Code of Practice – Methodology for the energy efficient retrofit of existing domestic dwellings

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Presentation

- **Brief background** on the development of the draft Code of Practice
- **Description** of the layout and structure of the document – how it can be utilised
- **Key points** regarding Planning a Retrofit and Building Science
- **Overview** of the Code of Practice sections that cover - Dwelling Fabric, Dwelling Ventilation and Dwelling Services
- **Guidance** regarding Project Management of a retrofit project
- **Benefits** that can gained from utilising the document

Retrofit Code of Practice - Draft

- **NSAI/DECLG/DCENR/SEAI** - S.R.54: Code of Practice — Methodology for the energy efficient retrofit of existing domestic dwellings
- Public Consultation completed. Comments being reviewed.
- Consultants-**Building Research Establishment (BRE)**
- Provides guidance for design and building professionals
- Contents include overall approach, fabric and services
- Schedule for completion **Q4 2013**

Introduction

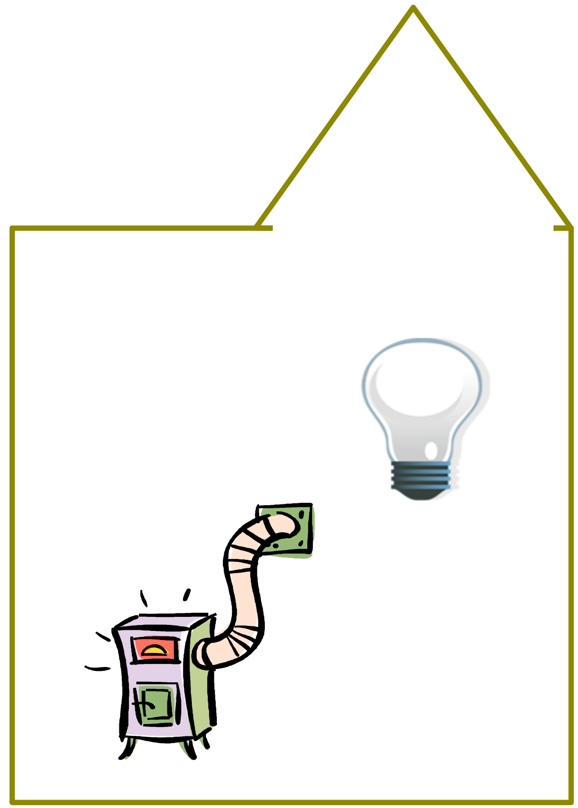
Purpose and scope	• Provide technical guidance on energy efficient refurbishment of post 1940s low-rise dwellings
Audience	• Property managers, designers, specifiers and installers
Use	• Application of measures to fabric, ventilation and services • Consult specific section for guidance but CoP considers refurbishment holistically
Level	• Detailed technical guidance - assumes users have appropriate qualification and experience of retrofit projects
Support	• Building Science section covers basic concepts • Management Section for delivering retrofit projects

Elements Addressed

Roofs
- Pitched
- Timber flat
- Concrete flat

Heating
- Gas
- Oil
- Solid fuel
- Electric
- Warm air
- Room
- Pipework, emitters and controls

Ventilation
- Room
- MV
- PSV



Floors
- Suspended pre-cast
- Suspended timber
- Ground bearing

Lighting
- Lamps (tungsten, tungsten halogen, CFL, LED etc.)
- Luminaires
- Controls

Walls
- Hollow block
- Cavity
- Solid
- Timber frame
- Steel frame
- IWI/EWI/CWI

Retrofit Code of Practice
- Document Structure -

- **Scope**

- **Building Science**
- **Planning a Retrofit**
- **Dwelling Fabric**
  - Floors
  - Walls
  - Openings
  - Roofs
- **Dwelling Ventilation**
- **Dwelling Services**
  - Heating and Hot Water
  - Residential Lighting

- **Project Management**
- **U-values – Driven Rain Index – Thermal Bridging - Bibliography**

Retrofit Code of Practice
- Document Structure -

- **Same approach -** for each fabric element and service
- **Probable existing condition** – described for each, likely problems highlighted and current performance level
- **Options for a retrofit** – list of those considered acceptable
- **Design Considerations** for each retrofit option, e.g.
  - Materials to use
  - Adapting to existing conditions
  - Technical risks etc.
- **Installation considerations,** e.g.
  - Construction Sequence
  - Particular detailing to avoid thermal bridging etc.

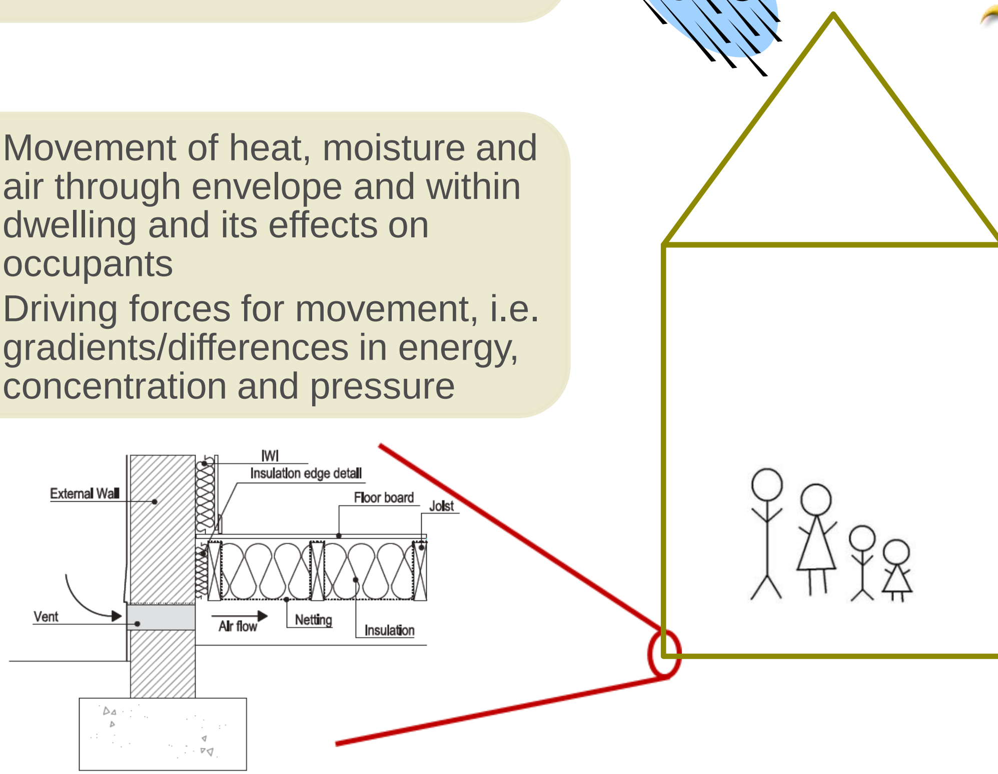
Building Science - General

Purpose

- Provides users of the Code of Practice with basics of building physics
- Supports technical aspects and is a reference section

Dwelling treated as a system

- Movement of heat, moisture and air through envelope and within dwelling and its effects on occupants
- Driving forces for movement, i.e. gradients/differences in energy, concentration and pressure



Building Science - Structure

Heat

- Conduction
- Convection
- Radiation

Moisture

- Water vapour
- Liquid
- Solid

Air

- Wind pressure
- Stack pressure

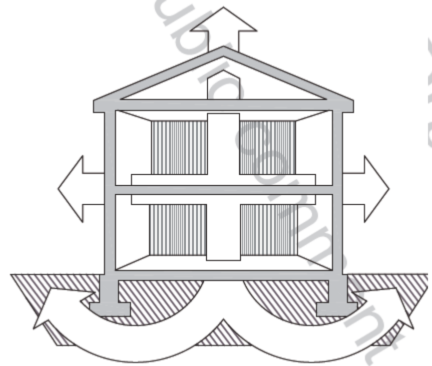
Flow through envelope and within dwelling

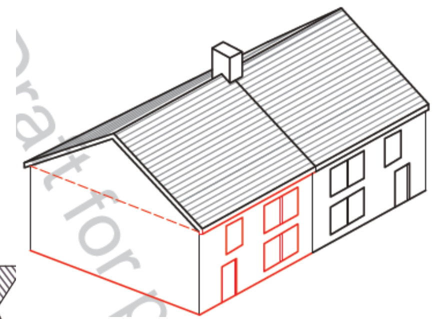
Effect on occupants

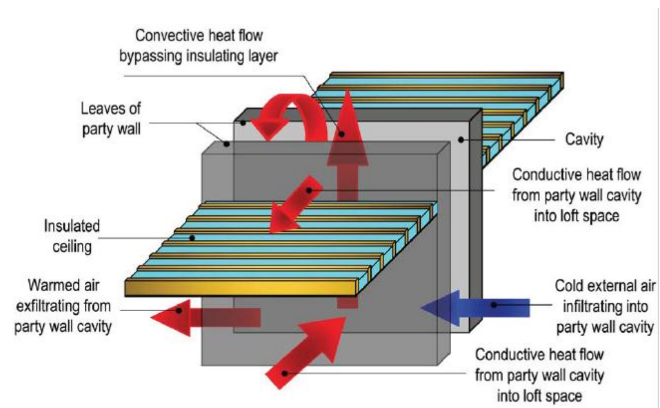
Building Science – Flow through dwelling

Insulation Material		Thermal conductivity range[a] (W / mK)						
		0,00	0,01	0,02	0,03	0,04	0,05	0,06
Highest performance	Vacuum insulation panels	0,008						
	Aerogel		0,013					
Polyurethane	Polyurethane with pentane up to 32kg / m³			0,027	0,030			
	Polyurethane soy based			0,026	0,038			
	Foil-faced Polyurethane with pentane up to 32 kg / ³			0,020				
	Polyurethane with CO_2				0,035			
	In-situ applied Polyurethane (sprayed or injected)			0,026				
Polyisocyanurate (PIR)	Polyisocyanurate up to 32 kg / m³			0,026				
	Foil faced Polyisocyanurate up to 32 kg / m³			0,023				
	In-situ applied Polyisocyanurate (sprayed)			0,025				
Phenolic foam	Phenolic foam			0,023				
	Foil-faced Phenolic foam			0,022				
Expanded polystyrene (EPS)	Expanded polystyrene up to 30 kg / m³				0,030	0,045		
	Expanded polystyrene with graphite (grey)				0,031			
Extruded polystyrene (XPS)	Extruded polystyrene with CO_2			0,025	0,037			
	Extruded polystyrene with HFC 35 kg / m³			0,029	0,031			
Wool and fibre	Glass wool [up to 48 kg / m³]				0,030	0,044		
	Glass wool [equal / greater then 48 kg / m³]				0,036			
	Stone wool [less than 160 kg / m³]				0,036			
	Stone wool [160 kg / m³]				0,037	0,040		
	Sheep's wool [25 kg / m³]				0,034		0,054	
	Cellulose fibre [dry blown 24 kg / m³]				0,035	0,046		
	Hemp fibre				0,039			
	Polyester fibre				0,035	0,044		
	Wood fibre (WF)				0,039			0,061

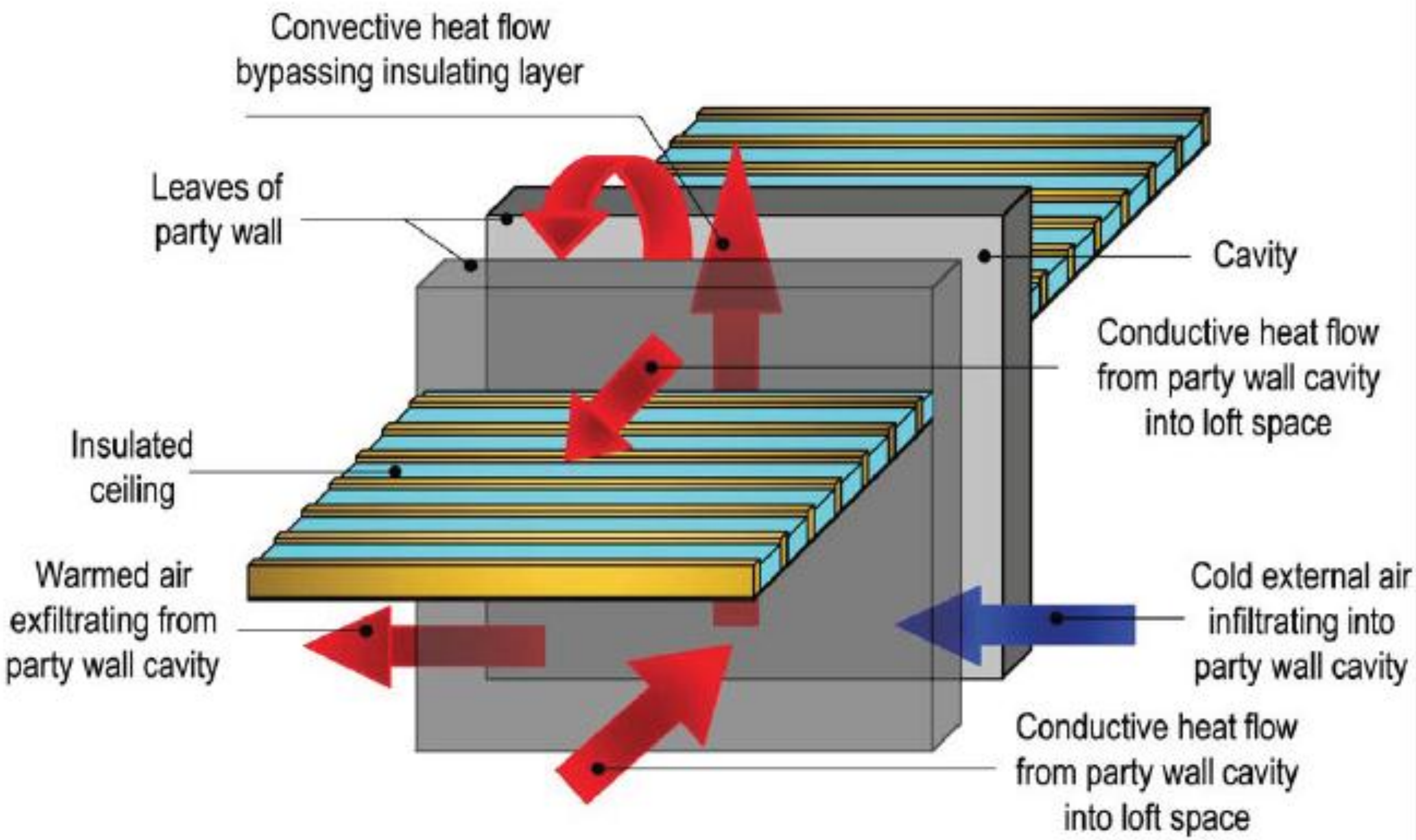
[a] Thermal conductivity ranges are a minimum and maximum obtained from the thermal conductivity values declared by manufacturers (or suppliers) and those given in the European Thermal Values publication







Building Science – Flow through dwelling



Planning a Retrofit - General

Purpose

- Sets out retrofit planning and assessment – Energy Surveys & Improvement Plans
- Gives context in how to use the Code of Practice to achieve successful retrofit

Scope

- Impact of Planning and Building Regulations requirements
- Suitable use of materials
- Process to define scope of retrofit project
- Dwelling Survey to benchmark performance and identify relevant issues for retrofit
- Examples of retrofit projects using performance levels contained in the code

Planning a Retrofit - Project Stages and Scope

Defining Project Scope

- Size (single task, multiple tasks, whole house or multiple dwellings)
- Budget
- Performance required
- Time available
- Disruption

- Survey
- Selection and specification of measures
- Works
- Commissioning and Handover

Described in detail in Code of Practice

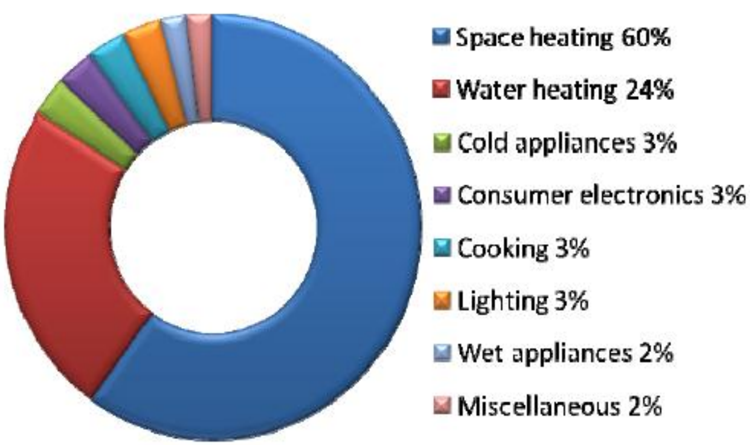
Planning a Retrofit - Survey 1

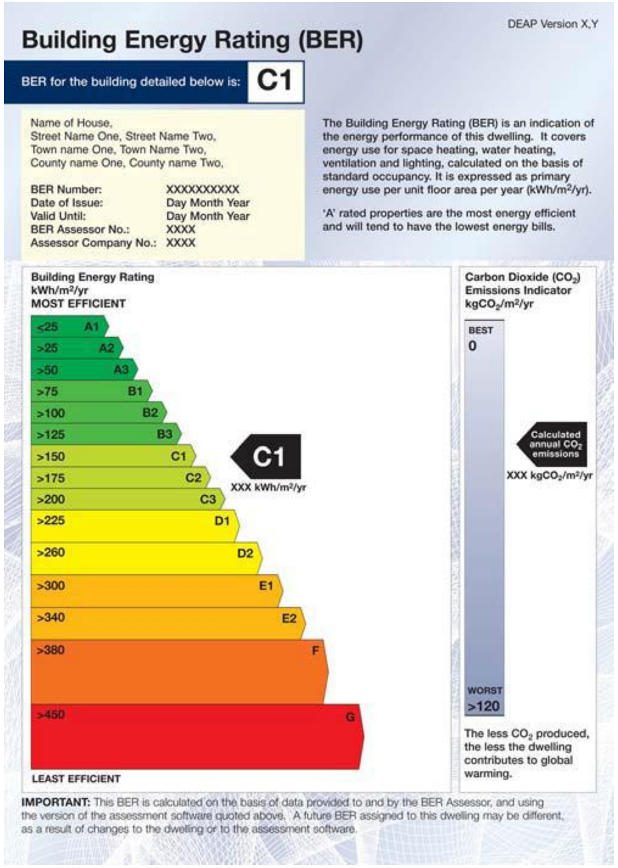
Benchmark existing performance &

Potential for improvement through energy survey

Energy Improvement Plan

- Meets needs of occupants
- Assess capital costs, savings, improved comfort
- Considers possible future works
- Assess likely disruption





Planning a Retrofit - Survey 2

Depending on extent of proposed work then further survey to assess condition of existing fabric and services

Wall, roof and floor	•Type (e.g. hollow block), presence of insulation (e.g. CWI) •Condition and cause (e.g. condensation, damaged rain water goods, soil levels etc.)
Windows and doors	•Type – use laser gauges to identify thickness, air gap width etc. •Condition, particularly with respect to proposed intervention
Heating	•Type and fuel used •Condition •Presence of thermostats and controls •If off-gas scope for provision or potential to store fuel
Ventilation and airtightness	•Presence of openings, including under-floor and under eaves •Assess airtightness by visual inspection or by test
Lighting	•Types of lamps and fitting •Scope to enhance natural daylight
Layout and size	•Identify heating zones, in particular Zone 1 •Size and height of rooms •Widths of stairs, doorways and passageways

Planning a Retrofit - Application

Examples based on **Tabula**

Semi-detached house, 1981

Description

Semi-detached or end of terrace house commonly built in Dublin with a red-brick front with a small cavity behind it on the ground floor and 225 mm hollow block walls elsewhere. Insulation first appeared in 1978 and these walls would be typically be drylined with 25 mm polystyrene board or with 50 mm of insulation fibre between battens.

Building elements		Insulation	U-Value
Walls	Concrete hollow block, drylined	15-25 mm	1,1
Roofs	Pitched, insulation between joists	100 mm	0,4
Floors	Solid	10-15 mm	0,57
Windows	Double glazed, metal frame, 6 mm gap	n/a	3,7
Doors	Double glazed, metal frame, 6 mm gap (front)	n/a	3,7
	Solid wood (kitchen door)	none	3,0
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, pipework uninsulated	Mains gas	70 %
Secondary	Open fire in grate	Solid multi-fuel	30 %
Hot water	From primary heating system. Electric immersion heater is used in summer		
Cylinder	Insulated with loose jacket, 35 mm thick, no thermostat		
Controls	Programmer		

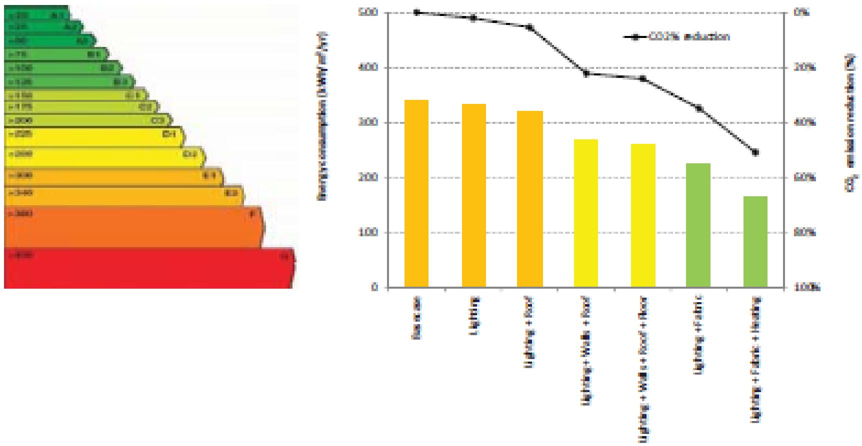
Planning a Retrofit - Application

Table 6 — Specification for different performance levels for Semi-detached dwelling (hollow block)

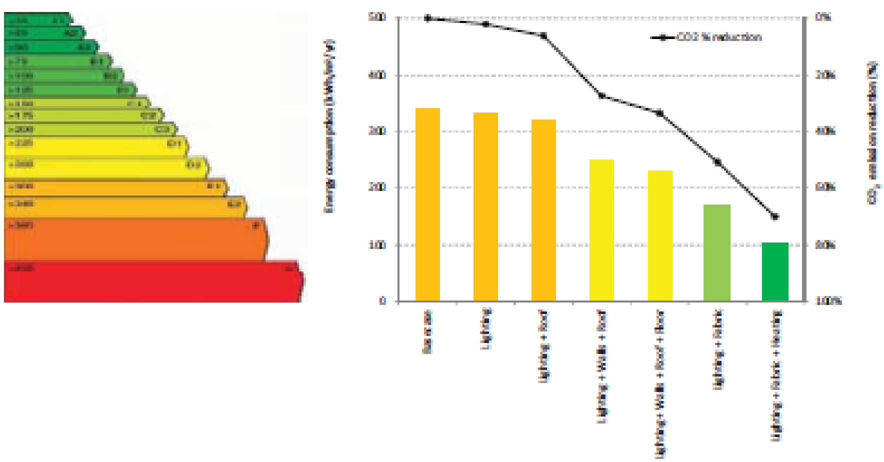
Element	**Base Case**	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Roof – Pitched					
Insulation	100 mm between joists	250 mm between and over joists	300 mm between and over joists	400 mm between and over joists	400 mm between and over joists
Conductivity	0.04 W/mK	0.04 W/mK	0.04 W/mK	0.04 W/mK	0.04 W/mK
U-Value	0.4 W/m^{2}K	0.16 W/m^{2}K	0.14 W/m^{2}K	0.10 W/m^{2}K	0.10 W/m^{2}K
Walls – Hollow block					
Internal insulation (IWI)	15-25mm drylined	60mm IWI	90mm IWI	120mm IWI	160mm IWI
Conductivity		0,025 W/mK	0,025 W/mK	0,025 W/mK	0,025 W/mK
U-value	1,1 W/m2K	0,35 W/m2K	0,27 W/m2K	0,021 W/mK	0,015 W/mK
		OR	OR	OR	OR
External insulation (EWI)		90 mm EWI	120 mm EWI	160 mm EWI	220 mm EWI
Conductivity		0,035 W/mK	0,035 W/mK	0,035 W/mK	0,035 W/mK
U-value		0,35 W/m^{2}K	0,27 W/m^{2}K	0,21 W/m^{2}K	0,15 W/m^{2}K
Floor					
Insulation	Solid 10-15mm	Solid 20 mm	Solid 70 mm	Solid 100 mm	Solid 120 mm
Conductivity	0,035 W/mK	0,035 W/mK	0,035 W/mK	0,035 W/mK	0,025 W/mK
U-value	0,57 W/m^{2}K	0,45 W/m^{2}K	0,25 W/m^{2}K	0,21 W/m^{2}K	0,15 W/m^{2}K
Windows					
Type	Metal frame, double glazed, 6 mm gap	High performance double glazed, low-e, argon	High performance double glazed, thermally broken, low-e	High performance double glazed, thermally broken	High performance double glazed, thermally broken
U-value	3,7 W/m^{2}K	1,6 W/m^{2}K	1,4 W/m^{2}K	1,3 W/m^{2}K	1,3 W/m^{2}K
Doors					
Type (Front)	Double glazed, metal frame 6mm gap	High performance double glazed, low-e, argon	High performance triple glazed, low-e	High performance triple glazed, low-e, argon	High performance triple glazed, low-e, argon
U-value (Front)	3,7 W/m^{2}K	1,6 W/m^{2}K	1,4 W/m^{2}K	1,3 W/m^{2}K	1,3 W/m^{2}K

Planning a Retrofit - Application

Semi detached house (1981, Hollow blocks) - Refurbishment level 1



Semi detached house (1981, Hollow blocks) - Refurbishment level 3/4



Floors - General

Purpose

- Different types of floor construction
- Insulation methods
- Materials available
- To achieve the targeted energy savings.

Scope

- Three typical types of floor -
  - suspended precast concrete floors,
  - suspended timber floor, and,
  - ground supported concrete floor.

Floors - Suspended Precast Concrete

	Un-insulated floor	Level 1	Level 2	Level 3	Level 4 [a]
U-value[b] W/m^{2}K:	0,58	0,45	0,25	0,21	0,15
Insulation conductivity (λ) W/mK	**Insulation thickness needed (mm)**				
0,040	-	20	90	120	200
0,035	-	20	80	100	170
0,030	-	20	70	90	150
0,025	-	10	60	80	120
0,020	-	10	50	60	100
0,015	-	10	35	45	75

[a] The U-value given for Level 4 is the value required when installing underfloor heating.

[b] House type used for calculations is a semi detached house with a ground floor area of 63 m² with an exposed perimeter of 23 m^2

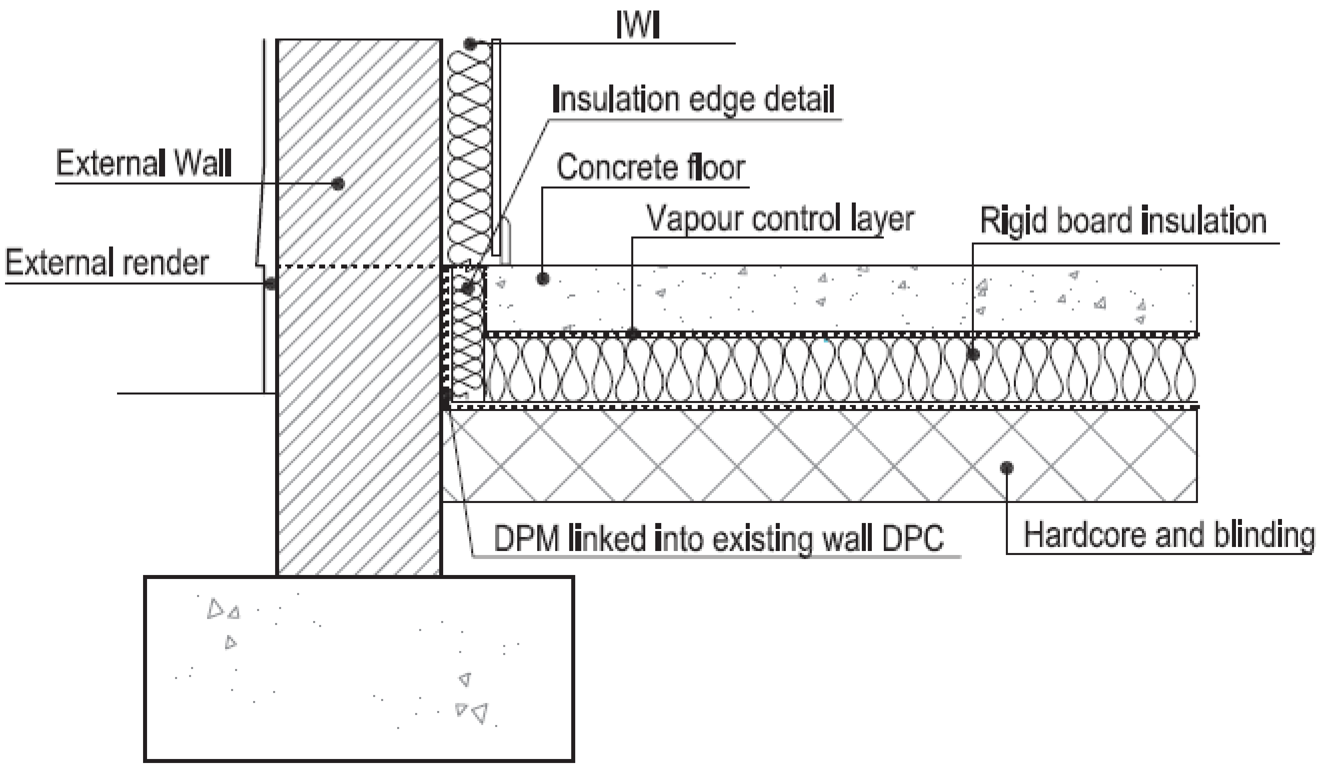
Floors – Design Considerations

Occupant disruption	• Overfloor solutions will require skirting boards, low level sockets and possibly door heads to be raised. • Underfloor solutions will most likely require decanting the occupant during the retrofit.
Floor conditions	• Timber floor joists may require replacing • Underfloor ventilation to be maintained or increased • Areas of dampness in retained concrete floors to be addressed, leaking services can allow for localised repair.
Underfloor heating	• Where underfloor insulation solutions being provided, consider provision of underfloor heating, either for the installation of a heat pump now or in the future.

Floors – Installation Considerations

Airtightness	• Ensure that all service penetrations and floor perimeters are sealed correctly. • Provision of full central heating may lead to shrinkage of existing floor boards, so consider replacing flooring or overdecking.
Suspended timber floors	• Mesh not to be so taught as to compress insulation • Seal joints between sections of rigid insulation • Ensure that gap between last joist and wall is insulated.
Ground supported concrete floors	• Provide a radon barrier and radon sump for replacement floors.

Floors – Ground Supported Concrete



Walls – General

Purpose

- This section covers the different types of wall construction, insulation methods and materials available to achieve the targeted energy savings.

Scope

- There are four typical constructions:
  - Hollow block walls,
  - Cavity walls,
  - Solid walls, and
  - Timber/steel frame walls

Walls – General

Survey & Preparatory Works

- Construction Type & Structure
- Airtightness & Ventilation
- Condensation
- Dampness
- Exposure

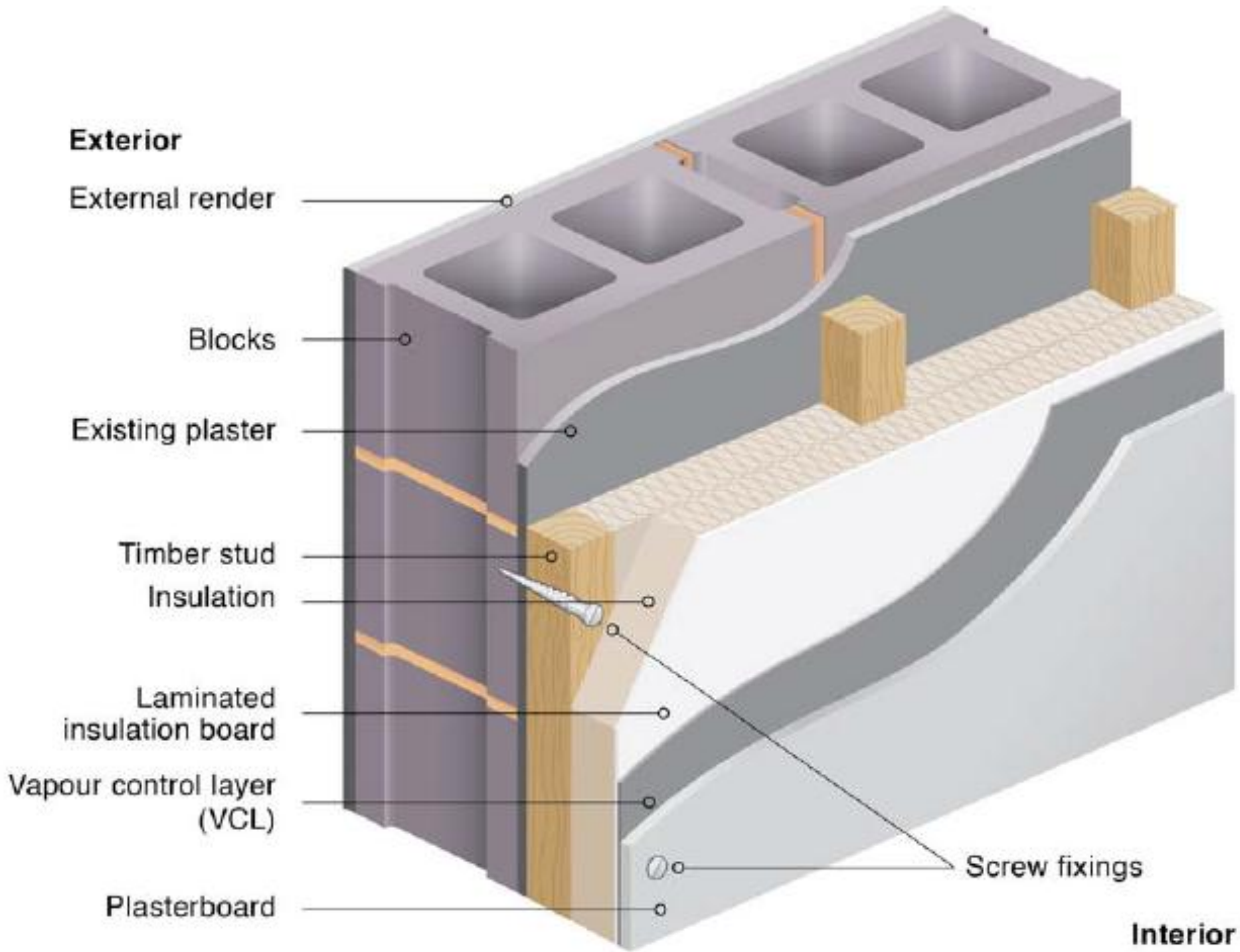
Retrofit Options

- EWI – External Wall Insulation
- IWI – Internal Wall Insulation
- CWI – Cavity Wall Insulation
- Selection Table

Walls – Selection Criteria for Insulation

	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	No[a]
7.	External services (e.g. downpipes, gullies, cables, gas meter box, electricity meter box, flues, etc.) may require relocation	Yes	No	No
8.	May require planning approval for works which materially alter exterior appearance of the dwelling	Yes	No	No
9.	System requires approved installers for works	Yes	No	Yes
10.	Internal pipes, radiators, electrics etc. require relocation	No	Yes	No
11.	Internal skirting, architrave, fitted kitchens, wardrobes etc. require relocation	No	Yes	No
12.	Internal vapour control layer required	No	Yes	No
13.	Practical to achieve advanced U-value without combining with another system	Yes	No	Yes
14.	Specification subject to wind driven rain exposure	No	Yes	Yes
15.	May impact on access provision to side of dwelling	Yes	No	No
16.	May impact external accessibility requirements to dwelling	Yes	No	No
17.	May impact on corridor/stair widths internally	No	Yes	No
18.	May require modification of eaves/gable roof line	Yes	No	No
19.	Improves external weatherproofing and appearance of building	Yes	No	No
20.	Local Authority consulted where encroaching on public footpath	Yes	No	No
a	Subject to installer's safety assessment			

Walls – Applicable Retrofit Methods – Internal Wall Insulation



Walls – Cavity Walls

Cavity Wall Types

- Clear cavity
- Partial filled cavity
- Cavity that cannot be filled

Cavities suitable for filling

- Clear cavities in moderate driven rain locations

Cavities not suitable for filling

- Partial filled cavities
- Clear cavities in severe driven rain locations
- Cavity width too narrow

Walls – Cavity Walls – Suitable for Cavity Fill Insulation, 2 Stage Process

Stage 1

- Fill cavity to achieve at least minimum performance.

Stage 2

- Provide either internal or external insulation to achieve improved performance.

Walls – Cavity Walls – Suitable for Cavity Fill, with Internal or External Insulation

Baseline U-Value (W/m^2K)		Cavity width												Target U-value (W/m^2K)
		50 mm				75 mm				110mm				
		0,67	0,64	0,60	0,52	0,50	0,47	0,44	0,38	0,36	0,35	0,32	0,27	
IW / EW Thermal conductivity (W/mK)	0,040													Level 1 (0,35)
	0,035													
	0,030													
	0,025													
	0,020													
	0,015													
	0,040	90	85	75	65	60	55	50	35	30	25	15	N/A	Level 2 (0,27)
	0,035	70	70	65	60	55	50	45	30	30	25	15	N/A	
	0,030	60	60	55	50	40	45	40	30	25	20	15	N/A	
	0,025	50	50	50	40	40	35	35	25	20	15	10	N/A	
	0,020	40	40	40	35	30	30	25	20	15	15	10	N/A	
	0,015	30	30	30	25	25	25	20	15	15	10	10	N/A	
	0,040	140	135	120	115	110	105	100	90	75	70	60	35	Level 3 (0,21)
	0,035	115	115	115	105	100	95	90	70	65	60	55	35	
	0,030	100	100	100	90	75	75	70	60	55	50	45	30	
	0,025	90	75	75	70	65	65	60	50	45	45	40	25	
	0,020	65	60	60	55	50	50	45	40	40	35	30	20	
	0,015	50	45	45	40	40	35	35	30	30	25	25	15	
	0,040	225	215	210	200	195	190	185	165	160	150	140	115	Level 4 (0,15)
	0,035	200	190	185	175	170	165	160	145	140	135	120	105	
	0,030	170	165	160	150	145	145	140	125	120	115	105	90	
	0,025	140	140	135	125	120	120	115	105	100	95	90	70	
	0,020	110	110	110	105	95	95	90	75	75	70	65	55	
	0,015	75	75	70	70	65	65	65	60	55	55	50	45	

NOTE 1 Where internal insulation thickness exceeds 75 mm (shaded in blue), the insulation may be installed in two or more layers: i.e. the first between battens, and the last layer as a laminate or separate layer.

NOTE 2 Where the overall thickness of the external insulation becomes significant (e.g. exceeds 100 mm) then the approach shall be to insulate the cavity to a higher performance level by using a cavity wall insulant of lower thermal conductivity.

Walls – Cavity Walls – Not Suitable for Cavity Fill Insulation

Option 1

- Provide internal wall insulation (IWI) to achieve required performance.

Option 2

- Fill cavity and provide external wall insulation (EWI) to achieve required performance.

Walls – Solid Walls

Cavity Wall Types

- Cavity that cannot be filled
- Clear cavity
- Partial filled cavity

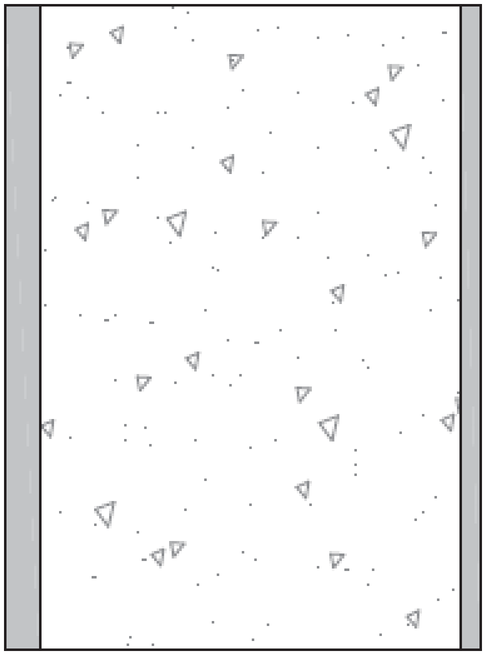
Prevalence

- Solid walls mainly consist of no fines concrete or mass concrete.
- Solid block walls and precast concrete panels also used, but less widespread

Existing performance

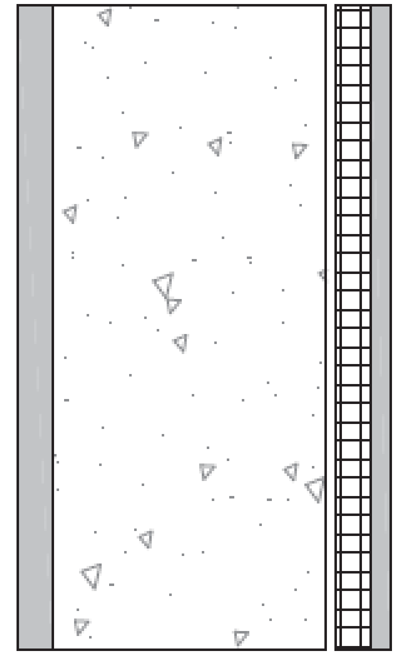
- Partial filled cavities
- Clear cavities in severe driven rain locations
- Cavity width too narrow

Walls – No Fines Concrete Walls



305 mm No-fines, two coat plaster Inner face, rendered outside U-value 1,53 W/m^{2}K

254 mm No-fines, drylined on studs or dabs Inner face, rendered outside, U-value 1,23 W/m^{2}K



203 mm No-fines, cellular cored drylining on studs or dabs Inner face, rendered outside U-value 1,10 W/m^{2}K

Walls – Framed Walls

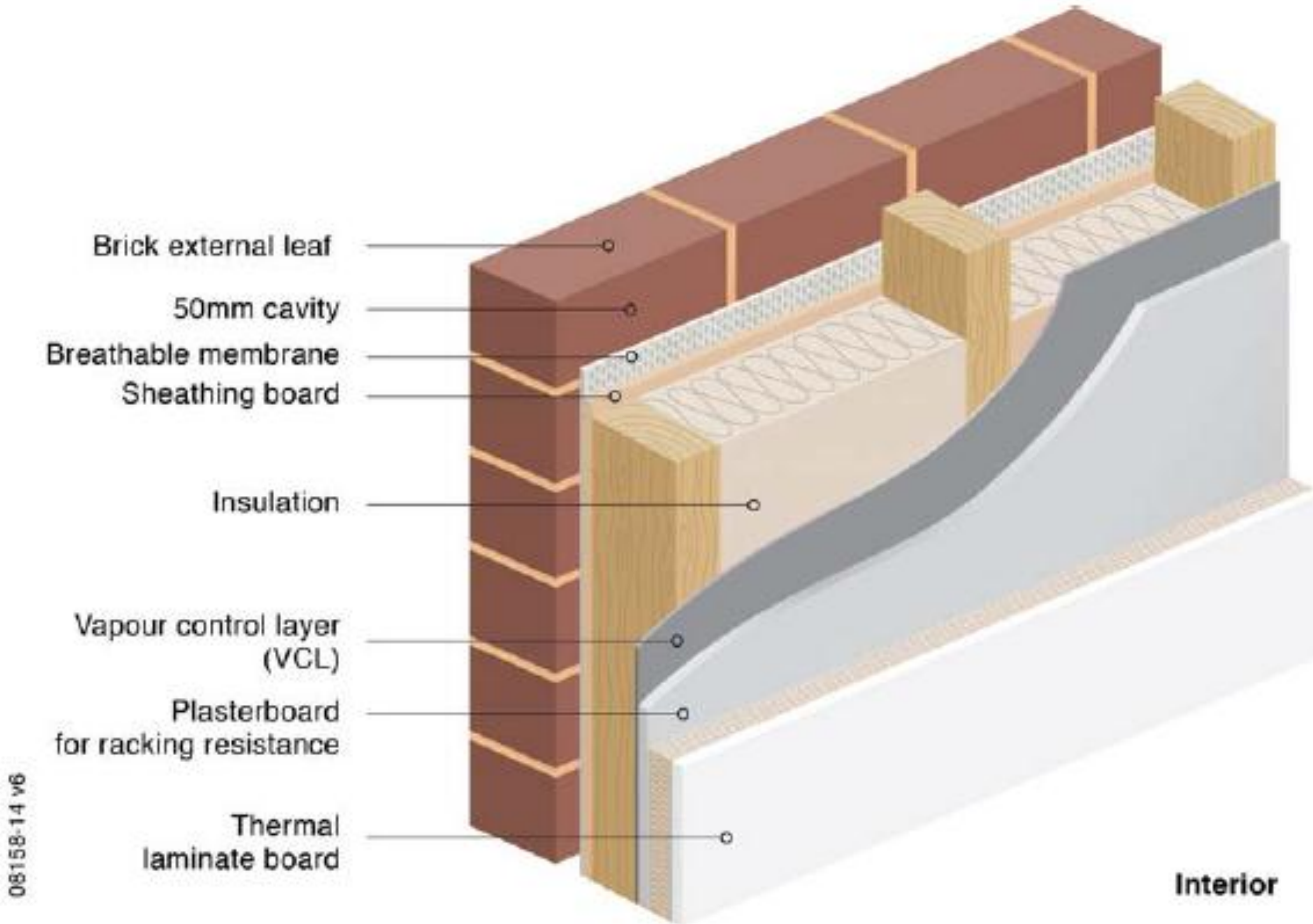
Timber frame

- Cavity wall construction with inner leaf of structural timber.
- More than 25 years old, little or no insulation.
- Less than 25 years old, insulation partially or fully filled

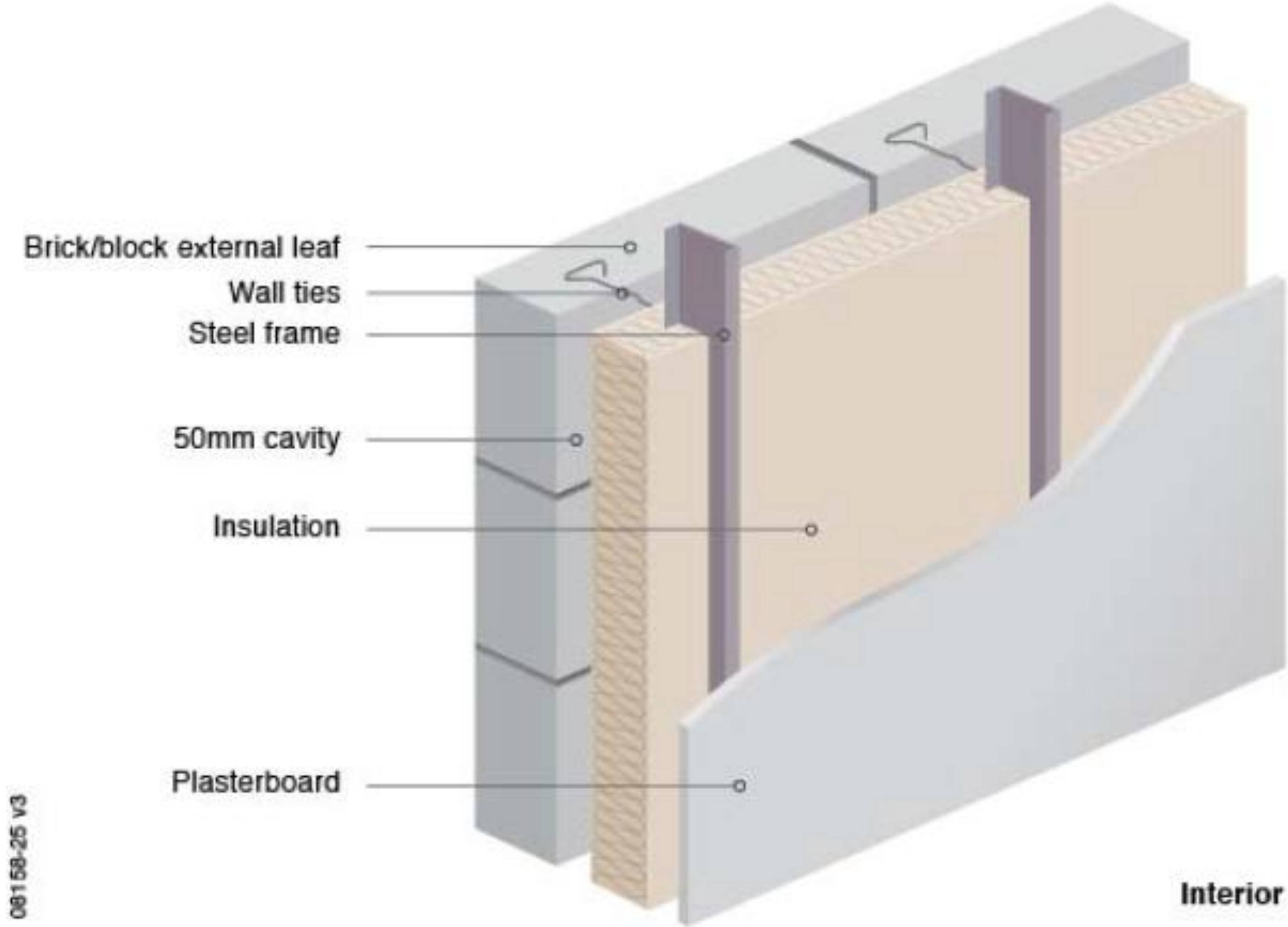
Steel frame

- Relatively recent form of construction
- Warm steel frame, insulation on the outside of frame.
- Hybrid steel frame, insulation on outside and between frame.

Walls – Timber Framed Walls – Partially Filled, Topped up and Overboarded with Thermal Laminate



Walls – Hybrid Steel Frame



Walls – Design Considerations

Occupant disruption

- External and cavity fill insulation solutions only minor disruption.
- Internal insulation solutions will most likely require decanting the occupant during the retrofit.

Wall type

- Ensure that correct wall type is identified by suitable survey.
- Driven rain exposure conditions may require external insulation, again ensure suitable survey.

Wall condition

- Rectify pre-existing defects, structural failure, dampness etc.

Walls – Design Considerations

Interstitial condensation	• Ensure consideration of preventing interstitial condensation done for whatever insulation solution proposed. • Internal insulation solutions to solid walls, WUFI modelling inconclusive due to lack of data and external rain penetration.
Ventilation	• Ensure that purpose provided ventilation for combustion appliances maintained • Background ventilation and subfloor ventilation to be maintained.
Thermal bypass or looping	• External insulation solutions to cavity walls, fill cavity also. • Hollow block walls, seal at roof insulation level.

Walls – Installations Considerations

Airtightness

- Ensure that all service penetrations and wall perimeters are sealed correctly.

External wall insulation

- Use certified system and installer
- Provide perimeter insulation down to ground level to reduce internal surface condensation
- Reposition services.
- Ensure level surface prior to installing insulation

Internal wall insulation

- Plasterboard on dabs may not be able to support internal wall insulation.
- Plasterboard provides fire resistance and may provide racking resistance to timber framed walls

Openings – General

Purpose

- This section covers the different types of openings and how to achieve the targeted energy savings.

Scope

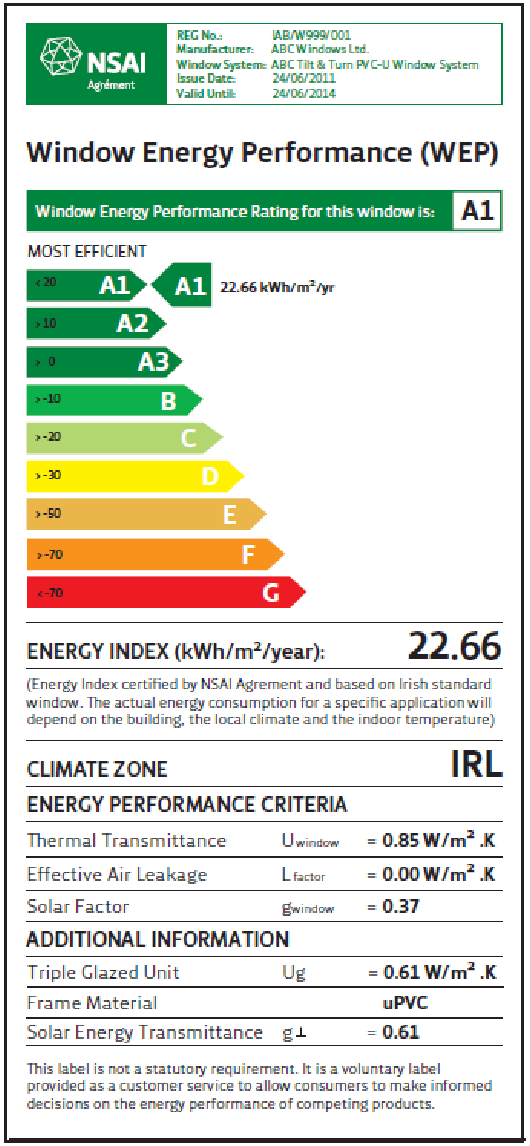
- There are three typical openings:
  - windows,
  - rooflights,
  - doors.

Openings – Windows and Rooflights – Applicable Retrofit Methods

Draughtproofing	• Either to frame, window or both.
Secondary glazing	• Windows only
Replacement glazing	• Existing double glazing unit replaced with high performance system
Replacement window unit	• Replacing single glazed window with double or triple glazed system

Openings – Overall Thermal Performance

U-value	• of glazing and whole unit.
Airtightness	• of whole frame.
Solar factor	• g-value, measure of potential solar heat gain.
Solar energy transmittance	• daylight gain, can have an effect on internal lighting requirement.



Openings – Design Considerations

Changes and disruption

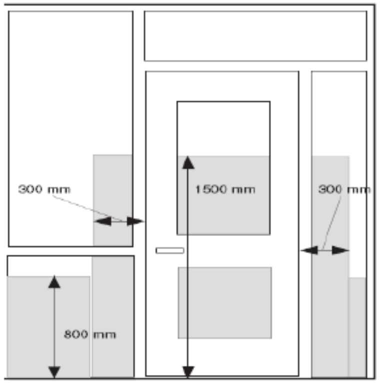
- Overhaul & Serviced, Upgraded or Replaced
- Replacement units may lead to rooms needing redecoration.
- Airtightness and ventilation

Means of escape

- Replacement units to allow for escape or rescue.

Safety glazing

- Replacement glazing or whole units in critical locations



Openings – Installation Considerations

Airtightness

- Correct installation of draughtproofing to existing and new windows and doors

Ventilation

- Maintain background ventilation
- Ensure permanent ventilation for combustion appliances maintained

DPCs

- Replacement windows and doors may allow the installation of vertical and horizontal DPCs around openings

Roofs – General

- Guidance covers both warm and cold roofs (depending on which side of insulation the main structural timbers are)

Pitched roof

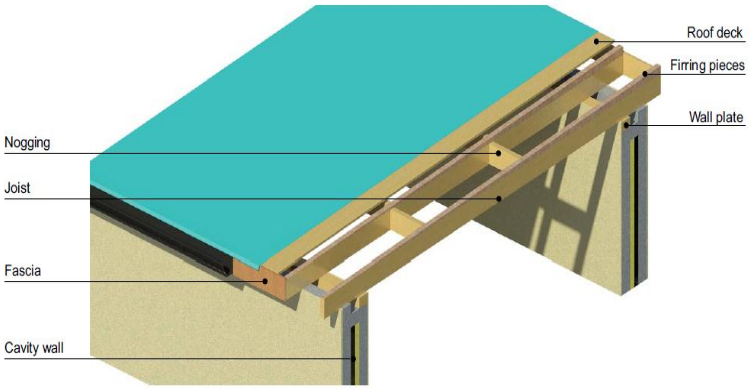
- Structural timbers or pre-fabricated roof trusses form roof void
- Structure covered by sarking and waterproof layer of slate or tile
- Typically, insulation 25-100mm at joist/ceiling level

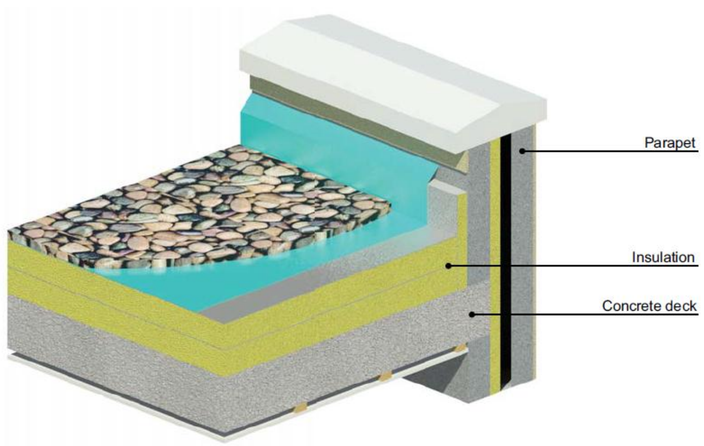
Flat roof - Timber

- Joists span opposing walls with firing to allow for drainage
- Covered by weatherproof sheeting and coverings

Flat roof - Concrete

- Concrete slab surrounded by parapet walls
- Insulation present above or below weatherproof layer





Roofs – Applicable Retrofit Methods

Pitched roof

- Lay (additional) insulation at ceiling level to achieve required performance
- Alternative is to insulate below and between rafters if loft conversion proposed
- Could insulate above if replacing roof coverings
- Existing room-in-the roof could have insulated laminated plasterboard to inside face of room

Flat roof - Timber

- **Cold deck roof** (Apply underside of ceiling and between roof joists where ceiling is replaced)
- **Warm deck sandwich roof** (On top of existing roof deck and covered with weatherproof membrane)
- **Warm deck inverted roof** (Laid directly on top roof surface)

Flat roof - Concrete

- Can only be applied above concrete surface
- New weatherproof membrane applied above or below insulation
- Upstand of parapet wall to be insulated

U-value tables in Annex C

Table C.1 — Insulation placed at ceiling level

	Uninsulated ceiling	Level 1	Level 2	Level 3
U-value (W/m2K)	2,30	0,16	0,14	0,10
Insulation thermal conductivity (λ) W/mK	Total insulation thickness needed (mm)[a]			
0,044		270	320	450[b]
0,040		250	300	400[b]
0,037		230	270	380[b]
0,032		220	240	350[b]
0,022[c]		160[c]	185[c]	260[c]

[a] NB The first layer is placed between the ceiling joists, with the remainder placed above

[b] Insulation thickness of 350 mm or above may cause problems achieving roof ventilation at eaves level – see section 9.3.2.3 for further information.

[c] High performance insulation can be used throughout or to facilitate inclusion of an access walkway or storage platform.

Table C.3 — Insulation placed above existing timber flat roof

	Uninsulated ceiling	Level 1	Level 2	Level 3
U-value (W/m^2K)	1,88	0,25	0,22	0,20
Insulation thermal conductivity (λ) W/mK	Total insulation thickness needed (mm)			
0,037		130	150	170
0,034		120	140	155
0,030		110	125	140
0,022		80	90	100
0,014[c]		55	60	65

Roofs – Design Considerations 1

Roof condition

- Work on roofs (e.g. replace waterproof layers, rotted timbers etc.) provides opportunity for insulation
- Survey and strengthen roof to future-proof or accommodate solar technologies

Services

- Freezing risk to water tanks/cylinders and pipework
- Overheating risk to cables and light fittings
- Airtightness around penetrations
- Access to services

Condensation

- Key concern with warm, moist air from dwelling below
- Installation of VCL
- Provision of purpose-built ventilation

Roofs – Design Considerations 2

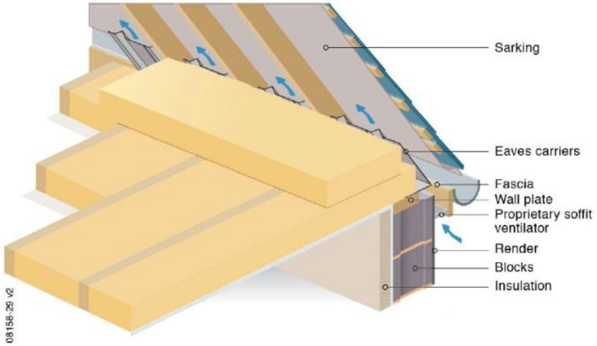
Thermal bridging	• Junction between walls and eaves is key so insulation needs to be continuous • Assessment in Annex G and H
Light shafts	• Insulate walls of light shafts in loft area
Flat roof access	• Access may be required for repair, means of escape etc. • Assess imposed loads to ensure thermal insulation has appropriate compressive strength
Cabling	• Insulation around cables can lead to overheating so best to route above • If not possible, increase cable size to carry load • Protect cables from polystyrene insulation

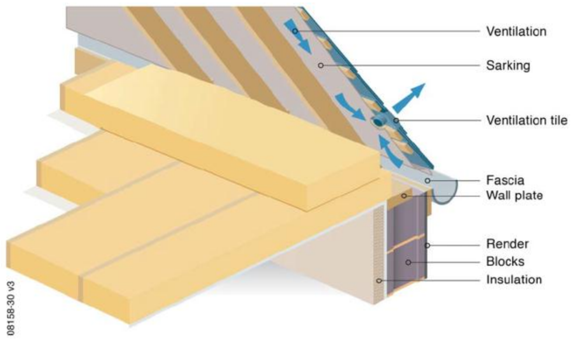
Roofs – Cold Pitched Roof, Ceiling Insulation

- Use flexible insulation, e.g. mineral wool, spray foam/cellulose or blown fibre
- Build-up layers between joists then lay across
- Use blown fibre where space restricted

Design considerations – Roof void ventilation

- **Eaves** –Vents should not block passage of air and use facia strips to help ensure 10mm gap
- **Ventilation tiles** – Located 450mm up slope (300mm above insulation) to provide 10mm gap
- **Breather membrane** – Can replace existing sarking if replacing roof coverings

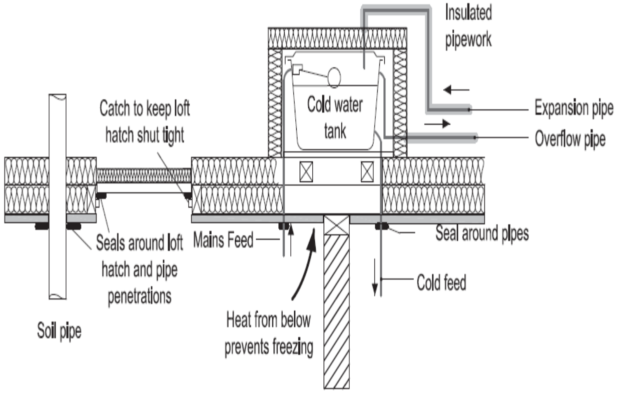


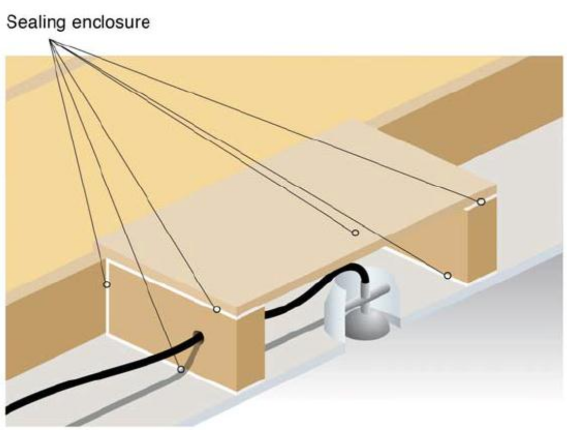


Roofs – Cold Pitched Roof, <u>Ceiling</u> Insulation

Design considerations – Moisture prevention

- **<u>Cold water tanks</u>** – insulate around and above tanks and seal tank
- **<u>Wet rooms</u>** – provide adequate ventilation
- **<u>Recessed light fittings</u>** – avoid if possible, but provide sealed enclosure that dissipates heat





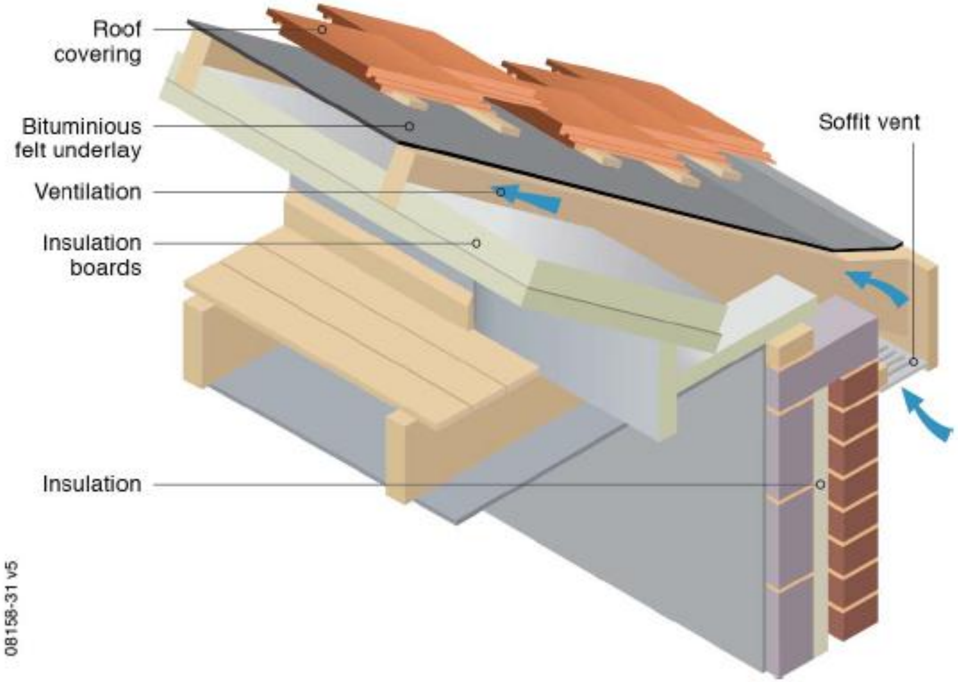
Roofs – Cold Pitched Roof, Ceiling Insulation

Installation considerations

- **Loft hatches** – Seal and insulate, using high performance insulation
- **Platforms** – Use high performance insulation beneath and on joists
- Laying pattern – 300-350mm mineral wool: lay between joists, then lay over and overlap platform
- **Recessed light fittings** – Seal and provide high performance insulation above

Roofs – Cold Pitched Roof, <u>Rafter</u> Insulation

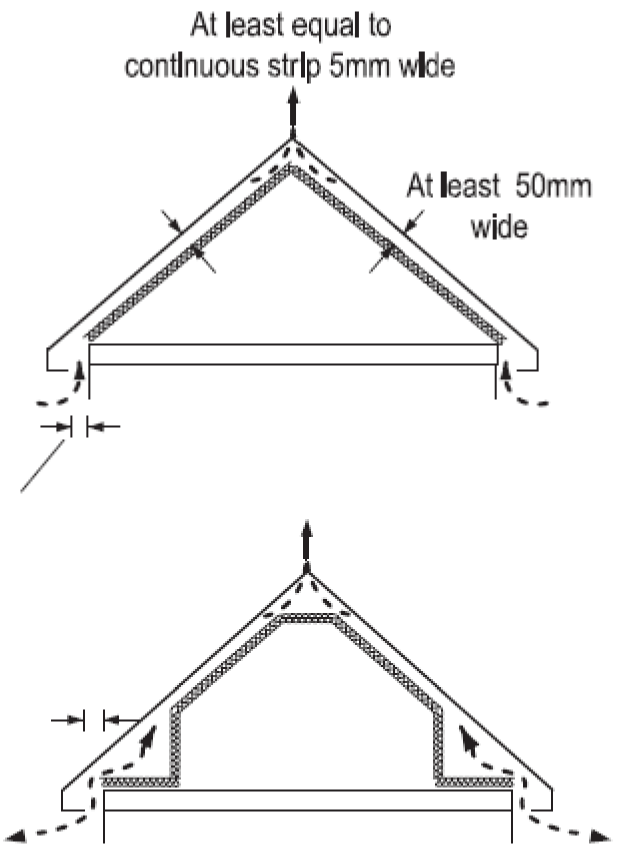
- Common where room-in-the-roof exists or proposed
- Insulation placed between or below rafters (or both) with vented void between rafters above insulation
- Use flexible and semi-rigid insulation but need significant thickness to achieve more demanding U-values so require high performance insulation



Roofs – Cold Pitched Roof, Rafter Insulation

Design considerations - ventilation

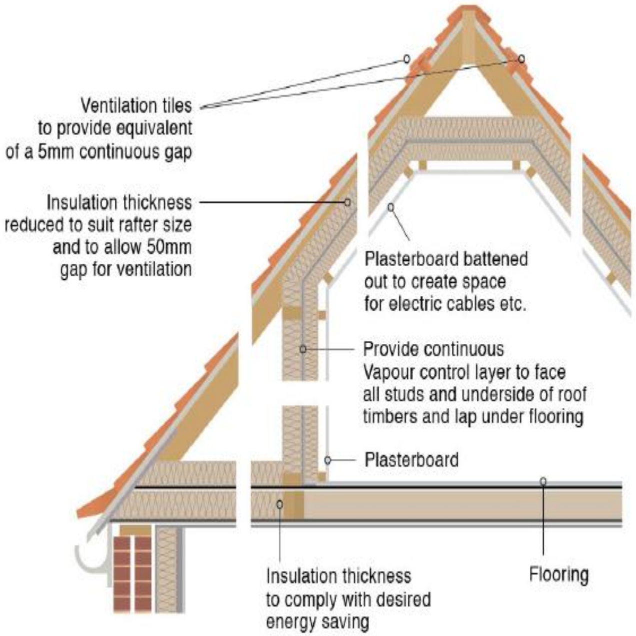
- **Preventing moisture** – As before
- **Eaves + ridge ventilation** – Provide 25mm gap within soffit or fascia, 5mm gap at ridge and 50mm gap between top of insulation and roof covering
- **Ventilation tiles** – Use where not possible to vent at eaves and ridge, equivalent to 25mm gap for every rafter void
- **Breather membrane** – Use if replacing existing sarking instead of providing 50mm gap



Roofs – Cold Pitched Roof, Rafter Insulation

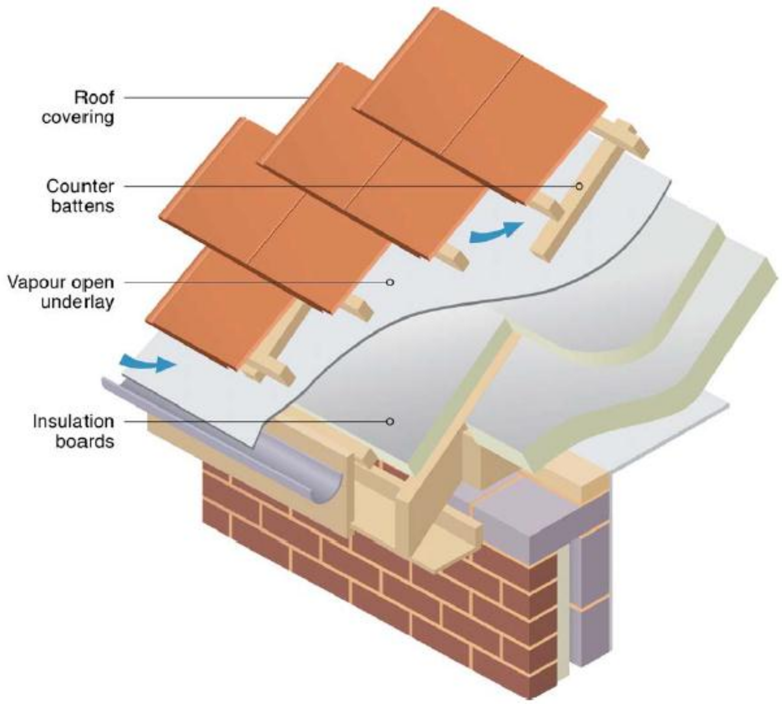
Installation considerations

- Overlap mineral wool, for dwarf stud walls place insulation between stud timbers and across wall faces
- Install VCL to insulation layer then internal insulation as separate layer
- Tape joints of foil backed insulation to achieve requirement of VCL
- Seal service penetrations, and cut rigid insulation to fit snugly between rafters



Roofs – Warm Pitched Roof

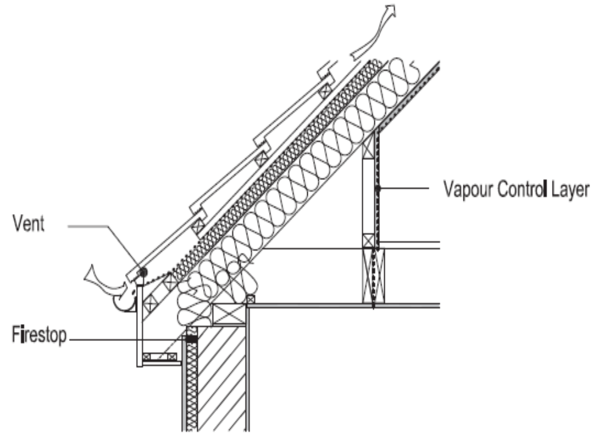
- Insulation placed over and sometimes between rafters
- Ventilation required between top of insulation and roof covering using counter battens
- Suitable when replacing roof covering and preparing for room-in-the-roof
- Slates/tiles fixed by battens through breathable membrane/insulation, needs to be rigid and max 100mm thickness, more can be placed between rafters

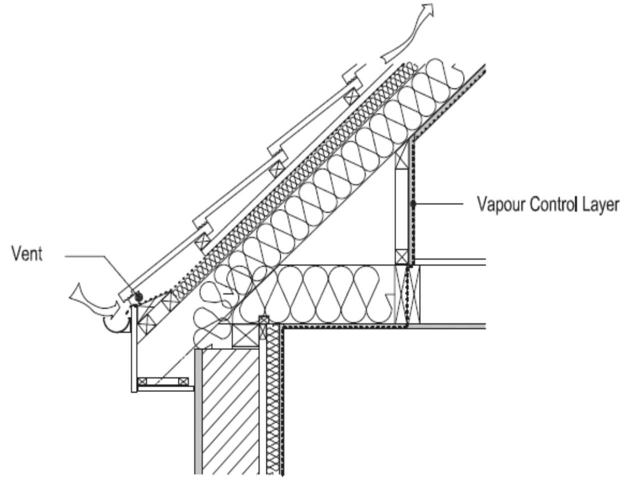


Roofs – Warm Pitched Roof

Design and installation considerations

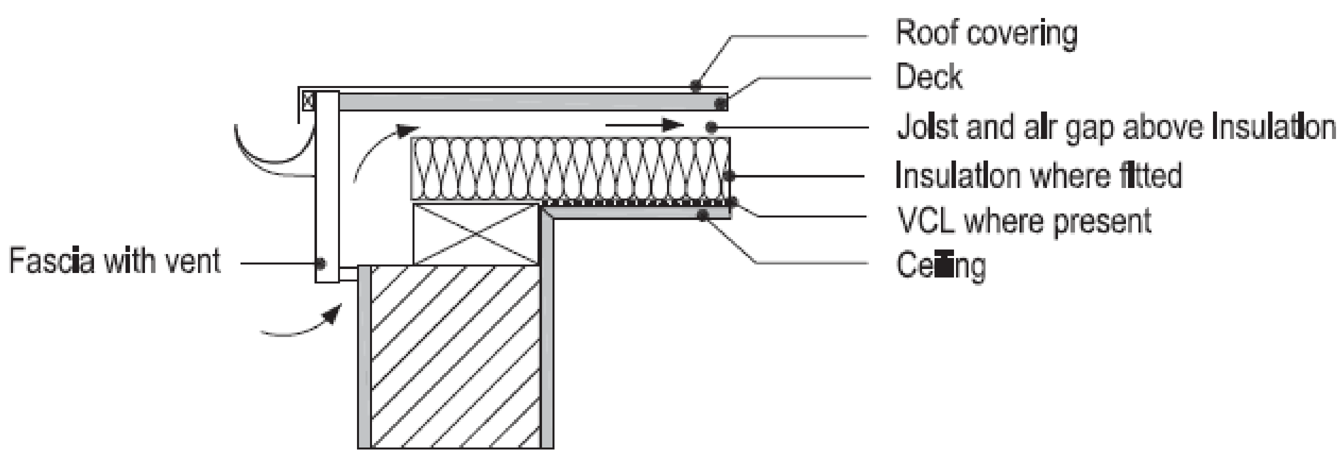
- **Ridge line** – May require planning
- **VCL** – As internal surfaces are on warm side of insulation then reduced risk of condensation but VCL helps to improve airtightness
- **Eaves details** – Avoid thermal bridging and maintain ventilation
- **Insulation** – Cut accurately to give snug fit
- **Moisture prevention** – As before





Roofs – Flat Roof, Cold Deck

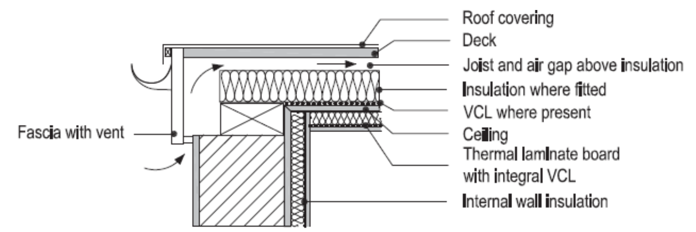
- Most common form of flat roof
- Insulation between joists, and void above is ventilated at eaves level at opposite sides
- Insulate between and below joists if roof replaced, or use insulated thermal laminate board if ceiling retained
- Might need high performance insulate to achieve more demanding U-values

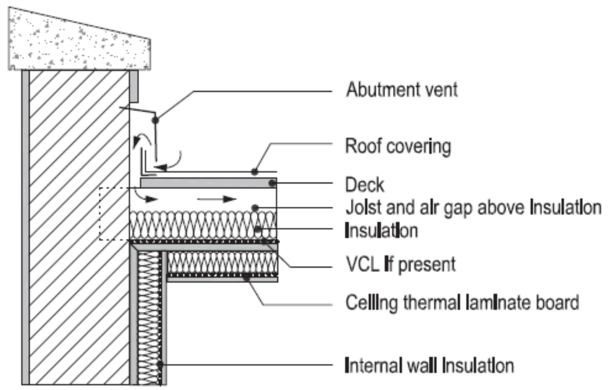


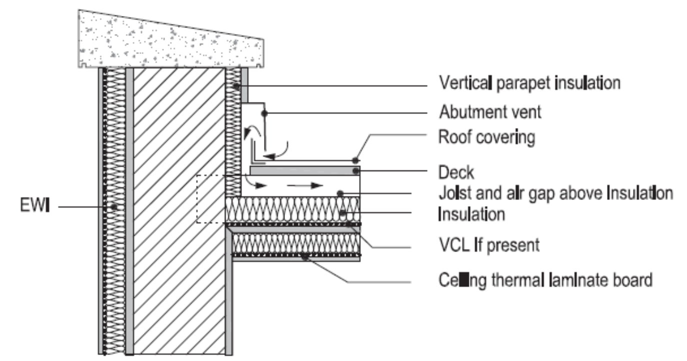
Roofs – Flat Roof, <u>Cold Deck</u>

Installation considerations

- **<u>Internal wall insulation</u>** – Use additional thermal laminate beneath ceiling to achieve required U-value; fit IWI before ceiling
- **<u>Parapet with EWI</u>** – Use abutment vent, insulate internal face of parapet wall and replace upper courses beneath coping with lightweight block

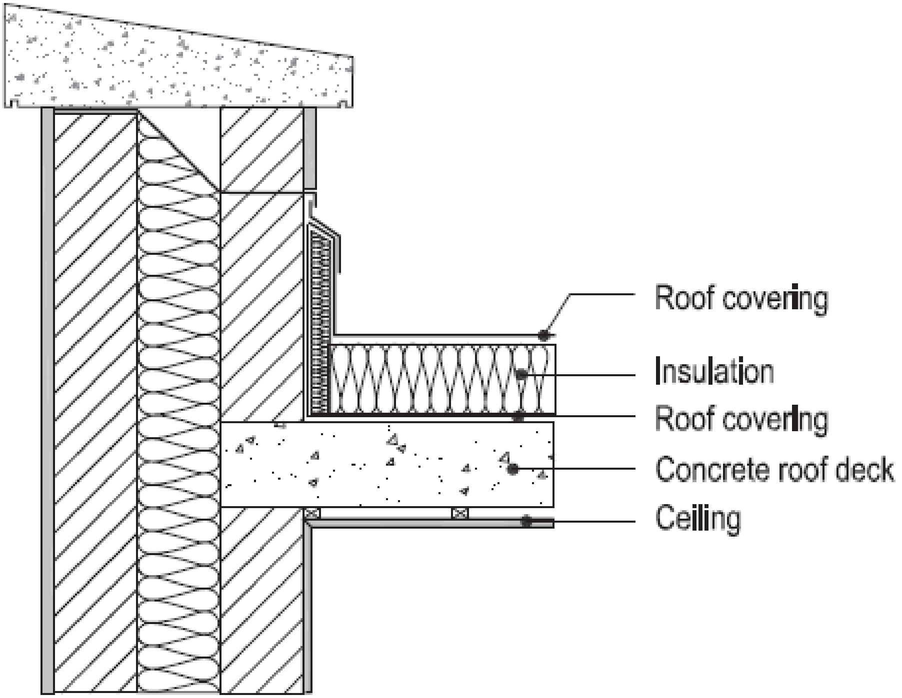






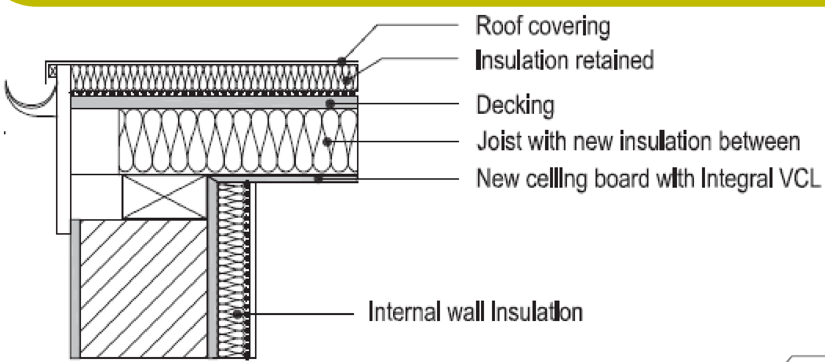
Roofs – Warm Deck, Sandwich Roof

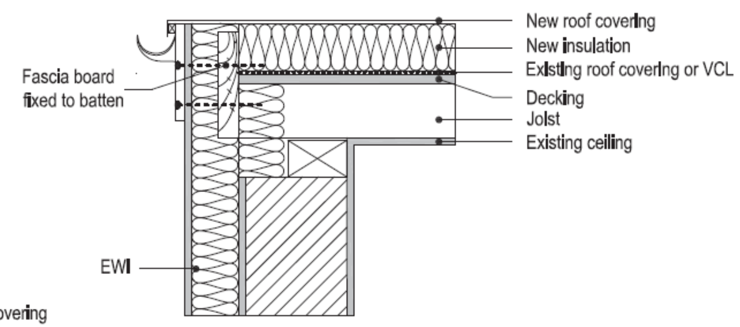
- Insulation on top of flat roof with roof covering above
- When proposed to renew roof coverings it is less disruptive to form warm flat roof rather than providing a cold vented roof

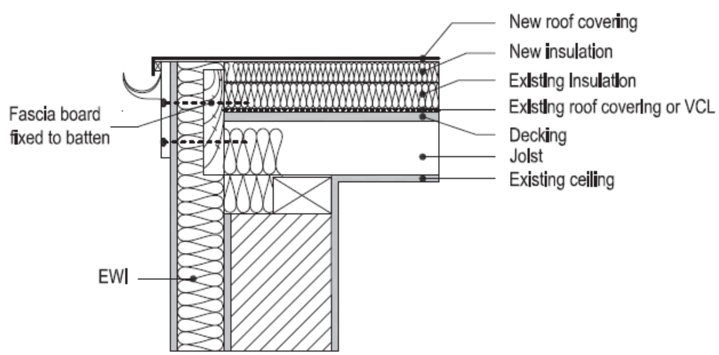


Roofs – Warm Deck Sandwich Roof, Improvement Options

- Can be improved with insulation below plus IWI, provided roof covering in good condition
- Also improved where existing insulation and covering are replaced plus EWI
- Equivalent to converting cold deck to warm deck which was previously uninsulated (or existing insulation removed)
- Top-up insulation and provide new roof covering plus EWI



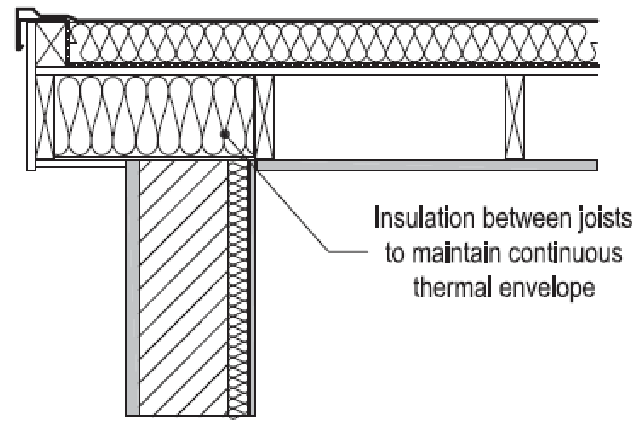


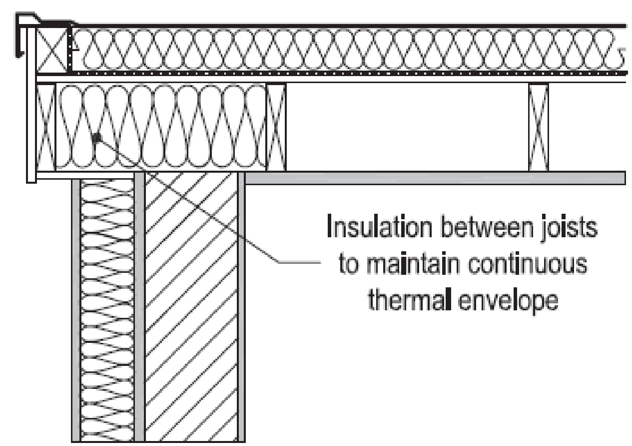


Roofs – Warm Deck Sandwich Roof

Design considerations

- Use dense semi rigid insulation
- Protective layer should bond to insulation without fixing unless is approved
- Raises roof height so might need new stepped dpc or cavity trays, and parapet walls raised
- Careful detailing at junctions with IWI and EWI





Roofs – Warm Deck Sandwich Roof

Installation considerations

- High performance VCL to be installed on top of decking with all joints taped
- Use solar reflective treatment to counteract higher temperatures and thermal movements they could induce
- Maintain existing drains internal to parapet walls

Ventilation – General

Traditional forms of ventilation

- Windows and doors
- Adventitious
- Background

Improvement methods

- Natural ventilation with intermittent extract fans
- Passive Stack Ventilation (PSV)
- Mechanical Extract Ventilation (MEV)

Airtightness – links to other CoP sections

- Loft hatches and light fittings (Roofs)
- Service entry points (Walls & Floors)
- Gaps around windows and doors (Openings)
- Use of wet plastering (Walls)

Forms part of the overall refurbishment strategy

Ventilation – Improvement Methods

- Integral part of the refurbishment strategy: *"Build tight, ventilate right"*
- Fabric improvements included in relevant sections of the CoP

Table 26 — Suitable ventilation strategies for dwelling refurbishment

Ventilation strategy	Level of refurbishment		
	Single room or partial house refurbishment	**Full house refurbishment**	**Refurbishment to advanced air permeability level**
Natural with extract fans	Y	Y	N
Natural with PSV	N	Y	N
SRHRV	Y	Y	N
MEV	N	Y	Y
MVHR	N	Y	Y

Increasing complexity

SFP <0.3 W/(l/s)

$<2m^3/m^2/hr$

Airtightness testing recommended ($<5m^3/m^2/hr$)

Heating

- Traditional heating systems - for space heating and hotwater.
- Consider improvements or replacements - using same or different fuel type

Identification

- Fuel Type
- Heat Generator
- Hotwater Storage
- Distribution and Circulation
- Controls

User Demand

- Space Heating – whole house sizing method or room by room heat loss sizing method
- Water Heating – CIBSE Domestic Heating Design Guide or BS 6700

Potential for Improvements

- Retain & improve or replace. Question whether -
- Repair
- Modify or
- Upgrade

Heating

- Replacement of heating and hot water systems can also involve replacement of the fuel type curently used

Energy Appliances and Fuel

- **Solid Fuel**
- **Gas (Mains, LPG)**
- **Oil**
- **Electricity**

- Duel Fuel Link Up

Replacement Options

- **Level A** – upgrade using same fuel as existing
- **Level B** – improved upgrade but different fuel
- **Level C** – Advanced upgrade

Heating

Fuel	Level A	Level B	Level C
Room Heating			
Solid fuel (SF)	**M1** A room heating appliance which consists of a firebox and flue outlet enclosed behind a door of heat proof glass. This category excludes any appliance for which the combustion air supply cannot be controlled. HETAS Appliance Categories E1, E2 and E3 from table 16 of Compliance Guide.	**B1 Closed room heater** fuelled by wood only. HETAS category E4 from table 16 of Compliance Guide.	
Central heating / hot water			
Solid fuel	**M4** Boiler. HETAS appliance categories F, G1, G2, J1, J2, J3 and J4 from Compliance Guide. Should have thermostatic control of burning rate. Indirect hot water cylinder with thermostat. Full set of basic controls (time switch or programmer, room thermostat, single heating zone control, boiler interlock where firing is electrically controlled.	**B4 Wood Pellet boiler.** HETAS category J5 from Compliance Guide. High performance indirect hot water cylinder with thermostat. Full set of controls: (programmer, room thermostat(s), two heating zones, two pipe system, TRVs on all radiators except in rooms with a room thermostat, boiler interlock).	**A4** As B4 with solar collector for water heating and twin coil cylinder.

Heating

- Replacement of an existing system with oil, gas or solid fuel alternatives

System Options

- Efficiency
- Appliance Type
- Fuel
- Flue Open/Balanced

Design Considerations

- Existing System Design
- Dwelling User Demand
- Sizing to maximum load - whole house sizing method or room by room heat loss sizing method

Installation Considerations

- Location, clearances
- Flues, ventilation, air supply
- Condensate Drain, Terminal Guard
- Storage of Fuel

- Replacement of electric systems – advanced appliances, electricity tariff options, controls, alternative system considerations etc

Lighting

Existing Types

- General Indoor Lighting
- Directional Indoor Lighting
- Outdoor Lighting

Lighting Technology

- Lamp Types
- Luminaires
- Controls – Manual, Dimmer, Presence/Absence, daylight sensors, timers, multi sensors

Replacement Performance Standards

- Level 1 Minimum Performance
- Level 2 Best Practice
- Level 3 Advanced Best Practice

Lighting

Replacement Considerations

- Lamp and Luminaire suitability
- Lamp and Controls suitability
- Colour Temperature 2700 – 3000 k
- Colour Rendering 100 is ideal

Table 39 — Lamp replacement options

Existing solution	Replacement option
Tungsten lamps	Plug-in CFLs of similar light output, warm colour appearance with colour temperatures (2 700 to 3 000) K, and compatible type and shape
T12 (38mm diameter) fluorescent lamps	Triphosphor T8 (25 mm diameter) tubes of similar length and wattage
Halophosphate T8 fluorescent lamps, normally have a 3 digit code starting with a lower number e.g. 630, 740	Triphosphor T8 tubes of similar length and wattage, (normally have a 3 digit code beginning 8 or 9 e.g. 830, 940)
Tungsten halogen reflector lamps used for general lighting in open luminaires	Highly efficient LED replacement lamps having warm colour appearance with colour temperatures (2 700 to 3 000) K

Lighting

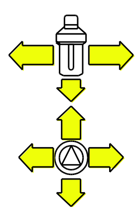
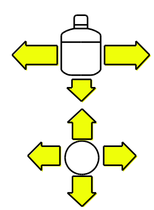
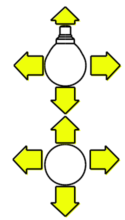
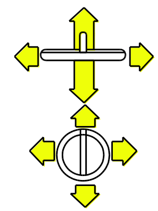
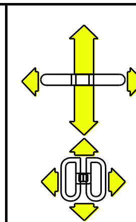
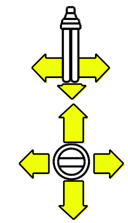
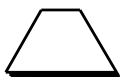
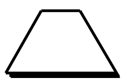
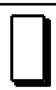
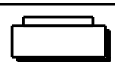
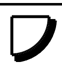
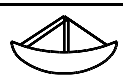
Table 1 — Summary of key characteristics for different lamp types

Lamp type	Sample image	Luminous efficacy (lm/W)	Colour appearance [A] (K)	Colour rendering (Ra)	Lamp life (hours)
Tungsten lamp		8 to 15	2 700	100	1 000
Tungsten halogen lamp		10 to 25	2 700 to 3 000	100	1 500 to 2 000
T8 linear fluorescent lamp		50 to 96	2 700 to 6 500	50 to 98	8 000 to 24 000
T5 linear fluorescent lamp		80 to 104	2 700 to 6 500	82 to 95	8 000 to 24 000
T2 linear fluorescent lamp		55 to 70	2 700 to 6 500	80 to 85	8 000 to 12 000
Plug-in compact fluorescent lamp		20 to 74	2 700 to 6 500	80 to 90	6 000 to 12 000
Pin-base compact fluorescent lamp		30 to 88	2 700 to 6 500	85 to 90	8 000 to 15 000
LED lamp		40 to 70	2 700 to 6 500	60 to 90	10 000 to 50 000

[A] Colour appearance can also be referred to as the colour temperature.

Lighting

Table 1 — Use of CFLs in common luminaire and their light distribution

Luminaire		**CFL type**					
							
	Translucent shade	**Y**	**Y**		**Y**	**Y**	
	Opaque shade			**Y**	**Y**	**Y**	
	Translucent cylinder	**Y**					**Y**
	Translucent drum	**Y**			**Y**	**Y**	**Y**
	Translucent sphere	**Y**					
	Wall uplighter	**Y**					**Y**
	Pendant/ Free standing uplighter				**Y**	**Y**	
	Lamp holder		**Y**	**Y**			

NOTE 1 The relative size of the arrows indicates the proportion of light in that direction.

NOTE 2 The Y indicates the most suitable CFL type for each style of luminaire.

Project Management

- Quotation and Estimate
- Level of Management and Oversight
- Specification
- Programme of Work
- Sequencing of Work Programme
- Method Statements
- Risk Assessments
- Contract Types

Thank you