

Liverpool John Moores University and Zenova Group Ltd. AKT Project 2022-2023

Exploring the performance of **thermal barrier coatings**
in a retrofit environment

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Project Overview



Aim:

To evaluate the performance a low profile, **novel thermal barrier coating** for use in retrofit applications

Objectives:

- **Collect and compare** pre and post installation data for - surface and ambient temperatures, humidity, U-value and air quality.
- **Install Thermal material coating** in 1920's exemplar house.
- Evaluate any change in **energy performance** of the room.
- **Produce report** on findings

Basic Methodology



Steps:

1. **Record** Baseline Data: Room response to heating and cooling, U-Value, thermal imaging
2. **Apply** Zenova thermal coating
3. **Record** post installation performance
4. **Compare** Findings



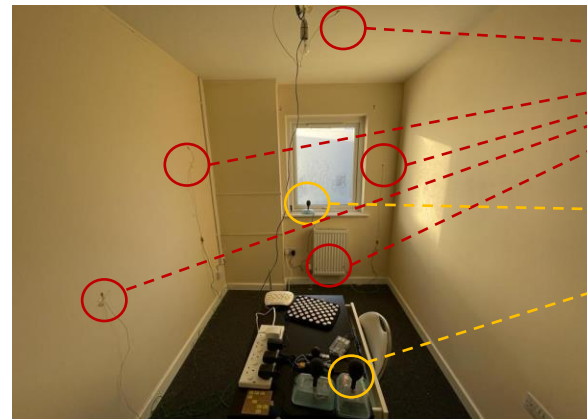
Pre-Installation Data Collection



Baseline Room



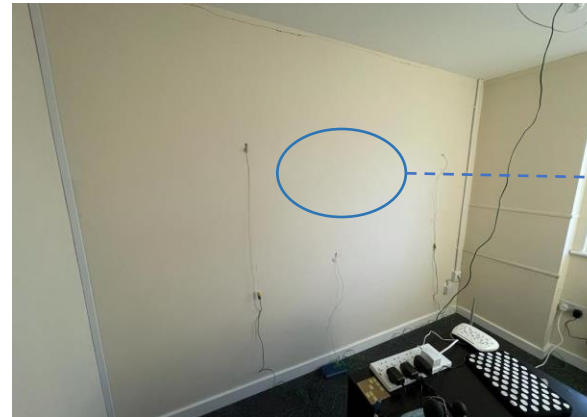
Sensor and Monitoring Installation



Surface Temperature Sensors

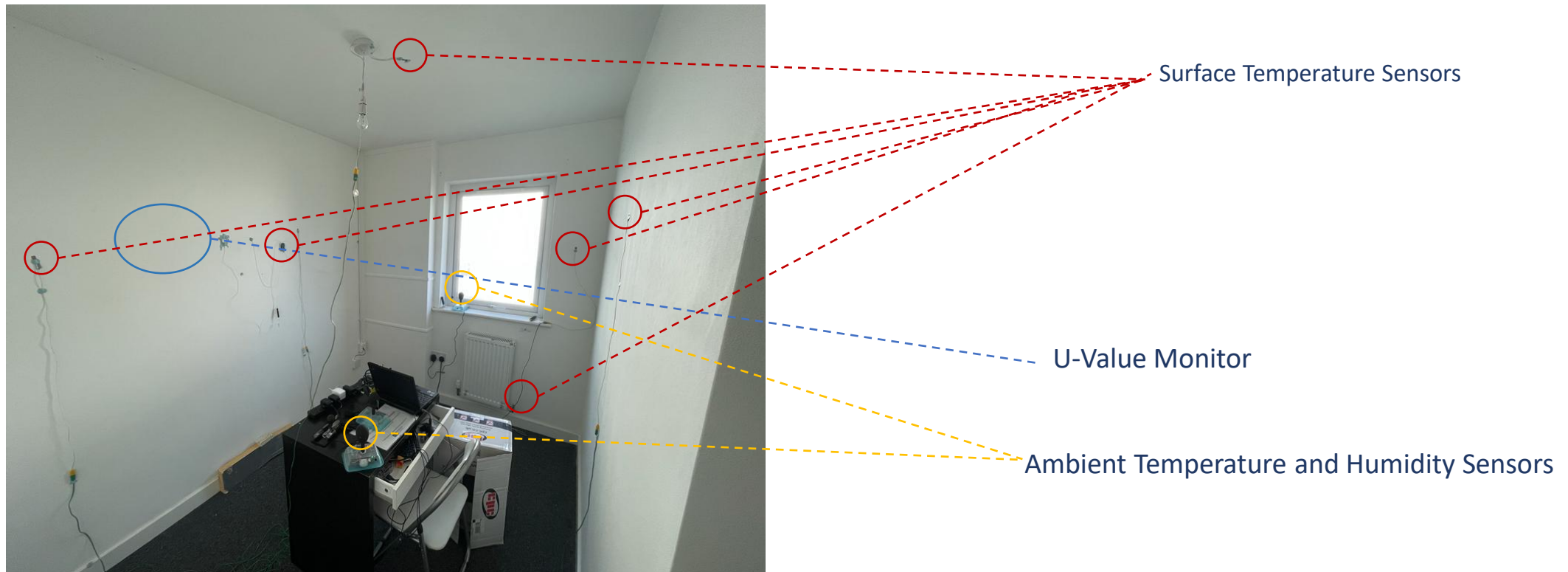
Ambient Temperature and Humidity Sensors

U-Value Monitors



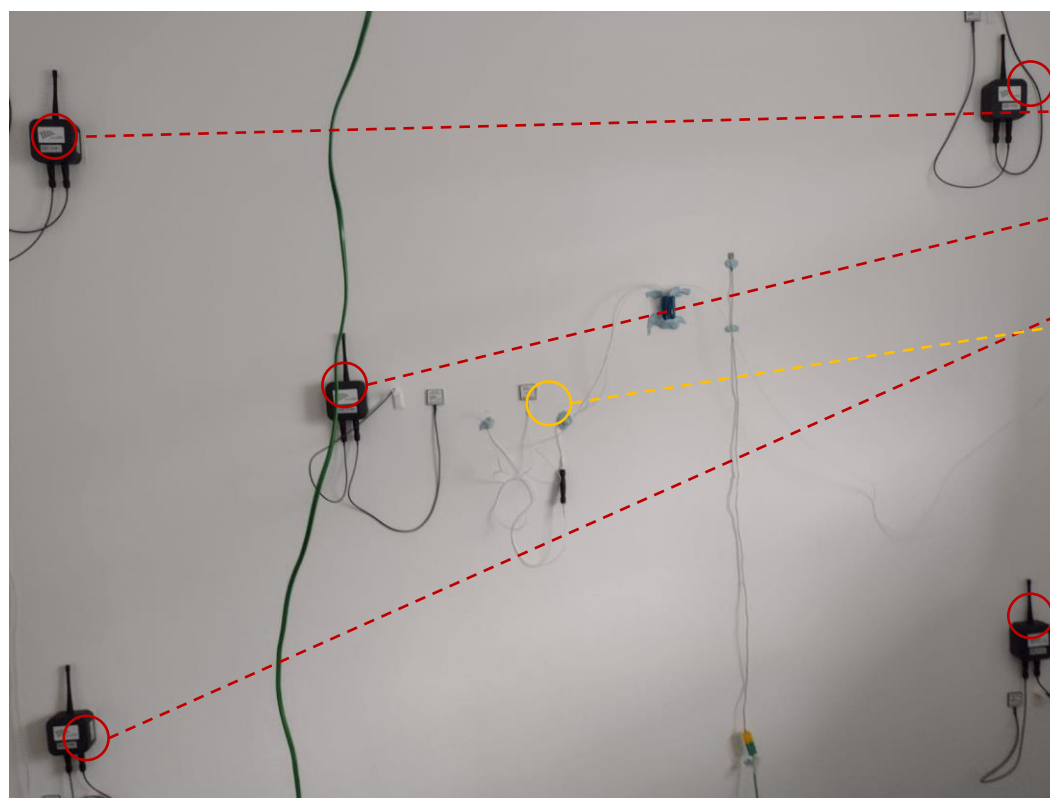
Post-Installation Data Collection

Post Installation Room



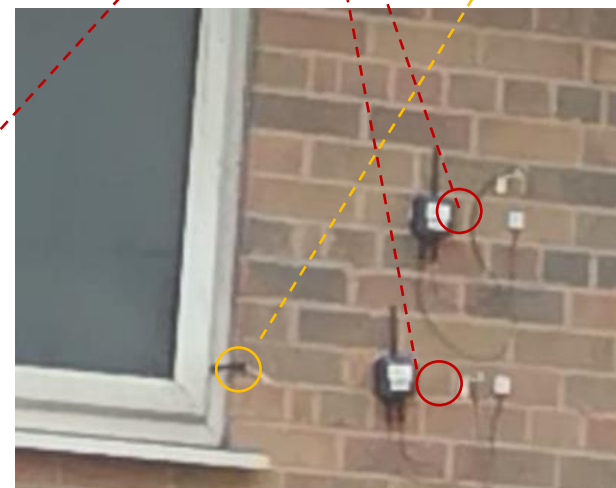
U-value Final Test (multi probe)

Post Installation Room



U-Value Monitor Wireless

U-Value Monitor Wired

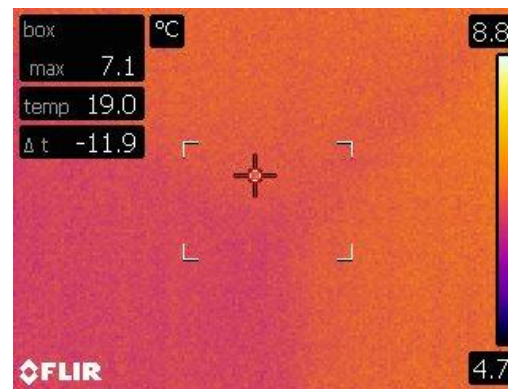


Outdoor
Sensors

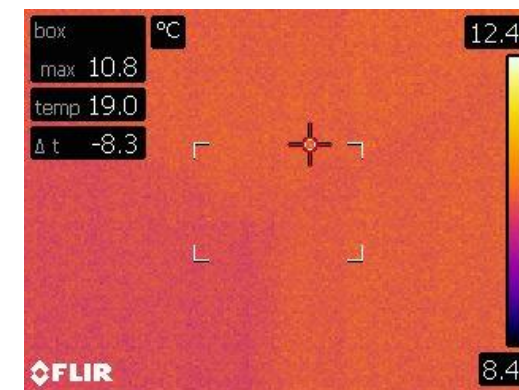
Thermal Camera Imaging



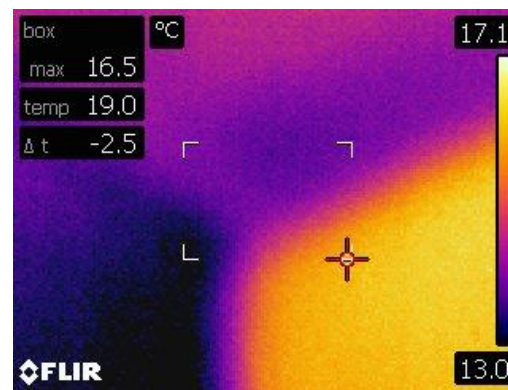
Pre-Installation



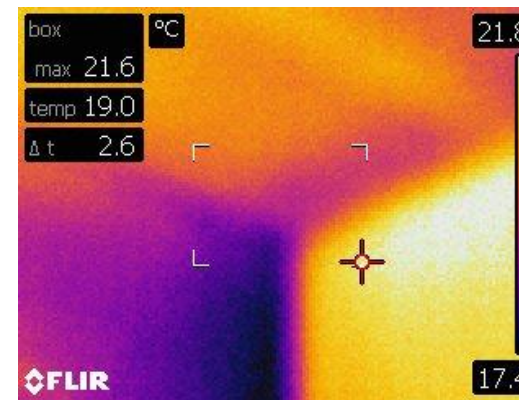
Post-Installation



cold



hot



U-Value Comparison



Pre-Installation U-Value

U-value analysis using average method (Section 7.1, ISO 9869-1:2014):

Analysis start time:	2022-12-12 19:14:00	U-value w/o last 24h (U24):	3.37 W/(m ² K)
Analysis end time:	2022-12-18 19:14:00	U-value first 2/3 (U2/3):	3.33 W/(m ² K)
Analysis period:	144 h	U-value last 2/3 (U2/3):	3.40 W/(m ² K)
U-value:	3.37 W/(m ² K)	dU24:	-0.1 %
		dU2/3:	-2.0 %
		dR24:	0.2 %
		dR2/3:	4.7 %

Measurement data fulfils requirements of ISO 9869-1:2014 section 7.1.

Post-Installation U-Value

U-value analysis using average method (Section 7.1, ISO 9869-1:2014):

Analysis start time:	2023-02-04 11:23:32	U-value w/o last 24h (U24):	2.26 W/(m ² K)
Analysis end time:	2023-02-07 11:23:32	U-value first 2/3 (U2/3):	2.26 W/(m ² K)
Analysis period:	72 h	U-value last 2/3 (U2/3):	2.22 W/(m ² K)
U-value:	2.27 W/(m ² K)	dU24:	0.2 %
		dU2/3:	1.9 %
		dR24:	-0.4 %
		dR2/3:	-3.0 %

Measurement data fulfils requirements of ISO 9869-1:2014 section 7.1.

Initial Recorded
Improvement of
1.1 W/(m²K)

U-Value Validation

Post-Installation U-Value

U-Value analysis:

Total measurement duration	120.00 h	Average values:	
Analysis start time:	2023-03-12 21:10:00	Heat Flux (HF):	19.10 W/m ²
Analysis end time:	2023-03-15 21:10:00	Inner Ambient Temp. (Ti)	15.44 °C
Analysis period:	72 h	Inner Surface Temp. (Tsi)	12.79 °C
dR2/3:	2.20 %	Outer Ambient Temp. (Te)	7.58 °C
dR24:	-4.89 %	Outer Surface Temp. (Tse)	8.38 °C
U-Value (U):	2.041 W/(m ² K)		
R-Value (R):	0.279 (m ² K)/W		

U-Value analysis:

Total measurement duration	120.00 h	Average values:	
Analysis start time:	2023-03-12 21:10:00	Heat Flux (HF):	19.39 W/m ²
Analysis end time:	2023-03-15 21:10:00	Inner Ambient Temp. (Ti)	16.44 °C
Analysis period:	72 h	Inner Surface Temp. (Tsi)	12.65 °C
dR2/3:	2.64 %	Outer Ambient Temp. (Te)	7.58 °C
dR24:	-4.77 %	Outer Surface Temp. (Tse)	8.38 °C
U-Value (U):	1.862 W/(m ² K)		
R-Value (R):	0.268 (m ² K)/W		

U-Value analysis:

Total measurement duration	120.00 h	Average values:	
Analysis start time:	2023-03-12 21:50:00	Heat Flux (HF):	17.73 W/m ²
Analysis end time:	2023-03-15 21:50:00	Inner Ambient Temp. (Ti)	14.12 °C
Analysis period:	72 h	Inner Surface Temp. (Tsi)	12.48 °C
dR2/3:	2.41 %	Outer Ambient Temp. (Te)	7.58 °C
dR24:	-4.83 %	Outer Surface Temp. (Tse)	8.38 °C
U-Value (U):	2.255 W/(m ² K)		
R-Value (R):	0.286 (m ² K)/W		

U-Value analysis:

Total measurement duration	120.00 h	Average values:	
Analysis start time:	2023-03-12 21:30:00	Heat Flux (HF):	23.51 W/m ²
Analysis end time:	2023-03-15 21:30:00	Inner Ambient Temp. (Ti)	16.55 °C
Analysis period:	72 h	Inner Surface Temp. (Tsi)	13.26 °C
dR2/3:	2.67 %	Outer Ambient Temp. (Te)	7.58 °C
dR24:	-4.91 %	Outer Surface Temp. (Tse)	8.38 °C
U-Value (U):	2.217 W/(m ² K)		
R-Value (R):	0.251 (m ² K)/W		

U-Value analysis:

Total measurement duration	120.00 h	Average values:	
Analysis start time:	2023-03-12 21:00:00	Heat Flux (HF):	18.58 W/m ²
Analysis end time:	2023-03-15 21:00:00	Inner Ambient Temp. (Ti)	14.72 °C
Analysis period:	72 h	Inner Surface Temp. (Tsi)	12.40 °C
dR2/3:	3.98 %	Outer Ambient Temp. (Te)	7.58 °C
dR24:	-4.88 %	Outer Surface Temp. (Tse)	8.38 °C
U-Value (U):	2.136 W/(m ² K)		
R-Value (R):	0.269 (m ² K)/W		

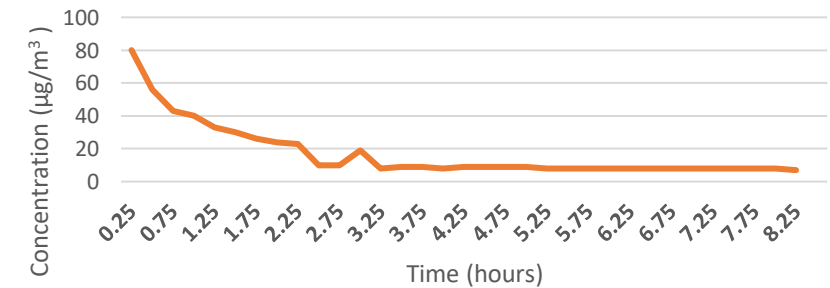
U-value average: 2.1022 W/m²K

Improvement of 1.2678 W/(m²K)

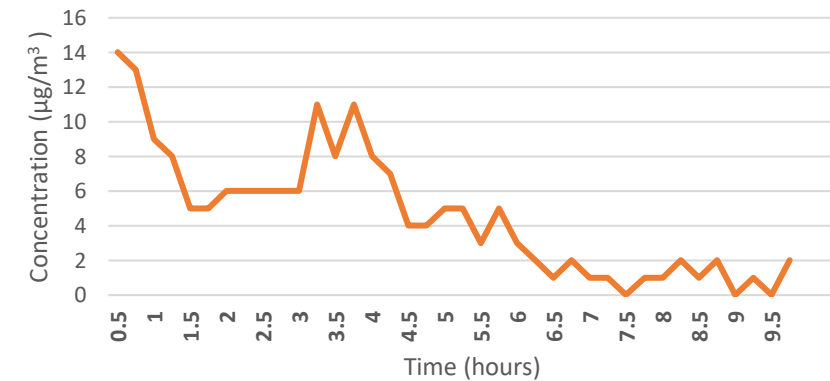
Air Quality Test Result

1. Before Painting: PM 2.5 = 2 $\mu\text{g}/\text{m}^3$;
VOCs = 0 mg/m^3
2. After the base coat: PM 2.5 = 9 $\mu\text{g}/\text{m}^3$;
VOCs = 0 mg/m^3
3. During the spray: PM 2.5 = 80 $\mu\text{g}/\text{m}^3$;
VOCs = 43.72 mg/m^3

Indoor Air Quality (PM 2.5) After
Thick Spray

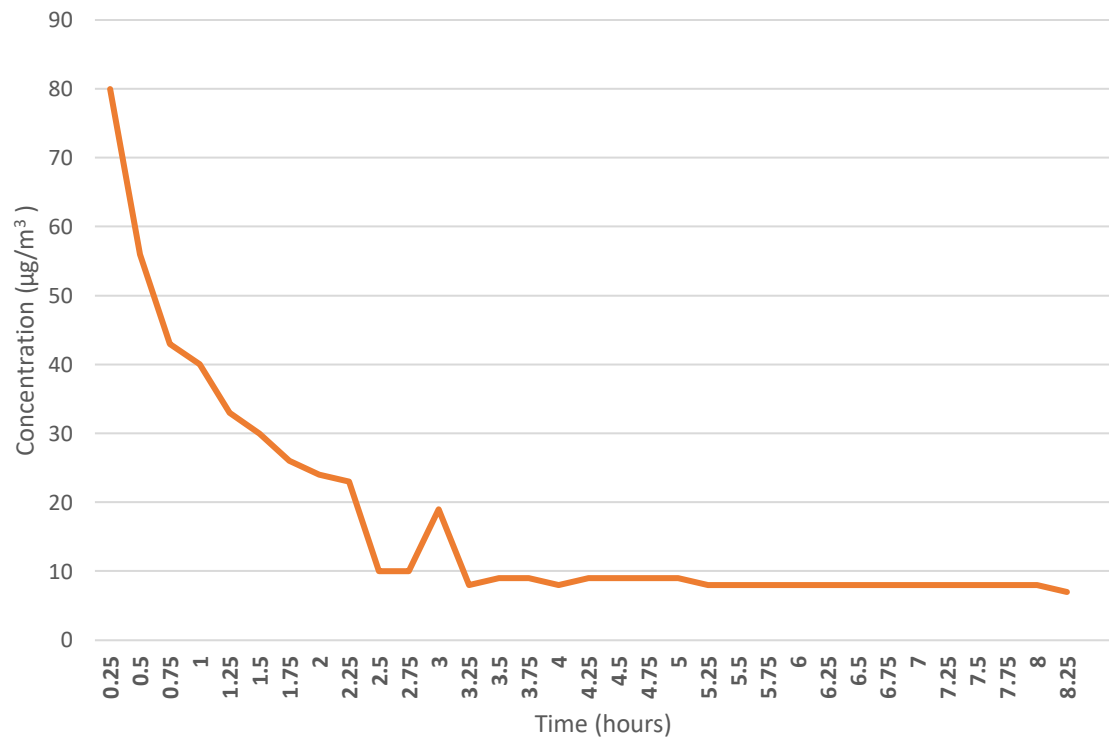


Indoor Air Quality (PM 2.5) After **Final Layer**

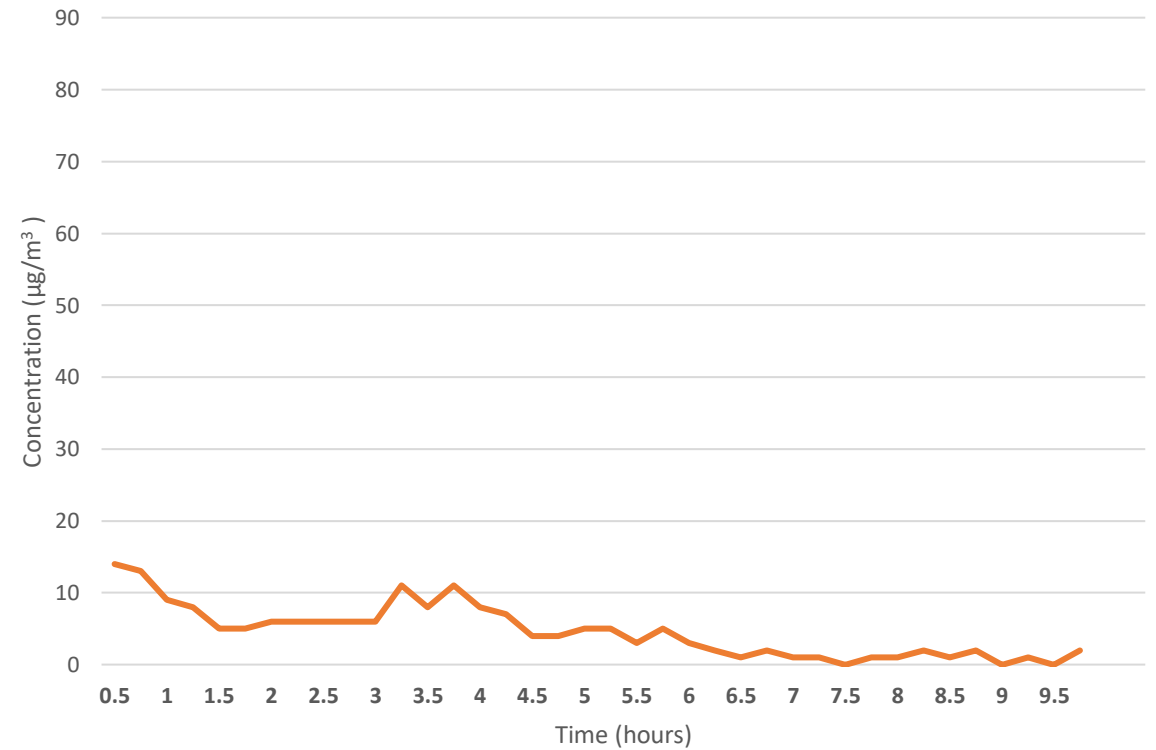


Air Quality Test Result

Indoor Air Quality (PM 2.5) After **Thick Spray**



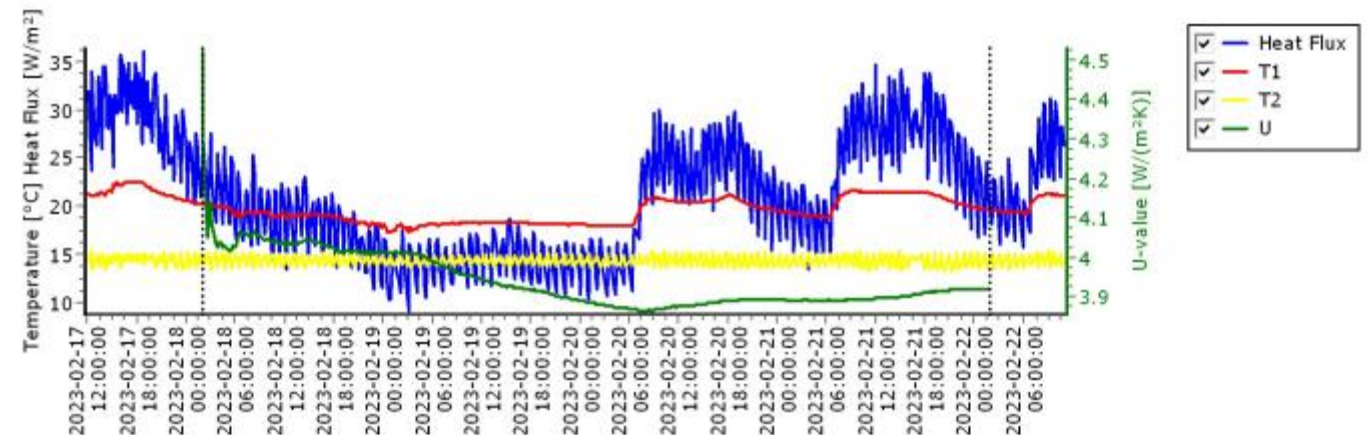
Indoor Air Quality (PM 2.5) After **Final Layer**



Material test Value

- The material test was done in the thermal chamber to simulate indoor and outdoor condition and was done with U-value test kit for at least 72 hours
- **1 mm thickness** material: U-value of **3.92** W/(m²K); thermal conductivity = 0.00392 W/mK

Measurement overview over t=118.83 h



U-value analysis using average method (Section 7.1, ISO 9869-1:2014):

Analysis start time:	2023-02-18 01:57:32	U-value w/o last 24h (U24):	3.89 W/(m ² K)
Analysis end time:	2023-02-22 01:57:32	U-value first 2/3 (U2/3):	3.88 W/(m ² K)
Analysis period:	96 h	U-value last 2/3 (U2/3):	3.94 W/(m ² K)
U-value:	3.92 W/(m ² K)	dU24:	0.7 %
		dU2/3:	-1.6 %
		dR24:	-2.2 %
		dR2/3:	4.7 %

Measurement data fulfils requirements of ISO 9869-1:2014 section 7.1.

Uncertainties due to improper installation or environmental influences must be estimated by user (see section 6.1).

Thermal Conductivity

- **Background**

Different measurement results of thermal conductivity to be verified. The variety of results were due to the uneven sample composition, the dryness of the sample, and the sensor imprecision.

- **Methods**

The value was fed to the IES VE Software to obtain the software calculated results from the digital twin.

Parameters for the digital twin:

- U-value test for pre-refurbishment: $3.37 \text{ W}/(\text{m}^2\text{K}) \rightarrow$ in the digital twin, the materials composition generated U-value of $3.2159 \text{ W}/(\text{m}^2\text{K})$
- Average U-value test for post-refurbishment: $2.1022 \text{ W}/(\text{m}^2\text{K})$
- Specific Heat Capacity: $966 \text{ J}/\text{kg} \cdot ^\circ\text{C}$
- Density $0.75 \text{ g}/\text{cm}^3 = 750 \text{ kg}/\text{m}^3$
- Vapour Resistivity: $50 \text{ GNs}/\text{kg m}$

The Digital Twin:

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 3.2159 $\text{W}/\text{m}^2\text{K}$ Thickness: 115.000 mm Thermal mass Cm: 77.9000 $\text{kJ}/(\text{m}^2\text{K})$
Total R-value: 0.1410 $\text{m}^2\text{K}/\text{W}$ Mass: 193.5000 kg/m^2 Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance ($\text{m}^2\text{K}/\text{W}$): 0.0400 ☒ Default Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance ($\text{m}^2\text{K}/\text{W}$): 0.1300 ☒ Default Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity $\text{W}/(\text{m}\text{K})$	Density kg/m^3	Specific Heat Capacity $\text{J}/(\text{kg}\text{K})$	Resistance $\text{m}^2\text{K}/\text{W}$	Vapour Resistivity $\text{GN}\cdot\text{s}/(\text{kg}\text{m})$	Category
[BRO.1] SINGLE BRICKWORK (OUTER LEAF)	110.0	0.8400	1700.0	800.0	0.1310	58.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster

System Materials... Project Materials...

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 $\text{W}/\text{m}^2\text{K}$ Thickness: 116.000 mm Thermal mass Cm: 0.0000 $\text{kJ}/(\text{m}^2\text{K})$
Total R-value: 0.4743 $\text{m}^2\text{K}/\text{W}$ Mass: 194.2500 kg/m^2 Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance ($\text{m}^2\text{K}/\text{W}$): 0.0400 ☒ Default Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance ($\text{m}^2\text{K}/\text{W}$): 0.1300 ☒ Default Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity $\text{W}/(\text{m}\text{K})$	Density kg/m^3	Specific Heat Capacity $\text{J}/(\text{kg}\text{K})$	Resistance $\text{m}^2\text{K}/\text{W}$	Vapour Resistivity $\text{GN}\cdot\text{s}/(\text{kg}\text{m})$	Category
[BRO.1] SINGLE BRICKWORK (OUTER LEAF)	110.0	0.8400	1700.0	800.0	0.1310	58.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[STD_PH.1] Zenova Insulation	1.0	0.0061	750.0	966.0	0.1647	50.000	Insulating Materials

System Materials... Project Materials...

Result: the thermal conductivity value of **0.0061** $\text{W}/(\text{m}\cdot\text{K})$

Similar Performing Materials (1)

Methods: Using the IES VE Software for the digital twin.

1. FELT & MEMBRANE - FELT - HF-E3 (31.3 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²K Thickness: 225.000 mm Thermal mass Cm: 187.6554 kJ/(m²K)
Total R-value: 0.7199 m²K/W Mass: 316.8100 kg/m² Mediumweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²K/W): 0.0400 ☒ Default Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²K/W): 0.1300 ☒ Default Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[USFM0000] FELT & MEMBRANE - FELT - HF-E3	31.3	0.1900	1121.0	1674.0	0.1647	15000.000	Insulating Materials

2. FELT & MEMBRANE - FINISH - HF-A6 (68.4 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²K Thickness: 120.000 mm Thermal mass Cm: 81.2946 kJ/(m²K)
Total R-value: 0.1530 m²K/W Mass: 199.7450 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²K/W): 0.0400 ☒ Default Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²K/W): 0.1300 ☒ Default Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[USFM0001] FELT & MEMBRANE - FINISH - HF-A6	68.4	0.4150	1249.0	1088.0	0.1647	15000.000	Insulating Materials

3. Expanded polystyrene (CIBSE) (5.8 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²K Thickness: 120.000 mm Thermal mass Cm: 0.0000 kJ/(m²K)
Total R-value: 0.2838 m²K/W Mass: 193.6250 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²K/W): 0.0400 ☒ Default Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²K/W): 0.1300 ☒ Default Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[EPSL] Expanded polystyrene (CIBSE)	5.8	0.0350	25.0	1400.0	0.1647	200.000	Insulating Materials

4. INSULATION BOARD - HF-B5 (7.2 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²K Thickness: 120.000 mm Thermal mass Cm: 0.0000 kJ/(m²K)
Total R-value: 0.2546 m²K/W Mass: 193.6000 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²K/W): 0.0400 ☒ Default Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²K/W): 0.1300 ☒ Default Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[USIN0001] INSULATION BOARD	7.2	0.0440	20.0	840.0	0.1647	5.000	Insulating Materials

Similar Performing Materials (2)

Methods: Using the IES VE Software for the digital twin.

5. POLYURETHANE BOARD (3.6 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²·K Thickness: 120.000 mm Thermal mass Cm: 0.0000 kJ/(m²·K)
Total R-value: 0.3682 m²·K/W Mass: 193.6500 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²·K/W): 0.0400 ☒ Default
Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²·K/W): 0.1300 ☒ Default
Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² ·K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[PUB] POLYURETHANE BOARD	3.6	0.0220	30.0	1400.0	0.1647	550.000	Insulating Materials

6. GLASSWOOL (6.6 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²·K Thickness: 120.000 mm Thermal mass Cm: 0.0000 kJ/(m²·K)
Total R-value: 0.2660 m²·K/W Mass: 194.5000 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²·K/W): 0.0400 ☒ Default
Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²·K/W): 0.1300 ☒ Default
Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² ·K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[GW] GLASSWOOL	6.6	0.0400	200.0	670.0	0.1647	6.000	Insulating Materials

7. THERMALITE "SHIELD"/"SMOOTH FACE" (28 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²·K Thickness: 120.000 mm Thermal mass Cm: 77.9125 kJ/(m²·K)
Total R-value: 0.1704 m²·K/W Mass: 196.7500 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²·K/W): 0.0400 ☒ Default
Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²·K/W): 0.1300 ☒ Default
Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² ·K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[THS] THERMALITE "SHIELD"/"SMOOTH FACE"	28.0	0.1700	650.0	1050.0	0.1647	83.000	Insulating Materials

8. SIPOREX (19.8 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²·K Thickness: 120.000 mm Thermal mass Cm: 77.2610 kJ/(m²·K)
Total R-value: 0.1826 m²·K/W Mass: 196.2500 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²·K/W): 0.0400 ☒ Default
Solar Absorbance: 0.700

Inside Emissivity: 0.900 Resistance (m²·K/W): 0.1300 ☒ Default
Solar Absorbance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² ·K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.5000	1300.0	1000.0	0.0100	50.000	Plaster
[S] SIPOREX	19.8	0.1200	550.0	1004.0	0.1647	50.000	Insulating Materials

Similar Performing Materials (3)

Methods: Using the IES VE Software for the digital twin.

9. CRATHERM BOARD (8.2 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²·K Thickness: 120.000 mm Thermal mass Cm: 0.0000 kJ/(m²·K)
Total R-value: 0.2410 m²·K/W Mass: 194.3800 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²·K/W): 0.0400 ☒ Default Solar Absorptance: 0.700

Inside Emissivity: 0.900 Resistance (m²·K/W): 0.1300 ☒ Default Solar Absorptance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² ·K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.3000	1300.0	1000.0	0.0100	50.000	Plaster
[CBA] CRATHERM BOARD	8.2	0.0500	176.0	837.0	0.1647	-	Insulating Materials

10. GLASS-FIBER - ORGANIC BONDED (ASHRAE) (5.9 mm thickness)

Project Construction (Opaque: External Wall)

Description: External Wall ID: WALL External Internal

Performance: EN-ISO

U-value: 2.1022 W/m²·K Thickness: 120.000 mm Thermal mass Cm: 0.0000 kJ/(m²·K)
Total R-value: 0.2798 m²·K/W Mass: 194.0000 kg/m² Very lightweight

Surfaces Functional Settings Regulations RadianceIES

Outside Emissivity: 0.900 Resistance (m²·K/W): 0.0400 ☒ Default Solar Absorptance: 0.700

Inside Emissivity: 0.900 Resistance (m²·K/W): 0.1300 ☒ Default Solar Absorptance: 0.550

Construction Layers (Outside To Inside)

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m ³	Specific Heat Capacity J/(kg·K)	Resistance m ² ·K/W	Vapour Resistivity GN·s/(kg·m)	Category
[BRCK0000] Single Brickwork (Outer Leaf)	110.0	0.8400	1700.0	800.0	0.1310	0.000	Brick & Blockwork
[PLD] PLASTER (DENSE)	5.0	0.3000	1300.0	1000.0	0.0100	50.000	Plaster
[USGF0000] GLASS-FIBER - ORGANIC BONDED (ASHRAE)	5.9	0.0360	100.0	1000.0	0.1647	10.000	Insulating Materials

Summary:

Zenova material has the advantage of the thickness against other insulation materials.

No	Materials	Thickness (in mm)
1	Zenova	1
2	FELT & MEMBRANE - FELT - HF-E3	31.3
3	FELT & MEMBRANE - FINISH - HF-A6	68.4
4	Expanded polystyrene (CIBSE)	5.8
5	INSULATION BOARD - HF-B5	7.2
6	POLYURETHANE BOARD	3.6
7	GLASSWOOL	6.6
8	THERMALITE "SHIELD"/"SMOOTH FACE"	28
9	SIPOREX	19.8
10	CRATHERM BOARD	8.2
11	GLASS-FIBER - ORGANIC BONDED (ASHRAE)	5.9

Thermal Modeling & Simulation of Exemplar 1920 House with Zenova Product

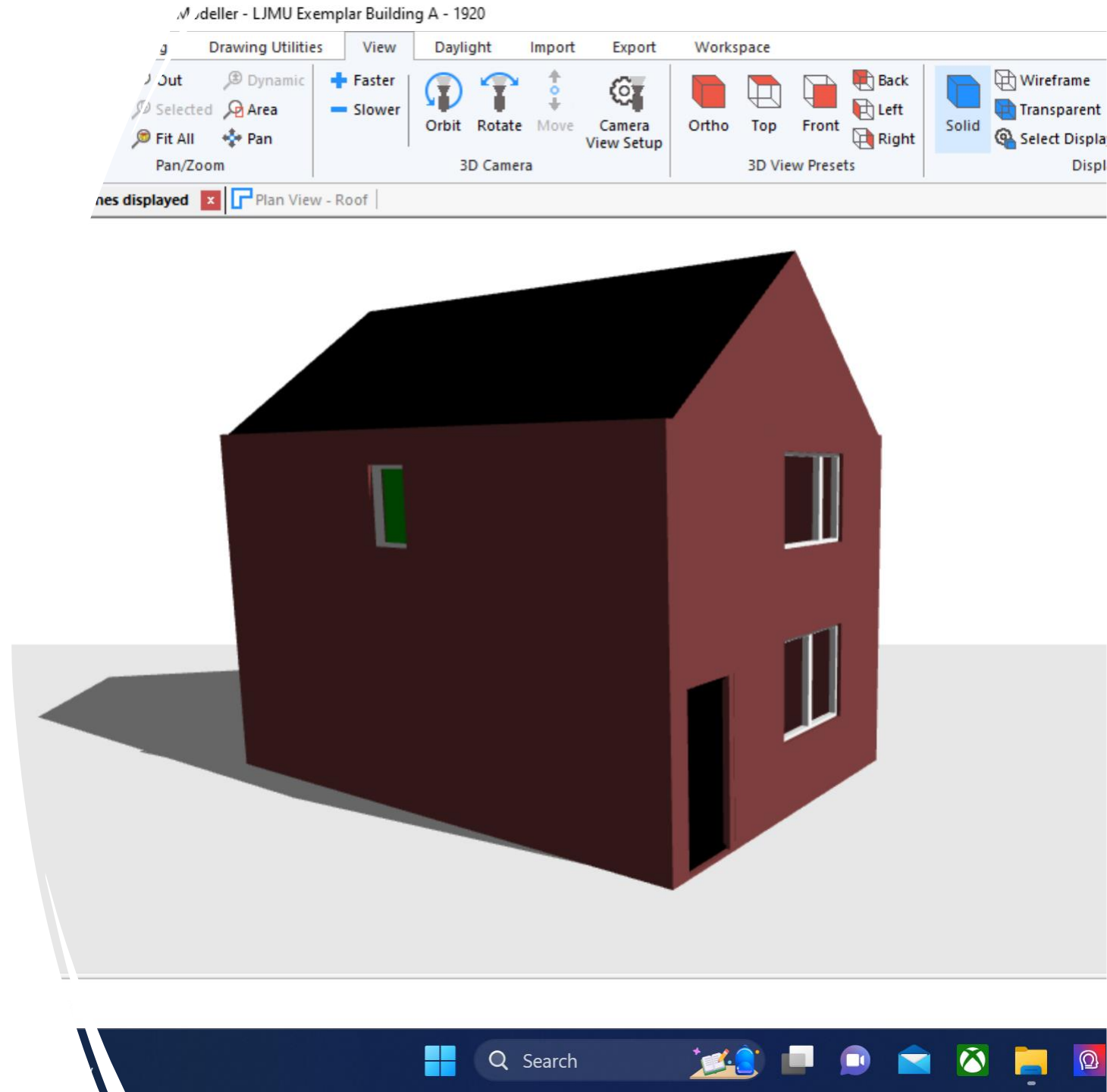
EDSL TAS software

Modeling & Simulation Assumptions

- Whole house modelled as detached
- Various Scenarios – Part L (SBEM Method)
- GHG Conversion Factors
(Electricity – 0.519, Natural Gas – 0.216)
- Internal Condition – NCM v5.2.7

RESULTS – (BRUKL Output Document/EPC)

- U – values
- Energy Performance Certificate (EPC - Rating)
- Energy Consumption (Heating)
- CO₂ Emission Rate



Building Elements

1920 Existing External Wall

LIMU Exemplar Building A - 1920 - Tas Building Simulator

File Model Apertures Simulation Navigation 3D Visualisation Import / Export Add-Ins

Building Element Substitution Surface Output Spec

Building Element

Zone

3D Visualisation

Design Sizing Wizard

Design Day

GF W04 (1)-frame
GF W04 (1)-pane
GF W04 (2)-frame
GF W04 (2)-pane
GF W12 (1)-frame
GF W12 (1)-pane
GF W12 (2)-frame
GF W12 (2)-pane
Ground Floor
Internal Floor/Internal Ceil
Internal Wall
Null
Roof
Zone Groups
Zones
Internal Conditions
Schedules
Constructions
6 mm single glazing (clear glass)
Heavy partition wall
Internal concrete floor (with cor)
Pitched roof, insul at rafters
Pitched roof, no insulation, U=2
Plastic frame, 2 hollow chambe
Solid brick wall, 115 mm, uninsul
Solid ground floor (E&W) 1990
Uninsulated personnel door
Wood frame, metal spacer
Aperture Types
Substitute Elements
Feature Shades
Surface Output Specifications
Inter Zone Air Movement

Opaque Construction

Name Solid brick wall, 115 Description Existing solid wall, with no insulation added, as commonly found in pre-1915

Solar Absorptance		Emissivity		Conductance	Time Constant
Ext. Surf.	Int. Surf.	External	Internal	(W/m ² ·°C)	
0.700	0.700	0.900	0.900	7.095	0.638

Layer	M-Code	Thickness (mm)	Conductivity (W/m·°C)	Convection (W/m ² ·°C)	Vapour Diff. (kg/m ² ·s)	Density (kg/m ³)	Specific H. (J/kg·°C)	Description
Inner	Brick, 110 mm	110.0	0.84	0.001	9999.000	1700.0	800.0	110 mm layer of brick (ou...
2	Plaster, dense	5.0	0.5	0.001	9999.000	1300.0	1000.0	Dense plasterwork, 5 mm ...

*layer ignored in U-Value/R-Value Calculation

U/R Values (ISO 6946) (Homogenous)

Flow Direction	Internal U Value (W/m ² ·°C)	External U Value (W/m ² ·°C)
Horizontal	2.494	3.216
Upward	2.933	3.559
Downward	2.079	2.849

Show U Values Show R Values Condensation...

Additional Heat Transfer 0.0% F-Factor 0.0 W/m²·°C

1920 Existing External Wall + 1mm Zenova Paint

LIMU Exemplar Building A - 1920 - Zenova (1mm) - Tas Building Simulator

File Model Apertures Simulation Navigation 3D Visualisation Import / Export Add-Ins

Building Element Substitution Surface Output Spec

Building Element

Zone

3D Visualisation

Design Sizing Wizard

Design Day

GF W04 (2)-pane
GF W12 (1)-frame
GF W12 (1)-pane
GF W12 (2)-frame
GF W12 (2)-pane
Ground Floor
Internal Floor/Internal Ceiling
Internal Wall
Null
Roof
Zone Groups
Zones
Internal Conditions
Schedules
Constructions
6 mm single glazing (clear glass)
1920 Ceiling - Zenova
1920 External Wall - Zenova
1920 Heavy partition wall - Zenova
Heavy partition wall
Internal concrete floor (with cor)
Pitched roof, insul at rafters, un
Pitched roof, no insulation, U=2
Plastic frame, 2 hollow chambe
Solid brick wall, 215 mm, uninsul
Solid ground floor (E&W) 1990
Uninsulated personnel door
Wood frame, metal spacer
Aperture Types
Substitute Elements
Feature Shades
Surface Output Specifications
Inter Zone Air Movement

Opaque Construction

Name 1920 External Wall - Description

Solar Absorptance		Emissivity		Conductance	Time Constant
Ext. Surf.	Int. Surf.	External	Internal	(W/m ² ·°C)	
0.700	0.166	0.900	0.880	3.251	1.546

Layer	M-Code	Thickness (mm)	Conductivity (W/m·°C)	Convection (W/m ² ·°C)	Vapour Diff. (kg/m ² ·s)	Density (kg/m ³)	Specific H. (J/kg·°C)	Description
Inner	Zenova Paint, 1mm	1.0	0.006	0.001	50.000	750.0	966.0	
2	Plaster, dense	5.0	0.5	0.001	9999.000	1300.0	1000.0	Dense plasterwork, 5 mm ...
3	Brick, 110 mm	110.0	0.84	0.001	9999.000	1700.0	800.0	110 mm layer of brick (ou...

*layer ignored in U-Value/R-Value Calculation

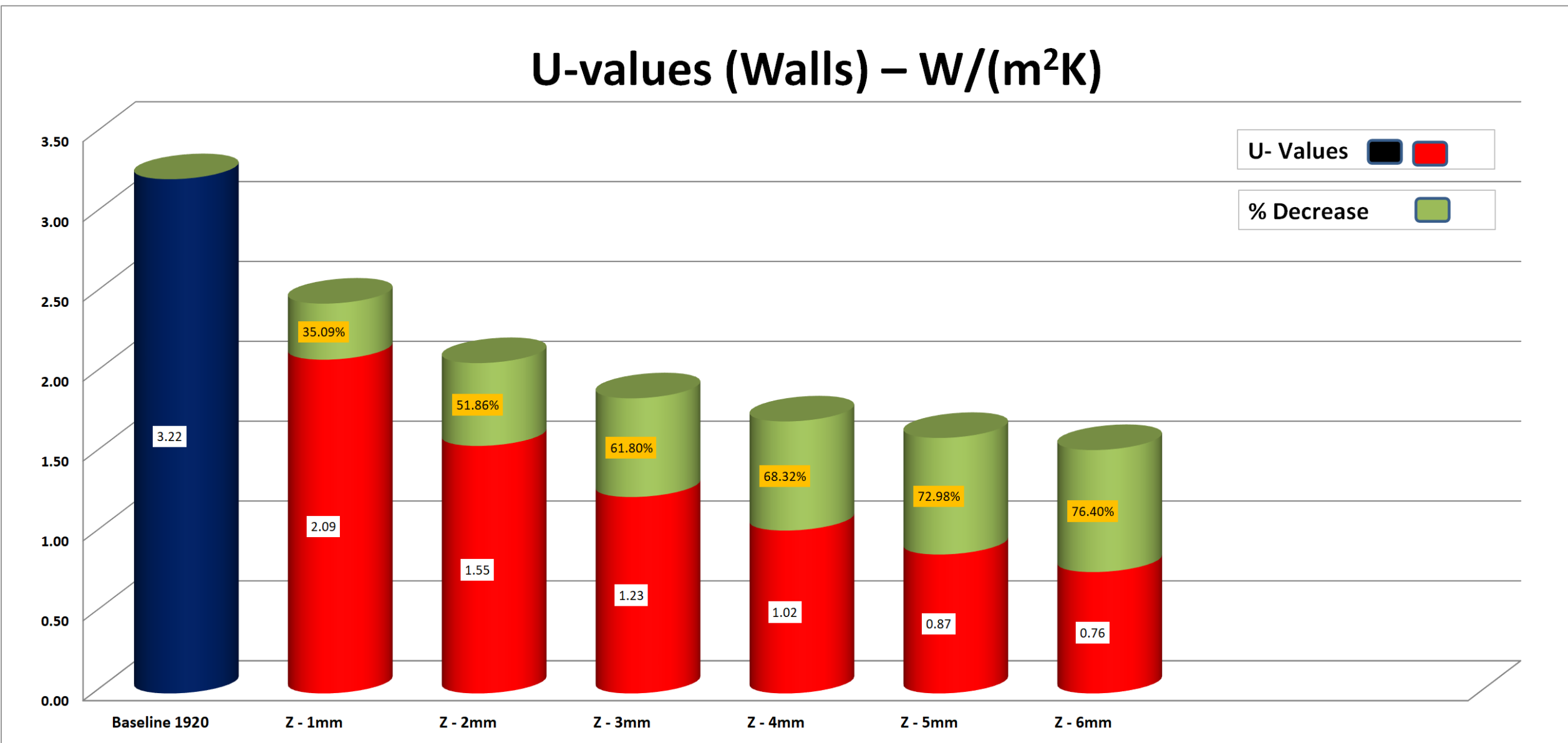
U/R Values (ISO 6946) (Homogenous)

Flow Direction	Internal U Value (W/m ² ·°C)	External U Value (W/m ² ·°C)
Horizontal	1.762	2.094
Upward	1.97	2.234
Downward	1.544	1.932

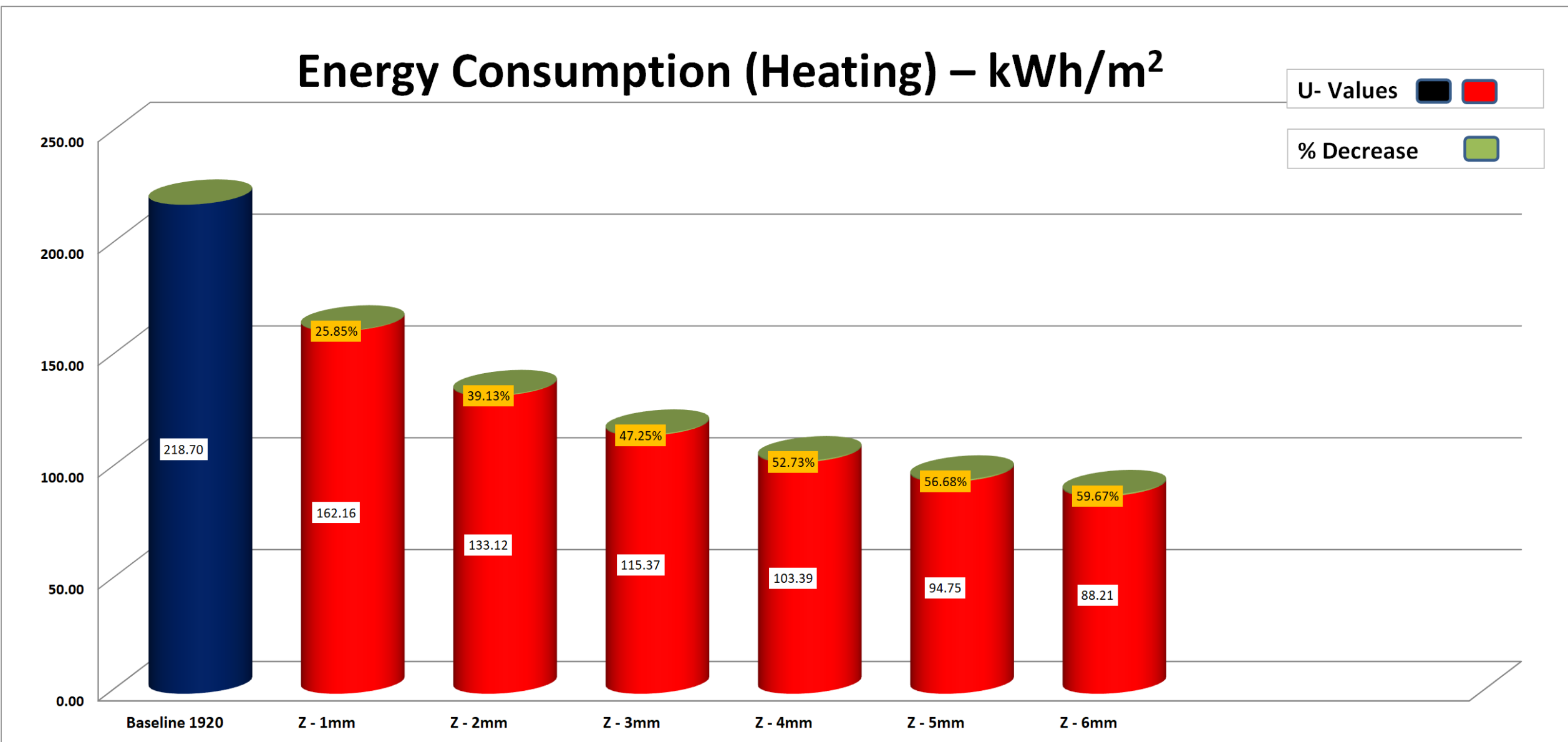
Show U Values Show R Values Condensation...

Additional Heat Transfer 0.0% F-Factor 0.0 W/m²·°C

Results – U-values (Walls) – W/(m²K)

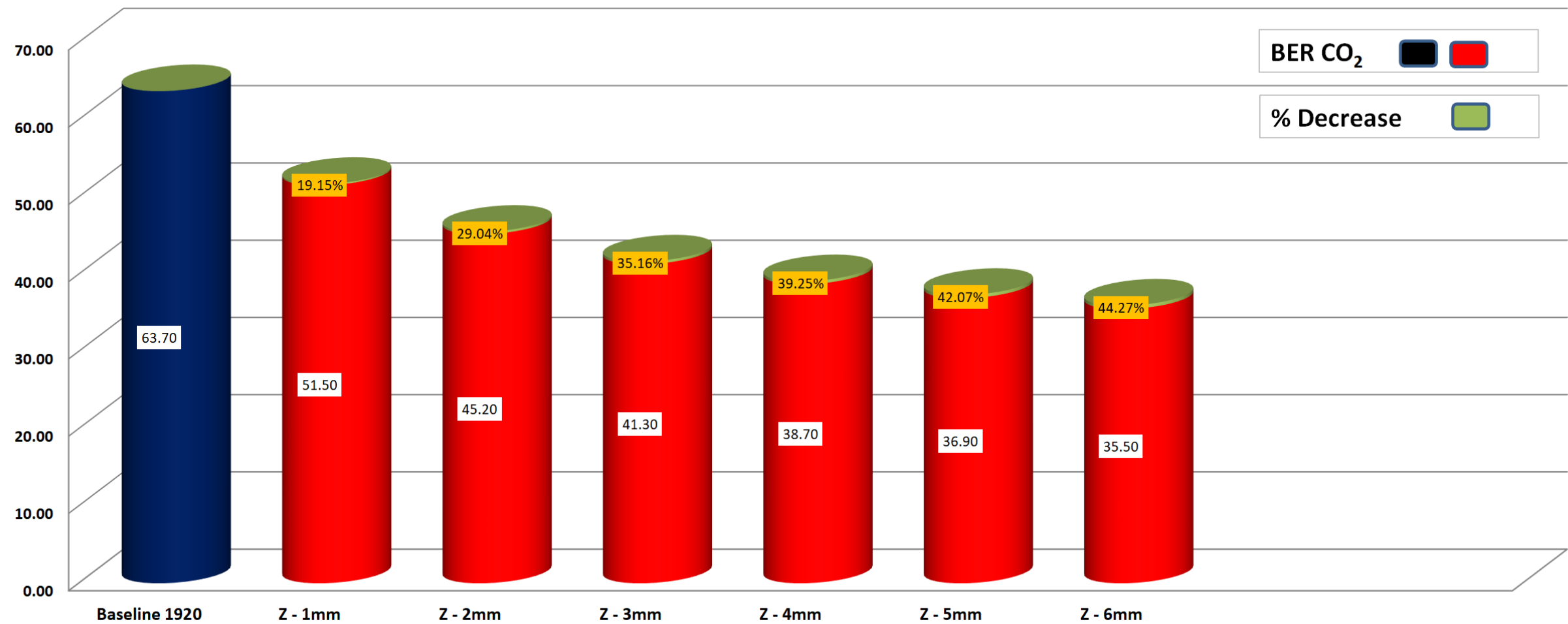


Energy Consumption (Heating) – kWh/m²

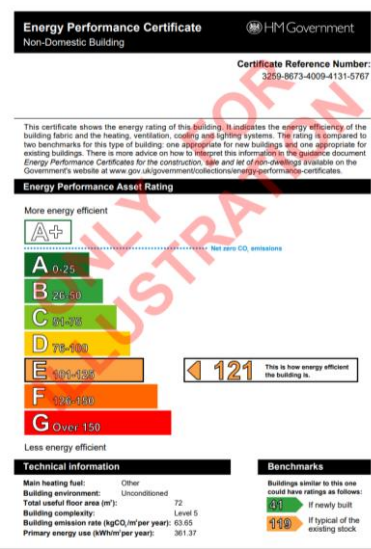


Building CO2 Emission Rate (BER) – kgCO₂/m².annum

Building CO₂ Emission Rate (kgCO₂/m².annum)



Energy Performance Asset Rating



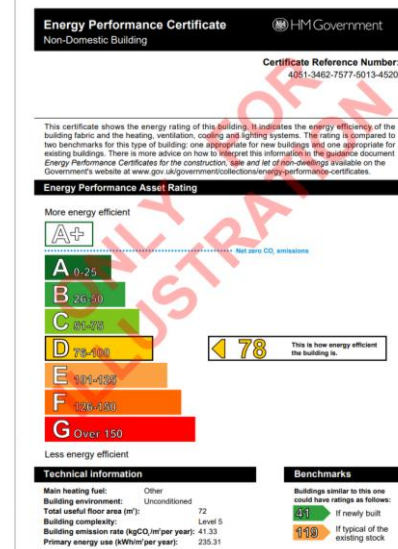
Base Line 1920



Zenova – 1mm



Zenova – 2mm



Zenova – 3mm



Zenova – 4mm

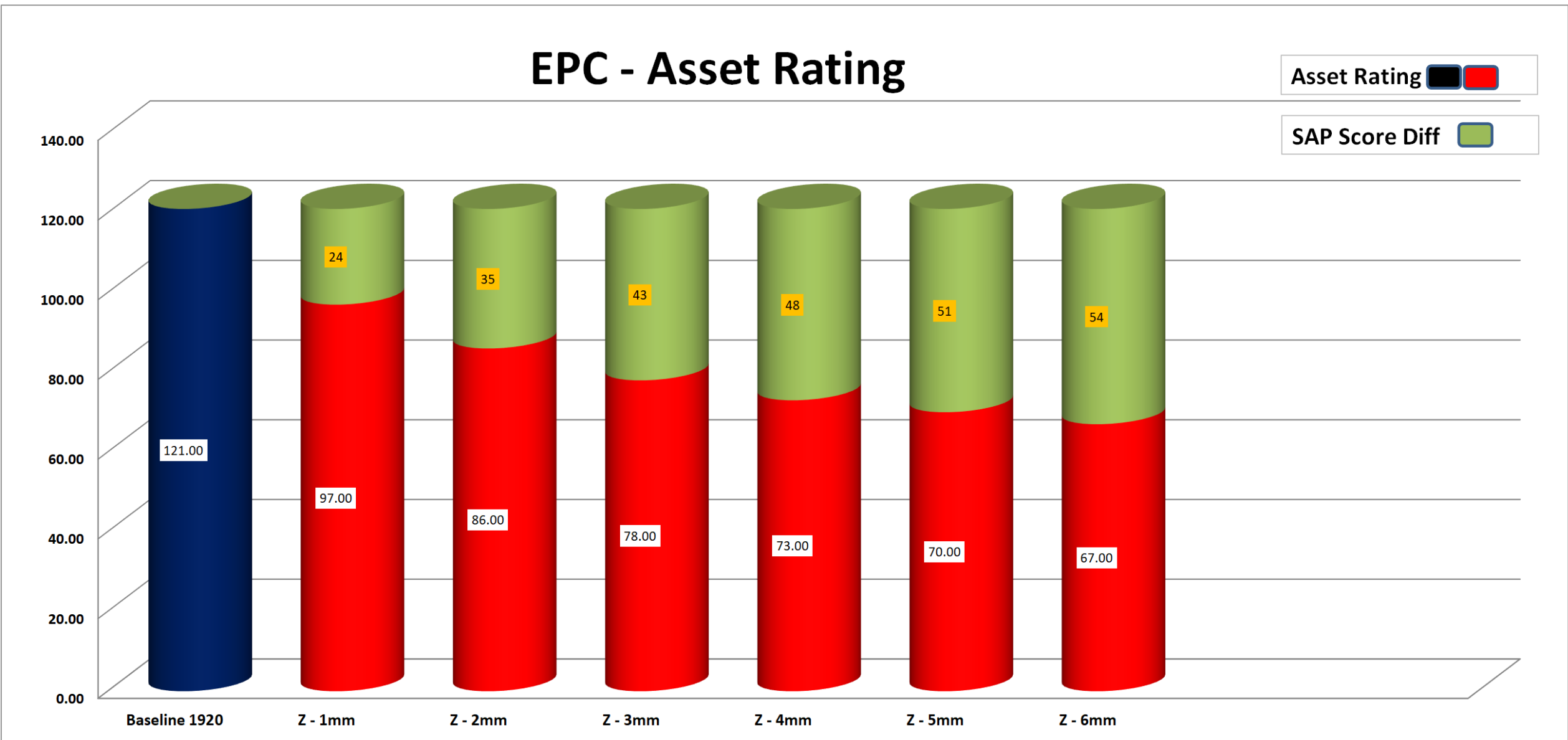


Zenova – 5mm



Zenova – 6mm

Energy Performance Asset Rating



Conclusion



1. **The promising** result shown by the U-value Improvement which is 1.2678 W/(m²K).
2. Zenova material has the **advantage of the thickness** against other insulation materials.
3. Modeling and simulation of whole building results show evidence of **significant reduction** in U-values, Energy Consumption (Heating), Building Emission Rate and Asset Rating with progressive increase in thickness application of Zenova material.

Future Works/ Considerations



1. Performance with **Varying** coating thickness.
2. Run the test and measure the **heating energy (KWh)** before and after refurbishment with dedicated heater.
3. Testing other buildings (1950, 2010) and **2021 New Building regulation**
4. Future over heating analysis using **CIBSETM59 for 2050-2080**