Planning responsible retrofit of traditional buildings

Responsible Retrofit Series

STBA
SUSTAINABLE TRADITIONAL BUILDINGS ALLIANCE

Sustainable Traditional Buildings Alliance (STBA)

The STBA is an alliance of not-for–profit organisations representing the sustainability, heritage and professional sectors in the UK. The STBA aims to promote and deliver a more sustainable traditional built environment through high quality research, education, training and policy.

The Responsible Retrofit Series of booklets provides short and usable guidance about traditional building retrofit, based upon best current research and practice, and which is holistic and realistic in its understanding and aims. These booklets will help to reduce risk and liability, while also improving outcomes in reality, not only in terms of energy, but also health and heritage. They are not tick box guidance, because there is unavoidable complexity and uncertainty in the way that old buildings, new technologies, nature and people perform and interact. Furthermore, retrofit often involves conflicting values and aims. There is no one-size-fits-all 'solution'. Responsible Retrofit means taking an informed, integrated and ethical attitude to these challenges. These guides are here to help people to do this.

Future planned Responsible Retrofit guides will cover 'How to Do' subjects such as External Wall Insulation, Internal Wall Insulation, Roof and Floor Insulation, Renewable Energy systems, and Usable Controls and Services.

We welcome feedback from retrofit projects. We encourage people to share their knowledge and experience with us as part of a collaborative national endeavour to improve and sustain our traditional built environment.

Visit our website: www.stbauk.org

This publication has been supported by the following organisations:

Construction Industry Training Board
The CITB works with employers to encourage training, helping to build a safe, professional and fully qualified workforce. It also develops specialist training for conservation and retrofit work.

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Cadw is the Welsh Government's historic environment service.

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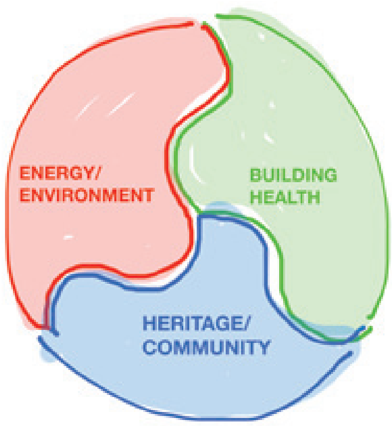
1 Introduction

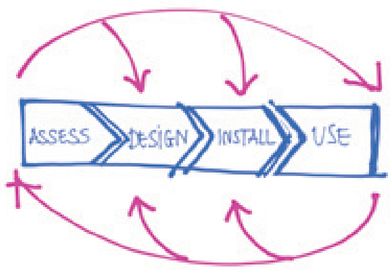
Retrofit principles

1 Think about:



2 Take a Whole Building Approach:

3 Use a Joined-up Process:



Who is this guidance for?

This guide is for anyone involved in a project aiming to reduce the energy use of a traditional building through technical interventions. This is what is primarily meant by 'retrofit'. The guidance will be useful for:

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

Why retrofit your building?

There are many reasons for retrofitting your 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, and to improve the value of a property. Some people are also obliged to retrofit because of legislation or building regulations.

What is this guidance for?

It is to enable people to reduce energy use in buildings in an effective way, which is also good for *health*, *heritage* and the *natural environment*. This is what we mean by ***responsible retrofit.***

Why is this guidance necessary?

There is increasing evidence that the retrofit of traditional buildings (and indeed all buildings) over the past few years has not led to the expected reductions in energy use, and has harmed the building fabric, heritage or health of building occupants. This is for three primary reasons:

- Incorrect standards and assessment of traditional buildings.
- Single or narrow focus approach to both risks and retrofit measures.
- Disjointed and poor quality building process.

This guide makes clear where existing standards and information are wrong.

It shows the need to consider three broad areas of risk: ***Energy and Environment***; ***Building Health*** (health of both fabric and people); and ***Heritage and Community***. Sometimes compromises must be made between these values to get the best overall outcome, and this guide demonstrates a practical approach to this problem.

It identifies and promotes a ***Whole Building Approach*** which integrates Fabric, Services (such as heating and ventilation) and Human Behaviour with the Context of the building. We show how this balanced approach is essential to long term performance.

Finally, it demonstrates the importance of a ***Joined-up Process,*** linking up assessment, design, construction and use with proper training, quality assurance and feedback.

In summary, this guidance illustrates these principles and demonstrates why they are essential factors in avoiding risks and pitfalls, and achieving lasting benefits.

What is a traditional building?

Traditional buildings are generally of solid wall (ie not cavity walls) or solid timber frame construction, which were built before 1919. Traditional construction differs significantly from modern construction, having different materials, construction methods and design. Traditional buildings make up about 25% of the UK's total building stock.

It is important to note that many traditional buildings have had alterations, additions or other changes to their fabric, services and use over the past century. Traditional buildings are neither pure nor unchanging.

What is retrofit?

Retrofit is the process of improving the energy and environmental performance of buildings through technical interventions, albeit that to achieve benefits, this process often needs to encompass occupants' lifestyle changes and involves an ongoing programme of repairs and maintenance. A prime focus of retrofit is on reducing heat losses through building fabric (ie, walls, doors, windows, floors and roof) – thereby cutting heating costs, energy use and CO_2 emissions. However, there are also other important ways of reducing these impacts, including improvement in services such as heating systems, controls and lighting and by the use of renewable energy. Different buildings and different occupants benefit from different approaches. Not all buildings can be retrofitted, and for some buildings and people there are more appropriate ways of reducing environmental impact than technical interventions.

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

All work on buildings requires an approach which is specific to their context. However there are some general qualities of traditional buildings which are worth defining in comparison with modern (post 1919) buildings, and which consequently require different understanding, skills and material solutions.

Traditional buildings are constructed from 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 move in a controlled way into and through their semi-permeable fabric. They also rely on sunshine, wind, heating and adequate internal ventilation through windows, chimneys and draughts in order to keep dry. In good condition and with regular maintenance, the system stays in balance. Changes to fabric performance, heating and ventilation, if not correctly undertaken, can change this balance and lead to problems of overheating, moulds and ill health.

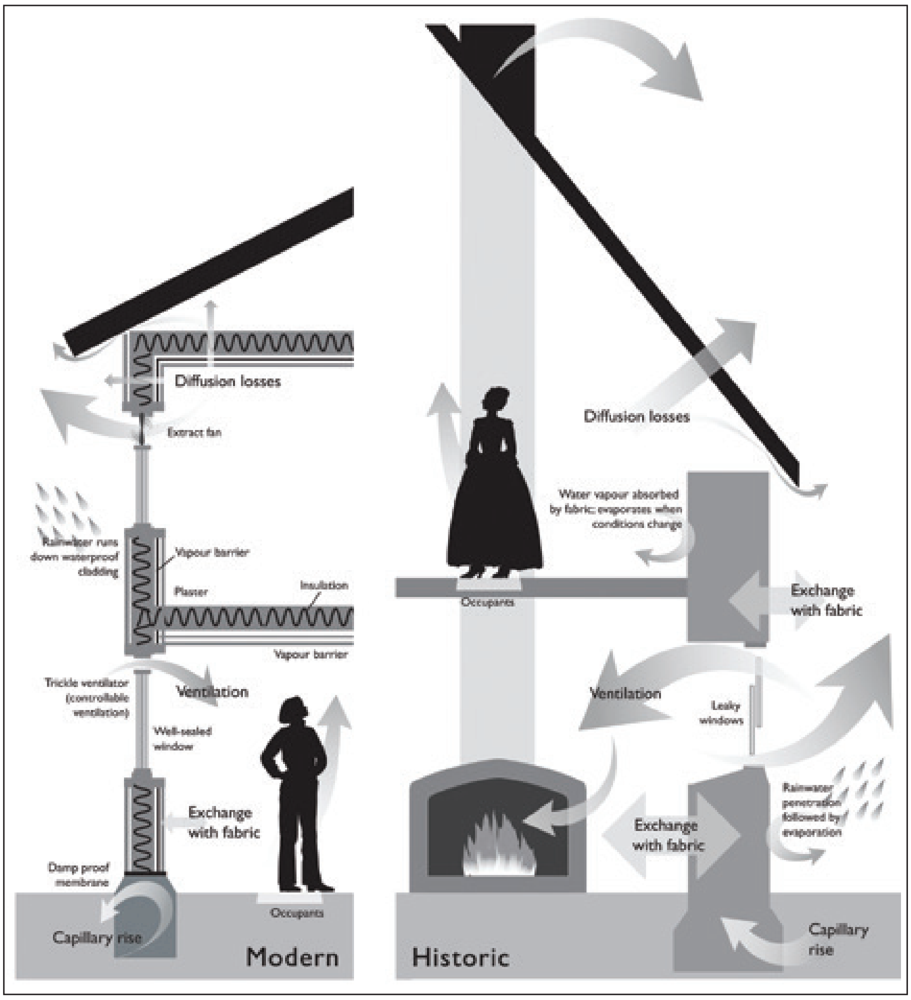
Culturally, traditional buildings provide local character and a very tangible connection to the past, with aesthetic and community benefits. All buildings do this, but traditional buildings reach further into the past and have greater links to locality and history, something which cannot be easily replaced.

Iain McCaig, Historic England

Nicholas Heath

ABOVE: Traditional buildings can be very different in age, construction, condition and use.

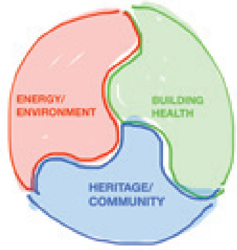
BELOW: Traditional buildings not only perform differently technically, but they represent a different way of living, and a connection with the past.



Robyn Pender, Historic England

2 Getting it right

Responsible retrofit should deliver sustained net reductions in energy use, at minimal environmental impact, while maintaining or improving the traditional built environment and making a positive contribution to human health.



Energy savings/Environmental improvement

Real reductions in energy use reduce costs as well as CO_2 emissions and ultimately contribute to improving everyone's fuel security. Long term savings are best achieved through simple and robust technical measures which are easy to use and maintain. Reducing CO_2 emissions is also essential in helping to reduce global warming. Responsible retrofit also minimises the 'embodied' impact of materials and construction in the build process and the mitigates the impact on resources and habitats.

Heritage protection and enhancement

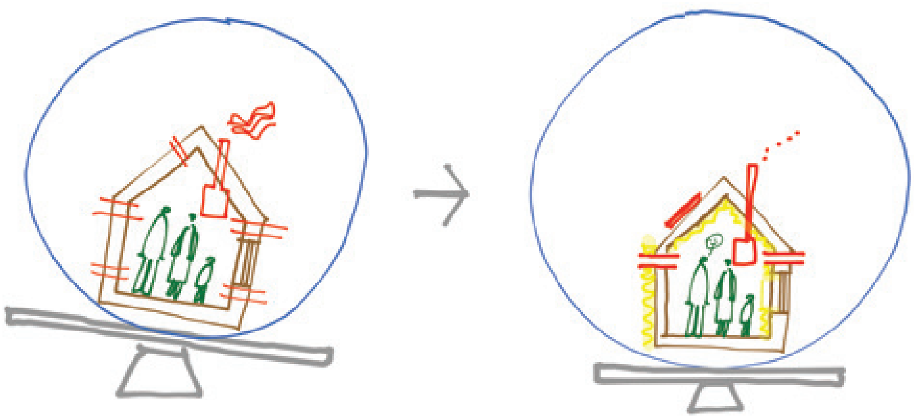
Most traditional buildings, including those that are listed, can be upgraded with at least some retrofit measures (to fabric or services). With appropriate care and user engagement, it is possible to achieve sustained reductions in energy use without damage to buildings or to streetscapes. Where buildings have fallen into disrepair they can be enhanced by sympathetic renovation and proper maintenance, which not only prolongs their life but also contributes to reductions in energy use.

Healthy buildings

Retrofit is an opportunity not only to improve energy use, but also to improve comfort and health for a building's occupants. Discomfort and ill health in buildings are often connected with moisture problems due to poor maintenance, inappropriate repairs and alterations or inadequate heating. All these omissions also affect the health of the building fabric. Toxins (such as radon), overheating and usability (it is important for occupants to be able to control their environment) are essential considerations for health and comfort. A health-focused strategy can prevent long-term side effects, illnesses and costs, and short-term failures.

Balance

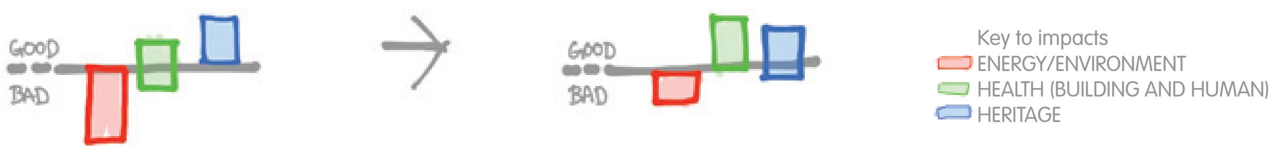
Achieving responsible retrofit often requires compromises between different values. It also requires a Whole Building Approach whereby there is integration of the fabric measures (such as insulation, new windows, draught proofing), and services (particularly ventilation, heating, controls and renewables) along with proper consideration of how people live and use the building. All of these must be adapted to the context of the building (its exposure, status, condition, form etc). When these are integrated well, a building is in balance.



LEFT: In the diagrams we show that an Unbalanced building can be retrofitted to a more Balanced building in a responsible retrofit using a Whole Building Approach. The bar charts give a snapshot of the risks and benefits of each. The idealised case study on the opposite page gives the details of such a project and may be considered a responsible and successful retrofit project and approach. Underpinning the success of any project is a Joined-up Process. See page 19 for a detailed breakdown of this process.

Unbalanced: draughty, loads of heat loss, traditional features maintained

More balanced: warmer and healthier, with slight loss of traditional character



Case Study – Georgian town house in poor condition

Some options for a Whole Building Approach retrofit undertaken by a young family

CONTEXT	
Location/orientation	Subject to driven rain at front but protected by street.
Form and condition	Bad pointing, leaky gutters, high ground levels. Chimney stack in poor condition, some dampness in walls and attics.
Heritage/community	Conservation area. Fine brickwork to front. Fine window details. Internal cornice. Original timber floors.

Nigel Griffiths, STBA

BEFORE	SOME GOOD OPTIONS: **FABRIC**
Uninsulated 9" solid brick	Vapour open EWI to back and gable. Moisture open IWI to walls (or blown IWI behind existing linings). Or insulated lime plaster internally. Repointing to front elevation, repairs to gutters, lowered ground levels.
Single glazed sash windows. Old shutters previously removed	Shutters reinstated and working and/or secondary glazing, or double glazed units in existing sashes, and/or thermal roller blinds.
Partially insulated roof space	Moisture open insulation to rafters (maintaining air flow above). Airtightness improved. Insulation between ceiling joists. Roof ventilation.
Uninsulated timber floors to front rooms	Timber floors lifted, draught proofed and insulated, ventilation checked and enhanced.

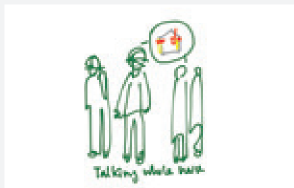
Roger Curtis, Historic Scotland

Roger Curtis, Historic Scotland

BEFORE	SOME GOOD OPTIONS: **SERVICES**
1980's era gas central heating	New condensing boiler; TRV's in all rooms; set back heating controls Radiant heating panels in bathroom and kitchen
No ventilation; windows and flues blocked shut	Controllable passive stack using existing hearths and stairwell rooflight or whole house MEV ventilation, with Humidity-sensitive Demand Control. Decision depends on level of airtightness, layout, disruption, etc.
No renewables or low carbon technologies	Ground or air source heat pumps possible. Photovoltaic panels, solar water heating and woodburning stoves all require planning consent.

Aereco

BEFORE	SOME GOOD OPTIONS: **PEOPLE**
Young family. Children have asthma. No understanding of building health or energy	Consultant/surveyor/designer/contractor works with owners to increase understanding of occupant role in building health, energy use and importance of maintenance. The whole retrofit project is undertaken responsibly using a Joined-up Process (see page 19).



WHAT MATTERS	BEFORE	AFTER
Energy/environment	Above average energy bills Above average CO_2 emissions.	60% or more reduction in energy (gas and electric) bills and CO_2 emissions, which are now considerably lower than UK average. Ongoing monitoring.
Building health	Peeling wallpaper, and mould in some areas. High RH in bathrooms leading to mould. High VOCs in kitchen. Insect attack in roof timbers. Children asthmatic. Low levels of comfort and health.	Rooms are now drier, no mould on window reveals RH and VOCs now safe for health/fabric. Timber decay arrested by drier conditions. Health improvements for all the family.
Heritage/community	Conservation area Original sash windows Original cornices in front rooms.	Visual impact on back minimal. Front kept same. Sashes preserved. Part of cornice covered, removed or re-moulded if costs allowed. Building has new lease of life.

3 The challenges of responsible retrofit

The success of a retrofit depends firstly on understanding the building and its context in sufficient detail and depth. Secondly, we need to understand that some of the formal standards and methods used by government and industry are incorrect or incomplete. Finally it is important to understand the interactions between all these different elements and how different aims for retrofit may conflict.

Understanding your building

What is your building made of? How do the fabric and services work together?

Traditional buildings differ widely in terms of their style and form, as well as in materials (see the Resources on page 22). The types of material (ie, brick, stone, timber, lime mortar, cob) vary widely in how they deal with moisture, heat and structural pressures. The type of construction, the thickness of walls, the sizes and types of window, the types of fire place and chimney, all affect the energy use, the health of the building and influence what can be done. For example, a thick limestone wall can be warmer than a thin brick construction, as well as dealing with rain and moisture better, so will require a different approach in retrofit. A building with large bay windows will be much more challenging to insulate than one with simple casement windows. Some buildings (like traditional timber frame) can be very draughty, but conversely, some can be very airtight.

However, technically, most traditional buildings work from the basic principles of balance and integration of moisture, heat and ventilation within the building type and context. On the other hand, very few traditional buildings are unaltered or in perfect condition, which can create challenges.

Alterations

Buildings which at first may appear similar have often been adapted and upgraded over a long period, with, for example, double glazing, loft and other insulation, loft and cellar conversions, extensions, subdivisions and changes of use. The addition of modern impermeable cement renders, removal and closing off chimneys and flues, the introduction of more air-tight membranes and vapour control layers and the addition of concrete floors are common. All these affect moisture movement, heat and ventilation (both designed and unplanned air movement) and may mean different strategies are required in different parts of the building. Today nearly all buildings in this country have central heating, baths, showers and washing machines. The extra pressure these modern comforts exert on traditional buildings can be considerable.

Condition

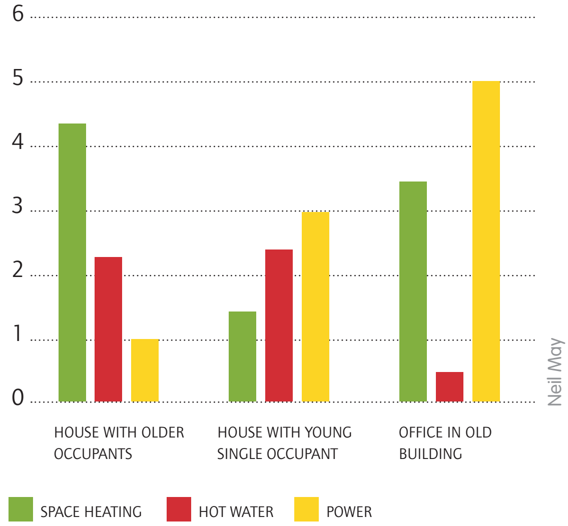
Condition is also highly variable. Dampness and draughts from poor maintenance can be the cause of much higher energy use, longer term structural problems and risks to health. It should be noted that in some cases due to alterations, modernisation and poor maintenance the building fabric may be at the *limits of its capacity* to handle water vapour or rain ingress, which can lead to failure if retrofit measures such as insulation or draught proofing are not undertaken as part of a whole building approach, or are incorrectly applied.

Take a careful look at your building and its construction history. It may be quite complex, with a mix of old and new work and alterations, requiring a multi-faceted approach.

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. A consideration, therefore, is to make sure that planned retrofit measures are appropriate for both current and future occupiers of a building.

Different building users also have different energy use. 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 in 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 occupant as well as the use of the building.



Energy use varies depending on the occupants' lifestyle.

Understanding the context of your building

Location and orientation

The location and orientation of a building makes a considerable difference to how a building performs and what can be done in retrofit. Specifically, where there is a lot of driven rain or flooding, especially in Wales, Northern Ireland, Cornwall, Cumbria and the West Coast of Scotland, 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. In some cases retrofit may not be appropriate, particularly where a building has a complex shape or is in poor condition. Conversely, a lot of sun can also cause problems with some internal wall insulation systems by 'pushing' water into the building during the summer This is called 'reverse condensation'.

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.

Marianne Suhr

Orientation and geography can affect the risks and benefits of some retrofit measures.

Heritage and community context

A building's shared history, beauty, place in the community and social life all contribute to its heritage and community value, which must be considered alongside its condition, occupant use and location in any retrofit strategy. For some buildings the heritage value is indicated in planning terms such as a Listed Building, Conservation Area, or an Area of Outstanding Natural Beauty (AONB). There will be planning constraints on how such buildings can be repaired or altered. However in many cases the heritage or community value is not formally designated, so a sympathetic understanding and sometimes research is required to identify what is *significant*. This is helpful in all cases. The appearance and use of some traditional buildings can also be significantly improved and enhanced by retrofit. Sometimes an approach will need to encompass a whole street or community area. These factors must all be considered to reduce risks to heritage and community. See Chapter 4, Understanding Risks.

Robyn Pender, Historic England

The historic context will have an impact on what should be done to a building.

Problems with standards and regulations

Traditional construction standards, data and modelling

As identified in the Responsible Retrofit of Traditional Buildings Report (see Resources section, page 22) there are still significant errors in the way that traditional buildings are treated in building standards, regulations and assessment systems (typically computer models). This means that much of the standard guidance and many of the current government funding schemes as well as commercial product certifications are misleading or incorrect. This is partly due to the gap between best current research knowledge and the adoption of such work by standards and regulatory agencies and partly due to the uncertainty of data and science of traditional buildings, something which will take many years to resolve. In particular the following should be noted:

1 We have a limited picture of how traditional buildings perform **thermally** (ie, in terms of keeping occupants warm). There is good evidence to suggest that overall they perform much better than the assumptions made in standard assessments. This is important, as the assessment models, including the Standard Assessment Procedures (SAP and RdSAP) which support Energy Performance Certificates (EPCs) can overestimate the cost savings available through retrofit, and make measures like insulation seem more beneficial than they really are.

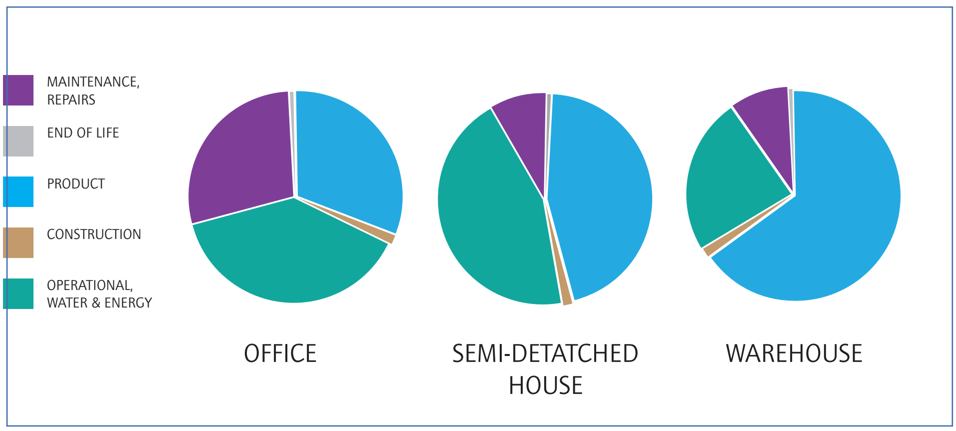
2 Building Regulations apply to any major retrofit in a number of ways, including provision of ventilation (Part F) and thermal requirements. However in the thermal requirements (Approved Documents Part L1B) there are important exemptions and conditions for 'traditional buildings of permeable fabric', which are often not understood or missed by assessors and those enforcing regulations.

3 There is a limited knowledge of how moisture moves in and out of solid wall construction, and in particular what happens to **moisture** movement when insulation is added and natural ventilation is reduced. The standards being used (particularly BS5250) are partial in this regard and can be misleading. Amendment of moisture standards is currently being addressed by the government with STBA assistance. Nonetheless this will remain an area of considerable uncertainty and complexity for many years to come.

4 The standards, advice and certification of **internal wall insulation (IWI)** for solid walls are currently wrong or misleading both in terms of moisture and heat loss. This can lead to very inefficient design and considerable mould problems.

The environmental impact of retrofit work

Retrofit is commonly measured in terms of its effect on the energy consumption and CO_2 emissions from buildings ***in use***. For responsible retrofit the 'embodied' impact of construction and materials should also be taken into consideration wherever possible. This can be substantial and sometimes even outweigh any savings in use. Retrofit materials require energy for manufacture and transport to site, and in many cases they are made from increasingly scarce resources such as oil, or are taken from vulnerable habitats. Unfortunately good information and standards are also lacking.



LEFT: The embodied impact varies with building type and use. This applies to traditional and non-traditional buildings in the same way.

Interactions

Technical Interactions

There are complex inter-relationships between the different 'thermal elements' of a building (walls, floors, roof, windows, doors), the space heating and ventilation systems, the use of the building and its 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:

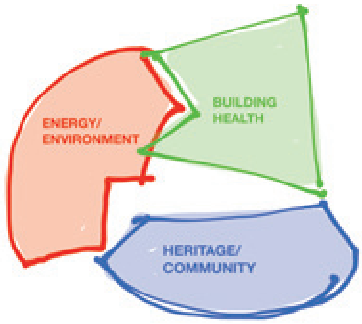
- space heating demand is reduced, so the heating system will need adjustment
- air leakage will be reduced, so additional ventilation may be required
- adjacent walls will become cooler in relation to the windows, so without good ventilation the risk of condensation on the reveals is increased.

For this reason it is essential to take a Whole Building Approach in a Joined-up Process.

Interactions are often complex.

Conflicting aims

While energy efficiency is often the primary aim of most retrofit strategies, there may be different reasons for this, such as the desire for cost savings, reductions in CO_2 emissions or improved comfort. Those involved in the retrofit at different stages may have varied and conflicting aims or priorities, for example occupant health issues, or historic character of the property. The Joined-up Process can resolve these conflicts.



Conflicting aims can cause problems.

The different effects of Context

Context is made up of all these challenges. Context of course also gives us character, connection, diversity and meaning. Each building's context is different!

A strong heritage context may mean improvements to performance rely on services (heating, renewables) and behaviour (including maintenance and repair).

The occupation context of overcrowding can put a lot of pressure on the health of building and occupants, particularly if the services and fabric are in poor condition. This can dominate performance more than external contexts.

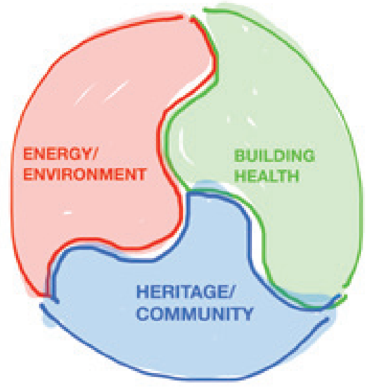
Heritage context – a careful approach?

Occupation context – overcrowded?

4 Understanding risks

Understanding your building and the challenges of its retrofit is largely about understanding risks. These risks can be broken down into three overarching categories:

1 Risks to building fabric and human health
2 Risks to heritage: damage to, and loss of, historic fabric; impact on neighbourhood or community
3 Risks to achieving expected energy savings; resulting environmental impact



This chapter identifies these broader risks and explains exactly why it is necessary to consider them. It then gives examples of specific risks likely to be encountered with each retrofit measure, taken from real projects, with action points for guidance on page 16 and 17.

1 Building health: risks to building fabric and human health

Inappropriate retrofit measures can lead to unintended consequences, such as condensation and mould growth or more serious ***fabric decay*** such as wet and dry rot. These issues arise when moisture (from poor building condition, internal moisture generation or from rain) is prevented from drying out or channelled into cold areas through poor design or installation of measures.

Trapped moisture and high levels of relative humidity can also lead to increases in mould spores and dust mites, both of which may affect ***human health***. Many fabric retrofit measures also reduce natural ventilation, leading to poor indoor air quality and further moisture build up. A good ventilation strategy is therefore essential in fabric retrofit. The UK has one of the highest rates of asthma in the Western world, which can be attributed in part to high moisture levels in buildings. There are also considerable risks to health from poor ventilation in radon areas.

2 Risks to heritage: damage to, and loss of, historic fabric; impact on neighbourhood or community

Heritage is a shared resource – shared between current owners of a building and future generations, and among communities. Future owners of buildings will have to live with the alterations made by previous owners.

Both fabric and service measures can affect the internal and external appearance and heritage value of a building, or sometimes a street or neighbourhood. This can be for good or bad. So understanding and determining the significance of a building or part of a building is an important task. Where either external solid wall insulation or window replacement is being considered there is a risk the building's external appearance may be substantially altered. Internal wall insulation can result in features such as historic cornicing and architraves being lost or obscured. Retrofit measures to roofs can damage or obscure decorative

Brian Ridout, Historic England

An extreme outbreak of dry rot and mould due to moisture ingress and lack of drying.

Anna-Marie Pagano

An insensitive external wall insulation application which damages the beauty and character of the whole street.

ceilings or internally visible roof structures. Historic floors may be damaged when insulation is retrofitted. Ventilation systems, heating systems, and renewable energy systems can also compromise the heritage value of a building, particularly if installed insensitively. Of course retrofit can also be a chance to correct previous mistakes, particularly where they are causing ongoing damage to fabric or health (for example inappropriate renders, blocking up of ventilation etc).

3 Risks to achieving expected energy savings: resulting environmental impact

As building elements are connected to one another, measures to improve the performance of any one part need to consider adjacent parts and their effect on the whole building. For example, the effectiveness of internal wall insulation can be reduced by an increase in heat loss through window reveals if they are not also insulated. This is one reason why a Whole Building Approach is important.

Even after buildings are retrofitted correctly, some of the gains in energy efficiency may not result in actual reductions in energy use. This happens for example when occupiers run the building at higher internal temperatures, because it is now possible to do this without prohibitive cost. This direct 'rebound' effect (aka the 'comfort factor') can be beneficial to occupant wellbeing but it means that savings will not be as high as may have been predicted.

Alternatively the financial savings which are gained by reducing energy use are often spent in other ways, which themselves use energy. This type of indirect rebound effect may mean that the overall impact of retrofit on carbon emissions is very low or even negative.

Finally the embodied impact of the retrofit measure and work (including the energy use and carbon emissions from in contracting) will reduce and may even outweigh the savings in use. Furthermore the use of scarce resources or materials from threatened habitats can harm the environment. When all these factors are taken into account often a more modest approach to retrofit is more beneficial to the environment.

istock: ©pablo_rodrigues1

Comfort taking is a common and understandable consequence of improving insulation and reducing draughts.

Energy savngs at home may mean environmental impacts elsewhere!

Taking a balanced approach

There are many challenges for responsible and successful retrofit.
Section 5 explains in more detail how to:

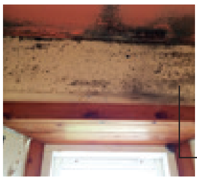
- Take a Whole Building Approach
- Make sure you engage in a Joined-up Process
- Aim for Balance overall, not for perfection in just one area.

Balance also means being cautious (not over-ambitious) and having enough capacity (in both building and financial terms) if things don't go quite as planned. It is important to note that in reality buildings and people can be quite robust. Compromises can work if we are clear which issues are really critical and if we keep an eye on things which are uncertain.

The three tables overleaf summarise the broad risks which can arise from poorly-planned or poorly-executed retrofit.

"It is important to note that in reality buildings and people can be quite robust. Compromises can work if we are clear which issues are really critical and if we keep an eye on things which are uncertain."

Brian Ridout
Historic England



Roger Curtis
Historic Scotland

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Risks to building fabric and human health

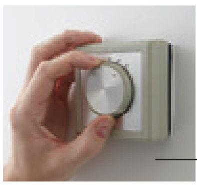
RISK	CAUSE
Fabric decay (including rot and infestation)	• Trapped moisture from moisture-closed materials • Liquid water from driving rain or leaks • Air leakage from inside house onto cold surfaces • Lack of ventilation • Lack of building maintenance
Surface condensation and mould growth	• Thermal bridging (due to lack of coherent insulation) • Reduction in ventilation or failed ventilation systems • High humidity levels (from use)
Poor indoor air quality	• Reduction in ventilation (because of improved draught proofing) • Inadequate, improperly used, or non-existent ventilation systems • High humidity levels (from use and overcrowding) • Toxins (VOCs, Radon etc) in under-ventilated spaces
Overheating or uneven temperatures	• Reduction in thermal mass (where masonry or solid floors are insulated from the inside) • Increased thermal resistance (from insulation generally) • Reduction in ventilation, lack of purge ventilation options such as window opening for night cooling • High amounts of south facing glazing • Heat island effect in cities affecting internal spaces

Jenny Knowles

Risks to heritage/community

RISK	CAUSE
Significant change in external appearance/ loss of historic fabric	• External wall insulation covering up significant masonry, historic render or architectural details including decorative brickwork, etc • Inappropriate window or glazing replacement • Incongruity of alterations with overall streetscape • Insensitive renewable technologies on historic roofs or in sensitive streetscapes
Change in internal appearance and/ or loss of historic fabric	• Loss of original features such as timber mouldings and plasterwork • Loss of original window frames and glazing • Insulation over historic floors • Ventilation and plumbing/electric intrusions

istock: ©PaulGrecaud



istock: ©pablo_rodrigues1

istock: © JHLloyd

Risks to achieving expected energy savings/environmental impact

RISK	CAUSE
Energy improvement not as large as expected	• Inaccurate assessment and modelling • Poor product quality • Poor design/installation/use • Failure to take Whole Building Approach
Environmental impact increased	• High embodied energy of retrofit measures • Failure to achieve energy reductions • Use of rare resources or materials from vulnerable habitats
Direct rebound effect	• Comfort taking (by increasing internal temperatures) • Under-heating of building prior to retrofit • Inadequate heating controls post retrofit • Lack of user understanding of building/controls
Indirect rebound effect	• Narrow focus of savings assessments • Lack of understanding of environmental impact

The challenges of keeping a good balance when retrofitting

KEY TO IMPACTS

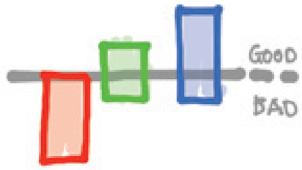
- ENERGY/ENVIRONMENT
- HEALTH (BUILDING AND HUMAN)
- HERITAGE/COMMUNITY

GOOD BALANCE

- Fabric/Services/People

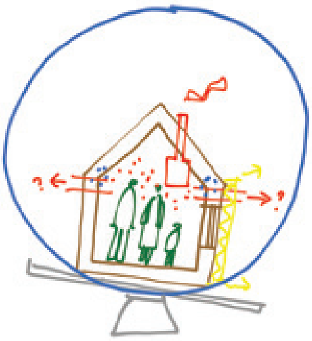
BUT

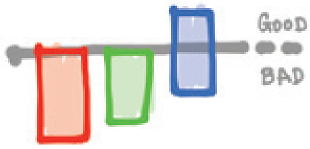
- A bit draughty and high energy use
- Possible maintenance problems.



SINGLE MEASURE UNBALANCE

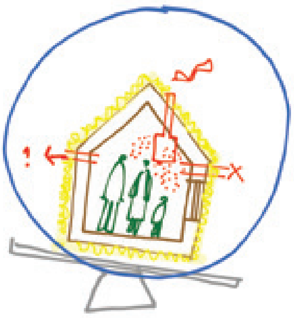
- Fabric not coherent
- Services (ventilation) stressed
- Moisture/mould/health issues
- Still lots of energy use
- Building health problems
- Heritage affected

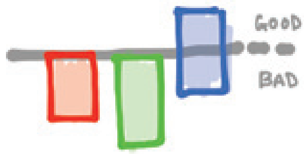




FABRIC FULLY INSULATED, BUT UNBALANCED SERVICES

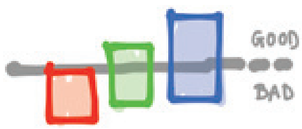
- Sufficient ventilation?
- Services stressed
- Moisture/mould/health issues
- Less energy use, but more ill health
- Heritage affected





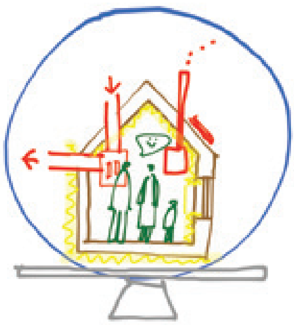
FABRIC INSULATED AND VENTILATION INSTALLED, BUT PEOPLE CONFUSED

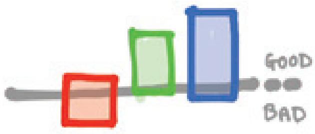
- More energy use than needed
- Confusion and some ill health
- Heritage affected

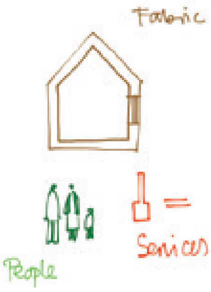


MORE BALANCED: FABRIC INSULATED SENSITIVELY, SERVICES INSTALLED. PEOPLE UNDERSTAND AND HAPPY TO USE

- Energy savings plus some renewables, warmer and healthier
- Heritage less affected or improved







The Whole Building Approach – Risks from specific retrofit measures

The key risks arising from specific retrofit measures are summarised below in regard to the three aspects of a Whole Building Approach – Fabric, Services and Human Behaviour. The fourth essential consideration is the building's Context, which significantly affects the level of risk.

Risks to building fabric

MEASURE	MAIN RISKS	ACTION	LEVEL OF RISK & CARE REQUIRE
External wall insulation	• Heritage impact (both to building and streetscape) • Moisture risks leading to rot of fabric. • Poor Indoor Air Quality (IAQ) from poor ventilation and damp • Heat loss from wet walls or thermal bridging	• Assess building properly for condition, context and interactions. If uncertain, take expert advice for heritage, moisture and thermal strategy • Take whole building approach especially junctions and ventilation • Use trained/qualified contractors.	High
Internal wall insulation	• Heritage impact (internal) • Moisture risks leading to rot of fabric. • Poor IAQ from poor ventilation and damp • Heat loss from wet walls or thermal bridging	• Assess building properly for condition, context, use and interactions. If uncertain, take expert advice for heritage, moisture and thermal strategy • Take whole building approach especially junctions and ventilation. • Use trained/qualified contractors.	Very high
Roof loft insulation	• Moisture risk	• Ensure ventilation at eaves and check roof space occasionally	Low
Roof rafter insulation	• Heritage impact (internal or external) • Moisture risk	• Ensure historic ceilings or roofs are not damaged. Ensure over rafter insulation takes account of heritage values of roof and streetscape. • Moisture safe design and detailing	Medium
Suspended floor insulation	• Heritage impact (internal) • Moisture risk	• Check historic value of floor • Moisture safe design and detailing. Ventilate below floor. Check effect on building ventilation.	High
Solid floor insulation	• Heritage impact (internal) • Moisture risk	• Check historic value of floor • Moisture safe design and detailing. Particular issues at floor wall junction.	High
Window	• Heritage impact (internal and external appearance) • Moisture risk (change in ventilation, thermal bridging)	• If uncertain, take expert advice for heritage, moisture and thermal strategy for windows • Whole Building Approach is essential.	High
Airtightness	• Heat loss reduction • Moisture risk (both to fabric and human health)	• Understand existing and post retrofit ventilation effects and put in additional ventilation if required.	High
Ventilation	• Heritage impact (from ventilation grills, ducting) • Heat loss from incorrect type or use	• Understand existing ventilation New systems must be designed and installed sensitively • Systems must be easy to operate and effective. Users must be informed properly.	High

Risks from services

MEASURE	MAIN RISKS	ACTION	LEVEL OF RISK & CARE REQUIRED
Mechanical systems	• Heritage impact (from inappropriate installations/pipework/flues, etc) • Heat loss from incorrect type or use	• 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 be informed properly	Low
Renewables	• Heritage impact (for roof applications) • Energy loss from incorrect type or use • Rebound effects	• Consult experts, community and planning for heritage risks. • Ensure correct specification and installation • Inform users	Low
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	Medium

Risks from human behaviour

MEASURE	MAIN RISKS	ACTION	LEVEL OF RISK & CARE REQUIRED
Use, repair and maintenance	• Heritage impact • Moisture risk (fabric and human health) • Energy loss (from services not working properly and from dampness in fabric)	• Ensure user/owner understanding of retrofit systems and building maintenance • Schedules of repairs important • Build into financial planning.	Medium
Capacity and caution	• Heritage impact • Health impact • Energy impact	• Ensure there is sufficient understanding, skills, time and budget for the project • Do not undertake over-ambitious or complicated measures • Look and learn at all times	Medium

Image: Robyn Pender, Historic England

FAR LEFT: a not entirely sensitive services installation!

LEFT: maintenance might seem a chore, but it is the most important way to keep traditional buildings healthy and efficient.

5 How to achieve responsible retrofit

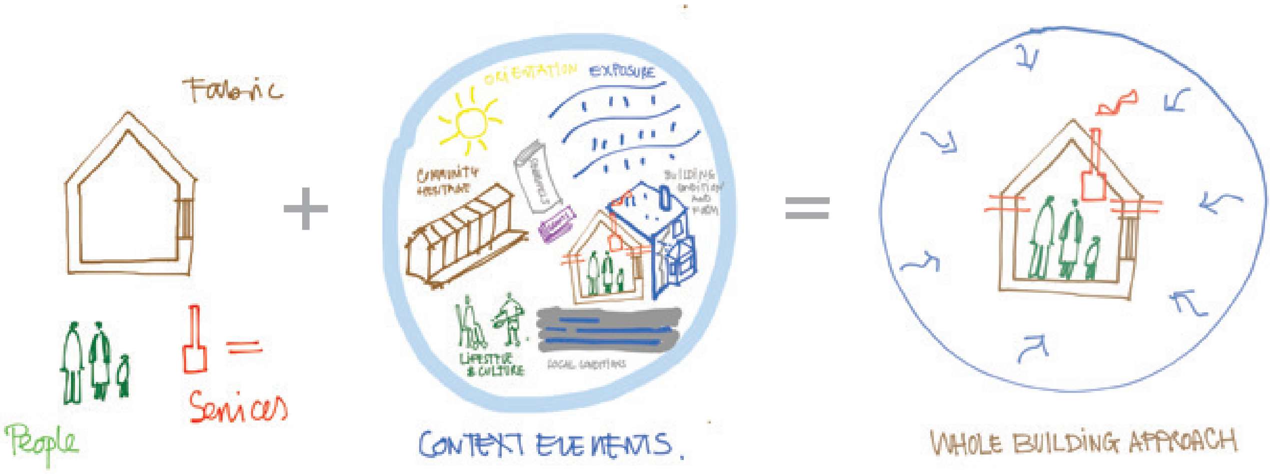
The Responsible Retrofit approach is based upon a Whole Building Approach in a Joined-Up Process. In this way the main benefits to Energy and the Environment, Heritage and Community, and Building Health (of people and fabric) can be achieved.

The Whole Building Approach means integration and balance of

- Fabric Measures such as insulation, draught proofing, glazing, rainwater protection (ie improvement to pointing and gutters)
- Services such as ventilation, heating, thermostatic controls, renewable energy and
- People in regard to how occupants understand, use and maintain their buildings

These all interact with each other. It is important to understand that if you insulate a wall, then this will to some extent also affect the windows, the floor and roof as well as the internal air quality. 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, which means its location, exposure to sun, rain and wind, the historic and community value, its condition, use and form, and the regulations and funding. All of these determine the way in which a Whole Building Approach should be carried out, and the options and constraints for retrofit.



The Joined-up Process is explained on the next page. Before this however there are some basic questions which you should ask yourself when contemplating a retrofit project:

Questions to ask yourself

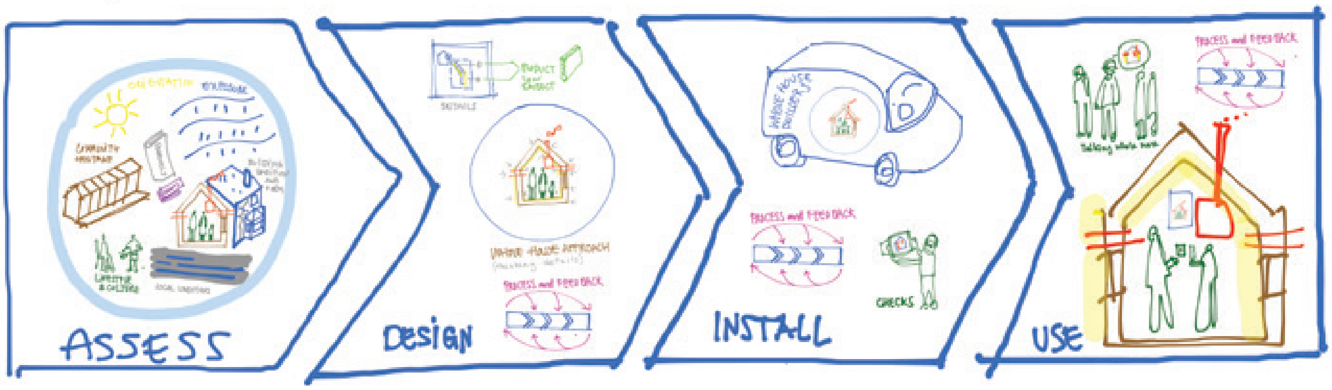
1 Do you have sufficient understanding? If not, can you find an expert surveyor, designer or installer who does? You can learn more by reading the resources or going on appropriate training courses (see page 22).

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. Whatever you do, make sure you keep to a Whole Building Approach and Joined-up Process.

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 the work programmes on the house to ensure Whole Building 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 to make lifestyle changes and simply to maintain the existing building well.

Joining up the process – a checklist for success



1 Assess the building and context

a What is the building made of, how does it work (or not work), and what is its condition? Is a special survey required?

b What is the use of the building (now and in future), what is the energy use, what are the moisture levels and Indoor Air Quality? Consider monitoring, look at past bills, check with Health England website for Radon risk.

c What is the heritage value, overall and in specific parts of the building? What is the relation to streetscape, landscape and community?

2 Design and specification

a Having better understood the building and its context, devise a strategy which integrates all issues and has sufficient capacity and caution where there is uncertainty or conflict.

b Ensure that design follows a Whole Building Approach.

c Specify low environmental impact products and process wherever possible.

d Make an exact specification of product wherever possible to ensure that lower quality products are not substituted.

e Include feedback and QA process in the specification and tender documents.

3 Installation

a Ensure that contractors have sufficient training, understanding and interest in the responsible retrofit approach.

b Ensure that contractors price the Whole House Approach and have feedback and checks agreed with designers and client.

c Ensure that a clerk of works or suitably trained person is on site with responsibility for the Whole Building Approach

d Ensure regular checks of detailed design.

e If necessary use air pressure testing and thermographic survey for QA check.

4 Use and maintenance

a Leave the occupant with a comprehensive user manual, written in Plain English with clear diagrams.

b Run through services and fabric measures to show the occupant the benefits of correct use and maintenance.

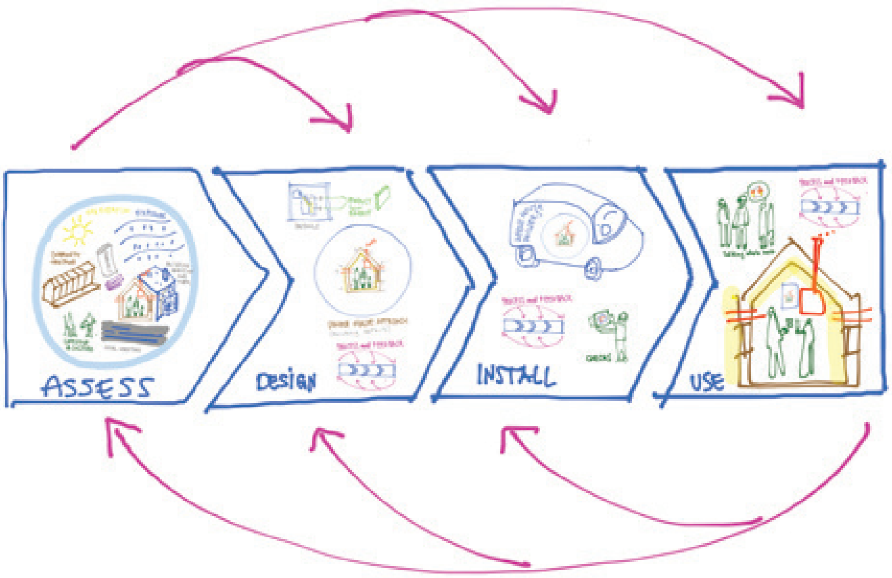
c Prepare a clear maintenance manual (this can be one sheet) with dates for work, estimated costs and contact details for the relevant tradespeople.

Feedback and learning at every stage

Wherever there is an uncertainty, particularly around fabric and health risks, it is essential to put in some kind of monitoring and feedback mechanism. See section 6.

There are lots of things to think about in retrofit of traditional buildings, but remember that these are significant and costly changes which may only occur every few decades, or even centuries, so it is worth getting it right! It's important that everyone involved keeps communicating and all learn from the process. This is the best way to reduce risks and improve performance.

BELOW: Feedback and learning are essential.



6 Look and learn

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.

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 mould forming on rafters would be 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 be easily lifted) to check for mould and damp. You can often smell and feel damp problems even if you haven't got a damp probe meter! If in doubt consult an expert who understands old buildings.

Jack Kelly

Checking under the floorboards by the wall is often a good way of monitoring the risks of insulation.

Maintenance

Appropriate maintenance 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.

Chimneys and gable ends are especially vulnerable to water penetration, so render, pointing, flashings, overhangs, and caps should all be maintained regularly. 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.

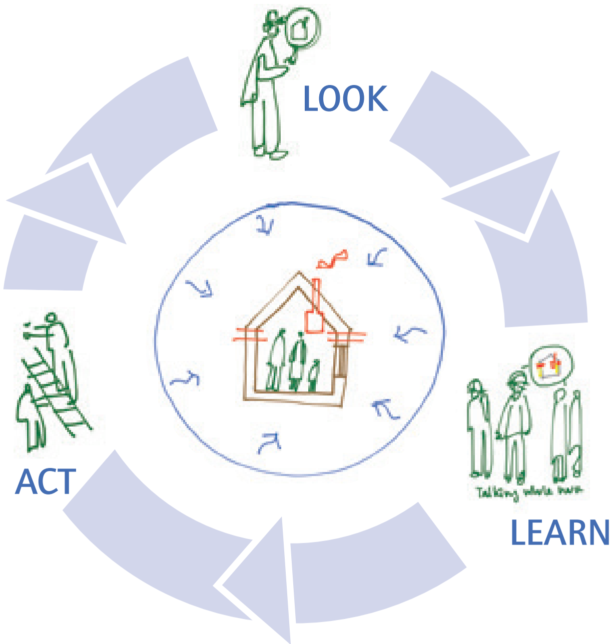
Nicholas Heath

Gutter maintenance and repair can be tricky sometimes. So make sure you have a maintenance plan.

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.

Learning about buildings in the widest and deepest sense protects buildings from risks, improves energy use and can bring real benefits for both occupier and contractor.



Continual 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 'fit and forget' activity either 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. Retrofit needs to be seen as part of an individual and national journey, which we should undertake with our eyes wide open, with patience and with humility. If we retrofit responsibly then we can act with confidence and be part of this journey to a better built environment.

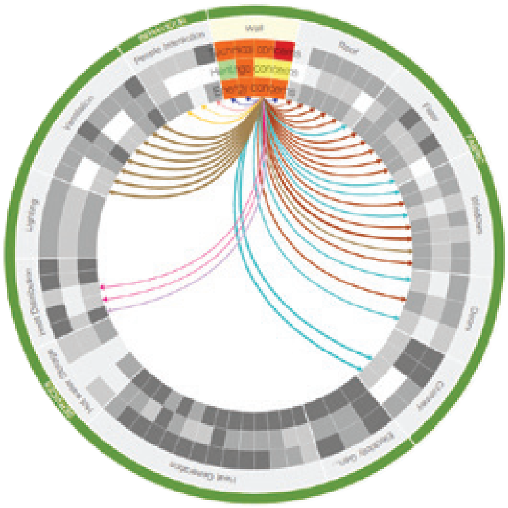
7 Resources

There is a range of help, guidance and training available to help owners and contractors achieve responsible retrofit. As made clear through this document, the understanding of traditional building retrofit is still in development and there are many uncertainties. All guidance is therefore prone to becoming out of date and misleading. All guidance, including that listed below, should be taken as guidance not gospel-truth, and should be used in conjunction with other guidance and with this document where possible. Guidance on individual measures or issues should not be taken in isolation. Strategies to retrofit buildings should consider how the whole building functions both before and after retrofit. Finally, new guidance, training and research is currently being developed, so it is recommended that those involved in retrofit subscribe to updates and new resources from named organisations regularly.

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/

Moisture Risk Assessment and Guidance

The purpose of this guidance is to provide the basis of an integrated and holistic approach to moisture risk throughout the design, construction, alteration, repair, maintenance and use of buildings. The scope of the guidance is work on all buildings, both new and existing, and all building elements. However, it is particularly relevant to retrofit. This technical guidance is developed from an understanding of the underlying building physics and provides three possible approaches, depending upon the context:

1 Prescriptive Guidance is provided where there is good evidence of success.
2 Modelling of building elements where relevant and possible. This is often not possible due to lack of good data or skills.
3 Principles based guidance: this is the main method of risk assessment and guidance wherever there is uncertainty or complexity. The five principles of Quality Process, Context, Coherence, Capacity and Caution are explained in detail.

General Guides

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

Historic Scotland: *Short Guide to Fabric Improvements for Energy Efficiency in Traditional Buildings* (2012)

Historic England: *Energy Efficiency and Historic Buildings – application of part L of the Building Regulations to historic and traditionally constructed buildings* (2012)

Historic England: *Energy Efficiency in Historic Buildings* (2012) – 12 guides covering the upgrade of different building elements.

Historic England: *Practical Building Conservation: Building Environment* (2014)

Republic of Ireland – *Environment, Heritage and Local Government: Energy Efficiency in Traditional Buildings* (2010)

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

Changeworks: *Energy Heritage – A Guide to Improving Energy Efficiency in Traditional and Historic Homes* (2008)

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
Historic England and Cadw both have ongoing research programmes.

Training

A range of Heritage, Conservation and Retrofit training programmes for supervisors and operatives is available from the CITB and other providers, which includes **Energy Efficiency and Retrofit of Pre-1919 Traditional Buildings**.

National Occupational Standards (NOS) for the retrofit are currently in place and have recently been updated. These standards have been used by Awarding Bodies such as Asset Skills, the SQA and Proqual to establish level 2 and 3 knowledge-based qualifications for the energy efficiency and retrofit market.

In Wales Agored Cymru offer a course entitled **Sustainability and Energy Efficiency in Pre- and Post-1919 Buildings**.

CITB are also developing a clear qualifications pathway in **Heritage Skills** (including retrofit issues) for people operating in both craft and supervisory areas.

The Centre of Refurbishment Excellence (CoRE) runs in-depth courses for retrofit co-ordinators.

General training on the repair and conservation of traditional buildings is available through SPAB and the National Heritage Training Group.

Contractor selection

Risks in retrofit can be significantly reduced by employing appropriately qualified builders and craftspeople. Builders who have completed Heritage Skills training programmes and who hold a CSCS Heritage Skills card will know how traditional buildings function and be aware of the common pitfalls in retrofit. Requiring the CSCS Heritage Skills card also embeds quality assurance into the retrofit process.

For more information:
www.stbauk.org

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Construction Industry Training Board

Historic England

Historic Scotland
Alba Aosmhor

Cadw

Llywodraeth Cymru
Welsh Government

Responsible Retrofit Series

STBA
SUSTAINABLE TRADITIONAL BUILDINGS ALLIANCE