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:ZA391Y
Properties: TSB114, TSB115 and TSB116

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

Technology Strategy Board
Driving Innovation

SBRI Government challenges. Ideas from business. Innovative solutions.

Final Report

Project information

- **ZA reference number: ZA391Y**

- **Location of properties:**

TSB115 **Dwelling P1 – Spacetherm** Thorpe Wakefield WF3 3	**TSB114** **Dwelling P2 – Polystud** East Ardsley Wakefield WF3 2	**TSB116** **Dwelling P3 – Super efficient** Lindley Huddersfield HD3 3

- **Lead participant details: Yorkshire Housing, 6 Innovation Close, Heslington, York, YO10 5ZF 01904 754484**

- **Date report issued: 4 August 2011**

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1. Project details and directory

This project covers three properties, all covered in this report. The first property (dwelling P3) has been retrofitted to a 'super efficient' standard. The other two are reference properties, retrofitted with alternative solid wall insulation systems. The properties have been referred to as Thorpe, East Ardsley and Lindley, referencing the area they are located.

- P1 (Thorpe). It has a combi boiler and 35mm of "Spacetherm" (made up of 25mm of Spacetherm insulation and 10mm Fermacell insulation). The combi boiler was selected for P1 as there is not enough storage space for a cylinder (required for a system boiler).
- P2 (East Ardsley). It has a system boiler and 75mm of Polystud insulation. The ceiling height has been lowered to reduce heat demand.
- P3 (Lindley). It has an air source heat pump and 50mm of Spacetherm (made up of 40mm Spacetherm and 10mm Fermacell). Spacetherm floor insulation is 6mm thick, with 18mm ply on top. The ceilings have been lowered to reduce heat demand in the upstairs front room. Solar photovoltaic panels and mechanical ventilation with heat recovery has also been installed.

The below addresses and photos are provided for reference for this report. They should not be used for any other purposes without the permission of Yorkshire Housing Ltd.

TSB115 **Dwelling P1 – Spacetherm** Wakefield West Yorkshire WF3	**TSB114** **Dwelling P2 – Polystud** Wakefield West Yorkshire WF3	**TSB116** **Dwelling P3 – Super efficient** Lindley Huddersfield West Yorkshire HD3

Left to right: Properties P1 (Thorpe), P2 (East Ardsley) and P3 (Lindley)

Key project roles:

Camco are the lead consultant, and have been the primary contact for the Technology Strategy Board. Camco's role on the project includes:

- Energy modelling
- SAP
- SAP Extension spreadsheet
- Parity Projects software (by Parity)
- TSB reporting
- Monitoring plan (with Parity)

Yorkshire Housing Ltd (YH Ltd), a housing association, is the client and property owner. The contract for the funding is between the Technology Strategy Board and YH Ltd. Their responsibilities include:

- Costs (supported by Camco/Parity)
- Installation plan
- Planning
- Dealing with customer issues

Role	Organisation	Contact Details
	Yorkshire Housing	6 Innovation Close Heslington York, YO10 5ZF 01904 754484
Yorkshire Housing	Yorkshire Housing	As above
Project Consultant	Camco	The Workstation, 15 Paternoster Row Sheffield, S11 8PN 0114 225 7746 www.camcoglobal.com
IWI and monitoring	Parity Projects	Block A, Unit 230/231, Riverside Business Centre, London SW18 4UQ 0208 643 6630 www.parityprojects.com
Customer liaison and learning	Yorkshire Housing – Environmental Performance Coordinator	6 Innovation Close Heslington York, YO10 5ZF 01904 754501
TSB project team manager	Yorkshire Housing – Investment Team	Yorkshire Housing, 87 Manningham Lane, Bradford, BD1 3BN 01274 203579

Role	Organisation	Contact Details
TSB project coordinator / liaison officer	Yorkshire Housing – Asset team	Yorkshire Housing, Unit B2 6 Airedale Business Centre, Millennium Road, Keighley Road, Skipton, North Yorkshire, BD23 2TZ 01756 702630
Main contractor	Strategic Team Group	Strategic Team Group Strategic Business Centre Blue Ridge Park Thunderhead Ridge Glasshoughton Castleford WF10 4UA 01977 522 402 www.strategicteamgroup.com
Sub-contractor – heating		Contact through Yorkshire Housing (above)
PV & ASHP installer	Strategic Energy	As for Strategic Team Group

2. Introduction

The original aim of the project was to address barriers to installing internal wall insulation in solid walled properties. Yorkshire Housing have 1,800 properties for which internal insulation is the only way of reducing heat loss through walls. They were keen to understand the most cost effective way of improving these properties, and identified the 'void' period as the best time to introduce upgrades. This is the period between one customer moving out and another one moving in, where building improvements are often made. The aim was to develop a practical system of intervention that is quick to apply, recognising the pressure on housing officers to re-let properties quickly.

A thin 'super insulation' product (Spacetherm) was identified for the trial (installed in dwelling P1). To test the value of the cost premium, a second property (dwelling P2) has been fitted with Polystud internal wall insulation – a thicker product that achieves the same U-value. Increased loft insulation has also been introduced into these two properties, along with new boilers and a general internal upgrade (typical for currently void YH Ltd properties). A key result from analysing these two properties will be a comparison of the performance (including cost, efficiency and comfort levels) of a system boiler against a combi boiler.

A third property (dwelling P3) has been 'super-insulated' with Spacetherm internal wall insulation, plus loft and floor insulation. It also has an air source heat pump (ASHP), mechanical ventilation with heat recovery (MVHR) and photovoltaic (PV) solar panels. The analysis of this property will help to assess the wall insulation, the heat recovery ventilation system, the running costs of the ASHP (to help review suitability for YH Ltd's off-gas properties) and other potential specification improvements.

3. Occupants

The occupants for all three properties are new occupants after the retrofit of a void property. We have no data on the previous occupants' energy demand or usage.

The new occupants were selected by YH Ltd housing officers to take part in the project. YH Ltd followed their general policy for selection of customers from the waiting list. However, in this case they also considered officers' knowledge of customers, to ensure they would be receptive to the monitoring. Before accepting the properties, YH Ltd briefed the customers on the benefits of being in an energy efficient property, what the monitoring would involve, and what would be required of them during the monitoring period.

Age band	P1 Thorpe	P2 East Ardsley	P3 Lindley
Under 5 years	1	1	
5-16 years			1
17-21 years			
22-50 years	2	1	1
51-65 years			
Over 65 years			
Married couple / partners	Yes	No	No
Couple / partners with children	Yes	No	No
Any disabled persons	No	No	No

4. Dates

Event	Date P1	Date P2	Date P3
Project start date (when was the first proposal discussed or agreed)	1/5/2009	1/5/2009	1/5/2009
Identification of properties	23/6/2010	23/6/2010	23/6/2010
First pre-start meeting	16/7/2010	16/7/2010	16/7/2010
Pre-start meeting with new contractors (STG)	25/10/2010	25/10/2010	25/10/2010
Contract for work let / signed	25/11/2010	25/11/2010	25/11/2010
Occupants moved out (properties were empty when identified)	Unknown	Unknown	Unknown
Start on site (including Spacetherm demo)	6/12/2010	6/12/2010	6/12/2010
Completion of retrofit	25/2/2011	25/2/2011	27/5/2011
Occupants moved in	11/3/2011	11/3/2011	27/5/2011
Monitoring system commissioned and operating properly	7/3/2011	7/3/2011	27/5/2011
Building defects corrected	30/6/2011	30/6/2011	30/6/2011
Building services and controls operating correctly	30/6/2011	30/6/2011	30/6/2011

The original proposed start date on-site was March 2010. However, it took longer than expected to identify three suitable and similar properties. They were identified in June 2010 and a pre-start meeting was held on the 16 July, but the start was subsequently delayed again as the main contractor (ROC) went into administration.

A planning application was required for the PV panel and ASHP at P3. Permission was granted after a review of the noise impact of the ASHP was carried out (an agreement was reached to move the external unit away from the property).

5. Pre-retrofit properties

The three properties were selected because they had the following characteristics in common:

- Solid stone wall construction
- Minimal loft insulation (approximately 100mm would have been installed to exceed the Decent Homes standard)
- Two bedrooms
- Mid terrace
- Two storey
- Double glazing throughout
- Void at time of selection
- The age of the properties is believed to be circa 1920s

Following funding approval from the Technology Strategy Board, YH Ltd sourced the three properties from within their building stock. The properties have been well selected for this comparative study.

As the properties were void, we have no record of energy demand prior to the retrofit. Heat tests were undertaken by YH Ltd prior to retrofit work starting but no firm conclusions could be drawn. People were going into the properties during the tests and they were not undertaken at the same time. The findings from these tests are summarised in Appendix A.

Thermal imaging was undertaken at the properties pre-retrofit. The results are summarised in Appendix C.

6. Design

The principle aim of the study was to assess options for internal wall insulation. A thin 'super insulation' product (Spacetherm) was identified for the trial (installed in dwelling P1). To test the value of the cost premium, a second property (dwelling P2) was fitted with Polystud internal wall insulation – a thicker product which achieves the same U-value. These two properties have also had loft insulation, new boilers and a general internal upgrade that would be typical for the current YH Ltd void process.

A third property (dwelling P3) has been 'super-insulated' with Spacetherm internal wall, loft and floor insulation. P3 also has an air source heat pump and photovoltaic solar panels. This property will assess the wall insulation, plus consider further future improvements that YH Ltd may decide to make.

YH Ltd also wanted to compare the performance of a regular system boiler (with hot water storage) with a combi-boiler. They have struggled to find good quality advice on which system is most appropriate.

The final properties matched the originally proposed design. The only significant exception is insulation added to the underside of floors where there was access from the basement, and lowering of ceilings where it was considered appropriate. These changes resulted from not identifying the properties before the funding application was made. More detail on what was installed is provided in the next section of this report.

SAP calculations performed at the proposal stage (before the properties had been selected) suggested the following performance targets for property P3. They include gains from renewable energy.

- TSB target 17 kg/CO_2m^2 – P3 target 15 kg/CO_2m^2
- TSB Primary energy 115 kWh/m^2/yr – P3 target 100 kWh/m^2/yr
- Space heating requirement 40 kWh/m^2/yr – P3 target 11 kWh/m^2/yr

Equivalent SAP calculations for the final properties showed these levels were not achieved, although significant improvements have been made. The reasons for this are discussed in the summary of the SAP calculation results in Appendix D.

7. Construction

Summary of contract structure
Work for all three properties was procured by Yorkshire Housing Ltd through a tender process. The contract type was a standard JCT.

Strategic Team Group (STG) were appointed as main contractor, with direct labour covering most trades.

Sub-contractors were employed for electrical and mechanical works, plus flooring works. The main contractor had a permanent site agent on the properties to supervise work. Parity Projects were procured directly through Yorkshire Housing Ltd for monitoring software purchase and installation.

Yorkshire Housing Ltd monitored the project through regular site visits.

Specialist equipment suppliers – the air source heat pump was supplied by Worcester Bosch.

Spacetherm installation
This product caused a number of issues in the properties it was installed in (P1 and P3). In P1, plaster was taken off the walls due to a miscommunication from the supplier. It turned out they would have been better attaching the Spacetherm directly to the existing plaster, as the bare brick wall was not flat enough for the insulation board, and the fixings from the manufacturer were not suitable due to the poor quality of the wall. The contractor had to batten out the wall to mount the insulation board, increasing the overall thickness of the wall; removing one of the material's benefits (thickness). One of the project team made an observation that they did not think the construction details for Spacetherm were well engineered. The contractors also found the Spacetherm difficult to work with – dust covers clothing and turns 'slimy' when wet which meant overalls had to be thrown away after use. The contractor was also disappointed in the fixing methods and the onsite training of such from the manufacturer. The photo to the right shows the Spacetherm on battens around a window reveal at P3.

Polystud insulation
This was only installed in property P2, for comparison with the Spacetherm. No major issues were reported with the installation and it was noted that it went in very easily.

In this property, the contractors were able to remove brickwork around the window reveals, allowing them to put 75mm polystud insulation right up to the window. This reduces the cold bridge created by the reveals.

Edge insulation at P1

In property P1 only, the contractor managed to add edge insulation above the ground floor ceiling (shown in the image to the right). 200mm of Rockwool was rolled between the first floor boards to a distance of 600mm from the wall. This is to prevent cold bridging in this space between the floors. It would have been done on other properties but there was a miscommunication. Thermal imaging of the inside and outside of the property will provide insight into the effectiveness of this insulation.

Lowered ceilings

Ceilings were lowered by 450mm to reduce the space heating demand, with an additional 150mm of insulation placed on top of the new ceiling. Ceilings were lowered as the existing ceilings needed replacing. The cheapest solution for these old ceilings with original plaster coving is to install a new MF ceiling. The bonus of this from an energy perspective is that the height is reduced from 9'6", leaving less space to heat. Ceiling constructions therefore consisted of:

- Ceiling plasterboard and battening
- 150mm rockwool insulation
- 300mm air gap / void
- Original ceiling plasterboard and joists
- 300mm rockwool insulation

This should be observed and considered during monitoring.

The effects of basements

Properties P1 and P2 have basements below the living room, which is where the meters are installed. Insulation was added to the ceiling of the basements. New plasterboard ceilings were then installed below the insulation, and sealed. In both properties the door to the basement has been draughtproofed. But there is still a 'cold spot' created by the internal wall to the basement stairs, and the door is not insulated. Also, the basement door does not have a contactor to indicate when it has been opened. This may need to be a consideration of user surveys.

It was discussed that YH Ltd could undertake this work as standard when a property with a cellar becomes void, and that it should be included in the 'Voids Standard'.

Airtightness

Particular attention was paid to airtightness during construction, with all trades informed of the importance. They were asked to seal up all gaps and cracks as they completed their particular works, rather than doing it at the end of the retrofit work, when it may not be possible to seal all leak paths thoroughly. Each property also had posters put up on windows reminding them of this; an example is shown in the photo on the right.

This attention to detail resulted in low levels of air leakage when tested. It was noted that the joiner was particularly useful, looking at sealant integrity around potential leak paths.

Radiators and wiring installed on internal or party walls avoids interaction with insulation, preventing another common leak path.

P1 originally failed the airtightness test, but it was found the reason was that the flue hadn't been sealed. This was corrected and the property passed. The results of the airtightness testing is summarised in Appendix B.

Windows

Windows were not replaced in any of the properties, as they were considered already suitable by YH Ltd. All have double glazed windows, but the U-value is not known. The original proposal was to install A-rated glazing in P3 but YH Ltd could not procure it for the low window reveals. The windows in this property are approximately 6 years old, which would indicate a building regulations U-value of 2.2 W/m^2K.

Monitoring equipment

A number of construction issues were caused by the wiring for monitoring equipment. The spec was changed as additional insulation was fixed between the battened out walls at P3, and another monitor installed at this depth.

There were issues with some wiring installed incorrectly. In some situations it was just chopped out, resulting in the need for complete rewiring. There was some discussion over whose responsibility it is to install the wires – Parity had left instructions and STG had done some of the work with mixed success. The key learning points from this were:

- Ensure instructions are clear
- If work is to be passed onto someone else, ensure that an electrician undertakes the work
- Involve all parties at the design stage to ensure that there is no duplication e.g. in meters

8. Commissioning and occupancy

The following technologies were commissioned:

- Air source heat pump (ASHP) (STG)
- PV panels (Strategic Energy)
- Heating systems (YH Ltd)
- MVHR (STG)
- Monitoring devices and software (Parity Projects)

Air Source Heat Pump

Worcester Bosch attended the handover meeting, and reported that he had noticed a number of errors in the installation of the heat pump, including incorrect wiring. These have been rectified by STG. He also suggested a buffer vessel should have been installed, to allow all radiators to have TRVs. It was agreed that Worcester should have been involved throughout the project to avoid these problems.

It was also noted that, due to the high levels of insulation and air tightness, the heat pump may be oversized. This shouldn't affect its performance but correct sizing would have resulted in a cost saving.

It was noted during the handover that the ASHP 'winter' setting occurs when the external temperature is less than 18°C. A representative of the Technology Strategy Board recommended reducing this to 13°C; a setting more suited to a highly insulated property. After discussion, it was agreed to reduce the setting to 15°C, with a 4 hour delay. This means the unit will only switch to winter setting if the external temperature falls to 15°C for more than 4 hours.

The heating system design was explained to the occupants in simple terms. They were advised to leave the heating on at all times, letting the control system take care of switching the unit on and off. Worcester Bosch are producing some simple guidance for customers that explains the heat pump system.

The planning requirement to move the external unit away from the building meant a trench had to be dug and pipes buried under the back yard. A cross section of the insulated pipe work is shown (right). There is a concern that heat lost in these pipes will affect the system coefficient of performance (COP). The representative from Worcester Bosch stated that he would like temperature sensors placed at each end of the pipe under the yard to measure the amount of heat loss.

Heat pump external unit shown with cover on (Left) and front cover off (Right)

Heat pump internal unit shown in the store cupboard, with cover on (Left) and front cover off (Right)

PV panels

PV generation patterns were explained to the client at handover. The Microgeneration Certification Scheme (MCS) declared a certified capacity of 1.18kW and 1,230kWh per annum.

The installer confirmed that the panels require little maintenance. However, one concern is that the inverters are in the loft and difficult to access. This creates a problem if there is a power cut, as they have to be reset, although following this issue being raised, the contractor installed a more accessible reset facility.

PV panels on the roof and PV invertors in loft space

Heating systems

Each property had a different control system. At P2, the installer was not fully familiar with the electronic control system, therefore the handover to the customer was poor. P1 had a simple clock with 'sliders' to set the time. P3 was different again, but all heating is controlled by the ASHP system, so doesn't require the customer to set times. It is felt that a more standardised heating control system would improve confidence in demonstration. However, it was noted that 'self-training controllers' will become the norm as the technology develops.

MVHR (mechanical ventilation heat recovery)

This equipment also suffered from access issues. It was also installed in the loft, with ductwork running to the bathroom and kitchen, and the supply air into the landing space. However, it did not have an accessible boost switch, and it was not clear how the 'summer bypass' setting worked. Following a visit by TSB to the property, the supplier clarified that the summer bypass works automatically, controlled by sensors within the unit. An accessible booster switch has also been installed.

An inspection of the loft by TSB and Camco found ductwork in the loft was not insulated. This is needed to avoid condensation, particularly on the cold supply from outside. This has also been corrected since the TSB visit. The photo to the right shows the unit in the loft space, with un-insulated ductwork.

Metering

A faulty pyranometer amplifier was noted at P3, which is understood to have now been fixed. Extra metering was recommended for the heat pump, which is being considered by TSB. General issues with design and installation coordination were encountered between the main contractor and the metering installer. This specialist equipment will need more guidance and forethought for future applications, if used.

Typical metering layout. The parity equipment is in the white box, shown open on the right

Handover and Training

All three properties were handed over effectively to the customers. For P3, YH Ltd produced an agenda for the handover, giving each person the necessary time to speak to the customer. However, it is appreciated that there is a lot to take in for the customers, especially during a stressful home move. The Environmental Performance Coordinator and Neighbourhood Officer (both from YH Ltd) went back to the properties two weeks after handover, to check that customers knew how all things worked and to give advice if not being used as it should. This proved very useful as customers were free to ask any questions and resolve queries. This explanation and repeat visit is considered essential to ensure customer understanding.

The Environmental Performance Coordinator at YH Ltd will make contact with the customers every two months, including at least two annual visits. She will also be arranging a meeting with the Technology Strategy Board for building user survey visits.

Literature provided by manufactures was generally not considered sufficient or suitable for customer use. Yorkshire Housing intends to look at writing up customer friendly advice on installations, which would not only serve these but all the housing stock where appropriate.

Early feedback

Customers at P1 have complained that there is ‘no air’. They are not using heating because it becomes too warm but they also don’t want to open the windows as it becomes too cold at night. YH Ltd are following up on this.

Thermal imaging is planned for October/November, when the weather is cold enough to give good readings.

9. Costs

Design stage budget

The following table was submitted with the original “Retrofit for the Future” application

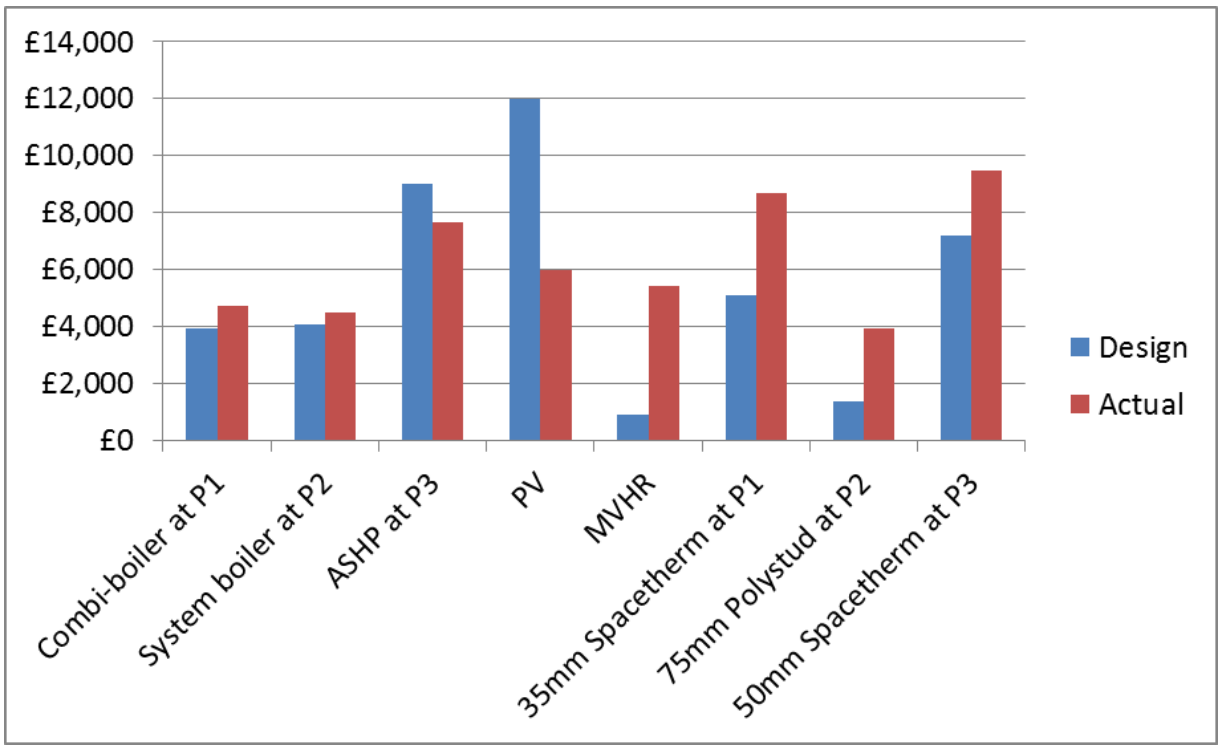
Measures	**P1**	**P2**	**P3**
Dry lining system including all associated works	12,026	12,026	12,026
Internal wall insulation - 50mm Spacetherm	0	0	7,176
Internal wall insulation - 35mm Spacetherm	5,082	0	0
Internal wall insulation - 75mm Polystud	0	1,380	0
HE Combi boiler: Ideal logic combi boiler (91.1% eff)) with 6 radiators	3,946	0	0
System boiler: Ideal Ikos System boiler with a Y plan and unvented cylinder 91.1% efficiency	0	4,066	0
Worcester Bosch ASHP with 6 radiators	0	0	9,000
PV array 2kW	0	0	12,000
Loft insulation	250	250	250
Air tightness	1,500	1,500	1,500
Floor insulation - 5mm spacetherm	0	0	2,450
Replacement windows and doors – A rated	0	0	3,140
Ventilation fan with heat recovery in kitchen and bathroom.	0	0	900
ADDITIONAL MEASURES	0	0	0
Remote monitoring & analysis	5,971	5,971	7,011
A rated energy efficient appliances	500	500	500
Low energy light bulbs	15	15	15
Behaviour change & RTD - real time displayer	350	350	350
Air pressure test per property	free	free	free
Close open fireplace and flue	1,000	1,000	1,000
Camco			17,625
Yorkshire Housing Ltd			5,000
TOTAL			**137,641**

Final costs

The following table was provided by the project QS (Quantity Surveyor) following completion of the three properties.

	P1 Thorpe	P2 East Ardsley	P3 Lindley
0. Prelims	8,850.00	7,594.00	10,154.00
1. Fabric			
2. Services (Conventional)	3,445.00	3,295.00	3,333.00
3. Low/ Zero carbon technologies			20,484.87
4. Other			
4a. Kitchen installation	2,158.80	1,691.85	1,783.50
4b. Bathroom installation	1,095.00	1,095.00	770.00
4c. Floor finishes	1,396.00	1,130.00	3,732.80
4d. Wall finishes	12,220.00	6,751.95	15,223.40
4e. Ceiling finishes	1,011.00	1,050.00	2,806.00
4f. Doors	2,625.00	1,350.00	2,490.00
4g. Parity sensors	692.22	692.22	692.22
5. Consequential Costs	7,878.68	10,545.20	8,481.99
Total	**41,371.70**	**35,195.22**	**69,951.78**

Following further scrutiny of costs with the QS, we were able to identify costs of the main study items, shown compared to design stage estimates in the chart below. The chart also shows the comparative costs of boilers compared to the ASHP and the comparative cost of Polystud and Spacetherm. Also noticeable is the high cost of the MVHR. The saving on the PV is due to a smaller system being installed than originally planned due to the smaller roof area.



Design vs Actual cost comparison for main technologies studied

9. Wash-up meeting

A wash-up meeting was held on 27 May 2011 at Parkside House, Huddersfield. The meeting was held the same day the final property (P3) was handed over. Both the design and construction teams attended. A representative of the Technology Strategy Board was also able to attend.

The minutes of this meeting are included in Appendix E.

10. Doing it again

YH Ltd's intention for the study was to inform a programme for the rest of their solid wall properties (approximately 1,800) and off-gas grid properties (approximately 800). They want to insulate solid wall properties while they are tenanted – a key consideration as Spacetherm is unsuitable if tenanted.

Internal wall insulation – Spacetherm vs Polystud
The clear outcome from the construction phase of this work is that the Polystud is the preferable product for YH Ltd. Spacetherm's main advantage is its thickness, but in the majority of cases it is felt that this does not outweigh the additional cost and installation difficulties.

YH Ltd plan to install Spacetherm in certain situations, for example in very small rooms where a reduction in space may make it difficult to install a kitchen unit. They will be better prepared for the installation issues having encountered them on this project. Spacetherm is also only suitable for void properties; dust created during installation would create health issues for an occupied property.
The Polystud insulation was fairly traditional and easy to use. Spacetherm, on the other hand, was found to be a 'messy' product. There were also issues with fixing Spacetherm to bare walls. At P3 the external walls were battened out. At P1 it was fixed directly to plaster where possible. Spacetherm also incurred a long lead time due to high demand, and the contractors didn't feel the manufactured board was a well-engineered product (i.e. layers poorly aligned). Training and advice from the company Was felt to be poor.

On a positive note, it was found that finishing trades had no problems fixing to newly insulated walls. This was originally a concern but Spacetherm has a plywood layer between it and the plasterboard. Similarly, Polystud has studding that can be fixed to.

Some existing window reveals had been previously 'padded-out' when sash windows were replaced with double glazing. Removing this padding allowed insulation to be installed right up to the reveal, without compromising the existing reveal. This is a useful feature that will exist on a lot of properties.

YH Ltd now intend to install Polystud as standard whenever kitchens or bathrooms are replaced. They also intend to use it on future void refurbishments.

Combi vs system boiler
This is highlighted here as it is a key part of the study for YH Ltd. We will not be able to make comparisons until we have completed the monitoring period.

Air source heat pump (ASHP)
YH Ltd have already retrofitted ASHPs in nine properties and installed ASHPs in thirty one new-build properties. This study is the first time they are assessing the cost of operation to such a detailed level. The technology is proving appropriate so far but planning issues are a barrier that will make other ASHPs less likely to be installed; there isn't time to deal with each application. Interestingly, YH Ltd are mainly looking at off-gas grid properties, where noise is more of an issue (off–gas grid properties tend to be rural with low levels of background noise). However, the alternative is often an oil fired back boiler, which can be noisier than an ASHP but does not require planning permission.
Worcester Bosch got involved after installation but should have been contacted earlier. This could have avoided minor installation issues, and perhaps provided a cost saving as the ASHP may be oversized for a well-insulated property.

Mechanical Ventilation Heat Recovery
YH Ltd didn't originally want to install this but felt they should to increase the chances of funding. It is still unclear if the technology is appropriate for this type of property.

Operation of the system was clearly not fully understood, demonstrated by a lack of access to controls. Windows were not replaced and already had trickle vents in them, but YH Ltd would still have installed trickle vents if replaced. One reason for this is that if a customer has a pre-payment meter, electricity can often switch off for the whole property, meaning no ventilation in an area where customers would be unwilling to leave windows open. The unit is also very large, so takes up a lot of space.

Our study is looking at three airtight properties. P1 and P2 have mechanical extract fans in the kitchen and bathroom, controlled by humidistats. It will be useful to see how the two systems perform, noting the nuisance effect of humidistat sensors, which often switch on fans during the night.

Unless this study proves the benefits more conclusively, it is unlikely MVHR will be used for retrofits. Especially considering the cost premium incurred for the MVHR system.

Photovoltaic panels
This technology was also added to the application in the hope that it would increase the chances of receiving funding. It will be monitored to see if TSB can find value, and they are looking at a more expansive PV programme of 300 installations at off-gas properties. But, at this stage it is unlikely PV will become part of YH Ltd's standard fit out works due to the capital cost.

The only problem encountered is the location of the DC cable from the Solar PV and the controls/action required if a power cut occurs. This originally meant going into the loft space to reset the inverters, but the issue has now been corrected with a reset switch installed within the main dwelling.

General

A noticeable success was the policy of installing wiring and radiators on internal or party walls to maintain the integrity of insulation. It was agreed that this reduced communication issues enormously. However, overall it is felt that coordination of trades needs to be better on these complex projects.

YH Ltd also noted that they didn't feel the contractors knew enough about the technologies being installed, and this was evidenced by small issues with the installation of the ASHP and MVHR systems. For future projects, YH Ltd Project Officers will need to have greater understanding of the technologies, so they can question the contractor and ensure they have understood the instructions. It was also advised that manufacturers are contacted for additional specific advice before installation.

In future, YH Ltd will provide more information to site operatives about the need for airtight construction and coordination of trades.

11. Business benefits

The work has crystallised YH Ltd's thinking on internal wall insulation options, and they are now making it part of standard kitchen and bathroom fit outs.

It is hoped that as a result of this study, YH Ltd will have physical evidence to show customers the cost of running an ASHP. They can then sell the case for switching with more conviction, as many customers have questioned the technology and haven't wanted to change from oil or coal fired heating. They also hope to have evidence to support selecting combi or system boilers.

With MVHR, we have learnt that there are a number of issues to consider when deciding on which system to use. At P3 the unit is installed in the loft, which creates a maintenance premium. A more accessible unit would be preferred. It was also found that the ducting is difficult to install in a retrofit property. YH Ltd will still use MVHR on new properties, but it is not considered appropriate at this stage for refurbishment.

When dealing with specialist contractors and areas that aren't fully understood, it is important to spend more time ensuring a clear specification. For some aspects of the project there was no formal specification of work, which lead to cost overrun and occasional extra costs.

Parity Projects were overly confident in the contractors' ability to install the wiring for meters and sensors. They felt they only needed to provide basic instructions, which caused several problems and resulted in them spending more time on site than planned.

Appendix A – Heating tests

In order to have an understanding of how much impact the refurbishment work has on heating costs for customers, we undertook monitoring of the heating at all three properties both before the work was undertaken and after work was carried out (but before customers moved in).

Methodology

Heating patterns used

Two heating patterns were monitored:

- 7am-9am and 4pm-11pm (the pattern used for research undertaken by the Energy Saving Trust)
- 7am-11pm (the heating pattern we believe is used by many YH customers, e.g. the elderly, customers with young children etc. who are at home all day).

Each pattern was monitored for 7 days. The thermostats were set to 21°C, and hot water not turned on. All trickle vents were closed. Access to the properties was minimised as much as possible during the monitoring periods.

Temperature monitoring with Tiny Tags

During the monitoring periods, temperature in the hall, living room, bed room and outside each property was measured at 30 minute intervals using Tiny Tags.

Images were taken using the thermal imaging camera at all three properties during the monitoring periods. These images can be seen in a separate report.

Heating systems in properties

	Original boiler	**New boiler**
P3	Combi boiler – Vokera Option	Worcester Bosch ASHP
P2	Gas back boiler - Baxi Bermuda	System boiler - Ideal
P1	Combi boiler – Vokera Maxin	Combi boiler - Ideal

Results

	Period	Average external temp °C	Units used	Cost (based on British gas standard tariff)	Heating pattern	Boiler
P3	18.10.10 - 25.10.10	7.4	445.75	£16.37	7-9, 4-11	Old boiler, before works
	25.10.10 - 1.11.10	9.6	445.76	£16.37	7am - 11pm	Old boiler, before works
P2	18.10.10 - 25.10.10	8.5	434.80	£16.01	7-9, 4-11	Old boiler, before works
	25.10.10 - 1.11.10	10.7	445.76	£16.37	7am - 11pm	Old boiler, before works
	10.11.10 - 17.11.10	6.2	579.49	£20.69	7-9, 4-11	New boiler, before works
	24.2.11 – 3.3.11	8.3	457.1	£16.73	7am - 11pm	New boiler, after works
	3.3.11 – 11.3.11	6.5	457.2	£16.74	7-9, 4-11	New boiler, after works
P1	10.11.10 - 17.11.10	6.8	846.94	£29.34	7am - 11pm	Old boiler, before works
	24.2.11 – 3.3.11	7.5	256.45	£10.25	7am - 11pm	New boiler, after works
	3.3.11 – 11.3.11	5.0	423.68	£15.65	7-9, 4-11	New boiler, after works

Main points to note:

- The cost to heat the properties is very dependent on external temperature, so it is difficult to compare usage at different times as the external temperature differs which affects the gas consumption.
- Although the thermostats in each property had been set to 21°C they cannot have been as accurate as we thought as the Tiny Tags recorded different temperatures in all three properties (24 - 25°C in P1, 21°C in P3 and 20°C in P2).
- These two factors make it very difficult to compare the results of different properties and also make it difficult to compare different heating patterns at the same property, unless the weather has been very similar. It also makes it difficult to compare heating patterns at the same property before and after works (e.g. at P1 before works it seems that the heating costs were very high, but this was actually because the property was being heated up to 24 - 25°C as compared to 21°C after works).

Difficulties encountered and lessons learnt

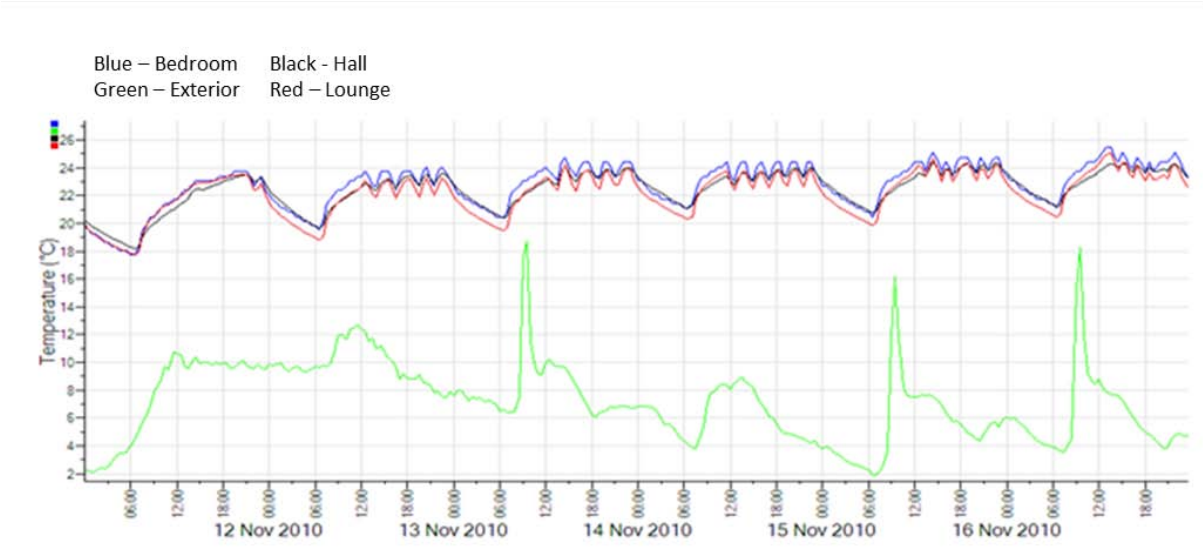
- The boiler thermostats were not as accurate as we had hoped, and we didn't realise the necessity to calibrate them. As such, the Tiny Tags in P1 recorded temperatures

of between 24 - 25°C, whereas at P3 the lounge temperature was raised to 21°C and at P2 the lounge temperature was raised to 20°C.

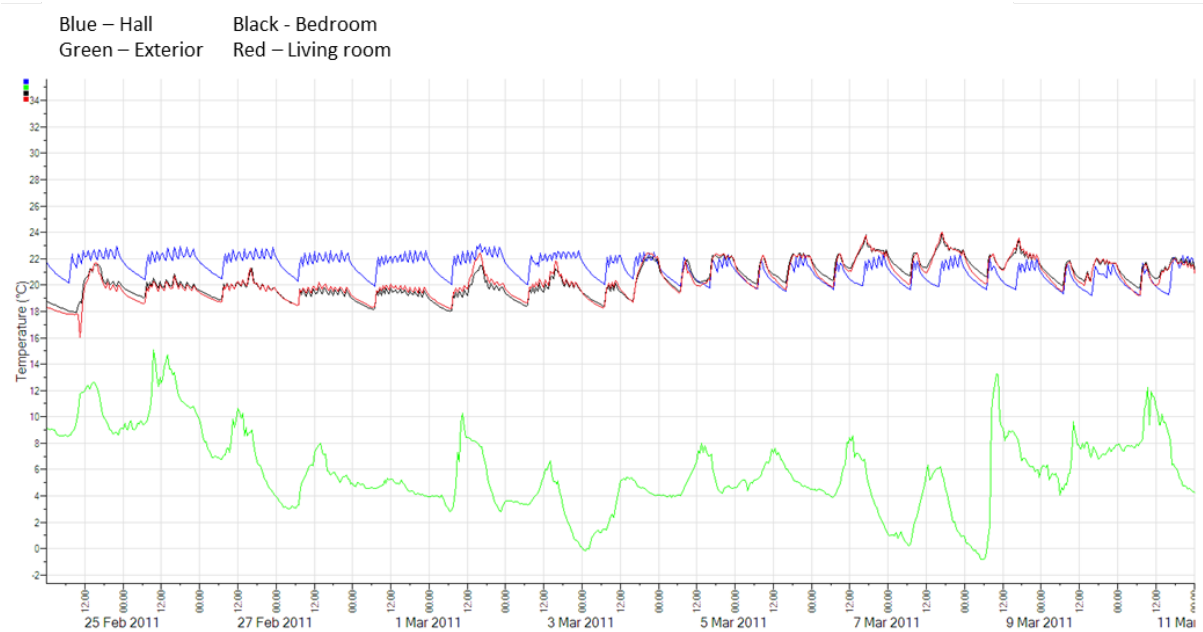
- Weather – poor weather meant that one visit to read meters could not be undertaken.
- The thermostat at P1 was altered by contractors to a higher temperature.
- Best results would have been obtained by monitoring each property on the same heating pattern at the same time. This would have enabled direct comparison between each property. This was not possible for a number of reasons.
- Tiny Tags proved a useful monitoring tool, but one point to note is that when positioning them care must be taken to ensure that other direct sources of heat do not interfere with the results. As such, they should not be positioned:
    - Near/above radiators;
    - In direct sunlight if placed outside;
    - Near things dark in colour, e.g. black drain pipes if placed outside.

Tiny Tag Results

P1 10.11.10 - 17.11.10 (7am-11pm)



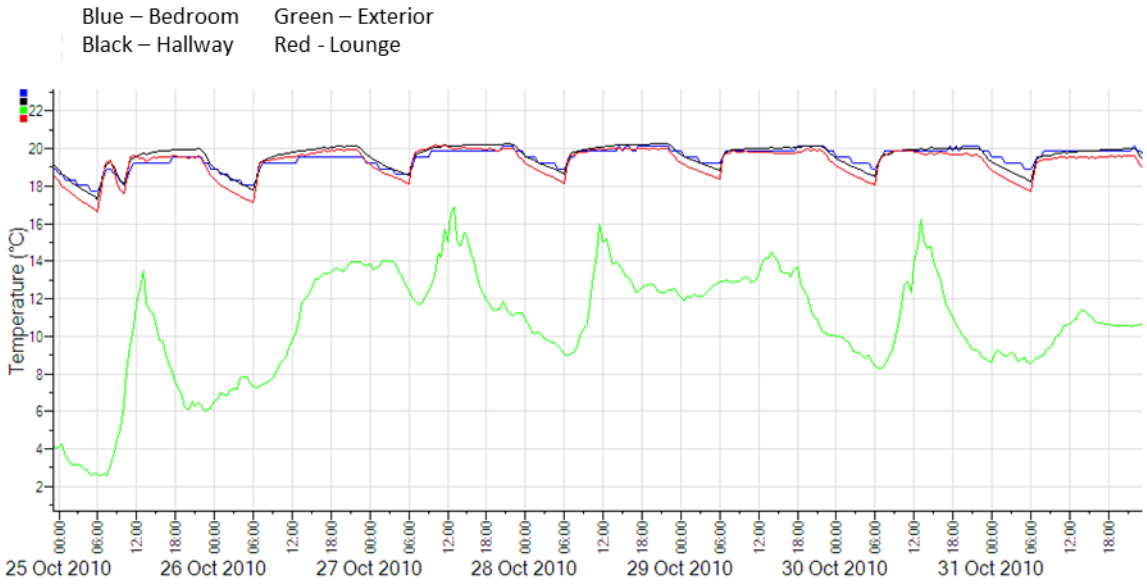
P1 24.2.11 – 3.3.11 (7am-11pm)
3.3.11 - 11.3.11 (7am – 9am and 4pm – 11pm)



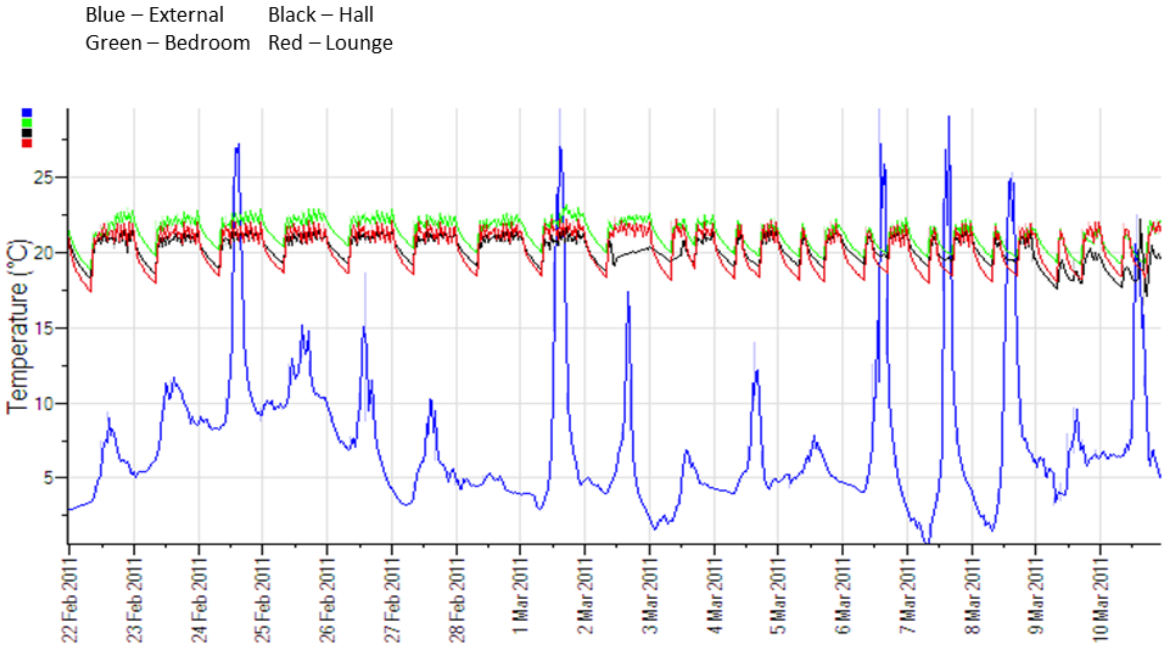
Points to note:

- In pre-works results, it is clear that thermostat was incorrectly calibrated, as the temperature was recorded at 23-24°C when the thermostat was set to 21°C.

P2 **25.10.10 – 1.11.10 (7am-11pm)**

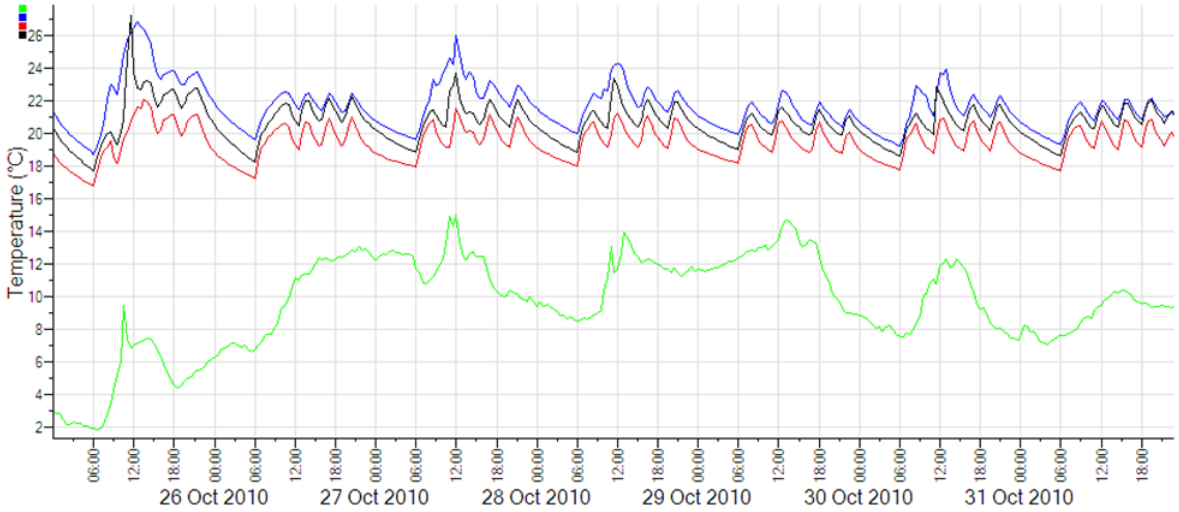


P2 **24.2.11 – 3.3.11 (7am-11pm)**
3.3.11 - 11.3.11 (7am – 9am and 4pm – 11pm)



P3 **25.10.10 – 1.11.10 (7am-11pm)**

Green – External Red – Lounge
Blue – Bedroom Black - Hallway



Appendix B – Airtightness testing

The three properties which have been renovated as part of the Technology Strategy Board were air pressure tested in February and March 2011, following completion of the renovation works.

What is air pressure testing?
Air pressure testing (also known as air tightness testing) is the procedure to trace unwanted draughts and uncontrolled air leakage through a building. Too much air leakage results in heat loss and higher CO_2 emissions. Older homes tend to be more airtight than modern homes, perhaps because of the less precise nature of modern workmanship and materials assembly.

Part L of the 2006 building regulations requires the air tightness of buildings to be measured.

- The Building Regulations 2006 standard is $10m^3/hr/m^2$
- Energy Saving Trust 'good practice' is $5m^3/hr/m^2$
- Energy Saving Trust 'best practice' is $3m^3/hr/m^2$
- AECB, the Sustainable Building Association, Gold Standard is $0.75m^{3/}h/m^2$

- **Process**
  All external doors and windows were closed, and internal doors opened. The front door opening was sealed and a fan was installed:

- All controlled sources of ventilation, e.g. extractor fans and trickle vents were sealed.
- The building was then 'depressurised' and the monitoring equipment measured the building's air tightness. At this stage, because the pressure inside the building is lower than that on the outside, any sources of draughts are more apparent and it is possible to feel even slight draughts, as air pours back in.

What work was carried out to improve air tightness?
During the renovation of all three properties, care and attention was taken to improve their air tightness, above and beyond what we might have undertaken on a more conventional renovation project. This included:

- Engaging all trades to ensure that all gaps, holes etc. were sealed as work progressed (e.g. carefully sealing gaps around waste and heating pipes)
- Sealing gaps around windows and doors
- Sealing gaps between skirting boards and floors
- Installing draught excluder strips around cellar doors
- Removing any sources of 'uncontrolled' air leakage where possible, such as air bricks

Results

	Before works (September 2010)	After works (February/March 2011)
P2	6.65 $m^3/hr/m^2$	3.20 $m^3/hr/m^2$
P1	6.47 $m^3/hr/m^2$	3.29 $m^3/hr/m^2$
P3	14.97 $m^3/hr/m^2$	6.44 $m^3/hr/m^2$

<u>P2</u>
Before works commenced, the air tightness of this property was measured at **6.65$m^3/hr/m^2$**. This is well within current building regulations, however sources of air leakage were found, mainly from the cellar through the timber floor (which actually lifted the carpet during the initial air pressure testing!) and a small amount of leakage through gaps under window cills, etc.

After completion of works, the air tightness was measured at **3.20$m^3/hr/m^2$**, which was a good result.

<u>P1</u>
Before works commenced, the air tightness of this property was measured at **6.47$m^3/hr/m^2$**. This is well within current building regulations, however sources of air leakage were found.

After completion of works, the air tightness was measured at **4.43$m^3/hr/m^2$**. Significant draughts were found behind the new electric fire suite (the chimney had not been fully sealed), through a channel made near the front door to house a sensor which had not been fully filled and through the smoke detector at the top of the stairs. These issues were dealt with and the test repeated a fortnight later, when the air tightness was measured at **3.29 $m^3/hr/m^2$**.

<u>P3</u>
Before works commenced, the air tightness of this property was measured at **14.97$m^3/hr/m^2$**. This was by far the least air tight property initially, with the main sources of air leakage being through the floor in the living room (from the large vent on the adjoining

pavement), through two large air bricks in the kitchen wall and through gaps around waste pipes through the kitchen wall.

After completion of works, the air tightness was measured at **6.44 m^3/hr/m^2**. This was a disappointing result, as we had been advised to aim for 3m^3/hr/m^2 to ensure the efficient running of the Air Source Heat Pump heating system. Draughts could still be felt as the test was ongoing, mainly around the bath panel, through trickle vents and in the cupboard built to house the internal Air Source Heat Pump unit. Pipes exiting the kitchen wall to serve the Air Source Heat Pump were also poorly sealed. These issues have been resolved. It was noted that although it is easy to locate draughts during air pressure testing, it is much more difficult to locate the source of the air leakage, as it can follow a complex path through the building. For example, it was noted the draught around the bath panel could be a result of air being drawn from the loft through gaps between the stone wall and insulation or of poorly sealed waste pipes on the external wall.

Learning Points

- It is important to engage all trades to ensure that each person working onsite is clear on the role they have to play in terms of achieving an air tight building.
- When undertaking full renovations of properties, we should carry out air tightness testing as a matter of course, as it can highlight air leakage which would not otherwise be apparent. Specifying that a post-refurbishment test will be carried out will ensure greater attention to detail during the refurbishment.
- Pipes should be sealed on inside and outside of the external wall, to ensure any air movement vertically through the wall itself is prevented.
- Ensure that the learning from this exercise is passed onto all YH Investment and Homeworks staff so that lessons learnt can be applied to all work in our properties, e.g. whilst installing new heating systems, new kitchens/bathrooms, new insulation measures, etc.

Appendix C – Thermal imaging

Introduction

Before and after renovation work was undertaken, thermal images ('thermographs') were taken both internally and externally at all three TSB properties. The aim of taking the thermographs was to be able to show an improvement in the thermal efficiency of the building following completion of the works.

Method

- Images were taken whilst heating was on in the properties (at the same time as undertaking the heating monitoring).
- Images were taken during November 2010 and February and March 2011 when it was hoped that external temperatures would be suitably cold enough to give good results.
- Similar images were taken before and after works to enable direct comparison.

Problems encountered

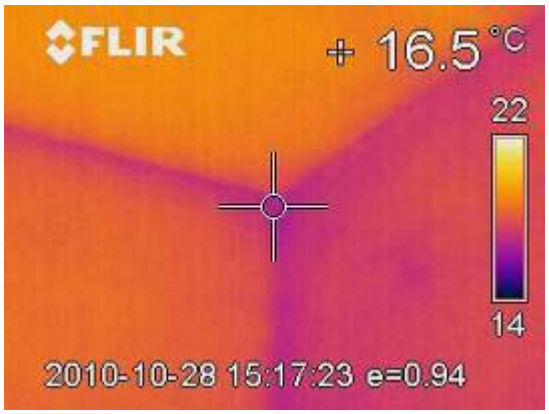
The images had to be taken whilst the heating monitoring was taking place to ensure that the heating was on. Unfortunately the weather was unseasonably warm and sunny on occasions meaning that the thermographs were not as good as they could have been, especially those taken outside as on sunny days, the sun warmed the external stone work and pipe work skewing results.

Results

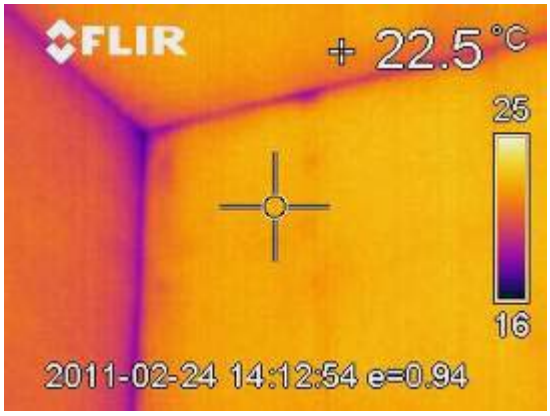
Thermal bridging

<u>P2 – Thermal bridging through external walls</u>

These images show a reduction in thermal bridging through external walls when insulation was installed:



In this image (pre-works) the external wall on the right hand side is cooler at 17.5°C than the party wall at 18.6°C.



In this image (post-works) the external wall on the right hand side is warmer at 23°C than the party wall at 21.3°C.

P1 – Thermal bridging through external walls in bedroom 2

These images show a reduction in thermal bridging through external walls was insulation was installed:

In this image (pre-works) the external wall on the right hand side is cooler at 18°C than the party wall at 20°C.

In this image (post-works) the external and party walls are both the same temperature at 19°C. Some thermal bridging of the insulation on the external wall is apparent, although this is very minimal.

P2 – Thermal bridging around windows

These images show a reduction in thermal bridging around windows:

In this image (pre-works) thermal bridging is extending across the whole depth of the window reveal.

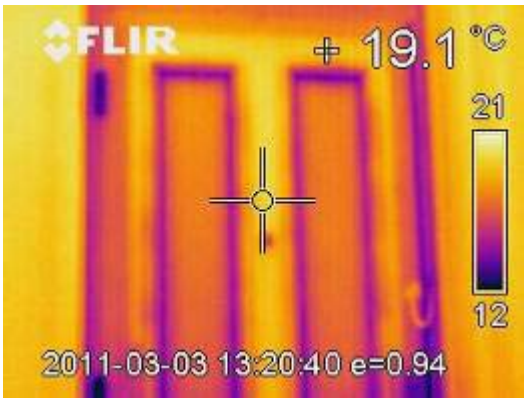
In this image (post-works) thermal bridging is confined to a small area of the window reveal around the corner.

P2 – Heat loss around front door

This image (pre-works) shows heat loss around the front door, particularly underneath.

P1 – Heat loss through front door

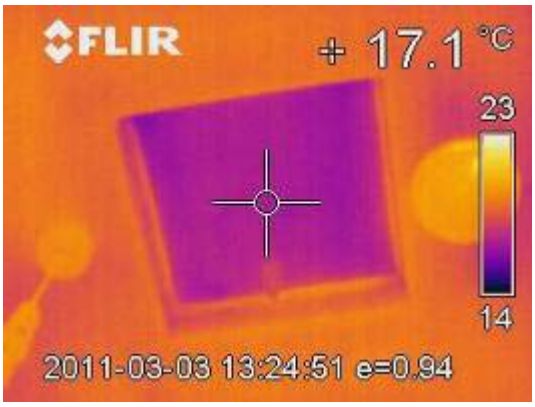
This image (pre-works) shows heat loss through glass on the composite front door. The right hand side double glazed unit was damaged, resulting in the temperature of this being 13.5°C. The temperature of the left hand side double glazed unit is 17.5°C.



This image (post works) shows heat loss through the new composite door. The temperature of the glass is 17.8 and the body of the door is 19.7, similar to that of the surrounding wall.

Heat loss post-works

P1 – Heat loss through loft hatch



This image (post works) shows that heat is still being lost through the loft hatch, even though it has been insulated. The temperature of the hatch is 17.3°C, surrounding ceiling is 19.5°C.

P2 - Thermal bridging between sheets of insulation

The wall on the left hand side is the insulated external wall, which is at 21.7°C. The darker sections between the sheets of insulation are cooler, at 19°C. The party wall is also cooler at 19°C and the corner is cooler still at 17°C due to cold bridging.

Future use of thermal imaging pictures

- When Yorkshire Housing is considering retrofitting insulation, then taking thermographs before work commences would be useful as it would highlight where heat is currently being lost.
- Taking thermographs upon completion of internal solid wall insulation does highlight where work has been successful or unsuccessful. However in most cases by the time work has been completed it is too late to go back to make any changes which the thermograph may highlight. What we could choose to do is to take thermographs once the insulation has been installed but before the property is plastered, to enable any remedial work to be carried out.
- In addition to using thermal imaging pictures when installing solid wall insulation, they can prove useful when checking:
    - the installation of loft insulation
    - for potential gaps around windows and doors
    - for thermal bridging
    - for damp and condensation

Appendix D – SAP Calculations

We completed SAP calculations for the three properties both pre and post retrofit.

With these figures, we have been able to compare P3 to the targets set out at bid stage.

Unfortunately, the post-retrofit SAP calculations reveal that we do not meet the original target. To understand why, we re-ran the SAP calculation for P3 post-retrofit, with changes to meet the original design intent. Basically the floor, windows and door U-values 'as-installed' are not what was proposed. This made quite a big difference, as shown in the table below.

We then made a second change, to look at the impact of under-floor heating (UFH). This makes a big difference, as SAP 2005 assumes the COP of an air source heat pump is 1.75 with radiators, but 2.5 with UFH. (This is the way SAP works – there is limited evidence to show this is the case, and the new SAP calculation for Part L 2010 assesses heat pumps more accurately). In this scenario we get very close to the carbon target.

	Target in application	**Post-retrofit calcs for P3**	**Design intent U-values**	**Design intent plus UFH**
Space heating demand ($kWh/m^2/yr$)	41	100	80	60
Whole house primary energy demand ($kWh/m^2/yr$)	100	140	120	100
Overall carbon target($kgCO_2/m^2/yr$)	15	21	19	16

The other main difference from bid stage is the addition of an electric fireplace in the living room. This is assumed to be a secondary heating source providing 10% of the dwelling heat demand.

It is worth re-iterating that SAP is a standardised assessment, and the assumptions it makes may not be reflected in real life. While we have not met the target, the dwellings all perform well, making a significant improvement from pre-retrofit. In my opinion, the three properties are on course to provide some very useful results, and the programme is going well. I have no doubt that TSB share this view.

P1

	Before	After
Assumptions	**Value**	**Value**
Year built	1920	1920
Terrain	Low Rise U/S	Low Rise U/S
Ground Floor Storey Height	2.72 m	2.72 m
Top Floor Storey Height	2.75 m	2.75 m
Living Room Floor Type/Construction	Floor above unheated basement/solid upper floor	Floor above unheated basement/solid upper floor
Living Room Floor Area	14 m2	14 m2
Living Room Floor U-value	2.573 W/m2K	0.306 W/m2K
Kitchen & Stairs Floor Type/Construction	Ground/solid ground floor	Ground/solid ground floor
Kitchen & Stairs Floor Area	22 m2	22 m2
Kitchen & Stairs Floor U-value	0.75 W/m2K	0.75 W/m2K
Total floor area	36 m2	36 m2
Front Ext wall area	23.6 m2	23.6 m2
Rear Ext wall area	23.4 m2	23.4 m2
Ext wall U-values	3.378 W/m2K	0.344 W/m2K
Roof U-value	2.443 W/m2K	0.157 W/m2K
Number of windows	5	5
U-value windows	2.2 W/m2K	2.2 W/m2K
Number of doors	2	2
U-value doors	1.3 W/m2K	1.3 W/m2K
Design air permeability rate	6.47 m3/hm2 (@50Pa)	3.29 m3/hm2 (@50Pa)
Mechanical ventilation product	Decentralised whole house extract (SAP default)	Ferrob Infinity 100
Boiler type	SAP default	Brand: Ideal Boilers Model Name: Logic Systems Model Qualifier: 30

SAP results summary	P1	
	Before	After
Heat loss parameter (38)	4.61	1.52
Space heating requirement (81)	15765.15	3822.68
Space heating main fuel (85)	23184.04	3995.83
Space heating secondary fuel (85a)	0	382.27
Energy for water heating (86a)	4435.89	3503.37
Elec for pumps and fans (87)	610.48	318.66
PV generation (95a)	0	0
SAP rating (100)	44	78
Total CO2 kg/year (112)	5771	1905.75
Total CO2 kg/m2/year (113)	80.15	26.47

P2

	Before	After
Assumption	**Value**	**Value**
Year built	1920	1920
Terrain	Low Rise U/S	Low Rise U/S
Ground Floor Storey Height	2.88 m	2.88 m
Top Floor Storey Height	2.89 m	2.89 m
Living Room Floor Type/Construction	Floor above unheated basement/solid upper floor	Floor above unheated basement/solid upper floor
Living Room Floor Area	19 m2	19 m2
Living Room Floor U-value	2.573 W/m2K	0.306 W/m2K
Kitchen & Stairs Floor Type/Construction	Ground/solid ground floor	Ground/solid ground floor
Kitchen & Stairs Floor Area	18.4 m2	18.4 m2
Kitchen & Stairs Floor U-value	0.75 W/m2K	0.75 W/m2K
Total floor area	37.4 m2	37.4 m2
Front Ext wall area	25.2 m2	25.2 m2
Rear Ext wall area	25.1 m2	25.1 m2
Ext wall U-values	3.378 W/m2K	0.408 W/m2K
Roof U-value	2.443 W/m2K	0.157 W/m2K
Number of windows	5	5
U-value windows	2.2 W/m2K	2.2 W/m2K
Number of doors	2	2
U-value doors	1.3 W/m2K	1.3 W/m2K
Design air permeability rate	6.65 m3/hm2 (@50Pa)	3.2 m3/hm2 (@50Pa)
Mechanical ventilation product	Decentralised whole house extract (SAP default)	Ferrob Infinity 100
Boiler type	SAP default	Brand: Ideal Boilers Model Name: Logic

		Combi Model Qualifier: 30

SAP results summary	P2	
	Before	After
Heat loss parameter (38)	4.82	1.56
Space heating requirement (81)	17195.44	4410.65
Space heating main fuel (85)	25287.41	4610.43
Space heating secondary fuel (85a)	0	441.06
Energy for water heating (86a)	4502.93	3127.56
Elec for pumps and fans (87)	657.25	371.65
PV generation (95a)	0	0
SAP rating (100)	42	77
Total CO2 kg/year (112)	6218.83	2006.28
Total CO2 kg/m2/year (113)	83.03	26.79

P3

	Before	After	Design intent	Design intent + underfloor heating
Assumption	**Value**	**Value**	**Value**	**Value**
Year built	1920	1920	1920	1920
Terrain	Low Rise U/S	Low Rise U/S	Low Rise U/S	Low Rise U/S
Ground Floor Storey Height	2.42 m	2.42 m	2.42 m	2.42 m
Top Floor Storey Height	2.31 m	2.31 m	2.31 m	2.31 m
Ground Floor Construction	Solid ground floor	Solid ground floor	Solid ground floor	Solid ground floor
Floor Area	40m2	40m2	40m2	40m2
Floor U-value	0.75 W/m2K	0.481 W/m2K	0.4 W/m2K	0.4 W/m2K
Front Ext wall area	23 m2	23 m2	23 m2	23 m2
Rear Ext wall area	18.6 m2	18.6 m2	18.6 m2	18.6 m2
Ext wall U-values	3.378 W/m2K	0.248 W/m2K	0.248 W/m2K	0.248 W/m2K
Roof U-value	2.443 W/m2K	0.106 W/m2K	0.106 W/m2K	0.106 W/m2K
Number of windows	6	6	6	6
U-value windows	2.2 W/m2K	2.2 W/m2K	1.3 W/m2K	1.3 W/m2K
Number of doors	2	2	2	2
U-value doors	1.3 W/m2K	1.3 W/m2K	1 W/m2K	1 W/m2K
Design air permeability rate	14.97 m3/hm2 (@50Pa)	6.44 m3/hm2 (@50Pa)	6.44 m3/hm2 (@50Pa)	6.44 m3/hm2 (@50Pa)
Mechanical ventilation product	Decentralised whole house extract (SAP default)	Itho HRU ECO 4	Itho HRU ECO 4	Itho HRU ECO 4
Heating System	Boiler (SAP default)	Air source heat pump	Air source heat pump	Air source heat pump
Heating emitter	Radiators	Radiators	Radiators	Underfloor (screed)

SAP results summary	P3	
	Before	After
Heat loss parameter (38)	4.02	1.17
Space heating requirement (81)	15387.54	2853.53
Space heating main fuel (85)	22628.74	1467.53
Space heating secondary fuel (85a)	0	285.35
Energy for water heating (86a)	4619.61	1795.05
Elec for pumps and fans (87)	591.65	273.06
PV generation (95a)	0	1667.2
SAP rating (100)	48	84
Total CO2 kg/year (112)	5707.44	837.07
Total CO2 kg/m2/year (113)	71.34	10.46

Appendix E – Wash-up meeting minutes

YORKSHIRE HOUSING

Minutes of the Retrofit for the Future Wash – up Meeting held on 27th May 2011 at Parkside House Huddersfield

Present: PH - YH Ltd, GH - YH Ltd, HA - YH Ltd, LC - YH Ltd, PS - YH Ltd, DH - YH Ltd, AD - Parity Projects, LB - STG, JT - Camco, PR - TSB, SG - Worcester Bosch

Apologies: AW

Minutes taken by HA and DH

Item No.		Action	Timing
1.0	JT proposed the agenda and PH chaired the meeting		
	Introduction		
1.1 **1.2**	PH gave a brief account of the project bid and the work stages outlining the work carried out to the three properties. She summarised how the learning from these would help inform a programme for the rest of solid wall properties (approx. 1,800) and off-gas properties (approx. 800) in the stock. YH is keen to learn about insulating solid wall properties and whether this could be done gradually whilst undertaking kitchen and bathroom improvements. YH was also keen to learn about using air source heat pumps and the differences in running costs of combi versus system boilers. The Technology Strategy Board's aims seemed to encourage the installation of the Mechanical Heat Recovery Ventilation System and the solar PV.		
	Recap of the design intent for the three properties		
1.3	**a. SAP calculations** JT gave a brief resume of the summary spreadsheet he had completed which was handed out with the reasons why the original targets had not been met through changes and the scenario if under floor heating had been used. The electric focal point fire in each property was estimated at 10% of the heat source but in practice would hope to be much less.		
	Programme Start and finish dates and reasons for delay		
1.4	• Locating properties – started April 2010. This took some time, and was the cause of the delay to the start of the project. • Properties found and agreed 23/6/2010. • Pre start Meeting 16/7/2010. • ROK Contractors ceased trading, which caused an additional delay. • YH Ltd installed gas central heating to two of the three properties in advance of main contract work these were monitored for a 2 week period using tiny tags. This caused some delay in commencing actual work. • STG Contractors appointed. • New Pre Start Meeting 25/10/10. • Spacetherm gave fixing demo at P3 6/12/11 • Work commenced stripping out properties 11/12/10. • Discovered planning permission needed for ASHP and Solar at P3		

Item No.		Action	Timing
1.5	Delays: 1) Hacking off wall plaster at P3 for spacetherm as spec by manufacturers – this would have been better left to give a better base as the bare walls needed to be battened out to compensate for the unevenness and out of plumb. 2) Additional wall plastering to all properties being old and perished – cold winter did not help drying out. 3) New suspended ceilings at P3 to reduce area to be heated, to help performance of ASHP. 4) Difficulties in accessing site in coldest winter for 20 years and time drying out. 5) Timing of Parity visits, fitting in with other works. 6) Remedial works after air tightness test – detailed in HA's report. 7 Work held up for planning permission at P3. • Handovers P1 and P2 11/3/2011 • Work resumed at P3 1/4/2011 • Further delays: 1) Ordering Solar PV; 2) Yard trench for flow & return to ASHP too shallow; 3) Air tightness test delayed – not fit to test – missing loft hatch and holes. • Handover of P3 and Wash-up meeting 27/5/2011 **Construction reality (how and why was design changed to adapt to circumstances on the ground** • 2 properties had basements that enabled part suspended ground floor to be insulated underneath. It was discussed that YH could undertake this work as standard when a property with a cellar becomes void. GH suggested including this in the voids standard. • Basement doors were draught proofed but doors and side walls were not insulated and need monitoring as these may cause cold spots. • Practical Challenges. The main challenge was that of the importance of informing all trades of the importance of sealing up all gaps, cracks, etc as each trade moves through a job, rather than doing this at the end of a job when it may not be possible to do a thorough job. • Monitoring Equipment wiring, the spec was changed as additional insulation was fixed between the battened out walls at P3 and another monitor installed at this depth. There were issues with some wiring be installed incorrectly, and where wiring was just chopped out resulting in the need for complete rewiring. There was some discussion over whose responsibility it is to install the wires – Parity had left instructions and STG had done some of the work with mixed success. It was concluded that learning points from this were: • Ensure instructions are clear; • If work is to be passed onto someone else, ensure that an electrician undertakes the work; • Involve all parties at the design stage to ensure that		

Item No.		Action	Timing
	there is no duplication, e.g. in meters. • SG reported that he had noticed a number of errors in the installation of the heat pump, which need rectifying soon and with be following this up with STG. It was agreed that Worcester should have been involved throughout the project to avoid these problems. SG also noted that due to the high levels of insulation and air tightness the heat pump may be oversized, however this shouldn't affect its performance.		
1.6	**Construction success Stories (what went well and why)** 1) The polystud insulation was fairly traditional and easy to use. 2) The conventional gas heating systems to the two properties had the boilers and radiators located on non external walls to minimise interaction between trades fixing the external wall insulation. Likewise all electric points and switches were located on non external walls. 3) Finishing trades mainly joinery/skirtings had no problems fixing to newly insulated walls. 4) Existing window reveal details with minor works allowed insulation levels to be uncompromised in reveals. 5) New customers were delighted in the finished results & pleased to take part in future monitoring.		
1.7	**Construction Problems (what was difficult, why and how it was over come)** 1) The Spacetherm could not be fixed to bare walls. At P3 the external walls were battened out. At P1 it was fixed directly to plaster where possible. 2) ASHP – Initially we were not aware that Planning Permission was required. An application was later submitted and approved with required changes to the location of the heat pump unit. 3) HA came up with a good idea on constructing a new cupboard under the stairs opening out to rear entrance for new cylinder and internal heating equipment. 4) The location of the DC cable from the Solar PV and the controls/action if a power cut occurs - this needs to be looked at.		
1.8	**System interactions (any issues or success stories in making technologies work together).** 1) The ASHP had not been installed to the manufacturer's instructions, this was discussed at length. SG to assist LB to resolve with subcontractors and AD to price for extra monitor. 2) Parity Monitoring equipment discussed, AD to come up with handover pack and resolve issues with web site and presentation of monitoring data. It was found that some monitors had been incorrectly sited which meant lifting and refitting insulation. There was a question mark over the availability of diagrams and whether an electrician had been used to fit them. AN and AW to confirm on his return. 3) Mechanical heat recovery ventilation system (MHRV system) - STG was not able to give guidance on operation and the following issues were identified (STG to gain answers for these queries from the manufacturer to pass onto customer at follow-up meeting):		

Item No.		Action	Timing
	• What is the recommended summer operation? • We need to advise customers to keep window trickle vents closed whilst the MHRV system is working. • Variable speed controller and timer – we need to advise the customer how best to use these. PS also noted that the ducts running to and from the unit in the loft require insulating. Guidance is required from the manufacturer regarding filter maintenance. PS also noted that the unit would have been better sited in the main body of the house rather than the loft (e.g. in cupboard on landing).		
1.9	**Lessons learned in commissioning or equipment and controls** 1) Literature provided by manufactures not sufficient or suitable for customer use. 2) HA to look at writing up customer friendly advice on installations which would not only serve these but all the housing stock where appropriate. 3) Heating programmer at P2 – when handing this over to customers no staff were familiar enough with it and the explanation was not very slick. 4) SG looking at ASHP handover over info to make simpler. 5) Self-training controllers – will become the norm as IT develops.		
1.10	**Handover and Training (how well was this handled and how well was it received by the customer)** 1) P3 went well having a timetable to work through with named persons. 2) Heating Programmers – electronic P2 and pegs P1, differences and not standardised reduces confidence in ability to demonstrate these. 3) HA and Neighbourhood Officer went back to first two properties after approx. 2 weeks to check that customers knew how all things worked and to give advice if not being used as it should. This proved very useful as customers were free to ask any questions and resolve queries. 4) Helen to revisit properties over next 2 years looking at data obtained from monitoring and offer advice where thought to be needed.		
1.11	**Costs (actual vs. budget, detail available for reporting scope for reducing costs)** DH to source this information and to pass onto JT for final report.		
1.12	**What should be repeated (reduced scope scheme for replication)** 1) Use of polystud on refurbs at the same time as kitchen or bathrooms replaced and behind boilers, walls not insulted in refurbs to be done on voids – programming needs to be looked at. Uncertain when this procedure will commence. 2) Spacetherm – although no one liked handling/cutting and fixing if pre cut may have use for narrow reveals. 3) ASHP – depending on planning permission requirements and running costs. 4) Better communication on operating both existing and new technologies for customers. 5) Solar PV – although thought needs to be given to what happens		

Item No.		Action	Timing
	following a power cut and remote monitoring of systems. **What should be avoided (technologies and process)** 1) Spacetherm unless there is no other solution. 2) MHRVs – unless more learning is available from installations in new build and other retrofitting projects. **Any early feedback from customers in first two properties**		
1.13	P2 – All seems OK. P1 – The customer complains that there is 'no air'. They are not using heating because its warm, does not open windows as it comes cold at night and does not want to use heating, also may be short of some manufacturer's instructions – HA suggested she would follow up.		
1.14	**Plans for Monitoring Period – what we will do over next two years** 1) HA has scheduled a programme of visits and will fit two of these in with visits from the EST. 2) Act on feedback from customers. 3) Monitoring equipment would best be with hourly results rather than every 5 minutes – JT to follow this up with Parity. 4) Access to TSB database for all to check other projects and consider using the best examples.		
1.15	**Writing Final Report (who needs input)** JT to put together liaising primarily with DA or direct with AW and LB. Costs from AW to be passed on by DA to JT. LB and AW to provide a summary from the construction perspective. PR stated the importance of teasing out what is individual about each property as well as common themes. Any additional information that we have can be included as an appendix.		
1.16	**AOB/Final Conclusions** 1) Generally impressed by end results at P3 2) Although the project is not the most innovative, the approach and method has highlighted what could be possible to roll a programme for YH Ltd 1,800 difficult to insulate solid wall properties. 3) SG stated that he would like temperature sensors placed at each end of the pipe under the yard to measure the amount of heat loss. 4) LB stated that learning points from their perspective are: • Improve communication between trades; • Involve all at the planning stage. 5) There was a discussion about how to improve communication through a project, and it was suggested that photos could be emailed periodically. 6) It was mentioned that employing a monitoring company more local to the site might have improved results in that area as they might have been able to visit site more frequently. However, there are very few companies which undertake this type of work.		
1.17			