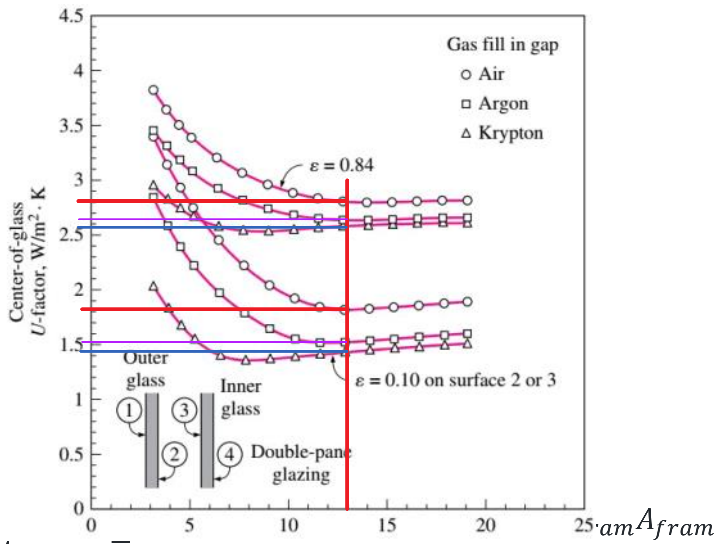
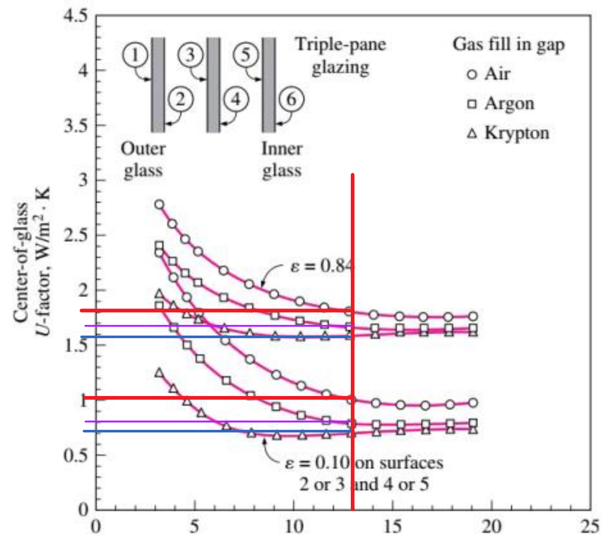
WEEK 8_ZHU CUILING

\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 thickenss to be 13 mm)





$$U_{window} = \frac{\ldots amA_{fram}}{A_{window}} = \frac{1}{\frac{1}{h_i} + \frac{1}{h_{space}} + \frac{1}{h_o}}$$

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

	Benchmark	**Window1**	**Window2**	**Window3**	**Window4**
GAP	13mm	13mm	13mm	13mm	13mm
ε	0.84	0.84	0.84	0.84	**0.10**
PANES	2	2	2	**3**	2
GAS	AIR	**ARGON**	**KRYPTON**	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 m^2 on the west, fixed 3.6 m^2 on the south and an operable 3.6 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°
T_{winter}: 20°
HEATING DB 99%: - 4.8
COOLING DB/MCWB 1%: 31.9
$\Delta T_{COOLING} = 31.9 - 24 = 7.9°C = 7.9K$
$\Delta T_{HEATING} = 20 - (-4.8) = 24.8°C = 24.8K$
EAST SIDE OF THE BUILDING
45° LATITUDE
No internal shading – IAC = 1
$DR = 11.9°C = 11.9K$

Table 10 Peak Irradiance, W/m²

Exposure		Latitude 20°	25°	30°	35°	40°	45°	50°	55°	60°
North	E_D	125	106	92	84	81	85	96	112	136
	E_d	128	115	103	93	84	76	69	62	55
	E_t	253	221	195	177	166	162	164	174	191
Northeast/Northwest	E_D	460	449	437	425	412	399	386	374	361
	E_d	177	169	162	156	151	147	143	140	137
	E_t	637	618	599	581	563	546	529	513	498
East/West	E_D	530	543	552	558	560	559	555	547	537
	E_d	200	196	193	190	189	188	187	187	187
	E_t	730	739	745	748	749	747	742	734	724
Southeast/Southwest	E_D	282	328	369	405	436	463	485	503	517
	E_d	204	203	203	204	205	207	210	212	215
	E_t	485	531	572	609	641	670	695	715	732
South	E_D	0	60	139	214	283	348	408	464	515
	E_d	166	193	196	200	204	209	214	219	225
	E_t	166	253	335	414	487	557	622	683	740
Horizontal	E_D	845	840	827	806	776	738	691	637	574
	E_d	170	170	170	170	170	170	170	170	170
	E_t	1015	1010	997	976	946	908	861	807	744

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

Window frame with **wooden**

1- Fixed on west/14.4m^2

COOLING LOAD

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

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

$PXI_{window1,west2} = E_D + E_d = 559 + 188 = 747$
$SHGC = 0.54$
$FF_S = 0.56$
$CF_{window1,west2} = PXI \times SHGC \times IAC \times FF_S$
$= 747 \times 0.54 \times 1 \times 0.56 \approx 225.89W/m^2$

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

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

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/3.6m^2

COOLING LOAD

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

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

$PXI_{window2,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.54$
$FF_s = 0.47$
$CF_{window2,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.54 \times 1 \times 0.47 \approx 141.37W/m^2$

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

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

HEATING LOAD

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

3- Operable on south/3.6m^2

COOLING LOAD

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

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

$PXI_{window3,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.46$
$FF_s = 0.47$
$CF_{window3,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.46 \times 1 \times 0.47 \approx 120.42W/m^2$

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

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

HEATING LOAD

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

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

Window frame with **aluminium**

1- Fixed on west/14.4m^2

COOLING LOAD

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

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

$PXI_{window1,west2} = E_D + E_d = 559 + 188 = 747$
$SHGC = 0.56$
$FF_s = 0.56$
$CF'_{window1,west2} = PXI \times SHGC \times IAC \times FF_s$
$= 747 \times 0.56 \times 1 \times 0.56 \approx 234.26W/m^2$

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

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

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^2

COOLING LOAD

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

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

$PXI_{window2,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.56$
$FF_s = 0.47$
$CF'_{window2,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.56 \times 1 \times 0.47 \approx 146.60W/m^2$

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

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

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^2

COOLING LOAD

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

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

$PXI_{window3,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.55$
$FF_s = 0.47$
$CF'_{window3,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.55 \times 1 \times 0.47 \approx 143.98W/m^2$

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

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

HEATING LOAD

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

$Q'_{total-c} = Q'_{window1,west-c} + Q'_{window2,south-c} + Q'_{window3,south-c} = 3499.49 + 559.30 + 558.68 = 4617.47W$
$Q'_{total-h} = Q'_{window1,west-h} + Q'_{window2,south-h} + Q'_{window3,south-h} = 1289.20 + 322.30 + 412.47 = 2026.67W$

$\Delta Q_{COOLING} = Q_{total-c} - Q'_{total-c} = 4364.34 - 4617.47 = -253.13W$
$\Delta Q_{HEATING} = Q_{total-h} - Q'_{total-h} = 1524.01 - 2026.67 = -502.66W$

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