Retrofit assessment: Getting it right from the start

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Abstract

The UK has some of the oldest buildings in Europe. They are also some of the worst performing in terms of energy performance. In tandem with these issues the UK has committed to making a substantial reduction in CO_2 emissions. UK homes are currently responsible for almost 20 per cent of CO_2 emissions. This leaves little option other than to make considerable progress with the retrofitting of homes to improve their energy performance. This is a technical process, however, and can introduce risks to building and their occupants. Examples exist of homes being retrofitted with disastrous consequences. Some of these issues can be due to the lack of thorough examination of a home before it undergoes a retrofit. This paper proposes a method that provides a detailed pre-retrofit assessment of a home, to fall in line with PAS 2035, a standard that provides guidance around publicly funded retrofit in the UK.

Keywords: retrofit, building performance, pathology, energy pathology, defects, energy

BACKGROUND TO RETROFIT

This paper presents a breakdown of the assessment process that can be carried out prior to a retrofit of a property. It is limited to and focuses entirely on improvement works to domestic, low-rise property, to improve its energy efficiency — generally termed as 'retrofit' or 'sustainable retrofit'.[1]

Policy

The UK government has committed the UK to becoming net zero by 2050.[2] A significant component of this will be achieved through the improvement of buildings. An example of this is the aim to improve the energy efficiency figure of all homes that are deemed to be fuel-poor to an Energy Performance Certificate (EPC) rating of a C by 2035.[3]

What is the need for retrofit?

The residential sector is responsible for 19.9 per cent of all CO_2 emissions in the UK. This is largely driven by the use of natural gas in homes for heating, hot water and cooking, but heating makes up the most significant portion of this.[4] To extenuate this, the UK has some of the poorest-quality homes in terms of energy efficiency in Europe.[5] This is due in the main to our ageing housing stock which is replaced at a very slow rate: The most common house type in the UK in the year 2050 will be a house built between 1919 and 1964.[6] Add to this the fact that one in five UK homes are more than 100 years old,[7] this leaves us with a housing stock that requires a huge effort to meet our policy obligations.

The sensible response to these issues is seen by many to be the retrofit of dwellings with fabric measures and energy-efficient heating and hot water systems. Retrofit, according to some, is straightforward, consisting only of simple measures in simple situations, such as topping up loft insulation or adding cavity wall insulation. Some also think that this is so simple that there will be no unintended consequences. As with most issues in the built environment, it is rarely so, or without complication. Retrofit, when done well, can save money, energy and improve the lives of the occupants. In the next section, however, we shall focus briefly on when retrofit goes wrong.

Fishwick external wall insulation scheme

Many retrofits of existing homes are carried out using external wall insulation (EWI), generally used in solid masonry walls or walls with very slender cavities. This scheme involved the retrofit of around 400 homes in Fishwick, Preston. The homes were solid wall structures built around 1900. The scheme specified the application of a rendered solid wall product added to the facades of rows of terraced housing (see Figure 1). The façades of these homes contained historic/heritage ornate features which needed to be overcome and considered as part of the scheme.

The retrofit of these homes led to many issues for the occupants and the homes themselves. A significant number of homes went on to suffer from damp, condensation and mould growth, driven largely by poor-quality workmanship and detailing. Attractive features of the buildings were maintained, such as decorative timber fascias, but this involved details that were not satisfactory and caused significant moisture issues (see Figure 2).

Whereas some of these issues are certainly down to poor installation, poor design and poor product selection, some of them may have been preventable by carrying out a thorough assessment of the homes. This may have led to different technical approaches being taken, and ultimately a more successful retrofit and healthier homes. We shall discuss this requirement for retrofit assessment in the following section.

Figure 1: An illustration of a difficult detail in terms of external wall insulation[8]

Figure 2: Moisture issues — fungal growth resulting from penetrating moisture[9]

HOW DO WE IMPROVE QUALITY OF RETROFIT?

This section will *not* cover the quality of retrofit works as such, rather the process of assessing a building before the design and installation process takes place. The call for a more detailed assessment process for retrofit has been made for some time, but formally this came as part of the Each Home Counts Review[10] commissioned by BEIS and DCLG, which oversaw retrofit and building regulation at that time. The report highlighted many shortfalls of the entire retrofit process. A key recommendation of this report was the introduction of a formal assessment of the home before retrofit works were considered. The report highlighted this as a key action:

> 'Provide confidence in the suitability of recommended energy efficiency and renewable energy measures made through a consistent and more complete assessment of the property.'[11]

With this recommendation in place (and many more that are not directly relevant to this paper), the decision was taken to produce an overarching publicly available standard (PAS) called PAS 2035.[12] This document provides guidance from inception to completion of a domestic retrofit project. An important part of this process is deemed as the retrofit assessment of the home before design decisions are made.

PAS 2035 is a detailed and lengthy document and will not be discussed in full in this paper; however, the process is charted in Figure 3. The process also creates several new roles, briefly described as follows:

- *Retrofit coordinator (RC)*: The RC is a project management role, but also has the unique ability to be able to act as any other, or all the roles in the process. It is unlikely, however, that they will also act as evaluator, as this could be a conflict of interest;
- *Retrofit assessor (RA)*: This role is concerned generally with pre-retrofit issues, the assessment of condition of the home, the examination of obstacles to retrofit and energy efficiency measures already installed;
- *Retrofit designer (RD)*: The person who designs the retrofit for the home, and also can generate the medium-term plan/strategy for the home;
- *Retrofit evaluator (RE)*: This role evaluates the outcome of the retrofit and helps find instances where defects/issues have arisen since the retrofit took place. This role feeds back to the RC.

The assessment process contained in PAS 2035 is detailed, but the text specifically calls for a rehash of the assessment process to be defined in a further British Standard. This standard has now begun and will shortly be completed. The standard is known as Retrofit Assessment for Domestic Dwellings – Code of Practice BS40104.

The next part of this paper will present the topics to be covered in the standard, why they are present and how they might be used.

A SUGGESTED APPROACH TO RETROFIT ASSESSMENT

The authors present below their own ideas for how the process for a detailed assessment of a property might be undertaken prior to retrofit.

The purpose of this proposed structure is to provide a tool that can be used to guide a designer/installer towards a retrofit solution that is suitable for the home and suitable for the occupant. A sensible approach to any assessment of property should be to use a structure. This can help provide a robust, comparable and complete assessment. It allows for a marketplace to be developed and for standards to be followed.

The data-gathering exercise can be split into two categories:

- *Desktop studies*: These can be captured using mapping services and other online services;
- *On-site assessment*: To be carried out at the subject property but possibly written up later.

Desktop studies

Context

This will describe the location of the house and the context in which it lies. In general surveying terms, some of these issues would not be seen as important for studies as building surveys etc., but when we are considering retrofit strategies and obstacles to these, a thorough assessment of the building must be carried out. The items and the reason for their inclusion are as follows:

- *Access*: Access to a home is key for a number of reasons with reference to retrofit. Examples of this are site deliveries, road widths, adjacency to obstacles such as main roads and accessibility to the façades. This is relevant as scaffolding might be needed for solar photovoltaic (PV) installation or EWI, for example;
- *Tree preservation orders (TPO)*: These can influence the choice of retrofit, as trees that are providing obstacles to the building will need consent from the local authority to be pruned or removed. Where items such as PV/EVI/turbines

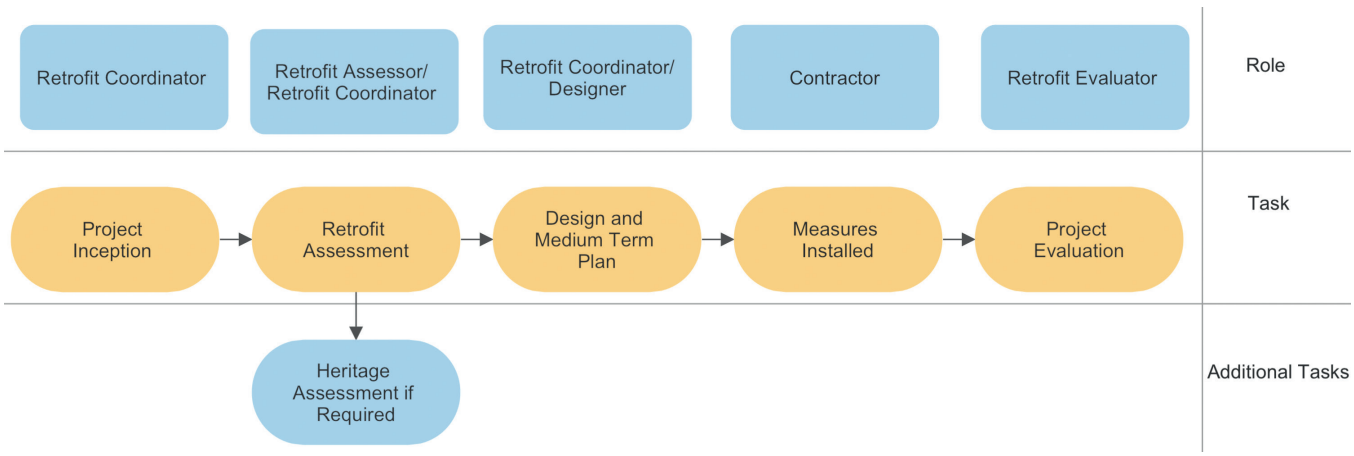

Figure 3: Flow chart showing PAS 2035 process and roles

are to be considered, this is a key data point;
- *Flood risk*: While flood risk may not appear directly relevant to retrofit, if a building may have flooded in the past or may flood in the future, this may affect the choice of retrofit materials applied to the building, and also electrical work;
- *Site topography and exposure levels*: Where a home is in an area of high levels of wind-driven rain exposure[13] or a with a high tendency to damage from freeze/thaw issues, this will affect retrofit choices. Also issues such as orientation, sheltering by neighbouring buildings, elevation and the prevailing wind should also be taken into consideration (*this is a large area of work and cannot be covered fully in this overview paper*). The makeup of the subsoil to the building can also be studied online, which will help indicate a building that may be more susceptible to damage from ground-borne risks. This can help inform defects around structural movements;
- *Smoke control area*: The assessor should make enquiries as to whether a smoke control area covers the property as this will affect the choice of secondary heating systems and some biomass installations;
- *Radon risk*: Radon is present at differing levels throughout the UK and checks should be made using online tools to examine the local levels, also equipment used for the mitigation of radon in a home should be recorded. The increased levels of airtightness associated with retrofit may present further issues;
- *Existing EPC*: The EPC is the backbone of most retrofit work carried out in the UK. PAS 20325 states that this should be carried out before and after the work. This will be used to help the decision-making process; it may also be carried out by the RA;
- *Statutory consents*: A web search may be made with the local authority to discover any works to the home that are planned or have taken place. This may help identify elements such as insulation levels/wall build-up in an extension or smaller items such as the date of a boiler replacement or the age of windows — all key data points that may be difficult to discover by a visual inspection;
- *Aerial photography and street level online imagery*: Pre-visit, the process of viewing the home on a digital map or other online resources is important. This will immediately present the orientation, adjacency and constraints to the site. Historical maps may also be useful in some assessments, in particular heritage properties.

Onsite assessment

Condition

While traditional pre-retrofit work has focused almost entirely on energy performance and occupancy assessments, PAS 2035 changes this. Condition assessment of the building is a key component of the retrofit assessment. This type of work is generally done by members of an institution such as the Royal Institute of Chartered Surveyors (RICS). In domestic work this generally takes the approach of three different levels of survey ranging from Levels 1–3, with Level 3 being the most detailed survey.

PAS 2035 originally suggested that the Level 3 survey was akin to what should have been prepared; however, this is work deemed suitable to be undertaken only by members of the RICS. This is not realistic, if the sheer volume of assessments predicted to take place were to come to fruition. There are obvious and valid concerns also about the ability of a RA to carry out a survey to Level 3. A condition assessment that can be delivered by non-chartered surveyors was needed. It has been decided therefore that the condition survey shall be covered by BS40104, and what follows is a precis of the authors' current ideas around this.

The area of condition assessment is a contentious one. The RA is *not* required to

complete a complete Level 3 study of the home, neither are they required to deliver a simple cursory tick-box exercise. A balance must be struck. This balance occurs by highlighting only defects that will affect retrofit, and while an understanding of buildings and defects (both cause and effect) is needed, it is not the RA's purpose to fully diagnose all defects. In essence: *observation of defects, not pathology of defects.*

The condition assessment focuses on several areas:

(1) *Type of concern*: What is the defect, where is it located and what is the effect it is having;
(2) *Level of concern*: Using a grading system, the assessor will decide how significant is this defect when related to retrofit. Three levels are presented in PAS 2035:
    (a) A defect that must be addressed before the retrofit commences in that area;
    (b) A defect exists that need not be repaired before retrofit (a lesser or cosmetic defect, for example);
    (c) A defect or suspected issue that requires further investigation before retrofit commences in this area;
(3) Photographic evidence showing location, nature and extent of defect should be captured;
(4) Details of any further investigation where required.

Occupancy

An overarching philosophy of PAS 2035 standard is that each home is unique and designed and installed retrofit should reflect this; not only is the home unique but the occupants are also. This means that the occupants themselves are a key factor in the decisions taken around retrofit. Failure to consider the occupants will lead to a retrofit that is not fit for purpose. To counter this, the RA should carry out an 'occupancy assessment' of the homes. This falls into two categories:

People in the property

This data point takes into account the more qualitative elements of the occupancy. These are likely to affect either the design or delivery of the upcoming retrofit and include questions around vulnerable people at the property, elderly people or those with requirements around disabilities. Other specific issues that pertain to retrofit can also be picked up here, such as overcrowding, poor living conditions or underusage of areas of the property, all of which can be considered by the RD.

Formal occupancy assessment linked to Reduced Data Standard Assessment Procedure (RdSAP)

This consists largely of quantitative and energy-related data such as the following:

- Actual fuel consumption for the property;
- Heating patterns and setpoints;
- Appliances (types and number);
- Cooking and washing behaviours.

This data can be used to form a more 'personalised' report around energy performance, which may help the RD with solutions that are more suitable and can give more accurate predictions around fuel usage and payback times of retrofit measures.

These occupancy inputs can help provide a retrofit design, customised to not only the house but also the occupants.

Ventilation

Ventilation is a key component of the PAS 2035 standard. Poor ventilation in homes can lead to problems with damp, condensation, mould and poor indoor air quality. PAS 2035 specifies the provision of good ventilation to the retrofitted building, and details how this should be provided; however, as with many things related to retrofit, this all begins with the assessment.

This, according to PAS 2035, should not be a cursory examination and should include

an assessment of the fixed mechanical ventilation systems present in the building. The assessor should provide an assessment of the building's ventilation routes (these provided by design, such as air bricks, trickle vents, etc.) and mechanical and passive ventilation systems. This should be done in line with BSRIA BG46.[14] This guidance provides detail on how to measure the performance of fixed mechanical ventilation systems in the home.

The work of the RA will focus generally on the inspection of typical and basic units such as extractor fans in kitchens and bathrooms; the performance of these devices should be measured with an airflow meter or powered hood device (see Figure 4). In conjunction with these measurements, other features should be checked, such as undercuts on doors to allow for airflow where extractor systems are used (extractor fans will not work if not linked by airflow to an incoming airflow path such as a trickle vent or similar). Other issues that may be linked to ventilation problems at the property should also be reported, such as taped-up vents, defective/broken fans, etc. Note: this work is separate to ventilation that is provided for the purposes of the structure rather than the occupant, such as sub-floor and soffit vents.

Energy performance

Given the entire process of PAS 2035 is intrinsically linked to the improvement of the energy efficiency of the home, clearly the assessment process requires the baseline energy performance of the building. This is achieved by the creation of an as-built energy model of the home. This is generally carried out using the well-established RdSAP methos currently used to produce the EPC in the UK. Other methods can be used where appropriate, however, such as the following:

- *SAP/full SAP*: This will deliver a more detailed report of the building where values such as U values or the level of airtightness are known using accepted test methods. This method allows for less assumptions to be made;
- *Passive house planning package (PHPP)*: The PHPP modelling tool can be used to provide a baseline energy model for properties and also to present retrofit package calculations, this tool is generally used when a project is subject to the Enerphit standard for low carbon homes.

Figure 4: Airflow measurement equipment

Significance

There are two categories of 'heritage' type homes that are treated differently in PAS 2035 (with good reason). They are as follows:

- *Protected building*: 'A building that is listed as of special architectural or historic interest, or located in a conservation area or World Heritage Site';
- *Traditional building*: 'A building with solid brick, stone or earth external walls, constructed with moisture-permeable materials and usually built prior to 1919, or pre-1919 timber-frame external walls with any infill'.

Both of the above building types should undergo an assessment of significance that meets BS 7913. It has been agreed in PAS 2035 that a simplified version of this can be used, which is included in the standard. The simplified significance assessment template is

supported by guidance and asks that the RA gathers information in the following areas:

- Approximate age of property;
- Built form (semi-detached, etc.);
- Similarity to other buildings;
- Importance of building in townscape/history of the area — is it linked with local historical people, industry or events?;
- Significance of materials or techniques used in each element, walls, roofs, fenestration and also internal characteristics.

Finally, the assessor is asked whether any features that purport to be significant have been covered/damaged over the years and whether a possible retrofit of this property presents an opportunity to improve this situation.

If the dwelling to be assessed is protected, then the RC may also choose to instruct a structural survey before retrofit design work commences to ensure that the building will not be placed at risk through the introduction of energy-saving measures. This is *not* part of the retrofit assessment.

REPORTING

This is one part of the PAS2035 standard that paradoxically is not standardised, with many RA and employing companies putting together ad-hoc reports, often consisting of handwritten or typed reports and drawings/sketches merged into PDF or Word formats to send further up the chain for the RC and RD to interpret and provide retrofit solutions. This means that most retrofit assessments currently have little or no commonality. While it practically may be possible for retrofit assessment to continue in this way for the short term, the lack of a standard approach to not only the minimum standard for data inputs, but also how the data collected is assembled and stored, could be a huge missed opportunity.

A structured dataset that is harmonised in its approach will lead to a higher quality of data collection, and the outputs can be cross-compared, stored and recalled more easily and can also present a dataset that can be well analysed by different stakeholders.

SKILLS: WHO DOES ALL THIS?

The PAS 2035 highlights the following in terms of qualifications. The RA should have (or be working towards) a Level 3 qualification in Domestic Energy Assessment (the standard qualification for provision of EPCs in domestic properties). The exception to this is that the RA role can also be covered by the RC, who has a Level 5 qualification, arguably bypassing the requirement of the Domestic Energy Assessor (DEA) qualification.

Where a building is designated as protected, the following further qualifications are required to allow heritage aspects to be correctly assessed:

- Level 3 Award in Energy Efficiency and Retrofit of Traditional Buildings;
- Scottish Level 6 Award in Energy Efficiency Measures for Older and Traditional Buildings;
- Welsh Level 3 Award in Energy Efficiency Measures for Older and Traditional Buildings.

These qualifications are very similar in terms of content; however, the issue presented is that neither the Welsh nor the Scottish qualification are active, as they are formally withdrawn.

These qualifications have caused much consternation among the retrofit and linked industries. As much as qualifications are specified that can be taken and recorded, the gap between the technical abilities of the DEA and those required to undertake the specified tasks of the RA presents an issue. This gap has been filled up to now by the provision of a set of criteria by the accreditation schemes responsible for the

RA roles. The Property Energy Professionals Association (PEPA) is a trade body which represents companies that are engaged in the provision of EPCs and provides the 'Scheme Operating Requirements' for the RA role. All accredited RAs should be proficient to this standard; however, this is not a formal qualification, rather a list of requirements.

The issue with providing only a list of requirements to train to is that every training establishment will deliver this in a different way and possibly to a different level, with varying degrees of content and quality.

Some groups are currently working on a formal qualification for the RA, with discussions ongoing around levels, content and assessment. One thing is clear, however: a more formalised qualification structure would be beneficial, as this will help to drive quality and may also help with the uptake of the RA role, as a formal qualification will be appealing to some.

DATA: HOW CAN WE BUILD ON THE DATA FOR THE GREATER GOOD?

Currently the RA for a typical property will gather the following amount of data for a typical detached home with several defects (this study was recently carried out by the authors):

- Seventy-two 'simple' data points (measurements, yes/no answers, etc.);
- Condition assessment;
- Ventilation assessment;
- Sixty-six high-resolution photographs;
- An EPC with XXX datapoints;
- Measured survey (elevations, sections of the main elements, floor plans);
- Sizes of all openings;
- Occupancy assessment.

This list of data represents a huge resource, not only for the purpose of retrofit, but could also act as a basic condition survey or home 'health check' for the occupant, landlord or building owner. The addition of a structured element to the RA dataset could provide policymakers, academics and other stakeholders with a valuable dataset that could be used for many applications.

CONCLUSION AND FURTHER WORK

This paper has highlighted the need for retrofit assessment. Without a detailed assessment, things can go wrong; however, a poor standard of retrofit with inadequate levels of training, delivery and data collected will not help. There is a clear requirement for a high standard of assessment of homes before design and delivery commences. It is hoped that the successful delivery of BS40104 will provide assistance in these aspects.

Further into the future, the prospect of common and harmonised standards of not only collection, but storage and presentation of this level of data across the housing stock could prove to be a wealth of knowledge to aid in the delivery of mass retrofit to those in maximum need, and to improve homes on a scale never seen before, as this data has simply never existed in the UK.

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