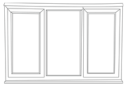
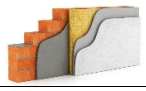
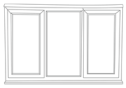
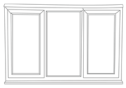
Annexe S1

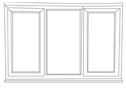
The model simulation general assumptions

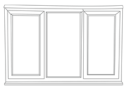
1- All single-family houses SFH are detached houses, low urban density oriented towards East and have an average shading rate
2- Top floor flats were chosen for simulation in all apartments BA and MFH
3- Pre 1945 dwellings are high thermal mass value whilst post 1965 are low thermal mass value
4- Location of all dwellings are in East Scotland specifically in Edinburgh
5- Dwelling pre 1944 has solid floor construction
6- No cavities in party walls in all dwellings
7- 70% of post 1965 dwellings have got cavity wall and loft insulation
8- Default total thermal bridging value of 0.15 W/m2K for all existing dwelling pre1945, 0.10 W/m2K (1945-1980) and 0.05W/m2K for post 1980
9- All dwellings subject to system upgrade (Air Source Heat Pump+ Mechanical Ventilation without Heat Recovery)
10- All dwellings are oriented east with possibility of installing PVs at inclination angle of 45' with little or no shadings

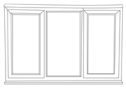
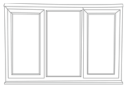
SFH Typology	Building Measures	Improvement actions
PRE 1919 TFA =198m^2 Height=2.5 m 2 storey house	Existing 	**Windows**; Double-glazed (east & west) PVCU 12mm air-filled U-value 2.1 W/m^{2}k **Door:** Half-Double glazed 12mm PVCU U-value 1.85 W/m^{2}k **Floor:** Solid floor 150mm concrete dense R-value 0.075 + soft plywood 20mm R-value 0.154, total U-value= 0.6 W/m^{2}k **External Wall**: Solid brickwork double BRE (102.50mm) + inner-leaf Plaster dense 20mm + render 20mm outer-leaf Total U-value1.95 W/m^{2}k **Roof:** tiles clay 12mm ventilated cavity 255mm + soft chipboard 15mm (U-value 2.2 W/m^{2}k). **System:** Natural ventilation, combi-gas boiler with radiators for heating and hot water + room thermostat efficiency 75%.
	Windows + ventilation 	**Windows**: Triple-glazed windows with argon filled U-value of 1.6W/m^{2}K, **System**: MVHR and ASHP installed to existing radiators, electric heat pump and DHW storage 250L provided with full insulation of 100mm for pipework.
	Roof & floor insulation 	**Floor:** Mineral wool Quilt 200mm added under the soft plywood layer (R-value 4.76) + Foil-Tec Single VCL (1 mm R=0.74) Total floor U-value 0.14 W/m^{2}K **Roof:** Felt/Bitumen Layers (1.5 mm) (R0.013) + Mineral Wool Quilt (300 m, R=7.14) + Foil-Tec Single VCL (1 mm R=0.74) **Total U-value = 0.12 W/m^{2}K**
	EWI/CWI/IWI + Ex-door 	**EWI:** Extruded Polystyrene (200 mm, R=7.407) + Foil-Tec Single VCL (1 mm R=0.74). **External door**: Triple-glazed argon filled PPCU 16mm U-value 1.4

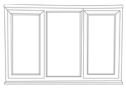
	Renewables 	4.5KWp of PV added to the roof oriented south with tilted angle of 45˚. Electricity generated by PVs = 3845.05 kWh/year
1919-1944 TFA = 153.20m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.56 W/m^{2}K) **External wall**= brickwork 223mm+ 20mm plaster+ 20mm render cement (total U-value 1.81 W/m^{2}K) **Roof**: Tiles (Clay 20 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity + loft insulation 100mm + Plasterboard Standard (15 mm) Total U-value = 1.61 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 1.85 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water **Door**: PVCU double glazed 16mm U-value= 2.0 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm U-value of 1.5 W/m^{2}K, windows half opened. **Balanced MVHR** and ASHP installed to existing radiators efficiency 170%, electric heat pump and DHW storage 250L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200m + Foil-Tec Single VCL (1 mm) + soft plywood 15mm (U-value 0.13 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Polyurethane Board (250 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Cement and Sand (20 mm) + Breather Foil-FR (2 mm) + XPS 200mm+ Solid Brickwork (Double layer 112.5*2) Foil-Tec Double VCL (1 mm) + Plaster (Dense) (20 mm) Total U-value 0.10 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.5 W/m^{2}K.
	Renewables 	4.1KWp of PV added to the roof oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = 3503.27 kWh/year
1945-1964 TFA = 134.40m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Unventilated Cavity 650mm + ground U-value 0.24 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Woodfibre 30mm + Plasterboard Standard (20 mm) U-value 0.6 W/m^{2}K. **Cavity wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Plaster (Dense) (20 mm) total U-value 0.49 W/m^{2}K. **Windows**: PVCU Double glazed 12mm U-value = 1.85 W/m^{2}K **Door:** Half-Double glazed 12mm PVCU U-value 1.85 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 250L.

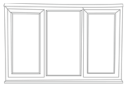
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.4 W/m^{2}K, windows half opened 50%. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 170%, electric heat pump and DHW storage 250L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (150 mm) + Unventilated Cavity 450mm + ground (U-value 0.13 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.12 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Extruded Polystyrene (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.15 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.5 W/m^{2}K.
	Renewables 	3.6KWp of PV added to the roof oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = 3076.04 kWh/year (South oriented roof area 48m^2).
1965-1980 TFA = 123.08m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Ventilated Cavity 650mm + ground U-value 0.42 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Mineral Wool Batt (70 mm)+ Plasterboard Standard (20 mm) U-value 0.55 W/m^{2}K. **Cavity wall**: Plasterboard High Density (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.47 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.8 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.8 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.2 W/m^{2}K, windows slightly open 5mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) + Unventilated Cavity 450mm + ground (U-value 0.12 W/m^{2}K).

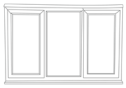
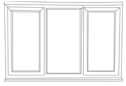
		**Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Extruded Polystyrene (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.15 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.2 W/m^{2}K.
	Renewables 	10KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -8544.56 kWh/year (South oriented roof area 61m^2).
Post 1980s TFA = 149.35m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (100 mm) + Ventilated Cavity 550mm + ground U-value 0.28 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Mineral Wool Batt (150 mm)+ Plasterboard Standard (20 mm) U-value 0.24 W/m^{2}K. **Cavity wall**: Plasterboard High Density (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Mineral Wool Quilt (50 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.58 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.6 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.5 W/m^{2}k **System**: Natural ventilation, Condensing combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.2 W/m^{2}K, windows slightly open 5mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) + Unventilated Cavity 450mm + ground (U-value 0.12 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Extruded Polystyrene (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.15 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.2 W/m^{2}K.

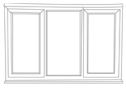
	Renewables 	10KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -8544.56 kWh/year (South oriented roof area 61m^2).
TH Typology	**Building Measures**	**Improvement actions**
PRE 1919 TFA = 104.62m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.60 W/m^{2}K) **External wall**= brickwork 223mm+ 20mm plaster+ 20mm render cement (total U-value 1.81 W/m^{2}K) **Roof**: Tiles (Clay 12 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity + loft insulation Mineral Wool Batt 50mm + Plasterboard Standard (15 mm) Total U-value = 0.55 W/m^{2}K **Windows**: PVCU Double glazed 16mm U-value = 1.65 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water **Door**: PVCU double glazed 16mm U-value= 1.80 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.5 W/m^{2}K, windows slightly open 5mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 180%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200mm + Foil-Tec Single VCL (1 mm) + soft plywood 20mm (U-value 0.12 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm)+ Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + brickwork - BRE (223mm) + Extruded Polystyrene (200 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.11 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.2 W/m^{2}K.
	Renewables 	8KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -6835.65 kWh/year (South oriented roof area 52m^2).
1919-1944 TFA = 153.20m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.62 W/m^{2}K) **External wall**= 20mm plaster+ brickwork 223mm+ 20mm render cement (total U-value 1.80 W/m^{2}K) **Roof**: Tiles (Clay 20 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity + Unventilated Cavity - (Roof - Low Emissivity) (300 mm) + loft insulation Mineral Wool Batt (50 mm) + Plasterboard Standard (15 mm) Total U-value = 0.51 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 1.85 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water

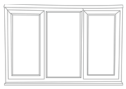
		Door: PVCU double glazed 16mm U-value= 2.0 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm U-value of 1.4 W/m^{2}K, windows half opened. **Balanced MVHR** and ASHP installed to existing radiators efficiency 180%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200m + Foil-Tec Single VCL (1 mm) + soft plywood 15mm (U-value 0.12 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Cement and Sand (20 mm) + Breather Foil-FR (2 mm) + XPS 200mm+ Solid Brickwork (Double layer 112.5*2) + Foil-Tec Double VCL (1 mm) + Plaster (Dense) (20 mm) Total U-value 0.09 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.4 W/m^{2}K.
	Renewables 	6.5KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -5553.97 kWh/year
1945-1964 TFA = 87.72m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Ventilated Cavity 700mm + ground U-value 0.46 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Woodfibre 30mm + Mineral Wool Batt (50 mm) Plasterboard Standard (20 mm) U-value 0.41 W/m^{2}K. **Cavity wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (112.5 mm) + Unventilated Cavity - (Wall - Low Emissivity) (80 mm) + Brickwork Inner Leaf - BRE (112.5 mm) + Plaster (Dense) (20 mm) total U-value 1.00 W/m^{2}K. **Windows**: PVCU Double glazed 12mm U-value = 1.80 W/m^{2}K **Door:** Half-Double glazed 12mm PVCU U-value 1.90 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 250L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.25 W/m^{2}K, windows half opened 50%. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) + Ventilated Cavity 400mm + ground (U-value 0.11 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.10 W/m^{2}K.

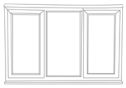
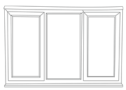
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (112.5 mm) + Extruded Polystyrene (80 mm) + Brickwork Inner Leaf - BRE (112.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard finishing (15 mm) Total U-value 0.12 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.4 W/m^{2}K.
	Renewables 	5.5KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -4699.51 kWh/year
1965-1980 TFA = 85.32m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (25 mm) + Polyurethane foam (40 mm) + Ventilated Cavity 650mm + ground U-value 0.29 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Mineral Wool Batt (50 mm) + Plasterboard Standard (20 mm) U-value 0.50 W/m^{2}K. **Cavity wall**: Plasterboard High Density (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.47 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.8 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.9 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.3 W/m^{2}K, windows slightly open 50mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) + Unventilated Cavity 400mm + ground (U-value 0.13 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.11 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (120 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.11 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.25 W/m^{2}K.
	Renewables 	6KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -5126.74 kWh/year

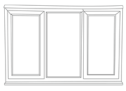
Post 1980s TFA = 98.40m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Ventilated Cavity 650mm + ground U-value 0.32 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Mineral Wool Batt (75 mm) + Plasterboard Standard (20 mm) U-value 0.40 W/m^{2}K. **Cavity wall**: Plasterboard High Density (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (50 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.55 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.55 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.65 W/m^{2}k **System**: Natural ventilation, Condensing combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.0 W/m^{2}K, windows slightly open 50mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) +Ventilated Cavity 450mm + ground (U-value 0.13 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.09 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (120 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.12 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.2 W/m^{2}K.
	Renewables 	6.5KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -5553.97 kWh/year
MFH Typology	**Building Measures**	**Improvement actions**
PRE 1919 TFA = 425 m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.55 W/m^{2}K) **External wall**= Render - Gypsum and Sand (20 mm) + brickwork 205mm+ 20mm plaster+ 20mm render cement (total U-value 1.9 W/m^{2}K) **Roof**: Tiles (Clay 12 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity + Mineral Wool Batt (75 mm)+ Plasterboard Standard (15 mm) Total U-value = 0.38 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 2.1 W/m^{2}K

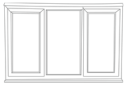
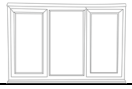
		System: Natural ventilation, combi-gas boiler with radiators for heating and hot water mains **Door**: PVCU double glazed 16mm U-value= 1.90 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.6 W/m^{2}K, half-way opened. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 170%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200mm + Foil-Tec Single VCL (1 mm) + soft plywood 20mm (U-value 0.13 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.11 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + brickwork - BRE (205mm) + Extruded Polystyrene (200 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.15 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.4 W/m^{2}K.
	Renewables 	22KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -15580.22kWh/
1919-1944 TFA = 480.81m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.44 W/m^{2}K) **External wall**= 20mm plaster+ brickwork 205mm+ 20mm render cement (total U-value 1.90 W/m^{2}K) **Roof**: Tiles (Clay 20 mm) + Wood Wool Slab (20 mm) + Unventilated Cavity - (Roof - Low Emissivity) (250 mm) + loft insulation Mineral Wool Batt (50 mm) + Plasterboard Standard (15 mm) Total U-value = 0.58 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 1.95 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water **Door**: PVCU double glazed 16mm U-value= 2.1 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm U-value of 1.25 W/m^{2}K, windows half opened. **Balanced MVHR** and ASHP installed to existing radiators efficiency 180%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200m + Foil-Tec Single VCL (1 mm) + soft plywood 15mm (U-value 0.12 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.12 W/m^{2}K.

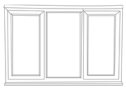
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Cement and Sand (20 mm) + Breather Foil-FR (2 mm) + XPS 200mm+ Solid Brickwork (Double layer 102.5*2) + Foil-Tec Double VCL (1 mm) + Plaster (Dense) (20 mm) Total U-value 0.12 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.5 W/m^{2}K.
	Renewables 	30KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -25633.69kWh/year
1945-1964 TFA = 447.09m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Ventilated Cavity 700mm + ground U-value 0.42W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Woodfibre 30mm + Mineral Wool Batt (50 mm) Plasterboard Standard (20 mm) U-value 0.53 W/m^{2}K. **Cavity wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Unventilated Cavity - (Wall - Low Emissivity) (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Plaster (Dense) (20 mm) total U-value 1.01 W/m^{2}K. **Windows**: PVCU Double glazed 12mm U-value = 1.85 W/m^{2}K **Door:** Half-Double glazed 12mm PVCU U-value 1.65 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 250L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.20 W/m^{2}K, windows half opened 50%. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 18 0%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) + Ventilated Cavity 400mm + ground (U-value 0.12 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.11 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (120 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard finishing (15 mm) Total U-value 0.10 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.2 W/m^{2}K.
	Renewables 	28KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -23924.78 kWh/year

1965-1980 TFA = 559.42m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Ventilated Cavity 650mm + ground U-value 0.31 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Unventilated Cavity - (Roof - Low Emissivity) (250 mm) + Mineral Wool Batt (50 mm) + Plasterboard Standard (20 mm) U-value 0.57 W/m^{2}K. **Cavity wall**: Render - Gypsum and Sand (20 mm)) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.46 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.85 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.95 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.2 W/m^{2}K, windows opened halfway. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 180%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) + Ventilated Cavity 450mm + ground (U-value 0.11 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.12 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.4 W/m^{2}K.
	Renewables 	35KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -29905.98kWh/year
Post 1980s TFA = 994.42m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Ventilated Cavity 650mm + ground U-value 0.25 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Ventilated Cavity - (Roof - Low Emissivity) (250 mm) + Mineral Wool Batt (75 mm) + Plasterboard Standard (20 mm) U-value 0.42 W/m^{2}K. **Cavity wall**: Plasterboard High Density (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.60 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.55 W/m^{2}K

		Door: Half-Double glazed 16mm PVCU U-value 1.60 W/m^{2}k **System**: Natural ventilation, Condensing combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.0 W/m^{2}K, windows slightly open 50mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) +Ventilated Cavity 450mm + ground (U-value 0.12 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.14 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.25 W/m^{2}K.
	Renewables 	45KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -38450.54 kWh/year
AB Typology	**Building Measures**	**Improvement actions**
PRE 1919 TFA = 496.26m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 25mm (total U-value 0.52 W/m^{2}K) **External wall**= Render - Gypsum and Sand (20 mm) + brickwork 205mm+ 20mm render cement (total U-value 1.9 W/m^{2}K) **Roof**: Tiles (Clay 12 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity + Mineral Wool Batt (75 mm) + Plasterboard Standard (15 mm) Total U-value = 0.51 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 1.90 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water mains **Door**: PVCU double glazed 16mm U-value= 1.85 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.45 W/m^{2}K, slightly opened 50mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 170%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation	**Floor:** Solid concrete Dense (150 mm) + EPS 200mm + Foil-Tec Single VCL (1 mm) + soft plywood 20mm (U-value 0.12 W/m^{2}K).

		**Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.13 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + brickwork - BRE (205mm) + Extruded Polystyrene (200 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.12 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.4 W/m^{2}K.
	Renewables 	30KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -25633.69 kWh/
1919-1944 TFA =886.78m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 25mm (total U-value 0.55 W/m^{2}K) **External wall**= 20mm plaster+ brickwork 225mm+ 20mm render cement (total U-value 1.80 W/m^{2}K) **Roof**: Tiles (Clay 20 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity - (Roof - Low Emissivity) (250 mm) + loft insulation Mineral Wool Batt (50 mm) + Plasterboard Standard (15 mm) Total U-value = 0.50 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 1.85 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water **Door**: PVCU double glazed 16mm U-value= 2.0 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm U-value of 1.20 W/m^{2}K, windows half opened. **Balanced MVHR** and ASHP installed to existing radiators efficiency 180%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200m + Foil-Tec Single VCL (1 mm) + soft plywood 15mm (U-value 0.12 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Cement and Sand (20 mm) + Breather Foil-FR (2 mm) + XPS 200mm+ Solid Brickwork (Double layer 112.5*2) + Foil-Tec Double VCL (1 mm) + Plaster (Dense) (20 mm) Total U-value 0.10 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.4 W/m^{2}K.
	Renewables 	50KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -42722.82 kWh/year
1945-1964	Existing	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.57 W/m^{2}K)

TFA =3362.70m^2 Height=2.5 m 2 storey house		**External wall**= 20mm Gypsum render + brickwork 225mm+ 20mm render cement (total U-value 1.85 W/m^{2}K) **Roof**: Tiles (Clay 20 mm) + Wood Wool Slab (20 mm) + Ventilated Cavity - (Roof - Low Emissivity) (250 mm) + loft insulation Mineral Wool Batt (50 mm) + Plasterboard Standard (15 mm) Total U-value = 0.52 W/m^{2}K **Windows**: PVCU Double glazed 12mm U-value = 1.90 W/m^{2}K **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water **Door**: PVCU double glazed 12mm U-value= 2.3 W/m^{2}K
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.25 W/m^{2}K, windows half opened 50%. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 180%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200m + Foil-Tec Single VCL (1 mm) + soft plywood 15mm (U-value 0.11 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.10 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum (20 mm) + Breather Foil-FR (2 mm) + XPS 200mm+ Solid Brickwork (225mm) + Foil-Tec Double VCL (1 mm) + Plaster (Dense) (20 mm) Total U-value 0.11 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.10 W/m^{2}K.
	Renewables 	90KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -76901.08 kWh/year
1965-1980 TFA =4357.12m^2 Height=2.5 m 2 storey house	Existing 	**Floor**= Solid concrete dense150mm+ soft plywood 20mm (total U-value 0.55 W/m^{2}K) **Pitched roof:** Tiles (Clay) (12 mm) + Ventilated Cavity - (Roof - Low Emissivity) (250 mm) + Mineral Wool Batt (100 mm) + Plasterboard Standard (20 mm) U-value 0.28 W/m^{2}K. **Cavity wall**: Render - Gypsum and Sand (20 mm)) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (50 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.38 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.80 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.85 W/m^{2}k **System**: Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.1 W/m^{2}K, windows opened halfway. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat

		pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Floor:** Solid concrete Dense (150 mm) + EPS 200m + Foil-Tec Single VCL (1 mm) + soft plywood 15mm (U-value 0.10 W/m^{2}K). **Roof:** Tiles (Clay) (12 mm) + Wood Wool Slab (15mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (12.5 mm) total U-value 0.09 W/m^{2}K.
	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (150 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.10 W/m^{2}K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.2 W/m^{2}K.
	Renewables 	200KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -170891.29 kWh/year
Post 1980s TFA = 4045.10m^2 Height=2.5 m 2 storey house	Existing 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Ventilated Cavity 650mm + ground U-value 0.28 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Ventilated Cavity - (Roof - Low Emissivity) (250 mm) + Mineral Wool Batt (75 mm) + Plasterboard Standard (20 mm) U-value 0.41 W/m^{2}K. **Cavity wall**: Plasterboard High Density (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) Total U-value 0.58 W/m^{2}K. **Windows**: PVCU Double glazed 16mm U-value = 1.50 W/m^{2}K **Door:** Half-Double glazed 16mm PVCU U-value 1.55 W/m^{2}k **System**: Natural ventilation, Condensing combi-gas boiler with radiators for heating and hot water storage tank in loft 300L.
	Windows + ventilation 	**Windows**: Triple-glazed argon filled 16mm or more U-value of 1.1 W/m^{2}K, windows slightly open 50mm. **Balanced MVHR** without heat recovery and ASHP installed to existing radiators with minimum efficiency of 190%, electric heat pump and DHW storage 300L provided with full insulation of 100mm for pipework and water heating timed separately.
	Roof & floor insulation 	**Suspended Floor**: Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (200 mm) +Ventilated Cavity 450mm + ground (U-value 0.10 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.11 W/m^{2}K.

	EWI/CWI/IWI + Ex-door 	**External wall**: Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.12 W/m^2K. **External door**: Half triple-glazed PVCU argon filled 16mm or more U-value 1.20 W/m^2K.
	Renewables 	150KWp of PV added to the roof-oriented south with tilted angle of 45˚ and very little or no shading. Electricity generated by PVs = -128168.47 kWh/year