CONSERVATION AREAS FIT FOR THE 21ST CENTURY

Advice on Energy Efficiency Measures in Conservation Areas – A Planning and Practical Guide

Chambers Conservation Ltd

Issue

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Contents

1.0 Introduction

1.1 How to use this document

1.1.1 This document should be read in conjunction with the document **Introduction to Conservation Areas for the 21st Century** **WEBLINK**, which can be downloaded from the National Park's website. This document contains an explanation of the purpose and methodology of the project, together with a general introduction to the history, landscape, buildings and settlement forms and planning and legislative context, including guidance on what development is controlled and where consents are required.

1.1.2 This document, **Advice on Energy Efficiency Measures in Conservation Areas, a Planning & Practical Guide** has been prepared in order to respond to the current climate change emergency, give practical advice on how to improve energy performance of traditional and locally significant buildings without harming their special character or technical performance.

1.1.3 In addition to these two documents individual Conservation Area Appraisals and Management Plans have been produced for each one of the National Park's 14 Conservation Areas. These documents can be found here: **WEBLINK**.

1.1.4 This document should be read in conjunction with the Introductory document and the individual Conservation Area Appraisals and Management Plans.

1.1.5 The document is intended to, primarily, provide guidance on traditional and historic buildings in conservation areas.

1.2 Energy Efficiency in Traditional and Historic Buildings, an Overview

1.2.1 The Welsh Government has made a commitment to be achieve 'net-zero Carbon Status' by 2030[1]. This is particularly pertinent to our building stock and the construction industry as buildings are estimated to be responsible for 35-45% of total carbon emissions[2].

01 Historic buildings combine embodied energy with character and history.

[1] https://gov.wales/sites/default/files/publications/2021-07/a-route-map-for-decarbonisation-across-the-welsh-public-sector.pdf
[2] Sturgis and Papakosta (2017). *Whole life carbon for the built environment* - https ://www.r i cs.org/uk/upholding-professional-sta ndards/sec tor-standards/building-surveying/whole-life- carbon-assessment-for-the-built-environment/

1.2.2 One-third of Welsh housing stock was built before 1919. Consequently, an extensive programme of retrofit is needed and this will inevitably need to include historic buildings, whilst ensuring that what makes them special is protected.

1.2.3 In the Snowdonia National Park there are 1,919 listed buildings, (12 Grade I, 116 Grade II* and 1,788 Grade II), 14 Conservation Areas and many locally significant historic buildings.

1.2.4 It is common to assume that older buildings are 'hard to treat', however trials over many years have shown that a good level of upgrade is achievable as long as interventions are sympathetic and allow the building to function as intended.

Historic Buildings or Traditional Buildings?

1.2.5 Historic buildings are not just functional, they enrich our lives and contribute to a sense of place and cultural identity. They are also robust and adaptable as long as they are understood and treated with care and respect.

1.2.6 As noted previously a third of domestic buildings in Wales are of traditional construction, this figure is greater when taking account of non-domestic buildings including commercial, ecclesiastical, industrial and cultural. This is not to say that they are necessarily of great historic significance, but that they were designed to function as outlined in the following sections and need to be treated in a manner which reflects this.

1.2.7 Traditionally constructed buildings are generally identified as those built before 1919, and use solid masonry walls, with pitched roofs finished in slate, tiles or thatch. Windows are usually single-glazed in timber frames (be they sash or casement). Masonry walls are lime plastered and the construction of dividing floor and walls usually in timber. The whole being designed to permit vapour exchange and air-movement through passive ventilation. See section 2.0

1.2.8 However a significant number of these buildings (and some of more modern origin) are considered to be historically significant. This significance can be achieved in a number of ways and the most important are protected through statutory listing, becoming 'listed buildings'. Others are protected as part of a conservation area. The Building Regulations also recognise that in these cases special provision is needed.

1.3 Energy Efficiency and Retro-fit

1.3.1 Retrofit is most usually defined as making changes or additions to buildings in order to reduce their energy use. This is intended to both reduce carbon usage and benefit occupants through reduced energy demand.

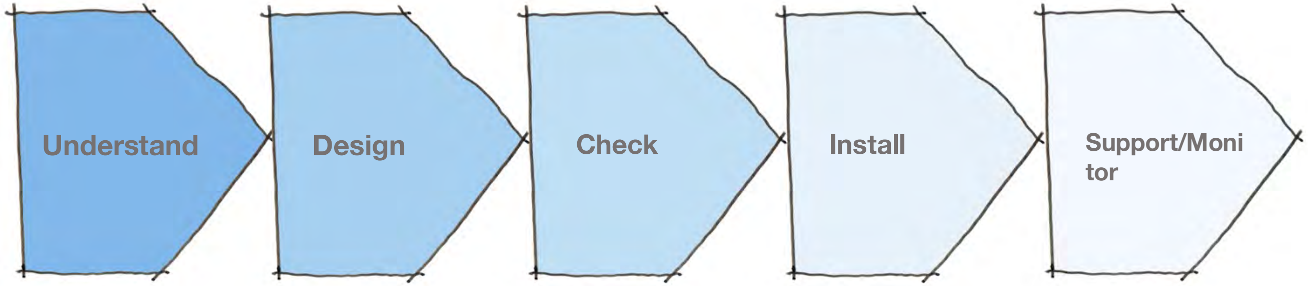
1.3.2 Retrofit has been around for a long time, but ill-considered work has previously led to numerous unintended consequences, including:

- Poorly considered materials, detailing and installation has led to damp and mould, compromised indoor air quality and affected human health.
- Damage has been caused to historic buildings and to their significance.
- Use of materials with a significant carbon footprint, such as cements/concrete or polyurethane board insulations can mean that the overall environmental impact can exceed the reduction achieved in use (i.e. embodied carbon of works exceeds the savings).

1.3.3 In more recent times there has been a significant move towards using materials that are inherently lower in embodied carbon and more suitable for use in traditional buildings, which should enable retrofit projects to be 'fit for purpose' both in terms of energy savings and the embodied carbon of the materials used in the works.

1.3.4 Another significant consideration is the use of sustainable technologies or 'renewable' technologies for servicing buildings. Whilst some of this is on a large scale (such as wind farms) Micro generation for individual buildings, groups of buildings or on a community scale is going to be essential to meet the Carbon-zero agenda. These can be suitable for use in traditional and historic buildings and settings, but need understanding, care and attention to detail.

1.3.5 It should be remembered that energy efficiency is not just about the fabric or services. It is about the way buildings are used and this will also need to change to meet the climate emergency.



02 A co-ordinated plan will be more likely to achieve a successful outcome (see section 6.0)

1.4 Striking the Right Balance

1.4.1 There needs to be a balance struck between achieving benefits by improving the energy efficiency of traditional and historic buildings and causing harm to the historic environment.

1.4.2 There is a great challenge in striking the right balance between benefit and harm. To avoid harm, firstly it essential to understand why a building or site is significant, then this can be an essential part of planning for energy efficiency.

1.4.3 This principle and other factors are considered in section 2.0 *Understanding*.

1.5 Limitations of this guidance

1.5.1 This guidance is intended to help those responsible for buildings to ask the right questions. There are many factors to consider in defining the right solution but this document is intended to give an overview of important things to consider and provide some examples of different approaches.

1.5.2 The notes in the permissions and consents and risks sections should be carefully considered, and appropriate professional advice and guidance should be sought in all cases.

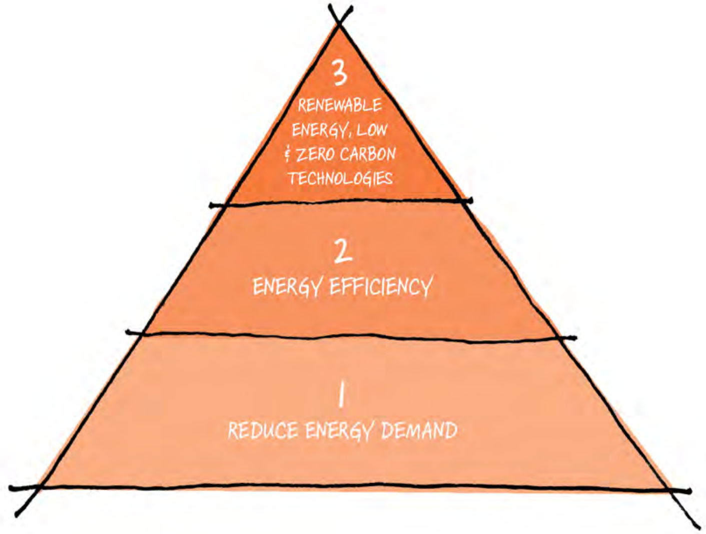
2.0 Understanding

2.1 The Energy Hierarchy

2.1.1 The energy hierarchy is a simple set of principles which should generally underpin any programme of retrofit or energy improvement related work. The principle is to start from reducing energy demand (for example turning heating down), then passive measures such as draught proofing or insulation are prioritised over higher-cost installations such as boilers and renewable technologies (see Fig 03).

2.1.2 These principles ensure that the energy demands are reduced before finding more sustainable means of meeting those demands. This is intended to avoid 'over specification' of heating/energy generation systems and consequent waste.

2.1.3 In traditional and historic buildings there are other factors, such as heritage significance and impact, which can influence the hierarchy, however the principles of reducing demand and appropriate energy efficiency measures should always be the first priority.



03 The Energy Hierarchy

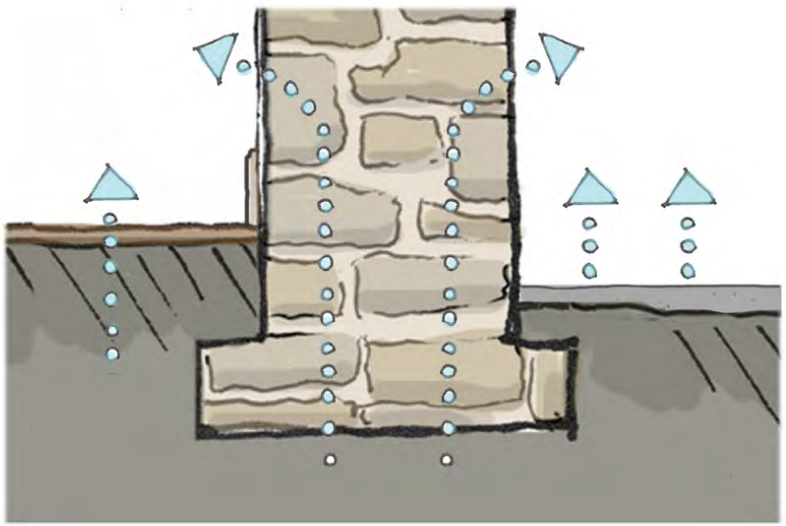
2.2 How Traditional Buildings Work

Damp and Moisture in traditional Buildings

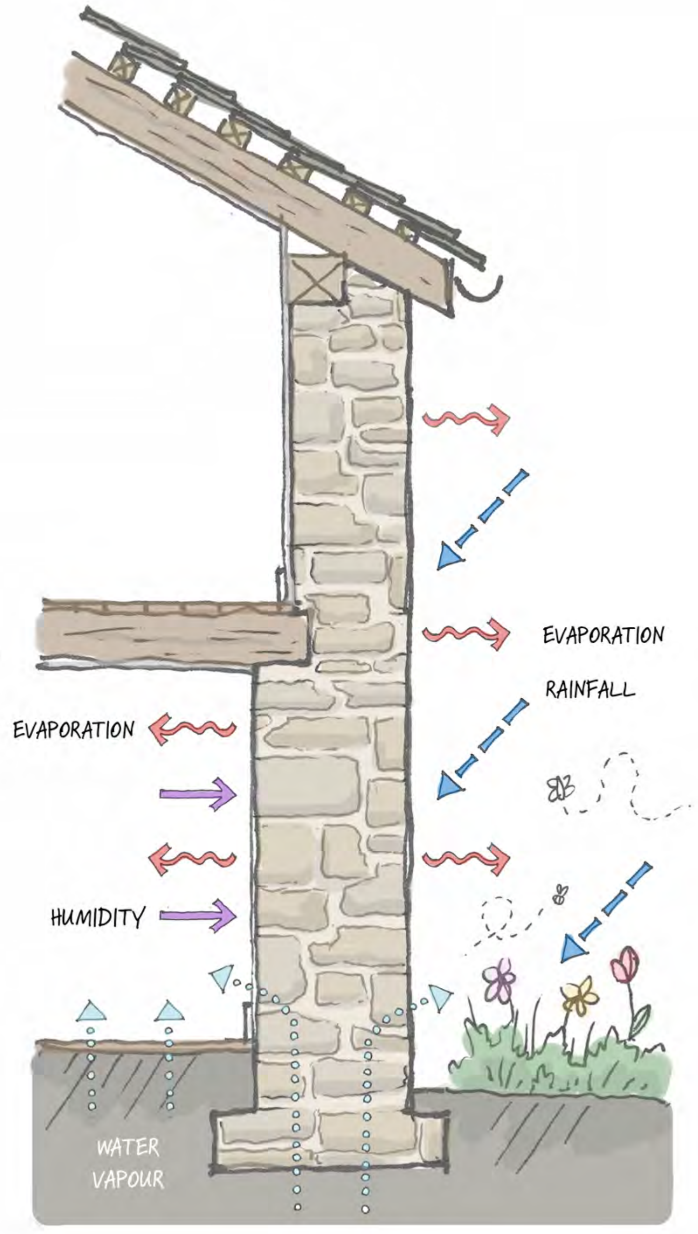
2.2.1 To stay dry, traditionally constructed buildings rely on the thickness of the walls and floors and the use of vapour permeable materials, which allow the walls to 'breathe'.

2.2.2 In wet conditions, moisture is absorbed by the wall (from rain, wet ground, moist air or from internal activity), but as the weather dries out, the vapour permeability of the materials, in tandem with good ventilation, allow the moisture to evaporate. This prevents the walls from retaining 'damp' allowing them to dry out.

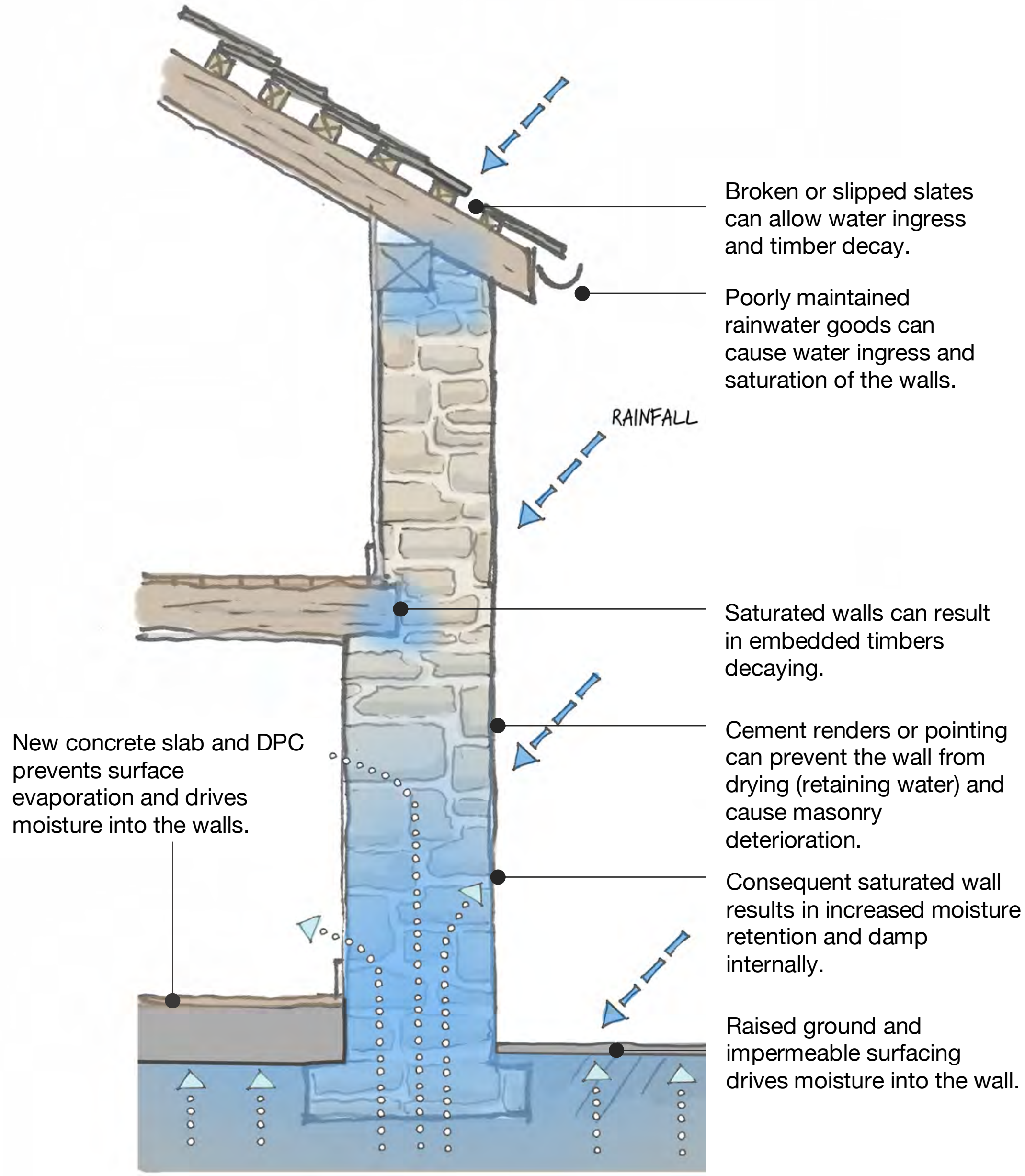
2.2.3 Traditional floors work in the same manner, with vapour-permeable materials allowing evaporation through the surface of the floor, regulating internal and ground based moisture.



04 Traditional Buildings manage moisture through evaporation.



05 Traditional Buildings successfully manage moisture through vapour permeability and evaporation.



06 Poor maintenance and later change can compromise the function of traditional buildings with some of the consequent problems illustrated.

2.2.4 Damp is often seen as a significant problem in traditional buildings and is often cited as a reason for making inappropriate modern changes, but it is most often later change which has resulted in the perceived problem.

2.2.5 Traditionally constructed buildings *do not* need to be damp, but they need to be understood. They function in a different way to a modern building and need to be treated in a different way. With care this can result in a warm, dry, healthy and good quality environment.

2.2.6 It should be noted that there is not one 'standard' type of traditional building and that each building should be properly understood, taking account of construction, orientation, later change, condition and other factors.

Ventilation

2.2.7 In order to ensure the evaporation of moisture, adequate ventilation in a traditional building is essential for both to the fabric of the building and the wellbeing of its occupants.

2.2.8 Air-tightness is often presented as desirable in modern buildings, but in old buildings draughts from windows, doors and open chimney flues provide essential ventilation.

2.2.9 Modern occupation, through bathrooms, kitchens etc also creates more moisture, making ventilation even more important to avoid the warm, moist air being trapped in the building, leading to condensation and potentially mould growth.

2.2.10 The vapour permeability of the materials also has a role to play in managing internal moisture, traditional materials allow moisture from the interior to enter the fabric too, evaporating later as conditions allow, naturally managing the internal environment.

Damaging Modern Alterations

2.2.11 Ill considered, but often well-intentioned, modern alterations can lead to the retention of damp in the structure and interest of a traditional building. Changes often result in encasing the previously vapour permeable wall in an impervious layer.

07 Mould growth in a listed building caused by a combination of poor maintenance, inappropriate materials and lack of ventilation.

08 Cement pointing causes stone to deteriorate, especially in softer masonry.

2.2.12 Changes often seen include the application of impervious coatings to breathable walls, such as cement renders, modern plaster, modern thermoplastic paints and cement-based mortars in lieu of traditional lime-based materials. Chimneys are often sealed and unventilated double-glazed windows installed.

2.2.13 These coatings and changes result in the traditional fabric being 'encased', preventing the evaporation of moisture (causing damp) and moisture entering the wall (potentially condensation and mould). In extreme circumstances these have been linked to respiratory problems and other health issues. As an analogy, *Think about a sponge being wrapped in a plastic bag, it will take much longer to dry than one exposed to the air and possibly go mouldy in the process.*

2.2.14 Retained damp in the building fabric is not only problematic for the occupants, it can also cause decay (dry-rot, wet-rot) and insect attack (woodworm) which, if not addressed correctly, can eventually cause structural deterioration.

2.2.15 This document is intended to consider thermal improvement to traditional properties, and a key first point of note is to understand that damp walls conduct heat far more rapidly than dry walls. *This leads to increased heat loss during cold weather and rising heating bills.* Underlining the need to work with the fundamental principles how a traditional building should work.

Key Point to Consider.

When considering energy improvement works to a traditional building, the materials and approach should respond to the way the building works, **ensuring that the building can 'breathe' and is adequately ventilated**, reducing condensation and other risks.

09 Badly maintained rawinwater goods hold moisture and can cause saturation and consequent decay of timber elements.

2.3 The Importance of Good Maintenance

What is Maintenance?

2.3.1 According to Cadw, '*Maintenance simply involves regular inspections to check on the condition of your building and its surroundings, and timely repairs if faults are found*'.[3]

2.3.2 General inspection does not require expert skills, but just an eye on what to look for and a systematic approach. If more serious problems exist or if a building is large or particularly complex, you may wish to consult a suitably skilled architect or surveyor.

2.3.3 Inspections should be regularly undertaken, but especially after adverse weather (such as heavy rain, snow or high winds). Blocked gutters, rainwater goods, gullies and drains can quickly cause damage and damp penetration.

2.3.4 Inspection of roofs (where safe to do so) is also essential. Look for dislodged slates or signs of water ingress internally, visually inspect chimney and other flashings.

2.3.5 Other elements to look for include failure of render or paint finishes which could allow water ingress.

2.3.6 Good advice on how to approach maintenance and inspections is available through various organisations, including the Society for the Protection of Ancient Buildings.[4]

2.3.7 Simple routine maintenance is unlikely to require consent even if the building is listed or in a conservation area but if more extensive repairs are necessary always check first with the National Park's conservation officer.

Why is Maintenance Important?

2.3.8 Good maintenance will protect the building for the future, saving money through repair rather than replacement.

2.3.9 Retention of original elements and fabric also has intrinsic environmental benefits, reflecting the embodied carbon in the existing fabric.

10 Poor maintenance of rainwater goods causes water penetration, exacerbated by modern render.

[3] https://cadw.gov.wales/advice-support/historic-assets/listed-buildings/looking-after-your-listed-building/why-maintenance
[4] https://www.spab.org.uk/advice/preventative-maintenance

2.3.10 Regular maintenance will also reduce the risk of more serious problems, such as dry rot, and avoid the cost and disruption of major repairs.

2.3.11 Employing regular maintenance to prevent water ingress (through regular maintenance of rainwater goods, drains, finishes), helps the fabric of a traditional building function as intended. Remember, wet walls conduct heat far more rapidly than dry walls, leading to increased heat loss during cold weather and rising heating bills.

2.3.12 BS7913: 2013 (Guide to the Conservation of Historic Buildings) states that walls can be 30% less energy efficient if damp. The Standard also states that: *'The most effective way of ensuring energy efficiency and sustainability is to keep historic buildings in good repair so that they last as long as possible, do not need replacement and do not suffer from avoidable decay that would require energy and carbon to rectify…'*.

Key Point to Consider.

Maintenance should be the first priority as it provides benefits, not only in terms of protecting the building fabric and saving money on remedial works but also in terms of energy consumption and sustainability.

2.4 The Significance of Historic Buildings

Historic or Traditional?

2.4.1 As noted at the start of this document a third of domestic buildings in Wales are of traditional construction. This is not to say that they are necessarily of great historic significance, but that they were designed to function as outlined above and need to be treated in a manner which reflects this.

2.4.2 However a significant number of these buildings (and some of more modern origin) are considered to be historically significant. This significance can be achieved in a number of ways and the most important are protected through statutory listing, becoming 'listed buildings'. Others are protected as part of a conservation area.

Listed Buildings

2.4.3 Historic buildings are a precious part of our collective heritage. They help to create Wales's distinctive character and contribute to our cultural identity and sense of place.

2.4.4 Buildings which are of special architectural or historic interest are protected by listing. Listed buildings are not necessarily traditional (although most are currently), but range in date from medieval to relatively modern. They can be domestic or industrial, civic or ecclesiastical. Listing demonstrates a building is of national or international importance.

2.4.5 Listing is not necessarily just associated with the architectural merit or the age of a building, it can be listed because of its association to a particularly significant person, technology or activity. Listing helps protect them for the benefit of future generations.

2.4.6 Most works to listed buildings will require *listed building consent*, and advice should be sought from the National Park's conservation officer.

Conservation Areas

2.4.7 Conservation areas are distinct parts of the historic environment designated by local planning authorities for their special architectural or historic interest. There are 14 Conservation Areas in the Eryri National Park, covered by the Conservation Area Appraisals which accompany this guide.[5]

2.4.8 The aim of designating conservation areas is to ensure that the character is not damaged, destroyed or undermined by inappropriate changes to the elements which shape the area. This can include changes such as energy retrofit, so the special character of each area needs considering before measures are proposed.

Locally Significant Buildings

2.4.9 Not all buildings of significance are protected by the statutory measures of listing or a conservation area. Other buildings can be considered of local significance and the approach should take account of their special qualities.

Defining Significance

2.4.10 Defining significance involves understanding the heritage values of a building or place and how these combine to achieve an overall level of

[5] https://www.snowdonia.gov.wales/planning/heritage-and-planning/conservation-areas

significance. Cadw's *Conservation Principles* offer clear guidance on how to approach this.[6]

2.4.11 Cadw's Conservation Principles in overview are:

1. *Historic assets will be managed to sustain their values.*
2. *Understanding the significance of historic assets is vital.*
3. *The historic environment is a shared resource.*
4. *Everyone will be able to participate in sustaining the historic environment.*
5. *Decisions about change must be reasonable, transparent and consistent.*
6. *Documenting and learning from decisions is essential.*

2.4.12 These principles are applied when conserving and enhancing/managing a historic asset (or a group of assets), in order to ensure they are conserved and enhanced/managed in a sustainable way. Balanced and justifiable decisions about change to the historic environment depend upon understanding who values different historic assets and why they do so, leading to a clear statement of their significance and, with it, the ability to understand the impact of the proposed change on that significance.

2.4.13 Significance is understood by defining value against four established heritage values:

- ***Evidential Value** is the potential of a place to yield evidence about past human activity.*
- ***Historic Value** Derives from the ways in which past people, events and aspects of life can be connected through a place to the present.*
- ***Aesthetic Value** Derives from the ways in which people draw sensory and intellectual stimulations from a place.*
- ***Communal Value** Derives from the meaning of a place for the people who relate to it, or for whom it figures in their collective experience or memory.*

[6] https://cadw.gov.wales/advice-support/conservation-principles/conservation-principles

2.4.14 In addition, the Conservation Area Appraisals which accompany this guide also help to bring definition to the special character of the conservation area, key buildings, key views, materials etc. These all need to be considered when planning appropriate energy retrofit measures.

Key Point to Consider.

When considering energy improvement works to a historic building or site, be it listed, in a conservation area or considered a heritage asset locally, the works should **not detrimentally affect what makes the building significant**. In order to do this the key first step is to make sure the significance of the building, area and site is properly understood before any works are proposed.

3.0 Reducing Energy Use in Traditional & Historic Buildings.

3.1 Overview.

3.1.1 Reducing energy use in traditional buildings is going to be essential as part of the wider climate agenda and, if done correctly, can provide owners and occupiers with tangible benefits through making buildings comfortable to live in and through potential savings in energy bills.

3.1.2 There are many factors which influence the use of energy in buildings. These include:

- Behavioural factors of the occupants, in use of energy, including heating levels, lighting, appliances.
- Orientation and topographical factors.
- Condition and Maintenance of the Building
- Performance of the building's fabric.
- Building services (heating, lighting etc).

- In most cases a combination of the above factors will lead to an appropriate solution, following the Energy Hierarchy previously discussed and taking account of the special qualities of the building in question. This can be best managed through the preparation of an ***Whole-house or Energy Retrofit plan.*** The preparation of which is considered later in this document in section 6.0. Below the above factors are discussed in more detail.

Key Point to Consider.

When considering energy improvement works there is a need range of factors, which can be brought together and properly considered through a **Whole-House or Energy Retrofit Plan**

Using Energy more efficiently.

3.1.3 When considering reducing the amount of energy used, an understanding and awareness is required of how energy is used and how it could be used more efficiently. This should be a starting point before considering alterations to the building.

3.1.4 There are a range of options to consider which can reduce energy usage and consumption without significant changes to a building. A few examples could include:

- Turning down the thermostat. Every degree of extra heating can increase energy usage between 6% and 8%.
- Use appliances as efficiently as possible, for example fridges work most efficiently when full, reduce the temperature for washing clothes.
- Use curtains, shutters, draught excluders.
- Turning off appliances and lights when not being used.
- Replacing light bulbs with energy efficient LED versions.

3.1.5 Guidance on simple steps is available via the Energy Saving Trust and other similar organisations.[7]

Key Point to Consider.

Adapting expectations together with living, working and usage patterns are the easiest, most sustainable and cost-effective ways of reducing energy consumption.

Other Factors

3.1.6 The location and orientation of a building can also significantly impact upon the performance of the building. The landscape of Eryri can be very exposed and subject to significant variations in weather conditions.

3.1.7 South-facing elevations will naturally benefit from solar gain through exposure to the sun. Elevations exposed to prevailing wind and rain can retain moisture for prolonged periods. This can hamper the thermal performance of the wall as previously noted.

3.1.8 Protection of very exposed walls can help performance and there a range of different ways of doing so. Traditional techniques in the region include slate-hanging, which can also include breathable insulation behind where properly considered, lime rough-cast renders (not to be confused with later pebble-dash) and lime-washing.

Key Point to Consider.

Consider context and orientation carefully. Protecting exposed elevations, where appropriate to do so, but avoid the application of impervious materials such as cement render or cement pointing. Consider lime renders, slate hanging or other appropriate techniques and seek appropriate advice.

A 'whole house' approach, creating an Energy Retrofit Plan

3.1.9 Problems can result if energy efficiency measures are undertaken 'one by one' without attention to how they'll interact. For example, adding double glazing and draught-proofing can increase damp problems if you haven't

[7] https://energysavingtrust.org.uk/hub/quick-tips-to-save-energy/

provided suitable ventilation or considered the ‘breathability’ of the building fabric.

3.1.10 The ‘whole house retrofit’ (or whole building) approach is intended to avoid these pitfalls. It’s important to look carefully at all aspects, including the significance of the building, behaviour, orientation as well as fabric related matters such as insulation, draught-proofing, ventilation and heating to create a structured plan.

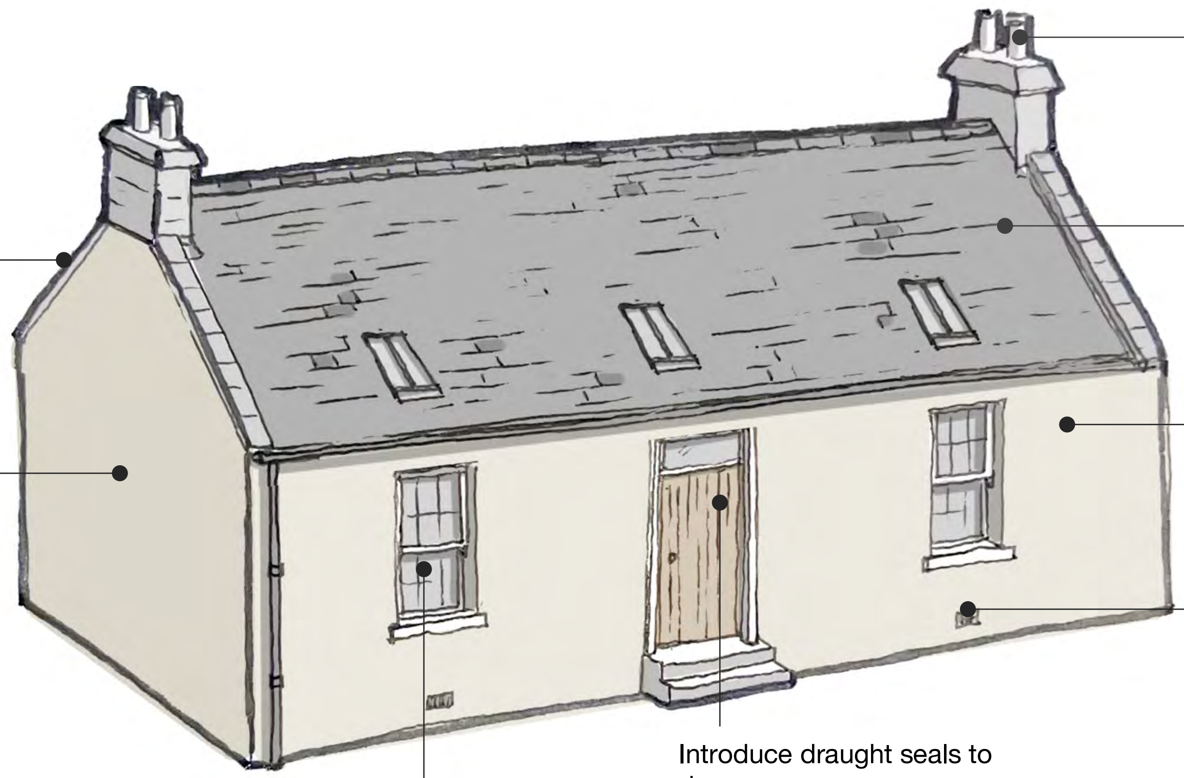
3.1.11 A retrofit project can be a big job, depending on the desired outcome. This may mean engaging specialist architect or consultant who properly understands traditional buildings and sustainable retrofit to develop the project.

3.1.12 Sometimes the cost of a retrofit project can seem daunting. There are some schemes available which can assist with the cost depending upon the scope of the proposals, the type of building and arrange of other factors.

Key Point to Consider.

Seek suitable professional advice at an early stage and seek to develop a comprehensive plan which encompasses the full range of measures, taking account of heritage factors as well as necessary permissions too.

Potential Areas for Energy Improvements.



- Provide Energy efficient boilers and heating systems.
- Renewables may be possible if sensitively sited.

11 Areas of a traditional building where energy improvement measures can be considered.

3.2 Building Fabric

This section gives a brief overview of some of the energy efficiency measures which can be retro-fitted to traditional buildings. It is intended as a summary. When undertaking energy retrofit works appropriate professional advice should always be sought for a specific situation.

Wall Insulation

3.2.1 There are a number of methods of insulating the walls of a traditional building, primarily external wall insulation, which is applied to the external face of the solid wall, and Internal wall insulation which is applied to the internal face. It should be noted that application of insulation to solid walls is challenging technically and specialist advice should always be sought.

3.2.2 There are other types (for example blown cavity wall insulation, or insulation for panels timber framed buildings), but external and internal are the most likely types to be considered to the traditional building types of Eryri, being *predominantly* of masonry construction.

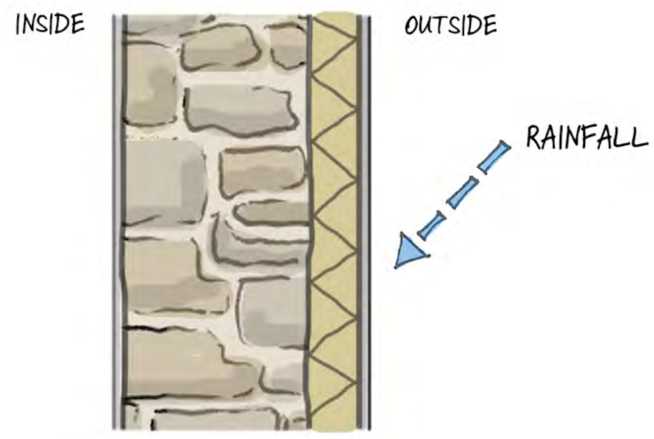
3.2.3 Before deciding on wall insulation, it is important to consider that traditional construction will often perform better than assumed, especially where a wall is well maintained, dry and functioning as intended (see *'how traditional buildings work'*).

3.2.4 Evidence also exists of retrofit projects where solid wall insulation has been installed not fully understanding a building's physics. This has led to significant problems with condensation, summer overheating and loss of benefits from heat retention and the cooling capabilities of solid walls. Poor installation of energy saving measures and inadequate skills training for their installation can also be problematic and need to be considered.

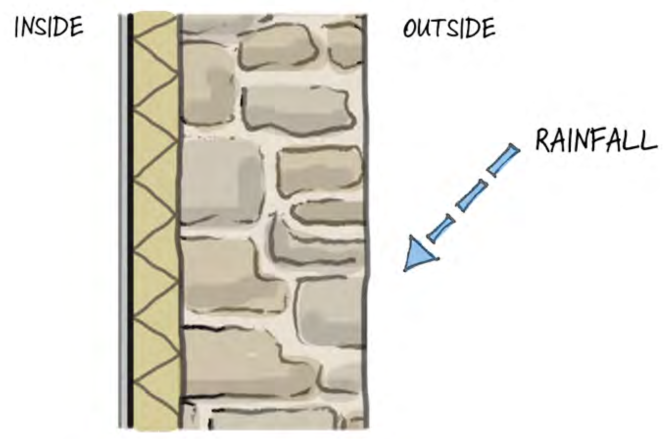
3.2.5 Below is an overview of the insulation types with factors which should be considered.

External Wall Insulation

3.2.6 Firstly, it is important to note that external wall insulation will probably require planning permission (see permissions). It is unlikely to be acceptable on a building where the material (e.g. rubble stone) is important to the building, its significance or is important to the special quality of the area.



12 External Wall Insulation



13 Internal Wall Insulation

3.2.7 External insulation is generally considered less 'risky' in technical terms than internal. There are a number of reasons for this:

- It maintains the solid wall as 'warm' which significantly reduces condensation risks.
- It exploits the thermal mass of the masonry by storing heat generated inside and releasing when the temperature drops.

3.2.8 External insulation obviously has a significant impact on the exterior appearance of a building. It is very unlikely to be appropriate where the external appearance of a stone wall (for example) is important. Assessment of heritage impact is therefore key.

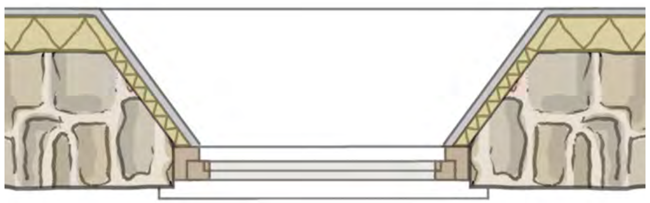
3.2.9 Where external insulation is considered appropriate there are some key issues to be considered:

- Existing damp issues must be resolved first, and time allowed for the masonry wall to dry.
- The insulation and finish should be breathable to allow movement of moisture through the wall and insulation to the outside.
- The finish and insulation type must take account of the orientation and exposure of the site. For example it could be appropriate in exposed locations to consider a finish such as hung-slate or roughcast, which is more adept at dealing with the conditions, over the insulation.
- Extending the depth of wall will have an impact upon eaves detailing as well as window openings, rainwater pipes, gullies etc. Detailing around verges and chimneys needs careful consideration.
- It is essential that the layer is 'continuous' as areas of cold bridging can easily result in damp and condensation internally.
- Insulation will usually need to be terminated above ground to avoid 'wicking' of moisture into the insulation.

3.2.10 There are many different types of external insulation on the market and it is beyond the scope of this document to outline all of the options, however an example is described in the case studies which follow.

Key Point to Consider.

Significance and context, external appearance. Are the walls are dry and all maintenance and drainage issues addressed?. Consider orientation and exposure which will have a significant impact upon the approach. Consider detailing around openings, chimneys and avoiding cold-bridges, involve professional advice regarding condensation. Use materials that are suitable for traditional buildings.



14 When insulating external walls, junctions are absolutely critical, avoiding cold-bridging at windows can be difficult as the reveals need to be insulated.

Internal Wall Insulation

3.2.11 Installation of internal insulation needs careful consideration. It will result in the loss of historic detail where present, such as cornices, skirtings and can detrimentally affect the appearance of historic houses unless carefully handled.

3.2.12 It can, however, be a good option when the external appearance of a building is more sensitive, sometimes the case in a conservation area for example or where the materiality of the exterior is a key factor. It is the most commonly used approach in, for example, conversion of masonry agricultural or industrial buildings.

3.2.13 There are several technical risks when installing internal insulation without the appropriate consideration. The two key risks are:

- Interstitial condensation caused by water vapour generated internally (from kitchens, bathrooms etc).
- Increased dampness due to driving rain (moisture retained in the wall for a longer period).

Both situations can result in serious problems, especially where there is embedded timber present.

3.2.14 Again, systems which will result in 'sealing' the wall should generally be avoided. Permeable systems, for example the use of breathable wood-fibre board and lime plasters internally can help manage the moisture in the wall (but need to be considered specifically for each case).

3.2.15 In very exposed situations it is generally advisable not to insulate internally, but to focus on keeping the walls dry as the risks are significant.

Key Point to Consider.

Internal details, historic features. Are the walls are dry and all maintenance and drainage issues addressed?. Consider orientation and exposure which will have a significant impact upon the approach. Consider detailing around openings and involve professional advice regarding condensation. Use materials that are suitable for traditional buildings.

Insulating Lime Plasters & Renders

3.2.16 Insulating plasters can be a good option where there is limited internal space and external insulation not possible.

3.2.17 They should not be used to replace historic plasters unless the original is beyond repair and use in a listed building would require consent.

3.2.18 There are a range of different types with different insulating 'additives' for example, hemp based plasters, glass beads etc.

3.2.19 Externally, insulating renders, such as cork-lime, are also gaining some popularity. These can be a good option in the right situation. They can be soft and vulnerable to damage, so perhaps not suitable for a location adjacent to a heavily trafficked path for example.

Insulating Floors

3.2.20 Traditional buildings usually have floors of solid or suspended timber construction.

3.2.21 Floors can contribute significantly to the special quality of a historic building so (as with any retrofit measure) must be considered in that context first.

3.2.22 Heat loss through floors can be significant, especially in buildings with suspended timber floors.

3.2.23 Before works on an old floor are undertaken it is essential that damp issues are addressed. This might include measures such as dealing with raised external ground levels or introducing external French drainage, but should not include chemical damp-proof courses or other moisture trapping systems.

15 Historic floors combine character with the ability to understand early uses. Here a drain in the floor of a 18th century dairy.

16 Decay in a suspended timber floor (this example is 19th century), caused by blocked ventilation and raised external ground levels.

3.2.24 Until recently, most old floors were often replaced with inappropriate concrete slabs, which included a polythene DPC. This has the tendency to drive moisture into the adjacent walls, causing decay in skirtings and low-level timber as well the often much misunderstood concept of 'rising damp'. See Fig 06.

3.2.25 There are now breathable systems such as limecrete (see case studies and Fig 18)[8]. These work well where an insulated ground floor is required and there is no damp proof course in the walls. The system generally comprises:

- Foam-glass aggregate wrapped in a geotextile.
- Limecrete (lime and aggregate) which can incorporate under-floor heating.
- A breathable lime-based screed is usually required if carpet (as opposed to stone flags or tiles) is required.
- The system is often combined with French/land drainage externally to assist in managing moisture in the walls and ground.

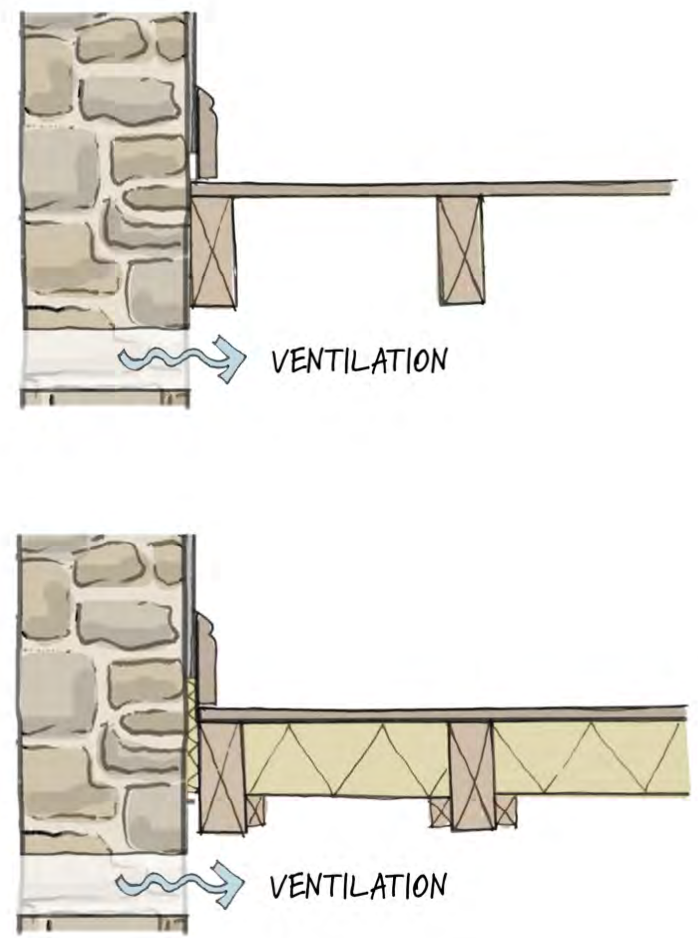
3.2.26 Where radon is present use of a breathable floor needs additional consideration. It is possible to adapt the system to include a sump and barrier, but specialist advice should always be sought.

3.2.27 Insulating timber floors normally requires the lifting of the floor boards. This needs to be considered with care if they are old or sensitive as damage can result from lifting. Appropriate insulation can be placed between the joists. This needs supporting, which can be done by an air-tightness membrane or battens depending on the type of insulation chosen.

It is critical to ensure that there is adequate ventilation below the timber floor. This is usually provided via air bricks or ventilation grilles in the walls. These can become blocked over time by rising ground levels or to prevent drafts, but this can result in decay in the timber floor structure.

Key Point to Consider.

Is the floor significant historically? Does it need to be lifted? Have external drainage and ground water issues been addressed. Check depth of foundations and below ground archaeology too.



17 Insulating a timber suspended floor, it is essential that adequate ventilation is maintained below the floor to reduce risks of retained moisture and timber decay.

[8] https://www.limecrete.net/faqs/

Roofs

3.2.28 It is estimated that up to a quarter of the heat loss in a house can be through the roof, so this element should always be high on the list for insulation.

3.2.29 Adding insulation to an unoccupied loft space is relatively simple and cost-effective, but where attics are occupied the considerations are more complex.

3.2.30 It should be noted that where a loft is being converted to a habitable room or a significant re-roofing is proposed, there is a requirement to enhance the thermal performance of an existing roof (consult the local authority building officer for more detail), and confirm any planning permission requirement.

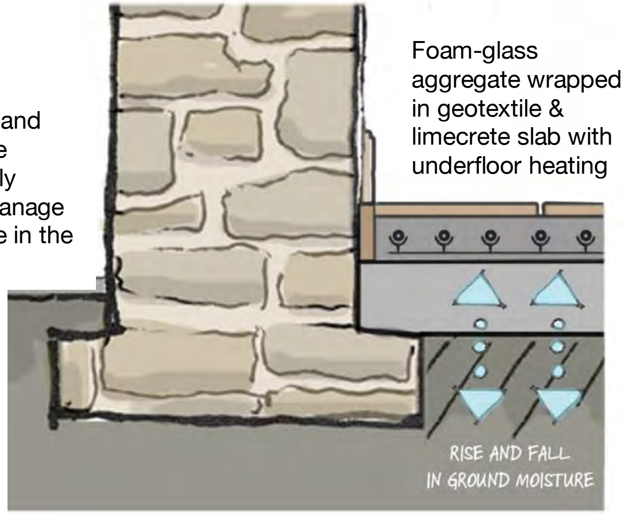
3.2.31 Fig 19 below shows the most common configurations of roof insulation and occupancy.

3.2.32 There are a significant number of factors to consider when insulating roofs.

- Ventilation is critical and must be carefully considered before undertaking any roof insulation work.
- There are significant risks of condensation if the build-up of insulation is not designed correctly.
- Is the roof of historic significance? Insulating at the rafter-line (for example) may detrimentally affect the fabric or change the height of the roof finish, which can have consequential impact on other details.
- Consider the condition of the roof, if may be more cost effective to undertake repairs at the same time as undertaking insulation work, but don't strip a historic roof unless absolutely necessary.
- When considering roofing membranes it is important to understand whether bats are present. If so, it will be important to use the correct membrane and detailing as modern breather membranes are not appropriate for use where bats are present.

French/land drainage externally helps manage moisture in the wall.

Foam-glass aggregate wrapped in geotextile & limecrete slab with underfloor heating

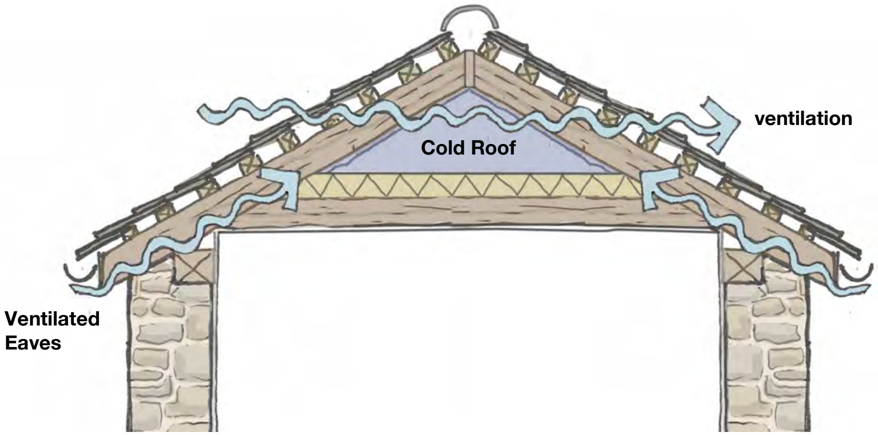


18 Limecrete floors provide a suitable alternative to concrete and can regulate moisture effectively. See also case studies.

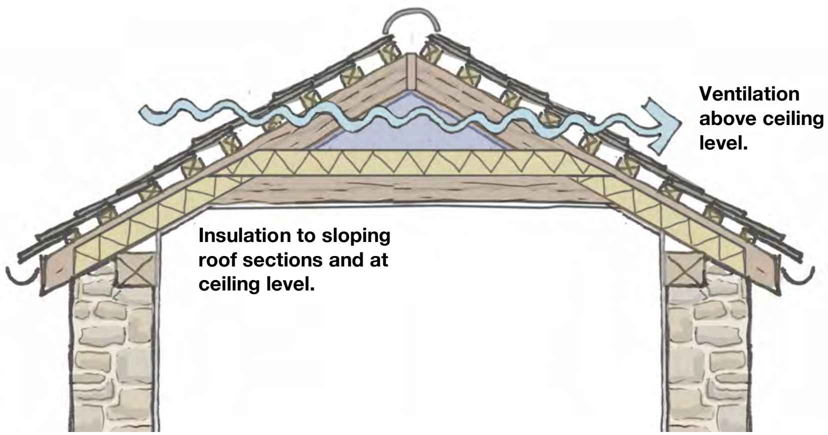
Key Point to Consider.

Is the roof in good condition? Is it historically significant e.g. diminishing coursed slates, pegged construction, retaining torching (lime pointing) underneath. Again, repair should be the first option. Always ensure sufficient ventilation and appropriate use of the right membranes where appropriate.

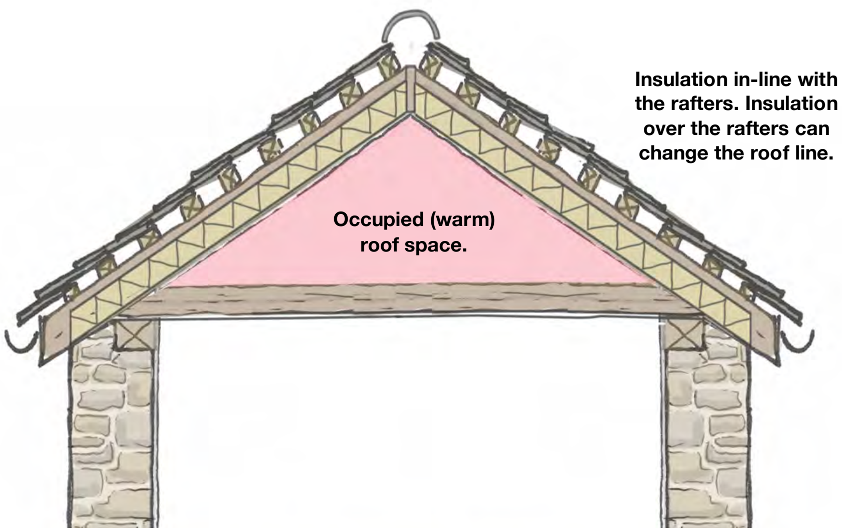
Most Common Types of Roof Space



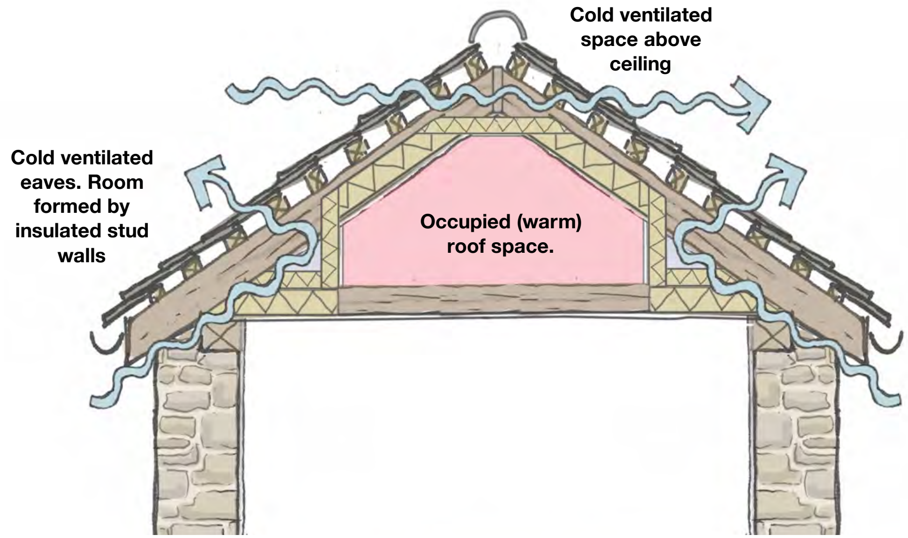
01 Cold Roof, uninhabited loft space, where rafter are exposed to the underside. Loft insulation, such as mineral wool or sheepswool can be installed at ceiling level.



02 Partially occupied roof space. A fairly common configuration in Eryri. Requires careful insulation of the eaves areas and consideration of adequate ventilation.



03 Warm roof, showing insulation in-line with the rafters. Sometimes insulation is also included over the rafters, but this will raise the roof line.



04 Warm roof, room formed with insulated ceiling and stud walls. Cold ventilated spaces behind and above ceiling.

19 The Most common types of roof space and insulation configurations.

Windows and Doors.

3.2.33 Windows and doors are a very important part of the historic environment. They are intrinsic to the character of many buildings and conservation areas.

3.2.34 There is often pressure to replace timber windows with uPVC. uPVC is toxic, inefficient to produce and difficult to recycle. Redundant windows often end up in landfill despite various recycling schemes. It is also, in most cases, damaging visually to traditional buildings and conservation areas.[9]

3.2.35 Repairing and upgrading existing windows should always be the preferred option, historically and environmentally.

3.2.36 Again, using Shutters, thick curtains or blinds, can make 35- 60% difference to the thermal efficiency of windows. Our behaviour is a huge factor, not just the materials!

3.2.37 Simple measures can be undertaken to upgrade old windows and doors, these include:

- Draught stripping and seals.
- Secondary glazing (windows).

3.2.38 Secondary glazing comes in many forms, from simple 'clip-on' or magnetic sheets, to full, internal windows (usually in metal frames). Choosing a system will depend on a variety of factors including the detail of the building and how the windows are used.

3.2.39 If the window doesn't retain historic glass (as a rule of thumb, look through the window and see how 'wobbly' the view looks, wobbly glass is often old glass!). If it has modern glass then it may be possible to introduce a slim-line double glazed unit (units of c.14mm depth are readily available and some include historic glasses).

3.2.40 Some old windows can be carefully adapted, but it needs skill and care for success. See Fig 24. Key points include:

- Is the glazing rebate deep enough, or can it be slightly increased in depth to take a slim double glazed unit.

20 Historic doors and windows are vitally important to the character of historic buildings and towns.

21 Replacement of windows with uPVC is detrimental both in terms of the historic environment and the embodied energy of the materials.

[9] Suhr, M and Hunt, R (2013) *The Old House Eco Handbook* (SPAB).

- Double glazed units need care when using linseed-oil putty. A putty replacement (tooled traditionally) or edge protection for the units will be needed.
- In more sensitive settings, double-glazed units can incorporate historic glasses externally.

3.2.41 If the building has modern windows, then replacement to an appropriate pattern should be considered and it may be possible to integrate double glazed units as well as the measures described previously.

Key Point to Consider.

Are the windows important to the character of the building or area? Do they have historic glass? Are they able to be repaired? If any of these are true, then **repair is likely to be the best option**. These factors will influence the most appropriate approach to upgrading.

3.3 Renewable Technologies

3.3.1 There are an increasing number of renewable technologies on the market. Below is a summary of some of the most commonly used types and some factors to consider when reviewing their use in the context of traditional and historic buildings in conservation areas.

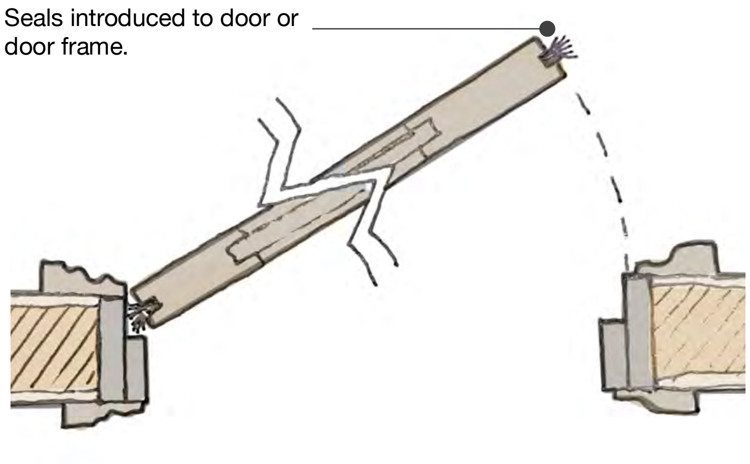
3.3.2 Renewable technology installations always require the input of a specialist to ensure the most appropriate technology or combination of technologies for the site is specified.

Solar Photo-Voltaic (PV) Panels.

3.3.3 In a Solar PV systems, the light hitting the cell is converted directly into electricity. A number of cells are combined to create a panel and a group of panels combine to create an 'array'.

3.3.4 The power generated can be used directly by the building and excess power exported to the National Grid.

3.3.5 To be most effective, panels ideally need to be orientated between south-east and south-west, and a pitch of 30-40 degrees.



22 Door or frame mounted seals can make a very big difference to draughts and heat loss, whilst maintaining the appearance of an old door.

23 Draught sealing sashes and other historic windows is relatively straightforward and makes a huge difference to thermal performance and comfort.

3.3.6 Panels are usually framed but come in a wide variety of shapes and sizes and finishes.

3.3.7 Panels are most often sited on the roofs of buildings or on a stand-alone frames. This can clearly have implications for the appearance and character of historic buildings and their settings.

3.3.8 PV systems can often be suitable for use in the historic environment, but only where there installation will not harm the character of the building of site or conservation area. Opportunities include:

- Valley gutters or parapet roofs not generally visible.
- Less sensitive outbuildings where away from key views.
- Free-standing installations potentially screened by planting.

Key Point to Consider.

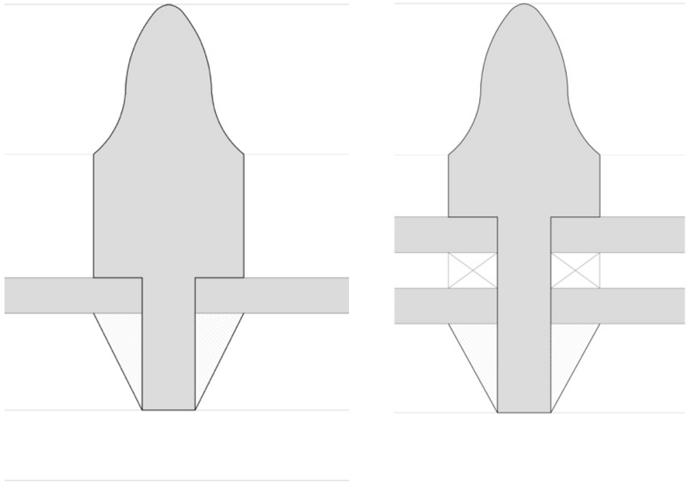
Appraisal by specialist to determine most appropriate renewable technologies to be used. If PV is considered an option, then review site options, orientation and locations, consider visibility, potential impact on the fabric of the building. If re-roofing panels can potentially be more discreet by installing flush with the roof slope.

Solar Thermal (Hot Water).

3.3.9 Solar hot water panels are now a relatively common technology due to their relative ease of installation and low cost. Simple systems consist of a solar collector (the panel), potentially a pump to circulate hot water and a hot-water cylinder. The cylinder often combines solar and boiler-fed hot water.

3.3.10 There are two primary panel types, flat and tube collectors. Tube collectors are generally more efficient, but more expensive and more visually obtrusive.

3.3.11 Orientation is generally as per PV, but tube collectors can also be installed on walls which provides additional opportunities for discreet siting.



24 In some cases careful insertion of slim-line double glazing into original glazing bars may be possible.

25 Solar thermal and Solar PV panels, rear elevation of Holyhead Market Hall.

Heat Pumps

3.3.12 Heat Pumps work by absorbing heat from the environment and transferring it to a fluid, which is compressed to increase its temperature. This heat is then transferred from the compressed fluid into the central heating system, to use for both heating and hot water.

3.3.13 The main difference between the two primary types of heat pumps is where they get heat from: air source heat pumps (ASHP) absorb heat from the air whereas ground source heat pumps (GSHP) absorb heat from the ground. Other types are available including water source, which can use water from lakes and rivers.[10]

3.3.14 Ground source heat pumps are generally more efficient (dependent on ground conditions) but have higher set-up costs than air-source.

3.3.15 In the historic environment, ground source are less visually obtrusive, but below-ground archaeology must be considered.

Key Point to Consider.

Appraisal by specialist to determine most appropriate renewable technologies to be used. If heat pumps are considered an option, then review site options, consider visual impact of air-source location, amount of available space and potential for below-ground archaeology if ground source is proposed.

26 Free standing PV panels (or solar thermal), can be discreetly located away from sensitive buildings and settings. © National Trust.

27 Air-source heat pumps are not attractive but can play an important role in a combined renewable solution. In the historic environment they need careful positioning

[10] https://energysavingtrust.org.uk/air-source-heat-pumps-vs-ground-source-heat-pumps/

Micro-Hydro & Micro-Wind

3.3.16 Eryri has natural opportunities for micro-hydro. Wind turbines are unlikely to be permitted in the national park (especially in a conservation area), so aren't discussed here.

3.3.17 Hydro-electric power generation has a long history in Eryri and surround areas. Some of the earliest schemes in the country are located nearby and Cwm Dyli near Beddgelert is now a grade II* listed building.[11]

3.3.18 More recently there has been an increase in smaller-scale micro-hydro schemes, some involving community-led companies such as Ynni Anafon (http://www.anafonhydro.co.uk) at Abergwyngregyn.

3.3.19 Schemes typically comprise a weir to divert the watercourse, leat or pipe, a building to house a turbine and generator (to convert the power of water to electricity) and an outflow pipe to return the water back to the watercourse.

3.3.20 The number of suitable sites will be limited, but different types of historic sites, including those in conservation areas can be suited to hydro-electric power generation. Mills, farms and other sites all have potential and have been successfully utilised.

3.3.21 Depending on the scale of the scheme, 'Power houses' can be quite small and formed to sit comfortably in the natural or historic environment. Simple modern structures, perhaps with a grass roof, or a more traditional form might be appropriate depending on the context.

3.3.22 Diversion of the watercourse will usually require a water abstraction licence and the impact upon wildlife (especially fish) must be considered and the necessary licences and permissions obtained. [12]

Key Point to Consider.

Always seek professional advice and commission feasibility to determine the viability and practicality. Is a scheme possible without damaging the historic environment unacceptably? Check, water abstraction licences, visual impact, and wildlife/ecological considerations.

28 Micro-hydro powerhouses can be small and discreetly located. This example is at Hafod-y-Llan, Nant Gwynant. © National Trust.

29 Cwm Dyli hydro-electric power station near Beddgelert (Wikimedia Commons).

[11] https://cadwpublic-api.azurewebsites.net/reports/listedbuilding/FullReport?lang=&id=20926
[12] https://historicengland.org.uk/images-books/publications/micro-hydroelectric-power-and-historic-environment/micro-hydroelectric-power/

3.4 Summary

3.4.1 It is safest to choose installers with experience of historic buildings and certified by the Microgeneration Certification Scheme (MCS): a list of these can be found on the MCS website at www.microgenerationcertification.org.

3.4.2 Below is a simple diagram with key points to consider when considering renewable technologies to historic buildings and settings.

30 3.5kW micro hydro from a water wheel, Eskdale Mill, Cumbria (Grade II* listed). © Smith Engineering

31 Considerations for renewable installations in the historic environment.

KEY POINTS TO CONSIDER	RENEWABLE TECHNOLOGY	SOLAR ELECTRIC (PV)	SOLAR THERMAL (HOT WATER)	AIR-SOURCE HEAT PUMPS	GROUND-SOURCE HEAT PUMPS	MICRO-HYDRO
Install equipment away from the historic building or key views. Avoid installation to prominent roof slopes or within primary views (for example, see conservation area appraisals)		✓	✓	✓		
Consider impact upon the setting of the Conservation area or group of historic assets.		✓	✓	✓		✓
Consider finish of the technology, e.g. framing to solar panels, protrusion from roof slope (if building mounted). Etc		✓	✓	✓		
Excavation work must consider potential impacts on below-ground archaeology or historic surfaces.		✓	✓	✓	✓	✓
Battery storage, power houses or similar ideally situated remote from the primary historic structure to minimise risks.		✓				✓
Ensure equipment is, as far as possible, installed in a manner which is reversible (i.e. it can be removed and replaced without damaging the historic fabric.		✓	✓	✓		✓
Consider ecological impacts including bats, nesting birds, water courses (fish) etc.		✓	✓	✓	✓	✓
Seek advice from the local authorties conservation, planning and building control team at an early stage to inform the proposals.		✓	✓	✓	✓	✓
Seek professional advice to determine the most appropriate technology or group of technologies for the site. The professional should ideally be experienced or work with an experienced conservation professional.		✓	✓	✓	✓	✓

NB this table is based on that produced by Historic England in '*Energy Efficiency Measures in Historic Buildings*' but adapted for this guidance.

4.0 Case Studies

The Case Studies below have been prepared with *The Natural Building Centre* at Llanrwst and are not the author's projects. These are not intended to determine the appropriate approach for a particular building, which should always be based on a proper assessment of the individual building or sites requirements and opportunities.

The case studies are intended to give a 'real life' picture of the issues and opportunities and highlight some potential approaches appropriate to traditional buildings which could be considered.

4.1 External Wall Insulation

The building and the situation

4.1.1 External wall insulation is the most efficient way to insulate a solid walled building, this is because the thermal mass of the masonry holds the heat in the walls and there is very little heat lost to the outside.

4.1.2 External wall insulation such as this cork-board will often require significant alterations to the property, for example rooflines may need to be extended, and new windows, rainwater goods and sills may be required. On this project, the whole house was restored both inside and out, therefore there was an opportunity to make the alterations necessary and get the planning approvals to do so.

Approach adopted and why

4.1.3 This house has a 15th century timber cruck frame, with nine-inch thick solid brick walls. It had been modernised with products that were not suited to the building, such as cement and impermeable plasters and paints. The nature of the walls, together with the later changes, meant the building was always going to be cold and very inefficient to heat.

4.1.4 The clients were keen to use insulating products and a system that would not trap moisture or mean that they lost too much internal space. The building had already been rendered in the past, therefore a decision was made to apply an insulation board externally and render over the insulation. With other work needed, such as a new roof and new windows, it was therefore sensible to do all the work at the same time, to create a full insulating envelope around the building – a whole building approach.

32 Typical gable following removal of a later extension.

33 Application of Cork Board and render coats.

The technical challenges and objectives

4.1.5 In this case, a 100mm thick cork-board was fitted to the external face of the house - The method is to apply a lime splatter coat first onto the brick or render to create a good key. An adhesive coat then follows this that the boards are pushed onto, to create a fully bonded bed for the boards. The boards are then mechanically fixed using insulated plugs and washers. A base rail is fitted on the bottom of the wall to keep the boards of the ground. Once the boards are fitted and are level, two coats of plaster are then applied with a render mesh sandwiched in between. Over this meshed coat, a lime render is applied and painted with a breathable external paint.

4.1.6 If the walls of the building to be treated are relatively flat, this system is reasonably straightforward to apply. However with undulating and uneven walls, then applying the boards is more problematic, and there may be a need to apply a few levelling out coats first of lime render.

Outcomes and lessons learnt

4.1.7 The outcome of this project is a transformed building. A house that was once cold and difficult to heat, to a building that is modern and energy efficient. The materials used in the restoration are sustainable and have been manufactured from natural materials that are free of chemicals and synthetic products. The materials are also sympathetic to old solid walled buildings of traditional construction, because they do not trap moisture in the walls.

4.1.8 Such an approach is not cheap and should be seen as a once in a lifetime renovation, therefore the detailing and the execution of the work must be correct. Professional advice and experienced tradesman are important to achieve a good outcome.

4.1.9 By applying the insulation externally, it allows for more flexibility internally, which is especially important where historic features should not be covered up.

4.2 Insulating Plaster (Lime Hemp).

The building and the situation

4.2.1 This is a typical old building of Eryri, being of traditional solid wall construction, made up of random stone and traditional lime and earth mortars. This particular building dates back to the 15th Century and had been left to ruin. It was restored into a domestic dwelling in 2018.

34 Cork boards installed, prior to application of render coats.

35 Following application of lime render and breathable paint.

4.2.2 The building is situated in the National Park and is in a relatively sheltered location. Most of the original lime pointing and stonework was still in good condition, and only partial re-pointing using lime mortar to match the existing was necessary to make the masonry weather tight. As part of the project, the building also needed a new roof, new floors and new wooden windows, but the walls were more or less left untouched, apart from needing new internal lime plaster.

Approach adopted and why

4.2.3 The approach was to directly plaster onto the stone with a breathable insulating lime plaster. In this case lime hemp plaster was chosen because the walls were dry and it is a British product that is similar to some traditional plasters found locally where chaff or straw were mixed into original lime plasters.

4.2.4 In this case two 20mm coats of lime hemp plaster were applied. The first coat was applied directly on to the stone after it had been pointed in lime mortar, and then keyed ready for the next coat. The second coat was applied after the first coat had dried, and then troweled smooth to follow the contours of the walls. After the plaster had dried it was then painted with breathable clay paint.

The technical challenges and objectives

4.2.5 The challenge with this project was to restore a historic building using traditional materials whilst also adding some insulation to the property. It was important to maintain the walls ability to regulate moisture and not to create any barriers that would trap moisture or lose any of the character of the building.

4.2.6 This is a listed building, therefore a more sensitive approach was required. An alternative might also have been simply plastering with a standard aggregate based lime plaster. This option would have been absolutely fine, but would have offered little in the way of improving the insulating properties of the walls.

Outcomes and lessons learnt

4.2.7 Hemp lime plaster has some key benefits. 30mm to 40mm thickness can improve the insulation value of a traditional solid wall by up to 30%. It can be applied in two coats and finished with a smoother lime plaster. There is quite a significant labour saving compared to traditional lime plasters, but it

36 Application of initial coat of plaster.

37 Completed insulating plaster finished with breathable clay paint.

does take longer to dry. It is very easy to use and has good environmental benefits. Once it has dried it is has a robust surface and seems to regulate humidity very efficiently. The material can be bought ready-mixed from various suppliers, or the raw materials can be mixed on site, but needs a suitably experienced contractor.

4.2.8 If hemp lime is being considered, then the walls must remain dry. External work should be carried out first to rectify any damp issues, including the rainwater goods, groundwater and roofs. In Wales, hemp lime is usually used as an internal plaster and in the right circumstance it is an economic option that offers some insulation benefit, whilst minimising affect on internal space and character.

4.3 Solid Floor Insulation

The building and the situation

4.3.1 This project was a typical traditional Welsh barn, built of stone and lime mortar with an earth floor. The drainage work, including installation of land drains, externally had already been carried out, to manage the water run-off from the surrounding land that previously had come into the building after heavy rain.

4.3.2 The floor was still a little damp to the touch but had no standing water after heavy rain. The owner wanted to lay an insulated floor with a robust screeded finish, so that they could use the space as workshop but with a view to potentially developing the building in the future.

4.3.3 There was no issue with radon (which always should be checked) and the building was generally in a good state of repair. The floor area measured about 60 square meters, and the work was carried out in late autumn in wet conditions.

Approach adopted and why

4.3.4 The approach with this floor was to keep things as simple as possible, and to dig down as little as possible to avoid undermining the footings of the barn.

4.3.5 A re-cycled foamed glass aggregate, also known as insulating gravel was chosen. This material has three important capabilities in one re-cycled product.

4.3.6 It works very well as a hardcore, where the angular lightweight aggregate locks together when compressed, but without breaking. It has very good

38 Insulating aggregate, geotextile visible to perimeter.

39 Limecrete slab being laid.

insulating properties; because so much air is trapped into the closed sphered foamed glass. Lastly the aggregate is a capillary break and moisture cannot climb up through the lightweight material to reach the slab. This method requires no plastic barrier and therefore does not trap moisture and push moisture sideways towards the walls.

4.3.7 With minimum depths of 250mm for both the sub-layer and screed combined, it is equal or less depth than a conventional insulated concrete floor.

The technical challenges and objectives

4.3.8 The beauty of this system is how easy it is to install. The hard bit is digging the floor in the first place. When dug, a layer of geotextile is laid over the bare earth, this is then followed by the insulating gravel, which is then compacted, but not crushed. Over the compacted surface another layer of geotextile is fitted to stop fine materials falling down into the gravel beneath. The hydraulic lime screed is then laid at a 100m thickness, and can either be left or it can be covered with a floor covering once the screed has dried.

4.3.9 This system lends itself especially well to water under-floor heating systems. The pipework is fitted to a grid on the second layer of geotextile between the sub-layer and the screed. The heat is transferred into the dense slab rather than the insulated layer beneath.

Outcomes and lessons learnt

4.3.10 From the point of view of efficiency and ease of use, this system works very well. The insulating aggregate is lightweight and can be poured directly onto the floor, without hard to fit layers of insulation board and plastic membrane. Importantly, this system does not compromise the traditional construction of solid walled buildings, because the moisture in the floor is not trapped, and the insulating aggregate simply acts as capillary break.

4.3.11 If in the event that there was an increase in water, either coming up from the ground or beneath the slab, perhaps due to a blocked drain or extreme weather, the 150mm – 200mm depth of aggregate can allow the water to sit and to drain away in drier conditions, without causing damage to the screed. Other insulation products after getting wet need to be dug up and replaced.

4.3.12 This system has local authority building control approval (NB permission still required), and the insulation values can be calculated to give a depth for

40 Finished floor.

41 Gable before erection of internal timber frame.

the insulating aggregate. The materials are readily available, and the technical skill required is relatively easy.

4.4 Internal Wall Insulation

The building and the situation

4.4.1 This project involved restoring a derelict building into a single bedroom and open-plan living space. The building is not listed nor has it ever previously been a dwelling, therefore it had to meet the same strict insulation targets that a new-build would have to meet.

4.4.2 The property was completely derelict at the start of the project, with only the four walls still standing. Although it is not listed, it was considered that the exterior of the building was of architectural importance, and therefore should not change in appearance. This meant that all the insulation required to meet the building regulations, had to be installed internally including the walls, roof and floor.

Approach adopted and why

4.4.3 Building control required that the walls met modern insulation standards. It would not have been possible to achieve this insulation target, with only an insulating plaster that was applied directly to the walls.

4.4.4 Solid walled buildings of traditional construction have the ability to pass moisture from the inside to the outside, by capillary action of the lime mortar. The thickness of the walls allows them to get wet and when the rain stops, they immediately start to dry out. This type of wall is often referred to as being able to breathe. It was vital in this project that the breathability of the wall was not compromised, whilst adding the insulation needed to meet the regulations.

4.4.5 To maintain the breathability of the wall, it meant only using insulation materials that are vapour permeable. Materials such as sheep's wool, compressed wood, lime plasters and intelligent breather membranes were designed to work together in allowing moisture to pass through the wall.

The technical challenges and objectives

42 Internal timber frame and membrane.

43 Membrane and wood-wool boards being installed.

4.4.6 The walls internally were quite uneven, and it would have been difficult to fix a solid thick board such as cork or wood-fibre directly to the wall, without leaving gaps behind.

4.4.7 The method adopted was to fit a 100mm deep, studded wooden frame against all the external walls (isolated from any damp surface). The timber stud was free standing and fixed to the floor and to the ceiling, with no fixings directly into the wall. The first fix electrics and pipework were then hidden in the studwork. Before fixing the stud, the walls were pointed with a lime mortar to fill any holes and then a breather membrane fitted over the face of the wall and the joints taped up.

4.4.8 Between the studs, 100mm of wool insulation was fitted, and then another breather membrane stapled to the stud and the joints taped for air tightness. Over this membrane, 25mm compressed wood wool board were screwed to the stud with stainless steel washers. The joints in the boards were plastered first, and re-enforced with jute scrim. The boards were then plastered with a 6mm coat of hemp lime plaster that was meshed, and followed by a smooth 3mm lime plaster topcoat to finish.

Outcomes and lessons learnt

4.4.9 The approach taken for the internal wall insulation in this project suited the building. The internal layout was simple and square, but the walls were uneven, so fixing timber studs, rather than boards directly to the walls was easier. Fixing studwork to all the walls allowed for all the first fix electrics, plumbing and fire suppression system to be hidden.

4.4.10 The insulation values achieved were excellent, making the building energy efficient. The added bonus of the insulating materials used, is their ability to manage the internal humidity by their capacity to absorb and release moisture, which creates a healthier internal environment.

4.4.11 The surface finishes are smooth and modern, and the property has a contemporary feel, reflecting a contemporary conversion. There was some loss of internal space of about 140mm on each wall.

4.5 Warm Roof Insulation

The building and the situation

44 Completed plaster finish.

45 Warm-roof insulation, the renewal of the roof helped dictate the approach.

4.5.1 See 4.4

Approach adopted and why

4.5.2 The requirement for the roof was for it to be very well insulated, and to have extremely good sound insulation. Equally important was the desire to make the pitched roof as efficient as possible, in managing to regulate humidity through the construction materials within the roof. The insulation and plastering materials chosen for this construction were natural fibre products that have both good insulation values and can also absorb and release moisture. With the pitched roof being such a large surface area in the building, it made sense to make it as breathable as possible, and to create a modern, spacious and healthy internal environment.

4.5.3 The alternative to this approach would have been to use materials that are not breathable, therefore requiring a greater reliance on mechanical ventilation to regulate moisture within the property

The technical challenges and objectives

4.5.4 To achieve modern insulation standards for the roof, the materials used were 200mm of sheep's wool insulation, fitted between the rafters. 40mm wood-fibre board was fixed to the underside of the rafters, followed by two tight coats of wood-fibre lime plaster. A breather membrane was fitted above the rafters, and the roof was counter battened before slating. A breather membrane was also fitted between the wood-fibre board and rafters for air tightness and further vapour control.

4.5.5 The boards used were tongue and grooved, which meant little waste because they didn't need to be cut to the rafter. All the joints were first plastered with jute scrim, and then followed by two coats of lime plaster. The finish was smooth, sharp and modern and painted with breathable clay paint.

Outcomes and lessons learnt

4.5.6 The approach worked very well for this project, because a new roof was needed it meant the insulation thicknesses could be built into the design of the roof before starting. The materials used were lightweight and easy to use, and all the products were made from natural materials with low-embodied energy. In the future, the materials can be disposed of easily, with no detrimental consequence for the planet. All the products are certificated, and the system has local authority building regulation approval.

46 New roof and membrane.

47 Plaster and finish.

5.0 Permissions

5.1 Overview

5.1.1 Below is a brief summary of the primary permissions which affect retrofit works in the historic environment. Note that there may be other permissions required depending on the nature and type of work undertaken.

5.2 Listed Building Consent

5.2.1 Listed buildings are those included on the national register of Buildings of Special Architectural or Historic Interest. These have special protection and would require listed building consent for changes affecting the building's character as one of special architectural or historic interest, such as materials, details and finishes (internally or externally).

5.2.2 It is likely that most of the physical measures discussed in this document will require listed building consent where applied to a listed building. Advice from the Eryri Conservation Officer should be sought before proceeding with any retrofit or fabric works.

5.2.3 Is the building listed? Consult the Cadw database:

- https://cadw.gov.wales/advice-support/cof-cymru

5.3 Planning

5.3.1 Most of the more significant measures described here will require formal planning consent.

5.3.2 A summary overview of the likely consent position is given in Fig 50. However this should always be confirmed with the planning officers at the National Park.

5.4 Building Regulations

5.4.1 The Building Regulations in Wales recognise the need to treat historic and traditional buildings differently. The regulations make the following specific provisions which are helpful in the context of using the right techniques to historic and traditional buildings:

48 Completed internal view.

49 Completed external view.

5.4.2 *Historic and traditional buildings where special considerations apply* (12.2) and 12.2.1. In addition, special considerations apply to works to the following three classes of non-exempt existing buildings:

a) of architectural and historic interest and are referred to as a material consideration in a local authority's development plan or local development framework; or

b) of architectural and historic interest and are within national parks, areas of outstanding natural beauty, registered historic parks and gardens, registered battlefields, the curtilages of scheduled ancient monuments, and world heritage sites; or

c) or traditional construction with permeable fabric that both absorbs and readily allows the evaporation of moisture.

Dwellings of architectural or historical interest

a) restoring the historic character of a building that has been subject to a previous inappropriate alteration, for example, replacement windows and doors; or

b) rebuilding a former historic building, for example, following a fire or infilling a gap site in a terrace; or

c) enabling the fabric of historic buildings to 'breathe' to control moisture and potential long-term deterioration.

5.4.3 (12.2.6) When assessing dwellings of historic and architectural interest where special consideration may apply, it is important that the Building Control Body takes into account the advice of the local authority's conservation officer, particularly where the work requires planning permission and/or listed building consent.

5.4.4 This wording makes it possible to have a dialogue with the Building Control officer and to adopt solutions which are appropriate to traditional buildings.

5.5 Other Consents

5.5.1 Other consents may be necessary, especially where wildlife is present. Early consultation with the local authority ecologist and Natural Resources Wales (NRW) is recommended.

RETROFIT MEASURE	UNLISTED BUILDING IN A CONSERVATION AREA (NO ARTICLE 4 DIRECTIONS)	LISTED BUILDING	UNLISTED NOT IN A CONSERVATION AREA	COMMENTARY
LOFT INSULATION	1	1	1	Assumes loose laid loft insulation, not re-roofing works.
INTERNAL SOLID WALL INSULATION	1	3	1	May be suitable for listed buildings where being converted subject to detailed assessment of heritage impact. Review technical and potential heritage impact in all cases.
EXTERNAL SOLID WALL INSULATION	3	3	2	Unlikely to be suitable for a listed building or in a conservation area unless specific circumstances (e.g. previously rendered) - refer to case studies for an example.
LIMECRETE OR SIMILAR FLOOR/INSULATION	1	2	1	Needs to consider sensitivity of exsting floor/build up.
SUSPENDED TIMBER FLOOR INSULATION	1	2	1	Needs to consider sensitivity of exsting floor/build up.
SECONDARY GLAZING	1	2	1	Generally likely to be supported subject to correct detailing and assessment of internal sensitivity.
DOUBLE GLAZING (INTO EXISTING WINDOW REBATES)	1	2	1	Only appropriate in some cases where modern glass present and can be installed sensitively.
DOUBLE GLAZING (REPLACEMENT WINDOWS)	2	3	1	Unlikely to be suitable for a listed building or in a conservation area unless replacement of poor modern windows and replacements can be suitably detailed.
DRAUGHTPROOFING (WINDOWS AND DOORS)	1	1	1	Generally likely to be supported.
GROUND-SOURCE HEAT PUMPS	1	2	1	GSHP will depend on building type, siting and location.
AIR-SOURCE HEAT PUMPS	2	2	2	ASHP will depend on building type, siting and location.
SOLAR PV	2	2	1	Solar PV will depend on building type, siting and location.
SOLAR THERMAL	2	2	1	Solar Thermal will depend on building type, siting and location.

1	Measure unlikely to require permission or consent (may be permitted development).
2	Measure likely to require planning permissions or consent. May be acceptable subject to detailed design and consultation.
3	Measure likely to require planning permissions or consent. Unlikely to be acceptable in most cases.

50 Indication of likely consent requirements. Specific circumstances should always be checked with the National Park.

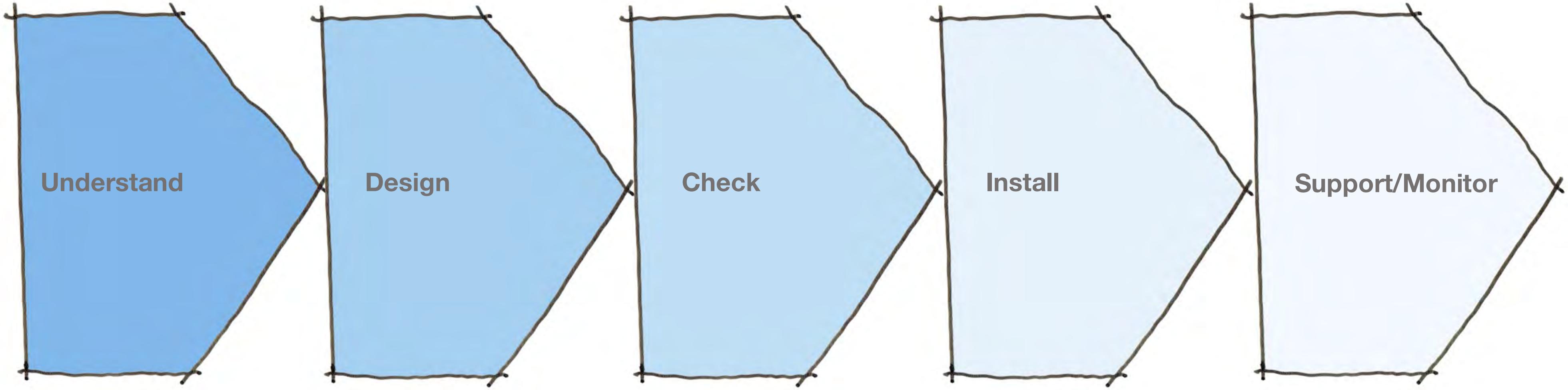
6.0 Planning for Retrofit Measures

6.1 Making a Whole House or Energy-Retrofit Plan

6.1.1 It is essential that a joined up approach to retrofit is undertaken and that this should take account of the factors previously discussed, including:

- Understanding the building
- Understanding the way the occupants use, maintain and operate the building.
- Simple fabric measures such as draught proofing.
- More complex measures such as insulation, secondary glazing etc.
- Servicing installations, controls and renewables.

6.1.2 All these elements are interdependent but need to be collectively brought together in a 'whole-house' approach for successful results. In summary:



Understanding

- How is the building constructed.
- Current and future use of the building.
- Orientation, setting, exposure.
- Current energy performance.
- Understanding the heritage value, significance and sensitivity
- Planning, listed building, building regs and ecological requirements have been understood.

Design

- Define a strategy which encompasses all the elements but is cautious where there is uncertainty or conflict exist.
- Follows a whole building/comprehensive approach.
- A detailed and exact specification prepared by a specialist in upgrading traditional buildings.

Check

- Ensure all factors have been considered.
- Ensure necessary consents and licences are in place.
- Ensure that suggested contractors understand the approach and monitoring is built in.
- Thorough review of proposals.

Install

- Ensure contractors have requisite skills and understanding of retrofit in traditional and historic buildings.
- What is the use of the building.
- Suitably skilled person employed to monitor the works and ensure quality control.
- Necessary testing and building control inspections.

Monitor

- Clear manual and recommendations for owners/users.
- Training in use.
- Allow for feedback and learning from performance in use, feeding into wider assessment of upgrading measures.

51 A Whole House or Whole Building retro-fit approach.

7.0 Where to Find Out More?

7.1 Published Sources

7.1.1 There are some very good guides and publications which can provide additional guidance and detail, these include:

- Short Guide Fabric Improvements for Energy Efficiency in Traditional Buildings, Historic Scotland (2013)
- Energy Efficiency in Historic Buildings (AICARR), Associazione Italiana Condizionamento dell'Aria Riscaldament, 2014
- Energy Efficiency and Historic Buildings: How to Improve Energy Efficiency by David Pickles, Historic England.
- Energy Efficiency and Historic Buildings: Secondary Glazing for Windows by David Pickles, Historic England.
- Energy Efficiency and Historic Buildings: Insulating Solid Walls, by David Pickles, Historic England.
- Energy Efficiency and Historic Buildings: Insulating Suspended Timber Floors, by David Pickles, Historic England.
- Energy Efficiency and Historic Buildings: Insulating Solid Ground Floors, by David Pickles, Historic England.
- Energy Efficiency and Historic Buildings: Heat Pumps, Caroline Cattini, Historic England (2017).

  NB these Historic England guides are available for download, see link below (7.4).

- Energy Efficiency Solutions for Historic Buildings by Alexander Troi, Birkhauser (2014)
- The Old House Eco Handbook by Marianne Suhr and Roger Hunt, (SPAB).

7.2 Sustainable Traditional Buildings Alliance

7.2.1 https://stbauk.org

7.2.2 The STBA aims to develop policy, guidance and training to minimise risks and maximise benefits to traditional buildings and their owners with a focus on five key areas:

- The health of the occupant.
- The health and durability of the building fabric.
- The energy consumption attributed to the building/occupant.
- The impact on our communities and culture.
- The impact on the natural environment

7.2.3 The STBA champions the 'whole house' approach and has a range of very helpful guidance available through their website.

7.3 Cadw

7.3.1 https://cadw.gov.wales

7.3.2 Cadw is the Welsh Government's historic environment service. Cadw publish some good guidance as well as setting heritage in the context of the climate emergency through the *Historic Environment and Climate Change in Wales Sector Adaptation Plan.*[13]

7.3.3 Cadw also publish useful guidance on Conservation Areas: https://cadw.gov.wales/advice-support/historic-assets/conservation-areas-other-historic-assets

7.4 Historic England

7.4.1 https://historicengland.org.uk

7.4.2 Historic England is Cadw's equivalent in England. Historic England provide a range of support and research documents offering advice and guidance on repair, conservation and energy improvement measures. See: https://historicengland.org.uk/advice/technical-advice/energy-efficiency-and-historic-buildings/

[13] https://cadw.gov.wales/advice-support/climate-change/adapting-to-climate-change

7.5 Historic Environment Scotland

7.5.1 https://www.historicenvironment.scot

7.5.2 Historic Environment Scotland (HES) is Cadw's equivalent in Scotland. HES, in particular, provide a range of very good support and research documents offering advice and guidance on conservation and energy improvement measures, including a range of informative case studies: https://www.historicenvironment.scot/archives-and-research/publications/?searchPubText=energy

7.6 Society for the Protection of Ancient Buildings (SPAB).

7.6.1 www.spab.org.uk

7.6.2 The Society for the Protection of Ancient buildings provide excellent advice on conservation and, in particular, maintenance: https://www.spab.org.uk/sites/default/files/maintenance-toolkit/Maitenance%20Calendar_4.pdf

7.7 Specialist Training, Suppliers and Manufacturers

7.7.1 Canolfan Tywi offer courses and advice both at the centre in Llandeilo and on-line in the conservation, repair and upgrading of traditional buildings: www.tywicentre.org.uk

7.7.2 The Centre for Alternative Technology at Machynlleth provide practical guidance and training: https://cat.org.uk

7.7.3 The Welsh Traditional Buildings Forum, promotes the development of traditional building skills and sustainability issues relating to all old buildings across Wales. https://www.wtbf.co.uk

7.7.4 Ty Mawr Lime are designers, manufacturers, and distributors of environmentally-friendly building materials and systems. https://www.lime.org.uk

7.7.5 Mike Wye are suppliers, manufacturers, consultants and contractors supplying sustainable and conservation products and services. https://www.mikewye.co.uk/about/