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: ZA152J
Property number: TSB024

Author: Octavia Housing

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Technology Strategy Board
Driving Innovation

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Final Report

Project information

- **ZA reference number:** ZA152J
- **Location of property:** London, W11
- **Date report issued:** July 2011

Contents

1. Project details and directory

The property in London, W11 has been retrofitted to PassivHaus standard.

Monitoring equipment has also been installed in two other properties on the same street, one unimproved and the other improved to Decent Homes standard to provide comparative data on energy usage.

Role	Name & Position	Organisation	Contact Details
Property Owner			
Housing Association		Octavia Housing	Address: Emily House 202-208 Kensal Road London W10 5BN Tel: 020 8354 5500 Website: www.octaviahousing.org.uk
Design Team			
Architect		Paul Davis + Partners Architects	Address: 178 Ebury Street London SW1W 8UP Tel: 0207 730 1178 Website: hwww.pauldavisandpartners.com
Engineer		Princedale EcoHaus	
QS		Pellings LLP	
Environmental Consultant		Jean Pierre Wack	
Contractor			
Main contractor		Princedale EcoHaus	Address: 44 Tunis Road W12 7EZ
Sub-contractor – electric		Princedale EcoHaus	Address: 44 Tunis Road W12 7EZ
Sub-contractor - heating		Princedale EcoHaus	Address: 44 Tunis Road W12 7EZ
PV installer (solar thermal)		Green Tomato Energy Ltd	Serendib House 67a Boston Manor Rd Brentford London TW8 9JQ 02083808908
Supplier - windows		Princedale EcoHaus	Address: 44 Tunis Road W12 7EZ

2. Introduction

The scheme strictly followed the principles of the German PassivHaus system and achieved the first retrofit certification in the UK in February 2011. This project has shown that a deep retrofit in London is possible even in a conservation area where only internal insulation was acceptable to the Planning Authority. The works included 200m^2 of internal insulation, the installation of MVHR ventilation, the provision of solar thermal panels on the roof and the development from scratch of triple glazed sash Victorian look-alike windows.

3. Occupants

The property had previously been used as a family house, but had been let on a short term basis prior to the works starting. The property was decanted and left unoccupied during the refurbishment. A permanent tenant and her family moved in after the works were completed in March 2011. The property was in such a poor condition that extensive works were required and no occupants could have realistically lived in the house whilst the workswere underway. The new occupants were selected by the Housing Association following interviews and visits. The tenant as well as being in housing need showed a keen interest in the principles of Passivhaus and energy conservation.

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	May 2009
Planning application submitted (if appropriate)	March 2010
Planning permission granted (if appropriate)	July 2010
Building Regulations application submitted (if appropriate)	March 2010
Building Regulations approval granted (if appropriate)	March2011
Contract for work let / signed	July 2010
Occupants moved out (state if they remained or property was empty)	March 2010
Start on site	April 2010
Completion of retrofit	November 2010
Occupants moved in	March 2011
Monitoring system commissioned and operating properly	July 2011
Building defects corrected	March 2011
Building services and controls operating correctly	September 2010

5. Pre-retrofit property

The property is a four storey Victorian terraced house built around 1840, which is located within the conservation area of Norland in Notting Hill in the Royal Borough of Kensington & Chelsea. It has been owned for many years by Octavia Housing, Registered Social Landlords.

It is aligned north/east and south/west which allows for pleasant internal daylight in the mornings and evenings.

The property was finally chosen because it was in very poor condition and there was plenty of scope for a deep retrofit. When put forward for the government Retrofit for the Future programme, the dwelling was in need of a full refurbishment. The existing stairs needed to be replaced and the walls entirely re-plastered. Externally, the house had not been altered from its original appearance, except for the ground floor front elevation that had been rendered. We understand that this street was previously fitted with shop fronts at ground level that could explain the 'plainness' and lack of ornamentation of this part of the elevation. The original footprint was relatively narrow and the room sizes constricted at the rear by the stair and circulation space.

A small brick shed, later demolished, was located at the rear of the building on the ground floor. Aesthetically, it did little to contribute to the character of the house and shaded the adjacent windows, diminishing the available light. Also, it did not appear to be an original feature of the house.

Two other properties on the same street will also be monitored for two years using the same equipment used at the retrofit property with the aim of providing comparable data. All three properties are terraced houses and have similar layouts and areas. However, the other two properties have been refurbished to a Decent Homes standard and a basic standard and have much lower levels of thermal insulation.

6. Design

Passivhaus is a design philosophy based on solid physics, quantified in a set of low energy standards and honed over 20 years of implementation across Europe. The design challenge in this project was to meet these rigorous standards in the retrofit of a Victorian house in a conservation area, whilst ensuring an end product capable of responding to the vagaries of the British climate. Aimed at social housing, the design had to be functional and robust with detailing kept neutral and simple to allow families to feel welcome. Removal of old plaster and chimney breasts has reduced the space loss from internal insulation to only 6m^2 (out of 160m^2) and careful consideration of layouts has ensured wide staircases, easy access and comfortable room sizes.

Standard building techniques and accessible materials have been adapted to produce innovative solutions throughout the building. The floors have been re-hung on steel beams which rest in insulated pockets within the party walls eliminating problems of airtightness, thermal bridging and condensation. Triple glazed imitation sash windows have been developed specially for the project to meet strict planning criteria. A labyrinthine

underground heat exchanger to provide warmth in winter and cooling in summer has been constructed under the cellar floor within the footprint of this small London dwelling. Insulation has been applied in two layers with an unbroken airtight layer sandwiched between these skins to allow Passivhaus design criteria to be met. Most hot water is provided by a high efficiency solar thermal system. This is connected to a “combi” unit which supplies the remainder of water heating as well as providing mechanical ventilation with heat recovery (MVHR) and all space requirements with an exhaust air heat pump. No central heating system or radiators are required.

The only change of consequence to the original design was to move the kitchen to the lower basement area from the ground floor living area as was originally planned. It became apparent as the construction progressed that the living room area on the ground floor would be too small for a family sized dwelling and the decision was therefore taken to lose the bedroom planned in the basement and replace it with a decent sized kitchen. This did not affect the planned energy conservation aspects of the scheme, but it did reduce potential occupancy from 4 Bed, 6 person to 3 bed, 5 person and hence the rental income stream and the financial viability of the scheme.

There were other smaller changes during the construction works, primarily to improve the amenity of the rear garden for the future tenants by installing raised wooden decking, providing a metal grill to the kitchen light well for safety and increasing the heights of the garden walls to adjacent properties to improve privacy. In carrying out the works, Octavia was mindful that the property when completed should be an attractive and functional family home.

The project has provided both proof of the original concept and the opportunity to showcase radical new designs. The previously damp, cold and draughty house has become a warm and comfortable home without condensation or moisture problems, with passive cooling in the summer and with a constant supply of fresh, filtered air significantly improving air quality. The exceedingly low energy demand of the house will insulate the tenants against future fluctuations in energy costs. The performance and comfort levels of the home will be monitored for two years minimum. It seems no exaggeration to say that this project, building on the architectural heritage of London, will provide a true home of the future.

7. Construction

- Procurement: Negotiated tender with Ryder Strategies (Europe) Ltd (now known as Princedale Ecohaus)
- Contract type: JCT 2005 - Design and Build Main Contract Revision 2 2009
- Contract structure: Main contract with direct labour covering most trades plus some sub-contractors
- Sub contractors: Green Tomato Energy Ltd who primarily provided project management advice on heating and energy conservation issues, particularly in relation to achieving PassivHaus accreditation. Eight Associates specialising in eco-ratings and energy modelling.
- Specialist installers: Insulation ties; Carbon ties; MVHR with heat pump (Genvex Ltd); Solar panels with drain back; Insulation (Kingspan); Foam glass.
- Specialist equipment suppliers: Triple glazed windows and highly insulated doors designed and manufactured by Ryder Strategies.
- Site supervision: Clerk of Works employed by client. Visiting inspections.
- Role of architect: Paul Davis & Partners retained to provide layout design and oversee construction detailing.

The main driver was to complete a prototype retrofit that achieved the rigorous requirement of the Passivhaus standard. But we were also keen to ensure that the finished project resulted in a comfortable and functional home for the new occupants. We tried to avoid the potential pitfall of concentrating on the former to the detriment of the latter. The role of the clerk of works we employed was vital in ensuring that the basic requirements of the building regulations were not forgotten in the excitement of installing and testing state of the art heating and ventilation systems. This same principle applied equally to the more mundane tasks of contract administration and health and safety compliance. In the event the Royal Borough of Kensington and Chelsea's Building Control Department, put the scheme forward for an award.

Another important feature of the construction process was the design and manufacture of windows and doors that had to meet Passivhaus standards of maximum air tightness. The components were not available in the UK and the decision was taken to manufacture them ourselves. Ryder Strategies were therefore tasked with buying the necessary machine tools and setting up a workshop to carry out the manufacture. Clearly this involved significant cost and time risks for the project overall. Target costs and programme were achieved and this was largely down to Ryder Strategies who had the necessary technical expertise and commitment to deliver the finished products. Ryders were given the copyright to the windows and doors produced and this undoubtedly incentivised their performance.

All the above was achieved by close co-operation between members of the project team led by the client. Regular monthly meetings of the project team were held on site and obstacles overcome and progress maintained.

8. Commissioning and occupancy

The commissioning of the mechanical and electrical services within the building was carried out by Green Tomato Ltd and Ryder Strategies Ltd. No issues or problems were reported to the client at the time and none have surfaced since the building was occupied in March 2011. The temperature and ventilation controls default levels were agreed by the client and the control unit in the living room was set at these levels.

The occupant was selected by Octavia's letting team from a list of potential nominations provided by RBKC. Our lettings team were fully briefed on the nature of this project and had been made aware of the need to choose a tenant who would themselves be interested in an environmentally advanced dwelling and would be able to adapt easily to this new environment. The new tenant was also provided with a bespoke resident's handbook that explained as clearly as possible the unusual nature of the scheme, how to operate the heating and ventilation controls, and the specialised maintenance procedures that would need to be undertaken periodically by Octavia.

9. Costs

Cost control was very important because not only were we employing new technology, we were also gutting a Victorian property with all the risks attendant on a complete refurbishment verging on a new build. A key task therefore was to obtain a realistic budget cost before work began. This was complicated by the fact that different elements of the work attracted different rates of VAT. We therefore established a system of variation pricing based on an open book approach at the outset even though we were using a D & B form of contract. This was needed because as well as identifying the need for extra work during the course of the contract, we as the client wanted to upgrade the specification from time to time, e.g. installing decking in the rear garden. The change in location of the kitchen also had to be carefully managed so as to minimise additional costs.

The costs shown below are exclusive of VAT and interest charges.

Item Stage>	Design stage		Post-construction		Comments
	Materials	Labour	Material	Labour	
Management and administration		9,900	14,935		Covers Octavia's, the employer's agent's and the CoW's costs
Design		12,000		3,141	All consultants' fees
Construction overall					
- Prelims				17,708	
- Fabric measures			36,438	54,654	Estimated breakdown between materials and labour.
- Building services (conventional)			16,218	6,950	Ditto
- Low /zero carbon technologies			58,010	14,503	Ditto
- Other				7196	Miscellaneous
- Consequential costs				11,430	Passivhaus accreditation & security costs
Occupant temporary housing					Property was vacant
Monitoring equipment			11,520	4,784	
Monitoring and reporting service					Currently unknown
R&D costs (please detail)		22,930	39,000		Cost of designing and manufacturing PH windows and doors

10. Wash-up meeting

Attended by the members of the project team, namely Octavia Housing, Ryder Strategies, Paul Davis & Partners, Green Tomato and Eight Associates.

A discussion of time scales and where we may go from here was discussed. The main meeting revolved around final costs and outstanding actions. Contributions for the Final report to the TSB were also sought.

11. Doing it again

1. This project has enabled us to trial the PassivHaus principle whilst refurbishing one of Octavia's oldest properties and has been a major positive for the organisation. The need to move away from mechanical solutions to deliver decent homes is becoming paramount as we consider the future delivery of heating systems. In the past, this has been limited to upgrading heating plant, typically by replacing an old "D" rated boiler with an "A" rated equivalent. In future, we are seeking to ensure that as far as possible heat generated is captured and retained (low losses) rather than running high inefficient heating systems. This project also shows that it is possible to move away from gas operated systems whilst producing low levels of CO_2.
2. The project did not specifically raise any issues that we would definitely not repeat, but it highlighted the fact that to obtain the very high levels of thermal insulation and air tightness achieved at this property was an expensive option. The associated costs of the necessary plant and equipment would also limit us. Finally, the high cost of designing and manufacturing bespoke triple glazed windows and insulated external doors would also be an issue.
3. Clearly this was a single dwelling project and no economies of scale were possible. It was also located in a conservation area that required special design features, e.g. Victorian style windows. Achieving the PassivHaus criteria was our main goal and that required taking a number steps that we would not take in a normal refurbishment. In future refurbishments, we would not seek PassivHaus certification (a significant saving) and we would reduce the levels of thermal insulation on the external walls; nor would we use triple glazing.
4. More time was needed on the design prior to the start of work to carry out extended modelling and to investigate other thermal materials to perhaps capture savings that may have existed through a reduced specification. The project team embraced the spirit of the PassivHaus approach, but at a cost.
5. The operation was a total success, programmed time scales were achieved and the team worked to a very high standard; no major variations or improvements to the heating system were required once construction began.
6. The commissioning process was carried out by Octavia (client) and the operational team with minimum problems. The process of finding a tenant did cause some delays as a true PassivHaus property was not something we were familiar with and it was more difficult to put the concept across to potential residents. However, we designed an information handbook and a tenancy agreement that captured what we believed

to be the requirements necessary to live in such a property. For example, we had to stipulate that Octavia and the TSB required that monitoring equipment was to be installed and periodic access would be necessary for maintenance and other purposes.

7. Efficiency gains could clearly be made on a larger scale project involving more properties - a cost reduction of 20%-30% might be expected through bulk purchasing materials alone. However, the PassivHaus standard requires a level of skill in construction and finishing that is sadly not typical. Day to day site workers would need to be made fully aware of the reasons and outcomes of poor workmanship in this form of construction. In consequence, the need to train/monitor/manage a larger work force is likely to cost significantly more than a standard build. Nevertheless, we estimate a saving would still be expected of at least 20% on a 50+ property project.
8. To achieve full replication of this project together with the requisite standards across all future refurbishments is possible but at a cost that is basically more than most social landlords would be prepared to pay. A key component in helping to reduce this cost would be intervention by central government to provide grant funding at a higher level than currently exists. Currently the level of CERT/CESP funding is the same provided a set thermal value is achieved (U value), approx 0.35. The PassivHaus level is much more stringent at 0.15, but the level of funding is the same. The carbon savings are also much greater.

12. Business benefits

The kudos that Octavia Housing has gained from this project has been considerable. The number of interested people who have attended our open days has run into the hundreds. We realised the cost was going to be high but it was important to shatter the myth that it was not possible to achieve a PassivHaus standard on the refurbishment of a Victorian street property. Octavia Housing has approx 2000 street properties that could benefit from such a refurbishment. The objective of refurbishing a mid Victorian street property in a conservation area with no off street parking was clearly achieved and has led us to include six PassivHaus houses and flats in a new project in Shepherds Bush.

The costs of the TSB project and the energy data generated are available to all for scrutiny. Octavia staff have also attended a number of conferences to inform people about this exciting project and the tremendous levels of thermal insulation and CO_2 reduction that can be achieved in an older property.