Eco-Retrofit for Householders
Unit 3: Insulation

Richard Shears
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Contact details

Training by:

PEOPLE POWERED RETROFIT

For:

Towards Zero Carbon Cumbria
CAfS
Cumbria Action for Sustainability

Agenda

- Introductions
- Recap: the Whole House Approach
- Why insulate?
- Insulation approaches and materials
- Insulation performance: thermal conductivity and U-values
- Regulations, standards, and quality
- Wrap-up
- Q&A

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Introductions

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Recap:
Whole House Retrofit

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Which systems interact in a whole house retrofit?

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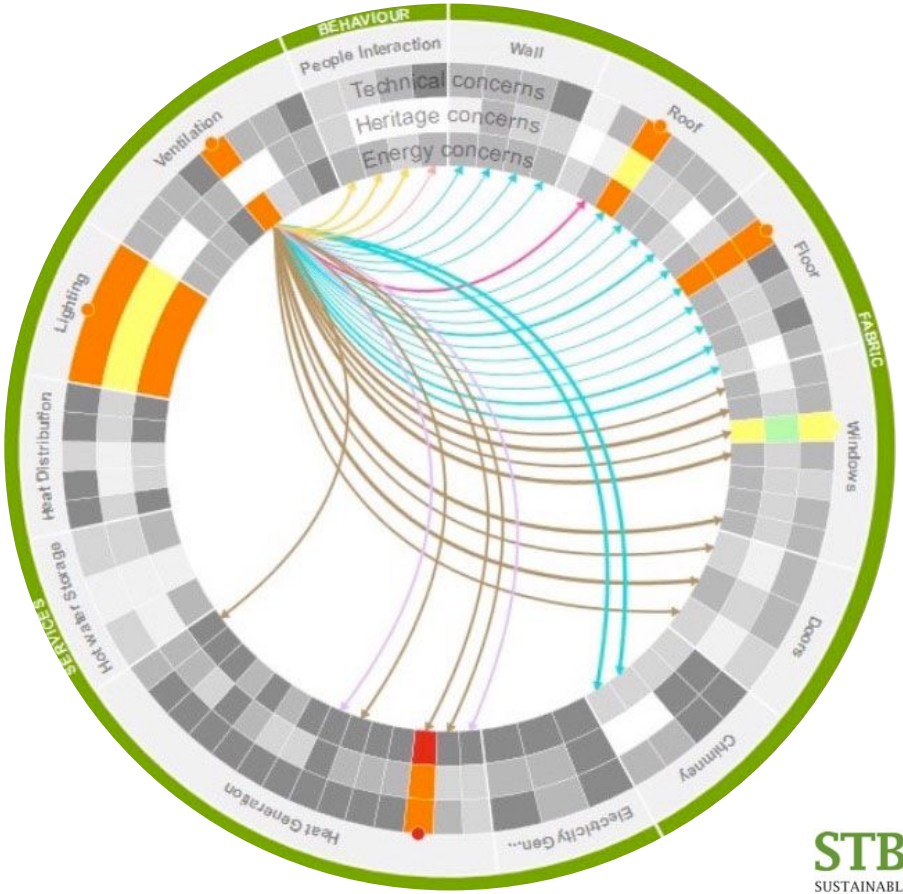
The Whole House Approach

- Houses are complex systems
- Context specific and ‘risk management’ approach
- Be aware of potential unintended consequences
- Any new measures must be well considered, well designed, well installed and understood by the resident



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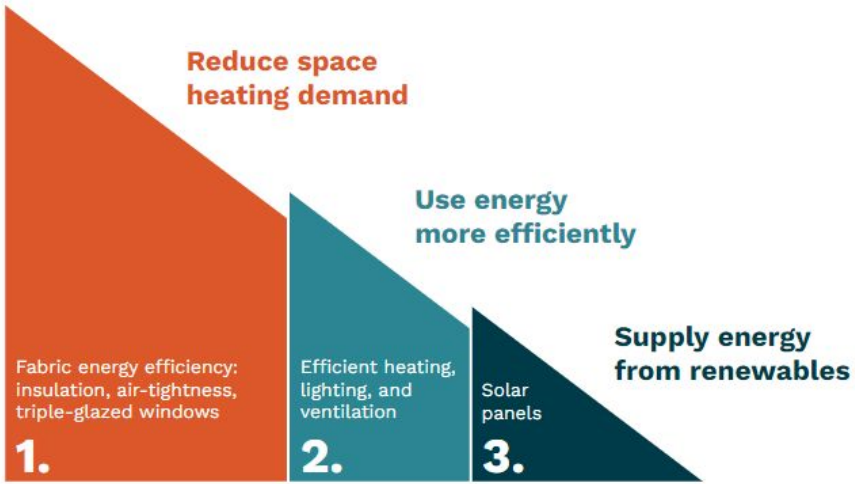
STBA
SUSTAINABLE TRADITIONAL BUILDINGS ALLIANCE

http://responsible-retrofit.org/wheel/

The Whole House Approach - Fabric First



Why?

- More effective building services
- Lower maintenance
- No unnecessary ‘eco-bling’
- Reduced ongoing costs
- Better living conditions

- Reduces fuel poverty
- Future-proofs homes
- Easier approach to meeting target CO2 savings

Why insulate?

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Why insulate?

- Address fabric heat loss
- Reduce space heating demand
- Reduce peak heating demand
- Improve comfort

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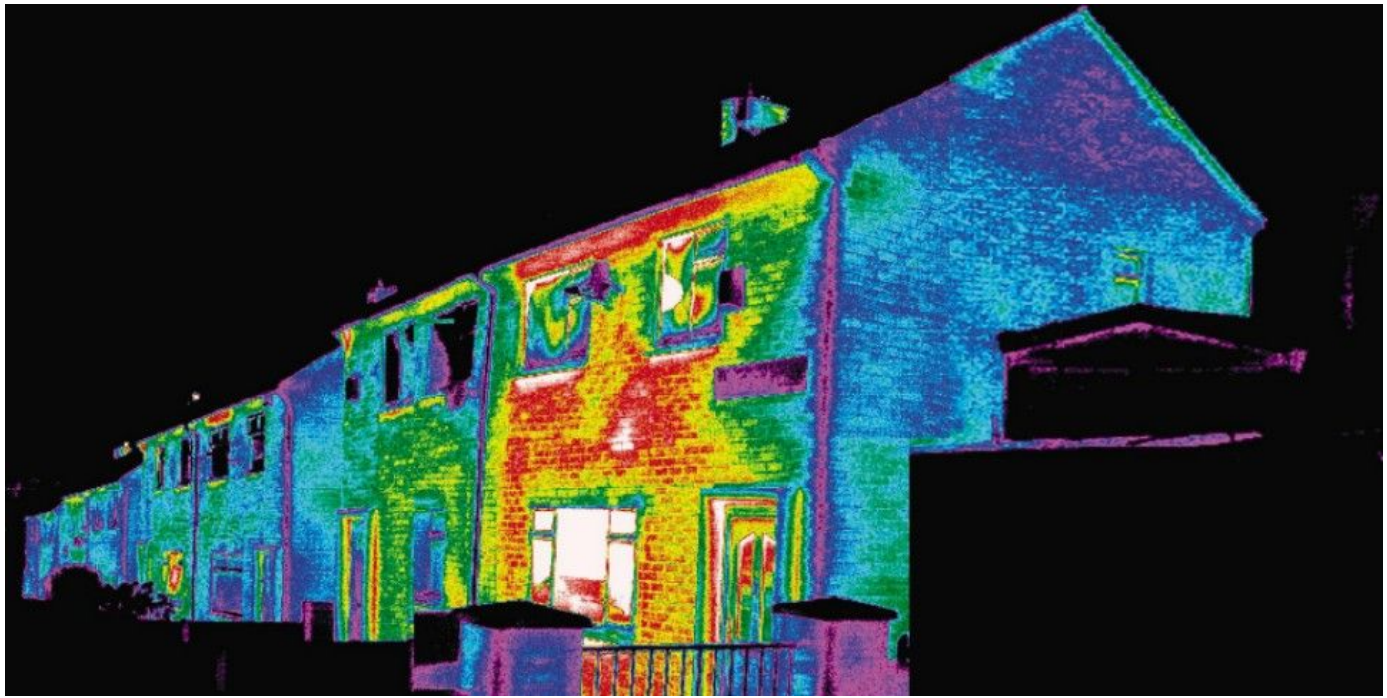
Address heat loss



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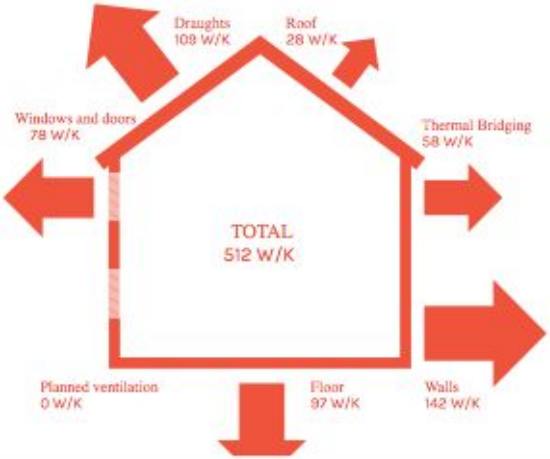
Address heat loss



Reducing heat loss

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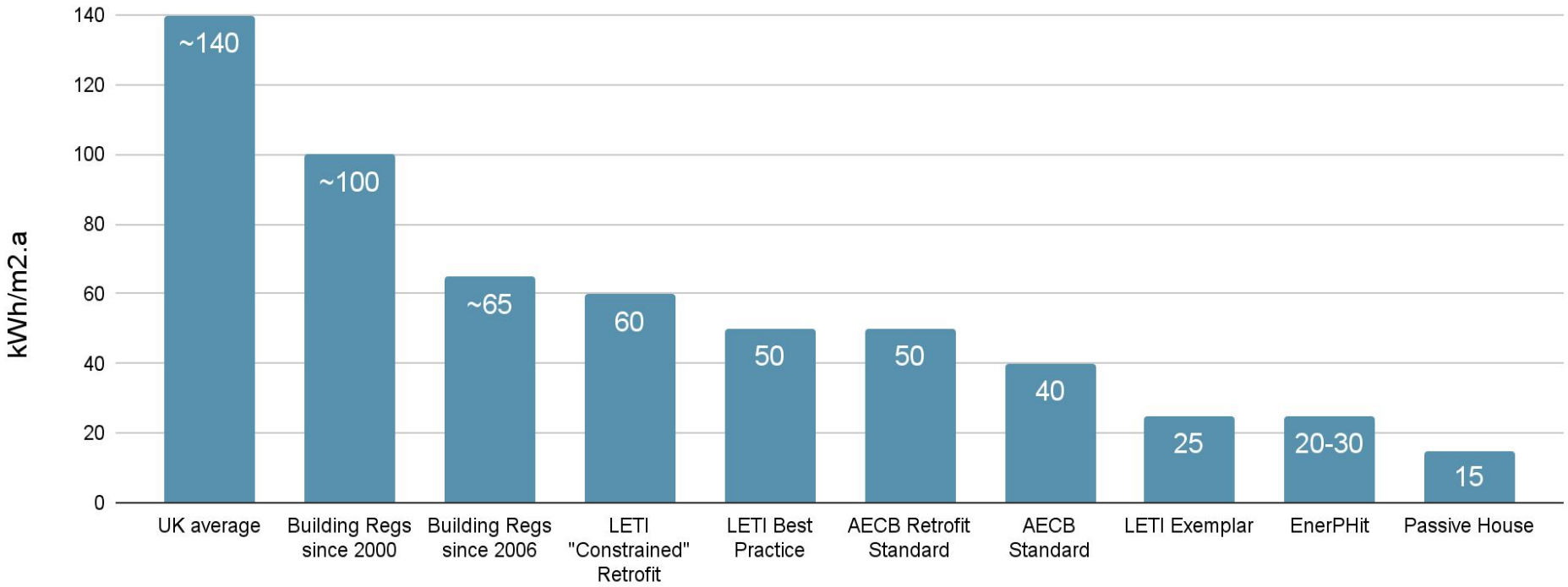
Space Heating Demand (kWh/m2.a)



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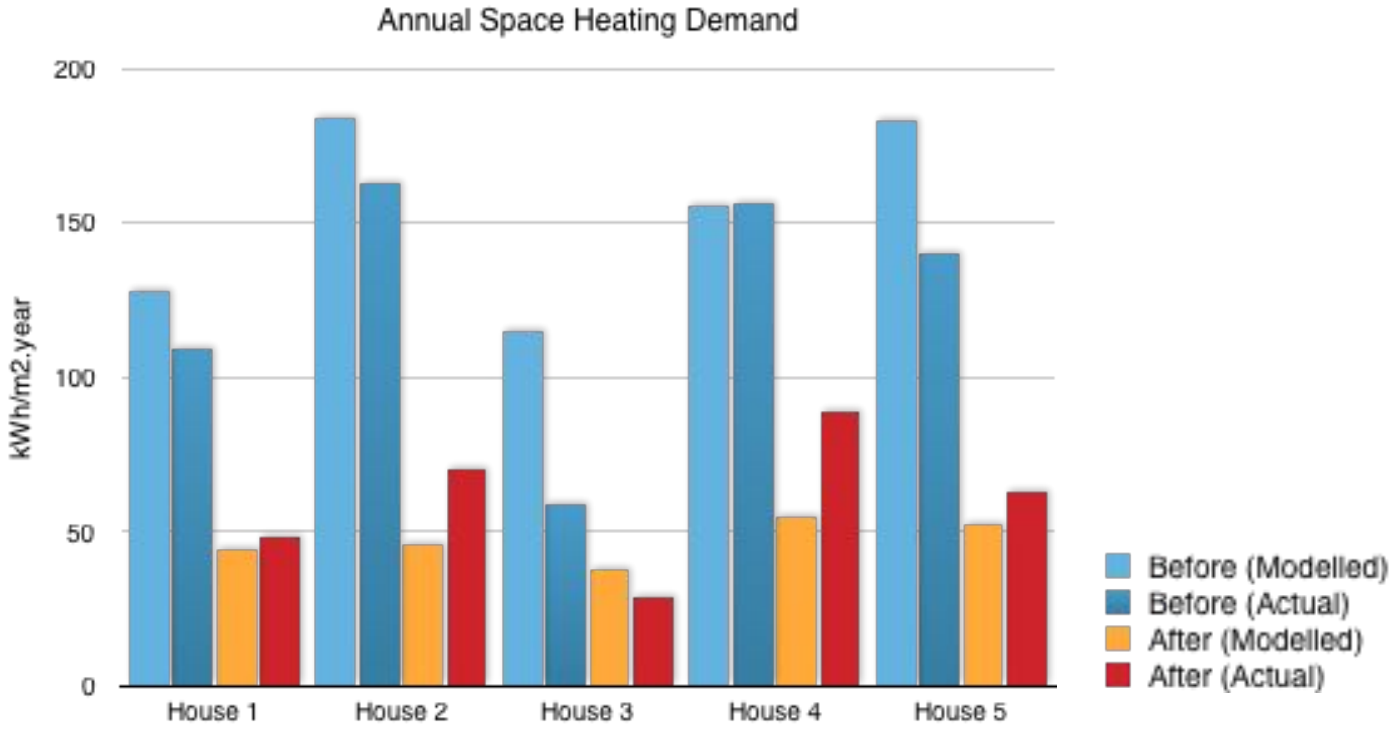
What's possible in retrofit?



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http://carbon.coop/sites/default/files/attachments/2017-06-22/20170622%20Powering%20Down%20Together%20case%20study%20-%20full%20report.pdf

Peak Heating Demand (w/K* design temperature)

Rate of heat input a building needs to maintain a comfortable internal temperature at peak usage e.g. cloudy, cold winter day

Used to:

- Sizing heating systems e.g. heat pump/radiators
- Considering impact on individual houses and impact on the grid (demand vs. capacity)

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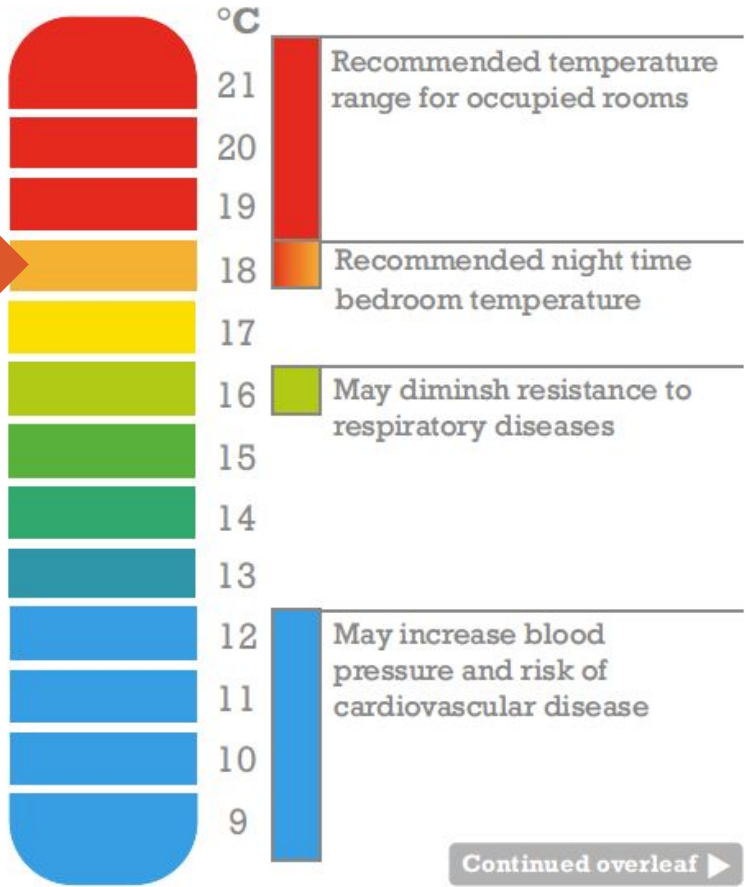
Improve comfort: Meet heating targets

Recommended minimum internal temperature for all occupied rooms by PHE



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Improve comfort: Addressing cold

Keeping warm when it’s cold

Insulation:

- Reduces conduction
- Raises surface temperatures

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Improve comfort: Addressing heat

Keeping cool when it’s hot

Consider:

- Position and amount of windows/glass
- Shade
- ‘Decrement delay’
- Ventilation
- Building services

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Insulation approaches and materials

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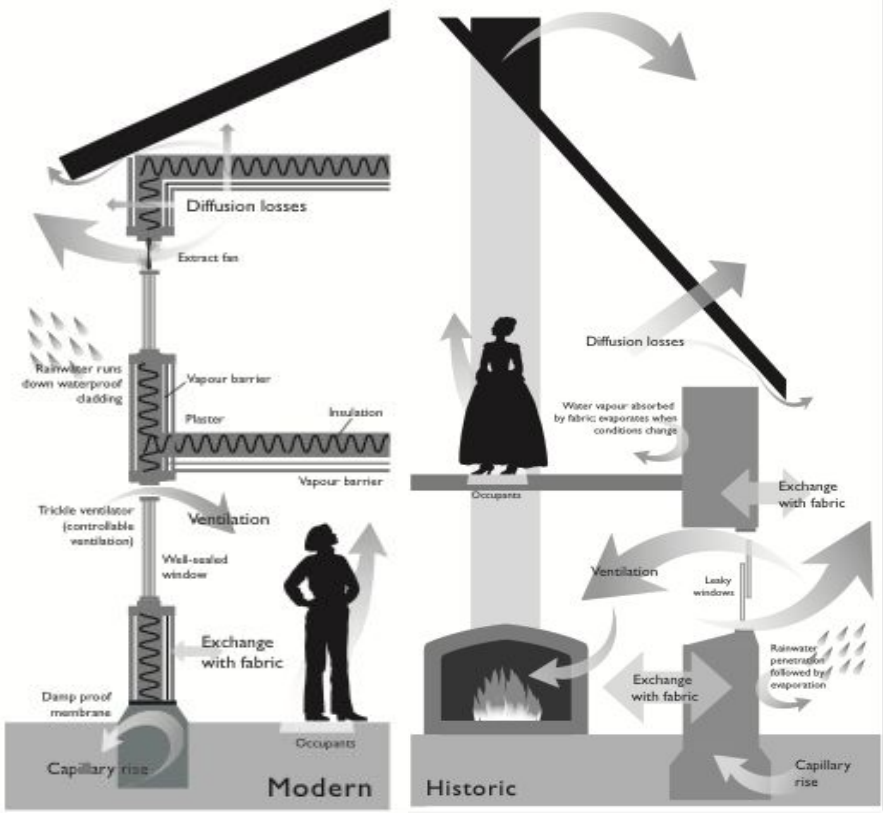
Building types

Modern homes:

- Central heating
- Double-glazing
- Draught-proofing



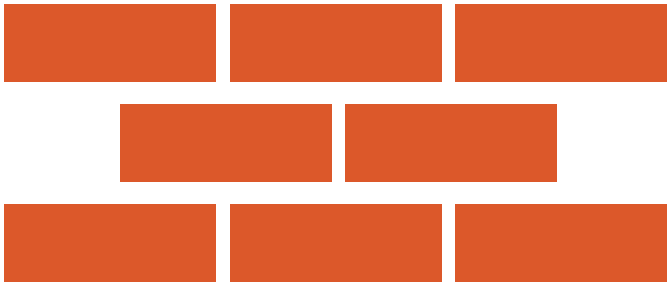
Older homes:

- Coal fires
- ‘Breathable’ materials

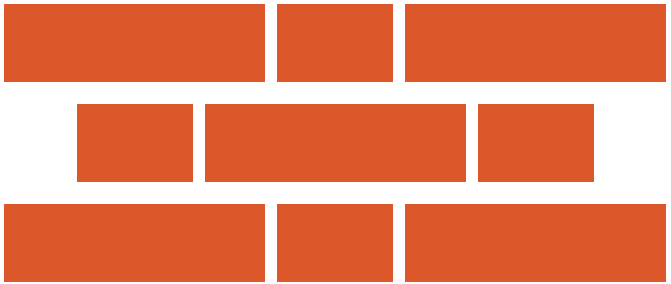
http://www.english-heritage.org.uk/publications/energy-efficiency-historic-buildings-ptl/

Walls

Cavity wall



Solid wall



Not always easy to tell the difference!

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Walls: Cavity wall insulation

- Injecting polystyrene beads or mineral fibre
- Solutions available for narrower cavities and those difficult to access
- Requires professional installation
- https://ciga.co.uk/
- Can be combined with EWI

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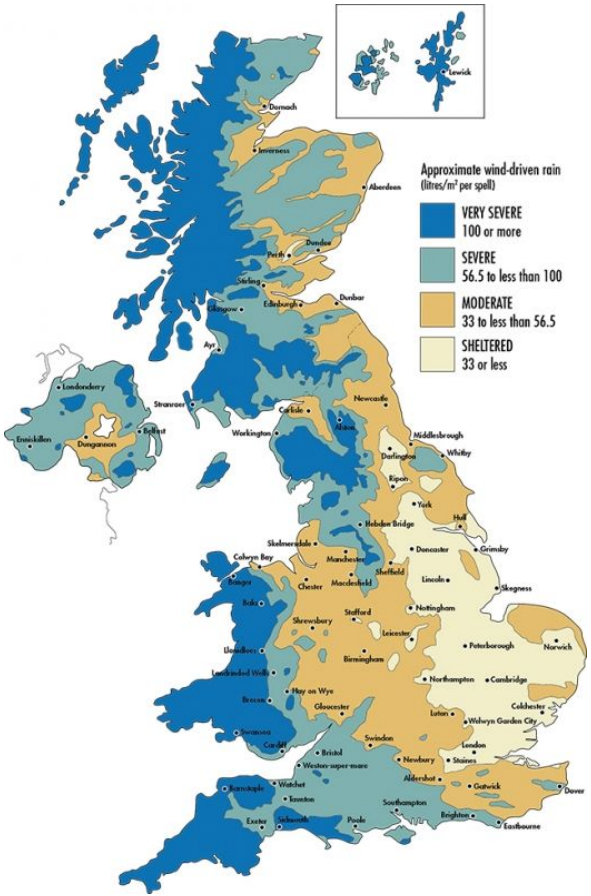
Walls: Cavity wall insulation



Benefits

- Can reduce heat loss through the wall by ~75%
- Quick and minimal disruption

Take care

- Exposure and wind-driven rain (see LABC map)
- Condition of the cavity
- Off-gassing
- Vents sleeved?
- Holes plugged afterwards?
- Full fill (avoiding cold spots)
- Closures: window/door openings; top of walls
- Difficult to extract if done wrong

https://www.labc.co.uk/news/full-fill-masonry-cavity-walls-and-exposure-wind-driven-rain

Walls: External wall insulation (EWI)

- Insulation fixed to outside walls
- Solid or cavity walls (if cavity checked and filled)
- Render, cladding, brick slip finish or tile hanging

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Walls: External wall insulation (EWI)

Figure 24 Note large areas of exposed building elements

Figure 25 Large thermal bridge created by lamppost

Benefits

- No loss of internal living space
- Minimal internal disruption

Take care

- Details (see images), ventilation, cold bridges
- Planning permission
- Additional costs: scaffolding, party wall, moving services, excavation etc.
- Fire risks: combustible materials and surface spread of flame
- Material choice

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Image credit and further reading:
https://historicengland.org.uk/research/results/reports/88-2014/ExternalWallInsulationinTraditionalBuildings

Walls: Internal wall insulation (IWI)

- Insulation added to internal walls
- Solid walls
- External aesthetics

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Walls: Internal wall insulation (IWI)

Benefits

- Maintains external appearance of the home
- One room at a time is possible (if you ensure joining for thermal and air-tight performance)

Take care

- Disruptive and messy!
- Condition of external wall and level of exposure
- Requires good understanding of moisture movement through walls and airtightness skills
- Hanging pictures/shelves etc. afterwards!

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Walls: Multiple methods

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Roofs and lofts

- Insulation added to the floor of a loft space or at rafter level
- Installed from above or below

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Walls: Roof/Loft Insulation

Benefits

- Can be DIY
- Very cost-effective
- Material choice – including recycled options

Take care

- Condensation!
- Storage
- Cold water tank
- Electrical cables and recessed lighting

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Floors

Insulation between joists (suspended timber floor) or above/below a concrete slab.

Typically 200mm (between joists) or 100 – 160mm (concrete slab)

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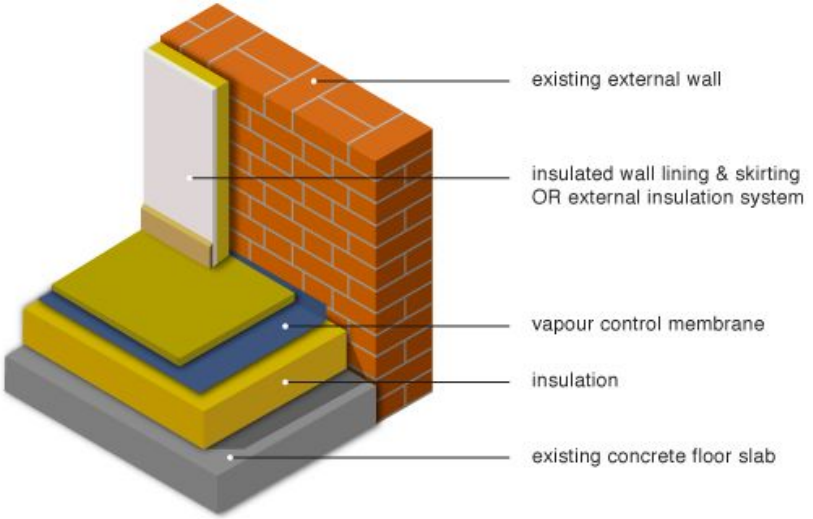
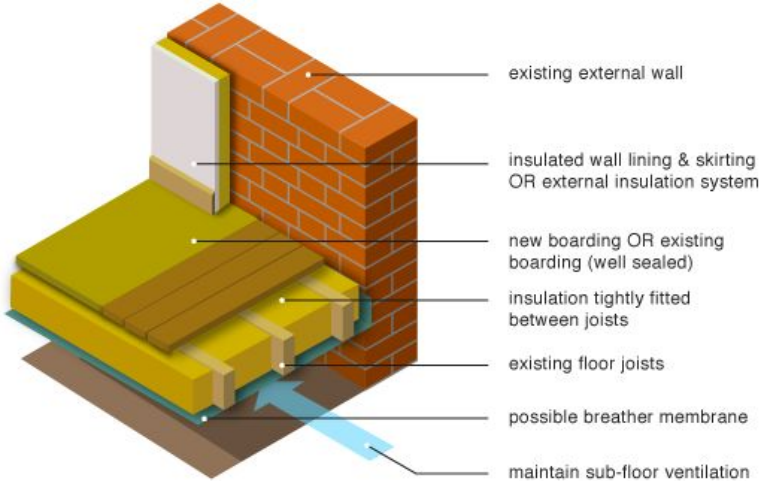
Floors

Upgrading an existing slab



- Dig up and replace
- Leave and insulate at perimeter

Upgrading an existing suspended timber floor



Floors

Benefits

Comfort

Less disruptive (if accessible)

Take care

Access to sub-floor void

Maintain sub-floor ventilation

Check condition of existing floor carefully

Joins with wall insulation

Airtightness

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Considerations when choosing insulating materials

- Petrochemical vs.non-petrochemical
- Fibre vs.foam
- Flexible vs.rigid
- Vapour permeability
- Diffusion
- Capillary action
- Thermal conductivity
- Fire retardancy
- Price

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Insulating materials: Examples


Mineral wool


Wood fibre

Phenolic


Expanded polystyrene (EPS)


Aerogel

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Windows and doors

Double/triple glazing

Low-e glass

Filled with inert gas e.g. argon, krypton etc.

Warm edge spacers

Can reduce fabric and draught heat-loss

Secondary glazing

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Windows and doors

Benefits

Comfort

Noise

Take care

Installation key to reduce air leakage

Refurbishing existing frames – cost vs. performance

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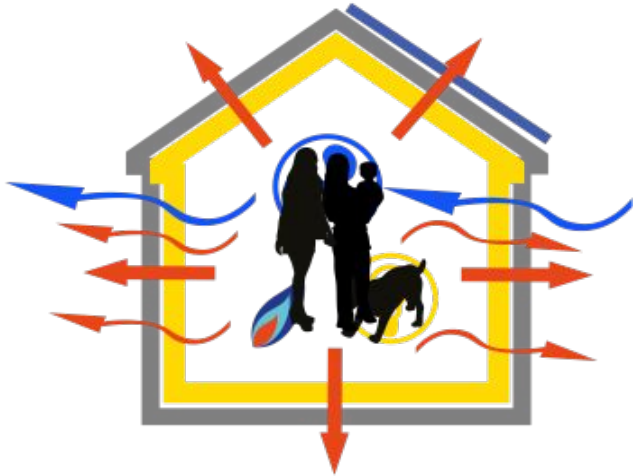
Reminder: Whole house Approach

Insulation +

Air-tightness +

Ventilation



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Knowledge check

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What features should you consider when choosing insulating materials, and why?

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Insulation performance: thermal conductivity and U-values

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Thermal conductivity

Table 1

Material	Thermal conductivity (W/m K)
Copper	390
Aluminium	237
Steel	43
Dense concrete (2100 kg/m^3)	1.40
Glass	0.93
Plasterboard	0.21
Polystyrene	0.15
Timber (650 kg/m^3)	0.14
Mineral wool slab (25 kg/m^3)*	0.035
Expanded Polystyrene (EPS)*	0.032-0.040
Extruded Polystyrene (XPS)*	0.029-0.038
Polyurethane (PUR)*	0.022-0.035
Polyisocyanurate (PIR)*	0.022-0.028

*These are fibre and foamed materials, not solid.

Lower score = more insulating

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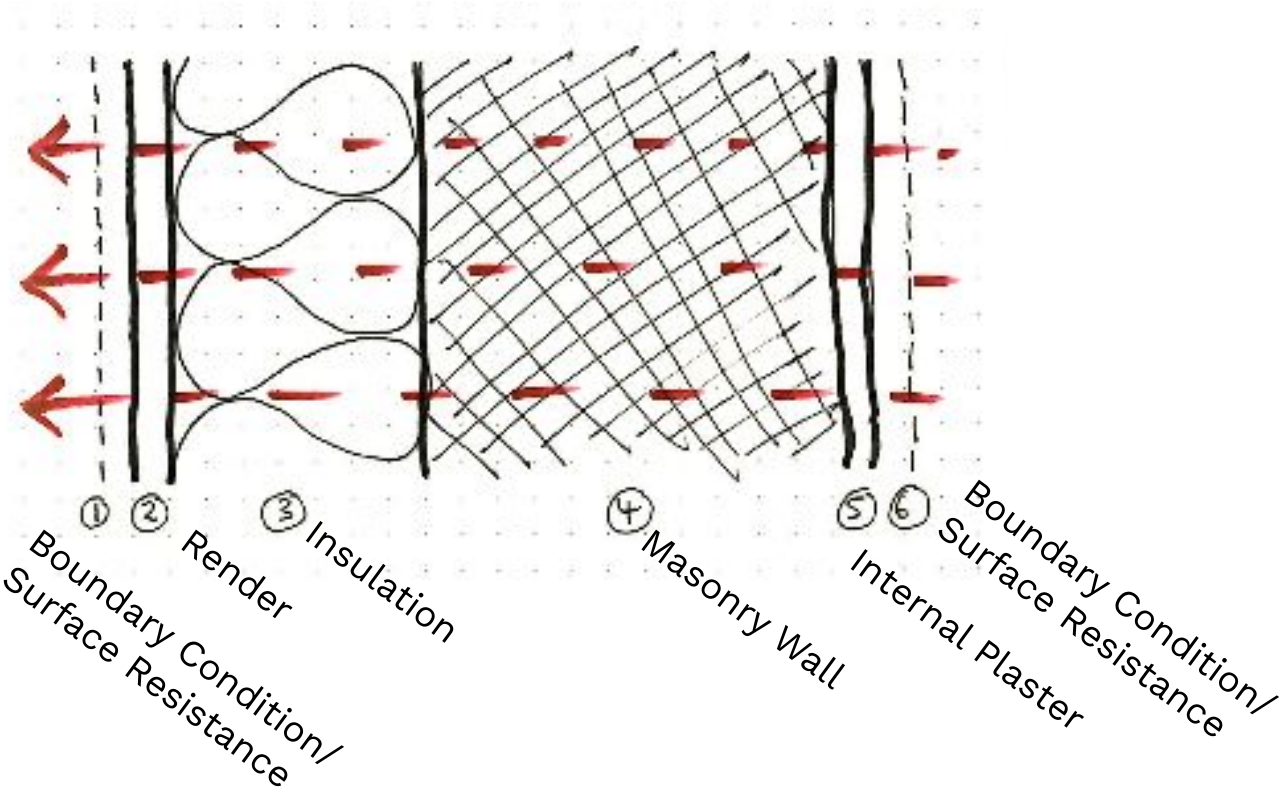
http://www.greenspec.co.uk/building-design/insulation-materials-thermal-

U-values



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http://www.greenspec.co.uk/building-design/u-value-introduction/

Typical U-values

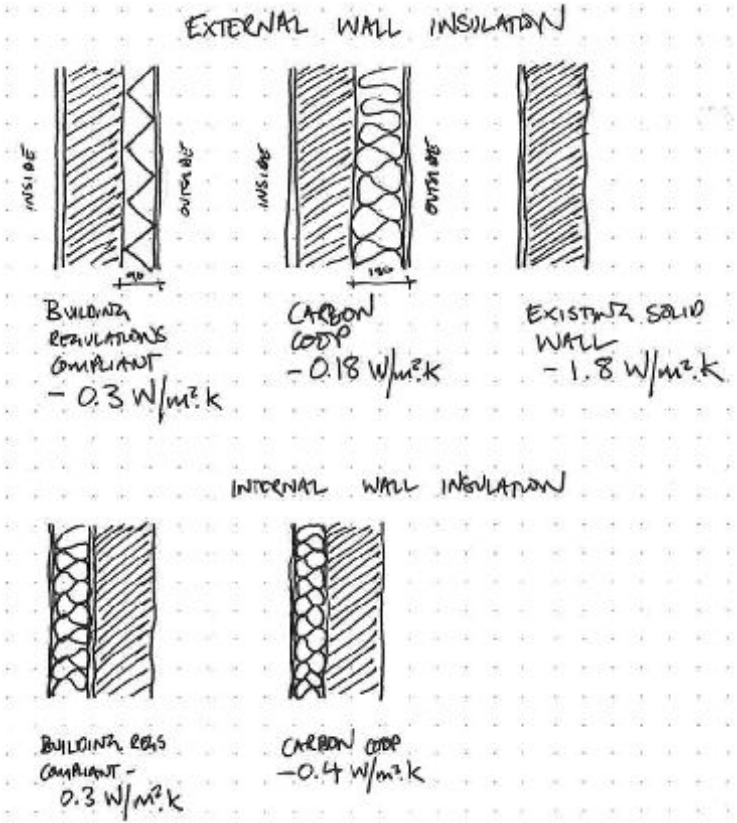
- Un-insulated roof: 2.5 W/m^2.K
- Insulated roof (at rafters): 0.16 W/m^2.K
- Insulate loft (at ceiling): 0.11 W/m^2.K

- Uninsulated Floor: 0.8 W/m^2.K
- Solid floor (perimeter insulation only: 0.45W/m^2.K
- Fully Insulated Floor: 0.2 W/m^2.K

- Uninsulated Solid Wall: 1.7-2.1 W/m^2.K
- Uninsulated Cavity Wall: 1.5 W/m^2.K

- Insulated Cavity Wall: 0.4 W/m^2.K
- External Wall Insulation: 0.3-0.15 W/m^2.K
- Internal Wall Insulation: 0.4 W/m^2.K

- Single glazed window: 5.6 W/m^2.K
- Double glazed window: 1.2-2.4 W/m^2.K
- Triple glazed window: 0.6-1.1 W/m^2.



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Typical U-values in practice

A 10 square metre area of wall has a U-value of 2 W/m2.K

The internal temperature is 20C. The external temperature is 0C.

What is the rate of heat loss through the wall?

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Typical U-values in practice

A **10** square metre area of uninsulated solid wall has a U-value of **1.8** W/m2.K

The internal temperature is **20**C. The external temperature is 0C.

What is the rate of heat loss through the wall?

= 10 x 1.8 x 20

= 360 Watt

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Typical U-values in practice

Rate of heat loss through wall = 360 Watt

How much energy is lost through the wall in two hours, if the temperature stays the same?

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Typical U-values in practice

Rate of heat loss through wall = 360 Watt

How much energy is lost through the wall in two hours, if the temperature stays the same?

= **360 Watt** x **2** hours

= **720 Watt** hours

= **0.72kWh**

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Typical U-values in practice

Uninsulated wall: 0.72kWh lost in two hours

How does this change if we consider a 10 square metre area of solid wall with external wall insulation, with a U-value of 0.3 W/m2.K, in the same conditions?

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Typical U-values in practice

A 10 square metre area of externally insulated solid wall has a U-value of 0.3 W/m2.K

The internal temperature is 20C. The external temperature is 0C.

What is the rate of heat loss through the wall?

= 10 x 0.3 x 20

= 60 Watt

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Typical U-values in practice

Rate of heat loss through wall = 60 Watt

How much energy is lost through the wall in two hours, if the temperature stays the same?

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Typical U-values in practice

Rate of heat loss through wall = 60 Watt

How much energy is lost through the wall in two hours, if the temperature stays the same?

= **60 Watt** x **2** hours

= **120 Watt** hours

= **0.12kWh**

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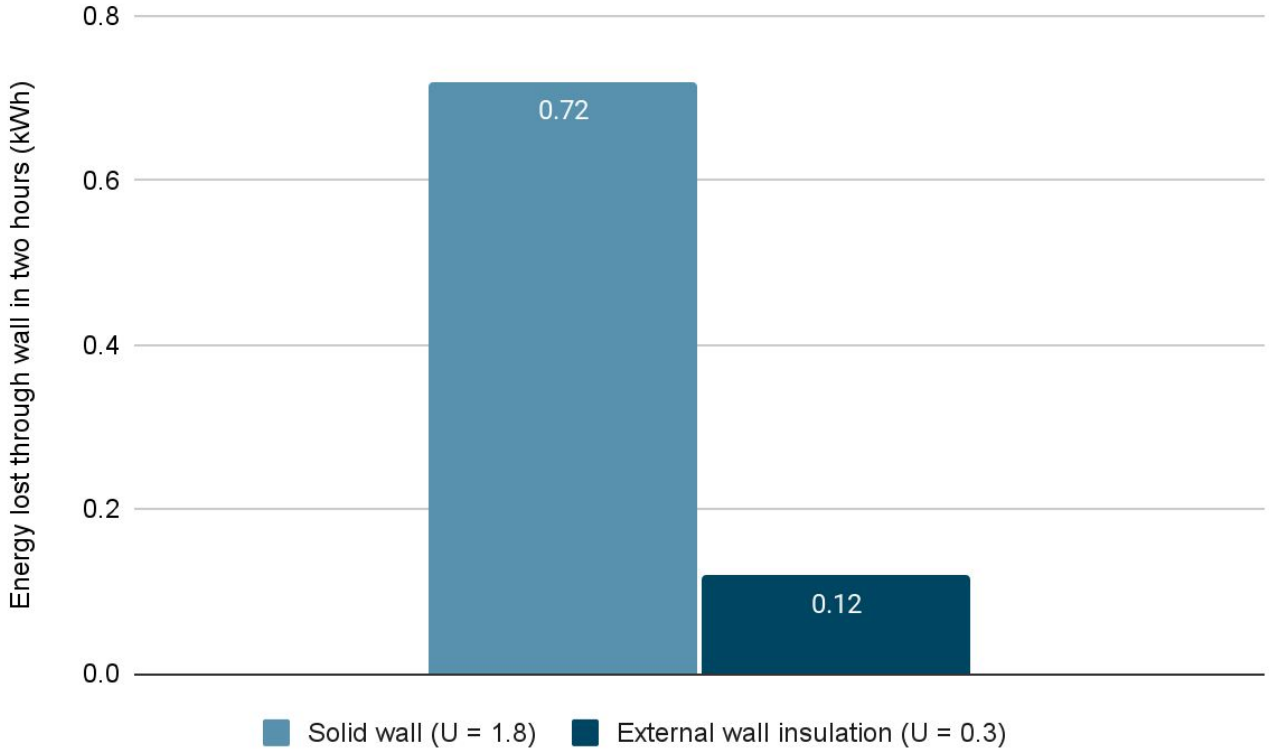
Typical U-values in practice



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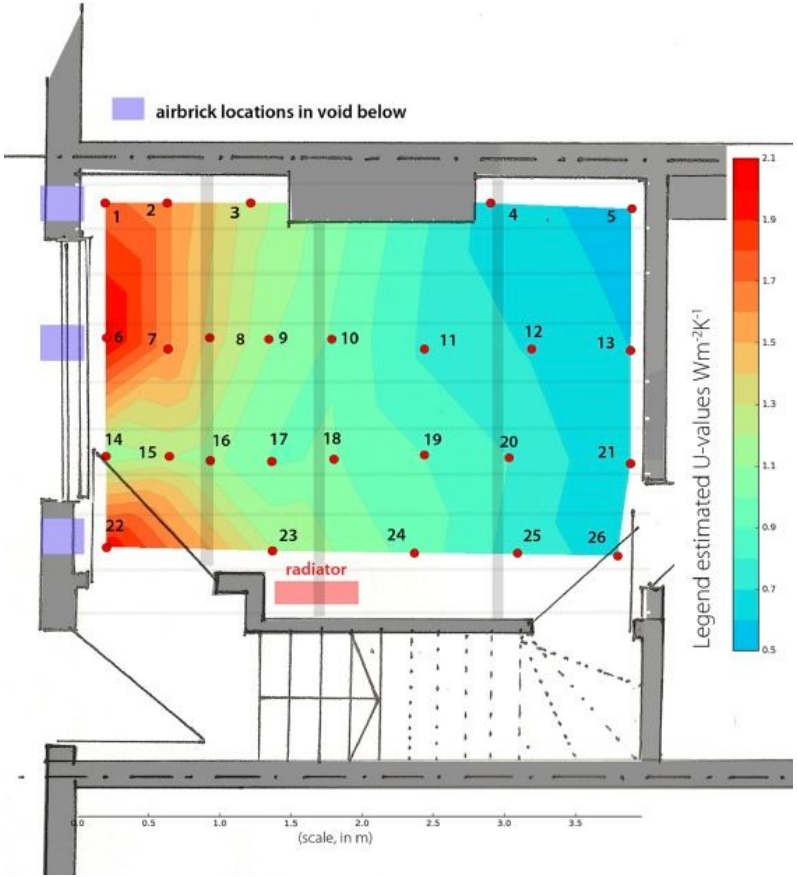
U-values: Roofs and Floors

Roofs: pitch

Solid floors: ratio of exposed perimeter to floor area - most heat is lost from the perimeter of floor

Suspended floors: temperature and ventilation of sub-floor void (see image)



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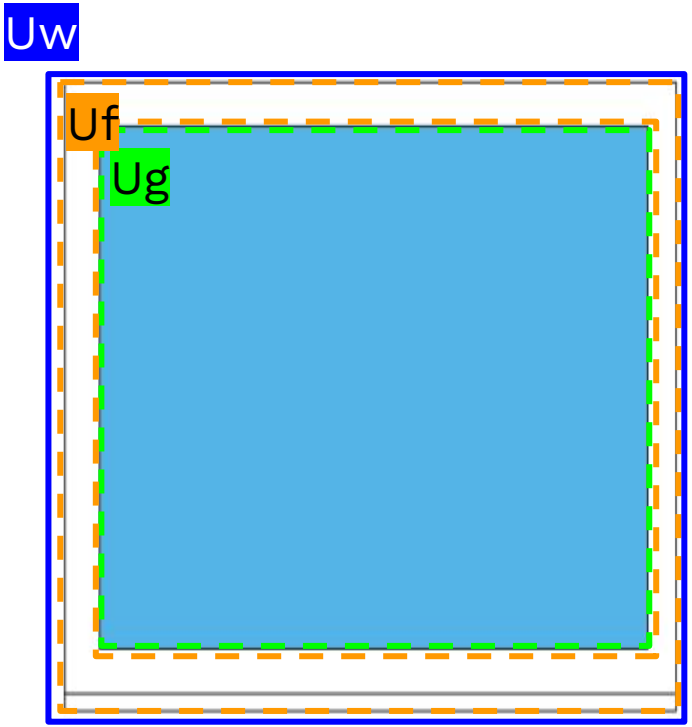
Sofie Pelsmakers work on suspended timber floors is interesting:
http://www.sciencedirect.com/science/article/pii/S0378778817311350

U-values: Windows

U_g: glazing

U_f: frame

U_w: overall; frame and glazing



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Further reading: https://www.wbdg.org/resources/windows-and-glazing

U-values: Doors

U_g: glazing

U_f: frame

U_D: overall; frame and glazing

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Window and Door Installation

Air-tight installation of the window and door is just as important as U-value!

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Your turn!

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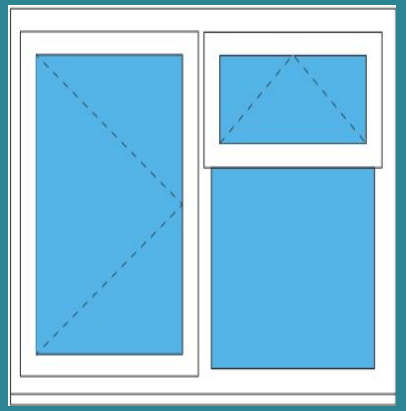
Which window has the better U_w value?

A



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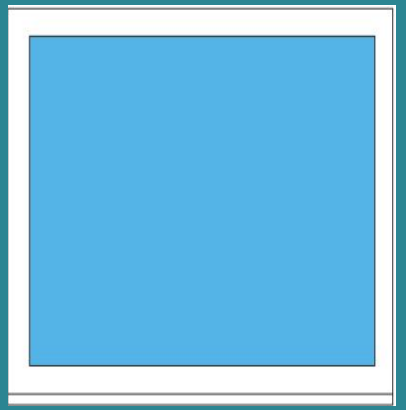

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Regulations, standards, and quality

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Building Regulations

Part A Structure

Part B Fire

Part C Moisture

Part F Ventilation

Part G Water use

Part J Fuel burning appliances

Part L Energy use

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https://www.planningportal.co.uk/applications/building-control-applications/building-control/approved-documents

Standards

[AECB Retrofit Standard]

[LETI]

[Passive House Standards]

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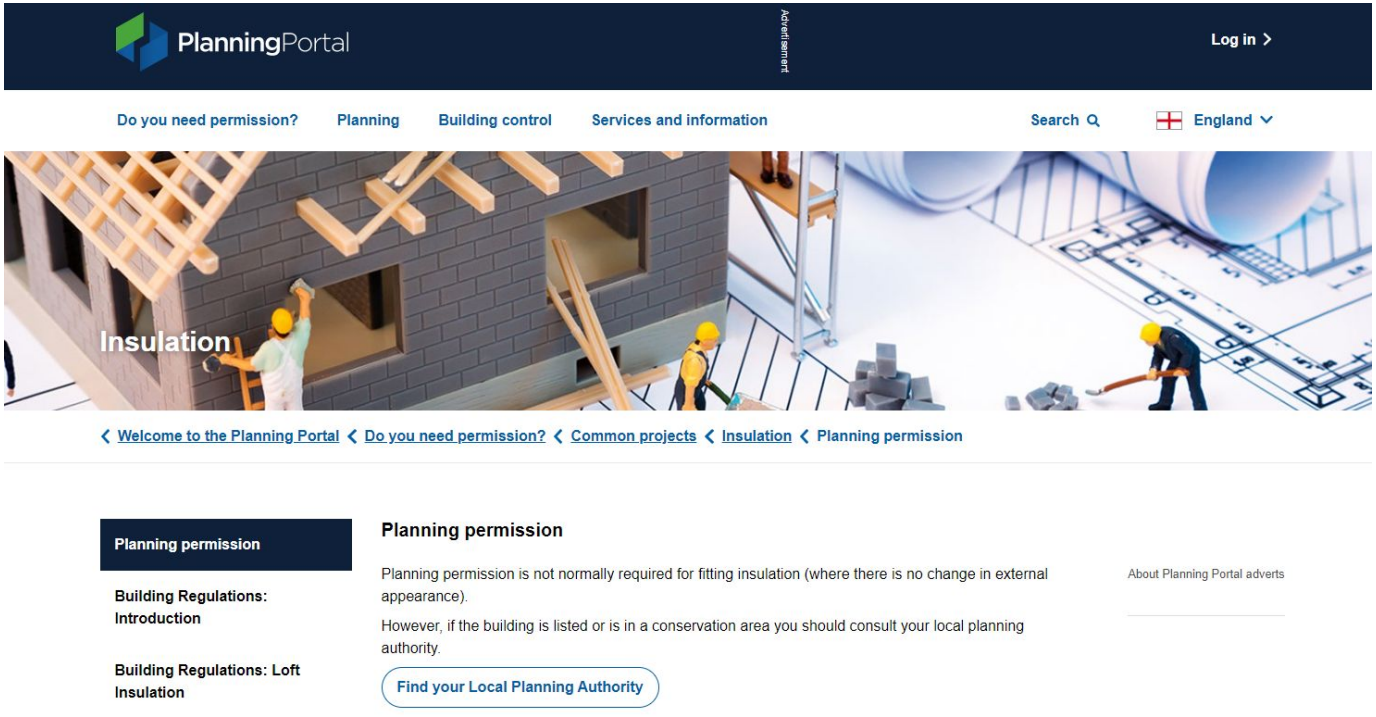
Planning permission



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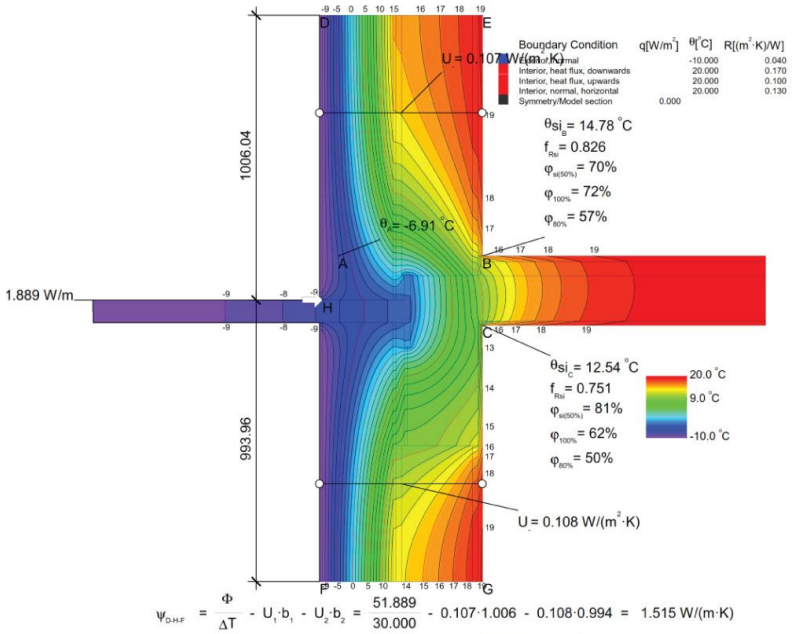
https://www.planningportal.co.uk/permission/common-projects/insulation/planning-permission

Quality: Thermal bridging

- Weak link in ‘thermal envelope’
- Adds complexity when insulating in retrofit
- Reduces effectiveness
- Cold spots cause mould



BEWARE: Quality!

BEWARE: Quality!

Your turn!

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Spot the thermal bridges:

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Spot the thermal bridges:

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Spot the thermal bridges:

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Spot the thermal bridges:

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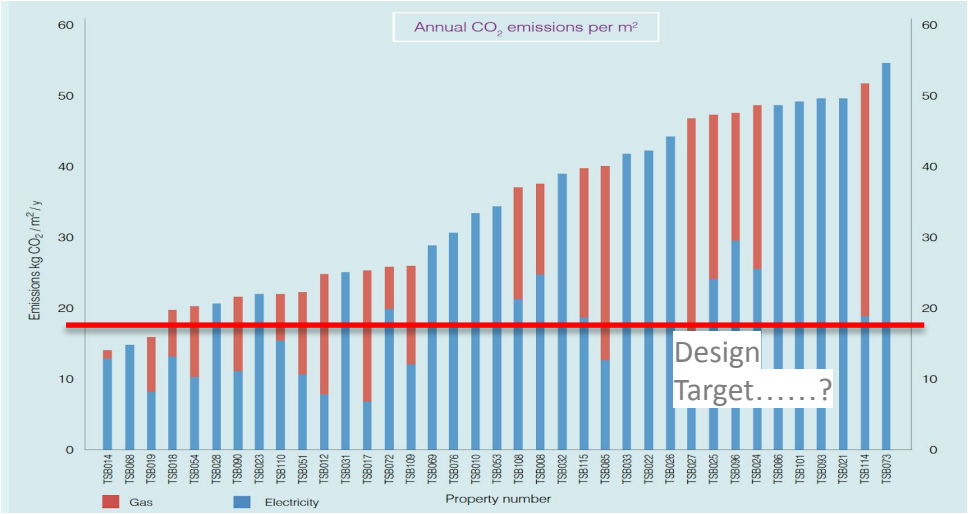
The Performance Gap

Where does it come from?:

- Modelling?
- Design?
- Construction quality?
- User behaviour?
- Design target?



From: 'Retrofit Revealed' (2012)
Report on TSB Retrofit for the Future Programme.

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Wrap-up

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Factors to consider

- Performance
- Practicality
- Sustainable materials
- Cost

What is most important to you?

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Questions?

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Learn more

- https://cafs.org.uk/
- https://carbon.coop/carbon-co-op-webinar-programme/
- https://www.cse.org.uk/advice/advice-and-support
- https://cat.org.uk/
- https://responsible-retrofit.org/
- https://www.changeworks.org.uk/
- https://www.backtoearth.co.uk/
- https://passipedia.org/
- https://aecb.net/aecb-retrofit-standard/
- https://www.leti.london/
- https://www.passivhaustrust.org.uk/

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Thank you to URBED