Week 8_Qureshi, Nahid

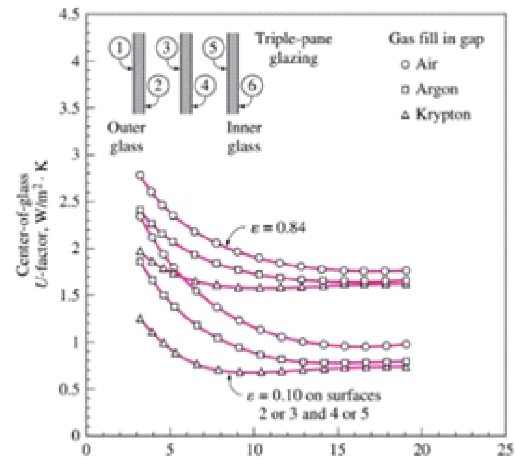
QUESTION 1

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 thickens to be 13 mm)?

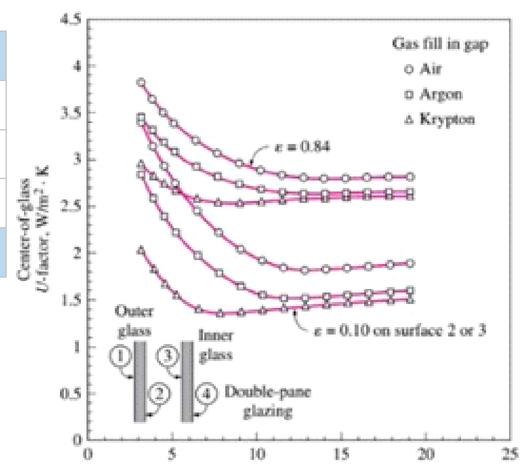
ANSWER

U value with respect to a benchmark case of double layer glazing (ε=0.84) with air and no coating (gap thickness to be 13 mm) is 2.8 $\frac{W}{m^2K}$

ε value	0.84		0.10		
No. of panels	2	2	2	2	2
Gas	Argon	Krypton	Air	Argon	Krypton
U value	2.65	2.6	1.8	1.5	1.4
% of change	5.4	7.2	35.7	46.4	50



ε value	0.84			0.10		
No. of panels	3	3	3	3	3	3
Gas	Air	Argon	Krypton	Air	Argon	krypton
U value	1.8	1.7	1.6	1	0.8	0.7
% of change	35.7	39.2	42.8	64.3	71.4	75



QUESTION 2

Consider the house that we analyzed in the last two examples, calculate the heating and cooling load of the other windows which are fixed 14.4 m2 on the west, fixed 3.6 m2 on the south and an operable 3.6 m2 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 aluminum?

ANSWER

PIACENZA, Italy WMO#: 160840

Lat: 44.92N Long: 9.73E Elev: 138 StdP: 99.68 Time Zone: 1.00 (EUW) Period: 89-10 WBAN: 99999

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
			99.6%			99%			0.4%		1%				
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	
1	-6.2	-4.8	-11.6	1.4	3.1	-8.8	1.8	1.8	8.8	5.6	7.7	6.2	2.1	250	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
		0.4%		1%		2%		0.4%		1%		2%				
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
8	11.9	33.1	22.7	31.9	22.4	30.3	21.8	24.6	30.2	23.7	29.2	22.9	28.3	2.4	90	(2)

Latitude ≈ 45

The cooling design temperature $T_{cooling}$ = 24°C and

heating design temperature $T_{heating}$ = 20°C

$\Delta T_{cooling}$ = 31.9°C - 24°C = 7.9°C = 7.9K

$\Delta T_{heating}$ = 20°C - (-4.8)°C = 24.8 °C = 24.8K

From the table above DR = 11.9 °C = 11.9K

					Frame									
					Operable					Fixed				
Glazing Type	Glazing Layers	ID[b]	Property[c,d]	Center of Glazing	Aluminum	Aluminum with Thermal Break	Reinforced Vinyl/Aluminum Clad Wood	Wood/Vinyl	Insulated Fiberglass/Vinyl	Aluminum	Aluminum with Thermal Break	Reinforced Vinyl/Aluminum Clad Wood	Wood/Vinyl	Insulated Fiberglass/Vinyl
Clear	1	1a	U	5.91	7.24	6.12	5.14	5.05	4.61	6.42	6.07	5.55	5.55	5.35
			SHGC	0.86	0.75	0.75	0.64	0.64	0.64	0.78	0.78	0.75	0.75	0.75
	2	5a	U	2.73	4.62	3.42	3.00	2.87	5.83	3.61	3.22	2.86	2.84	2.72
			SHGC	0.76	0.67	0.67	0.57	0.57	0.57	0.69	0.69	0.67	0.67	0.67
	3	29a	U	1.76	3.80	2.60	2.25	2.19	1.91	2.76	2.39	2.05	2.01	1.93
			SHGC	0.68	0.60	0.60	0.51	0.51	0.51	0.62	0.62	0.60	0.60	0.60
Low-e, low-solar	2	25a	U	1.70	3.83	2.68	2.33	2.21	1.89	2.75	2.36	2.03	2.01	1.90
			SHGC	0.41	0.37	0.37	0.31	0.31	0.31	0.38	0.38	0.36	0.36	0.36
	3	40c	U	1.02	3.22	2.07	1.76	1.71	1.45	2.13	1.76	1.44	1.40	1.33
			SHGC	0.27	0.25	0.25	0.21	0.21	0.21	0.25	0.25	0.24	0.24	0.24
Low-e, high-solar	2	17c	U	1.99	4.05	2.89	2.52	2.39	2.07	2.99	2.60	2.26	2.24	2.13
			SHGC	0.70	0.62	0.62	0.52	0.52	0.52	0.64	0.64	0.61	0.61	0.61
	3	32c	U	1.42	3.54	2.36	2.02	1.97	1.70	2.47	2.10	1.77	1.73	1.66
			SHGC	0.62	0.55	0.55	0.46	0.46	0.46	0.56	0.56	0.54	0.54	0.54
Heat-absorbing	1	1c	U	5.91	7.24	6.12	5.14	5.05	4.61	6.42	6.07	5.55	5.55	5.35
			SHGC	0.73	0.64	0.64	0.54	0.54	0.54	0.66	0.66	0.64	0.64	0.64
	2	5c	U	2.73	4.62	3.42	3.00	2.87	2.53	3.61	3.22	2.86	2.84	2.72
			SHGC	0.62	0.55	0.55	0.46	0.46	0.46	0.56	0.56	0.54	0.54	0.54
	3	29c	U	1.76	3.80	2.60	2.25	2.19	1.91	2.76	2.39	2.05	2.01	1.93
			SHGC	0.34	0.31	0.31	0.26	0.26	0.26	0.31	0.31	0.30	0.30	0.30
Reflective	1	1l	U	5.91	7.24	6.12	5.14	5.05	4.61	6.42	6.07	5.55	5.55	5.35
			SHGC	0.31	0.28	0.28	0.24	0.24	0.24	0.29	0.29	0.27	0.27	0.27
	2	5p	U	2.73	4.62	3.42	3.00	2.87	2.53	3.61	3.22	2.86	2.84	2.72
			SHGC	0.29	0.27	0.27	0.22	0.22	0.22	0.27	0.27	0.26	0.26	0.26
	3	29c	U	1.76	3.80	2.60	2.25	2.19	1.91	2.76	2.39	2.05	2.01	1.93
			SHGC	0.34	0.31	0.31	0.26	0.26	0.26	0.31	0.31	0.30	0.30	0.30

WHEN THE FRAME IS WOODEN

CALCULATING THE COOLING LOAD OF THE FIXED WINDOW ON WEST SIDE

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

Area = 14.4 m²

$q_{west\ window} = A\ x\ CF_{west\ window}$

$CF_{west\ window(heat\ transfer)} = U_{west\ window}$ ($\Delta T_{cooling}$ - 0.46 DR)

$U_{west\ window} = 2.84 \frac{W}{m^2\ K}$

$CF_{west\ window(heat\ transfer)} = 2.84 \frac{W}{m^2\ K}$(7.9 K - 0.46 X 11.9K)

$\approx 6.89\ \frac{W}{m^2}$

PXI $_{west\ window}$ = E_D + E_d = 559 +188 = 747 (from table)

Since no internal shading, so IAC = 1

SHGC = 0.54

FF_s = 0.56

$CF_{west\ window(irradiation)} = PXI\ x\ SHGC\ x\ IAC\ x\ FF_s$

= 747 x 0.54 x 1 x 0.56 = 225.89

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

$q_{west\ window} = A\ x\ CF_{west\ window} = A\ x\ (CF_{west\ window(heat\ transfer)} + (CF_{west\ window(irradiation)})$

= 14.4 m^2 x (6.89 +225.89) $\frac{W}{m^2}$ = 3352.07 W

CALCULATING THE HEATING LOAD OF THE FIXED WINDOW ON WEST SIDE

$q_{west\ window} = A\ x\ HF_{west\ window} = A\ x\ U_{west\ window}\ x\ \Delta T_{heating}$

= 14.4 m^2 x 2.84 $\frac{W}{m^2\ K}$ x 24.8 k = 1014.22 W

WHEN THE FRAME IS ALUMINIUM $U'_{west\ window} = 3.61\ \frac{W}{m^2\ K}$, SHGC' = 0.56

COOLING LOAD

$CF'_{west\ window(heat\ transfer)} = U'_{west\ window}$ ($\Delta T_{cooling}$ - 0.46 DR)

= 3.61 $\frac{W}{m^2\ K}(7.9K - 0.46\ x\ 11.9\ k)$ = 8.76 $\frac{W}{m^2}$

$CF'_{west\ window(irradiation)} = PXI\ x\ SHGC'\ x\ IAC\ x\ FF_s$

= 747 x 0.56 x 1 x 0.56 = 234.26 $\frac{W}{m^2}$

$q'_{west\ window} = A\ x\ (CF'_{west\ window(heat\ transfer)} + (CF'_{west\ window(irradiation)})$

= 14.4 m^2 x (8.76 +234.26) $\frac{w}{m^2}$ = 3499.48W

HEATING LOAD

$q'_{west\ window} = A\ x\ HF'_{west\ window} = A\ x\ U'_{west\ window}\ x\ \Delta T_{heating}$

= 14.4 m^2 x 3.61 $\frac{W}{m^2\ K}$ x 24.8 K = 1289.20 W

WHEN THE FRAME IS WOODEN

CALCULATING THE COOLING LOAD OF THE FIXED WINDOW ON SOUTH SIDE

Area = 3.6 m^2

$q_{south\ window} = A\ x\ CF_{south\ window}$

$CF_{south\ window(heat\ transfer)} = U_{south\ window}$ ($\Delta T_{cooling}$ - 0.46 DR)

$U_{south\ window} = 2.84 \frac{W}{m^2\ K}$

$CF_{south\ window(heat\ transfer)} = 2.84 \frac{W}{m^2\ K}$ (7.9 K - 0.46 X 11.9K) $= 6.89\ \frac{W}{m^2}$

PXI $_{west\ window}$ = $E_D + E_d$ = 348 + 209 = 557

Since no internal shading, so IAC = 1

SHGC = 0.54

FF_s = 0.47

$CF_{south\ window(irradiation)} = PXI\ x\ SHGC\ x\ IAC\ x\ FF_S = 557 \text{ x } 0.54 \text{ x } 1 \text{ x } 0.47 = 141.36\ \frac{W}{m^2}$

$q_{south\ window} = AxCF_{southwindow} = Ax(CF_{south\ window(heat\ transfer)} + (CF_{south\ window(irradiation)})$

= 3.6 m^2 x (6.89 +141.36) $\frac{W}{m^2}$ = 533.72 W

CALCULATING THE HEATING LOAD OF THE FIXED WINDOW ON SOUTH SIDE

$q_{south\ window} = A\ x\ HF_{south\ window} = A\ x\ U_{south\ window}\ x\ \Delta T_{heating}$

= 3.6 m^2 x 2.84 $\frac{W}{m^2\ K}$ x 24.8 k = 253.56 W

WHEN THE FRAME IS ALUMINIUM $U'_{south\ window} = 3.61 \frac{W}{m^2\ K}$, SHGC' = 0.56

COOLING LOAD

$CF'_{south\ window(heat\ transfer)} = U'_{south\ window}\ (\Delta T_{cooling}$ - 0.46 DR)

= 3.61 $\frac{W}{m^2\ K}(7.9K - 0.46\ x\ 11.9\ k\ )$ = 8.76 $\frac{W}{m^2}$

$CF'_{south\ window(irradiation)} = PXI\ x\ SHGC'\ x\ IAC\ x\ FF_s$ = 557 x 0.56 x 1 x 0.47 = 146.6 $\frac{W}{m^2}$

$q'_{south\ window} = A\ x\ (CF'_{south\ window(heat\ transfer)} + (CF'_{south\ window(irradiation)})$

= 3.6 m^2 x (8.76 +146.60) $\frac{w}{m^2}$ = 559.30W

HEATING LOAD

$q'_{south\ window} = A\ x\ HF'_{south\ window} = A\ x\ U'_{south\ window}\ x\ \Delta T_{heating}$

= 3.6 m^2 x 3.61 $\frac{W}{m^2\ K}$ x 24.8 k = 322.30 W

WHEN THE FRAME IS WOODEN

CALCULATING THE COOLING LOAD OF THE OPERABLE WINDOW ON SOUTH SIDE

Area = 3.6 m^2

$q_{south\ window} = A\ x\ CF_{south\ window}$

$CF_{south\ window(heat\ transfer)} = U_{south\ window}\ (\Delta T_{cooling}$ - 0.46 DR)

$U_{south\ window} = 2.87 \frac{W}{m^2\ K}$

$CF_{south\ window(heat\ transfer)} = 2.87 \frac{W}{m^2\ K}$(7.9 k - 0.46 (11.9 k)) $= 6.96\ \frac{W}{m^2}$

PXI $_{south\ window}$ = $E_D + E_d$ = 348 + 209 = 557

Since no internal shading, so IAC = 1

SHGC = 0.46

FF_S = 0.47

$CF_{south\ window(irradiation)} = PXI\ x\ SHGC\ x\ IAC\ x\ FF_S = 557$ x 0.46 x 1 x 0.47 $= 120.42\ \frac{W}{m^2}$

$q_{south\ window} = AxCF_{south\ window} = A(CF_{south\ window(heat\ transfer)} + (CF_{south\ window(irradiation)})$

= 3.6 m^2 x (6.96 +120.42) $\frac{W}{m^2}$ = 458.58 W

CALCULATING THE HEATING LOAD OF THE OPERABLE WINDOW ON SOUTH SIDE

$q_{south\ window} = A\ x\ HF_{south\ window} = A\ x\ U_{south\ window}\ x\ \Delta T_{heating}$

= 3.6 m^2 x 2.87 $\frac{W}{m^2\ K}$ x 24.8 K = 256.23 W

WHEN THE FRAME IS ALUMINIUM $U_{south\ window} = 4.62 \frac{W}{m^2\ K}$, SHGC = 0.55

COOLING LOAD

$CF'_{south\ window(heat\ transfer)} = U'_{south\ window}$ ($\Delta T_{cooling}$ - 0.46 DR)

= $4.62 \frac{W}{m^2\ K}(7.9K - 0.46\ x\ 11.9\ K)$ = $11.21\frac{W}{m^2}$

$CF'_{south\ window(irradiation)} = PXI\ x\ SHGC'\ x\ IAC\ x\ FF_S$ = 557 x 0.55 x 1 x 0.47 = 143.98 $\frac{W}{m^2}$

$q'_{south\ window} = A\ x\ (CF'_{south\ window(heat\ transfer)} + (CF'_{south\ window(irradiation)})$

= 3.6 m^2 x (11.21 +143.98) $\frac{W}{m^2}$ = 558.70 W

HEATING LOAD

$q'_{south\ window} = A\ x\ HF'_{south\ window} = A\ x\ U'_{south\ window}\ x\ \Delta T_{heating}$

= 3.6 m^2 x 4.62 $\frac{W}{m^2\ K}$ x 24.8 K = 412.47 W