**#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 thickenss to be 13 mm)

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 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 ?

**Answers:**

**Task 1**

Answer:

From the diagram we can see that:

For double-pane (13mm) glazing:

$U_{air} = 2.8 \frac{w}{m^2} \cdot K$

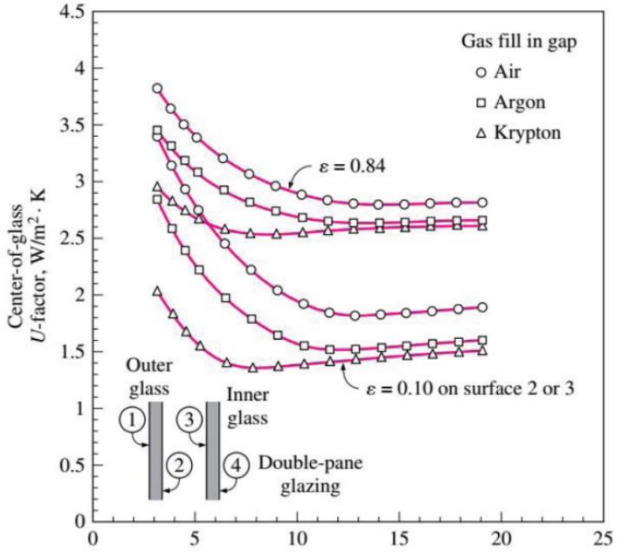
$U_{argon} = 2.7 \frac{w}{m^2} \cdot K$

$U_{krypton} = 2.6\ w/m^2 \cdot K$

So, when the gas is changing

Air → Argon: decrease about 4.57%

Air → Krypton: decrease about 7.14%

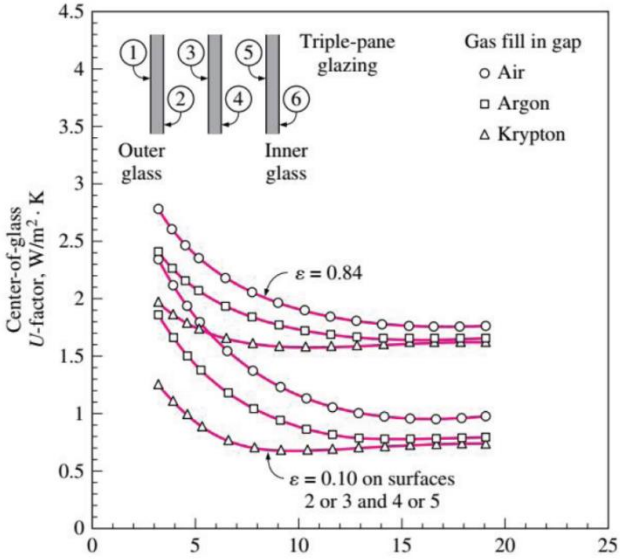



For triple-pane (13mm) glazing:

$U_{double} = 2.8\ w/m^2 \cdot K$

$U_{triple} = 1.8\ w/m^2 \cdot K$

So, when changing double-pane to triple-pane the U value will decrease about 35.71%




When the glass surfaces are coated with a film that has an emissivity of 0.1,

$U\_double0.1 = 1.8\ w/m^2 \cdot K$

$U\_triple0.1 = 1\ w/m^2 \cdot K$

So, when coating a film that has an emissivity of 0.1, the U value of double-pane decrease

about 35.71%, the U value of double-pane decrease about 44.44%.

## Task 2

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% | 99.6% DP | 99.6% HR | 99.6% MCDB | 99% DP | 99% HR | 99% MCDB | 0.4% WS | 0.4% MCDB | 1% WS | 1% 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 0.4% DB | 0.4% MCWB | 1% DB | 1% MCWB | 2% DB | 2% MCWB | Evaporation WB/MCDB 0.4% WB | 0.4% MCDB | 1% WB | 1% MCDB | 2% WB | 2% MCDB | MCWS/PCWD to 0.4% DB 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)

**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 |

| Glazing Type | Glazing Layers | ID[b] | Property[c,d] | Center of Glazing | Frame: Operable Aluminum | Operable Aluminum with Thermal Break | Operable Reinforced Vinyl/Aluminum Clad Wood | Operable Wood/Vinyl | Operable Insulated Fiberglass/Vinyl | Fixed Aluminum | Fixed Aluminum with Thermal Break | Fixed Reinforced Vinyl/Aluminum Clad Wood | Fixed Wood/Vinyl | Fixed 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 |

$$q_{fen} = A \times \mathrm{CF}_{fen}$$

$$\mathrm{CF}_{fen} = U(\Delta t - 0.46\,\mathrm{DR}) + \mathrm{PXI} \times \mathrm{SHGC} \times \mathrm{IAC} \times \mathrm{FF}_s$$

*where*

$q_{fen}$ = fenestration cooling load, W
$A$ = fenestration area (including frame), $m^2$
$\mathrm{CF}_{fen}$ = surface cooling factor, $W/m^2$
$U$ = fenestration NFRC *heating* U-factor, $W/(m^2 \cdot K)$
$\Delta t$ = cooling design temperature difference, K
PXI = peak exterior irradiance, including shading modifications, $W/m^2$ [see Equations (26) or (27)]
SHGC = fenestration rated or estimated NFRC solar heat gain coefficient
IAC = interior shading attenuation coefficient, Equation (29)
$\mathrm{FF}_s$ = fenestration solar load factor, Table 13

$\Delta T_{cooling} = 31.9 - 24 = 7.9℃$
$\Delta T_{heating} = 20 - (-4.8) = 24.8℃$
DR=11.9℃

**Wood Frames**

**Window1 (east, wood frame, fixed)**

$$A_{window1} = 14.4\ m^2$$

Heating:

$$U_{window1} = 2.84 \frac{w}{m^2} \cdot K$$

$$HF_{window1} = U_{window1} * \Delta T_{cooling} = 2.84 * 24.8 = 70.44\ w/m^2$$

$$Q_{window1} = HF_{window1} * A_{window} = 70.44 * 14.4 = 1014.2w$$

Cooling:

Heat transfer:

$$CF_{window1} = U_{window1(\Delta T_{cooling} - 0.46 * DR)} = 2.84(7.9 - 0.46 * 11.9) = 6.9w/m^2$$

Irradiation:

$$E_D = 559,\ \ E_d = 188,\ \ \ FF_{seast} = 0.31$$

$$PXI_{window1} = E_D + E_d = 559 + 188 = 747$$

$$CF_{window1} = PXI * SHGC * IAC * FF_{Seast} = 747 * 0.54 * 1 * 0.31 = 125.1$$

$$CF_{fenestration1} = U_{window1}(\Delta T cooling - 0.46 * DR) + PXI * SHGC * IAC * FF_{Seast}$$

$$= 6.9 + 125.1 = 132\ W/m^2$$

$$\dot{Q}_{window1} = CF_{fenestration1} * A_{window1} = 132 * 14.4 = 1900.8w$$

**Window2 (west, wood frame, fixed)**

$$\mathrm{A}_{\mathrm{window2}} = 14.4\ m^2$$

Heating:

U_window2=2.84 w/㎡·K

$$HF_{window2} = U_{window2} * \Delta T_{cooling} = 2.84 * 24.8 = 70.44\ w/㎡$$

$$Q_{window2} = HF_{window2} * A_{window} = 70.44 * 14.4 = 1014.2w$$

Cooling:

Heat transfer:

$$CF_{window}2 = U_{window}2(\Delta T\_cooling - 0.46 * DR)\ = 2.84(7.9 - 0.46 * 11.9) = 6.9w/㎡$$

Irradiation:

$$E_D = 559,\ \ E_d = 188,\ \ FF_{swest} = 0.56$$

$$PXI_{window1} = E_D + E_d = 559 + 188 = 747$$

$$CF\_window2 = PXI * SHGC * IAC * FF\_Swest = 747 * 0.54 * 1 * 0.56 = 225.9$$

$$CF\_fenestration2 = U\_window2\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF\_Swest$$

$$= 6.9 + 225.9 = 232.8\ W/㎡$$

$$\dot{Q}_{window2} = CF_{fenestration2} * A_{window2} = 232.8 * 14.4 = 3352.32w$$

**Window3 (south, wood frame, fixed)**

$$\mathrm{A_{window3}} = 3.6\ ㎡$$

Heating:

$$U_{window3} = 2.84\ w/㎡ \cdot K$$

$$HF_{window3} = U_{window3} * \Delta T_{cooling} = 2.84 * 24.8 = 70.44\ w/㎡$$

$$Q_{window3} = HF_{window3} * A_{window} = 70.44 * 3.6 = 253.6w$$

Cooling:

Heat transfer:

$$CF_{window3} = U_{window3}(\Delta T\_cooling - 0.46 * DR)\ = 2.84(7.9 - 0.46 * 11.9) = 6.9w/㎡$$

Irradiation:

$$E_D = 348,\ \ E_d = 209,\ \ FF_{ssouth} = 0.47$$

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

$$CF_{window3} = PXI * SHGC * IAC * FF\_ssouth = 557 * 0.54 * 1 * 0.47 = 141.4$$

$$CF_{fenestration3} = U_{window3}\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF_{ssouth}$$

$$= 6.9 + 141.4 = 148.3\ W/㎡$$

$$\dot{Q}_{window3} = CF_{fenestration3} * A_{window3} = 148.3 * 3.6 = 533.88w$$

**Window4 (south, wood frame, openable)**

$$\mathrm{A_{window3}} = 3.6\ ㎡$$

Heating:

$$U_{window4} = 2.87\ w/m^2 \cdot K$$

$$HF_{window4} = U_{window4} * \Delta T_{cooling} = 2.87 * 24.8 = 71.17\ w/m^2$$

$$Q_{window4} = HF_{window4} * A_{window} = 71.17 * 3.6 = 256.2w$$

Cooling:

Heat transfer:

$$CF_{window4} = U_{window4}(\Delta T_{cooling} - 0.46 * DR) = 2.87(7.9 - 0.46 * 11.9) = 6.96w/m^2$$

Irradiation:

$$E_D = 348, \quad E_d = 209, \quad SHGC = 0.46, \quad FF_{ssouth} = 0.47$$

$$PXI_{window4} = E_D + E_d = 348 + 209 = 557$$

$$CF_{window4} = PXI * SHGC * IAC * FF_{ssouth} = 557 * 0.46 * 1 * 0.47 = 120.4$$

$$CF_{fenestration4} = U_{window4}\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF_{ssouth}$$

$$= 6.9 + 120.4 = 127.3\ W/m^2$$

$$\dot{Q}_{window4} = CF_{fenestration4} * A_{window4} = 127.3 * 3.6 = 458.28w$$

$$\dot{Q}_{totalcoolingwood} = 1900.8 + 3352.32 + 533.88 + 458.28 = 6245.3w$$

$$\dot{Q}_{totalheatingwood} = 1014.2 + 1014.2 + 253.6 + 256.2 = 2538.2w$$

## Aluminum Frames

**Window1 (south, aluminum frame, fixed)**

Heating:

$$U_{window1} = 3.61\ w/m^2 \cdot K$$

$$HF_{window1} = U_{window1} * \Delta T_{cooling} = 3.61 * 24.8 = 89.52\ w/m^2$$

$$Q_{window1} = HF_{window1} * A_{window} = 89.52 * 14.4 = 1289.1w$$

Cooling:

Heat transfer:

$$CF_{window1} = U_{window1}(\Delta T_{cooling} - 0.46 * DR) = 3.61(7.9 - 0.46 * 11.9) = 8.7w/m^2$$

Irradiation:

$$E_D = 559, \quad E_d = 188, \quad SHGC = 0.56, \quad FF_{seast} = 0.31$$

$$PXI_{window1} = E_D + E_d = 559 + 188 = 747$$

$$CF_{window1} = PXI * SHGC * IAC * FF_{seast} = 747 * 0.56 * 1 * 0.31 = 129.6$$

$$CF_{fenestration1} = U_{window1}\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF_{seast}$$

$$= 8.7 + 129.6 = 138.3\ W/m^2$$

$$\dot{Q}_{window1} = CF_{fenestration1} * A_{window1} = 138.3 * 14.4 = 1991.5w$$

**Window2 (west, aluminum frame, fixed)**

$$\mathrm{A_{window2}} = 14.4\ m^2$$

Heating:

$$U_{window2} = 3.61\ w/㎡ \cdot K$$

$$HF_{window2} = U_{window2} * \Delta T_{cooling} = 3.61 * 24.8 = 89.52\ w/㎡$$

$$Q_{window2} = HF_{window2} * A_{window} = 59.52 * 14.4 = 1289.1w$$

Cooling:

Heat transfer:

$$CF_{window}2 = U_{window}2(\Delta T\_cooling - 0.46 * DR) = 3.61(7.9 - 0.46 * 11.9) = 8.7w/㎡$$

Irradiation:

$$E_D = 559,\ \ E_d = 188,\ \ FF_{swest} = 0.56$$

$$PXI_{window1} = E_D + E_d = 559 + 188 = 747$$

$$CF\_window2 = PXI * SHGC * IAC * FF\_Swest = 747 * 0.56 * 1 * 0.56 = 234.26$$

$$CF\_fenestration2 = U\_window2\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF\_Swest$$

$$= 8.7 + 234.26 = 242.96\ W/㎡$$

$$\dot{Q}_{window2} = CF_{fenestration2} * A_{window2} = 242.96 * 14.4 = 3498.6w$$

**Window3 (south, aluminum frame, fixed)**

$$\mathrm{A_{window3}} = 3.6\ ㎡$$

Heating:

$$U_{window3} = 3.61\ w/㎡ \cdot K$$

$$HF_{window3} = U_{window3} * \Delta T_{cooling} = 3.61 * 24.8 = 89.52\ w/㎡$$

$$Q_{window3} = HF_{window3} * A_{window} = 89.52 * 3.6 = 322.2w$$

Cooling:

Heat transfer:

$$CF_{window3} = U_{window3}(\Delta T\_cooling - 0.46 * DR) = 3.61(7.9 - 0.46 * 11.9) = 8.7w/㎡$$

Irradiation:

$$E_D = 348,\ \ E_d = 209,\ \ FF_{ssouth} = 0.47$$

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

$$CF_{window3} = PXI * SHGC * IAC * FF\_ssouth = 557 * 0.56 * 1 * 0.47 = 146.6$$

$$CF_{fenestration3} = U_{window3}\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF_{ssouth}$$

$$= 8.7 + 146.6 = 155.3\ W/㎡$$

$$\dot{Q}_{window3} = CF_{fenestration3} * A_{window3} = 155.3 * 3.6 = 559.08w$$

**Window4 (south, aluminum frame, openable)**

$$\mathrm{A_{window3}} = 3.6\ ㎡$$

Heating:

$$U_{window4} = 4.62\ w/m^2 \cdot K$$

$$HF_{window4} = U_{window4} * \Delta T_{cooling} = 4.62 * 24.8 = 114.57\ w/m^2$$

$$Q_{window4} = HF_{window4} * A_{window} = 114.57 * 3.6 = 412.4w$$

Cooling:

Heat transfer:

$$CF_{window4} = U_{window4}(\Delta T_{cooling} - 0.46 * DR) = 4.62(7.9 - 0.46 * 11.9) = 11.2w/m^2$$

Irradiation:

$$E_D = 348,\quad E_d = 209,\quad SHGC = 0.55,\quad FF_{ssouth} = 0.47$$

$$PXI_{window4} = E_D + E_d = 348 + 209 = 557$$

$$CF_{window4} = PXI * SHGC * IAC * FF_{ssouth} = 557 * 0.55 * 1 * 0.47 = 143.98$$

$$CF_{fenestration4} = U_{window4}\ (\Delta Tcooling - 0.46 * DR) + PXI * SHGC * IAC * FF_{ssouth}$$

$$= 11.2 + 143.98 = 155.18W/m^2$$

$$\dot{Q}_{window4} = CF_{fenestration4} * A_{window4} = 155.18 * 3.6 = 558.65w$$

$$\dot{Q}_{totalcoolingaluminum} = 1991.5 + 3498.6 + 559.08 + 558.65 = 6607.8w$$

$$\dot{Q}_{totalheatingaluminum} = 1289.1 + 1289.1 + 322.2 + 412.4 = 3312.8w$$

$$\frac{\dot{Q}_{totalcoolingwood}}{\dot{Q}_{totalcoolingaluminum}} = \frac{6245.3}{6607.8} = 94.5\%$$

$$\frac{\dot{Q}_{totalheatingwood}}{\dot{Q}_{totalheatingaluminum}} = \frac{2538.2}{3312.8} = 76.6\%$$

**Conclusion:**

It can be seen that window with wooden frame has better resistance in cooling and heating, aluminum frame window has 94.5% cooling and 76.6% heating resistance of a wooden one.