CONSTRUCTION BLUEPRINT

Module 11

Energy Renovation

Energy Efficiency for Construction

24 partners

12 countries

Date of Event

*Author/ **Institute***

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Energy Renovation| Summary

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To equip the learner with the relevant knowledge and skills required to understand the impact of using suitable materials and energy efficient equipment, with cost optimisation for renovating buildings

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Energy Renovation | Objectives

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1. Discuss the implications of **upgrading the energy performance of existing buildings** on skills for construction workers
2. Outline how to achieve **low-Risk, high-impact energy renovation** works using suitable materials and systems (technologies, equipment, controls)
3. Outline the importance of the choice of "**fit for purpose**" materials and products in traditional or protected buildings to maintain a healthy, energy improved building.
4. Identify and outline how to **detect building defects** using case studies
5. Outline an **energy retrofit strategy** taking into consideration air tightness, choice of insulation, ventilation, and renewable heating/cooling systems
6. Outline the principles needed to achieve **cost optimisation** for energy renovation
7. Identify cost analysis comparisons to achieve nZEB using **best practice** case studies

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Energy Renovation | Contents

On some of the following slides you will see this icon:

Click and play to find out more

1. Renovation Strategy

Key Guidance for Renovation

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This S.R.54 provides technical guidance on the energy efficient retrofit of the building fabric and services, the application of retrofit measures on a whole dwelling basis, general building science and the management of retrofit projects.

The building fabric and services clauses have the following structure:

- Typical existing construction and installations;
- Appropriate retrofit measures;
- Detailed design issues for each retrofit measure;
- Detailed installation measures for each retrofit measure

What's a 'Major Renovation'?

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Where more than **25%** of the surface area of a dwelling undergoes renovation

Surface area of "thermal envelope"
= surface area through which it can lose heat to the external environment or the ground, including walls, windows, floors and roof

Image Source: MosArt

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What Works Constitute a 'Major Renovation'?

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Table 6 **Elemental works that are included in the surface area calculation for major renovation[1,2,3]**
External walls renovation • External insulation of the heat-loss walls • Replacement or upgrade of the external walls' structure • Internal lining of the surface of heat-loss walls
Windows renovation • Replacement of windows
Roofs renovation • Replacement of roof structure
Floors renovation • Replacement of floors
Extension • Extension works which affect more than 25 % of the surface area of the existing dwelling

[1] Major renovation requirement can be activated by works to a single element or to a combination of elements as per column 1 of table 7.

[2] Where major renovations to walls, roofs and ground floors constitute essential repairs e.g. repair or renewal of works due to fire, storm or flood damage or damage as a result of a material defect such as reactive pyrite in sub-floor hardcore or defective concrete blockwork, it is not considered economically feasible to bring these renovations to a cost optimal level.

[3] Painting, re-plastering, rendering, re-slating, re-tiling, cavity wall insulation and insulation of ceiling are not considered major renovation works.

Typical Buildings versus Deep Retrofits

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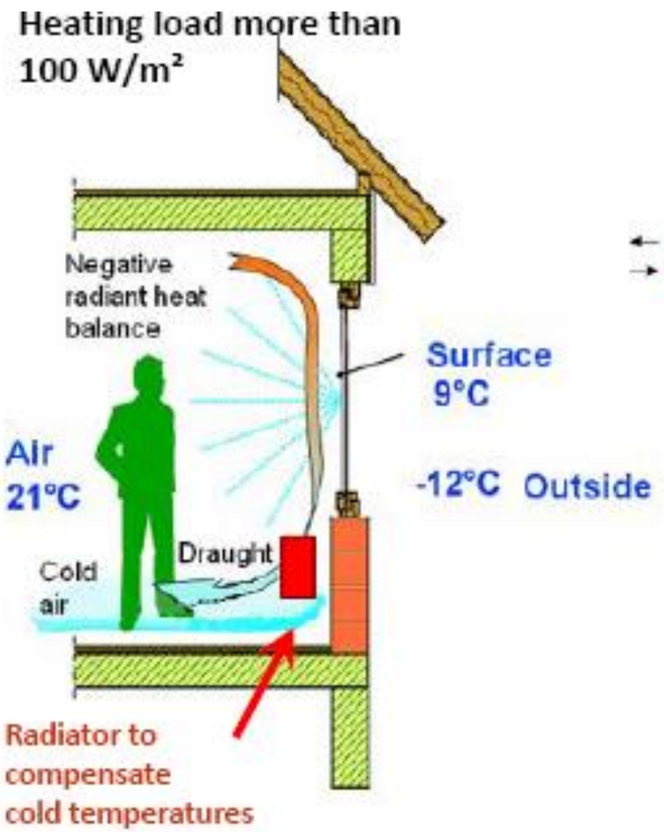
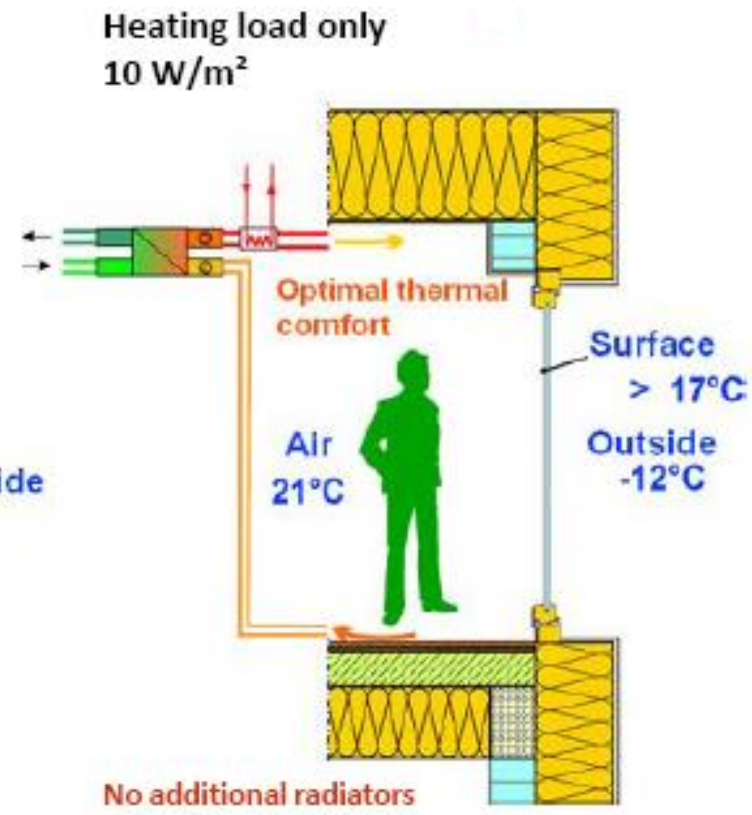
Building Stock



Major renovation/Deep retrofit



What about Extensions?

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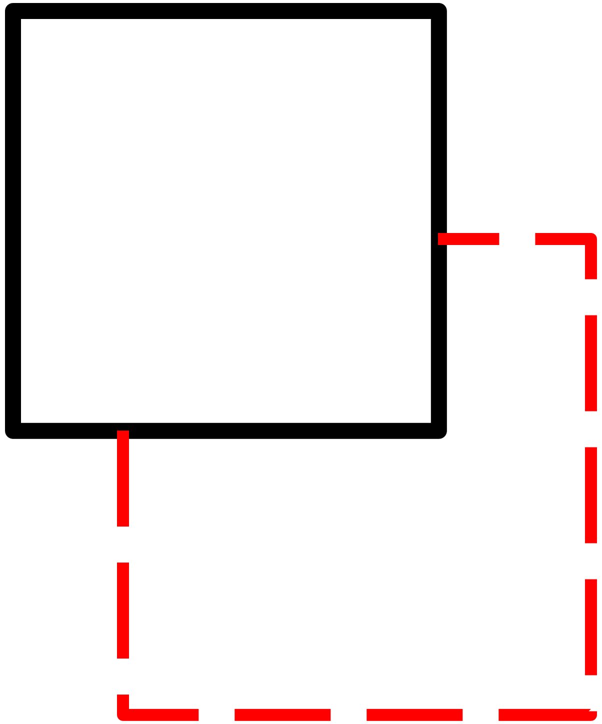
Where an extension affects > 25% of the surface area of the existing dwelling's envelope, then the final energy performance of the completed dwelling should achieve the cost optimal level.



(1) ≤ 125 kWh/m^2.year

Or

(2) Implement performance improvements

(same as above, plus need to upgrade walls if U-value > 0.55 W/m^{2}k for cavity and 0.35 for 'other walls')

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Case Study - Major Renovation Extension Trigger

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Total dwelling envelope area (based on insulation at ceiling level):

Floor and roof = 2 x 9m x 7m = $126m^2$

Gable wall = 9m x 5.1m = $45.9m^2$

Front & rear walls = 2 x 7m x 5.1m = $71.4m^2$

Total = $243.3m^2$

25% trigger **= $60.825 m^2$**

Image Source: MosArt

All dimensions are internal

Proposed works	Dwelling envelope area affected	% of dwelling envelope area affected	Major Renovation triggered
1 storey rear wall			
2 storey rear wall			
1 storey rear wall and gable wall			
2 storey rear wall and gable wall			

Case Study - Major Renovation Extension Trigger

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25% trigger = $60.825 m^2$

Image Source: WWETB-MosArt

All dimensions are internal

Proposed works	Dwelling envelope area affected	% of dwelling envelope area affected	Major Renovation triggered
1 storey rear wall	$17.85 m^2$	7.3 %	✗
2 storey rear wall	$35.7 m^2$	14.7 %	✗
1 storey rear wall and gable wall	$40.8 m^2$	16.8 %	✗
2 storey rear wall and gable wall	$81.6 m^2$	33.5 %	✓

Government Policy to Upgrade Housing Stock to B2 Rating

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Distribution of BERs in the BER database fort he national housing stock 2016.

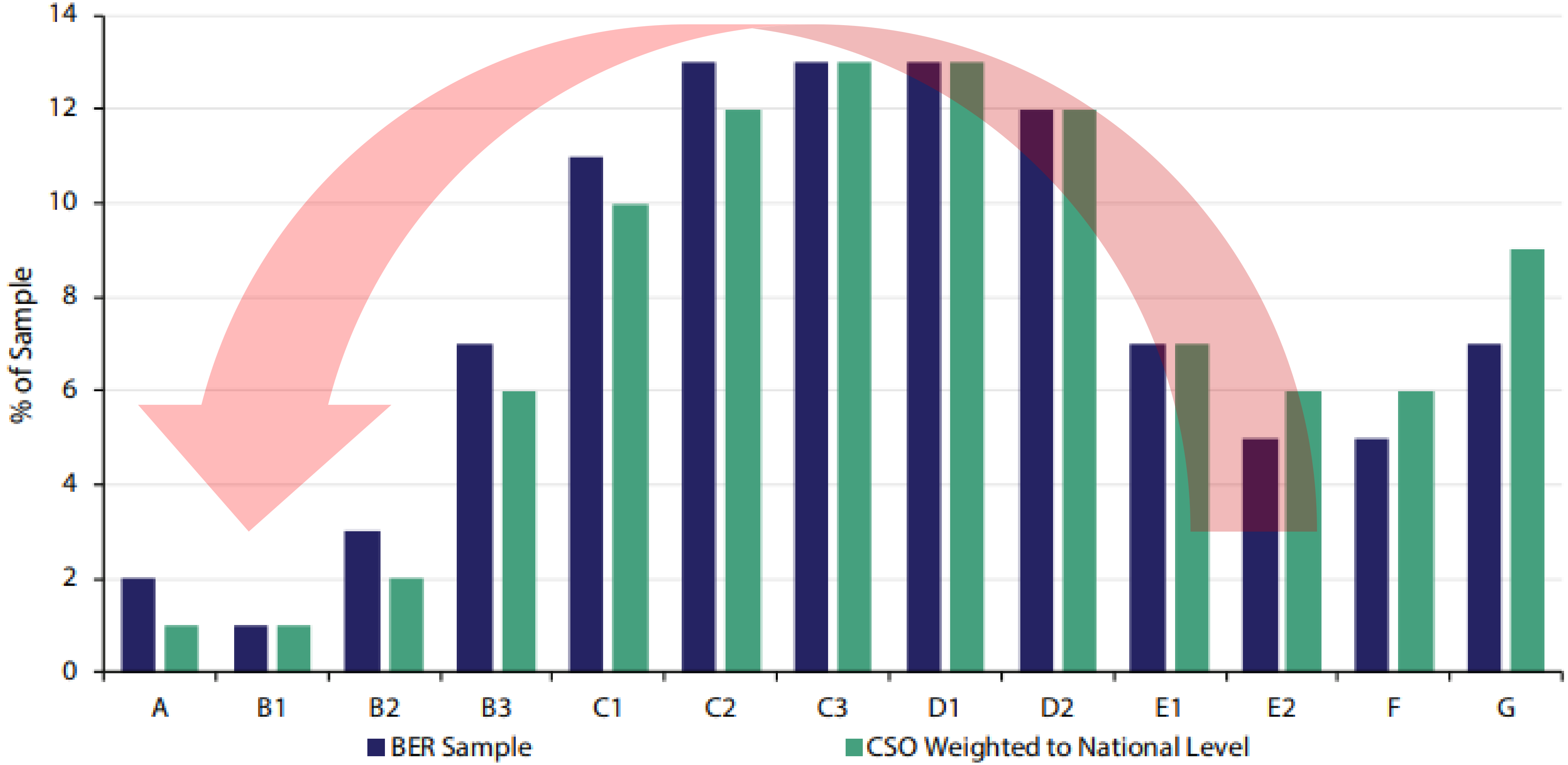

Image Source: CSO & SEAI

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Wall Insulation Method - Big Decision

Table 18 - Selection criteria for insulation methods

	Criterion	EWI	IWI	CWI
1.	Internal disruption to occupants	No	Yes	No
2.	Reduces thermal bridging	Yes	Yes	No
3.	Retains thermal mass of building	Yes	No	Yes
4.	Reduces dwelling floor space	No	Yes	No
5.	Installation affected by external weather conditions	Yes	No	No
6.	Scaffolding required	Yes	No	Yes[a]
7.	External services (e.g. downpipes, gullies, cables, gas meter box, electricity meter box, flues, etc.) may require relocation	Yes	No	No
8.	Requires planning approval for works which materially alter exterior appearance of the dwelling	Yes	No	No
9.	Internal pipes, radiators, electrics etc. require relocation	No	Yes	No
10.	Internal skirting, architrave, fitted kitchens, wardrobes etc. require relocation	No	Yes	No
11.	Internal vapour control layer required	No	Yes	No
12.	Practical to achieve advanced U-value without combining with another system	Yes	Yes	No[b]
13.	Specification subject to wind driven rain exposure	No	Yes	Yes
14.	Impact on access provision to side of dwelling	Yes	No	No
15.	Impact on external accessibility requirements to dwelling	Yes	No	No
16.	Impact on corridor/stair widths adjacent to external walls	No	Yes	No
17.	Requires modification of eaves/gable roof line	Yes	No	No
18.	Improves external weatherproofing and appearance of building	Yes	No	No
19.	Local Authority consulted where encroaching on public footpath	Yes	No	No

a Subject to installer's safety assessment.

b Advanced U-values requires a combination of methods.

EWI = External wall insulation

IWI = Internal Wall Insulation

CWI = Cavity Wall Insulation

Source: S.R. 54 by NSAI

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External Wall Insulation (EWI)

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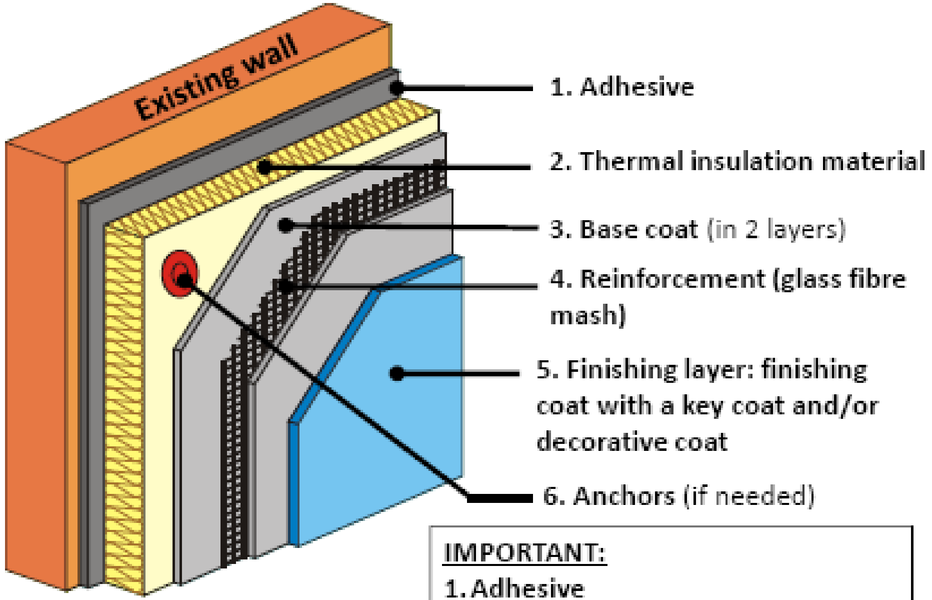
One of most commonly used systems for thermal enhancement of walls.

Thermal insulation material	Advantages	Disadvantages
Mineral wool	• Vapour permeable • Good reaction to fire • Good sound insulation	• 15-30% more expensive • More demanding for installation • Risk of damping
EPS-polystyrene	• Lower material price • Easier for installation • Greater choice of finishing layers	• Less vapour permeable • Weaker sound insulation • Weaker reaction to fire



IMPORTANT:
1. Adhesive
2. Reinforcement
3. Finishing layer have to be from the same producer

Source: HUPFAS [32]

External Wall Insulation (EWI)

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Phases of EWI Installation

1. Pre-treatment of the substrate + preparation works

2. Bonding

3. Anchoring

4. Reinforcement

5. Finishing coat with primer and paint coating

Each phase has its own specifics and it should be conducted respecting the professional guidelines!

Source: HUPFAS [32]

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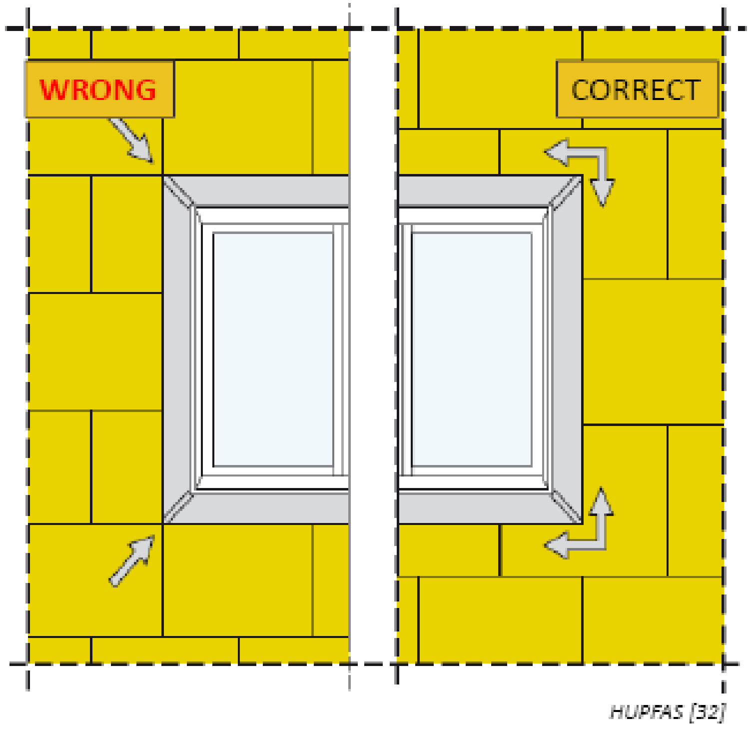
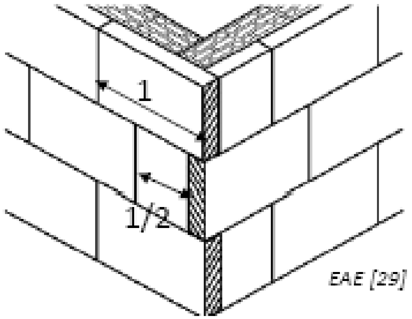
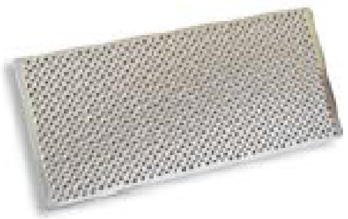
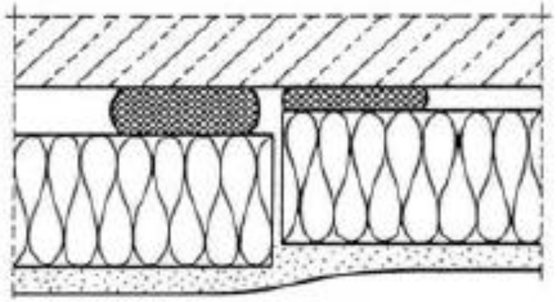
Bonding around windows, door and corners









- High risk of cracking (local strains)
- Rasping of board joint necessary before applying reinforcing
- Not possible to rasp mineral wool

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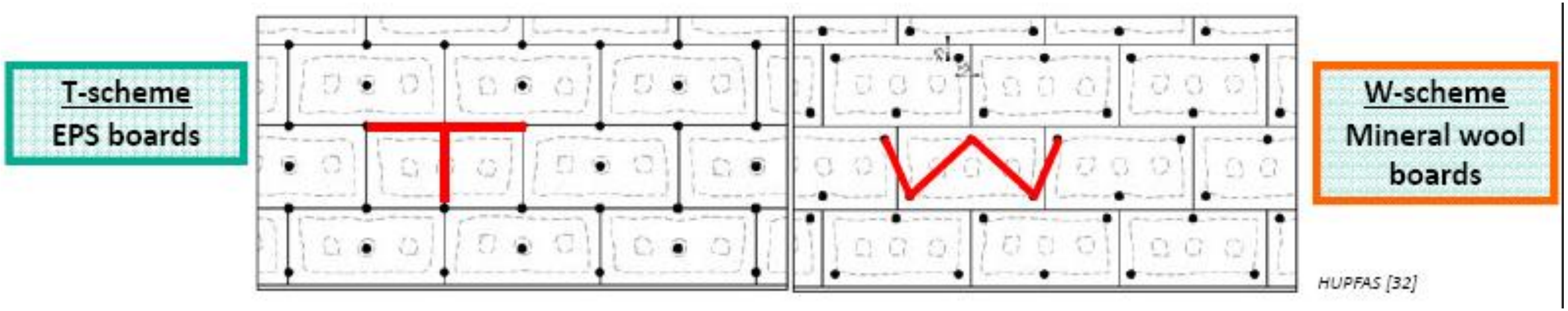
Anchors – how many and how to arrange them?

1) The number of anchors is determined by engineering calculations based on following parameters: the wind zone, building height, the weight of EWI system, substrate type, anchoring type...

2) When retrofitting existing buildings with substrate of questionable load capacity („pull-off" test)



External Wall Insulation (EWI)

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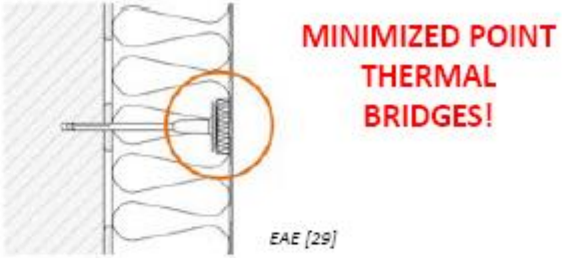
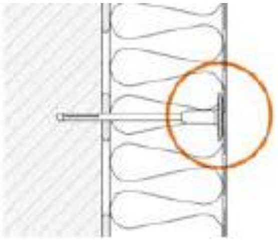
Anchor head countersunk into the insulation material

HUPFAS [32]



EAE [29]

Anchor applied flush with the surface of the insulation material



External Wall Insulation (EWI)

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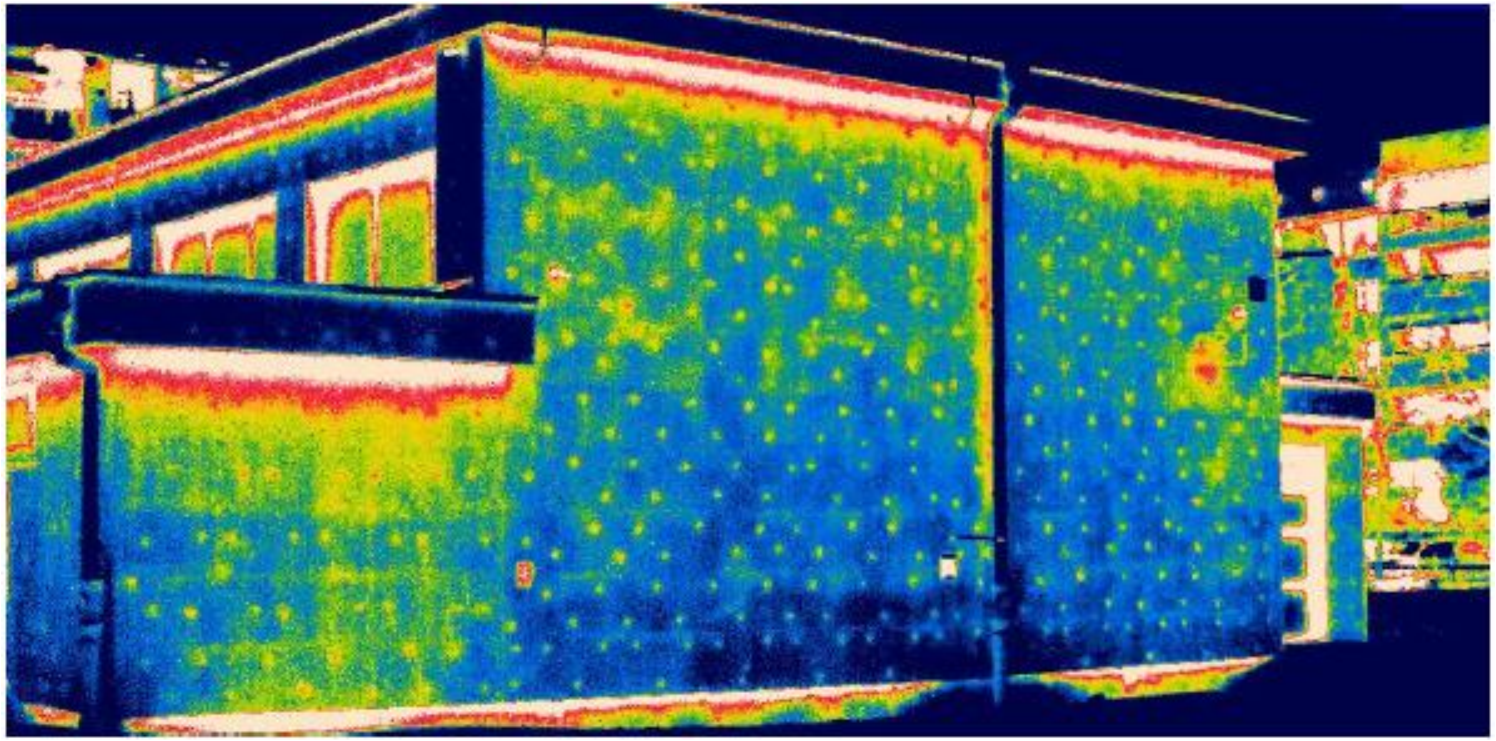
What human eye can't detect, infrared can! (Quality control)



External Wall Insulation (EWI)

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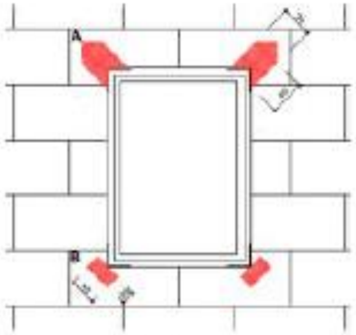
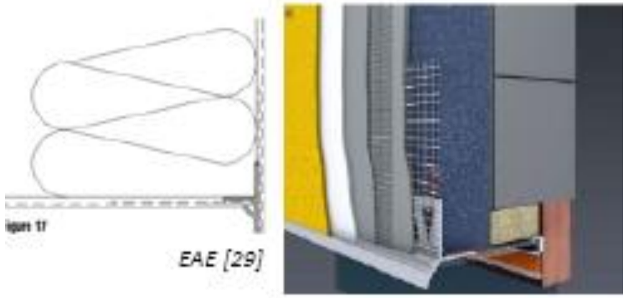
Diagonal reinforcements



HUPFAS [32]

Formation of edges, outer and inner corners

Formation of drip edges



EAE [29]

Asb.sk [35]

Expansion Joints

Meister Farben [36]

External Wall Insulation (EWI)

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Selection of finishing coat

COST →

Plaster Type:	Mineral	Silicate	Acrylic	Silicone
Water repellent	o	+	++	++
Vapour permeable	++	+	-	+
Dirt resistant	o	+	++	++
Elastic	-	o	++	+
Colour range	o	+	++	+

LEGEND: ++ very good + good o potentially good - poor

Types of Cavity Wall

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Type 1 – Cavity that cannot be filled: a cavity where no insulation is present but which cannot be filled, a sit is too narrow, or there is a risk of driven rain causing moisture ingress. e.g,. Un-rendered brickwork in a severe exposure area.

Type 2 – Clear cavity: originally a 50mm, 75mm or 110mm wide cavity which has the potential to be full-filled or has been full-filled as a result of previous energy efficiency improvements.

Type 3 – Partial cavity fill: a partial filled cavity which retains a residual cavity of approximately 50mm width or a width as specified by the product certification.
This can be further separated into:

Type 3a – cavities which cannot be filled
Type 3b – cavities which can be filled using a certified system.

Source: S.R. 54 by NSAI

Cavity Wall Insulation

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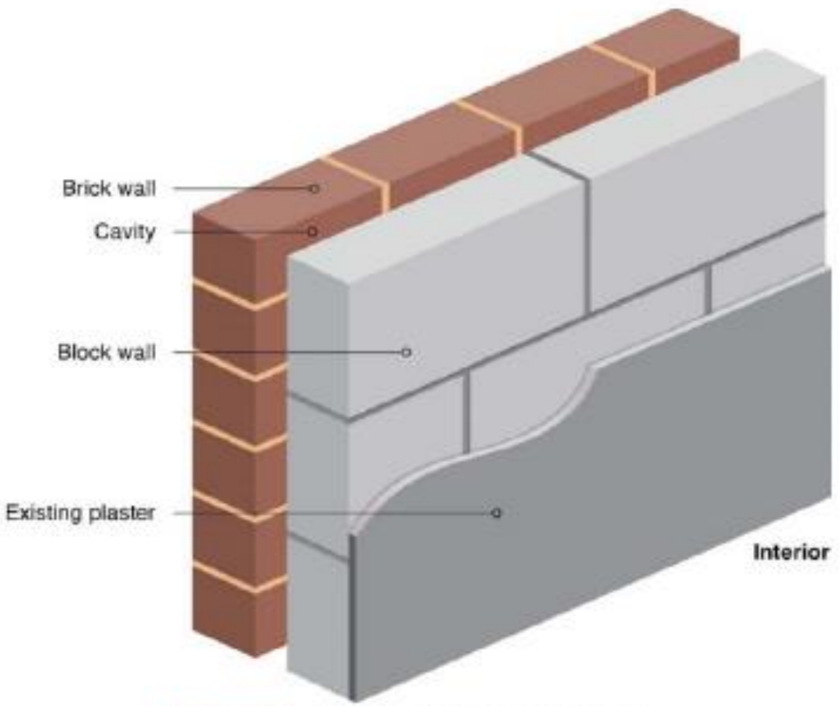

Figure 47 - Unfilled / clear cavity wall

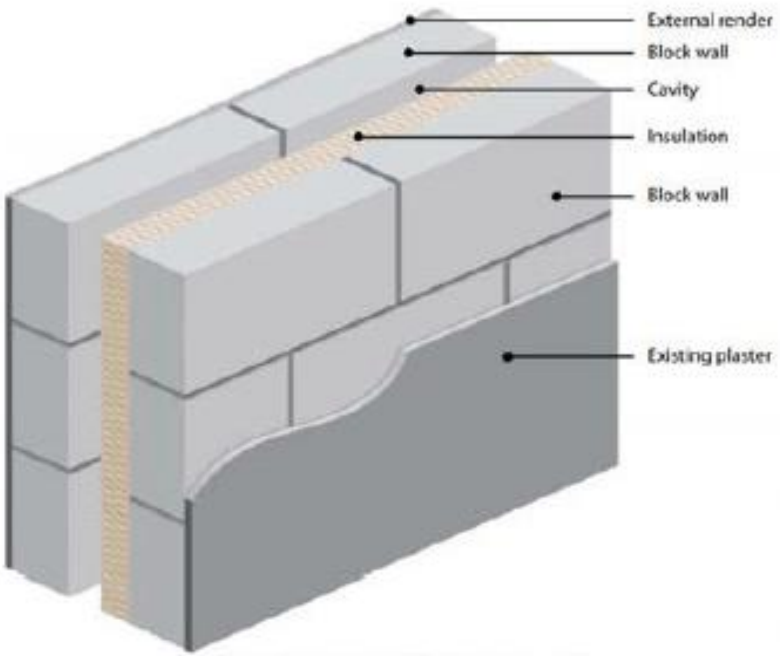

Figure 48 - Partial fill cavity wall

Source: S.R. 54 by NSAI

Cavity Wall Retrofit Methods

Co-funded by the Erasmus+ Programme of the European Union

Table 14 - Applicable retrofit methods for Type 1 to 3 cavity walls

	Baseline U-value (W/m².K)	Cavity wall insulation	External wall insulation	Internal wall insulation
Type 1	1,55	N	N	Y
Type 2	1,55	Y[a]	Y[b]	Y
Type 3a	0,70	N	N	Y
Type 3b		Y	Y[b]	Y

a Where cavity not filled previously.

b Provided cavity has been filled.

For further information on selecting the retrofit method, see 7.3.1

Driven rain and exposure dictates the suitability of filling the cavity

External insulation should not be filled with unfilled cavities due to the possibility of thermal bypass and thermal looping within the cavity. The cavity should be fully filled either as part of the original construction or as part of the retrofit measures where external insulation is used.

Where a cavity is retained in a wall, internal wall insulation should be used.

Source: S.R. 54 by NSAI

Internal Wall Insulation – WITH Service Void

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7.3.3.3.4 **Secondary layer over insulation between battens with service void fixed to single leaf walls**

Figure 63 shows the use of a timber batten to form a service void over insulation between studs (new or existing).

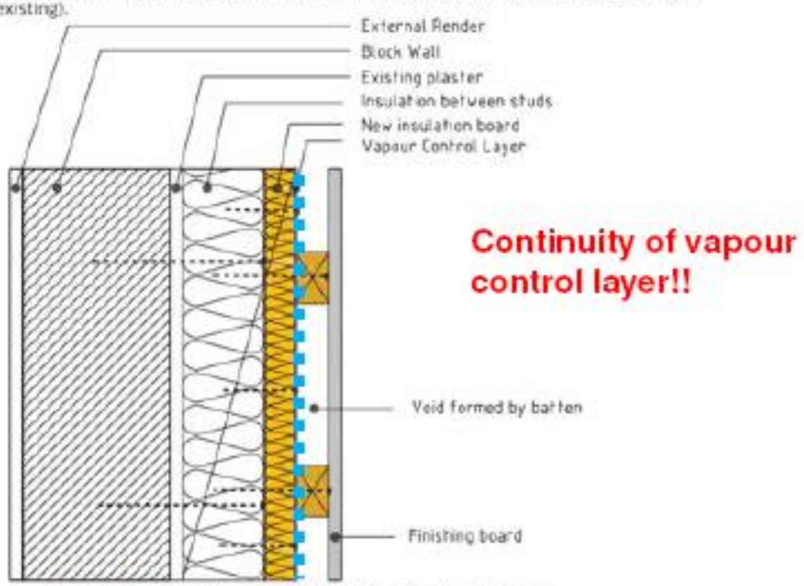


Figure 63 - Service void formed by timber batten

Timber studs

Figure 64 - Insulation board fixed to wall with cavity formed by Metal Furring (MF)

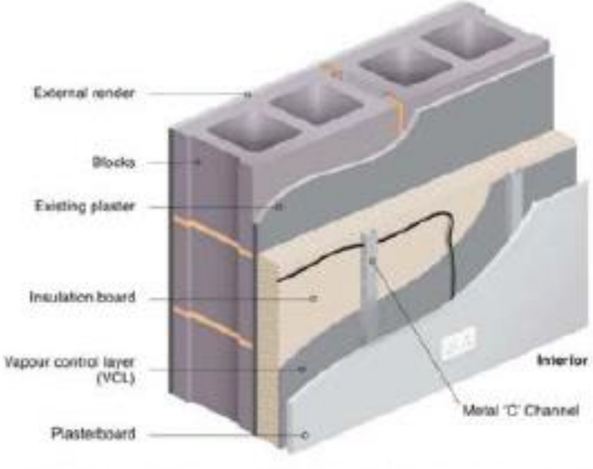
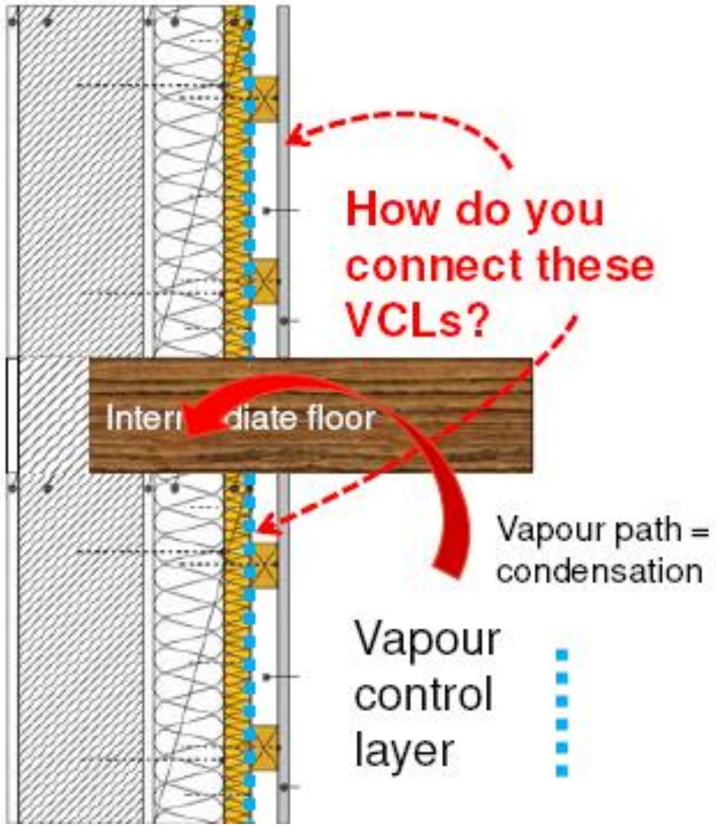


Figure 65 - Internal insulation and Metal Furrings channels

Metal studs

Internal Wall Insulation – WITH Service Void



Only way to do this correctly is to expose floor joists and seal them individually

Rotted Joist ends

Co-funded by the Erasmus+ Programme of the European Union

Source: Image Rentokil

Interior thermal insulation – External walls

Co-funded by the Erasmus+ Programme of the European Union

Interior thermal insulation - components

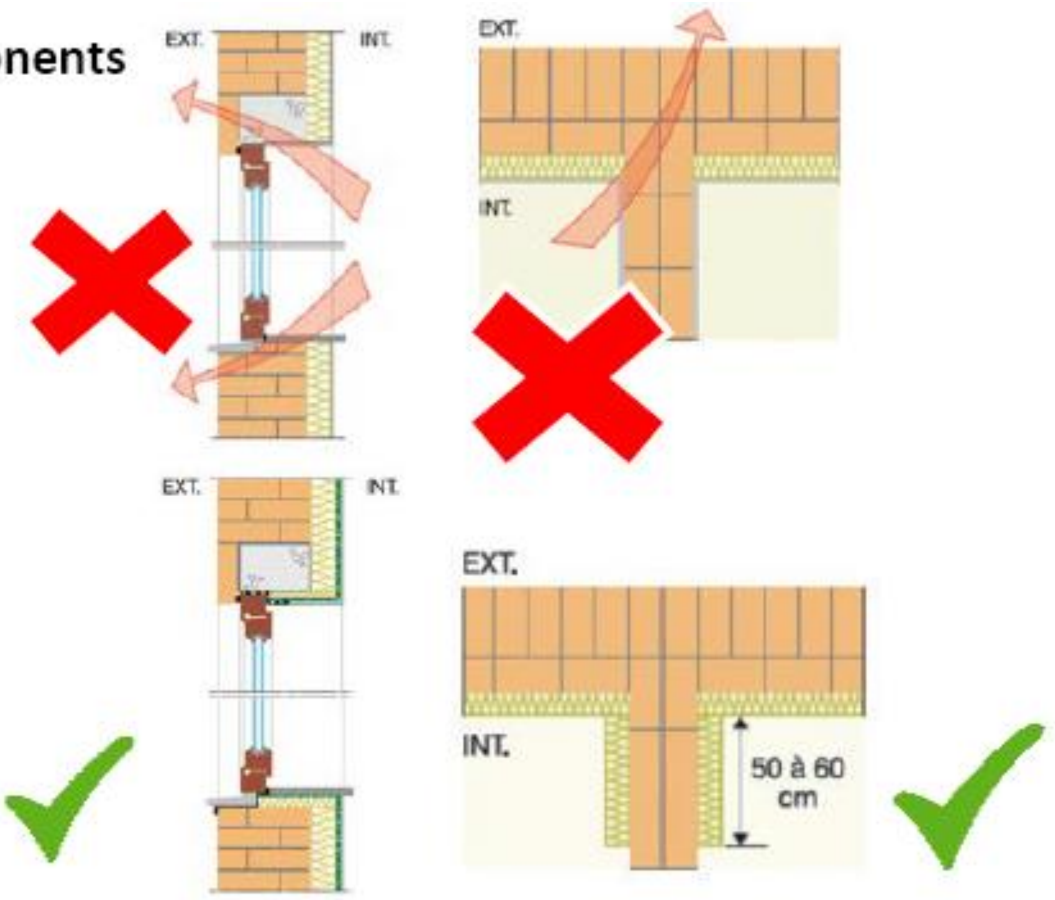
- **Profiles:**
  - Timber, polymer, metal studs

  Minimise thermal bridges

- **Thermal insulation:**
  - Mineral wool, EPS
  - VIP panels, Aerogel… other

- **Vapour control layer:**
  - depends on the type of thermal insulation

- **Interior finishing:**
  - Gypsum bord, OSB boardm Plasters …



Source: HUPFAS [32]

Interior thermal insulation – External walls

Co-funded by the Erasmus+ Programme of the European Union

Interior thermal insulation – phases of installation

- Remove window sills
- Move radiator unit
- Fill recess alcove of radiator unit with solid masonry
- Remove wallpaper
- Remove plaster?
- Remove old paint?
- Remove gypsum plaster?
- Improve base, adhesion?
- Extension of wires
- Heating pipes insulated where facing exterior wall
- Clarify details of ceiling connection
- Clarify details of wall connection

Source: INTENSE [55]

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Walk Through of Wall Types

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1. https://www.youtube.com/watch?v=9V2lv0SRIG8&list=PL8dmE01N8M7u4uAWl02eK_Y6KZaj0nqYx&index=15
2. https://www.youtube.com/watch?v=5NZSP1AFz68&list=PL8dmE01N8M7u4 uAWl02eK_Y6KZaj0nqYx&index=16
3. https://www.youtube.com/watch?v=3-taKbYx- OI&list=PL8dmE01N8M7u4uAWl02eK_Y6KZaj0nqYx&index=17
4. https://www.youtube.com/watch?v=SYW-pekZOoU&list=PL8dmE01N8M7u4uAWl02eK_Y6KZaj0nqYx&index=13

Source: HUPFAS [32]

Roofs

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Hygrothermal requirements are fullfilled by using:

1) Roof membranes (air and moisture control)

2) Thermal insulation (thermal protection)

3) Compressed tapes or coatings

Source: HUPFAS [32] and GUTEX [44]

Roofs

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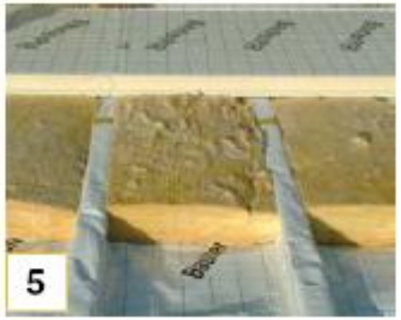
Insulating pitched roof – additional layer of thermal insulation above rafters



1) Installation of mineral wool between rafters
2) Additional layer of rigid mineral wool above rafters
3) Installation of watertight & vapour-permeable membrane
4) Overlapping membrane
5) Option: instead of rigid mineral wool boards additional layer of rigid PIR boards with integrated membrane can be installed

Source: HUPFAS [32]

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A high performance window can only be as good as the install

The installation must address several key issues:

- structurally sound,
- watertight,
- airtight,
- vapour smart and
- increase the installed thermal performance of the window.

Source: HUPFAS [32]

Windows

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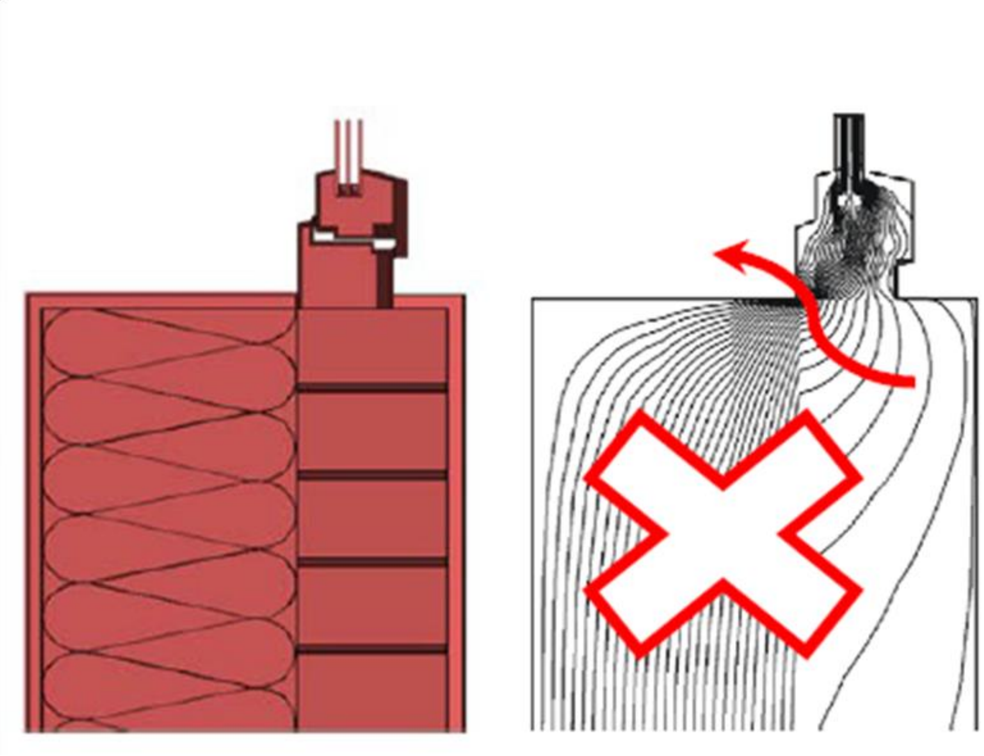
Thermally inefficient installation

$\Psi_{install} = 0.15\ W/(mK)$ $U_{w,eff} = 1.19\ W/(m^2K)$



Source: HUPFAS [32]

Windows

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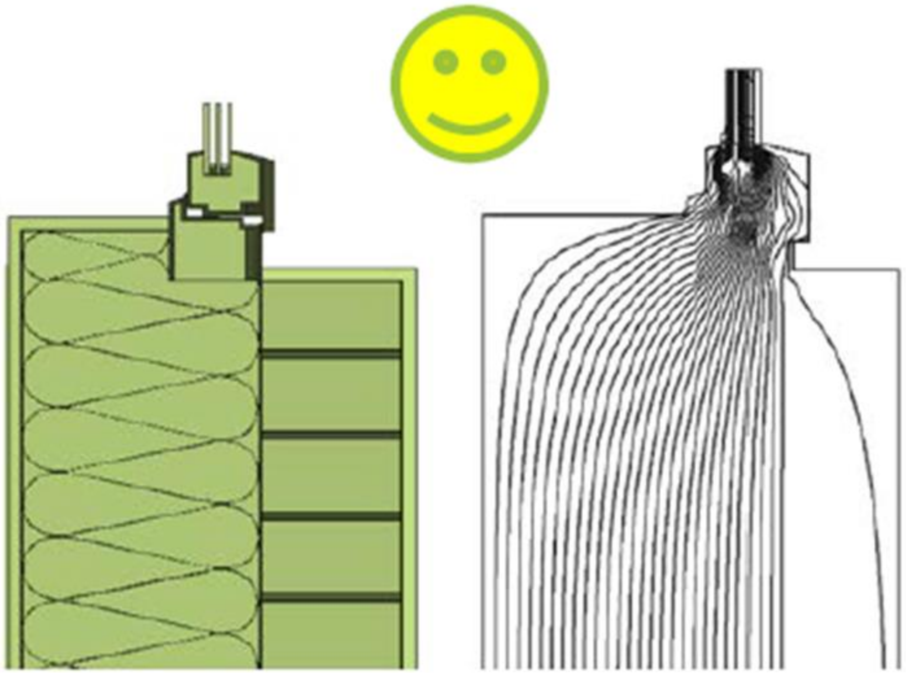
Recommended installation

$\Psi_{install} = 0.005\ W/(mK)\quad U_{w,eff} = 0.78\ W/(m^2K)$



Source: HUPFAS [32]

Case Study Window Installation – Rochestown Avenue EnerPHit Project

Co-funded by the Erasmus+ Programme of the European Union

Positioning window outboard of structural plane

Thermally optimised support using 'compac foam' bolted to structure

Source: EnerPHit

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Source: EnerPHit

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Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Larger windows supported by steel shelf-angle

'Compac Foam' used to separate window and steel

Steel to be clad in external insulation to eliminate thermal bridge effect

Source: EnerPHit

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Installation of flashing to window exterior

Fixing of metal reveal to window surround prior to installation of external insulation

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Flashing to underside of window (and supporting insulation) using 'peel-and-stick' membrane

Source: EnerPHit

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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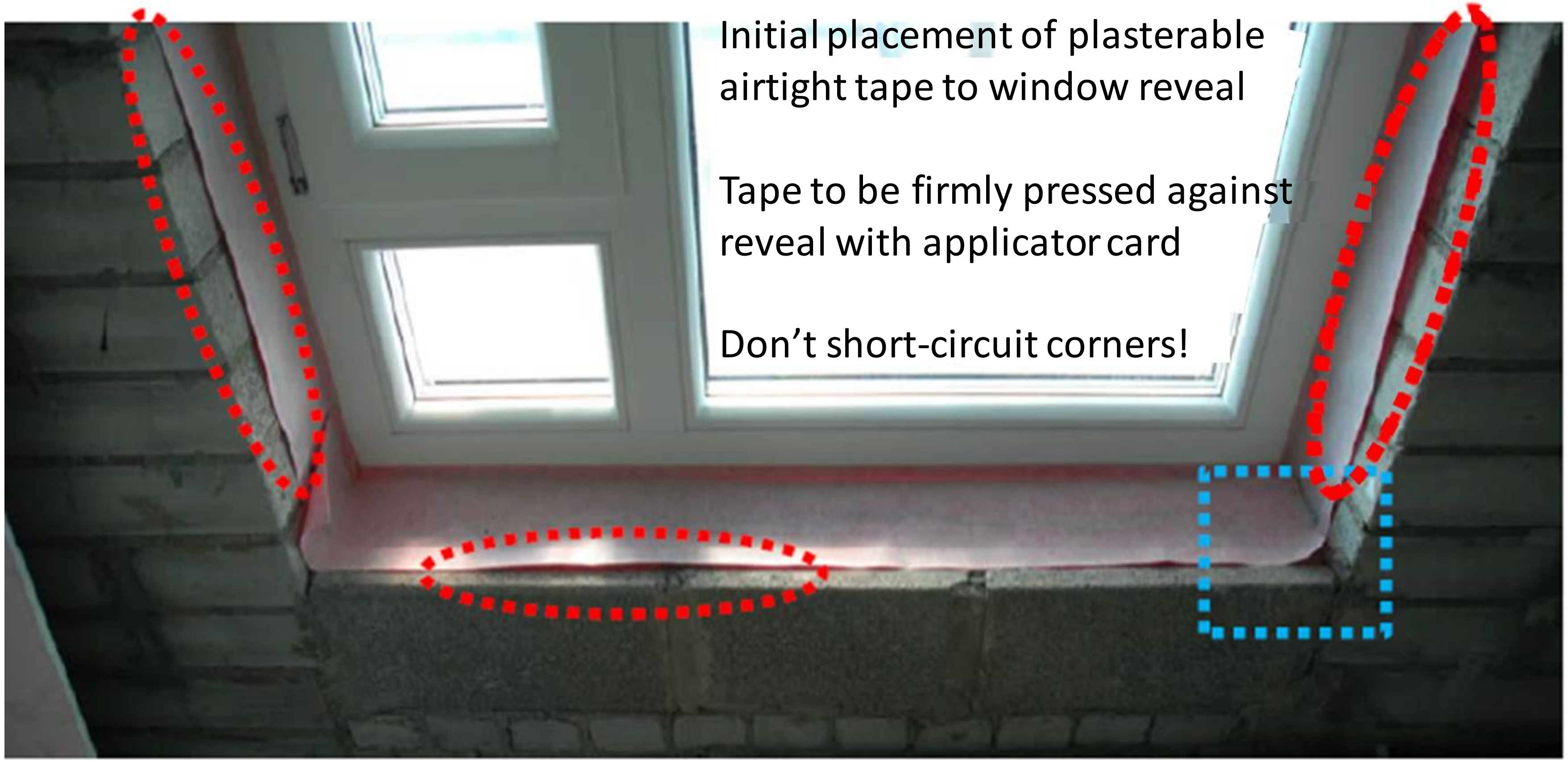

Initial placement of plasterable airtight tape to window reveal

Tape to be firmly pressed against reveal with applicator card

Don’t short-circuit corners!

Source: EnerPHit

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Airtight sealing of window to reveals on the interior using wide plasterable tapes

Note 10mm max overlap on window frame

Source: EnerPHit

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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External wall insulation (250mm) mechanically fixed to wall and 'notched' around window reveal.

Make sure any holes are filled with foam to avoid thermal looping!

Source: EnerPHit

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Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Surrounding of window with insulation

Gaps filled with sprayfoam

Note joints avoided in insulation at corners of windows to prevent cracking

Source: EnerPHit

Case Study Window Installation – Rochestown Avenue EnerPHit Project

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Before and after views
on completion of project

Source: EnerPHit

Video on Step by Step Deep Retrofit

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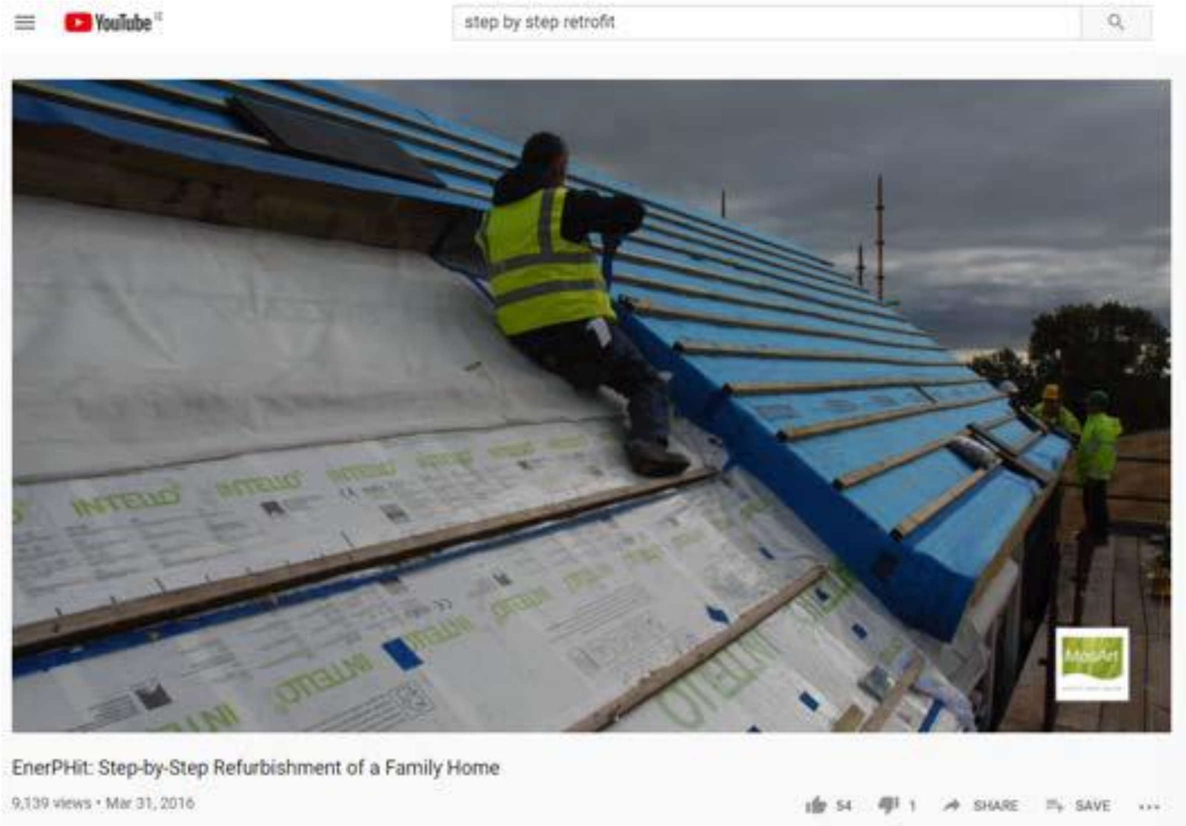

https://www.youtube.com/watch?v=uJyGE_kuEAA

Ventilation Strategies Decision

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Air permeability q_E50: > 3 $m^3/h.m^2$

Natural ventilation with intermittent fans mechanical extract

Relatively easy install

Air permeability q_E50: < 3 $m^3/h.m^2$

Continuous mechanical extract ventilation

Challenging install

Mechanical ventilation with heat recovery

Invasive install

Source: Technical Guidance Documents Part F, Ireland

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Ventilation Part F 2019 Points to S. R. 54 for Retrofit Guidance

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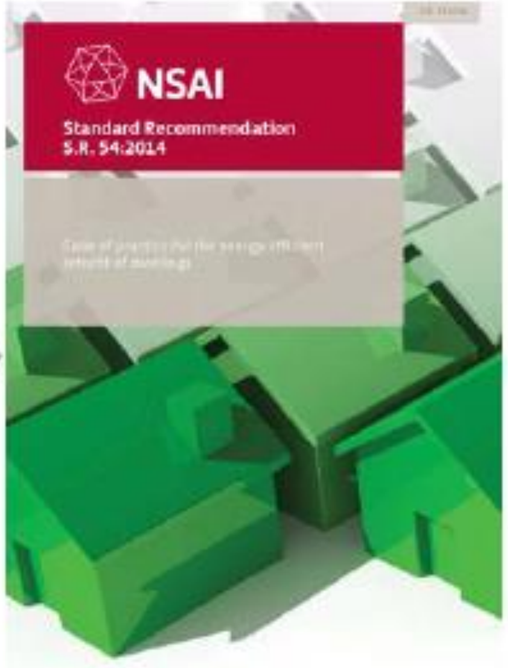
Existing Buildings

In the case of material alterations or change of use of existing buildings, the adoption without modification of the guidance in this document may not, in all circumstances, be appropriate. In particular, the adherence to guidance, including codes, standards or technical specifications, intended for application to new work may be unduly restrictive or impracticable. S.R. 54:2014 *Code of Practice for the energy efficient retrofit of dwellings* provides guidance for these dwellings.



Ventilation – How far do you want to go?

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Suitable ventilation strategies for residential retrofit

Ventilation strategy	Level of retrofit		
	Single room or partial house retrofit	Whole house retrofit	Retrofit to advanced air permeability level
Natural with extract fans	Y	Y	N
Natural with PSV	Y	Y	N
SRHRV	Y	Y	N
MEV	N	Y	Y
MVHR	N	Y	Y

PSV = Passive stack ventilation, SRHRV = single room heat recovery ventilation,
MEV = mechanical extract ventilation, MVHR = mechanical ventilation with heat recovery

Source: NSAI SR 54 Ireland

Mechanical Ventilation with Heat Recovery

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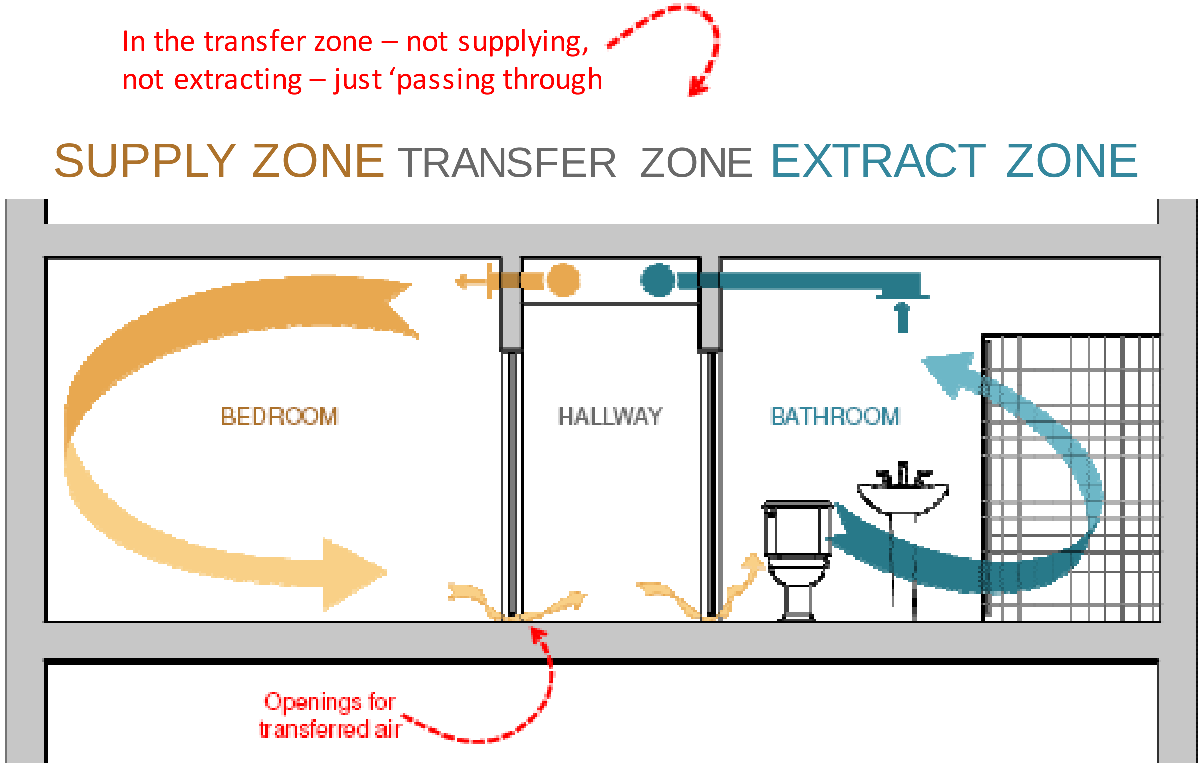
The distribution of ventilation (fresh air supply and stale air extraction) should use as little ductwork as possible but still provide air flow through the entire building:



Compact Unit with MVHR and Emitters

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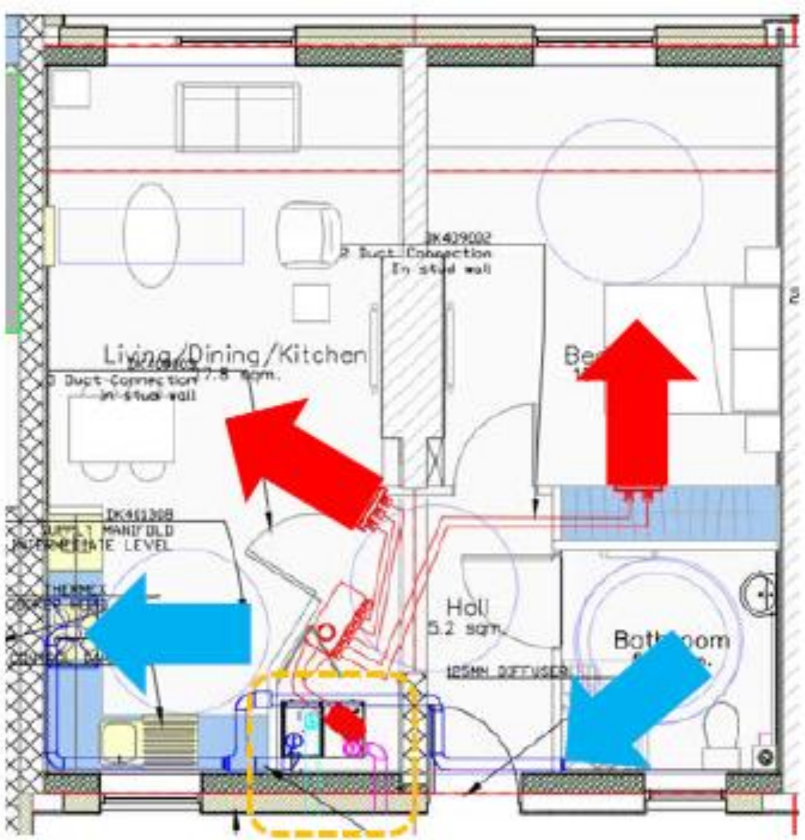
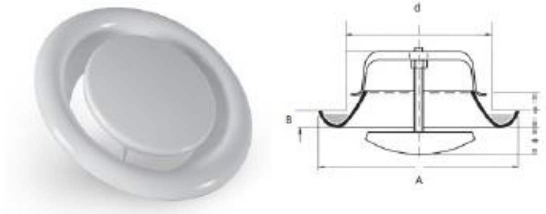
Supply valves

Exhaust valves

Compact unit and ducts to ambient





Typical ceiling mounted domestic supply air register

Typical ceiling mounted domestic extract air register

Linear slot diffuser for locating in walls for horizontal air flow

Source: Deep Retrofit to Arbour Hill Social Housing, Ireland

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Checklist of retrofit measures to achieve the required air permeability

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Checklist

- full double, triple or secondary glazing;
- effective closures on trickle vents and other controllable ventilation devices;
- all external doors fitted with integral draught seals and letter box seals;
- internal and external sealing around door and window frames;
- fully filled cavity external walls, externally insulated walls, walls using an internal airtightness
- barrier or solid external walls;
- impermeable overlays and effective edge sealing of suspended floors;
- careful sealing of junctions between building elements such as walls to floors and walls to
- ceilings;
- careful sealing around attic hatches;
- careful sealing around flue penetrations;
- careful sealing around internal soil pipe;
- careful sealing around domestic water and heating pipes passing into externally ventilated spaces;
- careful sealing of all service penetrations in the building fabric (electricity, gas, water, drainage,
- phone, TV aerial etc.);
- careful sealing around overflow pipe for WC;
- all cable channels for light switches and power sockets carefully sealed;
- all cable entry for lighting and ceiling roses carefully sealed. Recessed lighting should not
- penetrate ceilings separating attic spaces from rooms unless suitably sealed.

Due care and attention should be taken to achieve this performance level.

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For dwellings, "Renewable Energy" will mostly comprise of:

Heating

- Biomass and Biofuels
- Heat Pumps (ground, water or air source)
- Solar Thermal

Power Generation

- Solar Photovoltaic
- Wind ("aerogenerator")

Air Source Heat Pumps Increasingly Popular

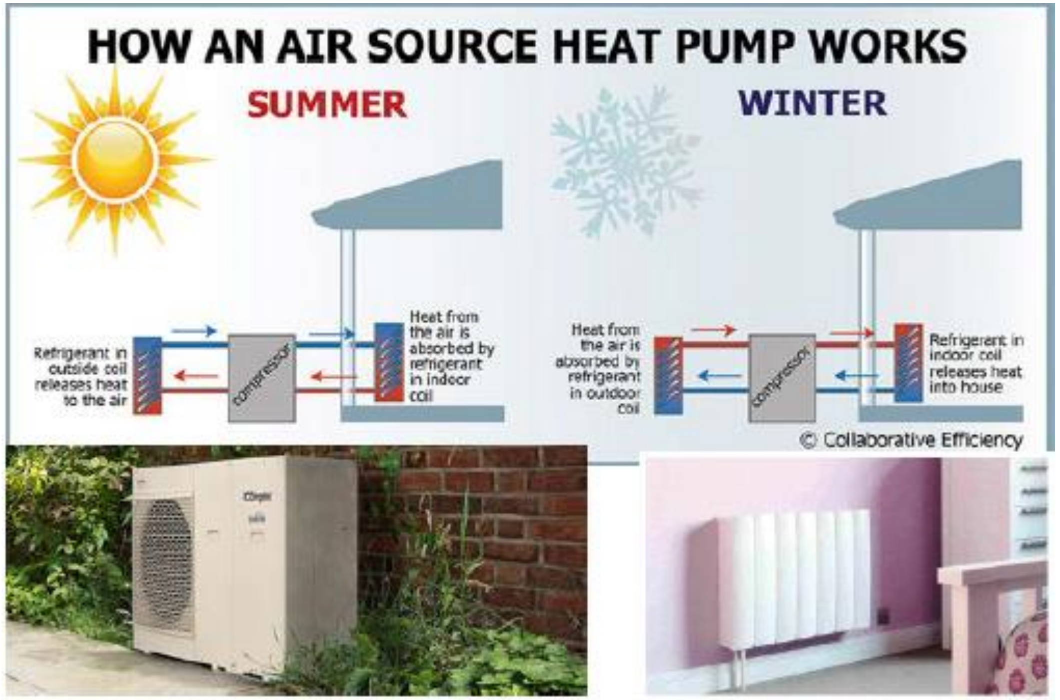

Image Source: Dimplex

Next Generation Compact HP Unit

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'Combo-systems' emerging on the market that provide the following functions:

1. Heating
2. Cooling
3. Domestic hot water
4. Mechanical ventilation with heat recovery

Warning!

- Contribution towards heating, cooling and hot water must be confirmed in an energy model
- In projects in Europe, these systems typically provide 50% of the heat load, with the remainder provided by radiators or other emitters.

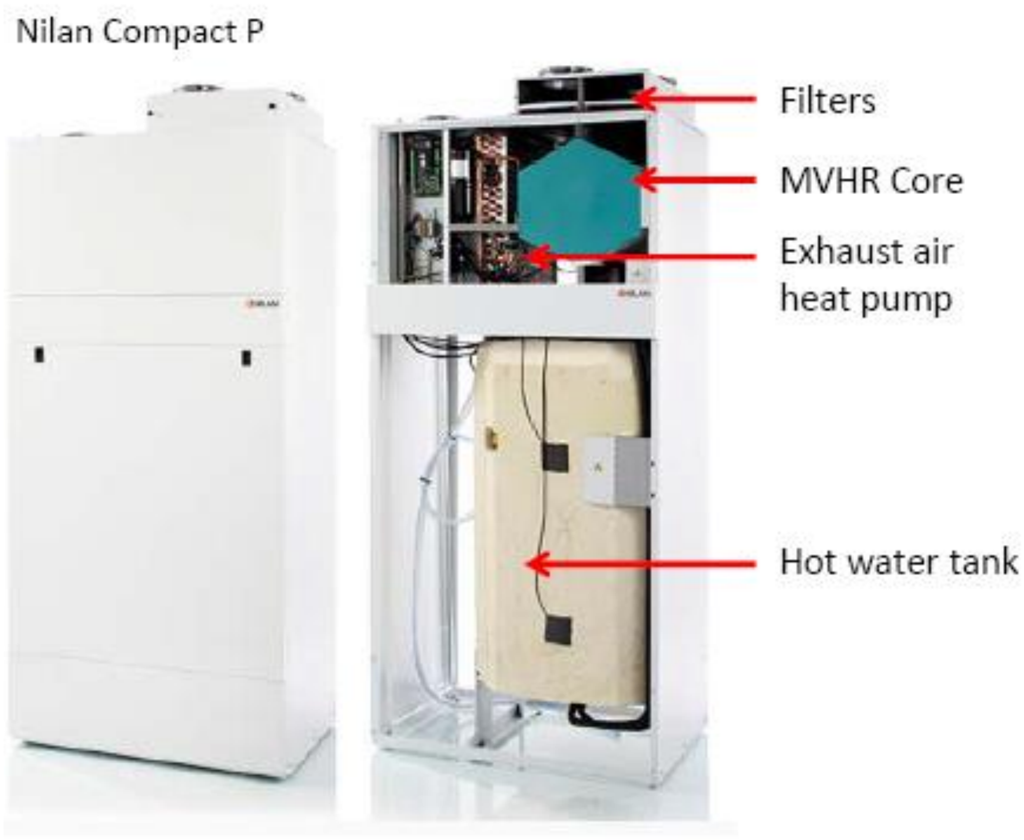

Image Source: Nilan

Space Heating and Hot Water Controls

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The aim should be to provide the following minimum level of control:

- Automatic control of **space heating** on the basis of room temperature

- Automatic control of heat input to **stored hot water** on the basis of stored water temperature

- **Separate and independent automatic time control** of space heating and hot water

- **Shut down of boiler** or other heat source when there is no demand for either space or water heating from that source

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2. Cost Optimisation

Major Renovation Might require Whole Dwelling Upgrade

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Where a dwelling undergoes "**major renovation**", the energy performance of the whole dwelling should be improved to **Cost Optimal** level insofar as this is technically, functionally and economically feasible.

Image Source: MosArt

What is 'Cost Optimal' Performance Level for Retrofit?

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Cost optimal performance defined as:

(1) **125 kWh/m².year** or less
(Equates to a B2)

Or

(2) **Implementing performance improvements** as set out in Table 7, Part L

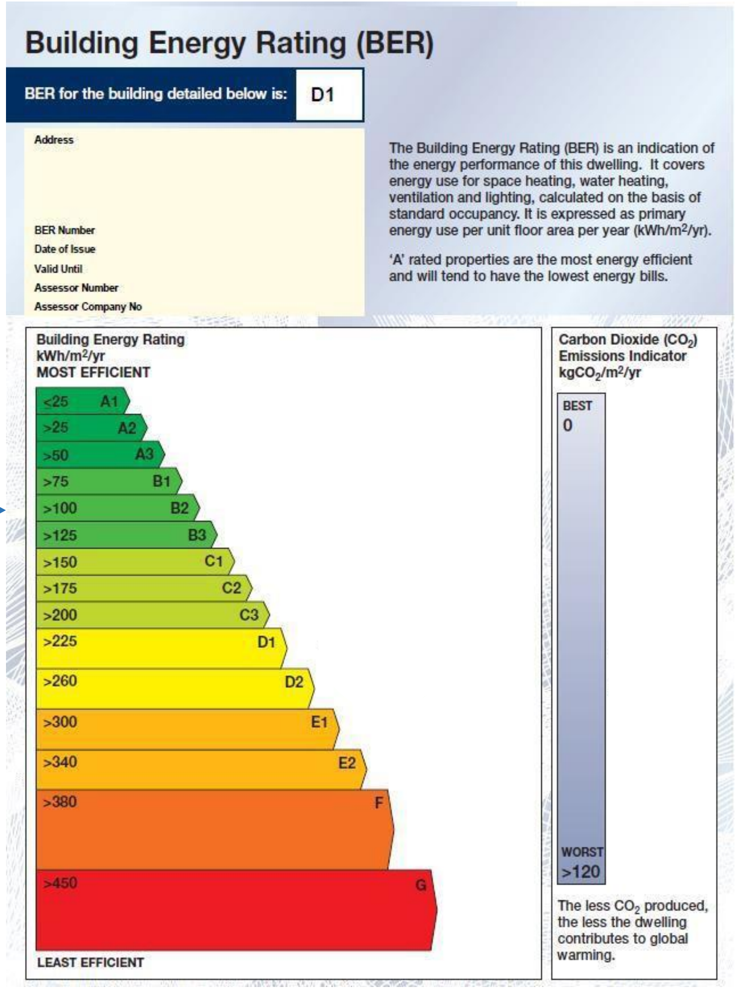

Image Source: SEAI

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Technical Guidance Document Part L

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Table 7 - Cost Optimal Works activated by Major Renovation

Major Renovation > 25 % surface area[1,2,3,5]	Cost Optimal level as calculated in DEAP (Paragraph 2.3.3 a.)	Works to bring dwelling to cost optimal level in so far as they are technically, economically and functionally feasible (Paragraph 2.3.3 b.)
External walls renovation	The cost optimal performance level to be achieved is 125 kWh/m²/yr.	Upgrade insulation at ceiling level (roof) where U-values are greater than in Table 5 and Oil or gas boiler replacement[6] and controls upgrade where the oil or gas boiler is more than 15 years old and efficiency less than 86 % and/or Replacement of electric storage heating[7] systems where more than 15 years old and with heat retention not less than 45 % measured according to IS EN 60531.
External walls and windows renovation		
External walls and roof renovation		
External walls and floor renovation		
New Extension affecting more than 25 % of the surface area of the existing dwelling's envelope (see 2.3.6)	The cost optimal performance level to be achieved is 125 kWh/m²/yr	Upgrade insulation at ceiling level (roof) where U-values are greater than in Table 5 and Oil or gas boiler replacement[6] and controls upgrade where the oil or gas boiler is more than 15 years old and efficiency less than 86 % and/or Replacement of electric storage heating[7] systems where more than 15 years old and with heat retention not less than 45 % measured according to IS EN 60531 and Upgrade insulation at wall level where U-values are greater than in table 5.
Windows Renovation	Not applicable[4]	Not applicable[4]
Roof Renovation		
Floor Renovation		
Roof and windows renovation		
Windows and floor renovation		
Roof and floor renovation		

[1] Where works are planned as a single project.
[2] Where major renovations to walls, roofs and ground floors constitute essential repairs e.g. repair or renewal of works due to fire, storm or flood damage or as a result of a material defect e.g. reactive pyrite in sub-floor hardcore, it is not considered economically feasible to bring these renovations to a cost optimal level.
[3] Major Renovation of external wall elements should also meet the requirements of Table 5
[4] It is not considered technically, functionally or economically feasible to bring the whole building to cost optimal level when replacing the surface area of these elements.
[5] Subject to the requirements of Table 5 for Material Alterations and window and door replacement.
[6] Oil or gas boiler replacement should be with a boiler or a renewable energy source with an efficiency as given in section 2.2.2.
[7] Replacement of electric storage heating should be with a heat generator with an efficiency as given in section 2.2.2.

2.3.3 The cost optimal level to be achieved is:

a) An energy performance of 125 kWh/m2/yr when calculated in DEAP as set out in column 2, Table 7

Or

b) Implementing the energy performance improvements as set out in column 3, Table 7 insofar as they are technically, functionally and economically feasible

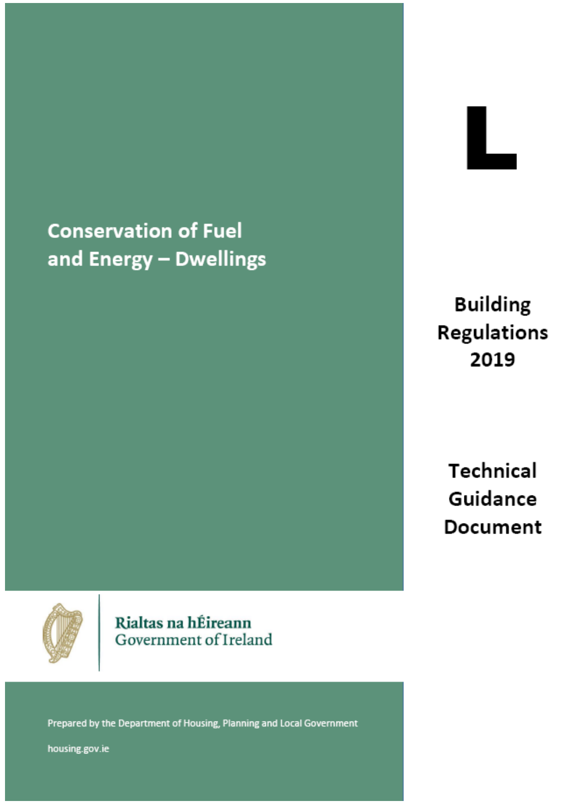

Image Source: TGD Part L, Ireland

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If not 125kWh/m².year- then need Performance Improvements

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Upgrade insulation at ceiling level where U-values are greater than **0.16 W/m²K**

AND

Oil or gas **boiler replacement & controls upgrade** where boiler > 15 years old and efficiency less than 86%

AND/OR

Replacement of electric storage heating systems > 15 years old and with heat retention not less than 45%

Image Source: Qualibuild

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Assessment

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QUIZ!

Thank You

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Special gratitude to Waterford Wexford Educational Training Board, Ireland for their contributions.