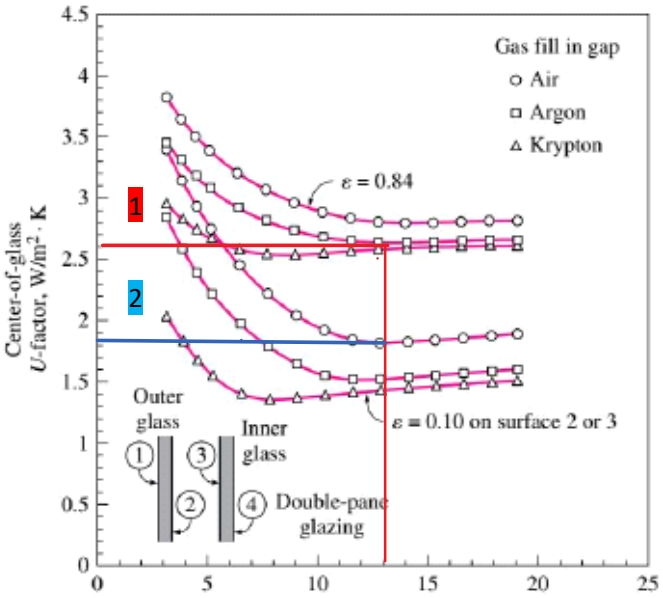
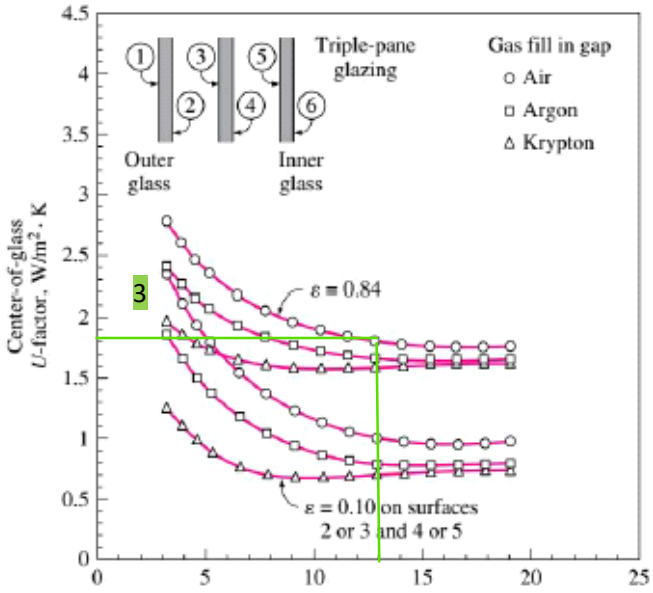
TASK 1

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)





Benchmark cases;

Gap : 13 mm
Pane number: 2
Gas type : Air
ϵ : 0.84
U-factor : 2.8 W/m^{2}K
Result : 100%

Case 1 ;

Gap : 13 mm
Pane number: 2
Gas type : Argon
ϵ : 0.84
U-factor : 2.6 W/m^{2}K
Result : 93%

Case 2 ;

Gap : 13 mm
Pane number: 2
Gas type : Air
ϵ : 0.10
U-factor : 1,8 W/m^{2}K
Result : 64%

Case 3 ;

Gap : 13 mm
Pane number: 3
Gas type : Air
ϵ : 0.84
U-factor : 1,8 W/m^{2}K
Result : 64%

TASK 2

Consider the house that we analysed in the also 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 aluminium ?

AT PIACENZA :
Lat : 44,92 N,
Long : 9,73 E,
Elev : 138
T_{summer} : 24 ℃
T_{winter} : 20 ℃
Heating DB 99% : -4,8
Cooling DB 1% : 31,9
ΔTcooling = 31,9 − 24 = 7,9 ℃
ΔTheating= 20 − (−4,8) = 24,8 ℃
East side of the building 45° Latitude
No internal shading – AIC = 1
DR = 11,9

WOOD FRAME - WINDOW 1 : A_{W1east}= 14,4 m^2

Heating
$HF_{w1east}= U_{W1east} \times \Delta T_{cooling}$
= 2.84 x 24.8 = 70.44 W/m2

$Q_{w1east}= HF_{W1east} \times A_{W1east}$
= 70.44 x 14,4 = 1014,2 W

Cooling - Heat transfer part

$CF_{W1east} = U_{W1east} \times (\Delta T_{cooling} – 0.46 \times DR)$

= 2,84 (7,9 − 0,46 x 11,9) = 6,9 W/m^2

Cooling - Irradiation part

E_D = 559

E_d= 188

East window of a detached house - FFS = 0.31

SHGC= 0.54

$PXI_{W1east} = E_D + E_d$

= 559 + 188 = 747

$CF_{W1east} = PXI \times SHGC \times IAC \times FF_s$

= 747 X 0.54 X 1 X 0.31=125.1

$CF_{fenestration1east}= U_{w1east} \times (\Delta T_{cooling} – 0.46 \times DR) + PXI \times SHGC \times IAC \times FF_s$

= 6.9 +125.1 =132 W/m^2

$\dot{Q}_{w1east} = CF_{fenestration1east} \times A_{W1east}$

= 132 X 14.4 = 1900.8 W

ALUMINIUM FRAME - WINDOW 1 : A_{W1east}= 14,4 m^2

Heating
$HF_{w1east}= U_{W1east} \times \Delta T_{cooling}$
= 3.61 X 24.8 = 89.52 W/m2

$Q_{w1east}= HF_{W1east} \times A_{W1east}$
= 89.52 X 14.4 = 1289.1 W

Cooling - Heat transfer part

$CF_{W1east} = U_{W1east} \times (\Delta T_{cooling} – 0.46 \times DR)$

= 3.61 (7.9 − 0.46 x 11.9) = 8.7 W/m^2

Cooling - Irradiation part

E_D = 559

E_d= 188

East window of a detached house - FFS = 0.31

SHGC= 0.56

$PXI_{W1east} = E_D + E_d$

= 559 + 188 = 747

$CF_{W1east} = PXI \times SHGC \times IAC \times FF_s$

= 747 X 0.56 X 1 X 0.31=129.6

$CF_{fenestration1east}= U_{w1east} \times (\Delta T_{cooling} – 0.46 \times DR) + PXI \times SHGC \times IAC \times FF_s$

= 8.7 +129.6 =138.3 W/m^2

$\dot{Q}_{w1east} = CF_{fenestration1east} \times A_{W1east}$

= 138.3 X 14.4 = 1991.5 W

WOOD FRAME - WINDOW 2 : $A_{W2south}$= 3.6 m^2

Heating

$HF_{W2south} = U_{W2south} \times \Delta T_{cooling}$

= 2.84 x 24.8 = 70.44 W/m2

$Q_{W2south} = HF_{W2south} \times A_{W2south}$

= 70.44 x 3.6 = 253.6 W

Cooling - Heat transfer part

$CF_{W2south} = U_{W2south} \times (\Delta T_{cooling} - 0.46 \times DR)$

= 2,84 (7,9 − 0,46 x 11,9) = 6,9 W/m^2

Cooling - Irradiation part

E_D = 348

E_d= 209

South window of a detached house - FFS = 0.31

SHGC= 0.54

$PXI_{W2south} = E_D + E_d$

= 348 + 209 = 557

$CF_{W2south}$ = PXI X SHGC X IAC X FF_s

= 557 X 0.54 X 1 X 0.47 = 141.4

$CF_{fenestration1east}$= $U_{W2south}$ X ($\Delta T_{cooling}$ – 0.46 X DR) +PXI X SHGC X IAC X FF_s

= 6.9 + 141.4 =148.3 W/m^2

$\dot{Q}_{W2south} = CF_{fenestration1east}$ X $A_{W2south}$

= 148.3 X 3.6 = 533.88 W

ALUMINIUM FRAME - WINDOW 2 : $A_{W2south}$= 3.6 m^2

Heating

$HF_{W2south} = U_{W2south} \times \Delta T_{cooling}$

= 3.61 x 24.8 = 89.52 W/m2

$Q_{W2south} = HF_{W2south} \times A_{W2south}$

= 89.52 x 3.6 = 322.2 W

Cooling - Heat transfer part

$CF_{W2south} = U_{W2south} \times (\Delta T_{cooling} - 0.46 \times DR)$

= 3.61 (7,9 − 0,46 x 11,9) = 8.7 W/m^2

Cooling - Irradiation part

E_D = 348

E_d= 209

South window of a detached house - FFS = 0.47

SHGC= 0.56

$PXI_{W2south} = E_D + E_d$

= 348 + 209 = 557

$CF_{W2south}$ = PXI X SHGC X IAC X FF_s

= 557 X 0.56 X 1 X 0.47 = 146.6

$CF_{fenestration1east}$= $U_{W2south}$ X ($\Delta T_{cooling}$ – 0.46 X DR) +PXI X SHGC X IAC X FF_s

= 8.7 + 146.6 = 155.3 W/m^2

$\dot{Q}_{W2south} = CF_{fenestration1east}$ X $A_{W2south}$

= 155.3 X 3.6 = 559.08 W

WOOD FRAME - WINDOW 3 : $A_{W3south}$= 3.6 m^2

Heating

$HF_{W3south} = U_{W3south} \times \Delta T_{cooling}$

= 2.87 x 24.8 = 71.17 W/m2

$Q_{W3south} = HF_{W3south} \times A_{W3south}$

= 71.17 x 3.6 = 256.2 W

Cooling - Heat transfer part

$CF_{W3south} = U_{W3south} \times (\Delta T_{cooling} - 0.46 \times DR)$

ALUMINIUM FRAME - WINDOW 3 : $A_{W3south}$= 3.6 m^2

Heating

$HF_{W3south} = U_{W3south} \times \Delta T_{cooling}$

= 4.62 x 24.8 = 114.57 W/m2

$Q_{W3south} = HF_{W3south} \times A_{W3south}$

= 114.57 x 3.6 = 412.4 W

Cooling - Heat transfer part

$CF_{W3south} = U_{W3south} \times (\Delta T_{cooling} - 0.46 \times DR)$

= 2,87 (7,9 − 0,46 x 11,9) = 6,96 W/m^2

Cooling - Irradiation part

E_D = 348

E_d= 209

South window of a detached house - FFS = 0.47

SHGC= 0.46

$PXI_{W3south} = E_D + E_d$

= 348 + 209 = 557

$CF_{W3south}$ = PXI X SHGC X IAC X FF_s

= 557 X 0.46 X 1 X 0.47 = 120.4

$CF_{fenestration1east}$= $U_{W3south}$ X ($\Delta T_{cooling}$ – 0.46 X DR) +PXI X SHGC X IAC X FF_s

= 6.9 + 120.4 =127.3 W/m^2

$\dot{Q}_{W3south}$ = $CF_{fenestration1east}$ X $A_{W3south}$

= 127.3 X 3.6 = 458.28 W

$\dot{Q}$ Total windows Heating wood frame

= 1014.2+253.6+256.2 = 1524 W

$\dot{Q}$ Total windows Cooling wood frame

= 1900.8 + 533.88 + 458.28 = 2892.96 W

= 4.62 (7,9 − 0,46 x 11,9) = 11.2 W/m^2

Cooling - Irradiation part

E_D = 348

E_d= 209

South window of a detached house - FFS = 0.47

SHGC= 0.55

$PXI_{W3south} = E_D + E_d$

= 348 + 209 = 557

$CF_{W3south}$ = PXI X SHGC X IAC X FF_s

= 557 X 0.55 X 1 X 0.47 = 143.95

$CF_{fenestration1east}$= $U_{W3south}$ X ($\Delta T_{cooling}$ – 0.46 X DR) +PXI X SHGC X IAC X FF_s

= 11.2 + 143.98 = 155.18 W/m^2

$\dot{Q}_{W3south}$ = $CF_{fenestration1east}$ X $A_{W3south}$

= 155.18 X 3.6 = 558.65 W

$\dot{Q}$ Total windows Heating Aluminium frame

= 1289.1 + 1289.1 + 322.2 + 412.4 = 2023.7 W

$\dot{Q}$ Total windows Cooling Aluminium frame

= 1991.5 + 3498.6 + 559.08 + 558.65 = 3109.2 W

$Q_{\text{Total windows Heating Aluminium frame}}$ (2023.7 W) > $Q_{\text{Total windows Heating wood frame}}$ (1524 W)

$Q_{\text{Total windows Cooling Aluminium frame}}$ (3109.2 W) > $Q_{\text{Total windows Cooling wood frame}}$ (2892.96 W)