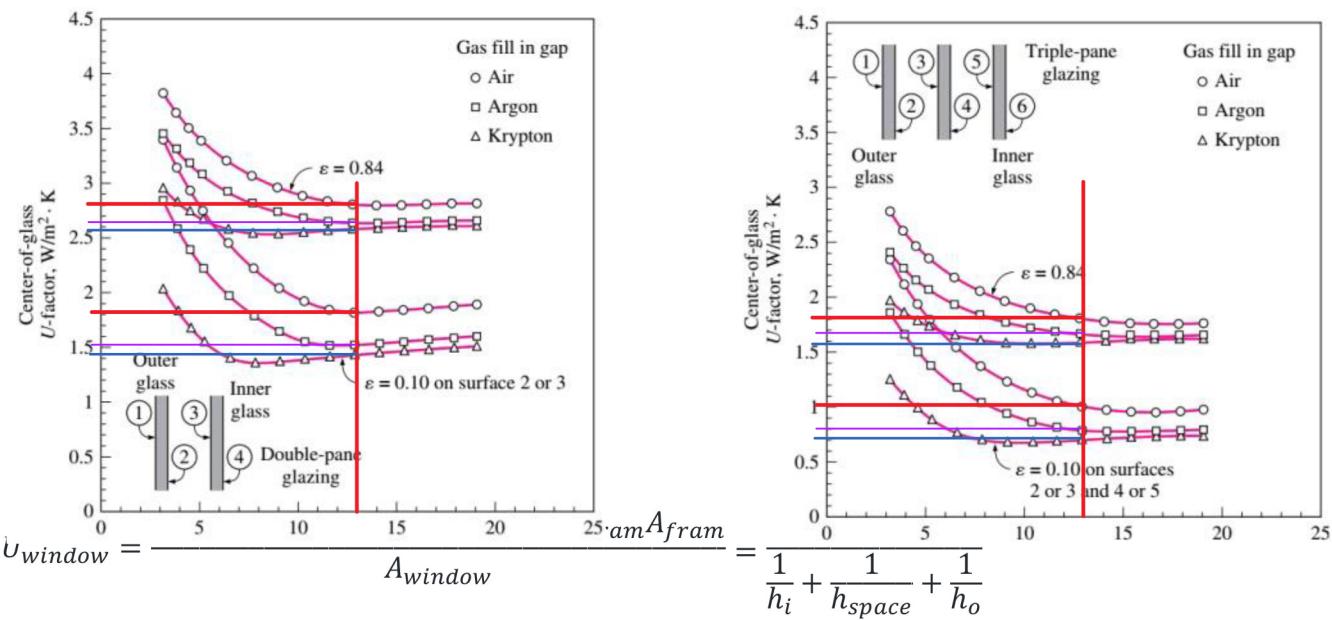


# WEEK 8

## \Task 1

Using the diagrams given in the presentation calculate how much (%) is the effect of applying different modifications (changing the gas, adding an extra pane, using a low emissivity coating) on the U value with respect to a benchmark case of double layer with air and no coating ? ( keep the gap thickness to be 13 mm)



$$h_{space} = h_{rad,space} + h_{conv,space}$$

	Benchmark	Window1	Window2	Window3	Window4
GAP	13mm	13mm	13mm	13mm	13mm
$\epsilon$	0.84	0.84	0.84	0.84	<b>0.10</b>
PANES	2	2	2	<b>3</b>	2
GAS	AIR	<b>ARGON</b>	<b>KRYPTON</b>	AIR	AIR
$U_{factor}$	$2.8W/m^2 \cdot K$	$2.65W/m^2 \cdot K$	$2.6W/m^2 \cdot K$	$1.8W/m^2 \cdot K$	$1.8W/m^2 \cdot K$
%	100	94.64	92.86	64.29	64.29

### 1. Changing the gas

So, from the graph is can be see that by comparing the benchmark with the different gas(**ARGON/KRYPTON**), the  $U_{factor}$  – value decreases by **5.36%/7.14%**, little improving the thermal transmittance of the window.

### 2. Adding an extra pane

From the graph is can be see that by comparing the benchmark with the **triple-pane window**, the  $U_{factor}$  – value decreases by **35.71%**, more improving the thermal transmittance of the window.

### 3. Using a low emissivity coating

From the graph is can be see that by comparing the benchmark with a **low emissivity coating**, the  $U_{factor}$  – value decreases by **35.71%**, more improving the thermal transmittance of the window.

## \Task 2

Consider the house that we analysed in the alst two examples, calculate the heating and cooling load of the other windows which are fixed  $14.4 \text{ m}^2$  on the west, fixed  $3.6 \text{ m}^2$  on the south and an operable  $3.6 \text{ m}^2$  on the south (the same window and frame type). How much does the total value change if I change the frame of the window from **wooden** one to **aluminium** ?

PIACENZA

LAT: 44.92 N

LONG: 9.73 E

ELEV :138

$T_{summer}$ :  $24^\circ$

$T_{winter}$ :  $20^\circ$

HEATING DB 99%: - 4.8

COOLING DB/MCWB 1%: 31.9

$$\Delta T_{COOLING} = 31.9 - 24 = 7.9^\circ\text{C} = 7.9K$$

$$\Delta T_{HEATING} = 20 - (-4.8) = 24.8^\circ\text{C} = 24.8K$$

EAST SIDE OF THE BUILDING

$45^\circ$  LATITUDE

No internal shading – IAC = 1

$$DR = 11.9^\circ\text{C} = 11.9K$$

Window frame with **wooden**

1- Fixed on west/ $14.4 \text{ m}^2$

COOLING LOAD

$$U_{window1,west1} = 2.84 \text{ W/m}^2 \cdot K$$

$$CF_{window1,west1} = U_{window1,west1} (\Delta T_{COOLING} - 0.46 DR) \\ = 2.84 \times (7.9 - 0.46 \times 11.9) \approx 6.89 \text{ W/m}^2$$

$$PXi_{window1,west2} = E_D + E_d = 559 + 188 = 747$$

$$SHGC = 0.54$$

$$FF_s = 0.56$$

$$CF_{window1,west2} = PXI \times SHGC \times IAC \times FF_s \\ = 747 \times 0.54 \times 1 \times 0.56 \approx 225.89 \text{ W/m}^2$$

$$CF_{window1,west} = CF_{window1,west1} + CF_{window1,west2} = 6.89 + 225.89 = 232.78 \text{ W/m}^2$$

$$Q_{window1,west-c} = A \times CF_{window1,west} = 14.4 \times 232.78 \approx 3352.03W$$

HEATING LOAD

$$Q_{window1,west-h} = A \times HF_{window1,west} = A \times U_{window1,west} \times \Delta T_{HEATING} = 14.4 \times 2.84 \times 24.8 \approx 1014.22W$$

2- Fixed on south/ $3.6 \text{ m}^2$

Table 10 Peak Irradiance,  $\text{W/m}^2$

Exposure	Latitude							
	20°	25°	30°	35°	40°	45°	50°	55°
North	$E_D$	125	106	92	84	81	85	96
	$E_d$	128	115	103	93	84	76	69
	$E_t$	253	221	195	177	166	162	164
Northeast/Northwest	$E_D$	460	449	437	425	412	399	386
	$E_d$	177	169	162	156	151	147	143
	$E_t$	637	618	599	581	563	546	529
East/West	$E_D$	530	543	552	558	560	559	555
	$E_d$	200	196	193	190	189	188	187
	$E_t$	730	739	745	748	749	747	742
Southeast/Southwest	$E_D$	282	328	369	405	436	463	485
	$E_d$	204	203	203	204	205	207	210
	$E_t$	485	531	572	609	641	670	695
South	$E_D$	0	60	139	214	283	348	408
	$E_d$	166	193	196	200	204	209	214
	$E_t$	166	253	335	414	487	557	622
Horizontal	$E_D$	845	840	827	806	776	738	691
	$E_d$	170	170	170	170	170	170	170
	$E_t$	1015	1010	997	976	946	908	861

Table 13 Fenestration Solar Load Factors  $FF_s$

Exposure	Single Family Detached	Multifamily
North	0.44	0.27
Northeast	0.21	0.43
East	0.31	0.56
Southeast	0.37	0.54
South	0.47	0.53
Southwest	0.58	0.61
West	0.56	0.65
Northwest	0.46	0.57
Horizontal	0.58	0.73

## COOLING LOAD

$$U_{window2,south1} = 2.84 W/m^2 \cdot K$$

$$CF_{window2,south1} = U_{window2,south1} (\Delta T_{COOLING} - 0.46 DR) \\ = 2.84 \times (7.9 - 0.46 \times 11.9) \approx 6.89 W/m^2$$

$$PXI_{window2,south2} = E_D + E_d = 348 + 209 = 557$$

$$SHGC = 0.54$$

$$FF_s = 0.47$$

$$CF_{window2,south2} = PXI \times SHGC \times IAC \times FF_s \\ = 557 \times 0.54 \times 1 \times 0.47 \approx 141.37 W/m^2$$

$$CF_{window2,south} = CF_{window2,south1} + CF_{window2,south2} = 6.89 + 141.37 = 148.26 W/m^2$$

$$Q_{window2,south-c} = A \times CF_{window2,south} = 3.6 \times 148.26 \approx 553.74 W$$

## HEATING LOAD

$$Q_{window2,south-h} = A \times HF_{window2,south} = A \times U_{window2,south} \times \Delta T_{HEATING} = 3.6 \times 2.84 \times 24.8 \approx 253.56 W$$

## 3- Operable on south/3.6m<sup>2</sup>

### COOLING LOAD

$$U_{window3,south1} = 2.87 W/m^2 \cdot K$$

$$CF_{window3,south1} = U_{window3,south1} (\Delta T_{COOLING} - 0.46 DR) \\ = 2.87 \times (7.9 - 0.46 \times 11.9) \approx 6.96 W/m^2$$

$$PXI_{window3,south2} = E_D + E_d = 348 + 209 = 557$$

$$SHGC = 0.46$$

$$FF_s = 0.47$$

$$CF_{window3,south2} = PXI \times SHGC \times IAC \times FF_s \\ = 557 \times 0.46 \times 1 \times 0.47 \approx 120.42 W/m^2$$

$$CF_{window3,south} = CF_{window3,south1} + CF_{window3,south2} = 6.96 + 120.42 = 127.38 W/m^2$$

$$Q_{window3,south-c} = A \times CF_{window3,south} = 3.6 \times 127.38 \approx 458.57 W$$

## HEATING LOAD

$$Q_{window3,south-h} = A \times HF_{window3,south} = A \times U_{window3,south} \times \Delta T_{HEATING} = 3.6 \times 2.87 \times 24.8 \approx 256.23 W$$

$$Q_{total-c} = Q_{window1,west-c} + Q_{window2,south-c} + Q_{window3,south-c} = 3352.03 + 553.74 + 458.57 = 4364.34 W \\ Q_{total-h} = Q_{window1,west-h} + Q_{window2,south-h} + Q_{window3,south-h} = 1014.22 + 253.56 + 256.23 = 1524.01 W$$

## Window frame with **aluminium**

## 1- Fixed on west/14.4m<sup>2</sup>

### COOLING LOAD

$$U'_{window1,west1} = 3.61 W/m^2 \cdot K$$

$$CF'_{window1,west1} = U'_{window1,west1}(\Delta T_{COOLING} - 0.46DR) \\ = 3.61 \times (7.9 - 0.46 \times 11.9) \approx 8.76W/m^2$$

$$PXi_{window1,west2} = E_D + E_d = 559 + 188 = 747$$

$$SHGC = 0.56$$

$$FF_s = 0.56$$

$$CF'_{window1,west2} = PXI \times SHGC \times IAC \times FF_s \\ = 747 \times 0.56 \times 1 \times 0.56 \approx 234.26W/m^2$$

$$CF'_{window1,west} = CF'_{window1,west1} + CF'_{window1,west2} = 8.76 + 234.26 = 243.02W/m^2$$

$$Q'_{window1,west-h} = A \times CF'_{window1,west} = 14.4 \times 243.02 \approx 3499.49W$$

#### **HEATING LOAD**

$$Q'_{window1,west-h} = A \times HF'_{window1,west} = A \times U'_{window1,west} \times \Delta T_{HEATING} = 14.4 \times 2.87 \times 24.8 \approx 1289.20W$$

#### **2- Fixed on south/3.6m<sup>2</sup>**

##### **COOLING LOAD**

$$U'_{window2,south1} = 3.61W/m^2 \cdot K$$

$$CF'_{window2,south1} = U'_{window2,south1}(\Delta T_{COOLING} - 0.46DR) \\ = 3.61 \times (7.9 - 0.46 \times 11.9) \approx 8.76W/m^2$$

$$PXi_{window2,south2} = E_D + E_d = 348 + 209 = 557$$

$$SHGC = 0.56$$

$$FF_s = 0.47$$

$$CF'_{window2,south2} = PXI \times SHGC \times IAC \times FF_s \\ = 557 \times 0.56 \times 1 \times 0.47 \approx 146.60W/m^2$$

$$CF'_{window2,south} = CF'_{window2,south1} + CF'_{window2,south2} = 8.76 + 146.60 = 155.36W/m^2$$

$$Q'_{window2,south-h} = A \times CF'_{window2,south} = 3.6 \times 155.36 \approx 559.30W$$

#### **HEATING LOAD**

$$Q'_{window2,south-h} = A \times HF'_{window2,south} = A \times U'_{window2,south} \times \Delta T_{HEATING} = 3.6 \times 3.61 \times 24.8 \approx 322.30W$$

#### **3- Operable on south/3.6m<sup>2</sup>**

##### **COOLING LOAD**

$$U'_{window3,south1} = 4.62W/m^2 \cdot K$$

$$CF'_{window3,south1} = U'_{window3,south1}(\Delta T_{COOLING} - 0.46DR) \\ = 4.62 \times (7.9 - 0.46 \times 11.9) \approx 11.21W/m^2$$

$$PXi_{window3,south2} = E_D + E_d = 348 + 209 = 557$$

$$SHGC = 0.55$$

$$FF_s = 0.47$$

$$CF'_{window3,south2} = PXI \times SHGC \times IAC \times FF_s \\ = 557 \times 0.55 \times 1 \times 0.47 \approx 143.98W/m^2$$

$$CF'_{window3,south} = CF'_{window3,south1} + CF'_{window3,south2} = 11.21 + 143.98 = 155.19 W/m^2$$

$$Q'_{window3,south-c} = A \times CF'_{window3,south} = 3.6 \times 155.19 \approx 558.68 W$$

## HEATING LOAD

$$Q'_{window3,south-h} = A \times HF'_{window3,south} = A \times U'_{window3,south} \times \Delta T_{HEATING} = 3.6 \times 4.62 \times 24.8 \approx 412.47 W$$

$$Q'_{total-c} = Q'_{window1,west-c} + Q'_{window2,south-c} + Q'_{window3,south-c} = 3499.49 + 559.30 + 558.68 = 4617.47 W$$

$$Q'_{total-h} = Q'_{window1,west-h} + Q'_{window2,south-h} + Q'_{window3,south-h} = 1289.20 + 322.30 + 412.47 = 2026.67 W$$

So, it can be seen that frame with wooden has a greater resistance in cooling and heating than aluminium frame.