Module 11

Energy Renovation

Energy Efficiency for Construction
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.
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
Energy Renovation | Contents

Topic 1 – Renovation Strategy

Topic 2 – Cost Optimisation

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

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’?

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
What Works Constitute a ‘Major Renovation’?

<table>
<thead>
<tr>
<th>Table 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elemental works that are included in the surface area calculation for major renovation(^1,2,3)</td>
</tr>
<tr>
<td>External walls renovation</td>
</tr>
<tr>
<td>- External insulation of the heat-loss walls</td>
</tr>
<tr>
<td>- Replacement or upgrade of the external walls’ structure</td>
</tr>
<tr>
<td>- Internal lining of the surface of heat-loss walls</td>
</tr>
<tr>
<td>Windows renovation</td>
</tr>
<tr>
<td>- Replacement of windows</td>
</tr>
<tr>
<td>Roofs renovation</td>
</tr>
<tr>
<td>- Replacement of roof structure</td>
</tr>
<tr>
<td>Floors renovation</td>
</tr>
<tr>
<td>- Replacement of floors</td>
</tr>
<tr>
<td>Extension</td>
</tr>
<tr>
<td>- Extension works which affect more than 25% of the surface area of the existing dwelling</td>
</tr>
</tbody>
</table>

\(^1\) 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-sluating, re-tiling, cavity wall insulation and insulation of ceiling are not considered major renovation works.
Typical Buildings versus Deep Retrofits

Building Stock

Major renovation/Deep retrofit

Energy Efficiency for Construction: Energy Renovation

Image Source: Passive House Institute
What about Extensions?

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.

\((1) \leq 125 \text{ kWh/m}^2\text{.year}\)

Or

\((2) \text{ Implement performance improvements}\)

(same as above, plus need to upgrade walls if U-value > 0.55 W/m²k for cavity and 0.35 for ‘other walls’).
Case Study - Major Renovation Extension Trigger

Total dwelling envelope area (based on insulation at ceiling level):
Floor and roof = 2 x 9m x 7m = 126m²
Gable wall = 9m x 5.1m = 45.9m²
Front & rear walls = 2 x 7m x 5.1m = 71.4m²
Total = 243.3m²

25% trigger = 60.825 m²

<table>
<thead>
<tr>
<th>Proposed works</th>
<th>Dwelling envelope area affected</th>
<th>% of dwelling envelope area affected</th>
<th>Major Renovation triggered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 storey rear wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 storey rear wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 storey rear wall and gable wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 storey rear wall and gable wall</td>
<td></td>
<td></td>
<td></td>
</tr>
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<th>% of dwelling envelope area affected</th>
<th>Major Renovation triggered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 storey rear wall</td>
<td>17.85 m²</td>
<td>7.3 %</td>
<td>X</td>
</tr>
<tr>
<td>2 storey rear wall</td>
<td>35.7 m²</td>
<td>14.7 %</td>
<td>X</td>
</tr>
<tr>
<td>1 storey rear wall and gable wall</td>
<td>40.8 m²</td>
<td>16.8 %</td>
<td>X</td>
</tr>
<tr>
<td>2 storey rear wall and gable wall</td>
<td>81.6 m²</td>
<td>33.5 %</td>
<td>✓</td>
</tr>
</tbody>
</table>

All dimensions are internal

Image Source: WWETB-MosArt

Energy Efficiency for Construction: Energy Renovation
Government Policy to Upgrade Housing Stock to B2 Rating

Distribution of BERs in the BER database for the national housing stock 2016.
### Wall Insulation Method - Big Decision

**Table 18 - Selection criteria for insulation methods**

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

a) Subject to installer’s safety assessment.  
b) Advanced U-values requires a combination of methods.

d) Source: S.R. 54 by NSAI

e) EWI = External wall insulation  
f) IWI = Internal Wall Insulation  
g) CWI = Cavity Wall Insulation
External Wall Insulation (EWI)

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

<table>
<thead>
<tr>
<th>Thermal insulation material</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral wool</td>
<td>• Vapour permeable</td>
<td>• 15-30% more expensive</td>
</tr>
<tr>
<td></td>
<td>• Good reaction to fire</td>
<td>• More demanding for installation</td>
</tr>
<tr>
<td></td>
<td>• Good sound insulation</td>
<td>• Risk of dampening</td>
</tr>
<tr>
<td>EPS-polystyrene</td>
<td>• Lower material price</td>
<td>• Less vapour permeable</td>
</tr>
<tr>
<td></td>
<td>• Easier for installation</td>
<td>• Weaker sound insulation</td>
</tr>
<tr>
<td></td>
<td>• Greater choice of finishing layers</td>
<td>• Weaker reaction to fire</td>
</tr>
</tbody>
</table>

![Diagram of External Wall Insulation](image)

1. Adhesive
2. Thermal insulation material
3. Base coat (in 2 layers)
4. Reinforcement (glass fibre mesh)
5. Finishing layer: finishing coat with a key coat and/or decorative coat
6. Anchors (if needed)

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

Source: HUPFAS [32]
External Wall Insulation (EWI)

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]
Energy Efficiency for Construction: Energy Renovation

External Thermal Insulation – External Walls

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
External Wall Insulation (EWI)

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)

Anchor head countersunk into the insulation material

Anchor applied flush with the surface of the insulation material
External Wall Insulation (EWI)

What human eye can’t detect, infrared can! (Quality control)
External Wall Insulation (EWI)

Diagonal reinforcements

Formation of edges, outer and inner corners

Formation of drip edges

Expansion Joints
## External Wall Insulation (EWI)

### Selection of finishing coat

<table>
<thead>
<tr>
<th>Plaster Type</th>
<th>Mineral</th>
<th>Silicate</th>
<th>Acrylic</th>
<th>Silicone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water repellent</td>
<td>o</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Vapour permeable</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Dirt resistant</td>
<td>o</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Elastic</td>
<td>-</td>
<td>o</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Colour range</td>
<td>o</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

**LEGEND:** ++ very good + good o potentially good - poor
Types of Cavity Wall

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.
Cavity Wall Insulation

Figure 47 - Unfilled / clear cavity wall

Figure 48 - Partial fill cavity wall

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Source: S.R. 54 by NSAI
Cavity Wall Retrofit Methods

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.
Internal Wall Insulation – WITH Service Void

Continuity of vapour control layer!!

Timber studs

Metal studs

Source: S.R. 54 by NSAI
Internal Wall Insulation – WITH Service Void

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

How do you connect these VCLs?

Vapour path = condensation

Vapour control layer

Source: S.R. 54 by NSAI
Rotted Joist ends

Source: Image Rentokil
Interior thermal insulation – External walls

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

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]
Walk Through of Wall Types

1. https://www.youtube.com/watch?v=9V2lv0SRIG8&list=PL8dmE01N8M7u4uAWl02eK_Y6KZaj0nqYx&index=15
2. https://www.youtube.com/watch?v=5NZSP1AFz68&list=PL8dmE01N8M7u4uAWl02eK_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-pekJ0OoU&list=PL8dmE01N8M7u4uAWl02eK_Y6KZaj0nqYx&index=13
Hygrothermal requirements are fulfilled by using:

1) Roof membranes (air and moisture control)

2) Thermal insulation (thermal protection)

3) Compressed tapes or coatings
Roofs

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
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.
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Windows

Thermally inefficient installation

\[ \Psi_{\text{install}} = 0.15 \, \text{W/(mK)} \quad \Psi_{\text{eff}} = 1.19 \, \text{W/(m}^2\text{K)} \]

Source: HUPFAS [32]
Energy Efficiency for Construction: Energy Renovation

Recommended installation

\[ \Psi_{\text{inlet}} = 0.005 \text{ W/(mK)} \quad U_{\text{eff}} = 0.78 \text{ W/(m}^2\text{K)} \]
Positioning window outboard of structural plane

Thermally optimised support using ‘compac foam’ bolted to structure
Case Study Window Installation – Rochestown Avenue EnerPHit Project
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
Case Study Window Installation – Rochestown Avenue EnerPHit Project

Installation of flashing to window exterior

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

Source: EnerPHit
Case Study Window Installation – Rochestown Avenue EnerPHit Project

Flashing to underside of window (and supporting insulation) using ‘peel-and-stick’ membrane
Case Study Window Installation – Rochestown Avenue EnerPHit Project

Initial placement of plasterable airtight tape to window reveal

Tape to be firmly pressed against reveal with applicator card

Don’t short-circuit corners!
Airtight sealing of window to reveals on the interior using wide plasterable tapes

Note 10mm max overlap on window frame
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!
Case Study Window Installation – Rochestown Avenue EnerPHit Project

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

Before and after views on completion of project

Source: EnerPHit
Video on Step by Step Deep Retrofit

https://www.youtube.com/watch?v=uJyGE_kuEAA
**Ventilation Strategies Decision**

- **Natural ventilation with intermittent fans**
  - Mechanical extract
  - Relatively easy install

- **Continuous mechanical extract ventilation**
  - Challenging install

- **Mechanical ventilation with heat recovery**
  - Invasive install

---

**Air permeability $q_{E50}$:**

- **$> 3 \text{ m}^3/\text{h.m}^2$**
  - Natural ventilation with intermittent fans
  - Mechanical extract

- **$< 3 \text{ m}^3/\text{h.m}^2$**
  - Continuous mechanical extract ventilation
  - Mechanical ventilation with heat recovery

*Source: Technical Guidance Documents Part F, Ireland*
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.
### Suitable ventilation strategies for residential retrofit

<table>
<thead>
<tr>
<th>Ventilation strategy</th>
<th>Level of retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single room or partial house retrofit</td>
</tr>
<tr>
<td>Natural with extract fans</td>
<td>Y</td>
</tr>
<tr>
<td>Natural with PSV</td>
<td>Y</td>
</tr>
<tr>
<td>SRHRV</td>
<td>Y</td>
</tr>
<tr>
<td>MEV</td>
<td>N</td>
</tr>
<tr>
<td>MVHR</td>
<td>N</td>
</tr>
</tbody>
</table>

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

**Mechanical Ventilation with Heat Recovery**

In the transfer zone – not supplying, not extracting – just ‘passing through’

**SUPPLY ZONE TRANSFER ZONE EXTRACT ZONE**

Openings for transferred air

Source: Adapted from Passive House Institute
Compact Unit with MVHR and Emitters

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
Checklist of retrofit measures to achieve the required air permeability

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

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.
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”)
‘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.
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
2. Cost Optimisation
Major Renovation Might require Whole Dwelling Upgrade

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.
What is ‘Cost Optimal’ Performance Level for Retrofit?

Cost optimal performance defined as:

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

Or

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

Image Source: SEAI (1)

125 kWh/m².year or less (Equate to a B2)

Image Source: SEAI (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
If not 125kWh/m$^2$.year- then need Performance Improvements

Upgrade insulation at ceiling level where $U$-values are greater than 0.16 W/m$^2$K

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
Thank You

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