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: ZA491L
Property number(s): TSB027

Author(s): PRP Environmental

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

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SBRI Government challenges. Ideas from business. Innovative solutions.

Final Report

Project information

- **ZA reference number:** ZA491L
- **Location of property:** DA1, Dartford
- **Lead participant details:** PRP Architects, 10 Lindsey Street, London, EC1A 9HP
- **Date report issued:** 31 May 2011

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1. Project details and directory

Role	Organisation	Contact Details
	Dartford BC	Address:Dartford Borough Council, Civic Centre, Home Gardens, Dartford, Kent, DA1 1DR
LA	Dartford BC	Address:Dartford Borough Council, Civic Centre, Home Gardens, Dartford, Kent, DA1 1DR
Architect	PRP Architects	Address:10 Lindsey Street London EC1A 9HP Website: http://www.prparchitects.co.uk/
Engineer	Colin Toms & Partners	
QS		
CDM Coordinator	Bottone Associates	dom.dba@virgin.net
Main contractor	Connaught	No Longer Trading
Subcontractor – electric	G5 Consult	
Subcontractor - heating	Britheat	
PV installer	Newform Energy	
Supplier - windows	Sheerframe	

2. Introduction

From the outset our aim was to analyse the technical feasibility and economic viability of reducing carbon dioxide emissions from post war semi-detached houses, built using traditional masonry construction, by 80%. Our objective was to undertake this analysis utilising the skills of the expert consultants and contractor in our team, whilst engaging with the dwelling tenants and suppliers of innovative construction materials and technologies to develop a whole house solution which is appropriate for this house type and ultimately economically replicable around the UK. Another important objective was to develop a solution which can be implemented whilst the residents are in occupation, as we recognise the majority of homes will be occupied and circumstances will not typically allow residents to be relocated for the duration of the works.

We also recognise that the application of whole house solutions to the UK's housing stock could damage the character and heritage of our towns and cities, but could also be seen as an opportunity to improve the appearance of streetscapes. We believe the dwelling being considered has no specific architectural qualities and the external appearance can be enhanced through the installation of the proposed energy efficiency measures. The proposals will therefore not only reduce energy consumption and carbon dioxide emissions but improve the visual aesthetics of the house too, the combination of both will, we envisage, enthuse the residents to take greater ownership of where they live and take greater participation in playing their part as occupants in reducing emissions from the house.

3. Occupants

There were different occupants immediately before the retrofit and afterwards.

The project started whilst the original occupants were in-situ. This soon became an issue and the relationship between the tenant and contractor became stressed. It then became clear that at the outset we had put too much emphasis on choosing a property that suited retrofitting and did not pay enough consideration in choosing the right tenants. This resulted in the LA moving the tenants out and into another property whilst the remaining works were completed.

During the remaining construction period the LA interviewed prospective tenants and tested them specifically on their interest in energy saving measures, as well as their ability to test and use the products that we were fitting to the property.

This proved beneficial in the long run as once the works were completed the new tenants moved in and we were instantly able to educate them on the products within the property and liaise with them on any issues they had.

In our opinion, educating tenants before measures are installed, and involving them in the construction process is key to any successful retrofit project.

Make-up of occupants before and after the retrofit:

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

4. Dates

Event	Date
Project start date (when was the first proposal discussed or agreed)	04.02.10 Initial meeting with DBC/Connaught
Planning application submitted (if appropriate)	N.A
Planning permission granted (if appropriate)	N.A
Building Regulations application submitted (if appropriate)	19.03.10 Building Notice submitted
Building Regulations approval granted (if appropriate)	Acknowledged 25.03.10
Contract for work let / signed	22.04.10
Occupants moved out (state if they remained or property was empty)	Tenants in occupation during build
Start on site	19.04.10
Completion of retrofit	09.08.10
Occupants moved in	28.06.10 (Day of launch event)
Monitoring system commissioned and operating properly	
Building defects corrected	
Building services and controls operating correctly	
Programmed completion date (delayed by additional works items added by DBC and delays to PV-T)	18.06.10

5. Pre-retrofit property

The house is a post Second World War suburban mid terrace 2 bed house. It has masonry cavity wall construction, with painted pebble dash finish to all facades. The house has a rectangular shaped plan and a duo pitch front to back roof. Due to the nature of the mid terraced housing, access to the rear of the property is restricted (i.e. through the house).

Of the two neighbouring properties, one is in the ownership of Dartford Borough Council, whilst the other is in the ownership of a private freeholder. The property in the ownership of Dartford Borough Council has been selected for external insulation upgrades, but these works were carried out under a separate contract.

The property was selected from a shortlist of volunteer tenants.

6. Design

The following technologies and innovations were proposed to be used in conjunction with established approaches such as mineral fibre insulation to the roof space: -

- Photovoltaics and solar thermal –
  'PV-T' high efficiency hybrid solar panels from Newform Energy Product increased solar PV efficiency by water cooling PV panels and adding the waste heat to the solar thermal circuit, designed for ease of installation and low impact appearance.

- Greater than usual thickness of insulated external render - from Permarock UK

- Triple glazed windows from Janex

- Use of Nanogel insulation for the floor

- LED lighting - from PhotonStar LED Ltd (an SME based in Southampton)
  A new product developed for social housing that uses 6.7w lamps and has a much extended life over incandescent or even compact fluorescent bulbs. It will be used with a lighting control system to maximise efficiencies.

- Flue gas heat recovery –
  the Zenex Gas Saver, an innovative use in combination with a solar thermal system

- Waste water heat recovery system - the Recoh-Vert (subject to detailed design)

- Low-energy decentralised whole house ventilation - Part F type 3

- Real time energy display system - from Microwatt

- Solar doorbell

Proposals for the retrofit changed in the following areas.

<u>Real time Energy Display</u>
The Microwatt display was substituted for a technically superior Trio+ display from Green Energy Options

<u>Ventilation</u>
The original phase 1 proposal for a passive ventilation system was substituted at phase 2 with Distributed Whole House MEV (always on low energy extract fans in kitchen and bathroom) as it is our experience that residents do not trust passive systems as they associate the lack of fans with the idea that there is inadequate ventilation, often installing additional fans. It was also considered to be very difficult to design a retrofit passive stack system.

Some white goods different

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

The tenant also wished to retain their tumble dryer for which no A rated alternative exists. Instead the tenants were given advice about how much energy a tumble dryer uses compared to line drying. The real-time energy display should confirm this.

Solar doorbell

Omitted as no suitable product could be located.

Windows

Very high performance windows are often manufactured without trickle vents as they are detrimental to the thermal performance of the window frames and are likely to be used in Passive House performance standard dwellings with very low air permeability and MVHR. In retrofit projects where high levels of air tightness are difficult to guarantee, and where MVHR is not specified, the chosen ventilation strategy of distributed whole house MEV can comply with Part F building regulations only with airtightness and dwelling volume ratios sufficient to allow the fans to move enough air. Since the air tightness levels were unpredictable it was chosen to specify high performance trickle vents in the triple glazed window units to cover the risk of there being insufficient ventilation.

Waste Water Heat Recovery

It was possible to install WWHR at Willow Road but the originally intention to use the shower integrated 'showersave' unit was changed to a similar system which is suitable for the bath arrangement.

7. Construction

The contractor for this project (Connaught) ceased trading shortly after the completion of the retrofit process and are consequentially unavailable to comment on this section of the report. From the point of view of the other project partners construction aspects of the project appear to have been well handled.

Despite a poor tenant relationship the contractor expedited the project professionally and courteously.

Windows

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

8. Commissioning and occupancy

Commissioning of active equipment was mainly carried out by Connaught or their sub-contractor. These aspects of commissioning include the underfloor heating and boiler / FGHR and despite some initial issues with the weather compensator have been professionally and well dealt with.

The PV-T system was installed and commissioned by a sub-contractor of the supplier (Newform Energy) and continues to have issues. Beginning with a leaking roof and solar liquid circuitry these issues have been resolved where possible, initially by Connaught and later by a private contractor, led by an ex-Connaught member of staff. The continuing issues with the PV-T cannot effectively be resolved until monitoring is underway.

The retrofit environmental monitoring partner chosen by the team was Microwatt. There have been considerable issues in attempting to have the environmental monitoring installed and commissioned. There is currently a partial installation of some of the monitoring equipment; most specifically this does not include a heat / flow meter for the solar thermal aspect of the PV-T. Microwatt has recently ceased trading and Rickaby Thompson Associates are being commissioned to expedite the monitoring.

Utility monitoring has so far been faultless, however the tenant has recently been complaining of high electricity costs (potentially due to pre-payment meter use) and it is proving difficult to access meter data to assist in analysing this issue.

9. Costs

Item Stage	Design stage Materials	Design stage Labour	Post-construction Material	Post-construction Labour	Comments
Management and administration					
Design	£32,326.00		£32,326.00		PRP architectural, environmental and CDMC fees based on Connaught Contract BoQ
Construction overall	£120,774.00		£120,774.00		based on Connaught Contract BoQ
- Prelims	£23,438.86		£23,438.86		based on Connaught Contract BoQ
- Fabric measures	£30,683.50		£30,683.50		based on Connaught Contract BoQ
- Building services (conventional)	£17,494.89		£17,494.89		based on Connaught Contract BoQ
- Low /zero carbon technologies	£27,851.78				PV-T cost from Connaught Contract BoQ
- Other (add more rows and break down costs further if you wish)	£16,440.97		£16,440.97		Remainder from Contract sum, less monitoring cost (below) for Decent Homes works etc.
- Consequential costs	£0.00		£0.00		
Occupant temporary housing	£2,432.25		£2,432.25		Current Microwatt quote
Monitoring equipment	£2,431.75		£2,431.75		Remainder from total £4864 allowed for monitoring in BoQ

Monitoring and reporting service	£32,326.00	£32,326.00	PRP architectural, environmental and CDMC fees based on Connaught Contract BoQ
R&D costs (please detail)			

10. Doing it again

Definitely do again
-Wall Insulation
-Deep cills (moving windows forward into new external insulation)
-Launch event
-Secure products early on
-Undertake research into potential suppliers early on
-Waste water heat recovery (although attributing savings would be better)
-All thermal bridging measures
-Zenex FGHR / Alpha boiler FS1 system

Definitely not do again
Working with the tenants in situ throughout a whole house retrofit project was very stressful for the tenants and contractors alike.

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

Design process improvements
- Allowance for external calculation of savings outside SAP / PHPP - individual heat recovery ventilation, multiple appendix Q measures; time and temperature TRVs, more integration with construction team in terms of practicality of measures and explanation of scope of works.
-Methodology to include tenant behaviour; especially the likelihood of taking up in comfort increases potential savings.
-Use of 'greener' products where possible
-Modelling to actual tenants to help manage expectations
-A simple method for calculating thermal bridging, or rules of thumb for existing typical construction techniques, would improve this aspect of the design process. We chose to use the SAP default value both before and after improvement since it is difficult to calculate for the existing case and is likely to be poor and since, although we have included measures to counter thermal bridging we have perhaps simply corrected for increased thermal bridging due to better surrounding u-values.

Construction process improvements
-Toolbox talks
-More frequent during construction visits
-Restriction of subcontractors (and or closer management of sub-contractors by the whole team (including the design team)
-Keeping Decent Homes improvements more clearly separate from retrofit improvements financially Single organisation for integrated system provision (e.g. heat distribution, heating

system, and controls)

Commissioning improvements

Tenant advice sessions / training similar to that undertaken by RELISH (www.relish.org). Training of tenant / landlord liaison staff in the retrofit process, the systems installed and their efficient operation and maintenance

Replication at scale

We recognise that a fundamental principle of Retrofit for the Future will be the ability to apply specific proposals for one house to larger housing groups and wider areas. This must be judged not only in terms of technical feasibility, but also visual amenity, so that the low carbon home becomes the norm and acceptable to the majority of people. For these reasons we have not tried to radically change the appearance of the house in an eccentric way, but have opted for materials that will be familiar to residents and appropriate to long term maintenance whilst providing an improved visual aesthetic.

The overcladding we have chosen, whilst in this case has a familiar render surface, is capable of a range of other finishes so that 'becoming the norm' does not end up being monotonous and there is the opportunity for variations in material, texture and colour for individual homes or complete terraces.

A mechanism for decanting tenants at times of intense retrofit activity, alongside a programme of managing expectations to achieve the greatest satisfaction possible for the occupants with the improvement works and the process.

Market and policy certainty is needed, so that contractors and supply chains can gear up to undertake the millions of necessary retrofits.

Term agreements for contractors with larger landlords in order to extend the usual range of property services to include whole house retrofit.

Whole house plans for every property with identified trigger points for intervention e.g. when roof works are necessary take the opportunity to install rooftop solar technology; when a property becomes empty take the opportunity to complete the whole house retrofit - where a landlord has a typical 4% void rate potentially all properties could be retrofitted over 25 years without having to decant any resident

Smaller projects over a period of time would help complete the works whilst tenants were in occupation. This would make the construction phase shorter and more convenient to the tenants and also ease them into a retrofit/energy saving mindset.

We should also take the opportunity to retrofit whilst completing other large programmes of work such as kitchen and roof replacement.

11. Business benefits

Dartford BC have undertaken 2 major studies into their housing stock in order to progress towards roll-out of energy retrofit works, starting with an initial 100 home pilot and progressing to a whole stock plan. Budgetary requirements and mechanisms are currently being processed.

Dartford BC have benefitted from participation in the Retrofit for the Future programme and are currently assessing budgetary mechanisms to implement a whole stock retrofit programme. PRP have consolidated their reputation in the retrofit field and have participated in several multi-property (10-30) retrofit programmes as well as production of Retrofit Guides. It is expected that this sector will extend and expand over the next 5 years and that PRP will continue to develop in this area, with increasing demand.

12. Additional Information

The original specification, of flue gas heat recovery in combination with a system boiler (rather than the more usual combi' boiler), proved problematic in terms of supplier, with our initial supplier stating that this combination could only be provided as an experimental product, and therefore without warranty. Again the team were able to locate a second supplier without causing delay to the project.

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

A number of window manufacturers needed to be investigated in order to be certain of supply of windows that fit the design criteria and landlords requirements. There are very few manufacturers that can genuinely provide windows with the required whole opening U-value required for the project.

Avoid undertaking intensive works with tenants in situ wherever possible.

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

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

Clearer communication between tenant / landlord and subcontractors was needed, to arrange access and manage expectations

Greater advantage of funding opportunities: In this project it would have been better to remove PV from the TSB funding to allow the FiT to be claimed, but there still would have been a risk attached to this, since it could still be refused on the grounds of having already received Government funding.

Smart meter roll-out certainty.

System 3 ventilation might include heat recovery.

A whole house plan identified with trigger points for compatible potential improvements to be undertaken over a 25 year period with replacement items such as windows and boilers being made at natural cyclical replacement times.

Less reliance on maximum rooftop solar technologies at the outset, with provision to practical maximum included in whole house lifetime plan (rather than the amount needed to reach target).

Tenant reaction to the retrofit process is unpredictable, and one outcome of this project is a greater understanding of tenant expectation management.

'Hidden' advantages of works such as lessening summer overheating, e.g. faster wash times from A++ washing machines, better lighting quality from LED lights, need to be identified and communicated to residents and landlords.

Clearer demarcation of responsibilities would have improved the project, i. e. clearly delineating subcontractors responsible for measuring roof area for suitability.

Lack of product for solar doorbell a disappointment.

A solid floor insulation product is needed.

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

Monitoring organisations that can undertake utility, environmental, and renewable monitoring at a reasonable cost are few and far between at the time of writing.

Informing neighbours of the nature of the works and the construction timetable.

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

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