



WRAP (Whole-house Retrofit Application Process): Trial and delivery of a whole-house retrofit process and toolkit 2022

Final report

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Executive Summary

This project was run through the Sustainable Traditional Buildings Alliance (STBA), an SDF Programme. It acted as a pilot for the Whole-House approach to retrofit, as endorsed by the Government's *Each Home Counts* report (2016). Importantly, this project commenced in 2018, prior to the publication of the new Public Standard for domestic retrofit PAS 2035, which was released in 2019.

The principal aim of the project was to test out the Whole-House approach to retrofit. The subsidiary aim was to develop an improved process for domestic retrofit at scale, including new templates, training, decision-making protocols, monitoring protocols and reporting templates.

Based on plans to retrofit 40 homes in social ownership in South Wales, the project commenced with training for surveyors, followed by detailed surveys of each dwelling, including context and condition. A bespoke suite of retrofit measures was then developed for each property. The measures were selected to address human health and heritage as well as energy use, in line with the holistic approach required by the *Each Home Counts* report and enshrined by the ensuing PAS 2035.

Installation of measures was severely hindered by the Covid-19 pandemic. Personnel changes at the key social housing provider also led to a lack of internal support, which exacerbated difficulties associated with access to properties during the Covid 19 lockdowns. A second Housing Association was invited to participate in the project and further works were then carried out to two void properties within their portfolio.

A range of tools have been developed through this project, providing a comprehensive support package covering many aspects of the retrofit process, from survey through options appraisal through to monitoring of the retrofitted properties. These tools & supporting methodologies will be released for industry use across the UK.

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1. Introduction

1.1 Context

1.1.1 Failure in retrofit schemes

There have been several instances of serious failure in publicly-funded retrofit schemes in the UK. These notably include Fishwick - where people were forced to leave their homes due to health problems and the work had to be taken apart¹ - and the Arbed 1 schemes in Wales - where instances of damp rose sharply as a result of retrofit².

Many more retrofit schemes have been carried out with well-documented weaknesses, so it seems likely that more problems will manifest themselves in coming years.

1.1.2 The Whole House Approach and PAS 2035

In 2015, the Sustainable Traditional Buildings Alliance (STBA) developed its Whole House approach to retrofit; “Planning Responsible Retrofit” (2015) sets out the STBA’s protocols for assessing and managing risk for all major retrofit measures.

The Whole House approach was embraced and endorsed by the Each Home Counts report - the Government’s blueprint for the retrofit of the UK housing stock - released in 2016. One of the key recommendations in that report was the introduction of new public standards for retrofit, and the new PAS 2035 was released by BSI in 2019. The STBA served on the Steering Group for PAS 2035, so this project was developed and delivered in line with the principles of the new standard.

PAS 2035, in line with the Each Home Counts report, requires a whole house approach to retrofit. This includes the protection of human health and cultural heritage alongside achieving reductions in energy use. What this means in practice is that, prior to selecting and designing measures to improve energy performance, it is necessary to follow the procedures set out in the “BSI White Paper Moisture in Buildings: an integrated approach to risk assessment and guidance”. This includes assessing the condition of the building, its context, existing ventilation provision, and finally its heritage significance, then to take all this into account in the selection of measures and materials, and finally to monitor the results.

1.1.3 The Regeneration Approach

STBA’s own paper “What is Whole House Retrofit?” (2015) covers not only what has been incorporated in PAS 2035 but goes beyond this to begin to mention the many co-benefits of retrofit, described in that paper as “Advanced” whole house retrofit. This concept is developed considerably in STBA’s 2021 paper “From Retrofit to Regeneration”. This explores how and why the retrofit agenda became narrowed down to the limited metric of carbon emissions from

¹ <https://hansard.parliament.uk/commons/2018-10-24/debates/54D1F0D0-8376-435D-89AF-F6D057AF8A86/HomeInsulation>

²

<https://democratic.bridgend.gov.uk/documents/s23039/Appendix%201%20Report%20on%20the%20Evaluation%20of%20ARBED%201%20Programme%20in%20Caerau%20Rev%201.pdf>

buildings in use, and contrasts this with a multi-faceted approach which includes embodied energy, local employment, health, heritage, community cohesion, cleaning and re-greening the environment, plus local transport, and flood alleviation.

Since then, the term “whole house” has been used by UK government in a number of publications and most particularly in the Social Housing Decarbonisation Fund Demonstrator project and the ensuing Wave 1 of the main fund. While this has not mandated the broader approach set out in STBA’s Regeneration paper, it is worth noting that Welsh Government has since commissioned research into the co-benefits of decarbonisation and is already implementing a wider approach via the Optimised Retrofit Programme in Wales.

1.2 Purpose of the project

The aim of this project was to test out the Whole House Approach to retrofit, (as later came to be defined in PAS 2035) and to develop a series of toolkits which could be used widely throughout the industry to improve the quality of domestic retrofit.

The initial intention was to work on 40 homes of mixed construction types in South Wales owned by the Housing Association Melin Homes. Retrofit was already planned for these buildings, so the project aimed to enhance and upgrade the original plans to turn them into a genuine whole house approach.

The objectives of the project were to:

- Develop survey templates and techniques
- Assess potential interactions and risks associated with individual measures
- Develop education materials
- Develop monitoring specification
- Carry out enabling works on the properties to make them “retrofit ready”.
- Specify and design appropriate retrofit measures
- Carry out the selected works
- Monitor the buildings.

The advent of the Covid-19 pandemic caused severe delays to the project and necessitated some changes to the original intentions. Retrofit measures on the Melin Homes properties were scaled back and monitoring was more limited than originally intended. Instead, the STBA proceeded further than originally intended in developing the toolkits, and also worked with Rhondda Housing Association (RHA) to retrofit some void buildings within their portfolio.

The toolkits were originally intended to be a series of written guides. The project was changed to develop this much further into a comprehensive online system which not only records survey data but can also be used to assess embodied energy, carry out an options appraisal and produce a retrofit report.

2. Methodology

2.1 Development of new protocols and tools

The development of new protocols and tools was undertaken by STBA staff and is based on a variety of sources including:

- a. RICS Level 3 Survey
- b. PAS2035
- c. STBA Planning Responsible Retrofit of Traditional Buildings

The two key authors had both served on the PAS 2035 Steering Group so were fully conversant with the principles and processes of whole house retrofit, as set out in the Each Home Counts report. The survey tool element has been written by the Project Manager; a qualified Building Surveyor and Retrofit Co-ordinator.

The tools were trialed and refined with Melin Homes surveyors and independent surveyors from the National Trust. The Options Appraisal tool has been developed with the Green Building Encyclopedia and is being tested on a building project by the STBA in partnership with Historic Environment Scotland. The draft Significance element was developed by the project team in collaboration with Historic England, Historic Environment Scotland and others and was adapted for the proposed Annex E in PAS2035.

2.2 Practical testing with Housing Associations

The practical testing of the whole house approach to retrofit was carried out by working with two Housing Associations based in South Wales.

Social Housing was selected for this purpose because the housing owner (the Housing Association) has control over the properties and responsibility for their maintenance.

STBA staff worked closely with representatives from the two Housing Associations to:

- a. train surveyors, quality check information,
- b. carry out options appraisals, and
- c. help with the design, specification and procurement of contracts.

See Sections 5 and 6 for a detailed description of the retrofit projects carried out with the Housing Associations.

2.3 Refinement of the toolkits

Once drafted, the separate elements of the retrofit toolkits were shared with our internal experts and the STBA board and members of our Supporting Organisations. This ensured that the templates reflected current best practice and made best use of the industry-leading expertise available to us.

See Section 4 for a detailed description of the retrofit toolkits developed under this project.

3. Project timeline and scope

3.1. Original timeline and milestones

The original milestone schedule was as follows:

MS	Deliverable	Date
1	Draft survey templates	28/09/18
2	Draft training packages for surveyors. Property confirmation & householder engagement	15/11/18
3	Surveyor training delivery. Survey & Assessment of selected properties. Draft retrofit packages.	28/02/19
4	Retrofit designed and packages confirmed	30/04/19
5	Enabling works (repairs)	31/05/19
6	Installer & inspector training design & delivery. Monitoring design.	30/06/19
7	Stage 1 retrofits phase 1	31/08/19
8	Monitoring commences	30/09/19
9	Refine toolkits with National Trust and Parity Projects Stage 2 toolkits evaluation	31/12/19
10	WRAP Stage 1 retrofits phase 2	30/04/20
11	Monitoring complete (30/09/20)	30/11/20
12	Draft report, toolkits and dissemination plan to BEIS	31/01/21
13	Final report to BEIS Dissemination	31/03/21

3.2. Key factors affecting the project timeline

Covid-19

The most significant factor affecting the project timeline was the impact of the Covid-19 pandemic. As all work required visits to domestic properties, both for survey and for installation, this caused severe delays to the project. An extension of one year was granted by BEIS. Given that the pandemic lasted 2 years and led to well-documented shortages and bottlenecks in the building industry, this was not sufficient to ensure that all installations could be completed on time.

Melin Homes

Melin Homes were selected as the project partner largely because of their successful delivery of retrofits under the Arbed 2 programme in Wales. Unfortunately, Melin failed to secure a place on the follow-up programme Arbed 3, so most of the team including the Director responsible left the organisation. The team went from five full-time staff to one part-time staff member, who had also been assigned other development duties. This sole member of staff was also off sick for five months during 2021 and was furloughed during 2020 / 21. This led to delays in communications and ultimately to the overall project timetable. When coupled with a reluctance on the part of tenants to engage with the retrofit (during the pandemic in

particular), this exacerbated the issues in gaining consent for certain works and delayed the implementation of measures.

Rhondda Housing Association

To address the difficulties in obtaining consent for certain works at Melin Homes properties, STBA engaged with a second social housing provider - Rhondda Housing Association (RHA), also based in South Wales. We were ultimately able to work with their Asset team on two void properties. This allowed us to avoid delays associated with tenanted properties and to facilitate a deeper retrofit on the properties to test this aspect of Housing Association operations. This led to a concentration of milestones delivered towards the end of the project.

Worldwide shortages of Micro-chips

A global shortage of chips has affected numerous elements of the British economy and one notable effect has been on battery availability. This has been coupled with a huge rise in demand for said equipment as electricity and fuel prices soared. Four planned installs of battery and / or photovoltaic (PV) systems with Melin Homes were in the end limited to one PV / battery install and two PV panel only installs. This meant that the planned comparison between properties and usage patterns was not possible in the Melin Homes project, within the available timescale.

3.3. Final timeline and milestones

MS	Deliverable	Date
1	Draft survey templates	30/09/18
2	Draft training packages for surveyors Property confirmation & householder engagement	15/11/18
3	Surveyor training delivery Survey & Assessment of selected properties. Draft retrofit packages	28/02/19
4	Retrofit designed and packages confirmed Monitoring design	30/07/19
5	Monitoring installation Part 1	31/10/19
6	Repairs Phase 1	20/03/20
7	Course description for inspector training	31/10/19
8	Retrofits Phase 1	11/03/20
9a	Refine toolkits with National Trust and Parity Projects	28/02/20
9b	Repairs Phase 2 Retrofits Phase 2	20/03/20
10a	Accruals	31/03/21
10b	Retrofit works Phase 3 - Rhondda Monitoring installation Phase 2	31/01/22
11a	Melin works complete	29/03/22
11b	Monitoring and toolkits complete	
12	Draft report, toolkits and dissemination plan to BEIS	25/03/22
13	Final report to BEIS Dissemination	31/03/22

3.4 Changes to project scope

Due to the difficulty in installing retrofits on the Melin Homes properties as planned, STBA agreed with BEIS to transfer some of the project effort from physical installations into further development of the retrofit toolkits. This had the benefit of producing a more refined suite of tools for wider use across the retrofit industry after the completion of the project. The additions included:

- digitising the survey template
- an online Options Appraisal tool to assess and compare embodied energy of retrofit measures.

The toolkits will undergo a review by the STBA board subsequent to completion of this project, in order to ensure that they have been adequately peer-reviewed and are fit for purpose. The STBA Board will also consider how the toolkits should further inform the BS40104 Retrofit Assessment standard

4. The STBA Retrofit Toolkits

4.1 Survey Tool & stock database

The need for a new survey tool

Previous attempts at retrofit survey have traditionally focused on the need for individual measures to improve the u-value of thermal elements of the building, and on improvements to space and water heating and the efficiency of electrical services such as lighting.

As described by PAS 2035, high quality retrofit begins with an understanding of the building, an appreciation of its context, and detailed recording of its condition - including any pre-existing faults. To achieve this, and to lay the foundation for effective selection and specification of retrofit measures, a comprehensive survey protocol was required.

As this project proceeded prior to the release of PAS 2035, it became necessary to develop the required survey tools and template for this project. When it was eventually released, PAS 2035 contained certain prescriptive information regarding survey, including the minimum qualifications for surveyors. The intention remains to develop a new British Standard for survey (BS40104), which will be effectively called up by PAS 2035, in the same way that it calls up the standard for installation (PAS 2030). The survey tools developed in this project have helped to inform the development of BS 40104.

Contents of the survey tool

The STBA whole house retrofit survey tool is a comprehensive and detailed assessment of all relevant aspects of a dwelling and its context. The survey is broken down into 5 key stages:

- Pre-assessment
- Location issues
- *Outside the house*
- Inside the house
- Services

Each of these stages is then broken down into key elements. for example, "*Outside the house*" has the following 4 headings:

- *Main walls*
- Secondary walls (to reflect extensions etc)
- Windows & Doors
- Roof

Within each subsection, a series of detailed questions is then asked, all with pre-selected answers including yes/no where possible, for speed and simplicity. For example, under "*main walls*" the questions cover:

- Moisture permeability - open / closed / unknown
- Wall thickness
- Insulation
- DPC and any DPC bridging

- Dimensions

There are notes boxes provided to cover any items not on the main questions, and a further check box to record whether the element is “retrofit ready” - i.e. whether any repairs need to be carried out. This is critical, as condition is part of context, and repair must always precede retrofit - this is one area where many retrofits have failed in the past. The draft survey online form is available at <https://stbauk.tools>

Stock database

All information gathered through the retrofit survey template is fed into a stock database, addressable via the UPRN (the unique identifier) for each property. This database then enables portfolio owners to aggregate measures so that they can be effectively tendered.

4.2 Surveyor training

In order to use the new survey template effectively, surveyors needed to understand the principles and practice of whole house retrofit. All Melin Home surveyors therefore attended a 2-day in-house training course delivered by STBA executives and a further day on-site with the STBA Project Manager doing trial surveys. The surveyor training was split into 5 modules:

- a) Context of retrofit
- b) Assessing energy performance
- c) Principles of responsible retrofit
- d) Improvement options
- e) Whole house survey process

a) The Context module covers why there is a need to retrofit, the differing motivations including fuel poverty, health & wellbeing, building longevity, and climate change. We also explored policy, minimum standards and retrofit targets, plus heritage, significance, planning constraints and relevant British Standards. Safeguards such as Building Regulations and Standards are set out, the risk of unintended consequences is explained and finally the whole house approach is introduced as a response to these challenges.

b) The assessment of energy performance module covers differing house types and sets out the range of retrofit options available for each type. Heat loss is explained in detail, including the thermal performance of different materials. Lastly, different assessment methods are compared and contrasted, from simple EPCs to full energy modelling programmes, identifying what an assessor needs to know in order to use these models effectively.

c) Principles of Responsible Retrofit sets out in detail the whole house approach:

- Comprehensive survey
- Understanding of condition and maintenance requirements.
- Moisture movement within buildings and within building materials
- Thermal bridging and coherence
- Ventilation, air tightness and the interface with air quality
- Improvement options analysis
- Design
- Installation

- Occupant understanding
- Monitoring

d) The Improvement options module sets out the main retrofit strategies for each of the thermal elements (walls, floors, roof, windows & doors) then discusses options for services improvement, including source of space heating, distribution and control, domestic hot water provision, lighting, and ventilation. Survey requirements for any opportunities to introduce renewable energy are also addressed in this module. Lastly, surveyors are trained in the understanding of interactions between different aspects of building fabric, and between fabric and services. This includes use of the [STBA Guidance Wheel](#).

e) The survey process itself is explained in depth in the final module. This module is based on the STBA online survey tool and surveyors are shown how to populate it, and how to examine data across a portfolio of buildings. A case study is used so that surveyors can then use the tool themselves, and check that all requisite information has been captured.

4.3 Significance Assessment Tool

The survey tool asks about significance of the building as part of the ‘desk-top’ element; this then records the formal status of the building and what is significant about it using the categories defined by Historic England³.

The survey tool then allows the surveyor to record the significance of any individual element (windows, internal features, walls etc) and to make notes. The report produced by the survey then collates any of these notes into one section that specifically looks at significance.

4.4 Options Appraisal Tool

The Options Appraisal Tool has been developed with the Green Building Encyclopedia (GBE). The STBA owned tool uses a stripped back version of the full GBE Carbon Calculator to provide simplified and standardized output for comparative purposes. This is effectively a tool that can take the outputs from the survey tool to create an ‘energy model’ of a property. This energy model is then used to calculate the impacts of different options open to the user.

The ‘base model’ that is created via the website interface, or the survey, acts as the foundation for calculating a projected energy use for that property. The user then chooses different interventions (wall insulation, loft insulation, floor insulation, windows and doors, heating system) and the tool calculates:

- The changes in energy consumption associated with that choice
- The embodied carbon associated with different available material choices
- The moisture risk associated with each of those material choices
- Whether the choice would satisfy the required regulations for the property’s location (Scotland, being different for example to England)

4.5 Monitoring Protocol

³ <https://historicengland.org.uk/advice/constructive-conservation/conservation-principles/>

To assess the impact of retrofit measures, it is necessary to have a clear picture of certain key data both before and after the installation of the measures. This includes:

- internal temperatures
- energy use for space heating
- indoor air quality

A monitoring specification was therefore developed to capture this data.

What	How	Where
Internal Temperature	Sensors to measure temperature	Hallway
External Temperature	Sensor and logger to be installed on external elevation of dwelling.	North facing (First floor?)
Humidity	Sensor to measure RH humidity in a central location to monitor the overall levels of humidity in the dwelling and its trends over the day and year. No need for sensors as long as humidity controlled mechanical extractors are installed in key locations of bathrooms and kitchens.	Hallway Bathrooms and kitchens
CO ₂	Sensor to measure CO ₂ (as an indicator of IAQ) in a central location to monitor the overall CO ₂ in the dwelling and its trends over the day and year.	Hallway
Interstitial moisture	Sensors embedded into walls to monitor long term changes in the dwelling structure, if solid wall insulation (SWI) or cavity wall insulation (CWI) are installed.	Walls on a selected number of dwellings

Ideally, such data should be captured for a full 12 months both prior to retrofit and post retrofit. Given the way most retrofit projects are obliged to proceed, it is unlikely to achieve monitoring for more than a brief period prior to retrofit, but even this limited data can be very valuable in identifying dwellings with poor indoor air quality, or damp problems which need to be rectified prior to retrofit.

4.6 Retrofit Report Template

The project has started to develop a retrofit report template that is effectively a large spreadsheet that draws conclusions / recommendations / comments from the survey form. This is currently still at an early stage of development and will require further testing and assessment before it can be used more widely.

The report is driven by a series of 'if', 'and' plus 'then' commands. For example, 'if the wall spreadsheet cell is 'moisture open' 'and' the 'compromised wall' spreadsheet cell is 'Yes' 'then' print line XX. In this case, Line XX would state 'The walls of the property have been identified as being Moisture Open', which means that they naturally allow water vapour to pass through

them, however the survey noted that this moisture movement has been compromised. It is recommended that any moisture open walls should be allowed to breathe, and this may require the removal of the moisture closed element that is compromising the wall at present. It is important to get professional advice about this before proceeding with any wall insulation’.

The template is set out into distinct sections that cover the different areas of the survey, but it also collates information together. The current template is set out in the following sections:

- 1) Owner’s preferences and interests
- 2) Basic property summary
- 3) Contextual information
- 4) Significance report
- 5) Condition of building elements
- 6) Occupancy issues
- 7) Energy performance
- 8) Ventilation

This over-arching report template would require significant further development before it was suitable for wider application. Its relevance in the current market needs to be considered carefully before any decisions are made about investment in the next stage of development.

5. Retrofit projects with Melin Homes

5.1 Melin Homes dwelling stock and selection of properties

Melin Homes owns and manages a portfolio of over 4,000 dwellings for social housing. In common with other Housing Associations in Wales and the Welsh building stock more generally, approximately one third of these dwellings are of traditional construction. While the STBA focuses its efforts on the sustainability of the traditional building stock, the approach which we have developed is applicable to all building types, so a range of building types were included within the whole house retrofit project.

The selection process by Melin Homes focused on identifying properties that were deemed 'hard to treat', pre 1919 construction and with some improvement finances allocated to them. This would act as match funding to the project funds. The main funding was associated with Melin Home's window replacement schedule.

Many properties were explored by Melin Homes, sometimes in partnership with the STBA team. These included almshouses and a 1960 steel framed block of flats. The focus of the initial list was, though, on pre 1919 properties.

Name	No. of properties	Location	Built Form	Date of construction
Wainfelin Road	4	Pontypool	Flats in Semi-detached property	Pre 1919
Wainfelin Road	4	Pontypool	Flats in Semi-detached property	Pre 1919
Lower Garn Terrace	6	Pontypool	Mid-Terraced	Pre-1919
Upper Garn Terrace	5	Pontypool	Mid-Terraced or End-Terrace	Pre-1919
Lower Waun Street	6	Pontypool	Mid-Terraced or End-Terrace	Pre-1919
Upper Waun Street	5	Pontypool	Mid-Terraced	Pre-1919
Stow Park Avenue	1	Newport	Mid- Terrace	Pre-1919
Victoria Street	14	Cwmbran	Flats in Detached property	Pre-1919

A total of 39 Melin Homes properties were originally selected to be retrofitted. Interestingly some of the properties had already been 'improved' under past schemes including Arbed 1.



Figure 1 Properties on Wainfelin Road



Figure 2 Property in Lower Garn Terrace



Figure 3 Property in Upper Waun Street



Figure 4 Property in Victoria Street

5.2 Melin Homes retrofit measures selection

Once the survey data had been gathered, an options appraisal was conducted. A retrofit plan was then drawn up for each property in the trial. As this was an existing retrofit programme, the measures proposed by STBA and funded by BEIS to deliver a “Whole House” retrofit were in addition to measures that would normally have been carried out by Melin Homes.

The process of determining energy-saving measures and associated works such as ventilation was based on the knowledge of the STBA staff and were ultimately captured in a series of decision trees which were developed during the project. These recommendations were reviewed by Melin Homes and checked against their existing planned maintenance, repair and replacement cycles. Ultimately Melin Homes took the responsibility for the final allocation of funds and the level of intervention / works for each property. There were some important factors to acknowledge in this process:

1. The wishes of the tenants were considered, and some did not wish to have extensive works undertaken whilst in situ.
2. The planned works schedule formed the basis of any improvement works and any Whole House ‘extras’ were limited by what could be reasonably added to this. This meant that there were no ‘deep’ retrofits undertaken by Melin Homes, just the addition of logically agreed specific measures that formed part of a step-by-step approach towards the whole house plan.
3. The amount of funding available to each property was small (approx. £4,000 per property); this severely limited the options to minor improvements / changes to specifications rather than a true holistic and deep Whole House approach being used. It would have been useful to have a larger budget to facilitate deeper and more comprehensive retrofits.

Where the materials or techniques were unfamiliar to the existing contractor base, this entailed getting new contractors registered with the Housing Provider, which led to further delays.

5.3 Melin Homes retrofit measures delivered

The measures delivered under this programme were in addition to the retrofit programme already planned by Melin Homes for these properties and comprise:

Measure	No. of Dwellings
Repointing	4
Enabling works	2
Windows: New double-glazed argon-filled	22
Boiler: New high efficiency condensing	4
Loft insulation	3
Solar PV	3
Lighting	1
Ventilation	26

These measures can be broken down into 3 main categories:

Repair & Enabling works

Retrofit should always begin with repair - to make the building “retrofit-ready”. Of the properties surveyed the ones that showed the most need for repairs were those that had already been clad in external wall insulation (EWI). These properties required a series of repairs that were fundamentally related to failures in seals / adhesives in the EWI system. This is a worrying finding as there is an assumption that these systems are a ‘fit and forget’ solution that is ‘guaranteed’ for 20/25 years. It was also clear that issues like thermal bridging, ventilation and penetrating damp had not been considered during the previous works.

At four properties, which had previously had external wall insulation fitted, there were abutting garden walls that not only caused a thermal bridge in this insulation, but also acted as a point of moisture ingress into the properties. The houses therefore required ‘remedial repairs’. If budgets had been larger the remedy would have been to remove the thermal bridge caused by the wall and potentially to remove the wall and replace. However, funds meant that the only option was to repair the wall to help reduce the risk of moisture penetration. Compromise due to available budget was a recurring factor in the project.

Many of the measures that were undertaken required additional enabling works that were deemed as eligible expenditure. So, for example installing a PV system requires scaffolding / access costs. Whilst this was minimized with Melin Homes, because the work was linked to existing plans for maintenance/ repair, it would certainly be a factor in many circumstances and it was very evident in the RHA projects. The replacement of the roof in Pontypool was on a four-storey property and hence the scaffolding costs here were significant, but necessary for the works.

Energy saving and generation measures

Energy saving measures included windows, loft insulation, boiler replacement and PV installation. While these were not as extensive as originally envisaged, due to the pandemic, nonetheless they were a sufficient basis to trial the other aspects of the whole house approach. External wall insulation (EWI) was planned for several properties but difficulties with obtaining tenant consent meant that this could not proceed as planned in the Melin Homes. However, the specification developed for moisture-open EWI and the requisite monitoring specification can both be reused in other retrofit projects.

The whole house approach was reflected in the design of the windows. One of the aims of PAS 2035 is the “protection and enhancement of cultural heritage as represented by the building stock”. Replacing windows is thus an opportunity to enhance the offering to those properties in both a conservation area and within the boundary of the World Heritage Site of Blaenavon.

The original idea was to use locally produced timber windows as this was in line with Welsh Government Foundational Economy proposals. This avenue was followed until it became apparent that due to the following reasons it was not viable:

- No Welsh timber windows manufacturers could supply Secured By Design (SBD) compliant units
- The costs were prohibitive
- There were concerns over maintenance of timber
- There were no standardized specifications to make use easier in the long term
- There was no method within the wider Welsh timber industry to mark and trace Welsh wood

The issues thrown up by this project were relayed to Welsh Government and Wood Knowledge Wales. This in turn provided the final impetus for a WG sponsored project to address this issue. See <https://woodknowledge.wales/welsh-timber-windows>

Other interventions were:

- Top up loft insulation (this involved additional enabling work around clearance of lofts etc.)
- Energy efficient boiler replacement

Where there was little physical improvement possible with some properties, either due to cost, tenant wishes or other resource pressures, it was decided to install PV and battery systems.



Figure 5 2.5kW PV system in Upper Garn Terrace

Associated works: Ventilation

With virtually all thermal improvements there is a knock-on effect with ventilation. Building Regulations Part F dictates that ventilation should be 'no worse' after works. Great care was therefore taken especially around window replacement so that the works introduced a balanced centralized ventilation system. This work was specified so that the relative humidity (RH) controlled trickle vents were matched to the RH controlled centralized extractor. This was done with three important principles in place:

1. The same manufacturer supplied the trickle vents and extraction systems. This ensures a truly balanced system

2. Trickle vents were only installed in the habitable rooms (not wet rooms). This ensures that there are no 'short-circuits' in the ventilation and that high RH areas draw warmed air through the property, thus reducing risk associated with condensation.
3. Throughflow of air created / maintained. Where necessary, undercuts were created to ensure that there were ventilation routes through the properties.

This way of thinking about control of ventilation has enhanced the approaches to retrofit by Melin and will benefit the performance of their future projects.



Figure 6 Centralised RH controlled ventilation in central landing



Figure 7 Balanced RH controlled trickle vent in habitable room

5.4 Melin Homes Monitoring

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The initial intention with the monitoring was to install Sigfox based Whole House Monitoring with PassivUK. This system had been developed by PassivUK and STBA and trialed in similar properties in Cardiff. Using RH, CO2 and temperature readings from the homes to produce a score that was 'traffic light' colour coded.

Several factors prevented the full implementation of the monitoring strategy in the Melin Homes properties. Firstly, it emerged that there was insufficient coverage for the local Sigfox network to deliver the data from the monitors to the local data collection station. Inclement weather frustrated several attempts to install a booster once a suitable building had been located and permission obtained. Secondly, there was resistance from tenants regarding the monitoring equipment as an intrusion into their privacy and, despite reassurances, many rejected the installation. Thirdly the Covid-19 pandemic meant that access to domestic properties was severely limited during the period when pre-retrofit monitoring should have been carried out. Lastly, the late installation of many of the retrofit measures at Melin Homes properties meant that data was not collected post installation.

Monitoring focus was therefore switched over to the RHA, but it is hoped to use the PassivUK system on the Melin Homes properties where windows are installed given that the Sigfox network issues have been resolved.

Additional planned monitoring to look at the role of battery installs alongside PV was also cancelled due to the late PV installs and lack of available batteries.

5.5 Melin Homes key lessons learned

At the end of the project, STBA carried out an interview with the key liaison officer at Melin Homes. A number of key lessons were identified:

	Subject	Key Finding
(a)	Whole House Approach	Melin Homes were already moving away from the single measure approach to retrofit, so it was relatively simple for them to take on board the concept of whole house retrofit. Having a whole house plan is important to facilitate decision making into the future and also to justify making incremental improvements that follow this plan, rather than being solely driven by planned maintenance / ECO funding.
(b)	Survey	Surveyors found it easy to take on board the whole house approach and the additional requirements for survey. The training was well received.
(c)	Voids vs Occupied	It would have been easier to carry out whole house retrofit on void properties than on occupied properties.
(d)	Ventilation	In the social housing sector, the existing minimum quality standards (in this case Welsh Housing Quality Standards WHQS) already specify certain minimum requirements for ventilation - at least for wet rooms (kitchens & bathrooms) and trickle vents in windows. Centralised and balanced systems were new to Melin Homes as were the principles.

(e)	Repairs	Melin Homes hadn't considered the garden wall issue before - the thermal bridging and moisture risks; this was a good example of how their approach has now changed.
(f)	Heritage	Without the funds from the TEIF programme, the design of windows – associated with the protection and enhancement of cultural heritage - wouldn't have been considered previously, as this adds to cost.
(g)	Monitoring	(i) Signal is an issue in the Welsh valleys. (ii) Many tenants felt that Big Brother was watching them. Perhaps in future a different term needs to be used, and a different approach, in order to get buy-in. (iii) Cash incentives didn't work (iv) In rural areas, people aren't so concerned about indoor air quality IAQ, because they have no concerns about external AQ.
(h)	Suppliers	(i) Contractors are not familiar with some of the materials, such as lime mortar, which are needed to repair traditional buildings; though once they had used it the acceptance grew. (ii) Centralised whole house ventilation was new and required new contractors to join the framework. This was not easy though it was achieved eventually. (iii) The concept of conserving and enhancing heritage was new to the existing contractor base.
(i)	Internal project management	(i) This was not easy as many of the existing Melin Homes team left when they didn't win Arbed 3 funding. (ii) A great deal of internal project management & training is needed to embed this new approach, at least initially. (iii) The whole house approach interfaced well with WHQS and Welsh Optimised Retrofit Programme (ORP)
(j)	Targets	For Melin Homes it has been refreshing to get away from SAP or EPC targets and to do what's right for the property (otherwise you can get drawn into carrying out measures to chase SAP points - which might not be the optimal approach for the property). The correct approach will include making a place healthy to live in, so the approach is ultimately people-first not fabric first.
(k)	Legacy	The project gave Melin Homes a heads-up on what is required under PAS2035, which is being effectively replicated under the ORP, and will therefore help with plans for future retrofit programmes

From a STBA perspective the lessons learned from working with Melin Homes were:

	Topic	Reflections
(a)	Whole House Approach	Planned maintenance does provide match funding and it can be 'tweaked' to reflect the Whole House Approach.
(b)	Survey	Each property needs a Whole House Survey prior to any works so that any 'uplift' opportunities arising from Planned Maintenance can be taken.
(c)	Internal project management	The Whole House Approach needs to be cascaded through the whole organisation. Each department must have a keen

		<p>understanding of it and recognise their role in creating or maintaining it.</p> <p>It may be advisable to have a dedicated Retrofit Champion / Co-ordinator in-house that oversees all operations so that the Whole House Approach is embedded into the structure, thinking and operations of the RSL.</p> <p>Staff turnover can easily and quickly remove key personnel and therefore the RSL undertaking the retrofit should ideally have more than one Retrofit Champion/ Co-ordinator within their team, to provide cover and continuity if key personnel leave.</p>
(d)	Voids vs Occupied	<p>Void work tends to be less risky as it can be more comprehensive and hence more compatible with the Whole House Approach. However, it is likely to be more costly as the enabling works are not necessarily shared with planned maintenance budgets.</p> <p>Void targets for re-occupation may need to be reviewed so that they provide a void team with enough time to complete a Whole House Retrofit package.</p> <p>Working with in-situ tenants using planned maintenance is riskier as it is unlikely that the tenants would be content with long running works. However 'up-grading works' to enable later interventions is important so that resources are not wasted.</p> <p>Messaging tenants well in advance and with full information is important to maximise buy-in</p>
(e)	Ventilation	<p>If an RSL chooses a balanced and centralised ventilation system to be their preferred solution, then it needs to become enshrined in their operational plans. This is because it requires a cross cutting organisational approach as it impacts on Reactive Maintenance / Planned Maintenance / Service Compliance and any additional Thermal Improvement plans.</p>
(f)	Repairs	<p>Retrofitted Homes must not be regarded as 'complete' and safe for the next 25 years. Maintenance schedules have to reflect the finding that many insulation works fail after a short period of time due to the reliance on inappropriate seals.</p> <p>Retrofit plans must consider 'enabling works / repairs' as part of the costing plans. Without the building being in suitable condition prior to works commencing there is an increased risk of long-term failure.</p>
(g)	Heritage	<p>Heritage values are poorly understood by RSL staff and certainly contractors. It is essential that any Retrofit Champion / Co-ordinator engages and educates trades in significance / heritage both prior to works commencing and also onsite, probably via toolbox talks.</p>
(h)	Monitoring	<p>Monitoring needs to be explained carefully to tenants either as new tenants (after a void) or in-situ. Location of monitors needs to be sympathetic to tenants needs whilst remaining true to the requirements of the monitoring equipment. This will tend to lead to sensors being installed in hallways / living rooms. They need to be discreet and also potentially protected from interference.</p>

(i)	Suppliers	<p>Careful selection and training of contractors is vital. All new contracts should have the whole house approach shown explicitly at their core. It should be set out from the start what is expected for each intervention.</p> <p>Directly Employed Workforces will also require standardised guidelines to be in place.</p>
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6. Retrofit projects with Rhondda Housing Association (RHA)

6.1 Rhondda Housing Association dwelling stock and selection of properties

RHA owns and manages a portfolio of over 1,800 dwellings for social housing. In common with other Housing Associations in Wales and the Welsh building stock more generally, approximately 22% of their dwellings are of traditional construction.

When it became clear that Melin Homes did not have any void properties that fulfilled the criteria of the project, the STBA contacted several other Registered Social Landlords (RSLs) in Wales (inc Wales and West Housing Association, RHA and Adra). RHA was proactive in coming forward to embrace the opportunities afforded by this project.

An initial brief produced by STBA stated that there was an opportunity to part fund some innovative external wall insulation (EWI) / internal wall insulation (IWI) works on two to three void, solid wall properties that were external to the Optimised Retrofit Programme (ORP) in Wales.

RHA looked at suitable voids and were keen to trial new products but at the right pace and scale. 3 voids were identified and surveyed by the Asset Manager: Church St in Ton Pentre, Ynyswen Road in Treorchy and Thomas St in Blaen Clydach.

Thomas St is a mid-terrace, Victorian property but was deemed to be too costly and difficult to finish within the timeframe. Church St is a simple mid-terrace 2 up 2 down with no rear annex. Ynyswen Road was a very typical Valleys mid-terrace. Church St and Ynyswen Rd were then surveyed by STBA and confirmed as suitable for this project. Church St was identified as the preferred location for the EWI / IWI works.

6.2 Rhondda Housing Association retrofit measures selection

The two properties were voids and hence it was possible to undertake more in-depth retrofit works. Both properties were surveyed in partnership between RHA and STBA, and a normal RHA schedule was created for the refurbishment of a void property. It was decided that, given the available funds, the focus would be on Church Street for the innovative EWI / IWI products and interstitial monitoring. Ynyswen would undergo measures based on the whole house survey and assessment with a more standard monitoring package.

RHA and STBA then agreed the package of additional retrofit measures for each property needed to implement a whole house retrofit. This included thermal, ventilation, heritage, health and safety, water efficiency, energy generation and storage improvements. In line with the Whole House Approach certain elements (notably the windows) were kept as they were deemed to be in good condition and to current regulations / standards.



Figure 8 Property in Church St Ton Pentre



Figure 9 Property in Ynyswen Rd Treorchy

With 50% of eligible costs to be covered by the project, there was a willingness from RHA to embrace the Whole House Approach, partly because drivers for this approach have been growing in Wales, including the Optimised Retrofit Programme, PAS2035, Foundational Economy Strategy and the Wellbeing of Future Generations Act 2015. RHA were able to ‘match-fund’ using their normal void budgets.

6.3 Rhondda Housing Association measures delivered

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The measures delivered under this programme were in addition to the measures covered by the normal void budget already allocated by RHA for these properties. They comprised:

Measure	No. of Dwellings
Enabling works	2
PV panels and battery storage	2
Full IWI	1
Reveal IWI only	1
Lime rendering	1
Ventilation improvements	2
Loft insulation and improvements	2
Door replacement	1
Heritage improvements	1
Water efficiency improvements	1
Health and safety improvements	2
Interstitial monitoring	1
IAQ Monitoring	2

The properties both held surprises once works commenced:

- Church Street front wall was found to have been completely re-built out of blockwork rather than the expected stonework. This meant installing all the interstitial monitoring to the rear wall, rather than the front wall as initially planned.
- Ynyswen Road's annexe was found to have been rebuilt using a cavity construction rather than being solid brick as expected.

Enabling works

Installing an IWI system correctly requires a coherent, consistent and complete covering to the wall. This meant that installation required access to areas like: interfloor zone, party walls (for fold back insulation), behind stairwell, connections between internal walls and external walls. Therefore, the project had to either cut back / expose or temporarily remove internal walls, stairwell, fixtures and fittings (inc kitchen units), etc. All the internal plasters were hacked back to the base structure and the IWI system was designed to be a replacement to the current cement and gypsum plaster.

Application of the lime render also required the removal of the inappropriate cement render to the rear. The front render was left in situ due to the nature of the blockwork front wall.

The kitchen in Church Street had to be replaced as this would not have survived the disruption required for the access to the internal and external walls for the IWI.

Scaffolding was required for the application of the render, repairs to the roof and the installation of the PV panels. The lofts needed to have safe access created to install and service the batteries.



Figure 10 F/F Rear Wall



Figure 11 Enabling work required access to interfloor area and behind stairwell



Figure 12 New units installed. Also note re-instated splay to window reveals



Figure 13 New fuseboxes and services for PV / battery / Monitoring



Figure 14 Monitoring cupboard in FF rear bedroom. IWI painted with breathable paint

Energy efficiency

Two innovative IWI products were selected for trial:

1. A quick drying air lime render
2. An aerogel based IWI lime plaster



Figure 15 Render pump. External render was pumped, sprayed and harled on

The choice of wet based systems for improvements was a conscious one as this avoids the moisture risk profile associated with board-based systems that inherently have joints, corners and edges. It is these junctions that are most at risk from thermal bridging, moisture ingress

etc. Avoiding this was a key driver both in terms of material choice, but also the associated detailing.

1. The air lime render, whilst primarily a moisture control layer, is also deemed to be an energy efficiency measure as it should allow the wall to remain dry (and hence more energy efficient) and it also has an inherent insulating value.
2. The manufacture of the aerogel-based lime plaster initially calculated that to achieve the desired 0.7U value for the walls, 2cm of plaster would be needed; however, this was changed to 35mm as testing results were corroborated. This was easily achievable given the depth of plaster removed by the contractors.



Figure 16 IWI was mixed with plaster whisk and troweled on

In the end, an alternative non-aerogel-based IWI system was used on the front wall, largely for cost reasons.

The depth of plaster removed meant that the rear door had to be replaced. The original opening was much bigger than the existing door, so a new insulating door was therefore installed.

The reveals in the window openings in Ynyswen Road were insulated using the remaining / spare aerogel plaster to remove an existing thermal bridge.

The loft insulation was increased in both roofs and insulating and draughtproof loft hatches installed.

Moisture control

Ton Pentre is in Wind Driven Rain Index Zone 4 – very severe. Protecting the IWI requires the external render to be more ‘breathable’ via diffusion. The air lime render was chosen to provide this, plus it was deemed to be very quick drying and easy to apply compared to ‘standard’ lime renders.

The new render was applied in three coats using standard contractors and a variety of methods (spray, pump and harled). The contractors were able to install the render as required and work was finished in three consecutive days.

The bathroom in Ynyswen Road was not in great condition and the survey showed up various moisture ingress issues with the current tiling etc, so these were replaced.

The bathroom in Church Road also had a water spillage issue due to a design fault, so a small wall was constructed to protect the front wall from this.



Figure 17 Air lime render scratch coat, note rounded corners to minimise risk of damage



Figure 18 Staff from contractors travelled from Carmarthenshire for training



Figure 19 Rear of property with air lime render and limewash finish. note land drain

Ventilation

The ventilation in the properties was deemed to be sufficient and the budget would not facilitate the installation of a full balanced and centralized system, so the existing extractors were upgraded to relative humidity (RH) controlled units and undercuts were made to the doors where appropriate to allow movement of air across the property.

Water efficiency

The WC in Ynyswen Road was not dual flush and so was replaced. The showers were also refitted with thermally controlled mixer units to encourage showering and prevent scalding.

Renewable energy and storage

Both properties were fitted with solar PV and combined 5.2kWh battery storage. This should both make the properties more attractive to tenants as they should be cheaper to run.



Figure 20 PV panels installed

Heritage

The Rhondda Valleys are almost an emblem of Wales' industrial past and certainly are linked to coal mining in the 19th and 20th centuries. The typical Welsh valleys terrace is therefore the backdrop to the whole region. In Ynyswen Road the original bay had been removed and replaced with a cement rendered wall. This was reclad using stone.

6.4 Rhondda Housing Association monitoring

There are a number of sensors in the two properties. Church Street has interstitial monitoring embedded in the first floor east-facing stone wall. This is sensing RH and temperatures through a cross section of the wall. Sensors are recording figures on the inside surface, between the IWI and the main structure, approximately halfway through the wall and just behind the external render. This monitoring will supply the project with thermal and moisture performance data.



Figure 21 External monitoring equipment

Initial reports indicate that the IWI has improved the wall's thermal performance to a U value of 0.64 W/m²K, which is in line with the original specification and expectation.

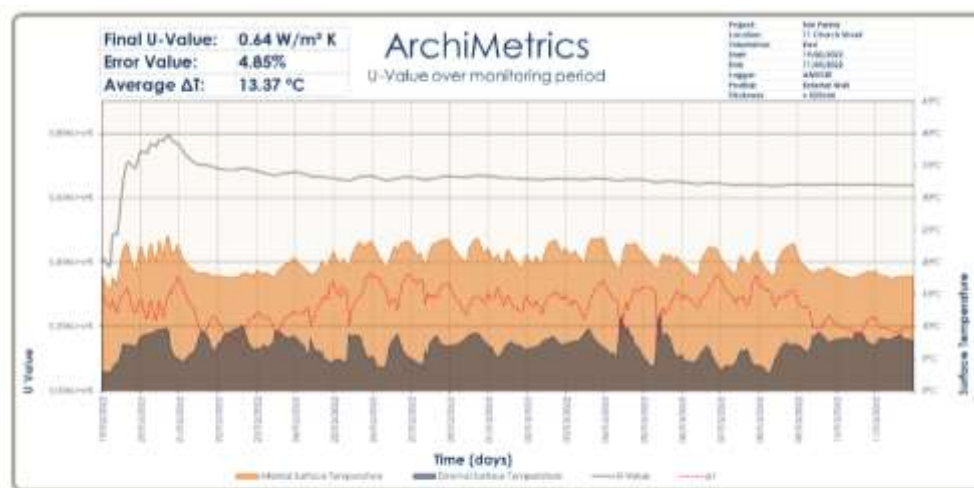


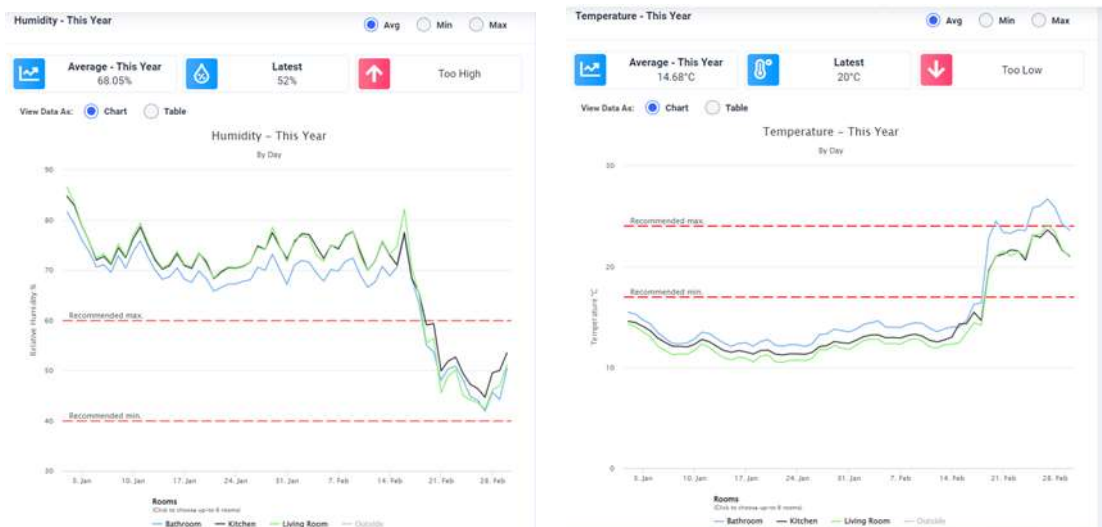
Figure 2. Measured in situ U-value, February – March 2022, Church Street, Ton Pentre.

Figure 22 U value calculations from Archimetrics report

RHA also installed monitors in the living room, bathroom and kitchen to provide data on internal temperatures and RH in these three areas.



Figure 23 Temperature controls and RH / Temp sensor in living room



As part of the Welsh Government's Optimised Retrofit Programme, RHA also installed further monitoring kit that reports back on energy usage to the Active Building Centre. It is currently uncertain whether individual data can be obtained for the properties.

The battery / PV systems are also providing data for the project. This shows data on how much electricity is being generated, stored and used for the tenants.



6.5 Rhondda Housing Association key lessons learned

At the end of the project, STBA carried out an interview with the project manager at Rhondda Housing Association. A number of key lessons were identified:

	Subject	Key Finding
(a)	Whole House Approach	It is important to have a knowledgeable advocate for the Whole House Approach (WHA) otherwise it can get lost in the fragmented organisational structure of a RSL
(b)	Survey	There is a need for training within the sector and RSLs to ensure that the vital survey stage identifies all key aspects required for a whole house approach. Older buildings can throw up the most unexpected challenges.
(c)	Voids vs Occupied	Working on the voids was a lot easier than working with tenants in-situ and really facilitated the whole house approach. Additional time may be required as a whole house approach may take longer then currently allowed for a standard void refurbishment. Planning a void programme with the WHA in mind would help ensure that this approach was taken.
(d)	Heritage	Enhancing heritage is not currently a criteria / KPI for the RSL to meet. Some simple efforts were made to preserve and enhance a heritage feel to the properties including: using the lime render, re-instating both the curved edges to window and door openings and the splayed internal window reveals, use of limewash to soften the rear of the property (and preserve breathability) plus recladding wall elements in stone.
(e)	Monitoring	Monitoring is key to RHA as there is an appetite for more projects of this nature; being able to prove the performance of different approaches will assist with making changes to ways of working internally to the RSL.

(f)	Suppliers / contractors	The suppliers were very well informed and can provide valuable information, for instance about application/ installation requirements associated with new products. Contractors were willing to train and learn and to adopt new practices / materials.
(g)	Internal project management	Having an external expert to help guide, inform and direct the project was essential to its adoption by management, as it gave them confidence in the process.
(h)	Targets	RSLs are still being driven by EPCs but there is a growing acknowledgement that this needs to change
(i)	Legacy	RHA are keen to see how issues like use of natural paints and limewash on the external render work out for tenants / and also any implications for reactive maintenance.

From a STBA perspective the additional lessons learned from working with RHA were:

	Topic	STBA Reflections
(a)	Whole House Approach	It is much easier to undertake a complete Whole House Retrofit on a void property.
(b)	Internal project management	Having 'buy-in' from a RSL board for innovation and sustainability facilitates projects such as this.
(c)	Tenant Engagement	Informing new tenants of any 'unusual' aspects of their new home is a key element that will help to ensure long term compliance with systems / materials.
(d)	Repairs	Being aware of ongoing material / equipment maintenance requirements is vital so that it can be factored into the work of the Reactive and Planned Maintenance teams
(e)	Monitoring	Results of monitoring are a key requirement to assess new systems. RHA will make decisions on the roll out of new materials / ways of working based on independent empirical evidence.
(f)	Suppliers	A supportive and engaged main contractor may help to secure better outcomes in terms of the whole house approach. Contractors' value on-site support and guidance and appreciate a named contact for queries.

7. Wider impact of BEIS TEIF Project

7.1 Welsh Timber Windows Project

The problems identified with procurement of timber windows in this project, led to the creation of a Welsh Government funded project to address the lack of timber windows, accredited to the Secure by Design Standard, that are available to the RSL market. This follow-on project, run by Wood Knowledge Wales, is bringing together SME window manufacturers to create a certified product for the market. Although initially focused on the new build sector it should also spill over into the repair, maintenance and improvement sector.

See: <https://woodknowledge.wales/welsh-timber-windows>

7.2 In situ testing of innovative products

The new IWI and render products used in Church Street with RHA have been independently monitored using interstitial monitoring of temperatures and humidity. An initial report suggests that the performance target of 0.7U has been achieved. This testing will continue and provide a clearer picture of the in-situ characteristics and performance of these innovative products.

See Appendix 2 for Archimetrics report.

7.3 Dissemination of findings

The STBA will produce a number of case studies and a summary version of the project for dissemination amongst the STBA members, patrons and partners, as well as to the wider industry. This will include a social media campaign through LinkedIn and Twitter to raise awareness of the results of the project.

The case studies will focus on:

- The Church Street property where the whole house approach was applied more fully,
- The wider experience of integrating the whole house approach into the ongoing maintenance programme of a Housing Association (Melin Homes)

The STBA has already presented the initial findings to the Whole House Retrofit stage at FutureBuild in 2022.

7.4 Influence on policy & standards

STBA's work in this project has already influenced the development of the Assessment guidelines for PAS 2035. The STBA Project Manager has been in close contact with the team charged with developing the new British Standard for Retrofit Assessment (BS40104). The draft survey forms were shared with this small team.

The Project Team were also involved with the BSI review of PAS2035 and actively used the learning from this BEIS TEIF project to highlight needs and opportunities associated with the PAS2035 process.

8. Financial reporting

8.1 Breakdown of expenditure

The total grant funding provided by BEIS under this project was £300,000. The Funding Intensity of grant is broken down as follows:

Item	Partners project costs as a proportion of total eligible costs %	Partners grant funding request as a proportion of their eligible project costs
Melin Homes retrofit upgrades	57%	50%
Rhondda HA retrofit upgrades	15%	50%
STBA support and development of Retrofit Toolkits	29%	59%

9. Conclusions

9.1 Use of the whole house approach within Housing Associations

The social housing sector represents a significant proportion (approx. 17%) of the UK housing stock, and an even higher proportion of those who are in fuel poverty. In social housing, the housing provider has control over the properties and can achieve economies of scale in delivering multiple measures to multiple properties.

From this trial we are able to draw 3 main conclusions:

- The Whole House approach to retrofit is consistent with the way that the sector is now moving, driven by emerging legislation (e.g. Welsh Future Generations Act) and standards (e.g. PAS 2035).
- Adoption of the Whole House approach in a social housing context will often mean fitting into existing programmes of repair and upgrade. The task thus becomes one of understanding how you can upgrade what is already being done, as part of a whole-house plan, rather than planning whole house retrofit from scratch in one step.
- 'Monitoring' is a challenging concept for tenants to accept, and a different approach is needed, perhaps based around the concept of safety checking.

9.2 Challenges in adopting the whole house approach

Thanks to the advent of PAS 2305 and its use within the Social Housing Decarbonisation Fund, the Whole House approach is now becoming more widespread. However, challenges remain , including:

- There is a limited pool of surveyors who are sufficiently trained to carry out whole house retrofit assessments. This needs to be resolved with RICS, BSI and suppliers of retrofit coordinator training. The Appended surveyor training syllabus may be useful in this respect.
- There is a lack of understanding of heritage and significance within the social housing market, and about the potential to use retrofit as an opportunity to enhance heritage - for example by the installation of durable timber windows to the original pattern.
- There are shortages of contractors in some areas, particularly those skilled in materials, such as lime mortar and render, which are essential in the repair and retrofit of pre-1919 buildings - comprising 25% of the UK stock and 33% of the stock in Wales.
- Existing framework contracts may not cover essential Whole House elements such as ventilation - from survey to provision.

9.3 Key lessons learned:

1. Comprehensive assessment systems are vital for good planning
2. There is a need to align planned, reactive and cyclical maintenance within Social Landlords (RSLs) in order to maximise the opportunities associated with a Whole-House approach
3. Void properties provide the easiest access point for a Whole House retrofit
4. Tenants' views have a large impact on what can be achieved whilst they are still in-situ
5. There is a need for comprehensive training in retrofit across the RMI (repair, maintenance & improvement) sector

Appendix 1: Whole House Retrofit Surveyor Training Syllabus

Synopsis

A two-day training course to give domestic building surveyors the knowledge and tools to be able to: understand the context of retrofit; understand energy performance and assessment processes for different house types; understand the key principles behind responsible retrofit; assess homes in a robust, detailed manner, identifying all pre-retrofit requirements and appropriate retrofit measures; understand the measures and their installation and monitoring processes; and engage effectively with occupants.

Training Outline

There are five modules in this course, as follows (a detailed breakdown of each module follows):

- Context of retrofit
- Assessing energy performance
- Principles for responsible retrofit
- Improvement options
- Whole house survey process

The course is delivered in-house by experienced professionals, with teaching based around slide presentations, exercises, discussion and practical survey tool application. Content covers both theory and practice, supported by the latest research, guidance and studies throughout to illustrate issues and solutions. Material samples are provided for illustration and discussion, and the survey tool developed as part of this training is tested by all delegates.

Resources

There is a wide range of resources available to delegates to explore both before and after the training course. A full list is provided as part of the training presentation slides which all delegates will receive. This covers technical guidance, research, case studies and practical tools to allow delegates to gain a deeper knowledge in this field.

Detailed course content

Module 1: Context of retrofit

- Why retrofit
Identification of different motivations, aims & challenges of retrofit
- Drivers
Climate change, fuel poverty, health & wellbeing, building sustainability, policies, funding, retrofit targets & minimum standards
- Heritage
Heritage & significance, conservation, building use & context, planning legislation & British Standards
- Safeguards
Building Regulations, common practice, industry standards, regulations vs practice
- Unintended consequences
Direct & indirect consequences of inappropriate, single-measure approaches
- Whole-house approach
Background & development, definition, need, future legislation

Module 2: Assessing energy performance

- House types
Range of house types, energy performance & appropriate upgrade options
- Heat loss
Fabric & infiltration, determinants, thermal performance of materials
- Assessing performance
Energy assessment mechanisms, Energy Performance Certificates, energy modelling options, strengths & weaknesses, assumptions, assessor understanding, what needs assessing

Module 3: Principles of responsible retrofit

- Survey
Building, context, occupancy
- Condition & maintenance
Importance of maintenance, enabling measures, introduction of 'Retrofit Ready' principle
- Moisture
Importance of moisture, risks & problems, vapour & liquid moisture movement in buildings, risk assessment mechanisms
- Insulation systems & materials
Material samples, 'moisture open' vs 'moisture closed', selection based on requirements & context, thermal performance vs other parameters
- Comfort
Year-round thermal comfort, overheating, health, indoor air quality
- Coherence & thermal bridging
Coherence of approach, continuity & bridging, insulation & airtightness, common challenges, impacts
- Ventilation, airtightness & indoor air quality
Importance, impacts, approaches, options, health & wellbeing, risk factors, management
- Design & installation
Detailing, communication, simplicity of approach, standard vs complex details, knowledge of designers & installers, oversight
- User engagement & understanding
Occupant understanding as a retrofit measure, importance in determining retrofit success
- Monitoring
Importance, options
- Understanding
The key to success

Module 4: Improvement options

- Walls
Cavity insulation, external insulation, internal insulation – functions, performance, risks, solutions, details
- Roofs
Joist-level insulation, rafter-level insulation – functions, performance, risks, solutions, details

- Floors
Suspended timber insulation (above & below), solid floor insulation (floating & replacement) – functions, performance, risks, solutions, details
- Windows
Enhancement & replacement options, addressing frames, glazing & reveals – functions, performance, risks, solutions, details
- Services
Ventilation, heating, lighting & appliances, controls, renewables
- Interactions between measures
Holistic understanding, impacts of measures on building & on other measures, STBA Responsible Retrofit Guidance Wheel

Module 5: Whole house survey process

- Survey process
Recap of survey importance & complexity, survey tool explanation, practical demonstration
- Exercises
Survey tool population using real case studies, discussion
- Are we 'retrofit ready'?
Recap, discussion, summary

Appendix 2: U Value Report 1 – Archimetrics

Project: Ton Pentre
Site: Church Street, Ton Pentre
Client: Sustainable Traditional Buildings Alliance (STBA)

U-value Report 1

Church Street, Ton Pentre,

Document Status: Final
Document Date: 18/03/2022
Monitoring Period: 19/02/22 to 11/03/22
Report by: ArchiMetrics Limited

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Introduction

As part of a larger retrofitting scheme, the solid stone external walls of 11 Church Street, Ton Pentre have been insulated with a new experiment insulating plaster, Thermulon, a lime-based product with an aerogel addition. ArchiMetrics have been commissioned to carry out interstitial hygrothermal and U-value monitoring to assess the performance of the insulated wall over a three-year period.

This is the first report which presents early-stage findings of a measured in situ U-value for the wall. It should be noted that retrofitting work at Ton Pentre was completed around the end of 2021 and the building only occupied (and heated) from mid-February 2022 onwards. The wall has been subject to new internal plaster and external render, both wet processes and it is clear from interstitial moisture monitoring that construction moisture is, unsurprisingly, still present within the fabric and that little drying has yet taken place. Therefore, this first measured U-value is likely to be higher than that found once the wall has dried down and should not be taken as an indication of the long-term performance of the insulated wall.

Wall & Monitoring Description:

The wall at Church Street appears to be constructed of local stone from the Pennant Sandstone formation, these include feldspathic, micaceous, lithic arenites types of sandstone as well as underlying beds of mud and siltstone (see Figure 1).¹ These stones are bedded in a lime mortar with a high proportion of coal dust waste used as an aggregate or filler. The stone component of the wall is approximately 455 mm or 1 ½' thick. As part of retrofitting work, the external wall face has been rendered using an air lime product, Vivus No.2 Render Basecoat to a nominal thickness of 30 mm and internally a lime-based aerogel insulating plaster, Thermulon, has been applied to a depth of ≈ 40 mm creating an overall wall thickness of about 525 mm.

¹ See British Geological Survey <https://webapps.bgs.ac.uk/lexicon/lexicon.cfm#pub=pes>

Project: Ton Pentre
Site: Church Street, Ton Pentre
Client: Sustainable Traditional Buildings Alliance (STBA)

In September 2021, the installation of interstitial hygrothermal gradient and U-value monitoring equipment commenced in the east facing external wall at first floor level at Church Street in a room used as bedroom (Figure 1).

Monitoring commenced in 14th December 2021 and the house was occupied in mid-February. The measurement of in situ U-values requires an average 10°C internal/external temperature difference over a set period, around 14 days or longer and therefore is more successfully carried out over the winter months with internal heating in operation. The measurement reported on here follows the conventions set out in BS ISO 9869 *Thermal insulation — Building elements — In-situ measurement of thermal resistance and thermal transmittance* and covers the period 19th February – 11th March 2022.

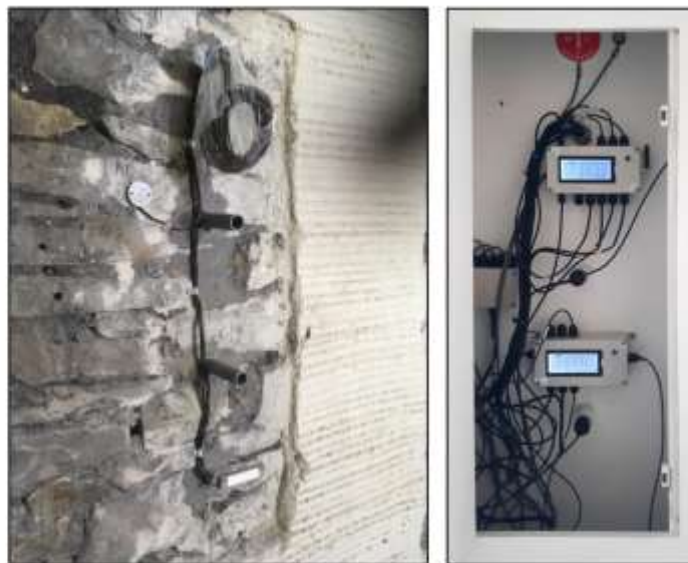


Figure 1. IHGM and U-value monitoring equipment, Church Street- mid-install and within completed cupboard enclosure.

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Findings

Measured in situ U-value

The measured in situ U-value found for the east facing 525 mm insulated stone wall at Church Street is **0.64 W/m²K** (Figure 2). As above, it should be borne in mind that construction moisture added to the wall at the time of rendering and plastering is still present within the fabric, therefore this U-value is likely to change and be lower once the wall has dried. Thus, this U-value should be seen as an interim, early-stage indication of the overall heat loss (thermal transmissivity) of this wall assembly.

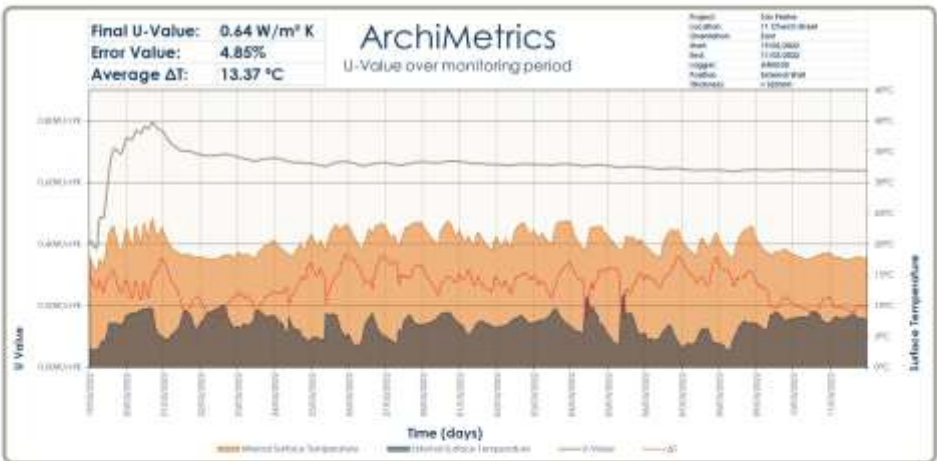


Figure 2. Measured in situ U-value, February – March 2022, Church Street, Ton Pentre.

Calculated U-value

For comparative purposes a range of 'standard' U-values (following BS EN ISO 6946 Building components and building elements — Thermal resistance and thermal transmittance — Calculation method) have also been calculated for this wall. A range is necessary because the properties of the existing wall materials, in particular the stones, are not well defined. For the calculations we identified a 'low', 'middle' and 'high' possible spread of densities for 'Pennant Stones' with an associated thermal conductivity value, scaled in relation to density: 1800 kg/m³ – 1.2 W/mK, 2400 kg/m³ – 2.3 W/mK and 3000 kg/m³ – 3.8 W/mK. As a traditionally-built solid stone wall, a proportion of the structure comprises of lime mortar. In order to account for the contribution this makes to the overall thermal performance of the wall it is necessary to identify a ratio which might describe the proportion of mortar to stone within the wall build-up. This was done by mapping an area of the internal wall surface to calculate the quantity of stone within the selected area, Figure 3. Using this method, we determined a 30:70 mortar/stone ratio for the Church Street wall. Table 1, below, provides details of the quantities used in each of the U-value calculations and the subsequent result.

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Figure 3. Surface area analysis to determine mortar:stone ratio for the Church Street wall.

Table 1. Quantities used in U-value Calculations for Church Street and calculation results.

Layer	Thickness mm	Material	Lambda W/mK	Calculated U-value W/m ² K
External Render	30	Vivus No.2 Basecoat Render	0.800	
Stone	318.5	Pennant Stone low - 1800 kg/m ³	1.200	0.90 W/m²K
		Pennant Stone mid - 2400 kg/m ³	2.300	1.01 W/m²K
		Pennant Stone high - 3000 kg/m ³	3.800	1.07 W/m²K
Mortar	136.5	Lime mortar	0.1365	
Internal Plaster	40	Thermulon Insulating Plaster		
Total	525 mm			

As can be seen from the table above the U-values calculated for the insulation solid stone wall at Church Street range from **0.90 – 1.07 W/m²K** depending upon the density/conductivity of the stone material selected. Without further investigation of the material properties of the stones used within the wall, which are likely to be extremely diverse, it is not possible to have greater certainty for these calculated U-values. Nevertheless, the process has followed conventional calculation practices and therefore these calculations represent figures that might be used in SAP and other type assessments of performance for this wall assembly. Therefore, it may be of note that the measured U-value indicates lower heat loss, **0.64 W/m²K** than that identified by the conventional calculations.

