EPOA
Essex Planning
Officers Association

Climate Change and the Historic Environment
V.1

Contents

Design Detail Section

1. Historic Buildings and Sustainability

Historic buildings have potential to contribute to tackling the challenges of climate change and are a resource for sustainability. This is largely due to the embodied carbon these buildings hold. Whilst a number of historic buildings have scope to reduce their operational carbon emissions which has the additional benefit of helping to tackle fuel poverty, it is important to distinguish between their embodied carbon and a building's associated operational carbon emissions.

Embodied carbon

Embodied carbon is the total greenhouse gases generated during the life cycle of a building. This can include the extraction, production and transportation of raw materials, construction, maintenance, replacement, demolition, and disposal (considerations of how much material is recycled, re-used or appropriately managed). The amount of embodied carbon will vary between buildings; for many historic buildings dating before the industrial revolution, there are lower levels of embodied carbon as there would have been fewer emissions during the production process of raw materials and their transportation.

Given the embodied carbon associated with building new development, it is becoming increasingly important to reuse existing historic buildings and future proof them for sustainable living. Whilst the archaeological, historical, architectural and artistic interests of a historic building from which its significance is drawn is important, the need to sustain a heritage asset in its optimum viable use is also a key consideration.

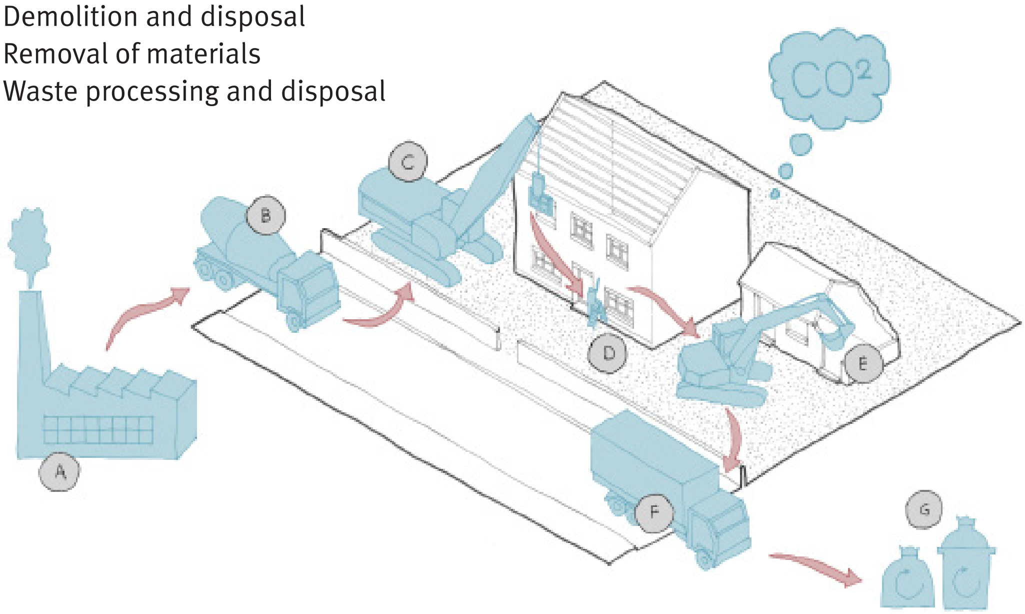
Further Reading on Embodied Carbon

Historic England, There's No Place Like Old Homes: Re-use and Recycle to Reduce Carbon, February 2020.

Carrig Conservation Research, Understanding Carbon in the Historic Environment, October 2019

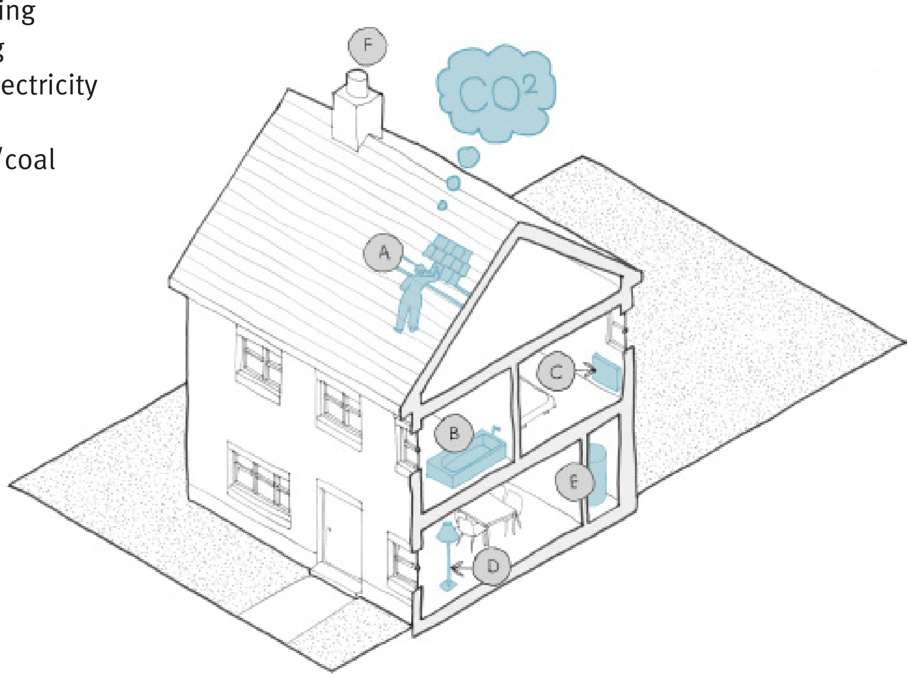
Case Study Arboreal Architecture, Bournville Low Carbon Retrofit – Full Carbon History

A. Manufacturing
B. Transportation
C. Installation of materials
D. Structure maintenance
E. Demolition and disposal
F. Removal of materials
G. Waste processing and disposal



Operational Carbon Emissions
The operational carbon emissions of an historic building are the greenhouse gases emitted as a result of a building's use. This can include heating, cooling, lighting, ventilation, maintenance, and the use of appliances. There are over six million traditional buildings, which currently accounts for almost one quarter of the housing stock in the UK.

A. Structure maintenance
B. Hot water heating
C. Spatial heating
D. Lighting and electricity
E. Cooling
F. Oil, fire (wood/coal smoke)



2. Understanding the building and how it performs

There are four key factors to consider when understanding how a building performs and consumes energy:

1. Every building has a unique historical development, physical alterations and extensions or differing programmes of maintenance. The different traditional and modern construction methods and fabrics result in fundamental differences between the performance of buildings. Traditional buildings are identified by their date, construction, and materials. Typical traditional materials used in historic buildings include lime, timber, brick and stone. They have hydroscopic properties and so are porous and permeable. Due to these properties, the materials are vapour permeable and rely on moisture being able to move through them. This is important to understand when planning changes to a building as inappropriate schemes can have a detrimental effect on a building's fabric and significance.
2. Location and orientation of a building is important when considering energy efficiency measures due to weather, which can have a significant impact on the performance of different building materials. Considering the orientation of a building, and any exposed elevations, will be important to understanding how it is required to perform or is being affected. The impact of climate change will likely mean that buildings in Essex are more susceptible to overheating.
3. Building services, including the type, their efficiency and use, have an impact on the energy consumption. Building services include, heating and cooling strategies, ventilation, hot water and water systems, lighting and other electrical equipment. Understanding the performance of existing building services can help to inform the approach for enhancement. One can use Historic England's How to Improve Energy Efficiency checklist on 'Understanding what you've got' to inform the baseline conditions of the building's services.
4. It is important to remember the baseline that 'Buildings don't use energy, people do'. The way buildings are used changes the way buildings perform or are required to perform. Understanding how a building is being used, and will be used in the future, can further inform what energy efficiency measures may be most appropriate.

3. Objectives of the Project

The objectives for undertaking building work may impact the proposed energy efficiency measures. Objectives and ambitions may include:

1. Complying with Building Regulations
2. Increase the EPC rating
3. Reduction in energy bills
4. Improvement of occupant's comfort levels
5. Sustainability and reducing the carbon footprint

For example, reduction in energy bills and carbon footprint may be achieved by minimal intervention, whereas needing to comply with building regulations and achieving U-values may require increased amounts of insultation with limited choices (subject to location and build up required). There are exemptions and particular considerations for historic and traditional buildings within both Building Regulations and Energy Efficiency Regulations. Refer to Historic England's guidance:

- Building Regulations and Energy Efficiency | Historic England
- Energy Performance Regulations | Historic England

Standards, Approaches and Guidance

To achieve the objectives of energy efficiency the following existing guidance and standards can be used:

3.1 PAS 2035 Retrofitting dwellings for improved energy efficiency

PAS 2035 is a British standard and provides a framework for preparing plans for domestic retrofit projects. Any retrofit designs that emerge from its specifications must be installed in accordance with the requirements outlined in PAS 2030.

PAS 2035 was commissioned following the recommendations in Each Home Counts and takes a whole house approach. It can be adopted by all professionals and contractors involved with recommending, managing and implementing energy efficiency measures. As well as the requirement for retrofit professionals and contractors, such as Retrofit Assessors.

Importantly the standard can be used with retrofitting traditional building, takes into consideration of the condition of the existing building and provides an overview of the interlinking measures and if they are compatible.

The BSI and Retrofit Academy provides further information on PAS2035.

Whole House Approach

The Whole House Approach has been developed by the Sustainable Traditional Buildings Alliance and is advocated by Historic England, Historic Environment Scotland, Cadw, RICS and RIBA. The approach has been endorsed by the UK Government through the Each Home Counts report from 2016.

For the Whole House Approach, any decision regarding energy efficiency measures should be a balanced judgement, taking account of the energy savings and environmental improvement; the heritage protection and building fabric; and enhancement and the health of the building and occupants.

Whole House Approach does not have requirements on space heating, heat loss or airtightness, working instead to balance the different aspects based, on the objectives of the project on the individual and their comfort levels.

3.2 Low Energy Building Standards

There are a number of low energy building standards that were first developed for new buildings and have high demand on achieving targets relating to space heating. Passivhaus is a renowned design that was founded in Germany. It is a low energy building that uses airtightness, thermal bridging and mechanical ventilation with heat recovery, with renewables resulting in requiring no or very little carbon emissions to function. It is designed using the Passive House Planning Package software. EnerPHit was developed by PassivHaus and uses the same principles. It was launched in the UK in 2010 for retrofit, recognising that the requirements of PassivHaus cannot be achieved in all buildings, for example installing triple glazing. The Association for Environment Conscious Building (AECB) produced a Retrofit Standard (previously known as the Silver Standard).

EnerPHit, AECB and Passivhaus is an energy specification, promoted as a standard and a scientific design tool. The starting position is to understand the existing condition of the building before works begin (similar to the Whole House Approach). However, there is little regard to the material being inserted, for example the type of insultation and the compatibility. There is high demand to make the building airtight with limited thermal bridging.

Whilst there have been a number of EnerPHit and AECB Retrofit Standards as case studies that have been achieved, this is a high-risk approach. When the work is being carried out, it needs to be undertaken by experienced and appropriate contractors as any details that are not properly managed can result in a detrimental impact to the occupant’s health and the building. For example, timber beams within walls not appropriately managed will have an increased risk of deterioration from moisture build up. This high-risk approach is informed by energy modelling software and pushes traditional buildings to standards they were not constructed for.

3.3 Historic England Energy Efficiency Series

Historic England have been a leading public body conducting research regarding performance of existing buildings, energy efficiency, retrofit and sustainability. As a result they have produced a wealth of research papers, advice and guidance. They have produced a suite of free technical advice and guidance documents on retrofitting historic buildings to improve their energy efficiency. This includes general improvement to more detailed advice on installing insulation.

Their principles follow the Whole House Approach. They advocate certain retrofit strategies, specifically those for modern construction, are not appropriate for traditional buildings.

3.4 Sustainable Traditional Buildings Alliance Guidance

The Sustainable Traditional Buildings Alliance have produced the Knowledge Centre as a resource for retrofitting Traditional buildings. The information provided is for assisting decision making and to increase knowledge about responsible retrofit.

Using the principles of the Whole House Approach, STBA have produced the Responsible Retrofit Guidance Wheel. This is an invaluable source that outlines the advantage of each measure, as well as demonstrates how each energy efficiency measures interlinks and the technical, heritage and energy concerns that can arise. The concerns are measured from minor to high. For example, proposing loft insulation has eight technical concerns, one heritage concern and two energy concerns. It also has the potential for 34 related measures.

3.5 London Energy Transformation Initiative (LETI) Guide

LETI is a network of built environment professionals and have produced a detailed Climate Emergency Retrofit Guide to be used by architects, engineers, Local Authorities, social landlords, energy professionals, contractors and homeowners. The guide uses six key principles for best retrofit practice. Whilst it does use the starting points of Whole House Approach, working to balance energy consumption, building health and heritage and occupant health, the LETI guide has a fabric first approach and sets out energy targets for the retrofit.

The free guidance document provides best practice approaches and design details for all elements, along with case studies for how to achieve retrofit.

4. Types of designation e.g. listed building, or location within a conservation area.

- As a general principle, all buildings that pre-date 1700 and are in a relatively intact condition will be listed, as will all buildings that date between 1750 and 1850. The selectivity is increased for buildings that date 1850 and 1945. There is a strict criterion for buildings built after 1945; buildings less than thirty years old are unlikely to be listed unless they have been deemed as exceptional examples of their type.
- Listed buildings are protected by government legislation and there are policies in place to ensure that any alterations, including energy efficiency measures, to a listed building will not affect its special interest. It is possible to alter a listed building, but this requires listed building consent and sometimes planning permission. The Historic England Advice Note 16: Listed Building Consent provides more information relating to works which require listed building consent.
- Conservation areas are designated by the Local Planning Authority as areas of special architectural or historic interest. Conservation area designation introduces additional planning controls and considerations, which exist to protect an area's special character and appearance and the features that make it unique and distinctive. Although designation introduces controls over the way that owners can develop their properties, it is generally considered that these controls are beneficial as they preserve and/or enhance the heritage significance of properties.
- External alterations or extensions to buildings in conservation areas will generally need planning permission. With regards to energy efficiency measures, generally external works to buildings in a Conservation Area will require planning permission. The approach to conservation areas may also be bespoke to each individual example. Firstly because each conservation area is uniquely distinctive and also because the Article 4 Directions (which remove permitted development rights) may vary between each designation. The Local Authority should be consulted for advice to understand the bespoke requirements for each area.
- To find out if a building is located in a conservation area, visit the planning section on the Local Planning Authority's website.
- Locally listed buildings and non-designated heritage assets are considered buildings of local special interest. To find out if your building is locally listed, visit the planning section on your Local Planning Authority's website.

5. Energy efficiency and retrofitting traditional buildings

Whilst there are considerable benefits in relation to reduced carbon emissions, retrofitting traditional buildings must be undertaken with caution. There are a number of risks to the occupants and the building. Extensive retrofits can result in intrusive works to the building and if the wrong materials are used or the work not carried out correctly, this can result in an adverse impact and detrimental result. This could prove costly to resolve and/or result in the loss of embodied carbon and the historic building.

Short Term Positive Considerations

There are several ways that energy use can be reduced which will require minimal intervention. Whilst they vary in cost, a number of these solutions can be cost effective. This includes:

1. Maintenance and Repair
2. Draughtproofing
3. Upgrade building services and controls
4. Occupant Behaviour

It is recommended that this is the starting point for any retrofit project, even if a much more extensive retrofit is being considered.

6. Maintenance & Repair

A building in good repair performs more efficiently. Maintenance is generally considered to be a preventative measure, whereas repair works are a reactive measure. Ongoing maintenance can limit, or even prevent, the need for repairs and therefore is cost-effective, whilst reducing the loss of embodied carbon (see BS 7913:2013).

BS 7913:2013 states; '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. They should provide occupancy in an efficient manner, involving minimal production of carbon and use of energy without harming significance or the physical performance of the historic fabric.'

Traditional buildings require regular maintenance with appropriate materials. If routine maintenance works are to be carried out using authentic materials and traditional craft techniques, on a like-for-like basis, check with the local planning authority to understand whether permission or consent is needed. The use of a contractor with the necessary skills and experience of working on historic buildings is essential. The use of inappropriate materials can lead to the deterioration of the built fabric and overall performance of the building.

For maintenance guides, refer to Historic England's guide for homeowners, including the Maintenance Checklist and the SPAB's Preventative Maintenance Guide and Maintenance Calendar

6.1 Repair Works

NOTE - Repair works should be carried out before undertaking any energy efficiency measures, as unresolved repairs could result in significant risks to performance.

Undertaking required repair works can make a building more energy efficient. Understanding and resolving the primary cause of damage, particularly where this relates to localised areas of a building, is important before carrying out repair works in order to ensure that repairs will not need to be repeated. In this case it is essential that an appropriate specialist is consulted.

Dealing with damp

Damp within buildings can have major impacts to the energy efficiency of the building through excessive heat loss (between 30 to 40%) as well as significant impacts to occupant health.

Sources of moisture ingress and the cause of damp varies and must be understood before carrying out any remedial work. It can include:

1. Poorly maintained and faulty rainwater goods
2. Plumbing defects and building faults resulting in leaks
3. Higher external ground floor levels
4. Impermeable ground surfaces, such as concrete
5. Excessive internal moisture loads

Typical examples of causes within walls include the application of cement render, this results in the walls not being able 'breathe' and leads to a build-up in moisture. This can lead to damp issues and the impact to other built elements, such as the rotting of timber joists and floorboards. Damp can also be influenced by occupant behaviour and activities.

To understand the moisture levels in a building and how this is effected, refer to the Moisture Balance Calculator. Developed by the UK Centre for Moisture in Buildings, the interactive calculator provides results and recommendations based on the submitted information, including moisture generation, occupancy, building condition, heating and ventilation.

Rising damp is very rare and any diagnosis should be double-checked before undertaking damp-proofing work, such as a chemical injection damp-proof course, as damp-proof courses can also have a detrimental effect on the building and should generally be avoided, regardless of the type of damp.

If a building has damp issues, this must be resolved before considering any retrofit measure, particularly insulation. This is because there will be an underlying cause; without addressing this, it might be exacerbated if the building is retrofitted. Also, as damp has an impact on the building's hydrothermal performance, reassessing the building's performance once the issues are rectified may change the approach for retrofit, or retrofit may no longer be necessary.

In 2022 RICS, Historic England and the Property Care Association produced a joint statement pertaining to the Investigation of moisture and its effect on traditional buildings.

Further information on damp:

General Damp Advice

The SPAB's Technical Advice Note on Control of Dampness

CAT's information on How to Improve Traditional Buildings

Historic Environment Scotland's Damp: Causes and Solutions

Damp in Basements and Cellars

Damp below Ground by Geoff Maybank

Rising Damp

The SPAB's advice on Rising Damp

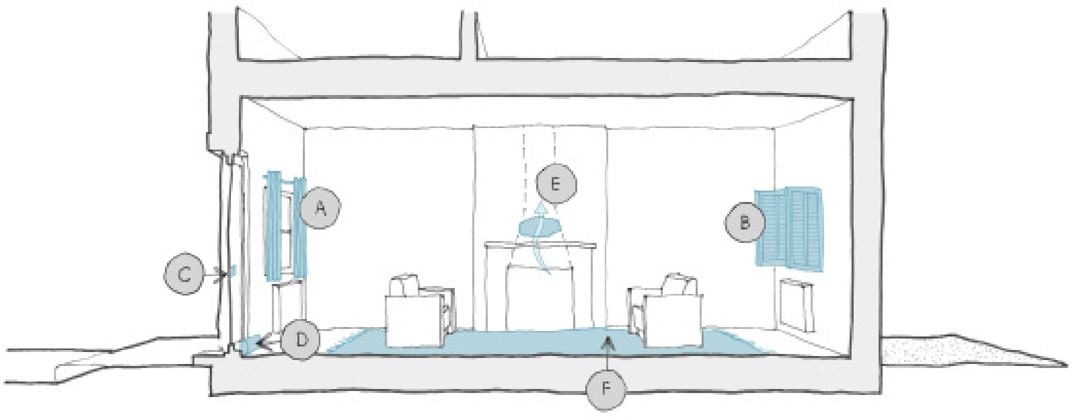
7. Draught Proofing

Uncontrolled ventilation, also referred to as air leakage, is a major source of heat loss. Draught-proofing is recognised as being one of the most cost-effective solutions that reduces energy use, improves occupant comfort and has little change to the building's appearance. It is effective in controlling the amount of unintended movement of air, as this impacts overall heat loss and air leakage. For example, Historic England's research has suggested draught-proofing windows can reduce air leakage from by between 33% and 50%. This substantially reduces the heating requirement needed for the effected space. If the building is an exposed timber-framed building, ensuring there are no gaps between the frame and the infill panels will also have a significant effect. Materials used to fill the gaps will need to be appropriate for the building. Details and diagrams pertaining to draft proofing are available in Historic England's Guidance Traditional Windows: Their Care, Repair an Upgrading.

Controlling ventilation in a building can reduce heat loss, as well as provide solutions for cross ventilation in the summer months, when there can be concerns of over-heating. For example, temporarily blocking unused chimney flues with a flue balloon in colder months and removing it in warmer months to encourage the flow of air when needed.

Controlling air leakage is different from ventilation. Ventilation is still required and is important for moisture control and occupant health. Any intended ventilation, such as extractor fans and air bricks, should not be sealed up.

A. Heavy curtains over doors and windows
B. Shutters over windows (if appropriate to the building)
C. Draftproofing letterbox
D. Draft exclusion
E. Flue draft excluder
F. Rugs



8. Building services and controls

Improving the efficiency of building services e.g. changing lighting to LED, upgrading boilers, refurbishing or replacing radiators, can be a highly effective method of improving the energy performance of buildings whilst having minimal or no impact on the building's fabric or significance. It has been estimated that replacing an outdated or ineffective boiler can make a 30 to 40% improvement in energy usage. Heating controls and smart meters can be valuable in understanding and controlling a building's energy usage. However, when upgrading appliances, there should be considerations of the life-time cost and if it is beneficial to upgrade before the existing appliances reaches the end of its life.

Further information on building services

Building Services

Historic England's How to Improve Energy Efficiency

Historic England's guidance for considerations when installing new services

Energy Saving Trust guide for Insulating tanks, pipes and radiators

Energy Saving Trust guide for buying energy efficient products, including lighting and home appliances

Heating Controls

Department for Business, Energy & Industrial Strategy Smart meters: a guide for households

Simple Energy Advice, Smart meters

Energy Saving Trust guide on heating controls and how to control heating systems

9. Occupant Behaviour

Occupant behaviour has a considerable bearing on the performance of a building, through energy usage and contributing and controlling the level of moisture.

Historic England and STBA have outlined that individual comfort is the most important test, rather than achieving specified space heating targets. Comfort levels have a particular influence on occupant behaviour. Understanding individual levels of discomfort is more treatable and will often require less intrusive works to the building.

10. Retrofitting

Any existing issue, relating to the efficiency and performance of a building should be addressed before further retrofitting options are considered. The performance of the building needs to be fully understood. When upgrading elements to achieve U-values, in-situ testing is recommended to understand the building performance before any works. Unfortunately, there are assumptions about the poor energy performance of older buildings, which are included within engery modelling systems and data. Historic England's research has suggested that performance of solid brick walls was a third better than the performance predicted by energy-performance models. This could impact the type of insulation being considered, as well as the amount and the overall cost of the works to achieve the U-value target.

Each element that could be retrofitted will be considered below. Whilst these elements are being considered in isolation, every change that is made will have an impact to a building's performance. As such, multiple energy efficiency measures will have interrelating considerations. This is considered as part of PAS2035. The STBA Guidance Wheel also provides further information on this and should be referred to before making any changes.

Each element has been identified as either a low, medium or high-risk intervention. Below identifies the considerations for the different levels of heritage risk.

Low risk:

Majority of or all historic fabric retained
No impact to the significance of the building
Is considered to be compatible with the existing building fabric and heritage asset's significance
Medium risk:

Subject to detail if it could result in unintended consequences, such as moisture build up ventilation
Limited to small impact to the significance of the building
Could be compatible with the existing building fabric
High risk:

Items that are subject to the design and detail
Little historic fabric retained/is at high risk of being lost in the future
High or detrimental impact to the significance of the building
Is considered not to be compatible with the existing building fabric

10.1 Energy efficiency and retrofitting traditional buildings: Key Documents and Links

Historic England Energy Efficiency Series

Historic Environment Scotland, Guide to Energy Retrofit

Historic Environment Scotland, How to improve energy efficiency

STBA Planning responsible retrofit of traditional buildings

STBA Knowledge Centre and Guidance Wheel

Grosvenor and Westminster City Council The Grosvenor Estate toolkit on sustainable refurbishment for leaseholders

LETI Climate Emergency Retrofit Guide, 2021

PAS 2035/2030:2019+A1:2022 Retrofitting dwellings for improved energy efficiency. Specification and guidance

Recommended Books

Historic England, Practical Building Conservation: Building Environment, Oxford: Routledge, 2014

The SPAB, Old House Eco Handbook: A Practical Guide to Retrofitting for Energy Efficiency and Sustainability, London: White Lion Publishing, 2019

Sofie Pelsmakers, The Environmental Design Pocketbook, 2nd ed., London: RIBA Publishing, 2015.

Christopher Day, The Eco-Home Design Guide: Principles and Practice for New-Build and Retrofit, Cambridge: Green Books, 2016

Prince's Regeneration Trust, The Green Guide for Historic Buildings: How to Improve the Environmental Performance of Listed and Historic Buildings, Norwich: TSO, 2010

11. Windows and Doors

It is estimated that heat loss through windows and doors can account for up to 25% overall loss from a building, so that addressing this can result in significant improvements to a building's energy efficiency.

11.1 Repairs, draught-proofing and other low risk options

The repair and refurbishment of windows can improve the thermal performance of historic windows. Where draughts are causing an issue, draught-proofing the windows and doors can have considerable improvements.

The use of shutters and heavy curtains for windows can make a significant improvement in reducing heat loss in windows. Historic England, Historic Environment Scotland and the SPAB have researched the improvements to heat loss achieved by these light-touch options. Historic England's research found that heavy curtains reduced heat loss in sash windows by 39% and well-fitting shutters reduced heat loss by 64%. Other benefits to shutters are achieved during warmer months as they can help with ventilation and avoiding over-heating.

Repairing, refurbishing and draught-proofing historic windows and doors can preserve the special interest of a building. From a sustainability perspective, it also retains embodied carbon.

11.2 Secondary Glazing

Secondary glazing is often a good energy efficiency measure that can improve building performance, whilst having little impact to a building's fabric. Research has found that in some instances secondary glazing performed better than double-glazing. Details pertaining to secondary glazing are available in Historic England's Guidance Traditional Windows: Their Care, Repair and Upgrading. Detailed design will need to consider appropriate materials, position and fixings into the window reveals, and how the design will respond to the existing window. Dependant on the form pf the windows, and its surround, secondary glazing may not always be possible.

11.3 Double-glazing

The approach to window replacement and repair will be bespoke to each building and as such it is difficult to prescribe set approaches. In all cases it is important that a baseline understanding of the significance of existing windows in undertaken to inform approach. Generally double-glazing should only be considered where the existing windows (if of heritage significance) are beyond repair. There is however a wider consideration, for example a double-glazed window replacement should not be applied to an elevation where all other fenestration is of significance and single glazed. In this circumstance there would likely be an intrusive aesthetic effect to architectural interest.

Should windows be not of significance then there may be opportunity for an appropriate double-glazed replacement. However, the replacement of windows that are not beyond repair, results in the loss of embodied carbon. It should also be noted that double-glazed units have a limited lifespan, generally warranties vary from 10-20 years. For example, the units will require replacing again when the seal fails as this will impact the vacuum between the glazing panels. Installing secondary glazing, if well maintained, may have a longer lifespan, particularly as there is no reliance on the vacuum between panels.

Where the installation of double-glazing is acceptable, any replacement windows should not be uPVC windows. They tend not compatible with the building fabric and can result in an increase of moisture issues and build up. Historic England's Guidance Traditional Windows: Their Care, Repair an Upgrading succinctly outlines the issue with uPVC windows in the historic environment.

Further information on windows and doors

Historic England's Traditional Windows: their care, repair and upgrading

SPAB Briefing Windows and Doors

CAT, Windows

Draught-proofing

Historic England's Draught-proofing windows and doors

STBA, Window draughtproofing

STBA, Door draughtproofing

Refurbishment

STBA, Window refurbishment

STBA, Door refurbishment

STBA, Window Shutters Refurbishment

Secondary glazing

Historic England's Secondary glazing for windows

STBA, Secondary glazing

Replacements

STBA, Energy efficient glazing

STBA, High performance doors

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Energy Efficiency Measure	**Planning Considerations**	**Risk**	**Further Considerations**
Draught proofing, heavy curtains and blinds	Does not generally require any consent or permission. The LPA should be consulted for methods of draft proofing window in listed buildings.	LOW RISK	
Shutters	• Listed building: Requires LBC • Conservation Area or Non-designation Heritage Asset: Internal shutters - Does not require planning permission. External shutters - Likely to require planning permission • Buildings with no designations: Does not require planning permission	MEDIUM RISK	Where appropriate and achievable, there is potential for significant gains.
Secondary Glazing	• Listed building: Requires LBC • Conservation Area or Non-designation Heritage Asset: Does not require planning permission • Buildings with no designations: Does not require planning permission	LOW RISK	Consider double glazed for secondary glazing to increase efficiency. This can be as efficient as triple glazing but needs to be sensitively designed.
Double Glazing	• Listed building: Requires LBC • Conservation Area or Non-designation Heritage Asset: May require planning permission • Buildings with no designations: Often permitted development if of a similar appearance to those existing. Check with the Local Planning Authority.		In many cases timber framed windows would be required to be compatible with the existing building fabric.

12. Walls

Any damp issues already existing in walls must be addressed before considering wall insulation. Resolving damp issues will result in improvements to the efficiency of the walls. If there is still a significant amount of heat loss once these issues have been resolved, wall insulation may be appropriate, but this must be carefully considered.

The hygrothermal properties, which is the movement of heat and water vapour through the building fabric, must be understood to determine if wall insulation is appropriate. The orientation and exposure of the walls will also impact the type, location and material of insulation being considered. Additionally, the specification, detailed design and installation is paramount to ensure there are no performance issues once installed.

External wall insulation

Typically, external wall insulation is applied to the external walls, with protective cladding over. This results in an increase to the depth to the wall. As such, detailed design needs to be carefully considered with adaptations to the roof overhang and wall junctions. There will also need to be consideration to the window reveals and sills, door surrounds, ground level and the repositioning of rainwater goods. There is a thermal bridging risk (though this is reduced comparative to internal wall insulation); as such design needs to be considered around door and window surrounds, under the roof parapet and at ground level.

Whilst technically, there can be relatively less risk from external wall insulation (compared to internal insulation), it will affect the appearance of the building. If the building is listed or in a conservation area, it can have a harmful impact on the building's heritage significance. If the building has decorative detailing or is particularly characterful, external insulation will result in a loss of significance. Even if the building is rendered, there will be a notable change due to the increase in depth. As such, this intervention may not be permitted or consented.

External insulation, where achievable, is often most appropriate for detached buildings. Semi-detached buildings and terraced properties will have difficulty installing external insulation due to party walls and how the junctions are dealt with. If it is not possible to insulate the whole building, priority should be given to exposed north walls.

If external insulation can be achieved, the materials used are an important consideration. Natural materials such as wood fibre boards, wood wool boards and cork boards are usually more appropriate for an historic building's existing fabric and qualities. However, due to the weight of some wood fibre boards, a structural engineer (a CARE Engineer is recommended for historic buildings) may need to be appointed to advise on the additional loads to the external walls. Synthetic materials such as modern closed-cell foam, other plastic-based insulations and the use of protective finishes are often not appropriate for an historic building, due to the lack of vapour permeability.

Lime render can have benefits for energy efficiency, particularly as it is able to assist in moisture movement. Where this can be achieved, thermal properties can be increased by lime render mixes containing natural materials, including hemp and cork. BRE have issued information papers for natural fibre insulation and hemp lime. Whilst they were authored in 2011, and there have been further developments in the products since then, they are still able to give a broad introduction to the materials.

12.1 Lime render

Lime is one of the oldest building materials in the world. It is produced by heating limestone in a kiln, leaving only calcium oxide, known as quicklime. Lime render is made from a specific mix ratio of lime, water and sand. The lime used in preparation will tend to be non-hydraulic lime or hydrated lime. This may also be called slaked lime, high calcium lime, air lime, or lime putty.

Lime renders were traditionally applied to give protection to walls constructed of traditional materials such as stone or porous brick, or to walls in exposed location facing driving winds. They help by acting like a sponge, absorbing moisture then allowing it to evaporate rather soak into the wall. Some traditional buildings would have been rendered originally and they tend to suffer from penetrating damp if the lime render is removed or replaced with a cement-rich render.

Lime render is considered carbon neutral as the carbon dioxide emitted during the creation of quicklime is reabsorbed by the lime render over years as it chemically converts back into limestone.

In contrast, the manufacture of cement accounts for 8% of human global emissions. When compared to the aviation industry which makes up 2% of CO_2 emissions, there is a clear environmental impact.

Internal wall insulation

Internal wall insulation is often considered when external insulation is not possible due to the potential impact on a building’s heritage significance. Whilst this may be thought of as a more achievable option, internal wall insulation results in more technical risk. There is also more disruption to the building and there will be a reduction in room space (a particular consideration for smaller properties). Adaptation of services and electrical cabling, and the relocation of skirting boards, architraves, and other joinery, where it is able to be reused, will also be necessary.

The increased technical risk from internal wall insulation is due to the amounts of junctions and interfaces, and therefore, the increased potential for thermal bridging. This includes around windows, door surrounds, ceilings, and floors. This is a particular consideration when the building is part of a terrace or semi-detached; any internal insulation along a party wall can result in the build-up of moisture in the adjacent property.

Understanding the moisture movement in walls is important, and ensuring that new insulation does not affect it, is vital for performance and to avoid negative impacts to the building, and occupant health. Installation of all types of insulation needs to be well executed with correct and well managed details, but this is particularly amplified for internal insultation. This is due to the thermal bridging potential, as well as hygrothermal considerations, ventilation, and overheating risks.

As with external insulation, natural materials such as wood fibre boards, wood wool boards, cork boards and wool are usually most appropriate for a building’s existing fabric and qualities. These systems come in a range of thicknesses that can be more appropriate for indoor spaces. A combination of materials, such as using slimline insulation around window reveals may be appropriate, however, as well as ensuring the materials are suitable for the existing fabric, there will need to be consideration of how the different insulations react with each other, and whether they are compatible.

Lime render can also have benefits for energy efficiency. Where this can be achieved, thermal properties can be increased by mixes with natural materials, including hemp and cork.

Synthetic materials such as modern closed-cell foam, or other plastic-based insulations are often not appropriate for traditional buildings, due to the lack of vapour permeability. For closed-cell insulation, impermeable vapour systems, moisture is generally dealt with by vapour control layer. However, there are technical risks with the control layer as it needs to be installed precise and well to function correctly. Any gaps will result in increased risk. Occupants will also need to be notified on the use and maintenance of the system applied. Any fixings, changes to electrical services or general damage from wear and tear can result in penetrations to the vapour control layer resulting in a build-up of condensation and moisture in those locations.

Cavity wall insulation

Cavity walls started to be constructed from the late nineteenth century and if a building dates after 1919, it is more likely to be constructed with a cavity wall. Due to the experimental stage of these cavity walls, they can vary in thickness and the use of ties. Insulation to cavity walls can be an option for these buildings that will have minimal impact on their character and external appearance.

As with all changes to building fabric, there is a technical risk, due to hygrothermal considerations. Being able to manage the risks and monitor the insulation is key. Any failings in the material will be difficult to identify due to the fact the cavity insultation is concealed. Further information on the risks, particularly due to moisture, have been highlighted by the IHBC and BRE: Solid wall heat losses and the potential for energy saving

Monitoring

For all types of insulation, a program of ongoing, post installation monitoring is key to ensuring that there are no performance issues. Embedding moisture meters into the walls as part of the installation process will assist with this and is the best way to manage the monitoring process.

Dealing with issues

If the building has already had wall insulation installed and is experiencing performance issues or deterioration, further information on how to deal with this can be found here: Energy Saving Trust: Insulation problems, Department for Business, Energy & Industrial Strategy: Cavity wall insulation (CWI): consumer guide to issues arising from installations, Property Care Association: Cavity wall insulation,

Energy Efficiency Measure	Planning Considerations	Risk	Further Considerations
	• Listed building: Requires LBC	HIGH RISK	Often due to the loss of decorative features, this type of insulation can be difficult to achieve for buildings with designations.
	• Listed building: Requires LBC • Conservation Area or Non-designation Heritage Asset: Does not require planning permission • Buildings with no designations: Does not require planning permission	HIGH RISK	The loss of decorative features should be considered even if the building is not designated. Refer to information above regarding the risks of internal wall insulation.

Further information on insulating walls

Solid Walls

Historic England's Insulating solid walls

BRE Reducing thermal bridging at junctions when designing and installing solid wall insulation

STBA and Bristol City Council, A Bristolian's Guide To Solid Wall Insulation (Whilst the guidance is specific to typical buildings within Bristol, this is comprehensive guidance that also covers solid walls and therefore, the principles are still relevant)

Energy Saving Trust, Solid wall insulation

Department for Business, Energy & Industrial Strategy, Retrofit internal wall insulation: best practice

STBA, External Wall insulation

STBA, Internal Wall insulation

STBA, Frame infill insulation

Timber-framed walls

Historic England's Insulating timber-framed walls

Robert Demaus, Insulation in Timber-framed Buildings

STBA

Cavity Walls

Historic England's Early cavity walls

Energy Saving Trust, Cavity wall insulation

STBA Cavity Wall Insulation

13. Floors

Depending on floor construction and materials, cold floors can be inefficient and floor insulation can reduce the amount of heat lost. Significant improvement to U-values (tested in-situ), to both solid floors and suspended timber floors can be achieved following insulation. However, the potential for application and improvements are subject to the floor and condition. Floor insulation, such as adaption of skirting boards, door frames and architraves with solid floor insulation, can also be disruptive, with consideration of the detail and materials necessary to ensure there are no resultant performance issues.

Non-intrusive options include draughtproofing for timber floors. The use of fabrics such as rugs and floor coverings have been noted for increasing occupant comfort, particularly with cold solid floors, such as flagstone floors that generally should not be altered, or suspended timber floors that introduce cold air from below.

Suspended timber floors

Where appropriate, insulation to suspended timber floors can be achieved by installing insulation between joists. To minimise disruption, floor insulation should be installed from below, where this is achievable. In some instances, insulation can be applied from the top, however this requires the floorboards carefully being removed and then re-laid. This can impact and damage the timber so cannot always be achievable, particularly where it is decorative.

Ventilation under the timbers is an important consideration. If there are any air bricks or vents that are located underneath the flooring that can be noted from the external elevations, these must not be covered as this would have a significant impact to the building's performance and would result in an accumulation of condensation and moisture.

Non-permeable insulating materials and boards should not be used on top of a timber floor or between joists as this will affect the moisture movement and can trap water vapour leading to deterioration and decay. Natural materials, such as wood fibre boards, would mitigate some of the risk, but still require appropriate detailing and careful installation.

Solid floor

Solid flagstone floors, or similar, can be easily damaged when lifted so may be difficult to install insulation underneath. No insultation should be installed on top of the flooring as it would be likely to have a detrimental impact to the floor.

If the original floor has been lost and it is now a concrete floor, rigid insulation can be laid on top. If a concrete floor needs to be removed, particularly if it is resulting in damp issues and affecting the performance of the building, installing an insulated lime concrete, sometimes with a foam glass floor, could be considered. This can be installed with underfloor heating systems, which can be more energy efficient.

Materials

As with all insulation, materials are key to ensure there will be no deterioration of fabric. A vapour permeable material is required and natural materials such as hemp and wood fibre board, are often most appropriate to ensure there is no accumulation of moisture. As with most insulation, synthetic options with closed cell systems, are not vapour permeable and therefore, can adversely affect performance.

In difficult to reach areas, spray foams are often considered as they can be achieved mechanically by a robot. However, this has a detrimental effect to a building fabric and its qualities, and therefore is not compatible with traditional buildings. Spray foams are not reversible and highly chemical; there use could also lead to issues with air quality and occupant health.

Energy Efficiency Measure	Planning Considerations	Risk	Further Considerations
	• Listed building: Requires LBC	LOW RISK	
	• Listed building: Requires LBC • Conservation Area or Non-designation Heritage Asset: Does not require planning permission • Buildings with no designations: Does not require planning permission	MEDIUM RISK	Subject to the application, use of materials and detail.

Further information on insulating floors

Suspended timber floors

Historic England's Insulation of suspended timber floors

The SPAB's Suspended timber floor insulation

Department for Business, Energy & Industrial Strategy, Retrofit insulation for suspended timber floors: best practice

Simple Energy Advice, Suspended floor insulation

STBA, Floor insulation between/under floor joists

STBA, Floor void filled with insulation

STBA, Exposed soffits to upper floors: Insulation in between joists or under soffit

Solid floors

Historic England's Insulating solid ground floors
Simple Energy Advice, Solid floor insulation

STBA, Replacement of existing ground floor with new concrete insulated solid ground floor

STBA, Floor Insulation on top of existing floor finish

14. Roofs

Typically, up to 25% of heat loss is through the roof. As such, installing roof insulation can often be an effective energy efficiency measure. However, as with insulating any element of a building, there careful consideration should be given to the type of insulation being installed and the method of insulation.

Types of roof insulation

The construction and use of the roof will determine where insulation can be laid.

'Cold roofs' are where insulation is laid at ceiling level, typically between the ceiling joists. This effectively turns the roof cold as there will be minimal heat rising to the area. Generally, this is considered the option with less risk as there is no inference with the timber rafters. However, this may not be an option if the roof is a useable space and/or used for storage, depending on the items.

'Warm roofs' is the application of insulation between the rafters in the pitch, thereby the roof space being a useable space.

Maintaining ventilation is important in both instances, however warm roofs are particularly at risk from deterioration if insulation is not installed correctly, or inappropriate materials have been used.

A. None-habitable room
B. Insulated loft hatch
C. Insulation
D. Road fill indication warm square
E. Ventilation

Cold Roof Space

A. Insulation
B. Ventililation
C. Road fill warm space

Warm Roof Space

14.1 Materials

Using inappropriate materials can result in moisture build up and can lead to the deterioration of the timber rafters. Natural materials should always be considered as they have better vapour permeability qualities and lessen the risk of condensation. Types of materials that can be appropriate are natural materials such as hemp fibre board or sheep's wool, recycled products made from newspaper and mineral wool.

Generally, it is considered that at least 270mm of insulation is needed for it to be fully effective. However, this is subject to the construction and performance of the roof.

Wood fibre boards between rafters can be a good material to use due to its qualities. However, depending on the thickness and areas of application, a structural engineer (A CARE Engineer is recommended) may need to assess the building prior to any works taking place due to the additional loads from the boards.

In difficult to reach areas, spray foams are often considered. However, this has a detrimental effect to the building fabric and its qualities, and therefore is not compatible with traditional buildings. Spray foams are not reversible and highly chemical, which could also lead to issues with air quality and occupant health.

Energy Efficiency Measure	Planning Considerations	Risk	Further Considerations
Roof insulation	• Listed building: Requires LBC • Conservation Area or Non-designation Heritage Asset: Does not require planning permission • Buildings with no designations: Does not require planning permission	MEDIUM RISK	

Further information on roofs

Loft insulation

Energy Saving Trust, Roof and loft insulation

Insulating at ceiling level – cold roof

Historic England's Insulating pitched roofs at ceiling level

The SPAB's Loft insulation

STBA, Loft insulation

Insulating at rafter level – warm roof

Historic England's Insulating pitched roofs at rafter level
Historic England's Insulating dormer windows

The SPAB's Rafter level insulation

Department for Business, Energy & Industrial Strategy, Retrofit room in roof insulation: guide to best practice

STBA, Rafter insulation

STBA, Room in roof insulation

Other roof types and considerations

Historic England's Open fires, chimneys and flues

Historic England's Insulating flat roofs

Historic England's Insulating thatched roofs

STBA, Flat roof insulation

STBA, Chimney blocking

STBA, Loft Hatch insulation

15. Key risks of Retrofitting

There can be a number of detrimental risks occurring from poorly detailed and/or inappropriate energy efficiency measures. This can range from affecting the occupant's health and deterioration of the building fabric. They can be interrelated and hence exacerbated.

15.1 Moisture and damp

Traditional building materials allow the movement of moisture and have hydrothermal properties. If there are not allowances for this when making energy efficiency measures, there is the risk of a build-up of condensation and trapping moisture in the existing historic fabric, which can lead to damp and deterioration. In extreme cases, this can impact the structural integrity of the building.

Natural air leakage in buildings and the properties of the traditional construction materials manage the moisture movement through the building. When considering draught-proofing or installing insulation there must be an understanding on the probable effect of this so there is not a build-up of moisture.

Relative humidity can influence indoor air quality and is subject to moisture levels and air temperature. Relative humidity can affect human health, thermal comfort and building health, particularly as there is an increased potential for pests and dust mites.

15.2 Airtightness and Ventilation

Many energy efficiency measures can have impacts on the ventilation of a building. Ventilation in traditional buildings can happen in a number of ways that manages moisture levels, including controlled ventilation, features such as chimneys, as well as infiltration and air flow through vapour permeable building fabric. Natural ventilation is affected by wind speed and the building's location and orientation. As noted above, a combination of poor ventilation and moisture can result in detrimental risks to a building and its occupants. This includes the deterioration of the fabric causing mould, thereby harming the occupants' health through poor indoor air quality.

Building Regulations Approved Document F paragraph 3.2 sets out ventilation requirements and considerations when carrying out works in existing dwellings:

replacing a window or door
doing energy efficiency work the ventilation of the dwelling should either:
meet the standards in the relevant approved document
not be less satisfactory than before the work was carried out.
NOTE: Ventilation through infiltration should be considered to be part of the ventilation provision of a dwelling. Reducing infiltration might reduce the indoor air quality of the dwelling below the standards given in Appendix B.

Balancing ventilation is important and can be complex, particularly if the building performance is not understood. Un-controlled ventilation can impact on the energy efficiency of the building and thermal comfort of the occupants, whereas too little ventilation can result in damp and overheating.

15.3 Rebound and performance gap

Understanding the objective of the project should determine the level of retrofit. Not using the Whole House Approach and considering the occupant's comfort can result in deep retrofit and rebound effects. Rebound effects are largely where, post energy efficiency measures, the occupants want a higher level of comfort, therefore the energy usage and bills can increase. In these instances, if the occupants' requirements had been understood first, some works to the building may not have been required, and others may have been more appropriately undertaken.

When predicted energy savings are set out before the works, for instance achieving space heating targets or U-values, and energy efficiency measures are installed, which do not then achieve the predicted energy savings, this is known as the performance gap. There are a number of reasons why this can happen, including poor understanding of the building's performance pre-works, lack of understanding of the occupant's requirements, and poor design and/or installation of the energy efficiency measures.

Further information on risks

Kate de Selincourt, The risks of retrofit

IHBC, How to deal with retrofit risks

Iain McCaig, Retrofit in Heritage Buildings: Understanding the Risks

Approved Document L, Conservation of fuel and power, Volume 1: Dwellings

Moisture

Neil May and Chris Sanders, Moisture in buildings: an integrated approach to risk assessment and guidance

STBA, Interstitial/surface Condensation

STBA, Trapped/accumulated moisture

STBA, Thermal Bridges

Airtightness and Ventilation

Ventilation: Approved Document F

CAT, Airtightness and Ventilation

STBA, Sufficient ventilation?

STBA, Overheating

Retrofit Academy, Ventilation guide

CAT, Airtightness and Ventilation

STBA, Sufficient ventilation?

STBA, Overheating

Retrofit Academy, Ventilation guide

16. Post monitoring and maintenance

If energy efficiency measures have been made, particularly if there have been multiple fabric interventions, monitoring the works and continuing a programme of general maintenance of a building is vital to maintain efficiency.

There needs to be an understanding of whether the objectives of the project have been achieved and if the comfort levels of the occupants have been improved, or if further works need to be undertaken.

Monitoring will help assess whether the energy efficiency measures are failing. For instance, if there are any visible signs of damp, this must be addressed as soon as possible as there will be the build-up of moisture that may be impacting indoor air quality, which can affect the occupant's health, as well as resulting in adverse impacts to the built fabric.

Further information on post monitoring and maintenance

STBA, Handover to user/s

STBA, Maintenance interval and complexity

STBA, Monitoring and feedback required

Historic England, Maintaining historic buildings

17. Costs and Savings

Energy Saving Trust can provide estimates on costs and savings for different energy efficiency measures, including insulation in different areas of a building.

The Energy Saving Trust regularly provides updates on what grants and loans are available. They have also compiled a list of energy efficiency tips that can be achieved on a budget: Energy saving on a budget

It is important to remember that the cost of retrofitting of a building varies, based on a number of factors:

1. Existing state of the building - for example, if remedial or repair work needs to be carried out first
2. Scale of the building - if the building is a detached house, semi-detached house, mid-terrace house or detached bungalow
3. Materials being used - whilst the cost of materials can change drastically, materials must be chosen based on what is compatible for the building. This will avoid costly repair and remedial works in the future
4. Cost of labour - whilst the cost of labour can vary, when working with traditional buildings, all contractors should ideally have experience working with similar types of buildings.
5. The amount of energy efficiency measures being proposed

- The more measures being proposed, the higher the cost
- A step-by-step approach may be a better option for those on a budget wanting to spread the cost. However, if this is the case it is important to inform the contractor that this is the long-term plan, as it may change the installation. For example, internal insulation will need to have allowances for connections across the threshold.

When dealing with historic and traditional buildings there may be a need to consult specialists as well as use more bespoke products which should be factored into costing. The requirement to obtain permissions and consent will also have an associated cost to be considered.

18. Renewables and Low Carbon Options for Traditional Buildings

There are a range of different renewables and low carbon options, such as, solar panels, solar thermal panels and heat pumps that may be applied to traditional buildings.

Installation of renewables or low carbon options should be considered after ensuring the building is performing efficiently. As output from renewables can fluctuate there is often still a requirement for electricity input. If the building is under performing, an increased amount of energy will be required, whereas if less energy is needed, there will be less demand on the renewables and the need for low carbon options to be heavily balanced with electricity will be reduced.

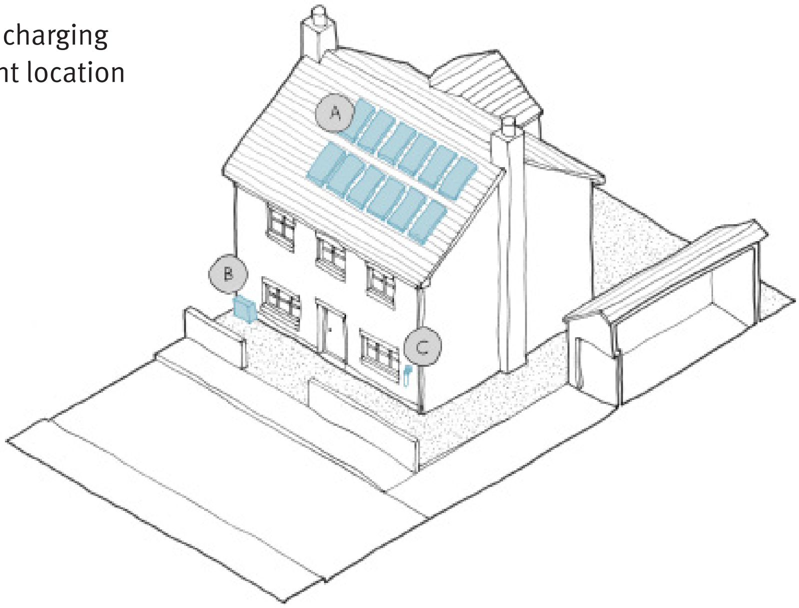
Historic England have set out a number of considerations when assessing options for low and zero carbon energy sources:

1. Does it suit the particular building and use?
2. What are the carbon reduction benefits?
3. Will the potential savings exceed the whole-life energy costs?
4. Can the system be fitted safely with no significant adverse impact on the building and its historic fabric?
5. What will be the visual impact on the building/heritage asset and its setting?
6. Are there any planning controlsthat affect your choice and positioning of the installation?

Renewable	Planning Considerations	Risk	Further Considerations
Active Solar Technology, Solar Panels or Solar Thermal either building mounted or domestic stand alone	• Active Solar Technology, Solar Panels or Solar Thermal either building mounted or domestic stand aloneListed Buildings: Requires LBC • Conservation Area or Non-designation Heritage Asset: Can be permitted development. Check with the Local Planning Authority. • Buildings with no designations: Often permitted development.	MEDIUM/ HIGH RISK	Subject to scale, design, and fixings. Location should be carefully considered and positioned sympathetically.
Ground Source Heat Pumps	• Listed Buildings: Within the setting of a listed building, likely to require planning permission. Servicing likely to require LBC. • Conservation Area or Non-designation Heritage Asset: Likely to require planning permission • Buildings with no designations: Often permitted development. Check with the Local Planning Authority.	MEDIUM RISK	Location should be carefully considered and positioned sympathetically.

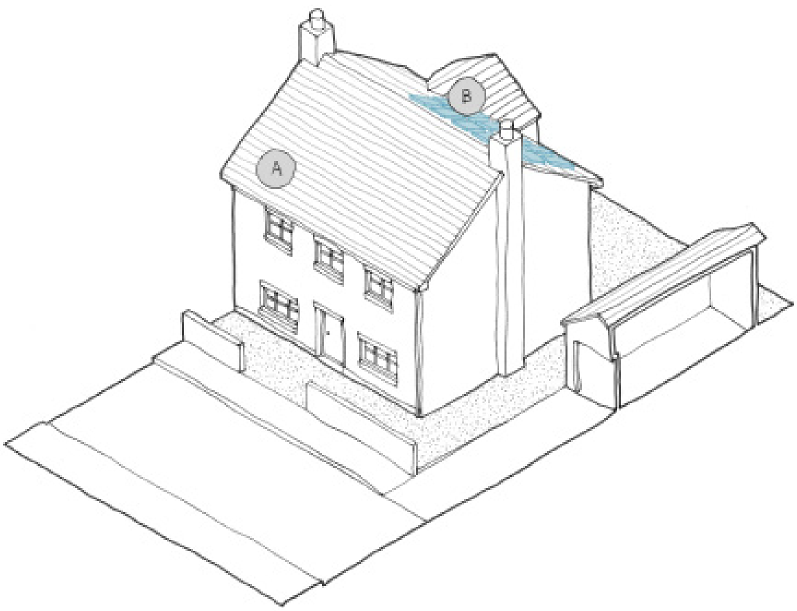
Renewable	Planning Considerations	Risk	Further Considerations
Air Source Heat Pumps	• Listed Buildings: Within the setting of a listed building, likely to require planning permission. Servicing likely to require LBC. • Conservation Area or Non-designation Heritage Asset: Subject to location, may be permitted development • Buildings with no designations: Often permitted development provided ALL the limits and conditions are met.	MEDIUM RISK	Location should be carefully considered and positioned sympathetically.
Wind – Building mounted	• Listed Buildings: Requires LBC • Conservation Area or Non-designation Heritage Asset: Likely to require planning permission. • Buildings with no designations: Often permitted development provided ALL the limits and conditions are met.	HIGH RISK	Minimal gains and risk to buildings
Wind – Stand alone	• Listed Buildings: Within the setting of a listed building, likely to require planning permission • Conservation Area or Non-designation Heritage Asset: Likely to require planning permission. • Buildings with no designations: Often permitted development provided ALL the limits and conditions are met.	LOW RISK	Very limited gains with domestic scale turbines. Likely to be limited to most due to the land needed for turbines of sufficient scale.
Biomass	• Listed Buildings: May need LBC subject to servicing • Conservation Area or Non-designation Heritage Asset: Often permitted development Check with the Local Planning Authority. • Buildings with no designations: Often permitted development Check with the Local Planning Authority.		

A. Avoid placing solar panels in a prominent location.
B. Avoid placing heat pumps in a prominent location.
C. Avoid placing EV charging points in a prominent location



Poor Placement to be Avoided

A. Avoid placing equipment in locations visible from the street where possible .
B. Potential locations for solar panels, refer to illustrations X for further information.



Preferred Placement

Key Documents and Links

Historic England, Low and Zero Carbon Technologies

Historic Environment Scotland, Short Guide 8: Micro-Renewables in the Historic Environment

Historic Environment Scotland, Managing Change in the Historic Environment: Micro-renewables

CAT, Energy options

Energy Saving Trust, Generating renewable electricity

Energy Saving Trust, Low carbon heating options

Energy Saving Trust, Heating & Hot Water

Microgeneration Certification Scheme is a nationally recognised quality assurance scheme, supported by the Department for Business, Energy & Industrial Strategy. MCS certifies microgeneration technologies used to produce electricity and heat from renewable sources.

19. Solar

Solar energy is a renewable source converted through panels. Photovoltaic (PV) Solar Panels converts sunlight energy into electricity, whereas Solar Thermals uses solar to heat water.

When considering solar technology, the following should be taken into account:

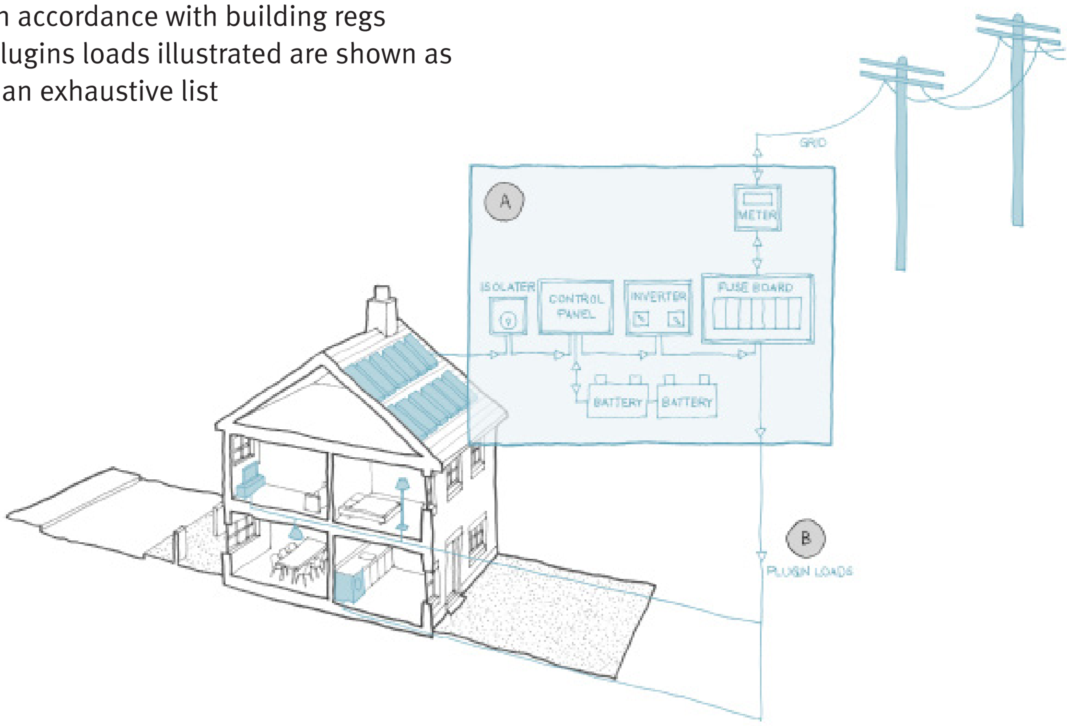
1. Location and orientation of the panels with regards to visual impact and effect on designated areas;
2. Location and orientation of the panels for solar gains;
3. Size and area of solar modules for required energy output for the household;
4. Design of panels, particularly for PV panels as the colour and appearance can vary

The visual impact needs to be considered if panels are installed on a heritage asset. Whilst the visual impacts can be minimised, this needs to be considered in the context of solar gains. If the orientation is north facing to minimise the visual impact, there will be minimal gains.

Generally, the following design considerations and criteria should be taken into account when installing solar technology onto a traditional building:

5. Planning the location of panels should be treated sequentially. If possible, installing panels within the grounds of the heritage asset should be considered in the first instance. Ground mounted solar panels may be installed and there location potentially screened to avoid adverse aesthetic impacts. This will also have benefits as application to roof pitches determine the aspect of a panel which is not an issue in the ground mounted option. If this is not possible the outbuildings and ancillary buildings should be considered before the listed building itself.
6. Equipment on a building should be sited, so far as is practicable, to minimise the effect on the external appearance of the building and the amenity of the surrounding area.
7. Panels should not be installed above the highest part of the roof (excluding the chimney) and should project no more than 200mm from the roof slope or wall surface.
8. Panels should not face onto the street (particularly if a designated asset)
9. Panels should be located on the least sensitive parts of the building, for example a later rear extension (particularly if the building is a designated asset)
10. When no longer needed equipment should be removed as soon as reasonably practicable.

A. Items within the boss to be provided at the location of the property in accordance with building regs
B. Potential plugins loads illustrated are shown as examples not an exhaustive list



Installing Solar Technology into a Traditional Building

Choosing a location for a proposed solar array

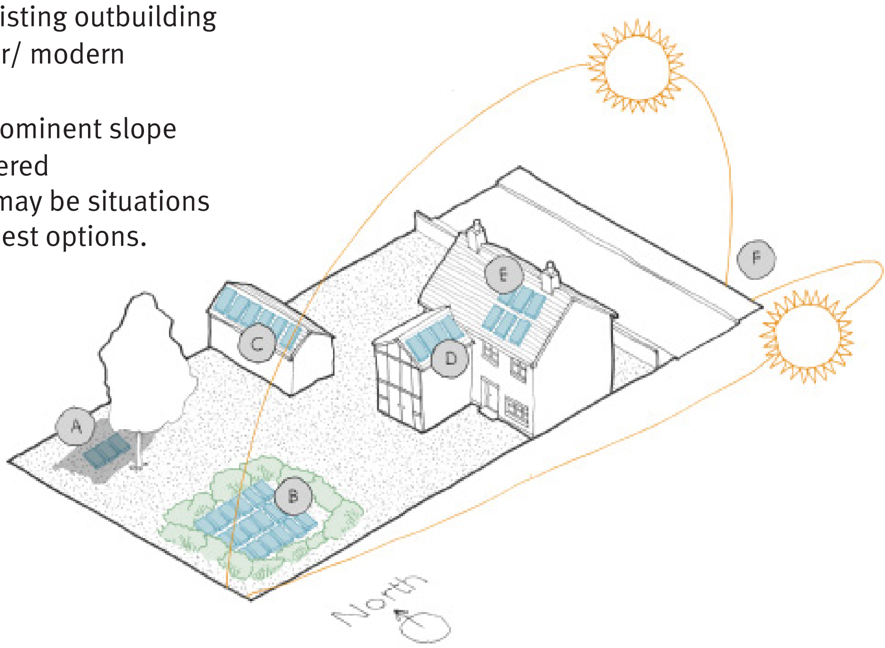
Whilst sustainability and energy efficiency are legitimate issues, for historic buildings a balance must be achieved between generating its own energy and avoiding damage both to the significance of the building and its fabric, and the visual impact of a renewable installation on the character and appearance of the historic building or site.

When choosing a location for a proposed solar array it is considered best practice to appraise each option sequentially in the following order of preference:

Ground-mounted

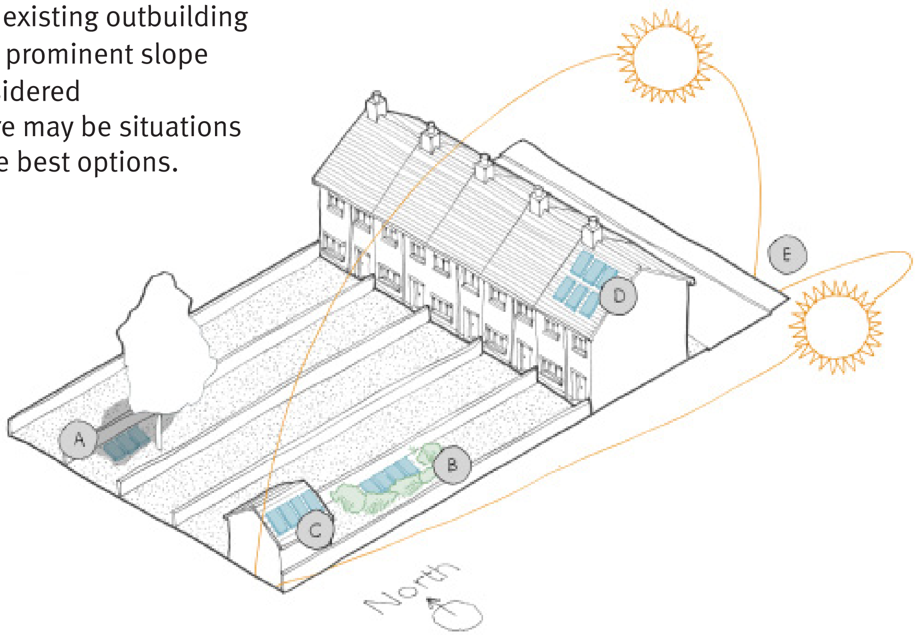
- To the roof of any outbuilding (such as a garage or shed)
- To the roof of a later / modern extension
- To the rear roof slope of the host dwelling

A. Avoid placing solar panels in the shadows of trees and buildings
B. Potential location 1. ground mounted within the site
C. Potential location 2. roof of an existing outbuilding
D. Potential location 3. roof of a later/ modern extension
E. Potential location 4. rear/least prominent slope
F. Optimum solar gain to be considered
NB: Whilst option are shown, there may be situations where solar panels may not be the best options.



Solar Location Detached House

A. Avoid placing solar panels in the shadows of trees and buildings
B. Potential location 1. ground mounted within the site
C. Potential location 2. roof of an existing outbuilding
D. Potential location 4. rear/least prominent slope
E. Optimum solar gain to be considered
NB: Whilst option are shown, there may be situations where solar panels may not be the best options.



Solar Location Terraced House

Before a proposed location can be supported in principle it must be adequately demonstrated that the previous preferred option(s) are not viable.

It should be noted that demonstrating that a preferred alternative location is not viable, does not mitigate any potential harm caused by solar panels to roofs, and some heritage assets may not have the capacity for this change. There is no presumption of acceptability without carefully considered options.

Key Documents and Links

Historic England Energy Efficiency and Historic Buildings: Solar Electric (Photovoltaics).

Campaign to Protect Rural England: Solar Design Tips

Photovoltaic (PV) Solar Panels

The main components of these systems are the PV panels, inverter, isolator, electrical distribution system, and often battery storage.

PV panels can be ground mounted or mounted onto buildings. Ground mounted solar panels involve limited intervention with the building fabric so can be a good solution where space and facilities allow. For properties that do not have sufficient space, installing PVs on the building may be the only option.

For panels installed on roof slopes, there are two different types of panels: fixed over the roof covering and integrated into the roof.

Panels that are fixed onto the roof have the potential for greater solar gains, due to their size and positioning. There is also less fabric intervention, and it is reversible. Generally, to mount the panels onto the roof, roof tiles are removed in specific areas for the batons to be fixed into the timber rafters. Cabling is installed and the tiles are then replaced. The invertor, isolator, electrical distribution system, and battery storage (if applicable) is stored internally. The majority of the built fabric has no intervention. There is however an aesthetic impact. Some roof structures in historic buildings are also of significance and cannot be altered due their significance, or structural integrity, to accommodate a PV.

Integrated solar panels, also referred to as in-roof solar panels, have the potential to limit visual impact in some instances. However, they are only compatible with certain roof tiles and slates and require the existing roof tiles to be removed. Therefore, they can have a significant amount of fabric intervention and are not a reversible solution. Overtime, there may be weathering to the roof tiles, that result in the PV panels being more prominent. Due to the scale and design of the panels, they have less solar gains and energy output as fixed panels. Generally, they should only be considered if the whole roof is being replaced, due to the disruption and loss of fabric.

Solar roof slates are small solar panels which absorb sunlight and generate electricity in exactly the same way. The key difference is that they perform just like normal roof tiles or slates and have less of a visual impact. However, as solar slates are engineered, they lack the authentic matt finish provided by natural slate; in this sense they represent the same problems as artificial slates in the historic built environment and may not be appropriate in some instances.

The Solar Energy Calculator provides estimates for the potential for fuel bill savings. The interactive tool calculates the estimate based on the potential for solar gains, including property details, roof slope, shading roof direction, and installation size.

Solar Thermals

The main components of solar thermals are solar panels/tubes (which are typically roof mounted), a pump managed by a controller unit and a hot water cylinder with heating coils.

Whilst the size of thermals varies, there is little alteration in design, and these can appear more prominent so particular care needs to be given to their orientation and location. The size of the solar thermals should be determined by the size of the household and the hot water usage. For heating water, solar thermals can be more efficient than PVs.

Further information on solar

Solar Thermals

CAT, Solar Water Heating

Centre for Sustainable Energy, Solar hot water

Simple Energy Advice, Solar thermal

Solar Panels

Historic England's Solar Electric (Photovoltaics)

CAT, Photovoltaic (PV) Solar Panels

Centre for Sustainable Energy, Solar electricity

Centre for Sustainable Energy, Battery storage

Centre for Sustainable Energy, Getting the most of solar panels

CPRE, Solar Design

CPRE and BRE, Ensuring place-responsive design for solar photovoltaics on buildings

Simple Energy Advice, Solar electric panels

20. Heat Pumps

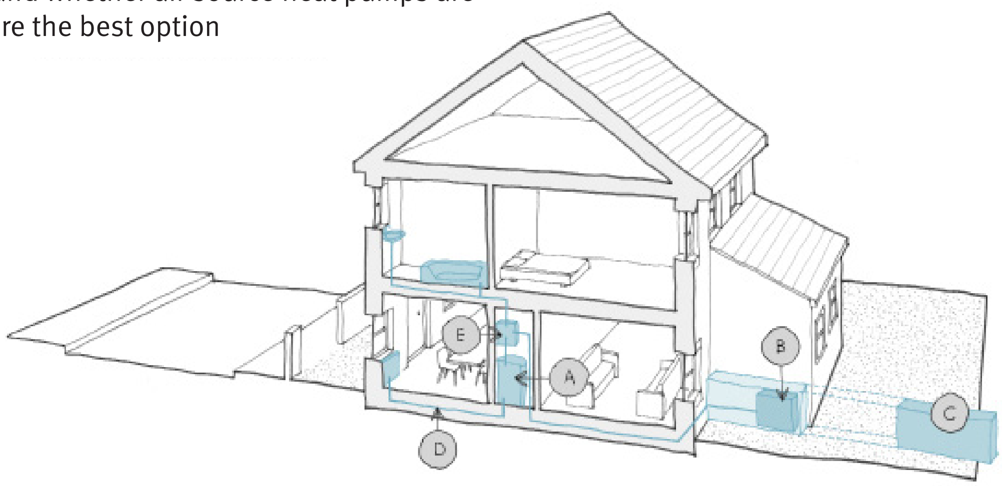
The process of heat pumps is complex, however fundamentally they extract heat/energy from the 'source' location, which is converted and upgraded for central heating. The source can be ground, air or water, though ground and air are more common as they can be accessible to most. Water source heat pumps require a water source that does not freeze during the winter months.

20.1 Air source heat pumps

Air source heat pumps extract heat through a fan. There are air-to-water systems used for hot water systems, or air-to-air systems for space heating, though this is less common in the UK.

They can be installed outside the building, with services connected through the wall. This can have an adverse visual impact, which may need to be a consideration with designated heritage assets. Mitigation can take the form of an appropriately design enclosure. The heat pumps can also be installed internally with the fan for the air source, connected through the wall. Whilst this has less of a visual impact externally, generally they can take up more space internally, and therefore may not be an option for smaller buildings. The routing of services should also be sympathetic.

A. Hot water cylinder
B. Air source heat pump with ventilated enclosed attached to dwelling
C. Air source heat pump with ventilated enclosed detached to dwelling
D. Pipework
E. Hydrobox and controller
NB: The building's holistic performance should be considered and whether air source heat pumps are the pumps are the best option

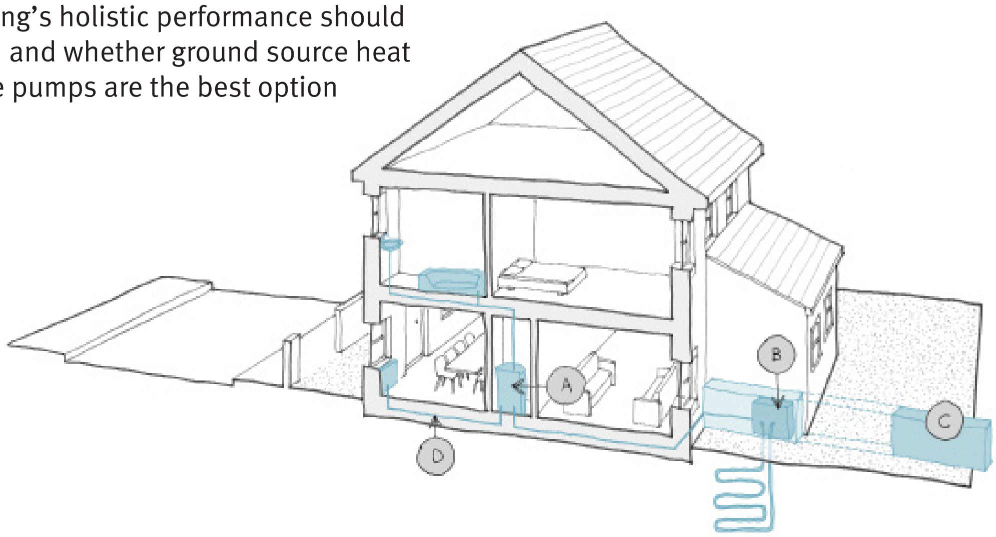


Air Source Heat Pumps

Ground source heat pumps

Ground source heat pumps extract heat via pipes inserted into the ground and connected to a building. Burial of the pipes is either through a closed loop system, that requires trenches, or open loop systems, requiring boreholes. Large drilling machinery is required for the installation, and this can be disruptive. Archaeological sensitivity may also need to be considered in some areas.

A. Hot water cylinder
B. Air source heat pump with ventilated enclosed attached to dwelling
C. Air source heat pump with ventilated enclosed detached to dwelling
D. Pipework
NB: The building's holistic performance should be considered and whether ground source heat pumps are the pumps are the best option



Ground Source Heat Pumps

Further information on heat pumps

Historic England, Heat Pumps

CAT, Heat Pumps

Heat Pump Association, What is a heat pump

Energy Saving Trust, Heat pumps

Air source heat pumps

Energy Saving Trust, Air source heat pumps

Centre for Sustainable Energy, Air source heat pumps

Centre for Sustainable Energy, Making the most of air source heat pumps

Ground source heat pumps

Energy Saving Trust, Ground source heat pumps

Centre for Sustainable Energy, Ground source heat pumps

Ground Source Heat Pump Association

The Environment Agency, Environmental good practice guide for ground source heating and cooling

21. Wind

On a national and industrial level, wind power has the potential to provide large amounts of green energy. However, on an individual and homeowner basis, it is difficult to utilise and capitalise on these gains as the amount of energy generated is relative to the size and speed of the wind. This is because the scale of the wind turbine that is required and the physics of the span relative to the amount of energy gained. Essentially the bigger the turbine, the better the gains. As such, small scale turbines have minimal gains.

There also needs to be considerations regarding proximity of nearby buildings, trees and landscape, as well as the visual impact. It is recommended that wind turbines are not attached to a traditional building, due to the minimal gains and the potential impact to the structure of the building. Larger wind turbines are required to be positioned away from buildings and not in a location that has an adverse impact on the setting of heritage assets.

Further information on wind

CAT, Wind power

Energy Saving Trust, Wind turbines

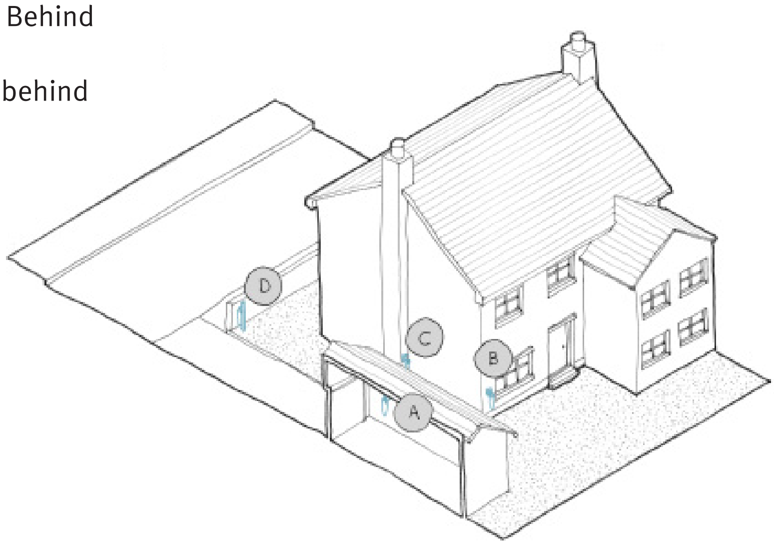
22. Low carbon travel

Electric cars can be a good solution for those wanting low carbon travel options with the potential for reduced running costs (particularly when public transport is limited).

Electric charging points will often be required to be installed at home to support EV use. However, consideration needs to be given to the location, positioning and scale of charging points. This is particularly the case if they are located within a conservation area or the host building is listed, as there can be a visual impact; the designs of charging points are currently limited, making it harder to source one that is visually sympathetic to the historic environment. Sympathetic locations for charging points may include to the rear of a building, hidden from view in an externa niche or hidden in a small enclosure or boundary treatment.

Installing charging points generally requires off-street parking. If the property does not have off-street parking, there may be difficulties with creating parking space. The loss of front gardens and garden boundaries is a common issue across conservation areas and therefore, any proposals including this are likely to be refused. It is recommended that this is checked with the local planning authority. If access requires dropping the kerb, planning permission is needed.

Locations in order of preferences
A. Potential location 1. Inside gargage
B. Potential Location 2. To the reas of the property
C. Potential Location 3. Behind the chimney slack
D. Potential location 4. behind existing garden wall



Preferred EV Charging Location

Further information on charging points

Planning Portal, Electric vehicle charging points

Planning Portal, Front garden paving

Energy Saving Trust, Charging electric vehicles

Energy Saving Trust, Smart Charging electric vehicles

23. Applying for Energy Efficiency and Retrofit works

23.1 Planning and Listed Building Consents

Internal works will normally require consent if the building is listed. For external works, planning permission (and listed building consent) may be required, however this is subject to designations e.g. listed building or Conservation Area, and the works being proposed. Refer to the Planning Portal's interactive house and When is permission required? guidance for further information regarding when planning permission is required, and contact the LPA

Heritage Statements and Heritage Impact Assessments

If planning permission or listed building consent is required, the proposal must be supported with a heritage statement, which describes the significance of any heritage assets affected. The level of detail should be proportionate to the assets' importance and no more than is sufficient to understand the potential impact of the proposal on their significance. For example, for a listed building, if the proposed works are intrusive and result in a high number of changes, a detailed report including the historic development of the building and an understanding of the existing fabric must be provided. This may have to be supported with additional reports such as a condition survey and a structural survey. It is good practice to undertake a Heritage Statement at the outset of the project, given the understanding of significance is fundamental to forming appropriate schemes.

To understand the significance of a building, the assessment must be in line with Historic England's Advice Note 12: Statements of Heritage Significance: Analysing Significance in Heritage Assets

Assessing Impacts of Energy Efficiency Measures

The NPPF outlines how the impact of proposals, including energy efficiency measures, should be assessed. Paragraph 195 states that local authorities 'avoid or minimise any conflict between the heritage asset's conservation and any aspect of the proposal.'

When assessing the impacts of energy efficiency measures to designated heritage assets, Paragraph 199 notes that great weight should be given to the conservation of the designated heritage asset, and a clear and convincing justification is required by Paragraph 200 of the NPPF. As such, whilst energy efficiency measures could be considered as a clear and convincing justification, particularly when the works are to make the building compliant with building regulations or improvements for EPC ratings, this should not be detrimental to the conservation and significance of the building or heritage asset, and great weight will be afforded to this principle. As a 'rule of thumb', the higher the level of harm to a designated heritage asset that will result from proposed energy efficiency measures, the greater the public benefits that are required to outweigh the harm. These public benefits will be challenging to justify at the scale of a single property.

23.2 Building Regulations

Planning permission and listed building consent only applies to certain buildings and works, however Building Regulations apply for any type of building, and is subject to the type of work being carried out.

Guidance for when approval will be required can be found here: Building regulations approval: When you need approval

Work covered by building regulations

The Building Regulations 2010 cover the construction and extension of buildings. The guidance sets out building regulations approval for may be needed for a number of alteration projects, this includes:

replace fuse boxes and connected electrics
install a bathroom that will involve plumbing
change electrics near a bath or shower
put in a fixed air-conditioning system
replace windows and doors
replace roof coverings on pitched and flat roofs
install or replace a heating system
add extra radiators to a heating system

Approved Documents for Energy Efficiency Measures

There are a number of relevant Approved Documents for Energy Efficiency Measures, including:

Approved Document L, Conservation of fuel and power, Volume 1: Dwellings

Ventilation: Approved Document F

Overheating: Approved Document O

The requirements of Energy Efficiency Measures to apply and when a building is exempt is cover by Approved Document L. Further guidance on this application of this document has been provided by Historic England: EEHB: Application of Part L of the Building Regulations to historic and traditionally constructed buildings.

Due to the impacts that energy efficiency measures and retrofit can have on the building and its performance, Approved Document F and Approved Document O also apply to minimise the risks of the project.

23.3 Key Documents and Links

Legislation and Planning Policy

Planning (Listed Buildings and Conservation Areas) Act 1990

National Planning Policy Framework, July 2021

Building Regulations

Government Advice on Building Regulations Approval

Building Regulations and Approved Documents index

Relevant Approved Documents for Energy Efficiency Measures -

Approved Document L, Conservation of fuel and power, Volume 1: Dwellings

Ventilation: Approved Document F

Overheating: Approved Document O

Local Guidance and Sustainability

UK Green Building Council Policy Map

Historic England Guidance

Advice Note 12: Statements of Heritage Significance: Analysing Significance in Heritage Assets

Advice Note 16: Listed Building Consent