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: ZA660T

Property number: TSB072

Authors:

Gifford, part of Ramboll

London Borough of Harrow

Kier Building Maintenance

West Gate Maintenance Ltd.

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:** ZA660T
- **Location of property:** HA7, Stanmore
- **Lead participant details:** Gifford, part of Ramboll, 76-80 Bankside Studios, London, SE1 0PN
- **Date report issued:** August 2011

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1. Project details and directory

Role	Organisation	Contact Details
Project Lead	Gifford, part of Ramboll	Address: 60 Newman Street London W1T 3DA Tel: 020 7631 5291 Website: www.gifford.uk.com
London Borough of Harrow		Address: Civic Centre Station Road, Harrow, HA1 2XY Tel: 0208 416 8049 Website: www.harrow.gov.uk
Engineer	Gifford, part of Ramboll	Address: 215, Atrium, C-Wing, 8th Floor, Andheri Kurla Road, Andheri (E) Mumbai - 400 059, India Phone +91 22 6117 0111 Website: www.gifford.uk.com
Engineer	Gifford, part of Ramboll	Address: 60 Newman Street London W1T 3DA Tel: 02079602424 Tel: 020 7631 5291 Website: www.gifford.uk.com
Contract Manager	Kier Building Maintenance	Address: KBM Harrow, Mead Ind Park River Way, Harlow, Essex CM20 2SE Tel: 07805 300464 Website: www.kier.co.uk
General Manager	Kier Building Maintenance	Address: KBM Harrow, Mead Ind Park River Way, Harlow, Essex CM20 2SE Tel: (0)208 8619 752 Website: www.kier.co.uk
QS	Kier Building Maintenance	Address: KBM Harrow, Mead Ind Park River Way, Harlow, Essex CM20 2SE Tel: 07877 665108 Website: www.kier.co.uk

2. Introduction

Gifford, part of Ramboll, partnered with the London Borough of Harrow to develop a design entry for the Retrofit for the Future competition. Proposals were to ‘eco-retrofit’ an existing 1960s semi- detached property, typical of social housing in the borough. As many properties were built during a time when there were no building regulations covering the conservation of fuel and power, the challenge was to bring these buildings in line with best practice energy efficiency, providing a solution that can be easily replicated to reduce the carbon impact of the local housing stock.

The local authority identified the property TSB072 for the project, which was unoccupied and awaiting extension work. The problem facing Harrow is that the majority of social housing is poorly insulated with some central heating systems up to 30 years old. It was intended that the retrofit project would be used as evidence and inspiration for social housing across the Borough, as well as private sector residents.

Figure 1: The property pre-retrofit

Figure 2: The property post-retrofit

3. Occupants

New occupants moved into TSB072 following the retrofit of a void property. The property underwent extension from a 3-bedroom to a 5-bedroom dwelling. The table below lists the details of the new tenants; unfortunately the details of previous tenants are not available.

Age band	Number before retrofit	Number after retrofit
Under 5 years	n/a	3
5-16 years		2
17-21 years		
22-50 years		2
51-65 years		
Over 65 years		
Please state if (yes/no):	**Before retrofit**	**After retrofit**
Married couple / partners	n/a	
Couple / partners with children		Yes
Any disabled persons		No

Occupants were selected following an application to the Local Authority for a 5-bedroom property, as well as showing an interest in the nature of the scheme. The London Borough of Harrow's Housing Team promoted the 'eco-retrofit' when letting the property, and it was stressed that tenants must be prepared to co-operate in the two-year monitoring period. White goods are not usually provided with affordable housing, so the 'gift' of the A++ rated fridge/freezer, dishwasher and washing machine was conditional on tenants' involvement during the period of data collection.

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	June 2009
Planning application submitted (if appropriate)	February 2010
Planning permission granted (if appropriate)	April 2010
Building Regulations application submitted (if appropriate)	February 2010
Building Regulations approval granted (if appropriate)	April 2010
Contract for work let / signed	November 2011
Occupants moved out (state if they remained or property was empty)	Property empty
Start on site	November 2010
Completion of retrofit	May 2011
Occupants moved in	June 2011
Monitoring system commissioned and operating properly	May 2011
Building defects corrected	May 2011
Building services and controls operating correctly	June 2011

5. Pre-retrofit property

Pre-retrofit, TSB072 was a 3-bedroom semi-detached property, constructed in the 1960s. The existing building was constructed with cavity brick walls, a solid concrete ground floor, internal masonry walls, suspended timber floors and a pitched roof with traditional tiles.

The property was selected because it demonstrates features typical of social housing abundant in Harrow. A visual inspection was undertaken of TSB072 and another house nearby – both similar properties awaiting extension works. It was important to choose a void property for the purposes of this pilot project, eliminating the costs and disruption associated with decanting tenants.

TSB072 was selected for the retrofit scheme. A number of site visits were undertaken to investigate levels of insulation, leakage paths and existing building services. Before construction began, the air tightness of the existing building was measured as 7.84m^3/hr/m^2 @50 Pa. Thermal images were taken of the building, and the data linked to Laser Aided Modelling ® to assist investigation of the building fabric.

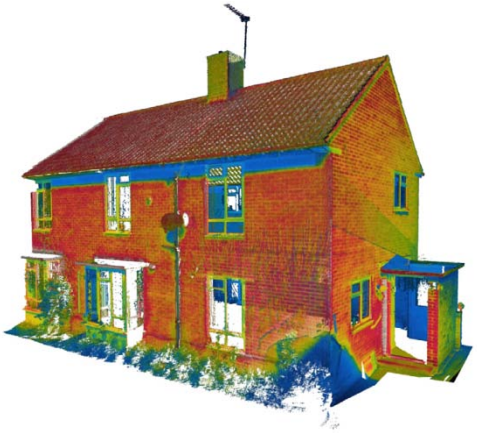

Figure 3: Front elevation thermal imaging

Figure 4: Rear elevation thermal imaging

Unfortunately, thermal imaging was undertaken in unsuitable climatic conditions and the results illustrate the heat from the sun on the building, rather than the heat being leaked out through the fabric. It was not possible for BSRIA Ltd to repeat the test.

We do not have energy consumption records for the original property.

6. Design

Extensive research was undertaken during the feasibility stage to inform a solution that doesn't focus on an individual technology but provides a coherent package for retrofitting properties to lower their carbon footprint. Our proposal focuses on getting the building fabric right before introducing complicated technologies.

IES Virtual Environment (version 6.0) was used to estimate the energy consumption and carbon savings associate with the retrofit works. This software is Government accredited to perform SAP calculations for AD Part L1A of the Building Regulations. At the competition stage the carbon footprint of the property was estimated as 13 $kgCO_2/m^2/yr$ using the SAP Extension Worksheet provided by the Technology Strategy Board.

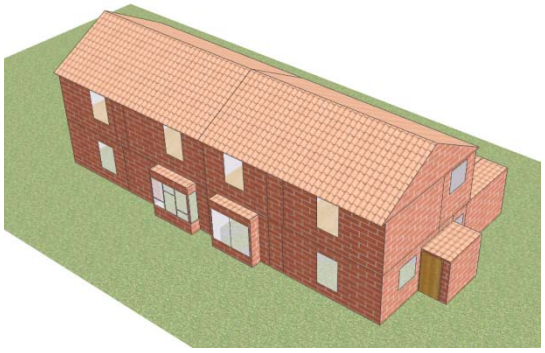

Figure 5: IES Model Front Elevation

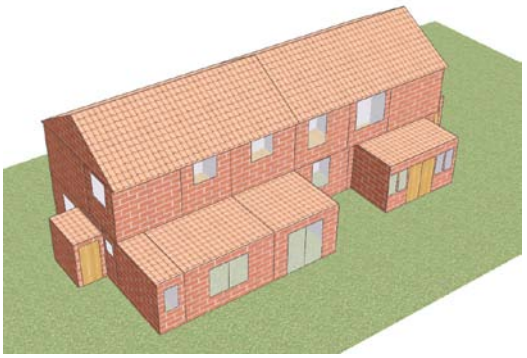

Figure 6: IES Model Rear Elevation

Key retrofit measures proposed at funding application stage:

- A combination of materials to 'super-insulate' the building envelope, including triple glazed windows, patio doors and Aerogel Spacetherm ™ internal insulation boards
- Existing vents and openings sealed to achieve an air leakage rate of 5 $m^3/hr/m^2$ @ 50 Pa
- Laser Aided Modelling ® to scan dimensions and openings to accurate create plans and 3D models, allowing pre-cutting of insulation to save time and money during construction
- A Positive Input Ventilation system with mechanical heat recovery, which uses the south facing roof as solar collector to preheat the supply air, without any modification to the building
- Low energy LED fittings in the kitchen, bathroom and living areas, with all other light fittings replaced with dedicated compact fluorescent fittings
- Daylight sensors in all rooms with additional motion sensors in bathrooms and outside the property
- Three solar thermal panels to provide 60% of the dwelling's annual hot water

- A bespoke controls system for heating, lighting and appliances:
    - eTRVs are a new wireless technology, simply retrofitted onto existing radiators. The system gives tenants the option of controlling heating on a room by room basis, or upstairs/downstairs, living areas/bedrooms split
    - A 'Last Man Out Switch', so that upon leaving the property residents can turn off all light fittings with a simple switch
    - 12 wireless 'Bye Bye Stand-by' devices which fit behind plugs, allowing tenants to choose which appliances they control e.g. lamps, computers, televisions
- The first combined rainwater harvesting and grey water recycling system in the UK to use a membrane pump, reducing the associated pumping energy by 90% and meeting all non-potable water demand in the property

Key differences between the retrofit 'As Designed' and 'As Built':

- The initial scheme involved the installation of a raised floor to insulate the concrete slab. This required shortening the doors in the property, which had not been allowed for in the cost plan. We researched a 'puncture-proof' insulation with an 'internal vacuum' capable of achieving the same heat loss using just 30mm of material – Vacupor™. Unfortunately, towards the end of construction, this had to be value engineered to Kingspan K3 Kooltherm™ insulation – increasing the proposed u-value from 0.16 W/m².K to 0.37 W/m².K

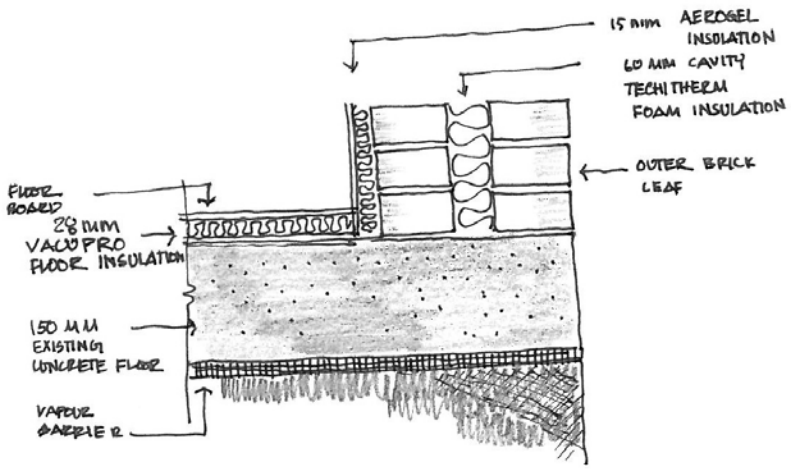

Figure 7: Original ground floor insulation

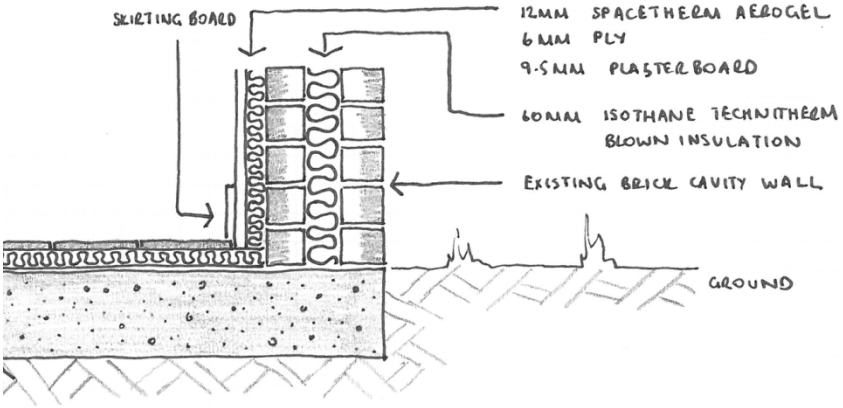

Figure 8: Final ground floor insulation

The final u-values achieved for the building fabric are as follows:

Element	Existing (W/m²K)	Retrofit (W/m²K)	New Extension
External wall	1.60	0.28	0.18
Ground floor	1.20	0.37	0.19
Roof	2.30	0.12	0.20
Windows	3.10	0.88	0.88
Door	3.10	1.00	-
Partition wall	1.57	1.10	-

Figure 9: U-Value Schedule TSB072

- During the period leading up to construction, new cavity wall insulation became available- Isothane Technitherm™, which allowed achievement of a superior u-value at no additional cost. This allowed us to reduce the thickness of Aerogel Spacetherm ™ insulation on the internal wall to maintain the same overall heat loss. The image below illustrates how foam is blown between brick walls to effectively seal and insulate the building.

Figure 10: Cavity wall insulation procedure

- The combined greywater and rainwater recycling system was replaced with a simpler rainwater harvesting alternative, as complete installation costs had not been appreciated at feasibility stage. The rainwater harvesting system provides an environmentally friendly method of washing clothes and flushing toilets – providing half of all non-potable water demand in the property.

- We originally intended to remove the existing chimney, which required strengthening works to the building structure. Once fully analysed by structural engineers, the costs were outside our budget. We formulated a new idea to reduce heat loss through the chimney, without requiring strengthening works. A thermal break plate was proposed at loft level – one of our most practical retrofit solutions.

- The ‘Last Man Out’ switch required a second electrical circuit to be wired which was not practically or economically feasible. Lighting controls were adapted to include ‘absence detection’, meaning that if spaces become unoccupied for a set period of time, lights automatically switch off.

Figure 11: 2000-litre Rainwater Harvesting Tank

The carbon footprint of TSB072 is now estimated as 17 $kgCO_2/m^2/yr$, accounting for the changes that took place during construction.

7. Construction

Kier Building Maintenance, acting as the framework partner to the London Borough of Harrow, obtained quotations for the project works from our supply chain of national suppliers and subcontractors. They then presented these in the form of an Agreed Maximum Price (AMP), together with management prelim costs, to the London Borough of Harrow for their scrutiny. This process was undertaken in accordance with the procurement requirements of the framework agreement, which are designed to provide and demonstrate market-testing and value for money.

Typically, three or more quotations were obtained for works packages. For some of the more specialist trades, fewer quotations were received due to a shortage of these trades on Kier's approved subcontractor / supplier database. Other specialists such as Nuaire Ltd were engaged by the design team at the project outset, and were novated to Kier for employment on the project.

The form of contract utilised was TPC2005. In addition to the Retrofit For the Future scheme, the project was combined with a pre-planned extension and refurbishment of the property, funded from a separate revenue stream provided by the London Borough of Harrow. A single-storey extension was built to the rear of the property to good practice building fabric standards, with new electrics and heating installed to the London Borough of Harrow's 'Decent Homes' specification.

Kier acted as the Principal Contractor. The works were sublet on a supply-and-fit basis, in works packages as follows:

- West Gate Maintenance Ltd - General building works
- Castle Point Gas & Heating Co – Gas central heating installation
- Nuaire Ltd – Positive Input Ventilation (PIV) and solar water heating systems
- Install Direct – Windows and door installation
- Kier Scaffolding – Scaffolding
- Hillingdon Flooring – Flooring
- Kershaw Contracting Services – Cavity wall and between-floor insulation
- John Beyer Associates, Conisbee, Hunters – Consultants / professional services

Specialist materials suppliers, procured and purchased by Kier, were as follows:

- Proctor Group – Aerogel Spacetherm™ insulation backed plasterboard
- Jeld-wen – Triple-glazed windows
- Chalmor – Heating and lighting controls
- Aquality – Rainwater harvesting equipment
- Manse Masterdor – Front door

A full time site foreman was provided by the main subcontractor (West Gate). Kier provided a site manager and contract manager, who had a daily presence on site and were responsible for the delivery of the programme, and whose time was divided between other projects to maximise value for money. The client provided a Clerk of Works who undertook regular site inspections.

The design team provided input and advice during the construction phase. The works were signed off by the client representatives (clerk of works and client representative).

Key issues arose during the construction process which necessitated alternative solutions and variations to be implemented:

1. The combined greywater recycling and rainwater harvesting tank. The originally specified location and overflow provision for the tank to the storm water sewer system was too large to be installed on the site, with issues around the size and depth of excavations, and the handling of large tanks and other equipment on a confined site. A smaller rainwater harvesting system was installed.

2. PIV ducting system. Issues arose with the location of the runs for the PIV ducting system, through the house to the loft, and their subsequent boxing in. It was not possible to run all ducting in concealed spaces due to the depth of the original floor joists and the absence of service risers. As a result, significant lengths of ducting were required to be boxed in within room spaces, which is unsightly and reduced the usable room space.

3. Structural issues. Within the loft space, structural issues arose and works to the roofing trusses and rafters were necessary to allow siting of the PIV equipment and access for future maintenance. Generally, the siting of such large equipment in an original loft space is not ideal in a domestic property.

4. Some specified materials had long lead in times for procurement and associated delivery to site.

5. The space behind the chimney breast in the kitchen area has turned out to be a wasted space.

6. The quality of the original 1950 build presented problems in terms of uneven floor levels, airtightness problems, and poor condition of floorboards on the first floor, and structural movement and cracking to the building fabric. All such matters required an increased level of various unforeseen works to remedy.

7. Generally, the experience of some of the specialist contractors and consultants was more suited to larger scale schemes; some of the technologies were difficult to scale and implement within the restrictions of a small site, and in a retrofit of an existing building.

8. Some compromises and complications resulted from the need to integrate the retrofit measures and specifications with the client’s housing specifications; for example, non-slip flooring in the kitchen and bathroom.

8. Commissioning and occupancy

The commissioning carried out at TSB072 was as follows:

1. Air tightness Test: BSRIA Ltd recorded an air leakage rate of 5.5m^3/hr/m^2 @50 Pa. A couple of leakage paths were noticed around ducts penetrating the loft level. The contractor has since sealed any outstanding gaps, and another air tightness test is planned. Unfortunately the tenants have been unable to provide appropriate access to the property in order to carry out the test.

2. Thermal Imaging: to be completed by BSRIA Ltd when the heating season starts.

3. Lighting Controls: Daylight and presence controls installed in the property were tested by Chalmor. Lux levels were adjusted to ensure lights remained switched off when there was sufficient daylight in the property.

4. Heating System: Commissioned Late April 2011, but not yet to be run in a heating season.

5. Solar Hot Water System: Commissioned May 2011 and was providing adequate hot water at time of handover and the resident moving in.

6. Ventilation System: Commissioned by BSRIA Ltd in May 2011. BSRIA noted some faults with the system. Following this, and prior to the tenants moving in, Nuaire Ltd visited the site to ensure the system was working correctly.

A 'handover workshop' was held with the new tenants to ensure occupants were provided with an awareness and understanding of the retrofit measures. Energy efficiency can only go so far; ultimately it is the responsibility of the tenant to conserve energy. Specialist manufacturers attended the workshop to demonstrate how to use the building services systems in practice, providing tenants with contact details in case of issues with systems going forward.

A visit was also arranged with the London Borough of Harrow's Housing team to present the completed retrofit and showcase solutions. A predicted maintenance schedule was provided from manufacturers to allow the local authority to proactively schedule and allocate funds for required maintenance activities. (Appendix D).

9. Costs

Below is a summary of the cost breakdown for the project – costs are not split between material and labour and are exclusive of VAT.

Item Stage>	Design stage estimate materials and labour	Post- construction actual spend materials and labour	Comments
Management and administration	£ 100.00	£ 98.46	Not including Client costs (Clerk of Works, Client Rep, department overheads etc.) Kier site overheads included in prelims section. Kier central / head-office overheads costs are included as a fixed percentage within the works costs.
Design Costs (not including Phase 1 Feasibility Work)	£14,102.61	£ 23,538.46	Design and Project Management costs for Gifford, part of Ramboll, far exceeded that estimated. Due to the complexity and innovative nature of the project, the overspend has been considerable.
Construction overall	£90,273.68	£96,014.33	
- Prelims	£ 9,980.40	£ 9,826.88	Prelims costs shared with the separately-funded extension and refurbishment, which achieved efficiency savings. Prelims would typically be around 15%. The actual cost to Kier was higher due to extra supervision required and due to delays.
- Fabric measures	£45,466.00	£40,496.01	Savings were achieved by the omission of some non-essential works and the value-engineered changes to more cost-effective materials.
- Building services (conventional)	£ 5,552.35	£ 5,466.94	A full electrical rewire and gas central heating system was installed, and the upgrade of kitchen and bathrooms was undertaken. Most of the cost of these works was covered by the client as part of the

			extension and refurbishment scheme carried out to the property in conjunction with the TSB retrofit works
- Low /zero carbon technologies	£24,873.22	£24,289.11	We would hope to be able to procure these items more cheaply in the future due to the now greater availability of these technologies through our supply chain.
- Consequential costs	£ 3,740.42	£15,836.94	Due to overall budget constraints, a risk register/ contingency of only £1,200.00 was allowed for within the cost plan. Typically we would include a contingency of around 10%. Approximately £12,000.00 of variations were instructed on-site, due to unforeseen works. Value-engineering was required to other areas to cover to cost of these works
Contingency budget	£12,407.25	£12,407.25	Complete contingency budget allocated towards construction costs.
Occupant temporary housing		n/a	No costs as property was unoccupied prior to commencement
Monitoring equipment and installation	£8,665.63	£8,665.63	Includes airtightness and thermal imaging testing. Installation included smart meters for gas, water and electricity; environmental monitoring of temperature, CO2 and humidity; heat and electricity meters for the solar hot water system. Additional meters are also being installed on the rainwater harvesting system courtesy of Aquality and West Gate to monitor water recycling and power consumption.
Monitoring and reporting service	n/a	n/a	Provided by BSRIA as per TSB arrangement. Courtesy of Aquality for rainwater harvesting system.

Combining Retrofit for the Future with extension works:

- As noted earlier in the report, the London Borough of Harrow decided to combine the Retrofit for the Future scheme with a project funded by the West London Development Agency, titled 'Grant Funded Extensions'. The project aims to extend and refurbish existing social housing properties to create larger capacity (4-5 bedroom) family houses, to address the current shortage of this type of social housing.
- The 'Grant Funded Extension' consisted of a single storey flat roofed extension to the width of the property, located at the rear. The project also included internal alterations, and the full refurbishment of the existing property to the 'Decent Homes' specification.
- Cost efficiencies were demonstrated by this combining of projects in terms of construction management and prelims.
- The cost management however was made more complicated by this combining of projects and budget streams. Many of the works and cost items were specific to either project and could simply be allocated to either budget, yet many items were split by cost between the two elements; for example, the electrical rewire costs, heating works and scaffolding.
- During the pre-contract design and development phase, Kier management and overhead costs were covered under a separate budget in order to minimise the costs on the Retrofit for the Future scheme. Likewise, Kier prelim costs were limited as part of the TSB budget, however the actual cost was in the region of 15%.
- As a result of the above, the cost plan of the project does not reflect the actual costs for some of the elements; the cost of overheads and associated works would have been higher if not combined with the extension and refurbishment scheme.

Procurement:

- We consider the cost for some particular items to be high, such as the triple glazed windows and the rainwater harvesting system. At the project development stage, these items were not easily procurable through our existing supply chain and, as a result, we were not able to obtain as many quotations as we would have preferred for some items. For example, some of the window suppliers we approached, who produced a suitable triple-glazed window product, did not typically deal with schemes on this scale, and were aimed at the larger-scale commercial or new-build markets. In addition, existing long-standing relationships with some of the nominated suppliers would have benefitted in the negotiation of rates. We are of the impression that these markets are now more developed, with more competition, and we would therefore expect to achieve further cost savings if we were to procure these services again.
- Due to the nature of such an innovative project, we are of the view that the costs for the general building works element were higher than we could achieve if we were to now carry out the process again. Due to the unknown factors in installing the new technologies and solutions, we believe the tenderers understandably priced-in additional risk.

Consequential Costs:

- The cost estimation work undertaken during the feasibility study was based on a number of provisional sums. The level of design work undertaken during Phase 1 of the project essentially took proposals to RIBA Stage C level of detail. Drawings and specifications were only developed during Phase 2 when the true costs of the scheme were realised. Fortunately we applied for a contingency budget equal to 20% of the construction cost at the application stage, which was used in full towards the cost of build.

- As previously highlighted, unforeseen works and associated variations arose during the construction phase of the project; the result of both construction and regulatory compliance factors. Such works emerged from the practical implementation of the main project works, and the experience gained has aided our understanding and will inform our consideration of similar works in the future.
- Other additional associated costs were incurred upon finalisation of design matters during the construction phase, including:
    - Boxing for the PIV ducting which was intended to be concealed in the floor void
    - The removal of a tree due to the change of location of the rainwater harvesting tank
    - The need to fit plywood covering over Sempatap™ insulation on the partition wall as it did not provide a suitable surface to fix kitchen units and tiling to (despite advice to the contrary by the manufacturer)
- The major unforeseen costs were associated with the installation of the rainwater harvesting tank, with significant additional drainage works required in order to connect to the existing outflow drains, and additional costs to hand-dig the excavations due to the physical constraints of the site.
- Due to design development and finalising of costs after the date of the original application for funding, there were insufficient monies in the budget to afford sufficient contingency going forward to construction. Savings were achieved on site for some items, and value engineering was undertaken for others; and some risk was absorbed by the London Borough of Harrow, Kier and Gifford, part of Ramboll, in order to complete the project.

VAT:
The contract value for the works was inclusive of VAT, which is unusual in construction. During the course of the project VAT rates fluctuated from 17.5% to 15%, back to 17.5% and then up to 20%. Fortunately, the initial increase to 17.5% was announced whilst cost plans were being developed, but value engineering was required to accommodate the increase to 20%.

During the course of the project it was discovered that HRMC levy a reduced VAT rate of 5% on a number of materials and technologies listed under their ‘Energy Saving Materials’ conditions, as well as associated installation costs. This significantly reduced the degree of value engineering required to complete the scheme.

9. Wash-up meeting

A ‘wash-up’ meeting was held on 22nd September 2011 with the project team. The final report is being prepared by UCL.

10. Doing it again

At this stage, immediately following building handover, it is difficult to comment on aspects which we would definitely do, or not do again, as the effectiveness and suitability of solutions are yet to be fully realised.

However, based on the experience of the project team to date, aspects which we would definitely repeat would be:

- Solar hot water panels. The effectiveness of the panels has been immediate.
- Cavity wall removal and replacement with blown Isothane Technitherm™. This was a straight forward procedure, and was very effective at reducing the u-value of external walls.
- The thermal break plate in the chimney was an innovative way to reduce heat loss through the existing chimney without compromising fire safety regulations.
- Feedback has indicated that the tenants are happy with the controlled environment provided by the mechanical ventilation system.

Aspects which we would not do again would be:

- Specify specialist technologies from organisations that are not responsible for the complete manufacture and installation of products. Difficulties were encountered with one organisation in particular, who subcontract installation works, blurring the lines of responsibility on site.
- Thermal imaging – unless correct climatic conditions are available, the results are irrelevant.

Things we would do differently would be:

- Specify more products from within the UK to reduce lead in times, if the same performance criteria is available.
- Use Laser Aided Modelling® results to pre-cut insulation panels, reducing the construction programme. This was the intention at TSB072, but it transpired that insulation manufacturers will not accept measurements from a third party. A more collaborative approach in the construction industry would help reduce issues such as this.
- Improve air leakage. BSRIA Ltd recorded an air leakage rate of 5.5m^3/m^2 @50 Pa and the design required 5.0m^3/m^2 @50 Pa to reach carbon targets. The intention at the outset of the project was to undertake an air tightness test after completing every room in the property, to isolate leakage paths and eliminate them. Unfortunately this was not possible due to the scheduling of site activities and a condensed construction period to meet the deadline for the project.
- Undertake a preliminary survey of drainage routes to inform the rainwater harvesting solution at the feasibility stage.
- Externally insulate. Issues were encountered with the detailing of the Aerogel Spacetherm™ internal insulation at junctions, especially around windows. It may be easier to externally insulate properties, but it's likely this would require a more detailed planning application.
- Ensure LED light fittings are supplied with the correct driver. The spot lights in the kitchen and living room blew due to incorrect drivers being fitted. This has now been rectified at the property but caused delays at the end of the project.

- The most expensive items for this project were the triple glazed windows, Aerogel Spacetherm™ insulation and rainwater harvesting system. Costs could be reduced by finding alternative products and systems. As mentioned previously, the costs for the builders' works element could also be reduced if the project were to be repeated.

Typically, engineering specifications and drawings are not provided for a project of this size. However, this would have assisted cost estimators and streamlined the construction process. Mechanical, electrical, public health and structural engineering duties were handed over to the principal contractor during construction. It may be beneficial for engineering duties to remain with consultants throughout construction, due to the innovative nature of the retrofit works.

The efficiency gains expected from a larger programme of retrofits of a similar age and design in a similar neighbourhood would be speed of construction and reduced cost. The contractor would be able to negotiate better rates, coordinate lead in times for the procurement of specialist items and associated delivery to sites, and the cost of builders' works would reduce.

The key to successful scaling up of retrofit works is collaboration. Detailed evaluation is required from the architect, engineer and contractor at an earlier stage of design than is usual for projects of this size. Contractors will be required to have connections with a range of specialist suppliers and subcontractors; capable of supplying and installing specialist technologies and systems. Consultants and contractors need to work together before construction begins, to ensure a scheme that meets performance targets within the funding envelope, and avoiding value engineering at late stages in the project, when options for reducing costs are limited.

The same is true during construction; a strong relationship is required between the project team to ensure effective communication when issues are encountered during the works, and to seek alternative solutions. The London Borough of Harrow, Kier, West Gate and Gifford, part of Ramboll, worked together to deliver this challenging project, and the relationships between the parties were key to completing the works.

11. Business benefits

Gifford, part of Ramboll has developed significant expertise in the retrofit sector following our participation in the project. The sustainability team now has a library of information relating to retrofit products and systems as a result of the feasibility study undertaken during Phase 1, which will assist efficiency on future retrofit projects. Engineers can suggest appropriate solutions, based on practical experience and the lessons learned during the delivery of the scheme at TSB072.

We have already had the opportunity to put a number of these new skills into practice on recent contracts for affordable housing regeneration, as well as commercial renovation schemes. We are also working on another research project looking at converting existing office buildings into residential accommodation. During the recession, we have seen an increased demand for retrofit skills as the market has shifted away from new build developments. We have justified overspend on this project against the potential opportunity for future contracts.

Kier and their supply chain partners are rapidly expanding into the renewable energy sector, with expertise in sustainable refurbishment of existing buildings and renewable heat generation. Undertaking innovative projects such as ZA660T ensures they are able to continuously develop specialist knowledge and practical skills, to implement the portfolio of ever changing environmental solutions they are able to provide, and tailor services to meet the specialist needs of their social housing clients.

Working with a team to deliver projects such as this, also enables them to share efficiencies and build on the lessons learnt throughout the process of inception, procurement and construction, thus continuing to develop best practice within the Kier group.

Poor quality housing and fuel poverty are two of the most serious problems facing tenants across the UK. Fuel price rises, which are likely to continue in future as global resources are depleted, deal a double blow to people in poor quality housing, making it more difficult to keep their property warm. Kier's expertise in retrofitting and refurbishing existing properties to a decent standard can not only improve the standard of living for householders, but can also help them manage spiralling heating costs.

At present, Kier have not had any further business leads or opportunities for future work relating to retrofit projects of this nature. The project will be appearing in a magazine article, where Kier will also be advertising a service for providing information to interested parties. Kier have also recently secured three large PV installations for local authority clients, which will be overseen by some members of the retrofit project team.

Being a relatively new market, and under the current economic climate, Kier would not expect to carry out more than two projects of this nature a year, with a predicted annual turnover of £150k per annum. However this is solely dependent on client investment opportunities.

West Gate's involvement in this scheme has been a positive tool in marketing and promoting our business; it has opened the eyes of the team to the future market potential: we see this as a progressive market that will increase with education. This is true of West Gate and our partnering contractors/suppliers involved in both the installation and supply of materials. Whilst we are using our involvement in this initiative as a strong marketing tool and actively promoting the technologies we, to date, have not had any positive business leads. We continue to actively promote the project and look forward to involvement in future schemes.

The opportunity to liaise and speak with specialist subcontractors and learn from their experiences was invaluable, whilst working with many of the technologies was a first for many of the team, and allowed them to question the benefits of technologies and how they can be used to greater benefit for future installations. Being part of the overall initiative and having access to the other parties has enhanced our knowledge of the available technologies and encouraged us to be bolder in our approach. It has also encourages us to try new innovations and technologies which we hope will enhance our business in the coming years.