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: ZA390M
Property number: TSB085

Author: Plus Dane Group

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: ZA390M**
- **Location of property: Liverpool, L15**
- **Lead participant details:**

Plus Dane Group
Address: 172 Park Road
Liverpool L8 6SJ
T: 0151 330 3476
Web: www.neighbourhoodinvestor.com

- **Date report issued: 23 May 2011**

## Contents

# 1. Project details and directory

**Project Team**

| Role | Organisation | Contact Details |
|---|---|---|
| Project Lead | | |
| Project Manager | Plus Dane Group | Address: 172 Park Road, Liverpool L8 6SJ<br>Tel:0151 330 3476<br>Website: www.neighbourhoodinvestor.com |
| Property Owner | | |
| Registered Social Landlord | Plus Dane Group | As above |
| Design Team | | |
| Building Surveyor | Larrosa Marshall & Associates (Building Surveyors) | 0151709 2141 |
| Energy Consultant | Camco | 172 Tottenham Court Road London W1T 7NS<br>T: +44 (0)20 7121 6100<br>Web: www.camcoglobal.com |
| Engineer | Rodney Environmental | |
| Contractor | | |
| Main contractor | Penny Lane Builders | |
| Insulation contractor | Maple | |
| Monitoring contractor | Parity Projects | |

## 2. Introduction

This is a highly innovative and truly inspirational project that incorporates the principles behind PassivHaus within the extensive refurbishment of a property. This pioneering approach attempts to address the energy needs of the property with a comprehensive package of measures, to achieve a significant emissions reduction. The work aimed to transform the property - not only about 'making good', but about making a fundamental change, which will bring the house back into use.

Applying PassivHaus (PH) standards is relatively limited in the UK, including for new build, although it is an established approach in parts of Europe. Applying PassivHaus to existing stock is even rarer. In this project, the principles behind PassivHaus were designed into the refurbishment right from the start, to aim for ambitious low energy and low carbon targets.

## 3. Occupants

The occupants are new occupants after the retrofit of an empty or void property.

**How the new occupants were selected**
Plus Dane distributed c. 1,200 leaflets within the immediate area around our property to seek expressions of interest from local families to move into the property once works were completed. There was a poor response to the leaflets. Immediately after this, the Liverpool Echo ran an article titled ‘Could you be Eco tenant?’ which highlighted plans for the house and Plus Dane received nearly 70 applications from families across Merseyside. Plus Dane shortlisted and interviewed these families, and selected a family of four who were ideal candidates. They were previously living in a small flat and needed more space. The family were also very much wanting to lead more sustainable lifestyles, but unable to do so in the existing accommodation.

## 4. Dates

**Timeline of key dates**

| Event | Date |
|---|---|
| Project start date | October 2009 |
| First proposal agreed | 06.11.2009 |
| Planning application submitted (if appropriate) | n/a |
| Planning permission granted (if appropriate) | n/a |
| Building Regulations application submitted (if appropriate) | 10.03.2010 |
| Building Regulations approval granted (if appropriate) | 25.05.2010 |
| Contract for work let / signed | February 2010 |
| Occupants moved out (state if they remained or property was empty) | Property was empty |
| Start on site | 01.03.2010 |
| Completion of retrofit | 28.10.2010 |
| Occupants moved in | 29.10.2010 |
| Monitoring system commissioned and operating properly | 21.10.2010 |
| Building defects corrected | 22.10.2010 |
| Building services and controls operating correctly | 21.10.2010 |

## 5. Pre-retrofit property

The house in this project (TSB085) is a 3 bed two storey 'L' shaped Victorian end terrace, with solid walls and a traditional pitched roof. The property was configured as two flats. It was in a poor state of repair, with a very low SAP score, primarily due to a lack of any thermal insulation except a settled, single layer of quilt in the roof. Heating was provided by two open front gas fires in each flat, with DHW provided by electric immersion.

This property was selected to demonstrate the potential for extensive whole house refurbishment for properties undergoing major works, providing the potential for radical improvement. Also, the project was selected to assess the potential for refurbishment using internal insulation measures.

Plus Dane Housing Group own and manage approximately 12,500 homes across Merseyside and Cheshire. Within this portfolio, there are approximately 1,300 homes of solid wall construction built more than 100 years ago. Many of these properties are located in traditional back-to-back terrace configurations and, due to planning and ownership issues, it is not always possible to undertake external insulation works. The only viable alternative to improve the thermal performance of external walls is through the provision of internal insulation measures.

## 6. Design

This project used PassivHaus principles, which unite key technologies in a new and innovative approach to a retrofit project. The essential measures contributing to this approach include high performance insulation and windows, high levels of air tightness, mechanical ventilation with heat recovery (MVHR) and solar water heating.

It is the first time (to the team's knowledge) that an MMC (Modern Method of Construction) system has been used in retrofit, in this case through the Maple SupaWall system. The key component of the SupaWall is a closed timber-framed panel, comprising 140mm studs sheathed both sides with Oriented Strand Board (OSB) and filled with polyurethane foam insulation. The interior of the panel is faced with a heat reflective membrane, and an air gap is left between it and the internal wall cladding.

The Paul Multi 100 MVHR unit features the highly efficient counter-flow channel-type heat exchanger, and is a PassivHaus accredited unit. It has a heat recovery efficiency up to 98%. The unit is entirely sound-proofed and heat-insulated, avoiding thermal bridging.

A solar thermal system was proposed to support hot water provision. A Solartwin solar water heating system was proposed at the design stage. The solar panel was changed to Worcester Greenskies as the Solar Twin system required a header tank, which the team considered problematic.

High performing triple glazed windows were proposed, in line with the ambition of achieving high thermal performance of the dwelling. NorDan's New NTech Passive windows were proposed at the design stage, but unfortunately the windows could not be delivered in time. So not to further delay the project, triple glazed windows were sourced from West Port, which are also PassivHaus accredited.

## 7. Construction

**Procurement**
The project was negotiated with one of Plus Dane's framework contactors, Penny Lane Builders. Penny Lane Builders has worked with Plus Dane for many years, and are considered an excellent local contractor. Penny Lane had been involved in a substantial long term void improvement / renovation project with Plus Dane and Larrosa Marshall. TSB085 was a property considered under that programme.

**Contract type**
The Intermediate contract 2005 was used, under a standard construction contact, Joint Contracts Tribunal (JCT).

**Contract structure and specialist installers**
The main contract was for direct labour, covering most trades, plus some sub-contractors for specialist installations (such as for specialist heating and plumbing and solar installations). Monitoring equipment and systems were installed by a specialist (Parity Projects) directly employed with assistance provided by Penny Lane, by the way of preliminary wiring.
Specialist equipment such as the Paul MVHR unit and solar thermal system were procured directly by Penny Lane.

**Site supervision**
Plus Dane provided a Clerk of Works and Penny Lane employed two levels of supervision, at management and site manager level.

## 8. Commissioning and occupancy

**Commissioning**
The monitoring equipment was tested and commissioned by Parity Projects. The solar thermal system was commissioned by the installing contractor and the back-up heating by Penny Lane's in-house plumbers.

The MVHR unit was commissioned by the manufacturer (Paul) and the system balanced by Rodney Environmental. Rodney Environmental and the Paul specialist briefed the occupants on the use of the system, and this was subsequently backed up with a user guide (Appendix A: Building User Guide).

**Occupancy**
Plus Dane has provided the new tenants with training on how to use the equipment within their home, most importantly the MVHR unit. A 10-inch home user display monitor has also been installed in the kitchen that displays current energy generation and usage throughout the property in real time. The team produced a plain English user-friendly guide for the residents on the use of the equipment (Appendix A: Building User Guide).

## 9. Costs

| Item Stage | Design stage | | Construction Phase | | Comments |
|---|---|---|---|---|---|
| | Materials | Labour | Material | Labour | |
| Management and administration | | | | | |
| Design | | £24,814 | | £24,814 | Larrosa Marshall |
| Construction overall | | | | | |
| - Prelims | £14,294 | | £14,294 | | |
| - Fabric measures | £12,000 | £4,000 | £12,000 | £7,000 | PLB assist pf Maple |
| - Building services (conventional) | £9,050 | £1,650 | £9,050 | £2,500 | Cost addition for parity wiring by PLB |
| - Low /zero carbon technologies | £6,160 | | £6,560 | | MVHR and Solar Thermal spec change |
| - Renew roof | £1,950 | £2,000 | £1,950 | £2,000 | |
| - Triple Glazing and Doors | £18,200 | £2,000 | £18,200 | £2,000 | |
| - Site preparation | £57,400 | £5,000 | £57,400 | £1,500 | Strip out and removal of asbestos. |
| - New Conservatory at rear | £2,800 | £1,200 | £2,800 | £1,200 | |
| - | | | | | |
| - Painting and Decorating | £1,500 | £2,000 | £1,500 | £2,000 | |
| - Other costs | £24,240 | | £21,090 | | Drainage, kitchen and bathroom fittings, external works |
| Occupant temporary housing | | | | | Property was empty |
| Monitoring equipment | £5,450 | | £5,450 | | Parity Projects |
| Monitoring and reporting service | | | | | |
| R&D costs (please detail) | | | | | |

## 10. Wash-up meeting

A wash up meeting was held on 6 December, 2010 attended by Plus Dane, Penny Lane Builders, Maple Timber Frame and Camco.

**Main elements discussed**

A whole house retrofit approach to the levels targeted under Retrofit for the Future is currently unfeasible and cannot be replicated across other void properties, due to the funds required. The air-test result is very good, considering the starting-point. However, the time and cost to achieve this is very high and will not be replicated for volume retrofit.

The market forces and lack of funding suggest projects in the near future may need to aim for 80% of the performance, at 50% less cost than this particular demonstration. Maple has proposed a matrix of solutions (different “grades” of thermal performance/solution) so that differing housing stock can be addressed with a choice of cost and performance measures.

There would be value in calculating which retrofit measures gave the best results in terms of reducing carbon emissions/reducing fuel bills versus their capital cost.

The group also discussed the human side to the project and how ultimately this is as important as the technological aspect. The project experienced initial problems with the pre-allocation of the house, and also struggled with the user-friendly guide. These obstacles should not be underestimated.

The project team recognised at an early stage that the works to TSB085 presented an opportunity to engage with the local community around the broader green agenda. The property is located close to a school and so early meetings were held with the Head Teacher, school co-ordinator, and pupils from the school council to discuss how the eco-principles behind the retrofit project could be used in a school project funded from Plus Dane’s neighbourhood budget. Two specific projects engaging with the school included:

- A dance workshop that had a theme of rainforest destruction, and the discussions on carbon emissions and climate change, which enabled a link to be made to the works at TSB085.
- An art project with 20 pupils designing and then constructing from recyclable materials, their model of an ideal eco house.

## 11. Doing it again

**Problems**

### Construction

- The Maple wall cassette system was very difficult to move and manoeuvre into and around the property.
- The interface between the Maple system and the existing first floor was a major problem. The installation of insulation and sealant between the joists were built into the external walls, but did not work fully, with air leakage resulting from this.
- Air literally poured through the party wall. This was very surprising as it is 215mm thick solid. It was cured by plastering it.
- Deliveries to site of the Maple insulation required man-handling off vehicles into the property.
- A cramped building area meant no stacking of “work in progress” so some components were left on the roadway until the crew were ready to install them.

### Other

- Identification of a family to occupy the property at an early stage was problematic, with very limited response to local leaflets. This was resolved by an article in the local newspaper that helped identify the family.
- At times it was difficult to establish what was required for the purpose of the competition. This was partly resolved by being in contact with the funding and monitoring organisations to keep informed of any developments or changes to requirements. However, this did delay progress of reports and the monitoring strategy.
- Location and time resources made it difficult for teams involved outside of Liverpool (Camco and Parity Projects) to attend meetings and keep updated on the progress of the project. This was resolved by being sent minutes of key meetings, and keeping in phone and email contact with Plus Dane and the design team.
- Some initial problems with linking collected data to the correct monitoring item.

**Good Points**

- Attention to detail, co-operation and enthusiasm of the project team were the main factors in the successful delivery of this project.
- The site operatives were briefed in detail of the aims and technical details of the project and they consequently worked with that knowledge.
- The team quickly became able to think on its feet and adapt as well as learning new ways to undertake conventional works to accommodate the comparatively more stringent PassivHaus principles.
- Clear understanding of the aim of the project by the whole team on the project and the new tenants. This united the whole project team and allowed for a more cooperative build process.
- Inclusion of the residents at a very early stage. The tenants were eager to contribute

to the project, keen to learn about measures brought in and willing to promote the wider benefits of the project.

**Lessons learned**

### Construction

- Lighter-weight/thinner wall panels can overcome the manoeuvrability issues of the Maple walling and cassette panels. A lightweight insulation glued to the external walls to obtain the required specification may also help, which could be easy and safe to carry and install. However, this may have been difficult for this project, given the extreme out-of-plumb and variable dimensions of the existing walls.
- First floor joists could be trimmed back from the walls with the area made good and plastered, allowing the insulation and membrane to pass through.
- The ground floor sub-ceiling worked very well in containing services and could be introduced at first floor ceiling level next time, to avoid penetrations through the top membrane.
- A heavily insulated solid floor would be preferable. The timber one requires a void below that needs ventilating.
- Maple integration was key to achieving the high thermal performance – but it clearly needed all other “builder’s work” and enabling activity to be completed well ahead of Maple manufacture and delivery to avoid any project delays. Key programming must allow all builders work to be completed before the new wall/flooring elements are installed.
- Scaffold co-ordination should allow for placing panels upstairs by using a “hiab” type lift on the lorry and scaffold with a loading-bay at front of building. This would get materials into the building more easily.

### Other

- A real emphasis on value for money on certain aspects of the build phase could have been undertaken more rigorously in order to reduce project costs without jeopardising the planned outcomes.
- High level of costs to deliver the project means that the potential to roll out to other properties is unfeasible at present.
- Ensure any competition requirements do not interfere with the schedule of works and progress of the project (e.g. air tightness tests).
- A more thorough screening process for selected measures that could not deliver for this project.
- Although the monitoring issues can be resolved remotely, the commissioning process will be revised in future by Parity Projects, to ensure that all lines of data are correctly attributed to the item being monitored before leaving site.
- Funding is essential in making replication at this scale successful.

## 12. Business benefits

**Lessons learned in terms of innovation, efficiency or increased opportunities**
The project has enabled Plus Dane to gain valuable experience in retrofitting project work and has also provided an excellent platform to showcase the benefits of retrofitting both to Plus Dane staff and external stakeholders. As a direct consequence of this project, Plus Dane is now preparing an Energy and Sustainability Strategy, which will provide a corporate focus on sustainability issues, with the full backing of the Finance team, Chief Executive Team and Board members.

Following this project, Maple still believe that the installation process can be done by local trades, after suitable training – which will address the task co-ordination/sequencing at site level and lower costs overall.

Larrosa Marshall and Penny Lane Builders have deepened their practical knowledge of applying the ambitious PassivHaus principles, and requirements for extensive low energy retrofits. Both organisations have learned how to ensure the process can be made more cost-effective by streamlining the works.

**Business leads and opportunities**
The Retrofit for the Future project has proved to be very useful in forging links with new suppliers, manufacturers and consultants (Maple Timber Frame, Worcester Bosch and Camco, for example), strengthened relationships with existing contractors and consultants (Penny Lane Builders and Larrosa Marshall). It has also proved to be an exceptional project for showcasing achievements with a great deal of interest from a wide range of stakeholders. Plus Dane has undertaken presentations to local and national forums and has placed the property in SEA's Old Homes Super Homes directory. This led to an 'Open Day' for visitors across the UK in early April 2011. During the Liberal Democrat conference in Liverpool in October 2010, Plus Dane arranged a visit to the property by Chris Huhne MP, thereby raising awareness of the project at the highest levels of central Government.

At present, Maple has seen no follow-on schemes resulting from this project. However, the retrofit agenda is gathering momentum so Maple is hopeful of using its experience for future projects.

The project has bolstered Camco's experience in low carbon refurbishment. The project provided an opportunity to build on PassivHaus expertise and using extensive insulation materials. The project also highlighted the barriers of implementing retrofit projects on the ground and the importance of the human side of such projects. This practical learning has supported the high level work Camco is engaged in.

**Value of retrofit business over the next 5 years**
As Plus Dane is moving forward with a corporate strategy for retrofitting (partly due to

the success of this project), an approximate sum of £500,000 per annum from the capital planned programme is being ring-fenced for delivering retrofitting projects across Merseyside and Cheshire. This will enable Plus Dane to provide match funding to complement other grant funding that it is receiving (ERDF, for example) to deliver a range of works including internal/external insulation, solar PV, solar thermal and biomass boilers.

## Appendix A: Building User Guide

plus dane group

# BUILDING USER GUIDE

Rodney Environmental Consultants
44 Rodney Street,
Liverpool,
L1 9AA.

Tel: 0151 708 0540
Fax: 0151 708 7627

# SYSTEMS OVERVIEW

This house was the subject of an extensive refurbishment in 2010 to achieve much lower energy costs by adopting PassivHaus principals of very high levels of insulation and air tightness.
The building has two systems both automatic with manual adjustment possible to control internal temperatures and fresh air ventilation.

## General

All the systems within the house are monitored externally via Parity Projects, and a simple flat screen monitor is located within the kitchen, and this shows the user within the house how much energy is being used within the house.

It is important to understand that, unlike most buildings, this house makes use of energy efficient ways of achieving internal conditions and that by using the building systems properly will result in a very low running cost for the occupier.

**Heating**
Heating is by radiators fitted with thermostatic valves. The radiators are fitted in ground floor living rooms and the hall. Pipe work has been run to other rooms in the house and it is possible to add radiators if required. The output of the boiler is much larger than the heating requirement of the house and has been sized to provide adequate tap hot water.

The boiler is a high efficiency condensing type and steam coming out of the wall flue is usual.

The user of the property can operate the radiator system via the boiler control unit; there are four options that they can operate.

**Timed:** The timed option is a pre-set option which enables the user to have the heating system on a timed setting, so it comes on at specific time as set by the user.
**Once:** On for one period during the day, as set by the user.
**On:** Heating system on continuously
**Off:** Heating system off continuously

The thermostatic radiator valves turn the radiators on and off in each room automatically on reaching room temperature. The setting of these should always be as low as possible typically around setting 3.Higher settings could result in overheating and they should be set to zero whenever possible once temperatures are reached.

Always expect that radiators will be hot at the top and cold at the bottom.

Radiators that are cold at the top and hot at the bottom are air locked and any air should be cleared by venting the radiator. It may be necessary to top up the boiler water pressure if air is vented out.
If the house is being vacated for any reason in cold weather setting the radiator valves to 2 leaves the heating on tick over.

The boiler should be left to run twice a day.

The dwelling should not be vacated in cold weather with the heating turned off and the MVHR unit left running as the ventilation unit will drive the air supply temperatures too low and the MVHR will lock out.

**Ventilation**
The building has been considerably improved in terms of thermal insulation and air tightness as part of the upgrade project. The air tightness is such that the fresh air ventilation is achieved by the MHVR unit being a Paul Novus 300 situated in the conservatory. This unit draws outside air into a heat exchanger and supplies it through a concealed system of plastic ductwork to ceiling grilles. A similar system of extract ductwork extracts air from the bathroom, kitchen WC and hall and passes the air through the MHVR unit to remove heat from the extract and add it to the supply as an energy recovery feature.

Thus the grilles in the living and bed rooms have fresh supply air passing through them into the room.

The purpose of the ventilation system is to provide a controlled supply and extract air system to each room to enable ventilation in cold weather instead of opening windows.

The opening windows can be used at any time as can the kitchen hood extract system to increase ventilation to remove smells or cool the house.

It will not harm the MVHR unit in any way but if windows are opened in cold weather higher heating costs will occur.

If the house is vacated for holidays or change in tenancy the MVHR unit should be left running.

Should the MVHR unit stop working the expectation will be that the house will become stuffy and windows should be used in the usual manner.

The MVHR ventilation system is controlled via a local control panel, which is located next to MVHR unit in the conservatory. It is fully automatic and needs no attention unless faults occur.

The filters in the MVHR unit should be cleaned and replaced in accordance with the manufacturer's guidelines.

The control of the MHVR does not have any effect on the radiators.

Users are able to amend the speed of the unit by selecting the speed setting on the control panel located next to the MHVR unit, this based on the following:

1- Low Speed
2- Medium Speed
3- High Speed (Highest permanent fan speed)

So in hot weather the usual expectation is that the user of MVHR unit will be able to adjust the system to allow more fresh air into house if required by adjusting the speed on the MVHR unit.
The fresh air inlet on the MHVR unit can alter to suit fresh air conditions entering the unit.

Because the conservatory will always be warmer than the outside then the MHVR unit should be set to draw air from the conservatory to use the free heat of the conservatory.

The conservatory has been constructed with high level air inlets just under the roof to allow air to be drawn in from the outside and these are always open.

When the weather is cold the dampers to the outside should be shut off, and the internal damper in the conservatory should be open.

When the weather is hot the damper in the conservatory should be closed and the damper to the outside should be open.

The decision regards whether the air is to be drawn from the conservatory is left to the user and when the house starts to become warm enough in milder weather the conservatory heat is not needed and the air can be drawn in from the grille in the back entry.

If the dampers are not changed over in the way described no harm will be caused but the conservatory heat will be drawn into the house with resulting overheating.

The MVHR unit has a drain at the bottom to drain condensate out through the wall in cold weather.
This condensate can freeze during very cold weather and the user should place a simple electric blow heater under the MVHR unit to prevent freezing.

The conservatory should be continuously heated in below freezing conditions but need only be heated to a very low setting on the electric heater. Any heat supplied by the heater will be drawn into the MVHR unit and supplied to the house and will therefore not be wasted.

## Hot & Cold Water

Mains cold water is provoded to all toilet cisterns, wash hand basins, bath & domestic sinks, dishwasher.

There is no cold water storage tank.

Hot water is heated by the boiler and the hot water storage cylinder is located in the airing cupboard on the 1st floor. The cylinder is also heated by solar panels and the expectation is that in winter the solar contribution will be around 10% and on sunny warmer days the solar may provide all the hot water heat depending on use.

The solar panels are not connected to the heating and cannot heat the radiators.

There is an electric immersion heater fitted in the cylinder, this is a back up to enable hot water to be heated should the boiler fails.

The immersion heater should be switched off at the local isolator for normal use.

The water running through the solar panels contains anti-freeze and is not the same water as flows from the hot water taps.

The solar panels need no maintenance or cleaning.

If the solar hot system cannot provide enough hot water because of the external conditions, the boiler is programmable to heat the hot water via the local boiler control panel located next to the boiler in the kitchen. The control panel has been automatically been set-up to suit the user of the house, the boiler can be overridden be the user by switching the control panel to on, this will make the boiler heat the hot water cylinder continuously until the user switches the control panel to off.
There are four options on the hot water control panel.

**Timed:** The timed option is a pre-set option which enables the user to have the hot water system on a timed setting, so it comes on at specific time as set by the user.

**Once:** On for one period during the day, as set by the user.
**On:** Hot water system on continuously
**Off:** Hot water system off continuously

All the water from all taps is safe to drink and is fed from the mains.

If the building is left for more than a few weeks with no occupation, a 20 second run of taps clears any possibility of water problems.

It is recommended however that kettles and any water to be used for drinking are usually drawn from the cold tap.