Improving the Thermal Performance of Historic Solid Wall Buildings

Church Street, Giggleswick, with St Alkelda's Church.© The Yorkshire Post

James Innerdale
Architect and Historic Buildings Consultant

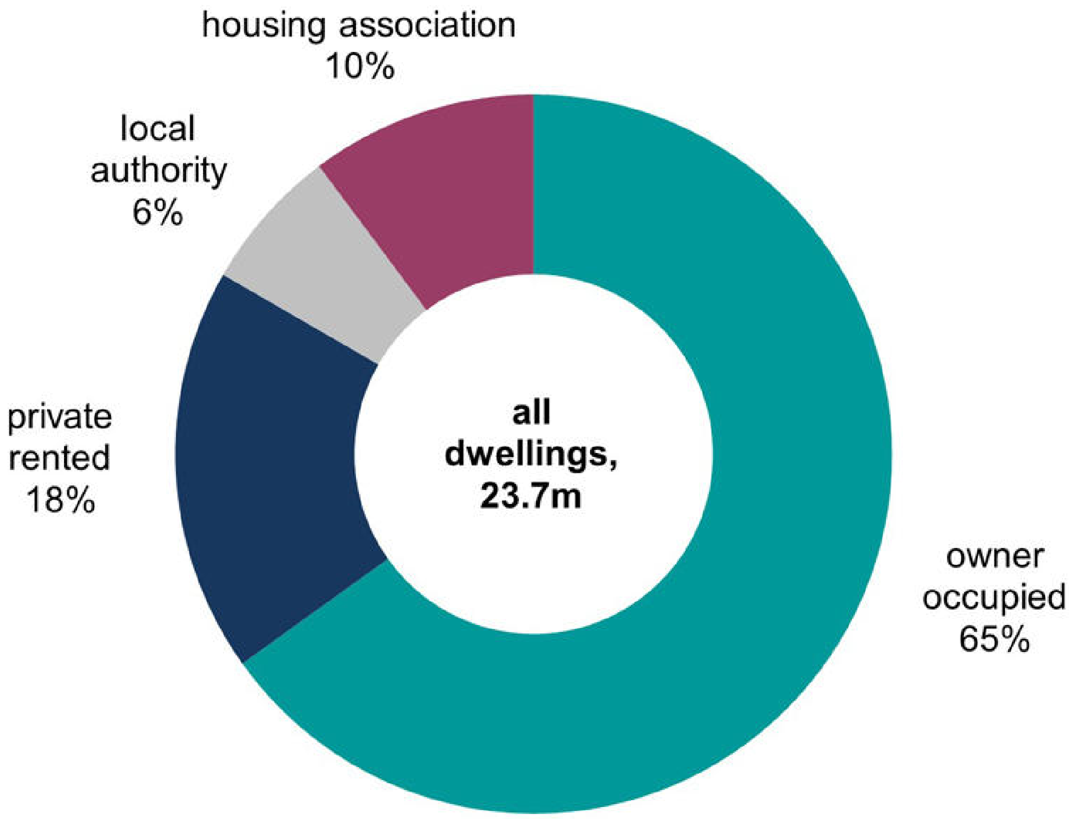
UK Building Stock Energy Usage

- Approximately **25 million homes** in the UK

- Account for around a quarter of the UK's CO2 emissions.

- Emissions from buildings comprise of:
49% direct emissions
(i.e. burning fossil fuels for heat) 51% indirect emissions (electricity related)

- Of the 25 million homes **4.5million** built before 1919 (solid wall construction).



2021 – 2022 English Housing Survey

Basic Tools and Definitions

U values is the measurement of heat transmission through an assembly of materials. The U value of a material is a gauge on how well heat passes through the material and the lower the U value, the greater the resistance to heat and therefore has a better insulating value. These are referred to in the building regulations and form part of the Standard Assessment Procedure (SAP) calculation.

SAP works by assessing how much energy a dwelling will consume and how much carbon dioxide (CO_2) will be emitted in delivering a defined level of comfort and service provision, based on standardised occupancy conditions. The calculation takes into account the areas of a houses external fabric and their U Values, it also considers ventilation losses and efficiencies of the heating system and appliances. The Energy Performance Certificate (EPC) is created from the SAP calculation.

Thermal conductivity (λ), called k-value is a material property, regardless of its shape or size. It is measured as heat flow density [W m-2] in a 1m thick body of the material with 10 K temperature difference between the two surfaces. Unit: W (mK)-1.

Thermal resistivity also called R-value is the thermal resistance for a material of a given thickness. A high R-value means a better insulator than a low R-value. Unit m2 K/W. - **It is the opposite of thermal conductivity**

Establishing Existing Performance

Malmstone

Gypsum plaster	15
Malmstone	310
Overall	325mm

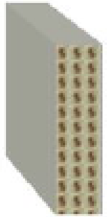
In situ U-value 1.34 W/m²K

Calculated U-value 2.09 W/m²K

timber design limited

Documentation of the component — 11. October 2010
Thermal transmittance (U-value) according to BS EN ISO 6946 — Page 1/1
Source: **own catalogue - Caroline**
Component: **11B**

OUTSIDE — INSIDE



Assignment: External wall

		Manufacturer	Name	Thickness [m], number	Lambda [W/(mK)]	Q	R [m²K/W]
		Rse					0.04
☑	1	BS EN 12524	Limestone, soft	0.310	1.100	D	0.28
☑	2	BS EN 12524	Gypsum plastering	0.015	0.570	D	0.03
		Rsi					0.13
				0.325			

$R_T = R_{se} + \Sigma R_i + R_{si} = 0.48\ m^2K/W$

$U = 1/R_T = 2.09\ W/(m^2K)$

Q .. The physical values of the building materials has been graded by their level of quality. These 5 levels are the following
A .. A: Data is entered and validated by the manufacturer or supplier. Data is continuously tested by 3rd party.
B .. B: Data is entered and validated by the manufacturer or supplier. Data is certified by 3rd party
C .. C: Data is entered and validated by the manufacturer or supplier.
D .. D: Information is entered by BuildDesk without special agreement with the manufacturer, supplier or others.
E .. E: Information is entered by the user of the BuildDesk software without special agreement with the manufacturer, supplier or others.

U_{max} = 0.35 W/(m²K) — U = 2.09 W/(m²K) — R_T = 0.48 m²K/W

Source of Umax value: England, Wales: Approved Document L1A (2006), Table 2 - New Build Dwellings

Calculated with BuildDesk 3.4.4

ArchiMetrics

Establishing Existing Performance

Problems with current U value analysis of traditional building fabric

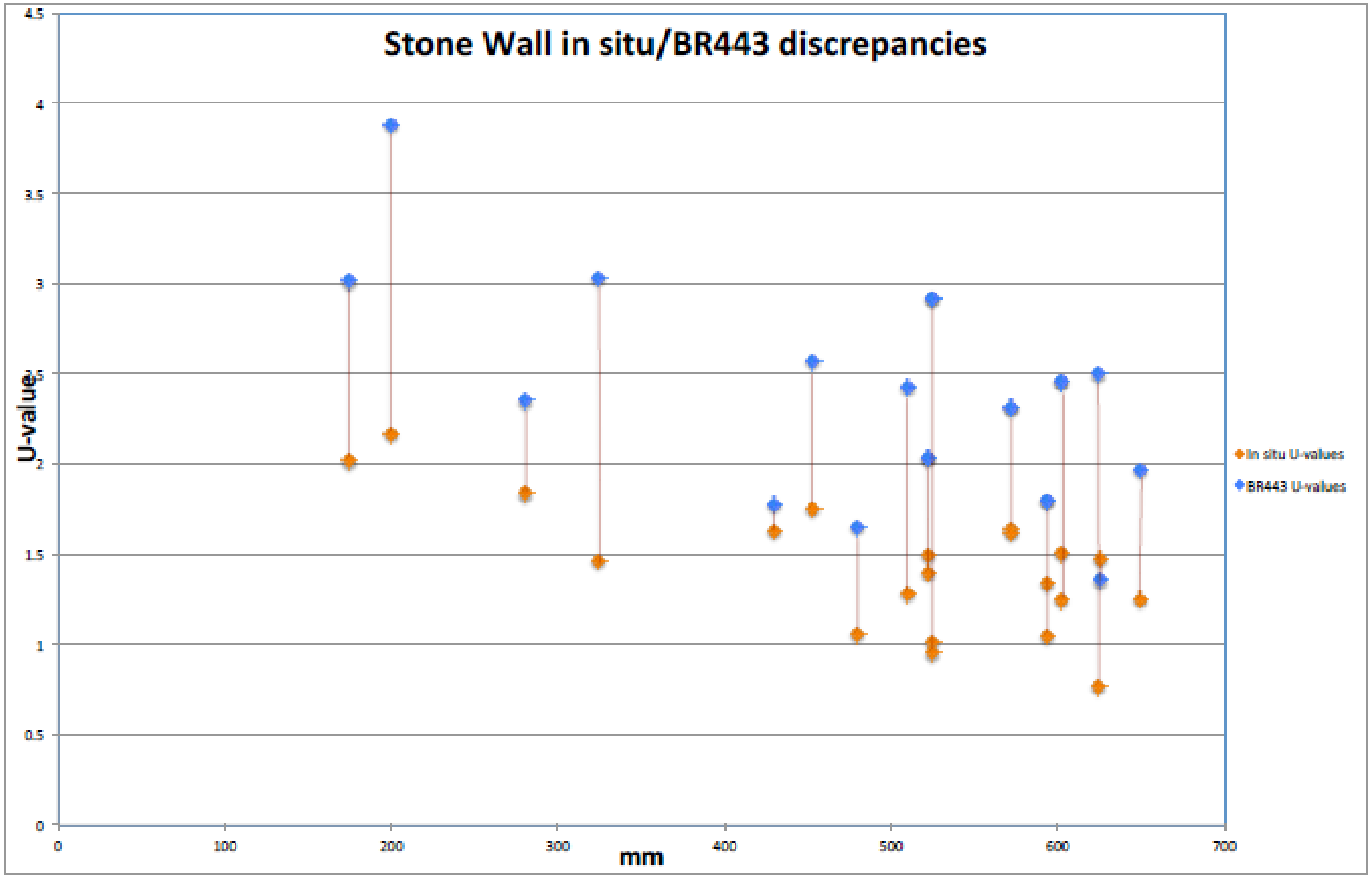
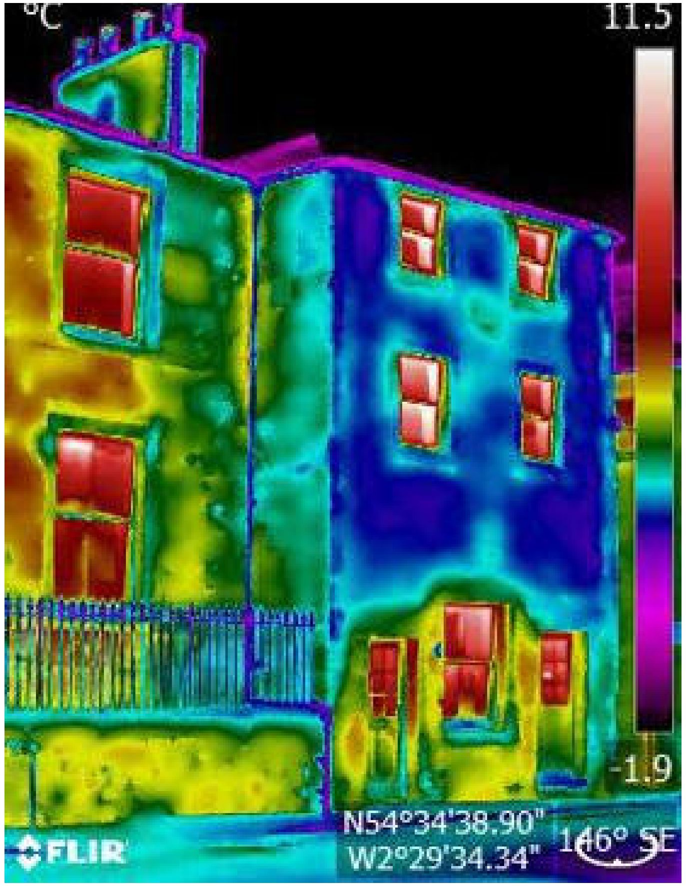


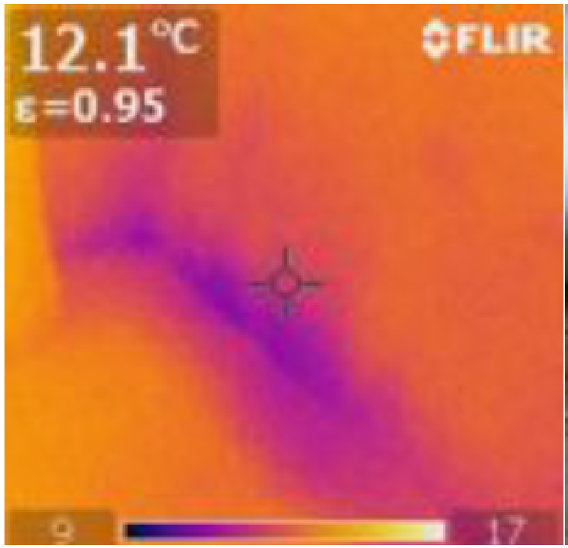
Figure 18. BuildDesk/*in situ* U-value comparison discrepancies for stone walls.

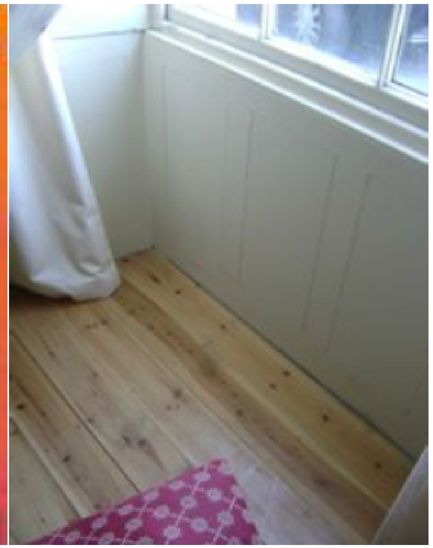
Establishing Existing Performance

Infra-red thermography – thermal imaging

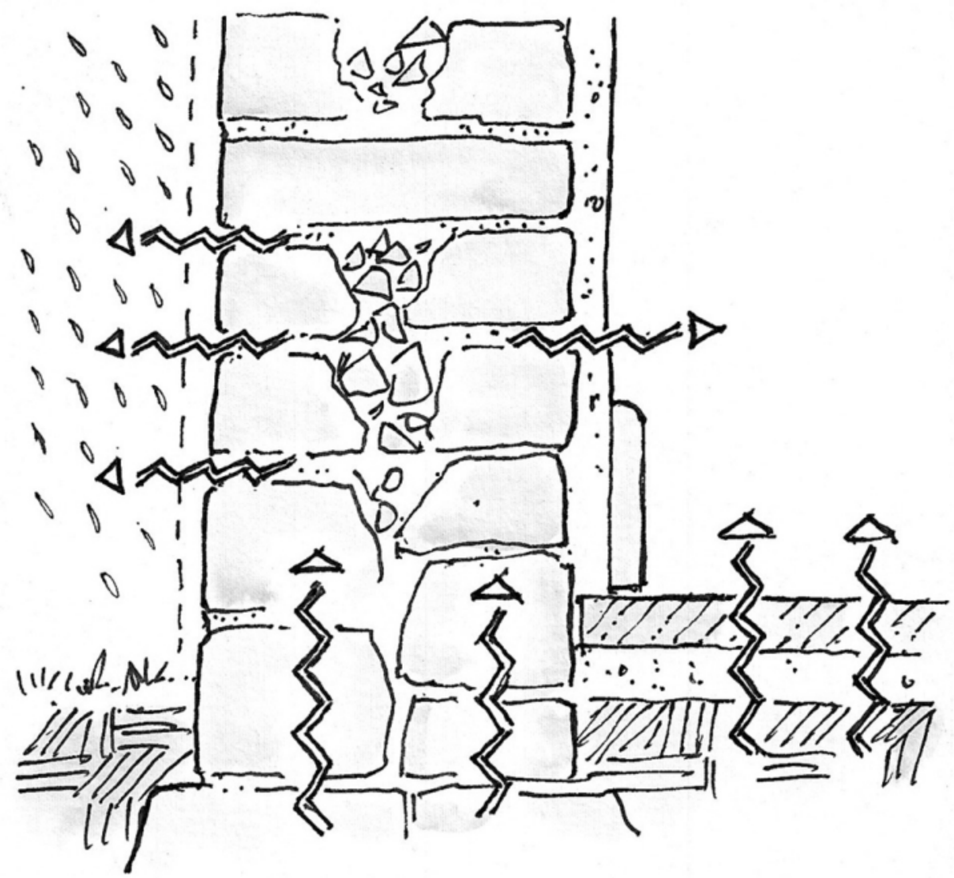
This involves a survey of the external envelope of a building using an infra-red camera, and gives an excellent visual indication of where heat may be escaping. It must be done when a good heat gradient exists through the wall preferably after dark in winter when the building is heated.



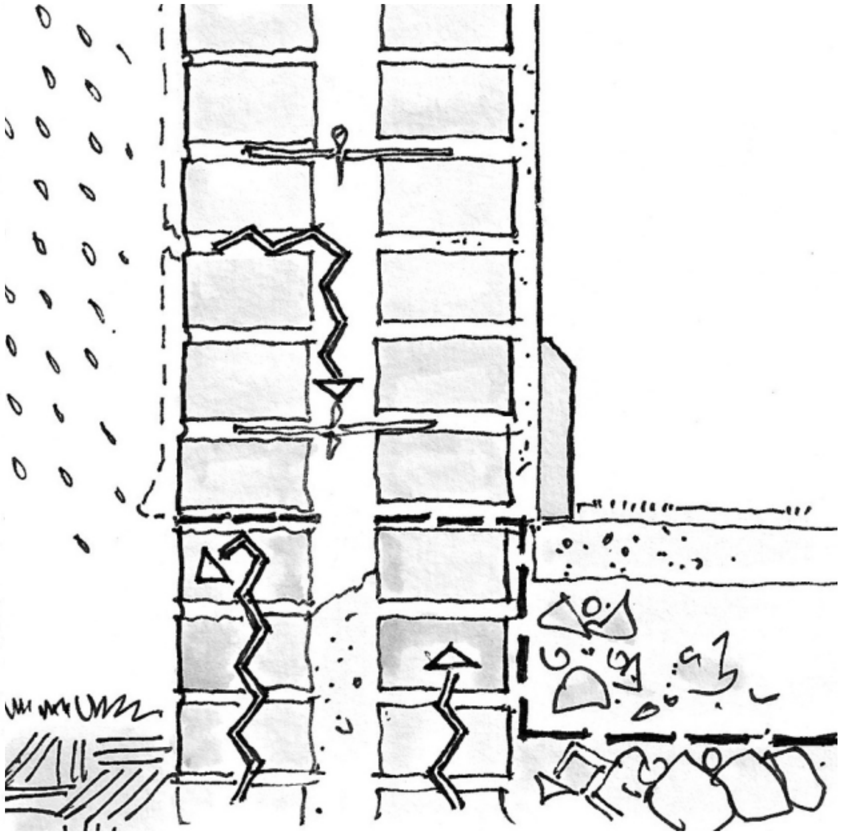




Walls - *the breathing building*

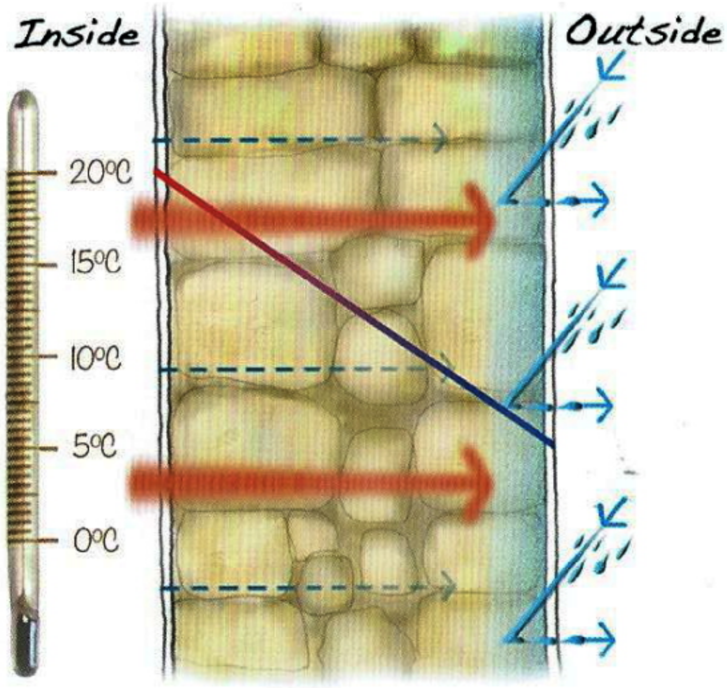


Traditional solid wall construction –
breathable, pervious, flexible materials –
moisture evaporates out

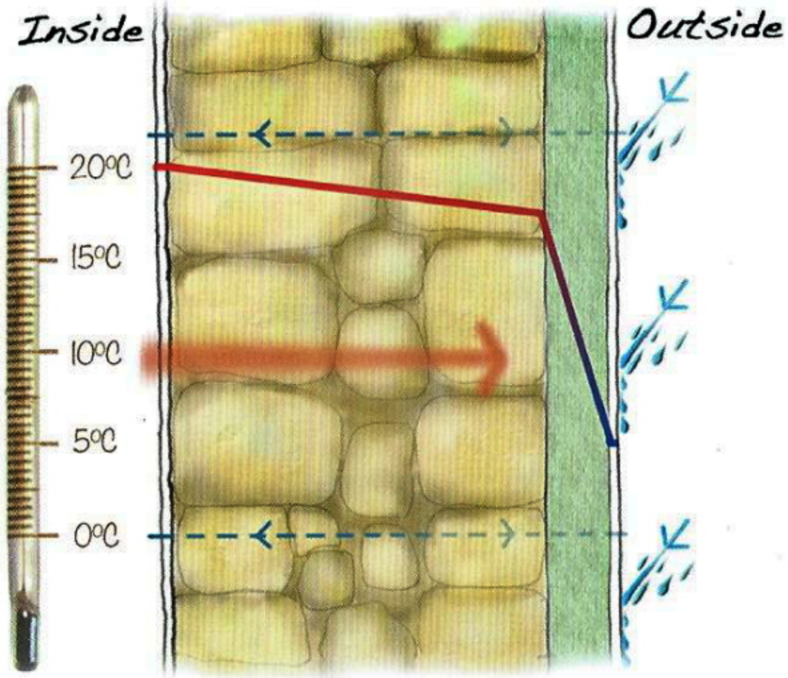


Modern cavity wall construction –
hard, waterproof, impervious, inflexible materials –
barriers to moisture until cracks develop

Walls - *the breathing building* -Hygro-Thermal Behaviour

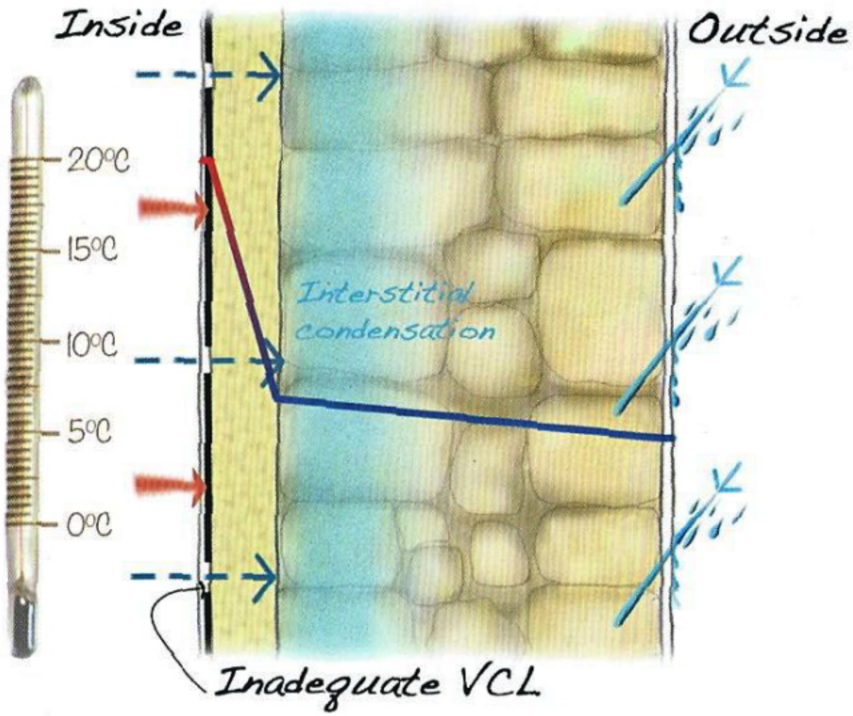


Above: Solid uninsulated walls lose heat via conductivity. This section through a rubble-stone wall shows the internal temperature is 20°C and the external air temperature is 5°C – a typical winter scenario. A graph showing the temperature gradient is plotted over the top, indicated by the red/blue line. In exposed situations, driving rain may penetrate the outside surface and be drawn in via capillary action. Over time the absorbed water evaporates, due to vapour pressure differential, assisted by heat flow through the wall.

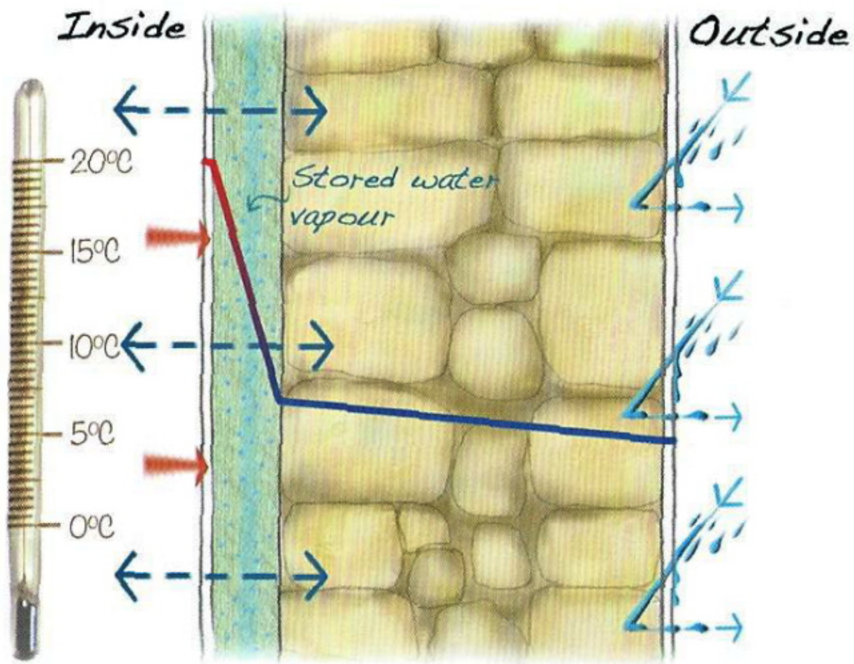


Above: When external insulation is added, the temperature gradient is dramatically altered. The red/blue line shows how the wall remains warm, dropping just a few degrees in temperature across its width, with the majority of the temperature drop occurring across the insulation. A properly specified external insulation should be breathable to allow the passage of water vapour from inside to outside, but resist the absorption of driving rain the other way.

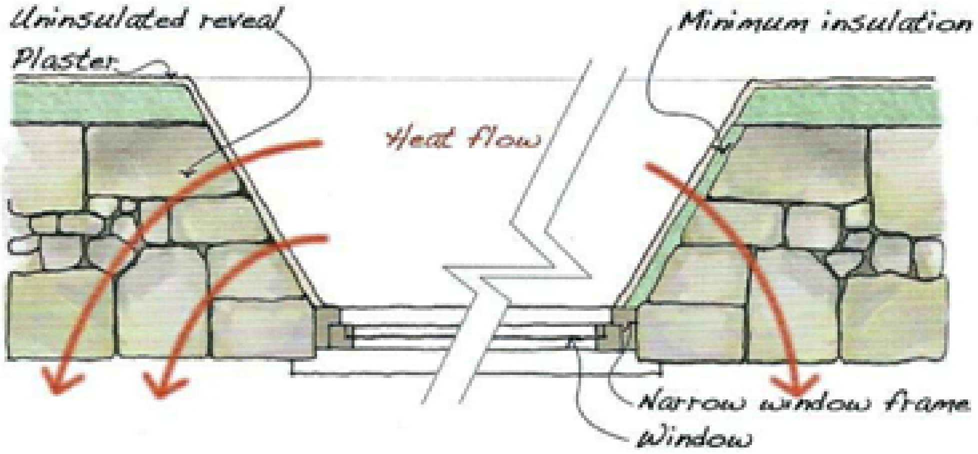
Hygro-Thermal Behaviour

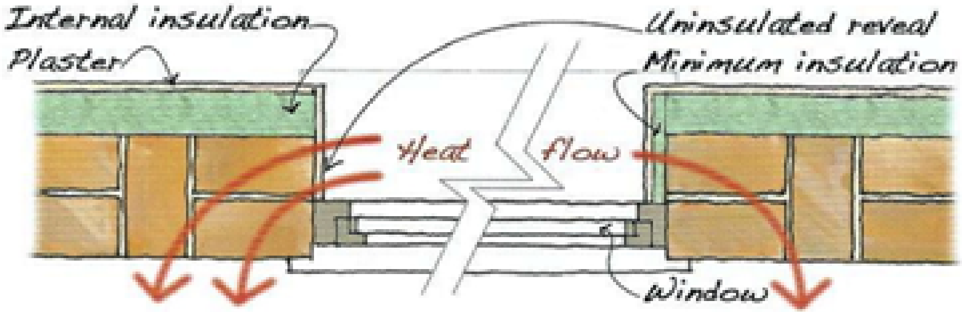


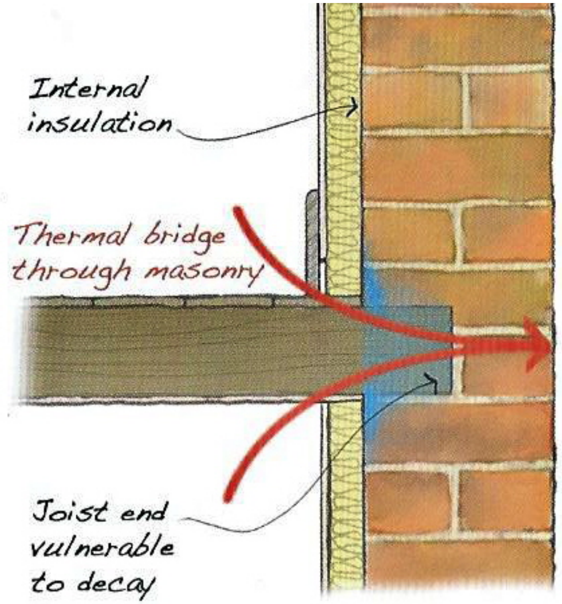
Above: When the VCL is punctured, poorly detailed or not properly taped, water vapour can pass through it and is likely to condense on, or within, the cold masonry wall when it reaches dewpoint temperature. This will cause interstitial condensation where it cannot be seen, and cannot escape.

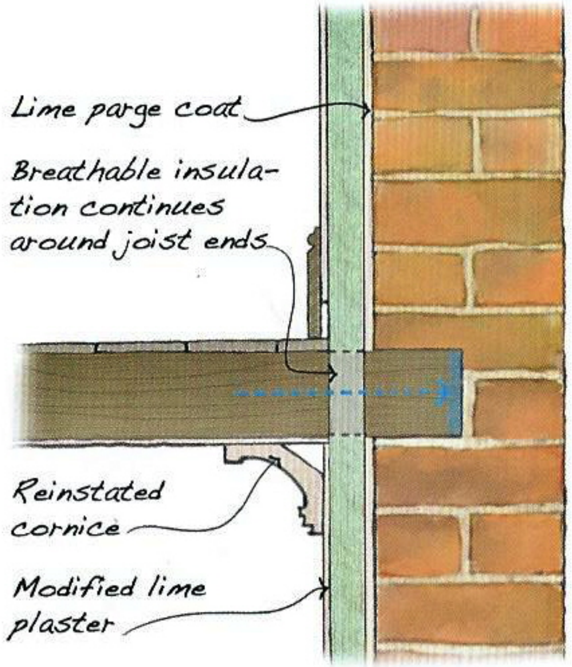


Above: Wood fibreboard is an option for internal insulation on solid walls. Unlike foam boards, its hygroscopic properties allow it to store a certain amount of water vapour, stopping it from reaching the cold masonry and condensing. It also allows a degree of moisture movement and evaporation in both directions. When the internal humidity drops, the stored vapour can evaporate harmlessly back into the room. Too much water vapour would eventually cause saturation of the insulation, and the formation of interstitial condensation.


Uninsulated reveal
Plaster
Heat flow
Minimum insulation
Narrow window frame
Window


Internal insulation
Plaster
Uninsulated reveal
Minimum insulation
Heat
flow
Window


Internal insulation
Thermal bridge through masonry
Joist end vulnerable to decay


Lime parge coat
Breathable insulation continues around joist ends
Reinstated cornice
Modified lime plaster

Material compatibility / types of insulation

There are basically three different types of insulation material:
Organic - those derived from natural vegetation or similar renewable sources, which tend to require a low energy use in manufacture (a low ‘embodied energy’). Examples are sheep’s wool, cellulose, cork, wood fibre, and hemp.

Inorganic - derived from naturally occurring minerals which are non-renewable but plentiful at source. Likely to have a higher embodied energy than organic materials. Examples are mineral/glass fibre, perlite and vermiculite (from volcanic rock) and rigid foamed glass.

Fossil organic - derived by chemical processes from fossilised vegetation (oil) - a finite resource. Fossil organic insulation materials such as expanded polystyrene and are highly processed, resulting in a high embodied energy.

If possible it is better to choose insulation materials that have not been heavily processed as this will reduce the carbon footprint and environmental impact of your home. But is it better to install cheaper inorganic or fossil organic materials with the right physical properties and a low thermal conductivity than to install nothing at all.

Options - Roof

Organic

- Sheepswool Batts
- Hemp and Jute Batts
- Woof Fibre Board
- Blown Cellulose

Breathable

Inorganic

- Glass and Earthwool
- Rock mineral wool

Fossil organic

- Multifoil
- Blown Foam (underside of slates)

Not breathable

Sheepswool bat

Blown foam insulation

© Earthwool

© Warmcell

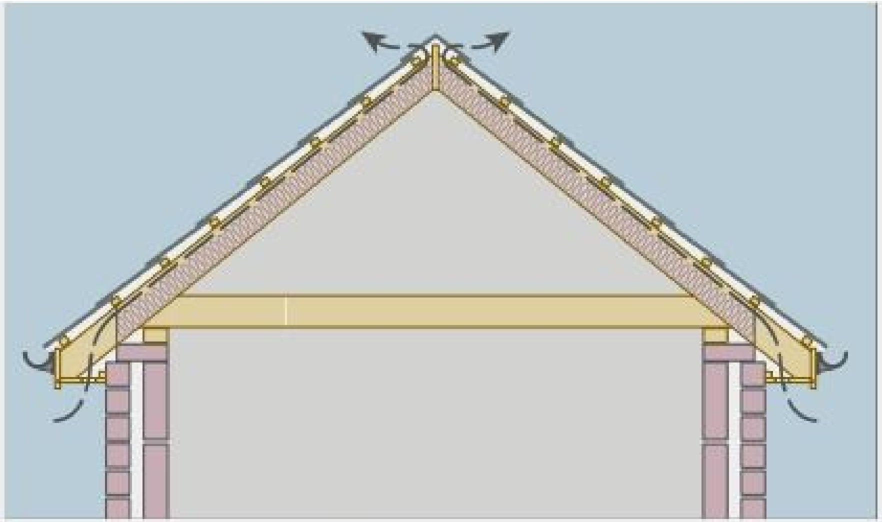
© Therma Fleece

Roof

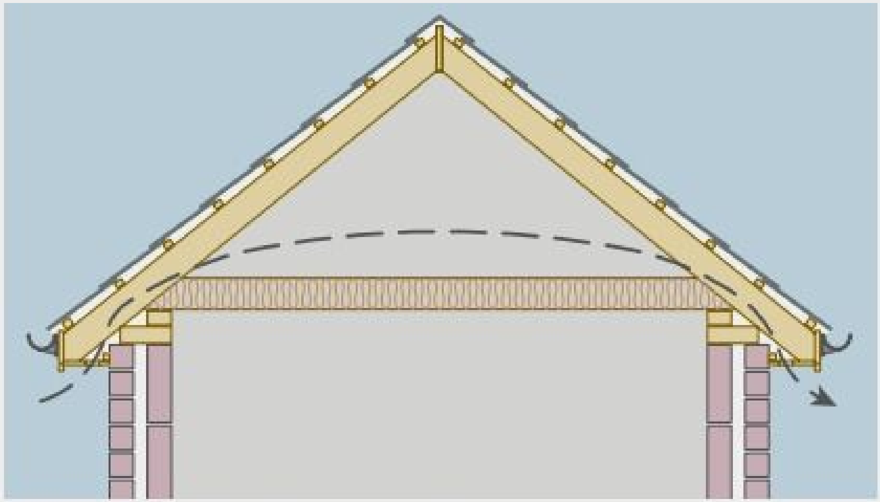
Changing the Environment /Lack of Ventilation

Installation

- Remove old insulation
- Good practice 250mm
- Maintain eaves ventilation
- Insulate water tanks and pipes
- Check electrical fittings that could overheat are not covered



Warm roof insulation at rafter level



Cold roof insulation at ceiling joist level

Laying sheepswool insulation

Options - Walls Internal

Organic

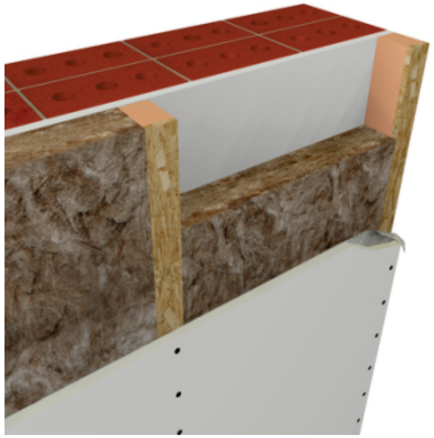
- Sheepswool, Hemp and Jute
- Blown Cellulose
- Woodfibre boards
- Breathable.

Inorganic

- Knauf Eco stud
- Glass or Earthwool
- Rock mineral wool
- Non or semi breathable

Fossil organic

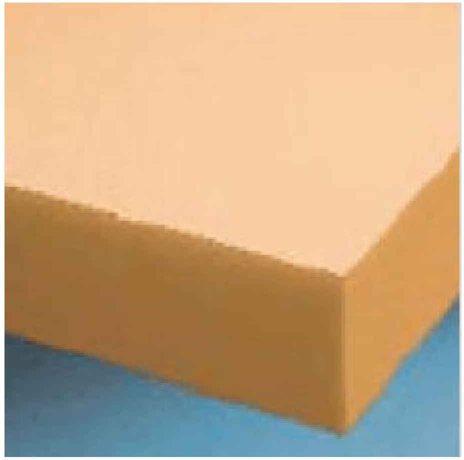
- Closed cell insulation
- Non breathable



© SWIP Internal Wall Insulation

© Calsitherm

© Gutex Woodfibre board



Closed cell insulation

Options – Walls Internal
Insulated Lime Plaster

- Eden Lime (hemp)
- Ty Mawr (hemp)
- Diathonite (cork)

Hemp lime plaster

© Diathonite

Options - Floors

Suspended timber floors

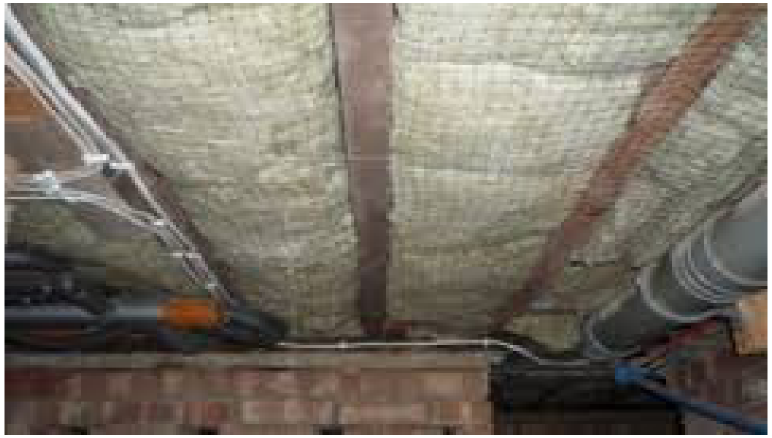
Between timber floor joists off membrane
Maintain underfloor ventilation

- Sheepswool and Hemp Batts
- Glass and Earthwool
- Rock mineral wool
- Multifoil

Solid floors

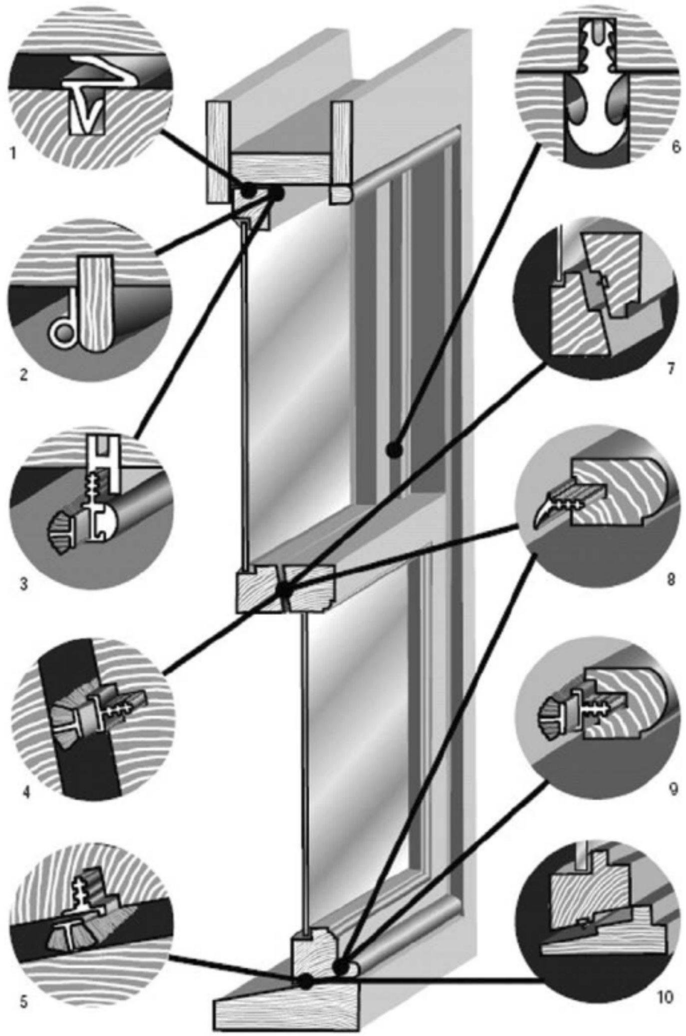
- Limecrete (Hempcrete)
  Breathable

- Concrete with dpm + board insulation
  Not breathable



Windows and Glazing – *overhaul*
Brushes, seals, curtains and shutters

1. Plastic or sprung V- or Z-strip
2. Glued or pinned silicone rubber tubing
3. Parting bead (Ventrolla)
4. Meeting rail brush (Ventrolla)
5. Bottom sash or sill brush (Ventrolla)
6. Parting bead weatherstrip (Mighton)
7. Brush for meeting rails (Draughtseal)
8. Standard weatherseal (Mighton)
9. Staff bead or button rod (Ventrolla)
10. Silicone seal (Draughtseal)



Windows and Glazing

- Double Glazing

Standard when replacing of a complete window, other than to listed buildings require consent.

Reduces immediate energy costs and improves comfort level. It may take years to return cost of manufacture and installation of new window.

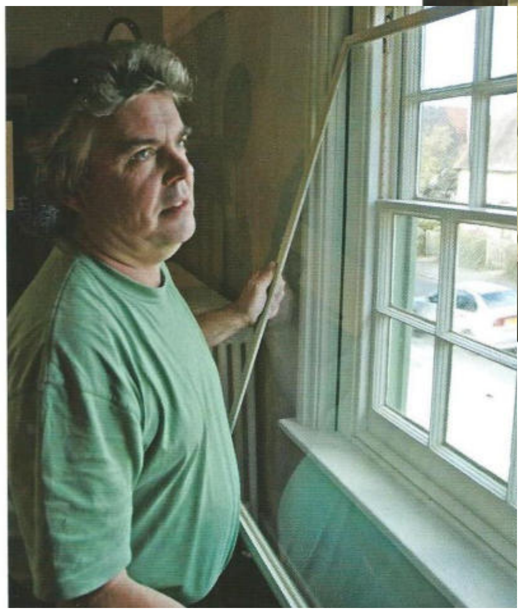
- Upgrading existing / Secondary glazing

Retains existing window and appearance. Can achieve close to performance of new double glazed units

Suppliers include: Clear view / The Plasti People / Ecoease / MagneGlaze Selectaglaze / Storm Windows

Slim double glazed unit

© Changeworks

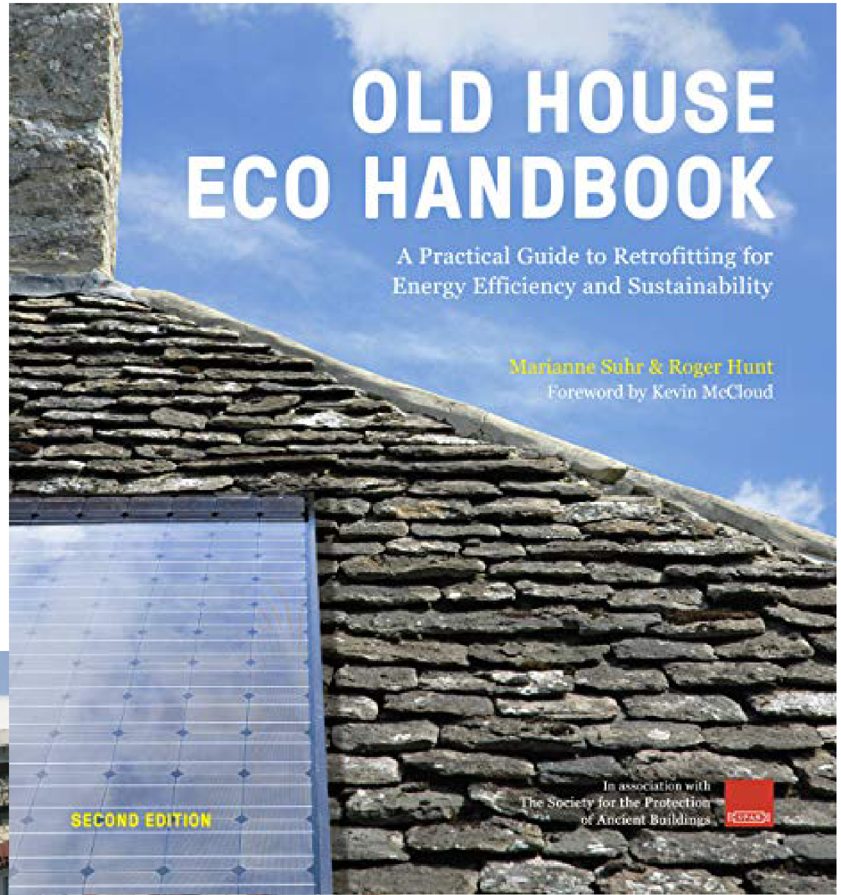


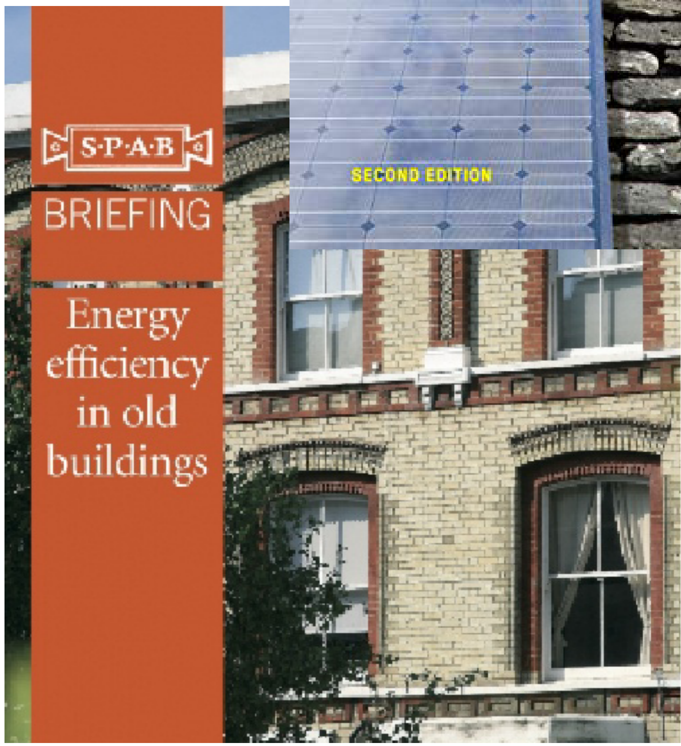
Installing secondary glazing
© SPAB

SPAB Material

- Vapour open principles
- U Value research in situ vs calculated
- Building Performance Survey
- Hygrothermal survey
- https://www.spab.org.uk/advice/energy-efficiency/

- SPAB Eco Handbook.
- Good illustrations.
- Good technical level.
- Courses as well…

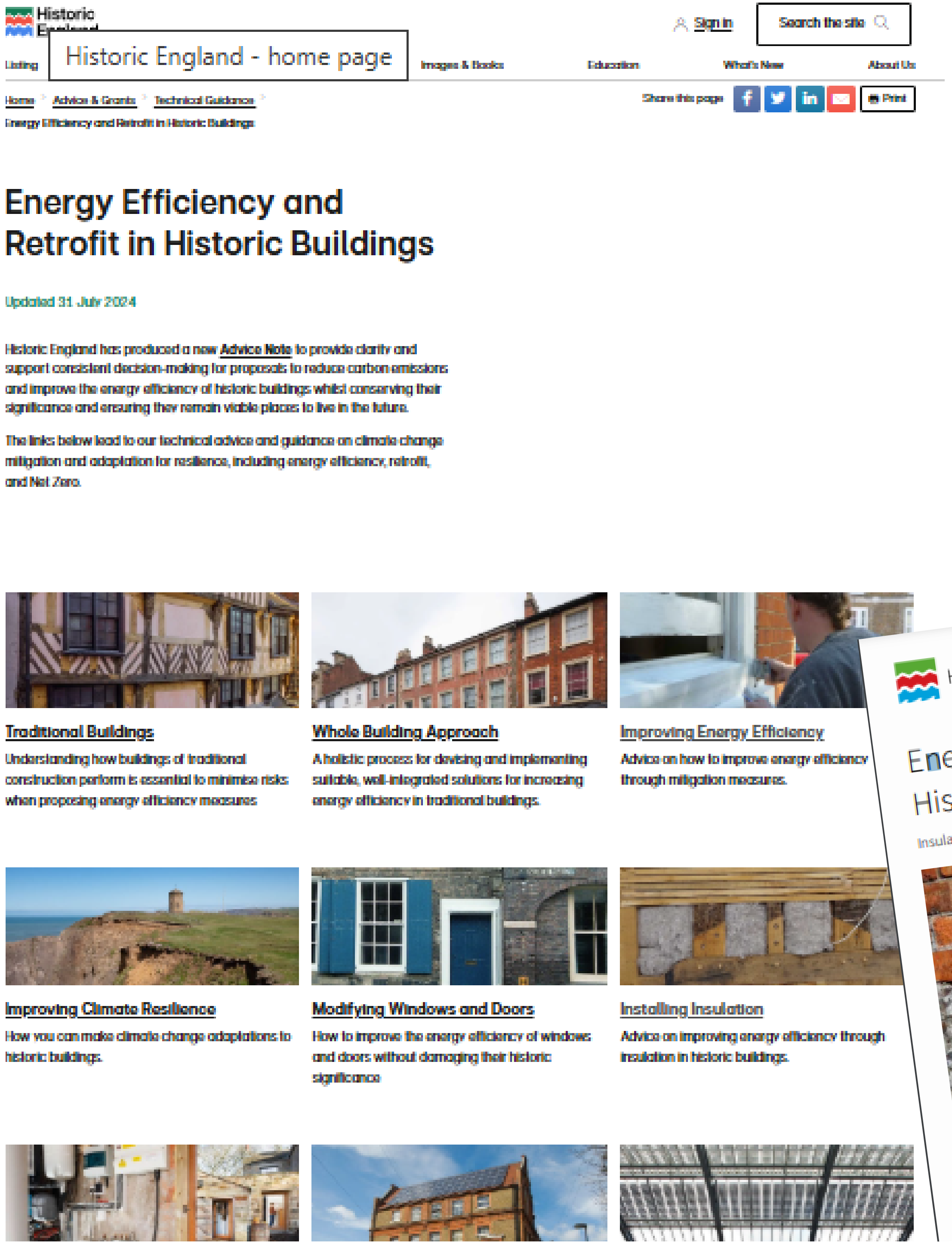




Historic England

(English Heritage)

- Web resource
- Advice on different elements of building
- Advice on reewables.
- Links to other publications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Energy Efficiency and Retrofit in Historic Buildings

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Energy Efficiency and Retrofit in Historic Buildings

Updated 31 July 2024

Historic England has produced a new Advice Note to provide clarity and support consistent decision-making for proposals to reduce carbon emissions and improve the energy efficiency of historic buildings whilst conserving their significance and ensuring they remain viable places to live in the future.

The links below lead to our technical advice and guidance on climate change mitigation and adaptation for resilience, including energy efficiency, retrofit, and Net Zero.

Traditional Buildings
Understanding how buildings of traditional construction perform is essential to minimise risks when proposing energy efficiency measures

Whole Building Approach
A holistic process for devising and implementing suitable, well-integrated solutions for increasing energy efficiency in traditional buildings.

Improving Energy Efficiency
Advice on how to improve energy efficiency through mitigation measures.

Improving Climate Resilience
How you can make climate change adaptations to historic buildings.

Modifying Windows and Doors
How to improve the energy efficiency of windows and doors without damaging their historic significance

Installing Insulation
Advice on improving energy efficiency through insulation in historic buildings.

Historic Environment Scotland - Short Guides & Refurbishment Case Studies

Short Guides

- Advice documents
- Issues to consider
- Illustrations of details
- Links to Technical papers

Refurbishment Case Studies

- Description of site work
- Abbreviated monitoring results
- Wider factors discussed
- Some cost information

James Innerdale
E: jamesinnerdale@yahoo.co.uk

The SPAB
W: spab.org.uk
Technical Advice Line: 020 7456 0916
E: info@spab.org.uk