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: ZA571W
Property number: TSB087

Author
BBP Regeneration Ltd

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Technology Strategy Board
Driving Innovation

SBRI
Government challenges.
Ideas from business.
Innovative solutions.

Final Report

Project information

- **ZA reference number:** ZA571W

- **Location of property:** ME11, Isle of Sheppey

- **Lead participant details:**
  BBP Regeneration Limited
  Corinthian House,
  279 Tottenham Court Road,
  London,
  W1T 7JR
  www.bbpregeneration.co.uk

- **Date report issued:** 15th April 2011

Contents

1. Project details and directory 4
2. Introduction 5
3. Occupants 6
4. Dates 7
5. Pre-retrofit property 8
6. Design 9
7. Construction 12
8. Commissioning and occupancy 14
9. Costs 15
10. Wash-up meeting 16
11. Doing it again 17
12. Business benefits 19

1. Project details and directory

PLEASE NOTE: ANOTHER REPORT IS PROVIDED FOR THE OTHER PROPERTY WITHIN THIS RETROFIT PROJECT, TSB100

Role	Organisation	Contact Details
Employer's Agent	BBP Regeneration Ltd	Address: Corinthian House, 279 Tottenham Court Road, London, W1T 7JR Website: www.bbpregeneration.co.uk
CDM Co-ordinator Clerk of Works	Amicus Horizon	Address: PO Box 322, Sittingbourne, Kent, ME9 8PQ Website: www.amicushorizon.org.uk
Employer's Sustainability Consultant	Daedalus Environmental Limited	Address: PO Box 1268, Maidstone, Kent, ME14 9NH Website: www.daedalusenvironmental.co.uk
QS/Cost Management	WT Partnership	Address: AMP House, Dingwall Road, Croydon, CR0 2LX Website: www.wtpartnership.com
Main contractor	Swale Heating Ltd	Address: Heard Road, Eurolink Ind Estate, Sittingbourne, Kent, ME10 3SA Website: www.swaleheating.com
Electrical installation	Swale Heating Ltd	As above
Central Heating	Swale Heating Ltd	As above
Solar thermal	Swale Heating Ltd	As above
PV installer	Swale Heating Ltd	As above
Internal Insulation	DCB (Kent Ltd)	Matts Hill Farm Road, Hartlip, Sittingbourne, Kent, ME9 7UY
MVHR	CSS Environmental Ltd	Unit 17 Hopewell Business Centre, 105 Hopewell Drive, Chatham, Kent ME5 7DX
Windows / Doors	DWL Home Improvements Ltd	Queenborough Business Park, Main Road, Queenborough, Kent, ME11 5DY

2. Introduction

This project came about as the first pilot phase of a wider regional retrofit project, which aims to retrofit a total of 1,500 homes over the next few years. This will help to ensure that existing properties, which are adjacent to a masterplan area of 2,000 new and highly efficient dwellings, are brought up to similar standards.

The project is a partnership between the local authority, RP AmicusHorizon and local community groups, with support from other professional organisations helping to facilitate the works. The team felt it would be beneficial to compare similar comprehensive retrofit solutions in two different property types, in order to maximise the potential for replicability, and so two properties were selected from AmicusHorizon's stock. This report focuses on one of these properties, TSB087; further details on the second property, TSB100 can be found in a separate report.

It is hoped that the RftF project will be able to demonstrate replicable technologies delivering comprehensive energy and carbon savings to residents, alongside the financial savings that are critical in a highly deprived location.

3. Occupants

New occupants moved into the property following the retrofit works.

The occupants were identified through AmicusHorizon transfer and mutual exchange lists, so as to ensure that there was some background knowledge of their experience as an AmicusHorizon resident. They needed to move into a three bedroom property and asked for the area; they were then interviewed to establish whether they would be interested in taking part in such an exciting project.

Ultimately, the new occupants did not fully engage with the project and had little interest in the technologies and measures that were being installed. They have no real prior experience or knowledge of sustainable energy issues, measures and technologies that would influence the performance of the building.

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

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	TSB approval confirmation 27/01/2010
Planning application submitted (if appropriate)	N/A
Planning permission granted (if appropriate)	N/A
Building Regulations application submitted (if appropriate)	21/05/2010
Building Regulations approval granted (if appropriate)	Ditto
Contract for work let / signed	01/06/2010
Occupants moved out (state if they remained or property was empty)	N/A
Start on site	01/06/2010
Completion of retrofit	Sectional completion achieved on 15/09/2010
Occupants moved in	N/A
Monitoring system commissioned and operating properly	13/07/2010
Building defects corrected	22/09/2010
Building services and controls operating correctly	15/09/2010

5. Pre-retrofit property

TSB087 is an early 1970's built terrace infill property, with a GIFA of approximate 70m^2. It has two storeys with 3 bedrooms and one bathroom; has cavity wall type construction, and prior to retrofit operated a back boiler heating system.

No monitoring of the property was carried out prior to the retrofit, as it was void in the period leading up to the works.

TSB087 was selected from a shortlist of two void property archetypes in the ME11 area, and because it represented a typical three-bed house archetype across AmicusHorizon's Kent and Sussex housing stock.

6. Design

The following is a list of the key technologies and measures that were originally proposed to be installed:

• Spacetherm C (aerogel nanotechnology) ground floor insulation – 10mm of the Spacetherm blanket is equivalent to 30mm of mineral wool insulation, producing increased benefit with minimal practical disruption
• 2No. Baxi SolarFlo in-roof solar thermal panel collectors providing hot water in summer months. Collector area of 2.32m2 per panel.
• 1.6kWp (8No. Sharp 200Wp) PV panel system
• 93% efficient Appendix Q rated mechanical ventilation and heat recovery unit - providing retained heat within a more air tight structure.
• Baxi Ecogen gas fired micro-CHP system - provides electricity into the property when generating heat for space heating and hot water. The system uses a free piston Stirling engine to generate up to 6kW of heat and 1kW of electricity. Heat loads above 6kW are then met using a high efficiency condensing boiler within the same unit. The overall efficiency of the system is 92% and it is virtually noise and vibration free.
• Kingspan Kooltherm K17 internal wall insulation for 0.25 U-value.

The PV panel specification was amended to Grovit panels. This was done due to the Swale Heating pricing and understanding of PV installations, in that the Swale Heating engineer was trained and the company supported by Grovit for the projects. All other items remained as per the specification.

During the pre-construction stage of the project and at the point of installation there was confusion over the best approach to dealing with the chimney, which needed to be blocked off, and with respect to any shading issues for the solar panels. It was finally decided to remove the top section of the chimney to deal with this latter issue. A chimney balloon, which had originally been proposed, was discounted and replaced with an insulated board which was subsequently rendered over.

The main issue in the property however was air tightness. The first results were inadequate, despite the belief that everything that could have been done, had been. There had been no allowance for the fact that there were no floor coverings however (these are left up to the future tenant), and as a result the upstairs floor boards needed to be covered with hardboard. The air was simply escaping into adjoining properties through the beams at first floor level, as the property is part of a terrace. The hardboard stopped the migration of air through the gaps in the tongue and grove flooring and was sealed at the edges to the skirting. The hardboard could possibly have been avoided if suitable floor coverings (underlay/carpet etc) were installed.

The hardboard has also thrown up the additional challenge of future access and maintenance to pipework and MVHR ducting, and will need to be removed and resealed if maintenance work does need to be carried out. In the interim, pipe/duct locations were marked on the top of the hardboard in permanent marker should it be necessary to access

them; this also raises the additional issue of needing to train future maintenance contractors however.

The internal solar thermal components, MVHR, PV inverter and hot water cylinder were all installed in the loft space. This decision was taken to provide more space to residents, and to keep the equipment out of harm's way. It is within the tenant's contract not to enter the loft space, but this had not been allowed for in the original specification and the loft space needed to be partially boarded for access and maintenance, and additional loft lighting and ladder access had to be provided. Inevitably this had some cost implications, and indeed the boarded area reduced the ability to install the planned depth of loft insulation. The boarding covers an area of approximately $3m^2$.

The team agreed to maximise the potential for replicability, and felt that it would be beneficial to compare similar comprehensive retrofit solutions in two different property types. Although there was some variation in the technologies used for the main heating system and the wall insulation, in the main the products and measures installed in the two properties were the same. With the benefit of hindsight this was perhaps a step too far given the extent of the works and associated budget, nevertheless, two exemplar refurbishments were completed within the available budget.

The technologies were selected on the basis of a combination of applicability and innovation – neither of the two main heating systems in the different properties had been installed in other properties on a commercial basis within the UK. We were keen to explore non simple gas boiler options, and the use of heat pumps did not, under the modelling scenarios, deliver the kinds of carbon savings necessary to warrant TSB investment. TSB087 is ideally oriented (rear faced directly south) and offered very good potential for the installation of solar technologies, so these were included in the project. The solar thermal panels did not offer very good complementarity with the CHP system however (competing as they do for the summer load), so the electrical benefit of the CHP was reduced. In spite of this, the benefits arising from the use of solar thermal were deemed to be of greater importance than the loss to the electrical output.

Insulation measures were chosen with a view to robustness (all well-established products) and guidance was sought from Kingspan as to any risks associated with condensation and moisture transfer, in particular with regard to the use of internal wall insulation on a cavity wall base. The cavity was also filled. Reducing air tightness to less than 5 also required improved ventilation, provided by an Appendix Q rated MVHR system.

Some key points to consider as the installation progressed / was amended:

- The CHP system weighed approximately 3 times that of a standard wall hung boiler – fortunately we had a structural wall upon which it could be mounted, but in other circumstances this might not be the case. The location of the CHP system is therefore a very important consideration for future projects.
- There were considerable difficulties in accommodating the MVHR pipework, which was 6" in diameter and was installed in some places side by side. The use of more flexible ductwork would be preferred in future, or possibly low profile ductwork.

Fortunately, the ceilings needed to be removed because of an asbestos issue, which worked in our favour as this enabled ductwork to be installed more easily.

- An allowance for the Spacetherm insulation had been made in terms of undercutting wooden doors internally, but we were faced with additional challenges with the external doors, where heights are restricted by lintels and door heights also fixed. All was fine in the end where the Spacetherm insulated board was installed and cuts made to accommodate.

Careful thought needs to be made to the form of contract used – for simplicity we used a design and build approach but co-ordination is a vital issue in retrofit projects. Overall, the project had to be flexible to accommodate the needs of the building owner and future tenant, and the extraneous issues brought about by unforeseen circumstances. Inevitably design development will always be a key feature, and allowances (both in time and financial terms) need to be made accordingly.

7. Construction

Procurement
Swale Heating were selected as a local company and one of the building owner AmicusHorizon's pre-tendered framework contractors via the South East Consortium.

Contract type
An amended form of JCT Standard Form of Design and Build Contract 2005 was implemented, incorporating Revision 2 and including Contractor and Sub-Contractor Warranties.

Contract structure
Main contractor with direct labour covering most trades plus some sub-contractors.

Sub-contractors
As in Section 1.

Specialist installers
As in Section 1: all specialist subcontractors were engaged via Swale Heating.

Specialist equipment suppliers
As in Section 1.

Site supervision
Clerk of Works, with daily visiting inspections.

Role of design team
The design team were retained to provide ongoing advice and support to the contracting team as the work progressed. The employer's agent signed off the works whilst WT Partnership certified the payments to the contractor.

Lessons learned

The question arose as to whether this was the right type of boiler for this property, being perhaps too large (both in terms of heat output and physical size). Whilst the Stirling engine CHP system itself was fine producing 6kW heat, the additional boiler within the unit is, perhaps, largely superfluous for the majority of the year given the high levels of insulation and air tightness and low levels of heat loss now in place. Future iterations of the CHP system, perhaps with smaller capacity, would be a better solution. The use of CHP was driven by the need to test technologies too, and this was thought equally as important for the purposes of this project. It will be useful to see the annual data showing heating demands above the 6kW threshold, and how often the main boiler unit fired up.

Given all considerations, the design specified for the whole property was the most appropriate at the time, but with different/emerging/updated technologies we could definitely see alternative approaches coming forward in the future.

From AmicusHorizon's perspective, all went well with ZA571W and a lot has been learned. Their greatest challenge was the restriction in terms of identifying the residents who could be given the property for rental. Due process in terms of Choice Based Lettings meant the resident could not simply be chosen on the basis of 'best fit'. The outcomes of the data analysis will therefore be very interesting to assess for a family who is less engaged with the issues of energy use and carbon emissions.

8. Commissioning and occupancy

Commissioning of the following systems was necessary:

- Wattbox control system – some small software glitches that were quickly rectified using an upload of a later version of the software.
- MVHR – most difficult element was getting the MVHR completed; there were problems getting it into different places. It was not sufficiently 'off the shelf' and all parts needed to be special ordered from Vent Axia and there was always a 24-48 hour wait for delivery.
- Renewable energy systems – commissioned in accordance with requirements of the MCS, no problems discovered.

The new residents were given the keys to the property following a handover interview with a Housing Officer and an Asset Management Surveyor. The residents then signed the usual tenancy agreement, and the additional paperwork as follows:

- Signatures for gifted A rated appliances.
- Signatures to abide with the terms and conditions set out in the handover documents, including the right for contractors and AmicusHorizon staff to access the property for maintenance and servicing of the installed equipment.
- Agreement to allow access to thermal imaging and monitoring equipment.

Choice Based Letting is the means by which AmicusHorizon connects residents with properties. This is a points based system. CBL causes issues in terms of effective resident engagement when void properties exist however, as it does not allowing sufficient time for extensive engagement with the resident prior to occupation. In the case of this project the appointment to move in was about 48 hours. In addition, it is not permitted under CBL to force residents to sign additional contractual information, and therefore we were relying on the tenant's goodwill to agree to the additional requirements under contract. The resident has been provided with a copy of the H&S file and a contact number should any concerns arise.

9. Costs

In the main, the costs pre and post retrofit were largely as expected. The deviations arose as a result of the unforeseen changes outlined above. For example, the removal of the chimney within TSB100 incurred additional labour costs. However because the contract was design and build, a fixed price was provided by Swale Heating, the main contractor. Any deviations from that price therefore either had to be absorbed by Swale Heating or, in some circumstances (such as the chimney), additional costs were negotiated at the discretion of the Employer's Agent.

This would certainly be our preferred route in the future if we were to carry out a project like this again, as, whilst inevitably there may be some pricing of risk initially, there is more certainty overall in the wider project costs. What remains a challenge is the issue of VAT – there is very little clarity from HMRC on what VAT rates apply to different elements, materials labour etc, and we relied on Swale Heating to provide guidance. It would be very useful if HMRC or the TSB (or preferably both) could provide a definitive guide to the VAT in retrofit projects.

10. Wash-up meeting

A wash-up meeting was held with the whole team present on the 21st of March 2011. The content of the meeting has been described elsewhere in the report.

11. Doing it again

Would definitely do again
AmicusHorizon – given the choice the RP would do it again but definitely with an occupational tenant. This is thought to be better in the long term for the operation of the property and the engagement of residents in the issues surrounding sustainable energy, despite the fact that the decanting cost can be significant for the building owner if residents need to be moved into another property for a period of time. For short periods B&B accommodation would be fine, and a lower cost.

In order to facilitate replicability (this housetype is typical of much of AmicusHorizon's stock) it is necessary to fully understand the property typology and the works schedule. More work needs to be undertaken initially as a building owner therefore, in order to better understand the possible implications of the retrofit.

Swale Heating, the main contractor, would do it again and the process has helped considerably on understanding costs. They would perhaps not do it again in the same way, but have learnt a phenomenal amount about the design implications and costs of:

- Insulation
- Flooring
- Construction details
- Glazing
- Acting as main contractor and as lead contractor to subcontractors
- Better commercial situation
- Planning of works and integration of activity

Would definitely not do again
The CHP system is the only thing on this property, mainly because of its size and weight.

Reduction of costs
If we'd carried out further detailed survey work prior to the start of the project, costs would have been saved through better planning and the avoidance of unforeseen circumstances. In practice it will always be a balance between causing greater disruption (especially in occupied premises) and making assumptions at design stage. The cost of technologies has also fallen even since the completion of this project, and therefore costs would have been saved further.

Improvement of the design process
Again this links to the above point about more detailed survey for whole house retrofit – the more informed the starting point, the better the design will be and the lower the risk. Having gained the experience of this retrofit (in conjunction with the other property within the ZA571W project), the process will only get better over time.

Improvement of the construction process
The works on TSB087 enabled better operation and smoother processes on the TSB100 property, as many of the technologies were the same and the design implications could be better anticipated. It also helped in explaining the scheme to the residents of TSB100, as it

could be used as a show house to increase buy in from them, and allowed them to better understand the general construction process.

Improvement of the commissioning and occupancy process
Please see point in Section 8 about the need to address the challenges of Choice Based Lettings and the issue of void properties.

Retrofit at scale
Efficiency gains

- There would definitely be economies of scale from buying in bulk, and depending on the product and size of project these are anticipated to be anywhere between 10 and 40%.
- A better understanding of the installation process could be gained through engaging in a wider programme of retrofits, and inevitably this would also reduce the amount of time spent on site
- As knowledge of technologies improves, simple things will get done more easily
- The community engagement aspects would also be key – a better understanding of how to engage residents and create the right message will also result in lower resistance

In order to make a project of this type replicable on a larger scale, it would be necessary to reduce costs down to a practicable level: on a per unit basis this would need to be in the region of £20,000. This would need to be achieved through a combination of the following:

- Repeated use of technologies and increase in knowledge
- Specification by ***installers*** not manufacturers – this helps with knowledge of the product and speed of installation
- Greater collaboration between, and with, known partners, so that the delivery model is understood by all parties
- Greater investment in more in-depth surveys
- Greater investment in community engagement from a very early stage
- There also needs to be clarity over the issues regarding maintenance; whose obligation it is and how it will be paid for on an ongoing basis. This is particularly challenging in a low income private household.

12. Business benefits

For AmicusHorizon, benefits are based around having a greater understanding of the need for education about new technologies. Information on these technologies needs to be properly worked through with residents; on Sheppey the Green Doctor approach is being used to help with this.

All parties felt that innovative products and their impacts, whilst vital, need to be more comprehensively understood before they're employed as part of a scope of works. Having now completed the work, there is a much better appreciation of the technologies used. The simple fact that the parties have now all been through the process means that things would be done differently in the future, design challenges more quickly overcome, and issues better anticipated. Inevitably, this will have a clear benefit in efficiency terms in future.

Will the RftF project provide a competitive advantage? Yes, insofar as the project will be actively used as a case study of practical experience in retrofit, and should help to demonstrate competence and ability in this emerging field.

It is clear that using the TSB project as an example of a completed, complex, whole house retrofit will be of vital importance in selling services in the future, but it is too early to know at this stage what the overall benefit will be and what leads will emerge as a result.