Retrofit of traditional buildings – what to consider when planning for the future

Historic Environment Division

Department for Communities

An Roinn Pobal

Depairtment fur Commonities

www.communities-ni.gov.uk

FRONT COVER IMAGE: Caledon Wool Store – roof insulation being installed during works as part of a Village Catalyst scheme (DfC)

The Construction Industry Training Board for Northern Ireland welcomes and endorses this guidance on improving the energy efficiency of traditional buildings. It creates a solid grounding for undertaking appropriate works to older and listed buildings, increasing knowledge and awareness of opportunities and challenges to ensure that Northern Ireland's historic environment retains its character and significance, whilst increasing occupant comfort and improving energy efficiency. Northern Ireland has an increasing number of pre-1919 buildings requiring repair and maintenance, and as we continue to move towards net zero targets, the retrofit of older buildings will form a significant part of regional construction output. Therefore, this guidance is not only important to the heritage sector, but also to the wider construction sector.

CITB
CONSTRUCTION INDUSTRY TRAINING BOARD NI

This document makes reference to the Sustainable Traditional Buildings Alliance (STBA)[1] booklet 'Planning Responsible Retrofit of Traditional Buildings'.

Disclaimer

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The technical drawings included in this guidance document are diagrammatic only and are used to illustrate general principles. They are not intended to be used as drawings for purposes of construction. Older buildings need to be evaluated individually to assess the most suitable form of construction based on a wide variety of possible variables. HED does not accept liability for loss or damage arising from the use of this information.

1 https://historicengland.org.uk/images-books/publications/planning-responsible-retrofit-of-traditional-buildings/responsible-retrofit-trad-bldgs/

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1 Introduction

Who is this guidance for?

This guide is for owners of historic buildings who want to reduce the energy use of a traditional building through technical interventions. This is what is primarily meant by 'retrofit'. Though aimed at owners, this guidance will also be useful for:

- Building tenants, managers and occupiers
- Architects, assessors and designers
- Project managers
- Building contractors

The guidance describes how to approach retrofit and its challenges. It will enable people to reduce energy use in traditional buildings in an effective way, and in a way which is also good for health, heritage and the natural environment. This is what is meant by 'responsible retrofit'.

Why is this guidance necessary?

There is increasing evidence that the well-intended retrofit of traditional buildings (and indeed all buildings) in recent years has not always led to the expected reductions in energy use. In fact, in some cases work carried out to improve energy performance has had the opposite effect and/or has harmed the building fabric, heritage value or health of building occupants. This occurs for the following reasons:

- the incorrect assessment of traditional buildings and standards used;
- a single or narrow consideration of both risks and retrofit measures;
- a disjointed and poor quality building process.

What is a traditional building?

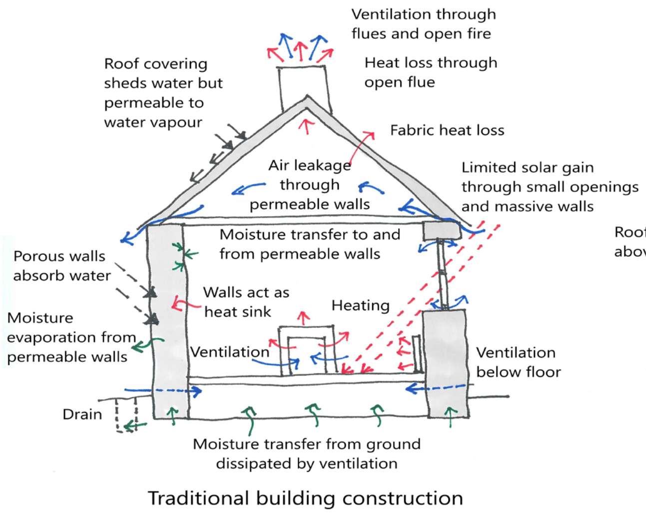
Many of our listed buildings are termed 'traditional'. Traditional buildings primarily consist of those built before 1919, with solid masonry walls of brick or stone, often originally finished with a lime-based render; the term 'traditional' is used to describe buildings with this vapour permeable (or 'breathable') construction. They often also have single-glazed timber or metal windows, and a timber-framed roof clad in slate, tiles, copper or lead. Only 16% of Northern Ireland's buildings are pre 1919 construction. (10% of Republic of Ireland's buildings are of the same period).

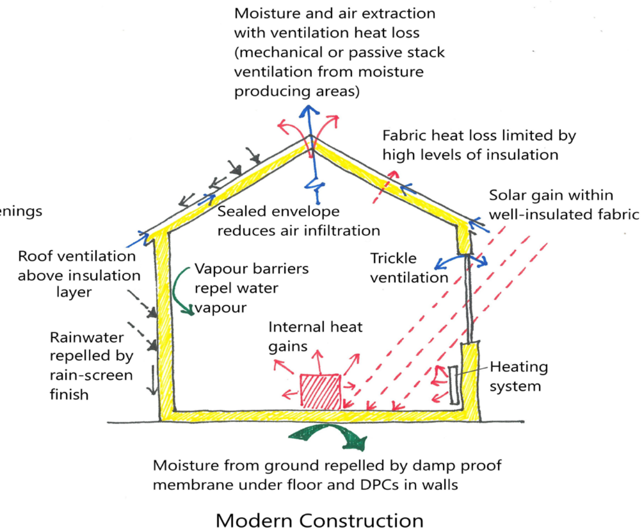
Their construction, which differs by material, method and design, means that their fabric behaves differently to a modern cavity built or framed building. This requires understanding, appropriate specialist skills and solutions to take a different approach to work on traditional buildings. In the case of listed buildings, interventions need to be considered with regard to their status, as they are protected by legislation.

The house shown above, is of traditional construction.

In a state of good repair, deep external masonry walls allow drying to occur before atmospheric moisture reaches the internal wall face. It is essential that all materials and finishes, including mortars and renders used on traditional walls, are vapour permeable to allow this natural transfer of moisture to occur.

Many traditional buildings have also had alterations, additions or other changes to their fabric, services and use over the past century, so they are often complex and seldom unchanged or unchanging.

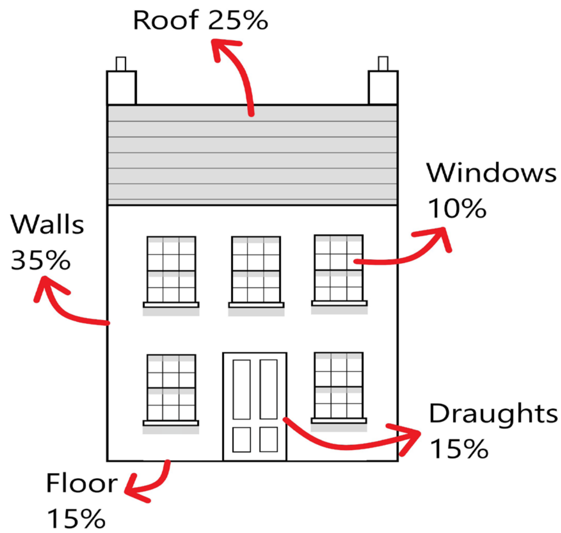




The diagram above shows moisture movement within modern construction versus traditional building construction.

What is retrofit?

In buildings, retrofit is the process of making interventions, usually additions or adaptations to improve the energy and environmental performance. Retrofitting does not need to be a ‘one-off’ project; it involves an ongoing programme of repair, enhancement and maintenance. The primary focus of retrofit is the reduction of heat losses through building fabric (i.e. walls, roof, doors, windows and floors) – thereby cutting heating costs, energy use and CO2 emissions.



The amount of heat being lost through any element will vary from building to building, dependent on many factors, but the approximate proportions illustrated in the figure (above) are a good indicator.

Although largely involving changes to building fabric, there are other important ways of reducing the carbon footprint. Improvement in services such as heating systems, controls and lighting and the use of renewable energy can reduce what is known as 'operational carbon' – carbon which is used during the day-to-day occupancy of buildings. Different buildings and different occupants benefit from bespoke approaches. Not all buildings can be retrofitted in the same way, and for some buildings and people there are more appropriate ways of reducing environmental impact than changes to building fabric. Sometimes, considerations around retrofit include small, simple lifestyle changes, non-invasive change and better maintenance.

So why retrofit your building?

There are many reasons for retrofitting a building. These include the desire to reduce carbon emissions, to save money, to improve comfort and health, to reduce worry about fuel bills and supply, or even to invest in the 'saleability' of a property. Some building owners are also obliged to retrofit because of legislation or building regulations.

However, traditional buildings and protected buildings, because of their different construction methods and/or their special interest, require special consideration which is provided for under legislation.

Re-using and maintaining an existing building is one of the first steps in contributing to a reduction in what is commonly termed 'carbon footprint'. This 'footprint' comprises everything about a building – from the distance the building materials travelled to get to site before it was built, to how sustainably sourced the building materials are, through to the operational or day to day carbon involved in heating and lighting, and on to demolition and how recyclable the building materials will be. The term used to describe the sum of these parts is 'Whole-life Carbon'.

Retaining traditional buildings means that the existing construction carbon footprint is secured, rather than adding further carbon waste and expenditure to the environment by demolishing and re-building. Comparatively, most traditionally constructed buildings used local building materials with a lower carbon footprint, which can be repaired and re-used, making them one of the most sustainable building types.

The desire for new build often comes from a desire to create energy efficient buildings. By retrofitting traditional buildings, the energy efficiency of a building can be improved, whilst potentially realising the benefits of a lower carbon footprint through the re-use of an existing building.

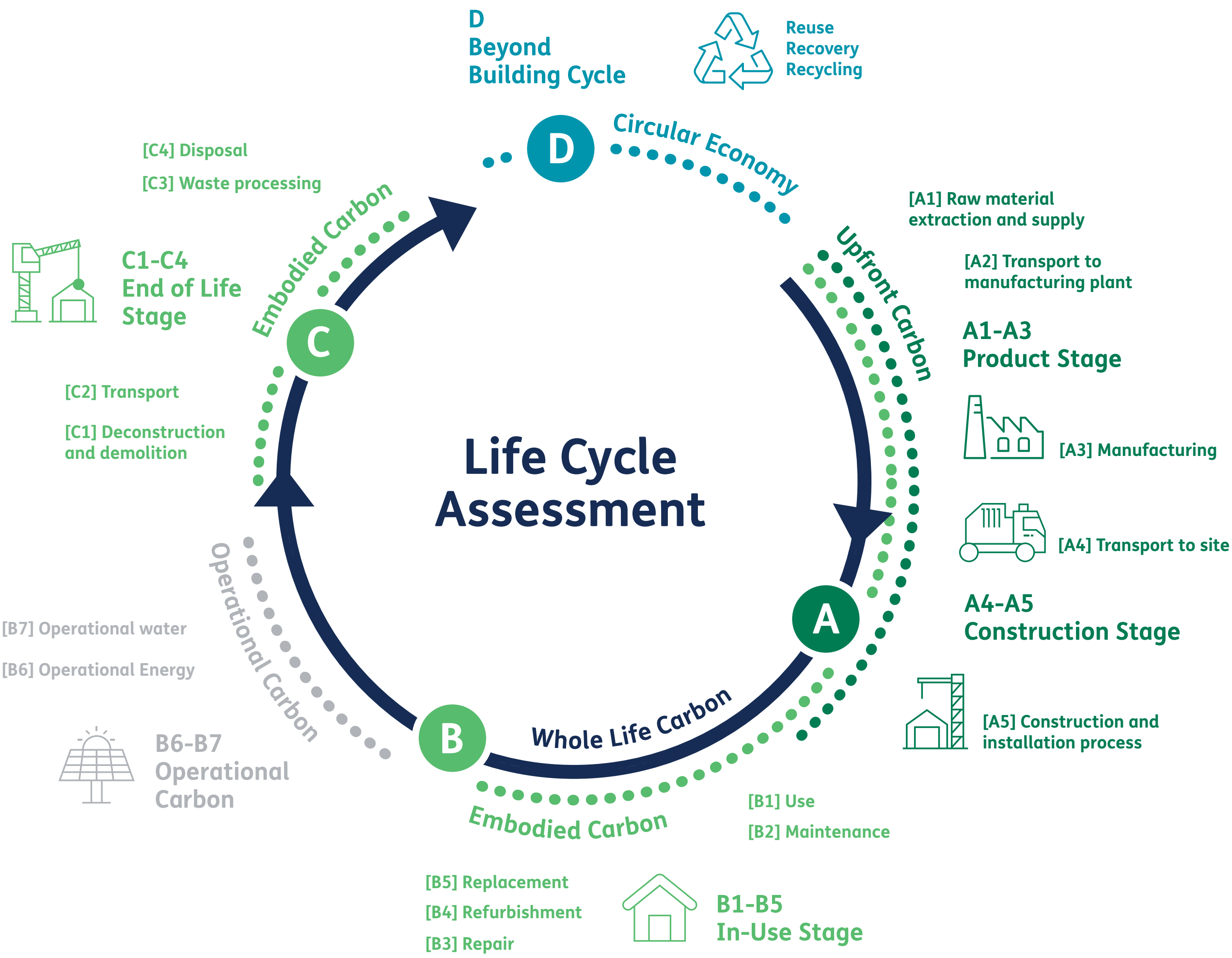


Diagram showing whole life carbon stages from **HED Whole Life Carbon Guidance**

Why does the retrofit of traditional buildings need a special approach?

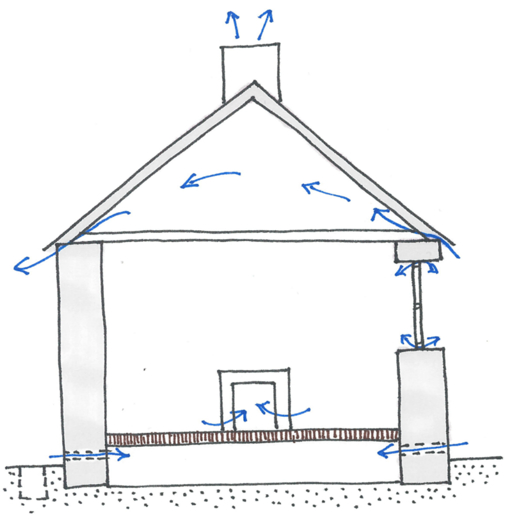
Traditional buildings were constructed using different materials and in different structural forms compared with modern buildings and consequently they perform differently. They usually heat up and cool down more slowly. Moreover, they deal with moisture differently, allowing rain, groundwater, and internal moisture (from washing, cooking and breathing) to evaporate and dissipate from their vapour permeable fabric.

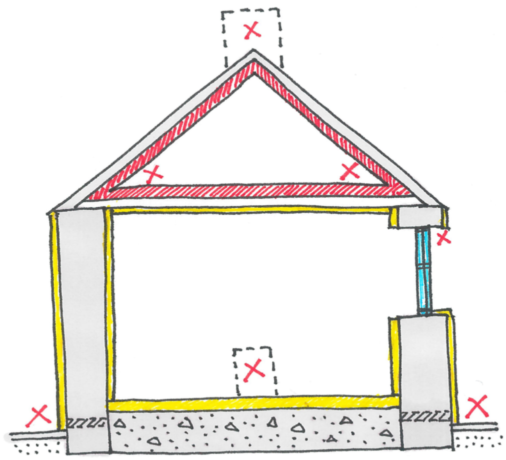
The retrofitted secondary glazing shown above with shutters in place has improved the thermal and acoustic performance of this traditional timber sliding sash window, which faces a busy road.

They also rely on cycles of drying provided by solar heat and air circulating (sun and wind), and internally, heating and adequate ventilation through windows, chimneys and draughts in order to stay dry. In good condition and with regular maintenance, the system stays in balance. Changes or additions
to fabric, heating and ventilation, if not correctly undertaken, can change this balance and lead to problems of overheating, moulds, damp and ill health.

Culturally, traditional buildings also provide local character and a very tangible connection to the past, with aesthetic and community benefits. All buildings do this, but traditional buildings reach further into the past and have greater links to locality and history. Historic buildings are a 'finite' resource – once lost they cannot be replaced. The traditional construction methods used in historic buildings have both functional and aesthetic qualities as well as having the benefit of longevity – they can be maintained and repaired for the benefit of future generations.

In some cases an historic building is considered to be of special architectural and/or historic interest, and is designated as a listed building. A small number of buildings and their surrounding area have also been identified as being of special archaeological interest and designated as scheduled monuments. This 'significance' should be taken into account when retrofitting is being considered.





The image above illustrates the difference between the principles of traditional ‘breathable ’ buildings versus buildings that have been inappropriately retro-fitted and no longer behave as intended (sometimes referred to as 'mal-adapted').

The image above shows an example of historic salts attracting moisture in solid walls manifesting above wainscotting line; wainscotting was vented to address the issue. .Lower part of wall was tanked.

How can I minimise the risk of getting it wrong?

This guidance document illustrates a practical approach to retrofit based on differences between modern and traditional buildings. It explains:

1. Understanding the risks

2. Using a 'Whole Building Approach'[3] when considering options

3. Carrying out works using a 'Joined up Process'[4]

3,4 These phrases were coined by Historic England in their guidance document 'Planning Responsible retrofit of Traditional buildings'. https://historicengland.org.uk/images-books/publications/planning-responsible-retrofit-of-traditional-buildings/responsible-retrofit-trad-bldgs/

Technical and Legislative considerations

When considering the retrofit of a building, it is important to ascertain whether planning and/or building control approval is needed, and whether the building is designated through listing or scheduling. Listed Building Consent or Scheduled Monument Consent will be required if this is the case. This will be best understood by a qualified and experienced conservation professional. An application to retrofit will be most successful when considered holistically i.e. energy efficiency is considered in tandem with heritage significance. Legislation provides for the special consideration of traditional and protected buildings.

2 How to achieve responsible retrofit – the 'Whole Building Approach'

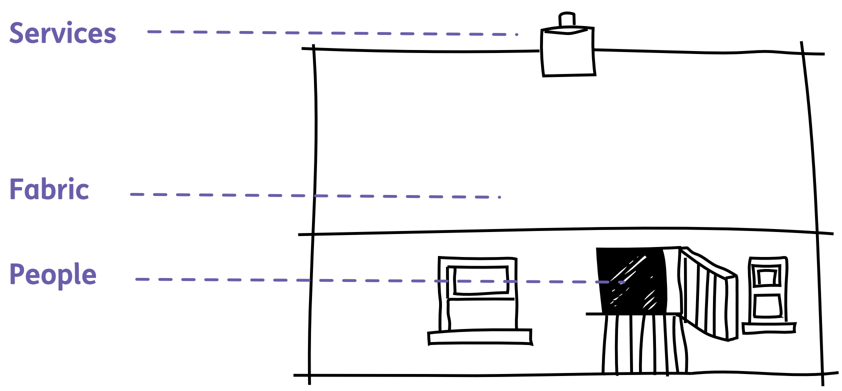
A 'Whole Building Approach' is recommended which integrates fabric, services (such as heating and ventilation) and human behaviour with the context of the building. This balanced approach is essential to long term performance.

It means the integration and balance of:

- **Fabric** measures such as insulation, draught proofing, glazing, weather (moisture) protection and management (i.e. improvement to pointing and gutters)
- **Services** such as ventilation, heating, thermostatic controls, renewable energy and
- **Human behaviour** in relation to how occupants understand, use and maintain their buildings.

These all interact with each other. It is important to understand, for example, that if a wall is insulated, then this will to some extent have a consequence for the windows, the floor and roof, as well as the internal air quality (IAQ). All measures, but particularly fabric measures, affect the rest of the building and the people who live or work in the building. Junctions and connections are particularly affected, but so are whole systems such as ventilation and heating. This is why we need a 'Whole Building Approach'.

This approach also depends strongly on the context of the building, as discussed later in the guidance, meaning its location, exposure to sun, rain and wind, the historic and community value, its condition, use and form, and the regulations and funding.



A 'Whole Building Approach' considers the balance between people, fabric and services to achieve better outcomes.

All of these determine the way in which a 'Whole Building Approach' should be carried out, and the options and constraints for retrofit.

The SBTA provide a useful tool called the **Responsible Retrofit Guidance Wheel** which shows interactions between the various measures, and their risk levels for technical, heritage and energy.

Getting it Right Adopting a 'Whole Building Approach' – Striking a Balance

A 'Whole Building Approach' seeks the best balance between saving energy, maintaining a healthy indoor environment and sustaining heritage significance, all by understanding the building in its context. Because opportunities and constraints vary widely depending on the building, the optimum solution in one case might be quite different in another, even though the buildings can appear to be very similar. Therefore the 'Whole Building Approach' is site-specific and considers all factors affecting energy use. It ensures that improvements are suitable, proportionate, timely, well-integrated, properly coordinated, effective and sustainable. It also helps to highlight and resolve uncertainties, reconcile conflicting aims (such as heritage and energy efficiency), and manage the risks of unintended consequences.

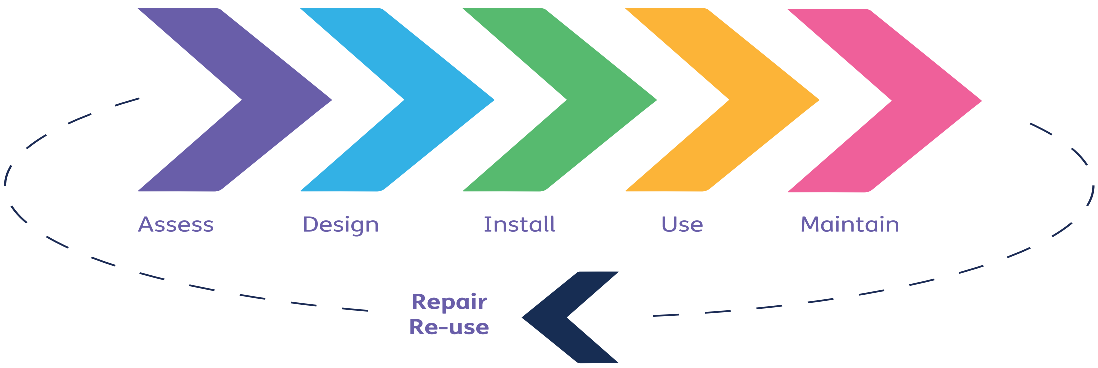
Chimneys are often blocked up because solid fuel is used less often. This can have technical, aesthetic and cultural implications. A whole building approach considers:

- the technical performance of the building - providing a ventilation grille at the base and a capped but vented chimney pot on the disused flue to provide ventilation for both the chimney void and the interior **(Services)**
- the aesthetic and architectural design of the house if considering removing a chimney piece or fireplace internally, **(Fabric)**
- as well as the cultural value - the habits and lifestyle of the occupants when considering the removal of a hearth which sits at the 'heart' of the home. **(People)**

Questions to ask yourself

1. Do you have sufficient understanding? If not, can you find an experienced, qualified professional (surveyor/architect) or experienced, qualified installer who does? You can learn more by reading online resources or going on appropriate training courses.
2. Do you have sufficient capacity, in terms of time, budget and patience (to cope with the disruption)? If you don't then either delay or plan the work in stages.
3. Is this the right time to do the work? What other work is required or will be undertaken in the future? Make sure you co-ordinate work programmes to ensure integration and best value for money.
4. Do you really need to do the work? How else can you improve your environmental impact, health and comfort or make cost savings? Sometimes it is easier, safer, and more environmentally friendly and to make more conservation–led lifestyle changes and simply to maintain the existing building well.

Joining up the process – a checklist for success



A 'Joined-Up Process' above considers the lifetime of a building in terms of 'whole life carbon', not just through use or 'operational carbon'.

A Joined-up Process is important, linking up **assessment, design, construction** and **use** with appropriate **training, quality assurance and feedback.** These are essential factors in avoiding risks and pitfalls and achieving lasting benefits. The following checklist sets out what to consider:

Assess the building and context

- ☑ How is the building constructed, how does it work (or not work), and what is its condition? Is a special survey required? (for example, archaeological)
- ☑ What is the current and future use of the building? What is the current level of energy use, what are the moisture levels and indoor air quality? Consider monitoring, look at past bills, check local record for radon risk.
- ☑ What is the heritage significance, overall and in specific parts of the building? Avoid or minimise harm to these; works will only be acceptable where they will balance any impact with a greater sustainability and/or enhancement of the asset. Refer to guidance on **Conservation Principles**
- ☑ What is the relationship to streetscape, landscape and community? Refer to guidance on **Setting in the Historic Environment**
- ☑ Consider level of specialist conservation input required and appoint appropriate person/s to assess and prepare reports, for example, statement of heritage significance, condition survey. This will depend on the magnitude of the proposals and the importance of the asset.

Set objectives and cost

- ☑ Set budget, consider long term offset energy/ payback costs
- ☑ Objectives might include:
    - reducing bills by upgrade of mechanical and electrical equipment, for example, more efficient boilers/ overhaul of existing boilers
    - use of greener fuel/ renewables
    - better comfort
    - adaptive/ flexible or new use
    - upgrading to support a new and sustainable use

  Sustainable objectives should have robust justification for any (minor) impacts to heritage.
- ☑ Consider realistic timing, to allow for the preparation of specifications, suitable detail design, obtaining necessary consents (Will work need to be phased and is building required to be in continuous use?)
- ☑ Be realistic about budget to align priorities and ensure adequate resources (human and financial) are available
- ☑ Balance objectives with heritage impacts – simple measures (draughtproofing, upgrade or service equipment) should be priority works before more invasive measures are undertaken after review of performance.
- ☑ Prioritise objectives and approach incrementally.

Design, specification and responsibility

- ☑ An appropriately qualified person should prepare the detail and specification for any proposal.
- ☑ Listed Building Consent (LBC) (see also below), Conservation Area Consent or Scheduled Monument consent (SMC) will be required if the building is listed, within a conservation area or scheduled. Ensure that the works meet local planning regulations– check with your local council and HED if you are in doubt.
- ☑ Having better understood the building, its status, significance and its context, devise a strategy which integrates all issues and has sufficient capacity and caution where there is uncertainty or conflict.
- ☑ Ensure that design follows a Whole Building Approach.
- ☑ Are there opportunities to better use the context/ environment/ orientation/ green spaces (microclimate)? For example, solar gain directly or solar gain through appropriate placement of solar panels, moving spaces occupied in the daytime to south facing/glazed locations to benefit from solar gain, planting shelter hedges to stop wind driven rain and reduce wetting of fabric.
- ☑ Are there opportunities to enhance significance and understanding while meeting users thermal needs? For example, removal of substandard and non-significant abutting buildings of poor construction causing damp (and thus cold) and distorting aesthetic of the original building
- ☑ Are there priorities which will give most benefit, such as repointing in lime to prevent air infiltration, removal of cement renders causing damp?
- ☑ Specify low environmental impact products and processes wherever possible.
- ☑ Make an exact specification of product wherever possible to ensure that lower quality products are not substituted.
- ☑ If substantial overhaul or upgrading of an element is proposed (rather than localised repair in compatible traditional material), your local building control office should be consulted.
- ☑ Include feedback and Quality Assurance (QA) process in the specification and tender documents.

Installation

- ☑ Ensure that contractors have sufficient training, understanding and interest in the responsible retrofit approach.
- ☑ Ensure that contractors price for the Whole Building Approach and have feedback and checks agreed with designers and client.
- ☑ Ensure that a clerk of works or suitably qualified/trained person is on site with overall responsibility for the Whole Building Approach.
- ☑ Ensure regular checks of detailed design, historic buildings can yield new information in the course of a project so be prepared to be flexible.
- ☑ Undertake recording of works for current and future owners or custodians.
- ☑ If necessary use air pressure testing and thermographic survey for QA check.

Review, use and maintenance

- ☑ The project lead or co-ordinator should ensure the occupant is provided with a comprehensive user manual at handover, written in plain language with clear diagrams, along with a checklist for management (eg. checks for mould, ensuring clear ventilation routes)
- ☑ The project lead or co-ordinator should run through services and fabric measures to show the occupant the benefits of correct use and maintenance. (As simple as regular 'purge' airing or efficient use of zoned heating controls, other ventilation strategy)
- ☑ Prepare a clear maintenance manual (this can be a simple, short document) with dates for work, estimated costs and contact details for the relevant tradespeople.
- ☑ Provide facility for current and future stakeholders to review performance. (eg. Review of energy bills, review of comfort strategies)

Feedback and learning at every stage

Wherever there is an uncertainty, particularly around fabric and health risks, it is good practice to put in some form of monitoring and feedback mechanism. Building professionals should take this opportunity to carry out a post occupancy evaluation of upgrades as much can be learned for future projects.

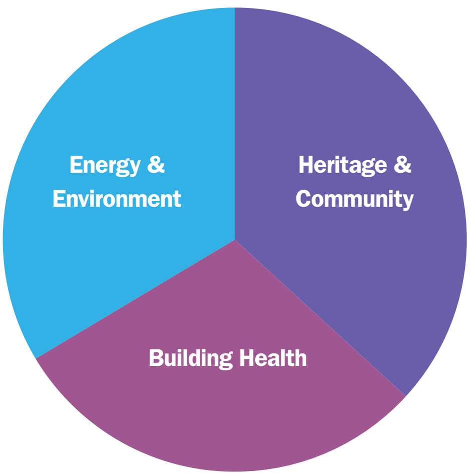
Refer to Chapter 4: Look and Learn in this document, which has further information on the observation and recording of the effects on your building due to works carried out, to monitor results and to learn from successes and failures.

3 The challenges of retrofitting traditional buildings

The success of a retrofit depends firstly on understanding the building and its context in sufficient detail and depth. There is also a need to understand that some building standards commonly used in the building industry are inappropriate for historic buildings or that the available information relating to all building types is incomplete.

When retrofitting traditional buildings, the STBA suggests that there is a need to consider three broad areas of risk:

- Energy and Environment
- Building Health (health of both fabric and people); and
- Heritage and Community.



The three areas of risk to be considered

Sometimes compromises must be made between these values to get the best overall outcome.

Energy and Environment

The current energy performance of the building

Traditional buildings vary widely in form, scale and construction. Therefore, their thermal characteristics can differ significantly. There has been a tendency to underestimate the energy performance of buildings of traditional solid wall construction, and so it is important to study a building carefully before making assumptions about its thermal performance. The assessment should record:

- dimensions,
- construction methods, and
- materials of the relevant building elements and components.

Existing energy-saving features should also be recorded:

- insulation,
- draught sealing,
- shutters,
- double or secondary glazing.

Aspects of the building fabric that might adversely affect comfort or energy performance should also be highlighted.

Climate

It is also a good idea to plan for the future. The National Trust have created a 'hazard map' which shows predicted changes in future weather patterns, as a result of climate change. While each building is unique and site specific, using information like this can be a useful tool when considering better future-proofing and any retrofit measures. This could further be considered alongside any long term adaptation plans or mitigation measures.

National Trust Climate Hazards (arcgis.com)

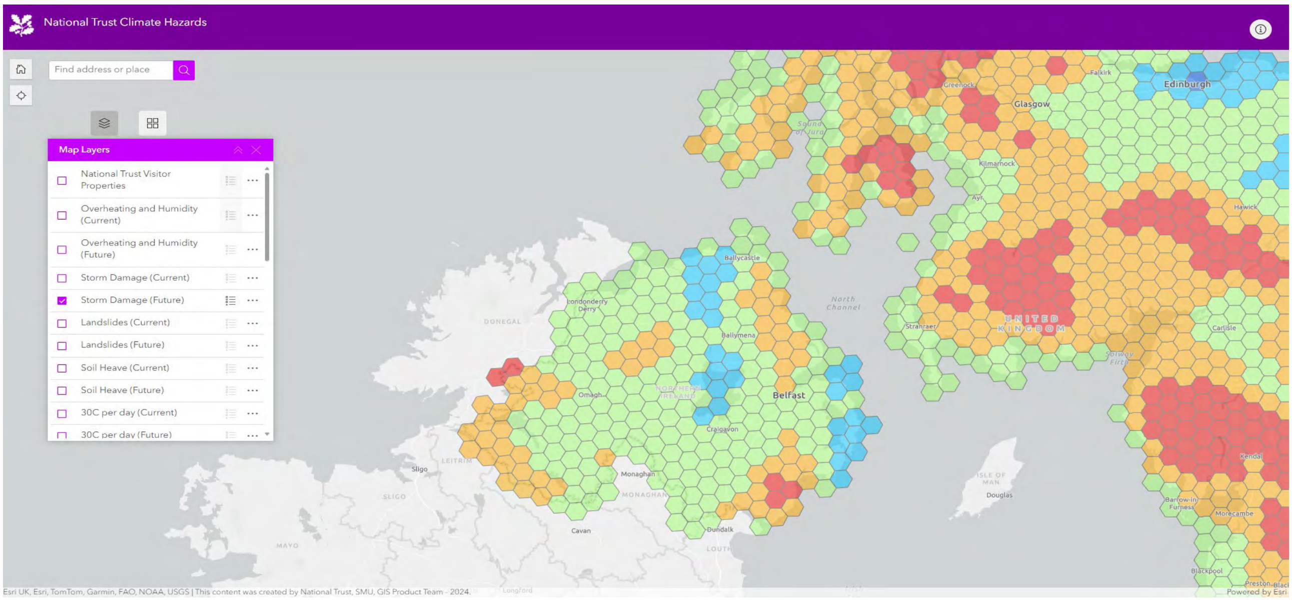


Image from **National Trust Climate Hazards (arcgis.com)**

The environmental impact of retrofit work

As previously acknowledged in this document, an existing building can in itself be inherently 'greener' than a new build due to its embodied energy or the energy used to bring it into being.

Retrofit is commonly measured in terms of its effect on the energy consumption and CO_2 emissions from buildings in use. It has been demonstrated that suitable and sensitive energy saving measures in traditional buildings can result in significant carbon reductions.

Undertaking 'responsible' retrofit means taking into account the carbon impact of new construction and materials. This can be substantial and sometimes even outweigh any savings in use as new retrofit materials themselves require energy for manufacture and transport to site, and in many cases are made from increasingly scarce resources such as oil, or are taken from vulnerable habitats.

It is possible to calculate the whole-life carbon life-cycle impact of a building using the RICS (2017) Whole-life carbon assessment for the built environment - **whole-life-carbon-assessment-for-the--built-environment-november-2017.pdf (rics.org).**

Building health (fabric and people)

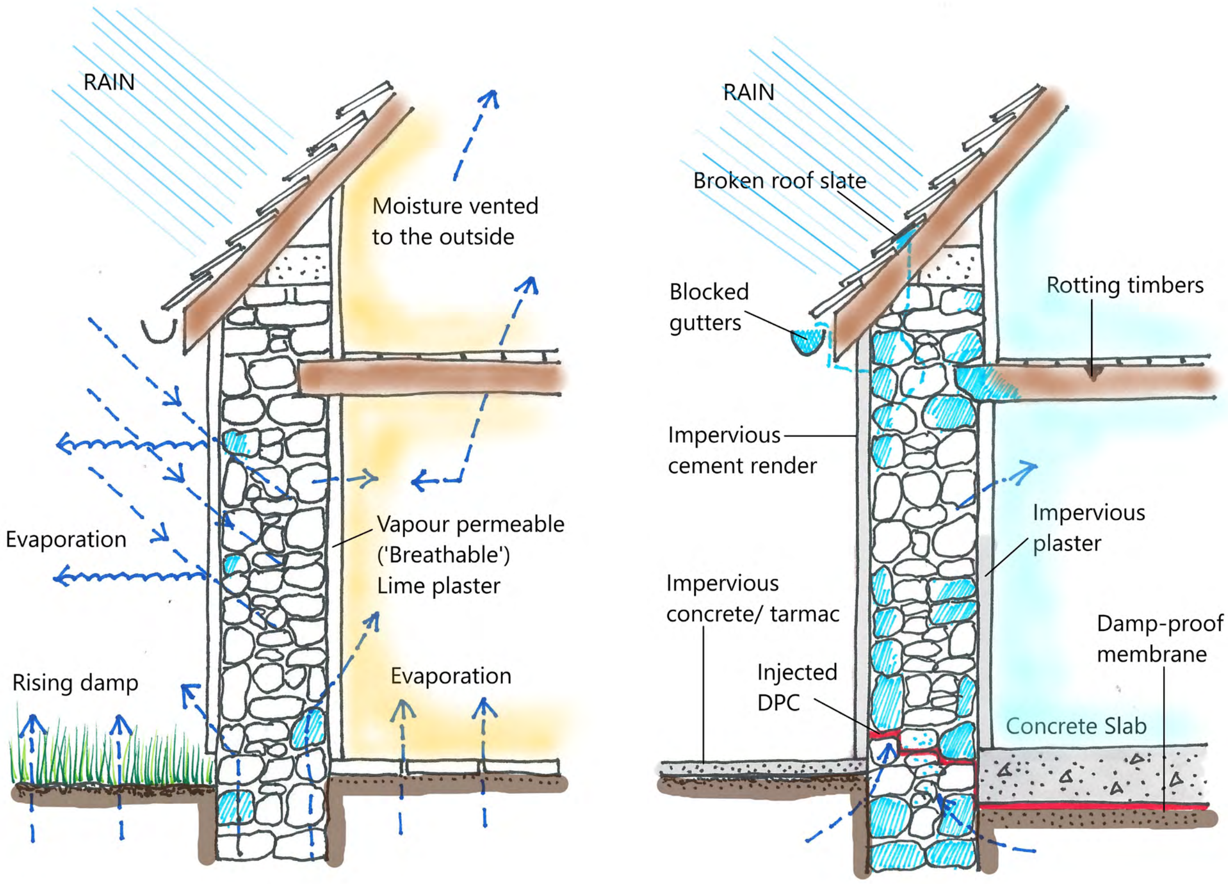
The condition of the building

When considering retrofitting measures, a primary concern is the current condition of the building, which can vary greatly. Building condition has a major influence on energy use and where a building is in poor condition retrofit may not be appropriate before remedying the condition first.

Wet fabric allows heat to be 'conducted' outwards much more easily, therefore resulting in accelerated heat loss. Dampness and draughts from poor maintenance can be the cause of much higher energy use, longer term structural problems and risks to health, and yet they can often be easily improved. Repairs are an important energy-saving measure in their own right. They are an essential prerequisite when considering some thermal improvements, such as the addition of wall insulation.

Close attention should always be paid to the adequacy and condition of rainwater disposal arrangements and drainage, and areas of dampness should be identified and diagnosed.

Failure to deal with leaking gutters and rainwater pipes, defective drainage and dampness before installation can lead to serious damage. In some cases due to alterations, modernisation and poor maintenance, the building fabric may be at the limits of its capacity to handle water vapour or rain ingress, which can lead to failure if further retrofit measures such as insulation or draught proofing are not undertaken as part of a whole building approach, or are incorrectly applied. Our more extreme climate (heavy, sudden downpours for example) means this is even more crucial.



Left above: a well-maintained traditional building which is adequately heated and ventilated; the daily and seasonal cycles of wetting and drying, heating and cooling, balance out. However, the equilibrium may be adversely affected when inappropriate changes are made to building fabric heating or ventilation to increase energy efficiency. This can lead to unintended consequences, including moisture accumulation, overheating, fabric damage, and ill health of householders due to poor indoor air quality (right). Therefore, when planning energy efficiency improvements, it is important to understand the way the building performs as an integrated environmental system.

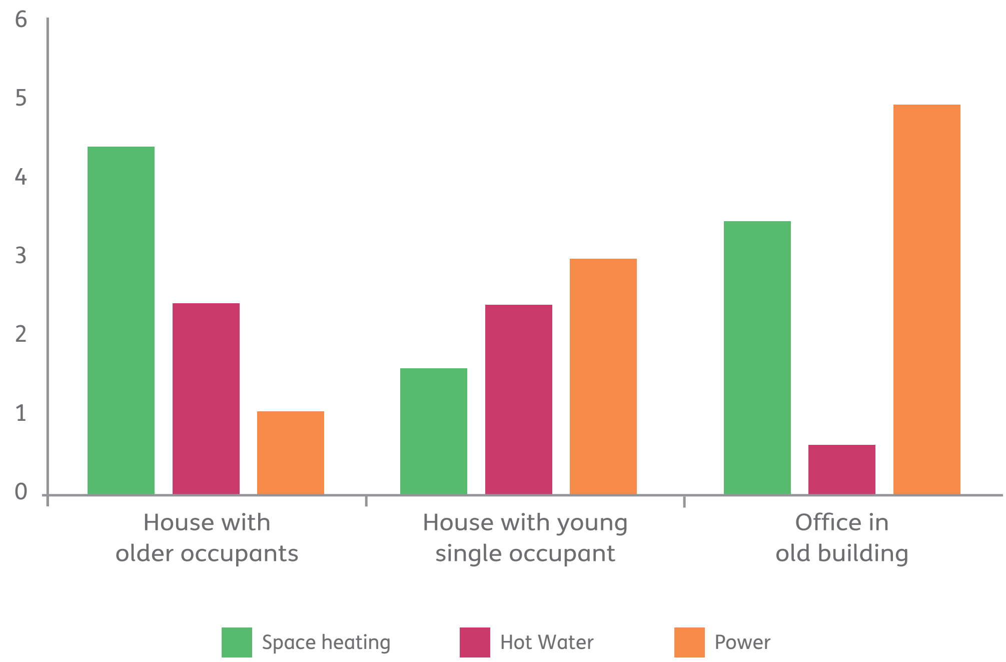
The images above show some possible detail differences between a well-maintained traditional building (left) and a badly adapted or ill-maintained building (right).

Occupation and Use

Just as the forms of traditional buildings vary widely, so do their occupation and use. Understanding the history of use and how this has changed is also important, as it gives clues to what might work and what might go wrong. For example, moisture levels will differ considerably with different building uses and lifestyles.

Different building users also have different energy usages. In most buildings the greatest energy use is for heating the building. However, office-based workers often use far more energy on appliances than heating, an elderly couple on their home might use hardly any appliances at all but have their heating on continuously. The energy use and cost-effectiveness of varying retrofit measures will, therefore, be highly influenced by the type of the occupant as well as the use of the building.

Energy use varies depending on the occupants' lifestlye



A sample chart showing energy usage (STBA) Planned retrofit measures should be appropriate for both current and potential future occupiers of a building.

How well services perform

The efficiency, control and management of existing building services- heating and cooling, hot water supply and lighting, and equipment and appliances – are key factors for consideration. Assessments should identify fuel sources and the type, size, age and condition of all the energy-consuming services and equipment. The way the engineering services are controlled and operated should also be reviewed. Any defects that need to be rectified and opportunities for improvement should be highlighted.

Strangford Conservation Area

Understanding the Context of your Building: Local climate, orientation and exposure. Strangford Conservation Area (above)

The location and orientation of a building makes a considerable difference to how a building performs and can widen or limit options for retrofit. In some locations - for example coastal areas of Northern Ireland - where there is a lot of driving rain or wet ground, walls can be very wet for long periods and this will mean that care has to be taken with any insulation or fabric measures, and good maintenance of buildings is absolutely essential.

Examples:

Ground levels can be reduced around a building to help with the drying out of walls. Even the type of ground surface can have an effect – tarmac which reaches to the very edge of a building can stop moisture percolating away. A French drain could be installed to help divert water away from the wall base.

The siting of nearby mature trees can have an effect on solar gain, but also affect maintenance plans for access to gutters and downpipes which would need to be checked more often for leave fall and root invasion from deciduous, mature trees.

Buildings in cities have different options from those in rural areas, due to what is called the 'heat island' effect which makes cities much warmer and sometimes causes overheating problems. There can also be issues with security and air pollution, which make changes to windows and ventilation more critical.

Heritage and community context

A building's shared history, beauty, place in the community and social life all contribute to its heritage significance and community value, which must be considered alongside its condition, occupant use and location in any retrofit strategy. For some buildings heritage value is defined in legislation such as when a building is designated as a Listed Building or Scheduled Monument or is located within a Conservation Area/Area of Townscape Character (ATC). There will be planning constraints on how these protected buildings can be repaired or altered.

However in some cases the heritage or community value is not formally designated, so a sympathetic understanding and sometimes research is required to identify what is significant. The appearance and use of some traditional buildings can be improved and enhanced by retrofit, and sometimes the approach taken to the works will need to consider an entire streetscape or community area. These factors must all be considered to minimise risks to heritage and community.

A traditional terrace highlighting the potential group and community value of buildings set within a streetscape – each building forms part of the others' setting.

Technical Interactions

It is essential to take a 'Whole Building Approach' within a 'Joined-up Process' as there are complex interrelations between the thermal elements, heating, use and context. If alterations are made to one element, then there may be knock-on effects with other elements.

For example, when introducing better-performing windows:

- Space heating demand is reduced, so the heating system will need adjustment
- Air leakage will be reduced, so additional ventilation may be required
- Adjacent walls may become cooler in relation to the windows, so without good ventilation the risk of condensation on the reveals may increase.

There is also a 'rebound' effect which can exacerbate problems (when occupiers run the building at higher internal temperatures, because it is now possible to do this without prohibitive cost).

The Conservation approach – minimum intervention / maximum retention

At times, technical solutions may not be necessary. When certain simple improvements can be made, such as hanging heavy curtains, or laying roof insulation, with minimal disruption to the building, but with just as effective an outcome, it is always worth initially considering the minimum amount of disruptive work needed and assess whether this will be enough.

Issues with standards and regulations : Traditional construction standards, data and modelling

As identified in the STBA report there is sometimes information missing in building standards, regulations and assessment systems (typically computer models) which doesn't always factor in the bespoke construction of traditional buildings. This is partly due to the time-lapse between best current research knowledge and published standards, and partly due to the uncertainty of data and science of traditional buildings.

Weighing risks against benefits

Given the right approach, the objectives of improving energy performance and sustaining heritage significance are compatible and achievable. However, there may sometimes be a temptation to achieve one objective at the expense of the other. Householders might aim to increase comfort and reduce energy bills and carbon emissions, while ignoring the possible harmful impacts on the physical structure of the building itself and its heritage significance. The example discussed above could go wrong if the chimney and hearth were removed. While this would reduce air infiltration and increase airtightness, such an action would more often than not be damaging to the aesthetic and architecture, as well as the cultural value.

Compromise is possible. Energy performance improvements may even present an opportunity to enhance a building's heritage significance through associated restoration works, which otherwise might not have happened.

Risks from Specific Retrofit Measures

Examples of the risks arising from specific retrofit measures are summarised under the headings:

- Building fabric
- Services
- Human Behaviour
- Context

Historic Glass including its aesthetic and historic properties can be lost when wholesale replacement or re-glazing of windows is suggested. In this example from an early 20th Century house in Belfast, openable secondary glazing could be installed internally. This would leave the original glass and frames untouched whilst improving the acoustic and thermal properties of the windows.

Image showing an attic vent- crucial to the dry condition of the roof timbers.

Risks to Building Fabric	Main Risks to be considered	Action Needed
Internal Wall Insulation:	- Heritage: visual and technical impact (internal) - Trapped moisture risks leading to rot of fabric - Poor indoor air quality from poor ventilation / damp - Heat loss from wet walls or thermal bridging - Future climate change risks (long term changes in temperature/humidity levels)	- Assess building fully for condition, context and interactions between building elements/materials. If uncertain take expert advice on heritage significance, the passage of moisture through the building and thermal strategy - Consider the Whole Building Approach especially at junctions and ventilation considerations - Use trained/ qualified specifiers and contractors.
External Wall Insulation:	- Heritage: visual and technical impact (both to building and streetscape) - Trapped moisture risks leading to decay of fabric - Poor indoor air quality from poor ventilation / damp - Heat loss from wet walls or thermal bridging - Future climate change risks (long term changes in temperature/humidity levels)	- Assess building fully for condition, context and interactions between materials and elements - if uncertain take expert advice on heritage significance, the passage of moisture through the building and thermal strategy - Consider the Whole Building Approach especially at junctions and during ventilation considerations - Use trained/qualified specifiers and contractors.
Roof Loft Insulation:	- Colder roof space/increased trapped moisture risk - Future climate change risks (long term changes in temperature/humidity levels)	- Ensure ventilation is adequate at eaves and check roof space regularly - There may be required insertion of increased ventilation which can alter the character of the roof; may be required changes to eaves/roof level which need to be managed/designed to suit if possible
Roof Rafter Insulation:	- Heritage: visual and technical impact (both to building and streetscape) - Trapped moisture risks leading to rot of fabric - Future climate change risks (long term changes in temperature/humidity levels - Future climate change risks (long term changes in temperature/humidity levels)	- Ensure historic ceilings or roofs are not damaged. Ensure over rafter insulation takes account of heritage values of roof and streetscape/eaves details. - Moisture safe design and detailing
Suspended Floor Insulation:	- Heritage: visual and technical impact (both to building and streetscape) - Trapped moisture risks leading to rot of fabric - Future climate change risks (long term changes in temperature/humidity levels)	- Check historic significance of floor – visual and technical - Moisture safe design and detailing. Ventilate below floor. Check effect on whole building ventilation flow.

Risks to Building Fabric	Main Risks to be considered	Action Needed
Solid Floor Insulation:	- Heritage: visual and technical impact (both to building and streetscape) - Trapped moisture risks leading to rot of fabric - Future climate change risks (long term changes in temperature/humidity levels)	- Check historic significance of floor – visual and technical - Moisture safe design and detailing. Ventilation below floor – check wall vents are adequate - Particular issues can arise at floor/wall junction
Window upgrade:	- Heritage: visual and technical impact (internal and external appearance) - Trapped moisture risk (change in ventilation, thermal bridging) - Secondary glazing needs to respect existing features eg. Shuttering, window reveal detail, joinery craft	- If uncertain, take expert advice for heritage, moisture and thermal strategy for windows - A Whole Building Approach is Essential - In certain cases the renewal of existing shutters, the hanging of thermal curtains and work to improve on draught-proofing such as adding brushes or strips to windows is adequate to improve thermal comfort of existing windows. **Note:** In buildings of historic significance double glazing is only permitted in certain circumstances and will be assessed on a case by case basis. Double glazing can dramatically change authenticity of historic windows through reflection of glass, depth of frame, inauthentic fixing methods. Loss of historic fabric (glass, timbers) is of prime importance and is not acceptable where glass is sound.
Airtightness:	- Heat loss reduction - Trapped moisture risk (both to fabric and human health)	- Understand existing and post retrofit ventilation effects - put in additional controlled ventilation if required. - Check for blocked existing ventilation pathways such as chimneys or wall vents.
Ventilation:	- Heritage: visual and technical impact (from ventilation grilles, ducting) - Heat loss from incorrect type of use	- Understand existing ventilation. - New systems must be designed and installed sensitively. Systems must be easy to operate and effective. Users must have a good understanding of how to use and manage ventilation both passively and mechanically. - Check for blocked existing ventilation pathways such as chimneys or wall vents.

Risks from Services	Main Risks to be considered	Action Needed
Mechanical Systems:	- Heritage: visual and technical impact (from inappropriate installations/pipework/flues, etc) - Heat loss from incorrect type or use - Future climate change risks (long term changes in temperature/humidity levels)	- Understand existing heating, cooling and ventilation demand. New systems must be designed and installed sensitively - Systems must be easy to operate and effective. Users must have a good understanding of how to use and manage equipment both passively and mechanically, as well as servicing and upkeep.
Renewables:	- Heritage: visual (including setting) and technical impact (for roof applications, or ground excavation) - Energy loss from incorrect type or use - Expected vs actual performance of renewables depending on site variables (eg. windspeed/ topography)	- Consult experts, community and statutory (planning) for heritage risks – visual and technical, as well as sound and visual disturbance considerations (wind turbines for example make noise and are constantly moving) - Ensure correct specification and installation - Users must have a good understanding of how to use and manage equipment both passively and mechanically, as well as servicing and upkeep
Controls of heating, lighting and ventilation Systems:	- Moisture risk - Energy loss from incorrect type or use	- All controls of systems and windows should be usable, intuitive and properly designed and specified. Users must have a good understanding of how to use and manage equipment both passively and mechanically, as well as servicing and upkeep.

Risk from Human Behaviour	Main Risks to be considered	Action Needed
Use, repair and maintenance:	- Heritage: visual and technical impact - Moisture risk (fabric and human health) - Energy loss (from services not working properly and from dampness in fabric)	- Ensure user/owner has an understanding of retrofit systems and building maintenance - Schedules of repairs are important - Build into long term financial planning
Capacity and Caution:	- Heritage: visual and technical impact - Health impact - Energy impact	- Ensure there is sufficient understanding, skills, time and budget for project - Try not to undertake over-ambitious or complicated measures - Look and learn at all times – this may mean revising plans, adapting and re-considering along the way

Considerations for Retrofitting Renewables

The solar panels shown above are installed on a slate roof. Consideration should be given to the aesthetic impact of solar panel installation (particularly on designated buildings where permitted development rights do not apply). Technical details should also be considered during both the installation and maintenance stages – how will the panels be accessed for cleaning and maintenance for example? Often, solar panels are best situated on a low outbuilding to the rear of a building where they are visually inobtrusive and easily accessed

Heat pumps as shown [here] are large and can be noisy. Care should be taken so as not to impact on the setting or character of buildings for installation and maintenance. Like solar panels, they are often best located at low level to the rear of a building, easily reached from the ground. Consideration should be given to the base and any plant required to connect the heat pump to the main building too.

In this context, ‘renewables’ are replenishable low- or zero-carbon energy (LZC) technologies, in contrast to fossil fuels, which are finite energy sources. Renewable energy sources include: solar, wind, hydro, thermal (ground, water, air), biomass and combined heat and power.

Many historic buildings or places are suited to some form of renewable energy generation. For buildings, the key is to establish the significance of the building at the outset. The renewables system should be carefully chosen to respect the building’s historic character and significance, for example, a wind turbine might be very effective to generate energy sited on a hill, but not if this is adjacent, within significant view, or on the site of a heritage asset. The character and significance of a historic building can include factors such as original purpose, style, elevations, profile, materials, detailing and setting . Consent may also be needed, particularly if you live in a listed building or in a conservation area.

Before retrofitting renewable energy technology into a building, it is recommended that all available energy efficiency measures, including efficient services and improved insulation where suitable, are considered as these are generally the most cost effective means to reduce the carbon footprint.

Where a building is sited and its immediate context (nearby trees/aspect for example) will have an impact on what kind of renewable technology will be available for use. Owners should also consider the effect any equipment would have on the character of the property, both visually and physically, including in the setting of, or approach to the building; consents may be required where a designation applies to the building or protected area.

Renewable energy systems will often have some visual or physical impact on the building or site they serve. It is important to minimise this impact to maintain the character and significance of the historic asset, whether it is a building, archaeological site, garden or designed landscape

The following should be considered when thinking about installing any renewable system:

- Where possible, installations on a building should avoid its main and visible or significant elevations. For instance, it may be possible to place installations on secondary parts of the building, adjacent outbuildings or the ground nearby.
- Renewables may have a visual impact beyond that of a single building or site; entire streetscapes or landscapes may be affected. In such cases the setting of a site should be carefully assessed.
- Impact of any vibrations, shadow flicker, emissions and noise.
- Renewables which require groundworks may impact on below ground archaeology and require careful planning and mitigation.

Every building is different and proposals must be considered on a case-by-case basis.

Solar panels or collectors: The sun's energy can be used in several ways, but the two most common are via solar photovoltaics (for electricity) and solar thermal collectors (for heat). Solar panels or photovoltaics (PV), convert sunlight into electrical energy whereas solar collectors use sunlight to warm up a heat transfer fluid, which is then pumped through an insulated pipe to a water cylinder. Both solar panels and solar collectors are usually mounted on roofs to catch the most direct sunlight – an unshaded sloping south-facing roof is ideal, 30-50^{o} for PV. However, it is generally not considered sympathetic to a building's appearance to have a solar panel or other equipment fixed to its main elevations; that is, the face or faces seen from the direction from which it is most commonly viewed and which is also more likely to be the most significant view of the building.

The location of the panels and managing their visual impact is an important part of the design. All parts of the system should be considered carefully, as not only those aspects of the system that are externally visible can be damaging to the building but also those parts hidden from view that require the removal or cutting into historic fabric can have a detrimental effect.

Even when carefully designed and managed, the installation, maintenance and eventual de-commissioning of solar panels or solar slates is likely to cause some damage to the historic fabric of the building. To mitigate this harm, it is therefore critical that the means of fixing and the operation of the panels or slates are planned and agreed in advance whilst also ensuring that their location does not impede on rainwater disposal or hinder maintenance work such as clearing gutters. In some cases, it may be appropriate to affix solar panels to outbuildings or directly to the ground in a location which does not detract from a building or its setting, nor require invasive work.

As solar slates require major intervention and displacement of fabric, they are often unsuitable, though they may be a feasible option where restoration affords an opportunity.

Ground, air and water source heat pumps: Heat pump systems provide energy by moving heat from one place to another. Heat at lower temperatures is collected from the air, ground or water and is raised using compression techniques to provide more usable, constant heat for a building.

A ground source heat pump absorbs heat through a system of pipes – a ground loop – buried in a borehole or trench. That heat is then transferred to a heat pump and used to heat indoor spaces. An air source heat pump works in a similar way, but using heat extracted from the air through a unit outside the property. Both will need a certain amount of open space but a ground loop is more invasive and may not be appropriate where there is below ground archaeology present..

There is some discussion around how efficient heat pumps are when installed within historic buildings. As with any building or measure, it is important in the first instance to ensure that the fabric of the building is in good condition, as this will directly impact how effective the heat pump is.

Heat pumps can be well suited to historic buildings which are in good condition, as they work efficiently when run on a constant low temperature, a method suited to buildings with thick masonry walls that are able to retain heat and release it slowly. For historic buildings, thought will also have to be given to the impact of any installation on the historic fabric and grounds associated with the building, including archaeological remains which may be present.

The design and installation of a heat pump system needs to be carefully planned so that its efficiency can be maximised, the impact of the installation minimised, and the largest possible savings achieved. Heat pumps are best suited to delivering underfloor heating at approximately 40º; for a radiator system they can deliver a maximum of 55º which is less than the 60-80º from a conventional boiler, so consider that an increased size or number of radiators will be required and the impact of that on the building.

The installation (and potential later removal) of the component parts of the heat pump system should also be considered.

Wind power: Wind turbines convert wind energy into electrical energy. The amount of electricity produced depends on the size of turbine and the speed of the wind. Trees, hills and neighbouring buildings can all have a negative effect on wind speed in the vicinity.

Among the renewable energy technologies, wind turbines require most careful consideration in regard to siting as they have the greatest visual effect on the landscape or wider environment. Owners should seek advice on siting at an early stage and check that buildings can structurally support a turbine if it is to be fixed to the wall or roof.

Wildlife needs to be considered as there is concern over the effect of turbines on the habitat of bats and birds who roost in or near buildings.

Photograph (above) of St Joseph's Star of the Sea Church, Killough with wind turbine in its setting. Advice on setting with regard to the historic environment is available from the Department: **Guidance on Setting and the Historic Environment | Department for Communities (communities-ni.gov.uk)**

Biomass: Biomass comes from a biological raw material such as wood,crop residues, animal waste, which are converted to fuel (pellets/chips/logs) by various processes.

Some stoves can also burn wood pellets and run a heating system. Carbon emissions are lower than those for coal or gas. There are some carbon emissions caused by the cultivation, manufacture, and transportation of the fuel, but if the fuel is sourced locally, these are much lower than the emissions from fossil fuels.

It generally requires a plant area, dependent on the size of the operation; it will need storage for the fuel, a boiler and suitable housing with chimneys or flues, and an accessible route for delivery of the fuel to the boiler. It will also need to link to the building or buildings it serves via pipework. All of these factors mean it will need careful consideration so that it is physically and visually unobtrusive.

Archaeology and renewables: Archaeological resources may survive within or beneath a historic building or place. These are important evidence of the past evolution of the site and its function, and allow a more complete appreciation of its significance. The installation of renewable systems can damage or destroy archaeological deposits. Ground-breaking works for elements such as pipework for ground source heat pumps and foundations, and in some cases intrusive work to structural fabric, need to be carefully planned to avoid disturbing known archaeological features and may need to be monitored to ensure unknown archaeology is not being damaged or lost during installation. Where any of the works are within an area designated as a Scheduled Monument, Scheduled Monument Consent will be needed.

Summary of considerations for various renewable technologies

For all of the technologies below, listed building consent (LBC) will be required where a building is listed, Scheduled Monument Consent where a site is scheduled (includes scheduled area); Conservation Area consent or planning permission may also be required but contact your local authority for planning guidance. If the installation has the potential to impact on the setting of a listed building or scheduled monument, local authorities will consult HED. Permitted development (PD) rights may apply if your building is not listed but check with your local authority for up-to-date guidance.

	Do....	DON'T....
Solar panels or fixtures (common to all types)	...ensure roof is in optimum condition before install ...site facing SE to SW (S and SW are optimum) ...site on a discreet, less significant part of the building or site ...consider a site on flat roofs behind a parapet where not overshadowed or viewed from above ...consider the weight of the install (consult a structural engineer)	...site on front, highly visible and/or significant areas of the building or site ... install behind a tall chimney or other sunpath obstructions as this has an impact on efficiency ...forget to consider installation in a hidden roof valley ...compromise the landscape setting to accommodate eg. through tree removal for example
Solar thermal (renewable heating)	..consider the length of run for insulated pipework – more pipework = greater expense + less efficiency ...consider installation is smaller than PV ...factor in that the system will need to feed into a cylinder alongside back up heating coil (new cylinder may be required) ...consider routes through ground for pipework need an archaeological consideration (but see above – efficiency)	...site a long way from the HW storage/user (see 'do's') ...omit design for a supplementary water heat source in winter – solar thermal provides approximately 50% HW annual requirements
Solar PV (renewable energy)	...ensure roof is in optimum condition before install ...site SE to SW (S and SW are optimum) ...consider this can have a big impact on your EPC band ... consider that PV is a larger area installation to accommodate ...consider a site not on the building if more suitable ...consider routes through ground for cabling need an archaeological consideration	...remove historic fabric (eg. slates) for a solar PV installation (solar slates or tiles)

Wind turbine (renewable energy)	...consider this can have a big impact on your EPC band ...site in the path of the prevailing wind (generally S-SW) ..site where there are no obstructions to winds path, and average flow is 5 m/s or more ...consider a site removed from your building even for small (c.4-10m) turbines	....neglect to consider potential damage by building mounted turbine, constant vibration can be detrimental to historic fabric and small size not effective in payback terms. ...assume a wide open parkland is a suitable site, these can be designated in their own right and can be part of a designed view ...forget excess electricity can be sold back to grid, or stored for later use (off grid)
Heat pumps generally	....ensure your built fabric is in optimum condition ...make upgrades to thermal efficiency before considering heat pumps ....account for a system which runs at a lower (design flow) temperature (30-50/55 max) and will need system modification for success ...account for electricity used in operation, will be more where system provides a higher temperature (bigger source to supply gap)	...underestimate system modifications needed for lower temperature operation, bigger radiators, underfloor heating
Air source Heat pumps (ASHP) (renewable heating)	...site external unit discreetly ...site on a sunny wall if possible (take advantage of solar gain) ...site a minimum 1m from neighbours ...consider noise (should be no louder than average boiler or fridge) ...allow space for associated plant inside	...enclose pump in a external 'cupboard' – even if vented, pump is likely to struggle and will be inefficient ...cover in any way, ensure ivy etc do not encroach ...neglect to account for cost of electricity to run pump
Ground source Heat pumps (GSHP) (renewable heating)	....consider archaeology ...consider if you have space for the length of coil (polyethylene ground loop), or depth (ie. not rock) to pursue a borehole installation ...allow space for associated plant inside (heat exchanger for GSHP is approximately size of small fridge freezer) ...consider the cost which is greater for ground source heat pump system (than ASHP) ....consider GSHPs are more efficient than ASHP ....consider that this is a visually unobtrusive option but a physically intensive one (for the ground)	
Heat pumps – water (renewable heating)	...consider WSHP can be as efficient as GSHP provided water does not freeze	
Biomass (renewable heating)	...ensure fuel is sustainably sourced (otherwise system will not be carbon neutral or low carbon) ...consider using existing buildings (eg. disused outbuildings) for plant and fuel storage ...take account of accessible delivery of logs/ pellets/chips which come in bags or via tanker	...neglect to take account for space for all the component parts of a system and access which could be visually obtrusive and physically disruptive

4 Look and learn

Monitoring

Once retrofit works have been completed, it is important to observe the effects on the building – both intended and unintended – to monitor results and to learn from successes and failures. In order to understand how things change it is helpful to check and record how things are working before you undertake the retrofit measures. This can also be part of any assessment process.

Energy savings – check energy bills before and after retrofit

Savings can only be assessed where there is adequate record of energy use prior to retrofit. This is a common mistake in retrofit projects. More than one year's data either side of retrofit is needed to take account of variations in energy use from one year to the next. Any changes in occupation, use or weather conditions need to be taken into account.

Be mindful of the 'rebound' effect. (See Page 26).

Technical risks – check annually

Technical risks can be simple to monitor.

Renewable energy systems can be checked by meter readings and fuel bills, although underperformance due to a technical fault may require an expert review.

For fabric measures, if loft insulation has been increased, annual checks for any signs of moisture or mould forming on rafters is advisable. Inside the property, surface mould and condensation on any cold spots are easy to see.

The most challenging areas are in wall, floor and rafter insulation, where failures can build up over years. It is therefore advisable to leave access in the most vulnerable areas (for example by a floorboard which can easily be lifted) to check for mould and damp. You can often smell and feel damp problems even if you don't have a damp probe meter. If in doubt consult an expert who understands old buildings.

Photograph of Underfloor Insulation being installed within a listed building;

Maintenance

Appropriate mantenance is essential both before and after retrofit projects.

Faulty rainwater systems are one of the most common causes of building failures and this becomes even more critical where solid wall insulation has been introduced. An annual clean of gutters and drains is highly recommended.

Attention should be paid to climate change considerations. Widening hidden gutters or adding in additional downpipes now can future-proof against storm events or increased rainfall. Some of these interventions may require consent, for example for a listed building or scheduled monument consent.

Chimneys and gable ends are especially vulnerable to water penetration, so render, pointing, flashings, overhangs and caps should all be checked regularly and promptly repaired if necessary.

Appropriate repair of roofs, masonry walls and render, maintenance of seals around windows and doors, and regular painting of external timber will reduce the risk of water entering and becoming trapped in the building fabric.

A stitch in time saves nine - A roof in need of repair which could have been avoided with routine maintenance.

A gutter in need of maintenance.

Learning

Learning is essential at all levels in the retrofit process, among owners, designers, contractors and subcontractors. Learning also needs to be documented and shared between current and future occupants of buildings so that the history of use and alteration is not lost and so that technical risks can continue to be monitored in the longer term.

Acquiring a comprehensive understanding of a building helps to protect it from risks, improves energy use and can bring real benefits.

Continuous improvement

Continuous improvement is possible by looking at energy savings and technical risks and learning what has worked, and what needs adjustment or improvement. Retrofit is not a ‘one and done' activity in terms of learning or in terms of maintenance. There are many types of retrofit, many uncertainties in the current science and technology, and every building and human being behaves differently, so there are always going to be many unknowns. This is also why it is so important to do no harm to historic buildings in the process and ensure any retrofit measure is reversible.

Retrofit needs to be seen as part of an individual and collective journey, which we should undertake with the right knowledge, but also with an openess to learn new things.

5 Case Studies

Above - Rosetta Cottages before works began - Long Elevation (Clanmil),

CASE STUDY 1: ROSETTA COTTAGES, 519-529 Ormeau Road, Belfast

Rosetta Cottages are a familiar sight on one of the major routes into Belfast. These listed houses date back to before 1817, making them amongst the oldest surviving houses in Belfast. Whilst two housed thriving local businesses, the remainder had lain empty for many years until Hearth Housing Association renovated them for use as social housing.

Rosetta Cottages - Fireplace (David Bunting ImageNI)

Rosetta Cottages – A rare surviving staircase (David Bunting ImageNI)

Rosetta Cottages - Wet rot in ceiling laths (Hearth)

Following Listed Building Consent, works began in 2017 to bring this listed terrace of cottages back into use, and were completed in summer of 2018. The project involved turning the original six dwellings into two one bedroom energy-efficient dwellings, taking care to retain the historically significant external envelope and repair, refurbish or reinstate as many original features as possible such as sash windows, skirtings, staircases, architraves and wainscoting.

Retrofit Works carried out:	
External Walls	• External lime render and Keim paint applied keeping masonry walls breathable, allowing the masonry walls to release moisture.
Internal Walls	• The deteriorated lath and plaster walls were replaced with lime plaster , allowing the masonry walls to release moisture to the well ventilated interior.
Roof	• Existing slates were repaired and re-used, with any broken slates replaced with like for like reclaimed natural slates. • Breathable sheep's wool insulation was installed between rafters. • Conservation style rooflights were installed. • All unused chimney flues were ventilated via the roofspace.
Windows	• The terrace is listed; windows to the street elevation were repaired where possible – these were hardwood single glazed, painted, six over six pane putty-fronted with no trickle vents in the original Georgian style, along with secondary glazing internally to ensure good acoustic and thermal insulation while retaining the original character externally. • As there were no existing rear windows, new rear windows were slim-line double glazed.
Floor	• A new insulated 'limecrete' solid floor was installed, with underfloor heating.
Ceiling	• Internal ceilings were finished in lath and lime plaster.
Heating	• A new energy efficient combi-boiler was installed with traditional radiators.
Rainwater goods	• New heavy gauge metal rainwater goods were installed throughout.
Options considered	• Ground floor external walls potentially lined with aerogel and magnesium board where tight for space, with sheep's wool-lined walls in attic space: these options were however ruled out as they would have minimal impact on thermal performance

Rosetta Cottages - Secondary Glazing (David Bunting ImageNI)

Rosetta Cottages - Rear elevations after work is complete (David Bunting ImageNI)

Rosetta Cottages finished front facade (David Bunting ImageNI)

CASE STUDY 2: QUARRY HILL FORMER PRESYBTERIAN CHURCH, CO.DOWN

Having been on the Heritage at Risk Register for many years, this listed de-consecrated church built in 1846 was bought by the current owners in 2016. Immediate repair works were carried out to the roof, windows and façade to make the building water tight. Conversion of the building into a 5-bedroom dwelling began in 2018, with completion in 2019. Original features were restored and new lightweight stud walls inserted towards the rear of the sanctuary space to provide new bedrooms and a mezzanine level.

Quarry Hill Church before retrofit and refurbishment works.

Quarry Hill Church Sanctuary looking towards front door before works

Quarry Hill Church Ceiling and window repairs

Retrofit Works carried out:	
External Walls	• External lime render repairs were carried out to the front façade and Keim paint applied, keeping masonry walls breathable. • Side walls had been previously wet dashed in the 1990's, but as they were still in good condition and not letting in water, these were left as they were for now. • Walls will be monitored for failure as part of a long term maintenance plan.
Internal Walls	• Existing lime plaster walls were repaired and painted with breathable paint. • Existing original timber wainscoting was repaired, painted with breathable paint and retained throughout.
Roof	• Existing slates were re-used and if any were damaged reclaimed natural slates were sourced to match. • Sheep's wool insulation was installed at ceiling level, taking care at eaves and junctions to ensure adequate ventilation. • New conservation style rooflights were installed in a new small rear extension
Windows	• All three existing tall Georgian style hardwood painted sliding sash windows on the south façade were restored on site, with rotten timbers removed and new timber spliced into place. Historic glass was retained where possible. This façade was most exposed to weather and vandalism, so little original glass existed, therefore new glass was installed where required. • Any new window openings were deliberately created and installed to rear elevations, so not affecting primary facades, and were slim-line double glazed.
Floor	• The existing suspended timber floor was insulated to the underside with sheep's wool insulation. Care was taken to avoid blocking existing floor vents; these were repaired or reinstated on the external walls where necessary.
Ceiling	• The existing lath and lime plaster internal ceiling was repaired where needed using lime plaster • A decorative plaster ceiling rose was professionally repaired, along with original cornicing
Rainwater goods	• Existing rainwater goods were not salvageable and were undersized; new heavy gauge metal rainwater goods were installed throughout to a suitable size.
Heating	• A new heating system was installed including an energy efficient combi-boiler. The performance of the boiler will be monitored over time.
Other Considerations	• New services were installed within the building via the underfloor void, in order to minimise disturbing the solid walls. • New low energy lighting was installed to the stone walls via exposed galvanised ducting, minimising the need to track original walls.

Quarry Hill Church external facade after works completed (Olivier Bernard credit)

Quarry Hill Church interior looking towards front door after works (Olivier Bernard credit)

Quarry Hill Church looking towards pulpit after works complete (Olivier Bernard credit)

Ormeau Park House before retrofit works

CASE STUDY 3:
ORMEAU PARK HOUSE

Built in 1878 for Ormeau Park's Superintendent, Ormeau Park House became vacant after the departure of the last gardener. Hearth Housing Association was able to agree the purchase of a long lease of the house from the Council in 2006, and the building, by now roofless and badly vandalised, was restored in 2007. This building is not listed, so the opportunity was taken to experiment with insulation types and new double-glazed windows.

Ormeau Park sheep's wool insulation being installed (Hearth)

Retrofit Works carried out:	
Internal Walls	• Walls were lined with sheep's wool insulation and thermally lined plasterboard.
Roof	• The roof was insulated and existing slates re-used; if any slates were damaged reclaimed natural slates were sourced to match
Windows	• New double glazed timber painted sliding sash windows were installed to 'secured by design' standards.
Floor	• A new insulated solid floor was installed with underfloor heating from an air-source heat pump.
Rainwater goods	• New heavy gauge metal rainwater goods were installed throughout.
Result	• High levels of airtightness were achieved where necessary, for new build construction. A highly energy efficient, warm building was the result.

Ormeau Park House after retrofit and refurbishment works

6 Resources

A range of help, guidance and training is available to help owners and contractors achieve responsible retrofit. As shown throughout this document, the understanding of traditional building retrofit is not always common practice, and requires a degree of initial investigation and understanding before any works should begin.

All guidance, including those listed below, should be taken as guidance and is no substitute for the advice of a suitably qualified and experienced architect, surveyor or skilled tradesperson. Guidance on individual measures or issues should not be taken in isolation, and all strategies to retrofit buildings must consider how the whole building functions both before and after retrofit. New guidance, training and research is always in development, so it is recommended that those involved in retrofit subscribe to updates and new resources from named organisations regularly.

As noted above, many heritage buildings are protected through designation as listed buildings, scheduled monuments or are in conservation areas, where consent may be required for any changes which might affect a building's special character.

Sources of general and related information

The Department for Communities Historic Environment Division is the lead statutory body for historic buildings in Northern Ireland, and can offer advice on technical issues including the retrofit of historic buildings and structures.

The Department has a web page which contains links to useful guidance : –

The partner document to this Retrofit document is:

Thermal upgrade of traditional buildings | Department for Communities (communities-ni.gov.uk)

Please also refer to:

Guidance on Setting and the Historic Environment | Department for Communities (communities-ni.gov.uk)

Whole Life Carbon Guidance | Department for Communities (communities-ni.gov.uk)

Heritage and Climate Change | Department for Communities (communities-ni.gov.uk).

Listed Buildings - An Introduction | Department for Communities (communities-ni.gov.uk)

Scheduled Historic Monuments | Department for Communities (communities-ni.gov.uk)

The Royal Society of Ulster Architects (RSUA)

The Royal Society of Ulster Architects provides a web based 'Find an Architect' web service, where 'Conservation' can be listed as a required speciality **Find an Architect - Royal Society of Ulster Architects (rsua.org.uk).**

Ulster Architectural Heritage (UAH)

Ulster Architectural Heritage is the lead independent voice for built heritage in Northern Ireland. A not-for-profit organisation, they have over 50 years of expertise in promoting the value of built heritage, encouraging its protection, conservation and heritage-led regeneration. They provide a wide range of resources, events and advice including a Directory of Traditional Building Skills, which can be found here: **Directory of Traditional Building Skills - UAH (ulsterarchitecturalheritage.org.uk)**

Risks in retrofit can be significantly reduced by employing appropriately qualified consultants, builders and craftspeople.

Sources of guidance on retrofitting

Society for the Protection of Ancient Buildings: Energy Efficiency in Old Buildings (2014)

Historic Scotland: **Guide to Energy Retrofit of Traditional Buildings | The Engine Shed**

Energy Efficiency and Historic Buildings: How to Improve Energy Efficiency | Historic England (June 2018)

Practical Building Conservation Series | Historic England

Energy_Efficiency_in_Traditional_Buildings.pdf (seai.ie) Department of Housing, Local Government and Heritage, Government of Ireland 2010

The Pebble Trust - Sustainable Renovation Guide (2023)

Roger Hunt and Marianne Suhr: Old House Eco Handbook (2013)

CITB NI: **Older Buildings for a Greener Future**

Sustainable Traditional Buildings Alliance (STBA) Responsible Retrofit Report

The Responsible Retrofit of Traditional Buildings Report (2012) was commissioned by The Department of Energy and Climate Change (DECC). This comprehensive report identified policy issues and errors in the existing conventions for assessing thermal performance and carrying out moisture risk assessment in traditional buildings. The report also identified research needs and addressed delivery issues such as a lack of training at all levels of the retrofit process. The report is available at: **http://stbauk.org/resources/stba-guidance-and-research-papers**

Guidance Wheel

The STBA Guidance Wheel is a free-to-access online tool which helps to enable informed decision-making about retrofit strategies. Having set the context for a specific building, users can select measures for its retrofit and the Wheel then flags up related measures which need to be considered, together with the reason for the connection. For example, wall insulation is linked to window refurbishment for reasons of air tightness and indoor air quality. The Wheel also provides an assessment of the level of technical risk for any particular measure, highlights its potential impact on heritage and identifies any reasons why the savings predicted may not be realised in full. The Guidance Wheel is available at **http://responsible-retrofit.org/wheel/**

Research and technical material

Historic Scotland publishes Technical Papers considering specific issues, including:

Technical Paper 1 Thermal Performance of Traditional Windows

Technical Paper 2 In situ U-value Measurements in Traditional Buildings

Technical Paper 6 Indoor Air Quality and Energy Efficiency in Traditional Buildings

Technical Paper 9 Slim-profile double glazing

Technical Paper 10 U-values and Traditional Buildings

Technical Paper 12 Indoor Environmental Quality in Refurbishment **http://www.historic-scotland.gov.uk/conservation-research.htm**

Technical paper 36: Architecture and Health in Traditional Buildings - **Technical Paper 36: Architecture and Health in Traditional Buildings (historicenvironment.scot)**

This paper discusses how different building features such as windows were designed to enable the proper ventilation of buildings. It also considers how good ventilation can help to prevent airborne diseases, build-up of chemical compounds and CO2 and overheating.

Historic England and Cadw both have ongoing research programmes.

Training

A range of Heritage, Conservation and Retrofit training programmes for supervisors and operatives are occasionally available from the CITBNI and other providers. See **CITB - Training (citbni.org.uk)** for further information.

General training on the repair and conservation of traditional buildings is available through Society for the Protection of Ancient Buildings (SPAB). Refer to **www.spab.org.uk** for further information.

The UK government has sponsored the publication of framework documents for the successful design and implementation of retrofit projects following concerns raised about the suitability, design, and execution of energy efficiency measures. PAS 2035, PAS 2038 and the accompanying PAS 2030 are publicly available specifications (PAS) specifically concerning retrofit of existing buildings. Various courses can be found online for levels of certification, as advisors, designers, project managers and installers.

National Occupational Standards (NOS) for retrofit are currently in place and have recently been updated. These standards have been used to establish level 2 and 3 knowledge-based qualifications for the energy efficiency and retrofit market. **Repository for all approved National Occupational Standards (ukstandards.org.uk)**

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