile overlaps and timber sharking boards on top of the rafters. These techniques are generally employed in Scotland and other similar locations in the UK.

The house has a duo pitch roof, a flat roofed front porch and a single storey rear extension containing a kitchen, which does not meet current social housing space standards. The small bathroom is on the first floor and has been formed by taking space from the second bedroom. The heating system is a closed room solid fuel heater. There is no natural gas supply to the property.

6. Design

Although the property is not in an officially protected area, external insulation would lead to the loss of architectural character, with consequential impacts on the larger character of the terrace and hamlet. Internal insulation is therefore proposed, with replacement triple glazed composite windows to match the originals.

The retrofit project of TSB026 utilises a number of environmental interventions in order to reduce the annual carbon footprint of the property. The methods employed are: increased loft insulation to 350mm; added internal wall insulation; replacement of windows with uPVC triple glazed low-e ones; integration of 1.0kWp, 8.3m2 polycrystalline photovoltaic cells to roof; Waste Water Heat Recovery System (WWHRS); installation of solar thermal panels to contribute in Domestic Hot water; a Ground Source Heat Pump system; replacement of lighting features with LED lighting; equipping the house with AA++ energy efficient appliances; Sun Pipes, Floor Insulation and alteration of layout (removing lobby from heated envelope by turning stairs).

The strategy will provide substantial improvements to the thermal performance of the external fabric of the house, providing affordable warmth for the occupants. In addition, the strategy will ensure costs associated with hot water production and electricity consumption will be reduced. As there is no local natural gas supply, ground source heat pumps are proposed. The suggested strategy has been developed to be applicable to any house of this type in any location in the UK. Where it is not appropriate to use ground source heat pumps, another heating source such as a biomass boiler or air source heat pumps can be used in conjunction with photovoltaic panels on the south, east or west facing roof slope to achieve the required carbon emission reduction.

What to do with the lobby

During the design phase of the project it was identified that insulating the poorly built entrance lobby would have very poor pay-back times and it was decided to look at alternatives. The decision was made to both simplify the building footprint and to remove the lobby from the heated envelope by turning the stairs at the lower steps and building a new insulated partition wall between the main part of the house and the lobby. Although this works well in energy terms there were some unforeseen consequences. It transpired that the original building had insufficient fire escape routes and that turning the stairs had drawn attention to this. Adjustments to the upper window fenestration were needed to provide a new fire egress opening.

Ventilation

The original proposal for a passive ventilation system was substituted with Distributed Whole House MEV (always on low energy extract fans in kitchen and bathroom), as it is our experience that residents do not trust passive systems as they associate the lack of fans with the idea that there is inadequate ventilation, often installing additional fans. It is also very difficult to design a retrofit passive stack system.

Zone control not installed

During the course of the project it was discovered by the contractor that to install zone control would require a complete re plumbing of almost the entire central heating system. Furthermore, the property itself is relatively small and has large open plan areas that reduce the benefits of having a full time and temperature zone control system. A simple room thermostat, programmer and TRV control system was retained. Although this change will have a detrimental effect on the CO_2 emission reductions, the targets should still be met.

Some white goods different

The original proposal included A++ 'white goods'. It was found that this specification is not commonly available (if indeed at all) for some product types. The highest energy specification products available within the budget were chosen; in some cases this was A or A+ rated only.

7. Construction

External Walls
On removal of the windows it was discovered that the walls were of cavity construction, rather than the solid walled construction that the age and brick pattern suggested. U-value calculations were undertaken and, due to the high performance insulation already being installed which makes cavity fill a very marginal measure (and potentially detrimental, due to the narrow and uneven cavity and potential wall tie cold bridging), as well as the age of the building, it was decided not to cavity fill in addition to the measures already being undertaken. This will have no impact on the final performance of the building.

Aerogel insulation
During the course of the project the manufacturers of the Aerogel insulation significantly increased the price of the product as well as increasing lead-in time estimates. The project team had already secured an adequate supply in anticipation of long-lead in times, and in the desire to complete the project as quickly as possible; without this, considerable project delay could have occurred.

Windows
A number of window manufacturers needed to be investigated in order to be certain of a supply of windows that fitted the design criteria and landlord's requirements. There were very few manufacturers that could genuinely provide windows with the required whole opening U-value required for the project.

GSHP
Although the push fit GSHP collector loop installation went smoothly, the positioning of the GSHP itself proved problematic, with the original suggested location being too small to house the heat pump. The newly externalised lobby was used to house the heat pump.

8. Commissioning and occupancy

The use and operation of the services installations were demonstrated to the new residents at the time of occupation. This proved to be inadequate however, particularly in terms of the heat pump, and numerous subsequent visits were made to resolve queries.

The ground source heat pump delivers heating in a different way to a conventional central heating system in that is does not provide quick reaching heat and is best left on for long periods at a lower temperature. Initially the residents were reluctant to leave the heating system on for long periods; for fear that energy consumption/costs would be high.

In future projects greater emphasis would be placed on providing residents with additional instruction and education at the outset.

9. Costs

Item Stage>	Design stage	Post-construction	Comments
Management and administration			
Design	£16,918.00	£16,918.00	PRP fees based on TSB app. Form
Construction overall	£117,325.00	£76,396.00	Design Stage: Based on TSB app. Form
• Prelims	£16,803.00	£14,300.00	Design Stage: Based on TSB app. Form
• Fabric measures	TBC by HP	TBC by HP	Insufficient data from Hill partnerships
• Building services (conventional)	TBC by HP	TBC by HP	Insufficient data from Hill partnerships
• Low /zero carbon technologies	TBC by HP	TBC by HP	Insufficient data from Hill partnerships
• Stats		£644.00	
Occupant temporary housing	N.A	N.A	
Monitoring equipment	£2,092.00	TBC by HP	Based on Microwatt quote
Monitoring and reporting service	£3,780.00	£2,630.00	Design Stage: Based on subtracting Microwatt fee from £10k monitoring allowance on TSB app. Form Post Construction: Microwatt deposit paid - Blog payment
Co-heating test	£4,128.00	£0.00	Not done

10. Wash-up meeting

No wash-up meeting was held.

11. Doing it again

1. Definitely do again

- Wall Insulation (although the project highlighted how difficult it would be to install internal wall insulation with residents in occupation)
- Secure products early on
- Undertake research into potential suppliers early on
- Waste water heat recovery (although attributing savings would be better)
- Solar lighting tube. This proved very effective at lighting the stairwell which had no natural light, but is not reflected in the attributed savings.
- LED lighting
- All thermal bridging measures

2. Definitely not do again

Provide kitchen appliances. As a housing provider the Trust does not normally provide such items and without a procedure in place to deal with break downs the on-going maintenance placed an additional burden on the Trust. Supply and maintenance of such items also requires diversion of financial resources from other areas of the business.

3. Reduction of costs (what might be left out and how things could be made cheaper)

- Restrict the use of Aerogel (or other premium insulation products such as Vacuum Insulated Panels – VIP) to areas where space is valuable
- LED bulbs rather than whole fittings
- Leasing or borrowing monitoring equipment

4. Improvement of the design process (better informed design decisions, more professional input, etc.)

Design process improvements

- Allowance for external calculation of savings outside SAP / PHPP - individual heat recovery ventilation, multiple appendix Q measures; time and temperature TRVs
- More integration with construction team in terms of practicality of measures and explanation of scope of works
- Methodology needs to include tenant behaviour; especially the likelihood of taking up increased comfort, and its impact on potential savings.
- Use of 'greener' products where possible
- A simple method for calculating thermal bridging, or rules of thumb for existing typical construction techniques, would improve this aspect of the design process. We chose

to use the SAP default value for both pre and post retrofit. For the pre-retrofit case it is difficult to calculate the thermal bridge value. For the post-retrofit case, we have included measures to counter thermal bridging, and by improving the surrounding u-values we have perhaps simply corrected for increased thermal bridging.

5. **Improvement of the construction process** (reduce timescale, smooth operation, etc.)

Construction process improvements

- Toolbox talks
- More visits during construction
- Restriction of subcontractors (and/or closer management of subcontractors by the whole team, including the design team)
- Single organisation for integrated system provision (e.g. heat distribution, heating system, and controls)

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

Commissioning improvements

- Tenant advice sessions / training similar to that undertaken by RELISH
- Training of tenant / landlord liaison staff in the retrofit process, the systems installed and their efficient operation and maintenance
- A mechanism for decanting tenants at times of intense retrofit activity is needed, alongside a programme of managing expectations to achieve the greatest satisfaction for the occupants possible with the improvement works and the process.
- Market and Policy certainty is needed, so that contractors and supply chains can gear up to undertake the millions of necessary retrofits.
- Term agreements for contractors with larger landlords, in order to extend the usual range of property services to include whole house retrofit.
- Whole house plans for every property with identified trigger points for intervention e.g. when roof works are necessary, the opportunity to install rooftop solar technology should be taken; when a property becomes empty, the opportunity should be taken to complete the whole house retrofit. Where a landlord has a typical 4% void rate potentially all properties could be retrofitted over 25 years without having to decant any resident

12. Business benefits

To date, the cost of retrofitting new technologies into existing properties has been prohibitive.

The introduction of the Government's Green Deal initiative has provided the additional funding to allow the Trust to actively engage with local businesses to treat solid wall properties with external wall insulation.

13. Additional Information

Aerogel insulation
During the course of the project the manufacturers of the Aerogel insulation significantly increased the price of the product, as well as increasing lead-in time estimates. The project team had already secured an adequate supply (in anticipation of long-lead in times, and in the desire to complete the project as quickly as possible); without this, considerable project delay could have occurred.

Windows
A number of window manufacturers needed to be investigated in order to be certain of supply of windows that fitted the design criteria and the landlord's requirements. There were very few manufacturers that could genuinely provide windows with the required whole opening U-value required for the project.

Additional costs of measures over traditional materials / technologies should be used for economic feasibility calculations rather than full costs. So the difference in price and performance between standard, building regulations-compliant, double glazing and high performance triple glazing.

Materials should be chosen for longevity, and choice of materials should not be dictated by conservatism within maintenance teams. The choice of uPVC windows is typically dictated by the landlord's maintenance teams, but it would be far better to educate these teams to maintain wooden or composite windows that can have a whole building lifecycle (as opposed to potentially as little as 15 years for uPVC).

Clear communication is needed between the tenant / landlord and subcontractors (such as those working with monitoring equipment), to arrange access and manage expectations

Extensions
In regards to lean-tos and extensions (whether originally constructed or later added): The decision to rebuild rather than retrofit should be made at a lower threshold to any decision to retrofit the whole building.

Other
System 3 ventilation might include heat recovery
eTRVs
A whole house plan should be identified, with trigger points for compatible potential improvements to be undertaken over a 25 year period, with replacement of items such as windows and boilers being made at natural cyclical replacement times.
Less reliance on maximum rooftop solar technologies at the outset, with provision to practical maximum (rather than amount to reach target) included in whole house lifetime plan.
Tenant reaction to the retrofit process is unpredictable and one outcome of this project is a greater understanding of tenant expectation management.

'Hidden' advantages of works, such as faster wash times from A++ washing machines and better lighting quality from LED lights, need to be identified and communicated to residents and landlords.
Clearer demarcation of responsibilities (i.e. with the subcontractors responsible for measuring roof area for product compatibility)
The lack of a product for the solar doorbell was a disappointment
A solid floor insulation product is needed

The issue of potentially claiming funding from the Feed in Tariff (or, in the future, the RHI) needs to be considered. For new build the HCA have only recently made clear the boundary between their funding and the FiT. There is too much risk in this area to be able to guarantee funding for renewable energy by deciding early on to arrange funding in any particular way.

Monitoring organisations that can undertake utility, environmental, and renewable monitoring at a reasonable cost are few and far between

Neighbours should be informed of the nature of the works and the construction timetable

A mechanism for provision of energy efficient appliances to tenants is needed. Social landlords do not typically provide tenants with appliances, and the provision of these in this project unearthed a number of issues of responsibility.

A referable guide to energy efficient appliances would be useful. Procurement of the required A++ rated appliances was surprisingly difficult considering that the energy rating of appliances is a long established scheme.