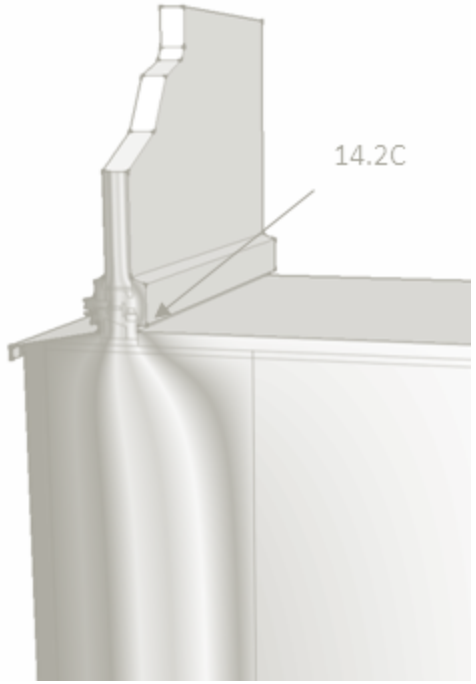
The Influence of a Window's Position in a Wall on the Window's U-value

A Case Study With
Software Modelling



Window U-value – Installed and Uninstalled

- The way in which a window is installed has an influence on overall heat loss, as its installation can form a thermal bridge
- This becomes more important in highly insulated buildings, as a percentage of overall heat loss
- To account for this, the Passive House Institute (PHI) distinguishes between U-values for installed and uninstalled windows
- The U-value of the installed window is calculated with the help of the Linear Thermal Transmittance (Ψi - Psi installation) value. Ψi can be imagined as a correction factor
- The U-value for an installed window is usually higher than for an uninstalled window

What is the significance?

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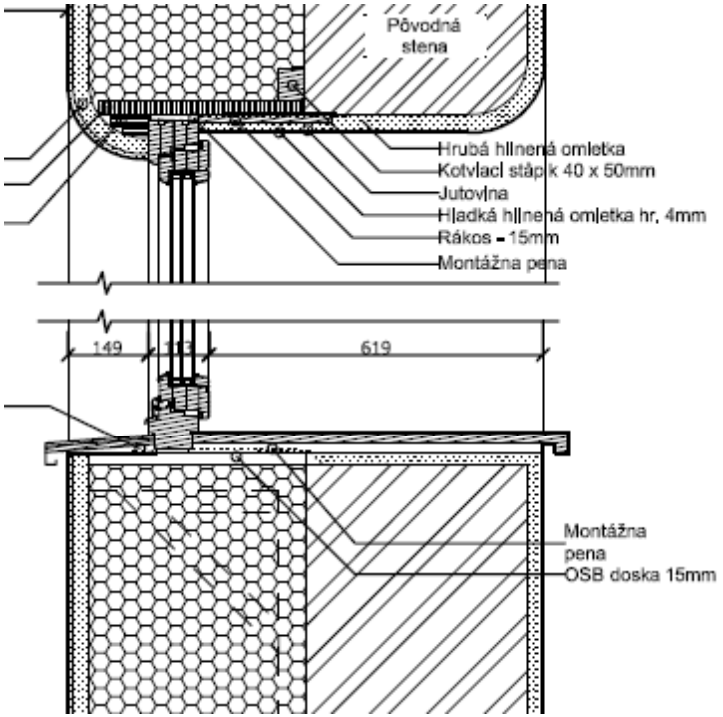
Modelled Detail

Straw-bale wrap renovation by
Createrra studio,
Brestovec, Slovakia

Author of the design
Ing. Arch. Daniel Marinica

From Marian Ontkoc



From Marian Ontkoc

Window in an OSB box

Modelled Scenarios

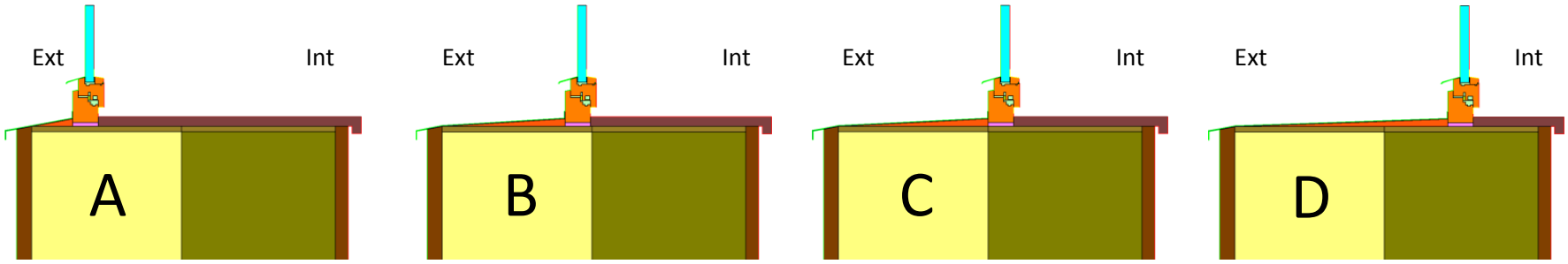
The difference between four methods of window installation:

A - Window in the middle of insulation

B - Window at the inner edge of insulation

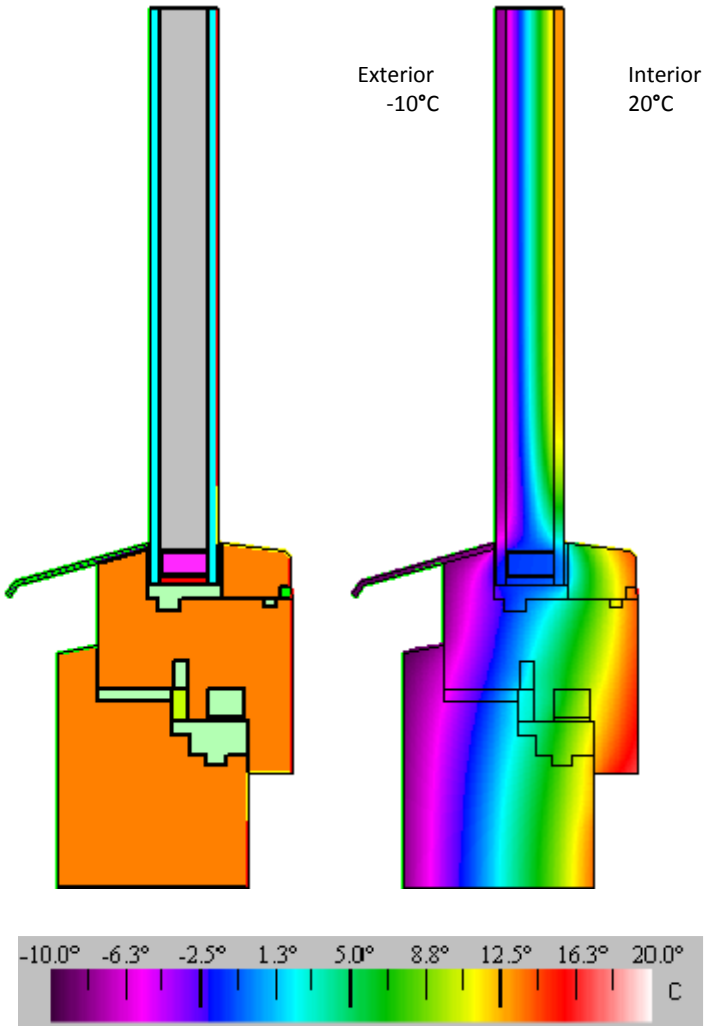
C - Window at the outer edge of masonry

D - Window in the middle of masonry



Simulation software - THERM 6.3 and WINDOW 6.3 software packages from LBLN

Sample Window



Window

- double glazed
- low-emissivity
- wooden frame
- size 1.23 x 1.48 m

Uw = 1.816 W/m^2K

Ug = 1.78 W/m^2K

Uf = 1.36 W/m^2K

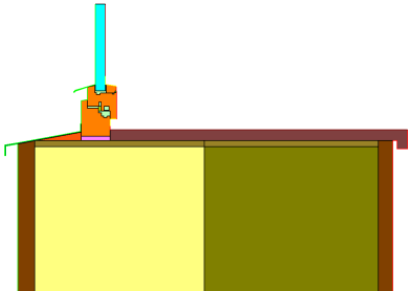
Ψg = 0.083 W/mK

Spacer – generic Al product

The window was modeled following the ISO EN 10077 & EN 673 method ; adaptation – external temperature = -10°C as per the PHI

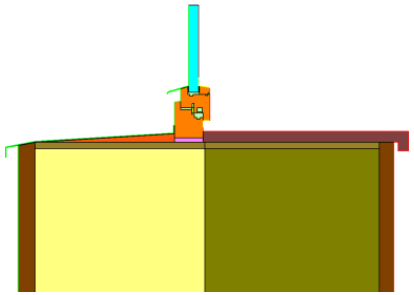
Materials and Simulation Conditions

A



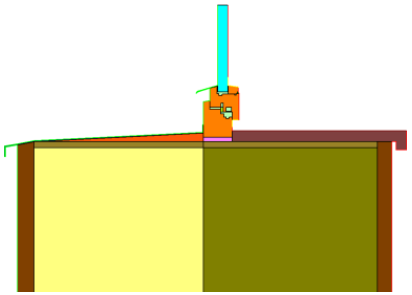
Window in the middle of insulation

B



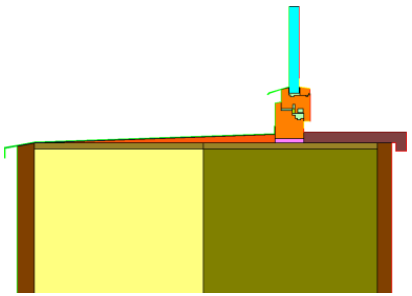
Window at the inner edge of insulation

C



Window at the outer edge of masonry

D



Window in the middle of masonry

Material	λ[W/(m·K)]
Brick work 0.77	0.770
Compriband 0.048	0.048
EPDM 0.25	0.250
Earth plaster 0.95	0.950
Harwood (Oak, Maple) 0.16	0.160
OSB 0.13	0.130
Spurce 0.13	0.130
Straw perp 0.052	0.052
Window plate 0.035	0.035

Boundary conditions

Temperature external -10°C
Temperature internal 20°C

Rse = 0.04 W/m^2K
Rsi = 0.13 W/m^2K
Rsi up = 0.10 W/m^2K*
Rsi down = 0.17 W/m^2K*
Rsi increased = 0.20 W/m^2K as per the ISO 10077-2 2012

NOTE – for the purpose of the Ψi calculation, the glazing was replaced with an insulation panel with λ = 0.035W/m^2K. This has no influence the Ψi value.

* Including the head and jambs calculations

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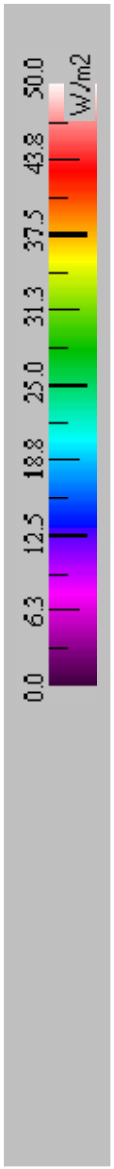
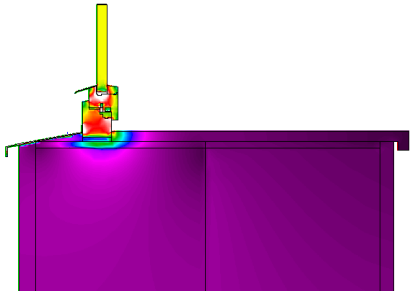
Simulation – Heat Flux

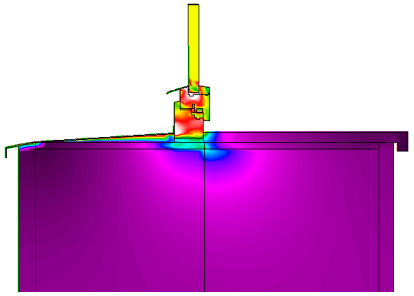


A



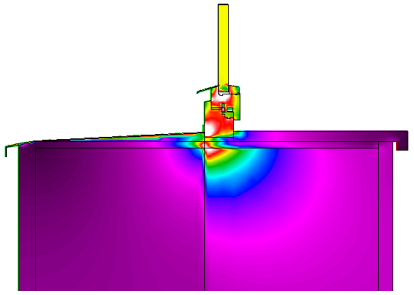
Window in the middle of insulation

B



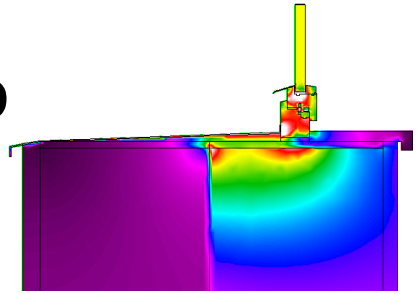
Window at the inner edge of insulation

C



Window at the outer edge of masonry

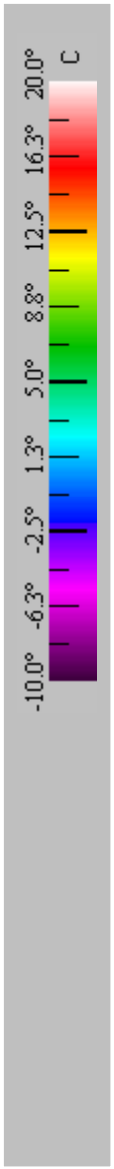
D

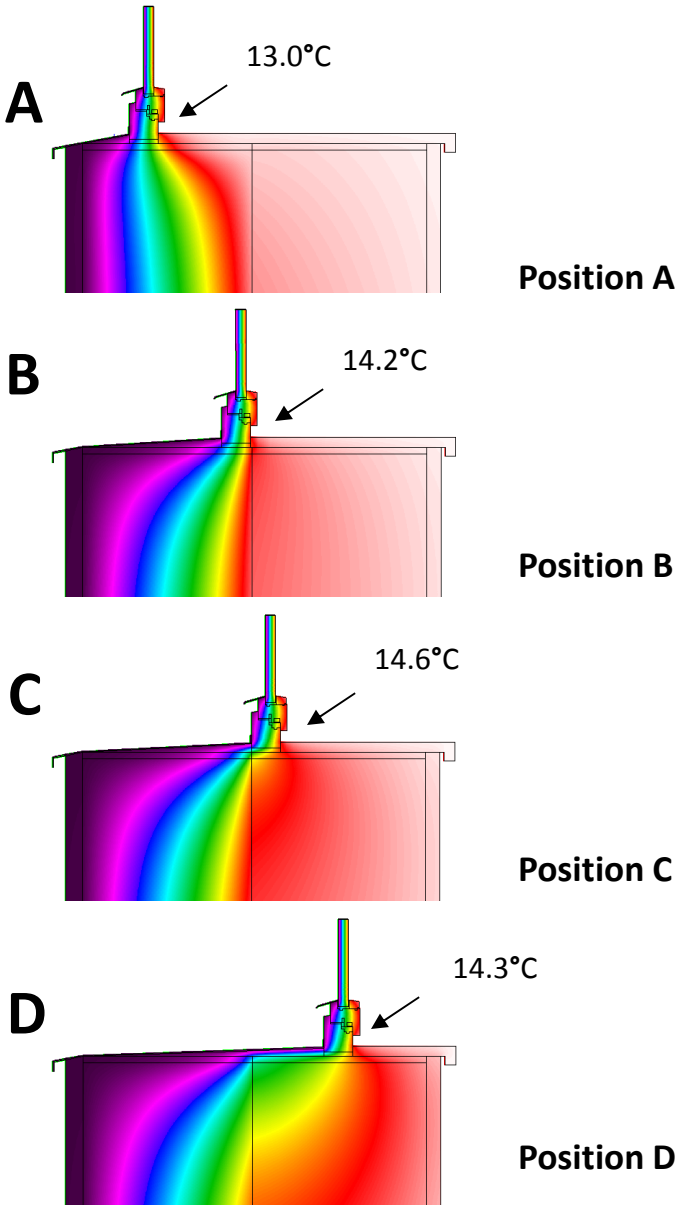


Window in the middle of masonry

Heat Flux at ΔT = 30°C

Simulation – Junction Surface Temperature





External temperature = -10°C
Internal temperature = 20°C

Surface temperatures are useful for the assessment of comfort and hygiene requirements

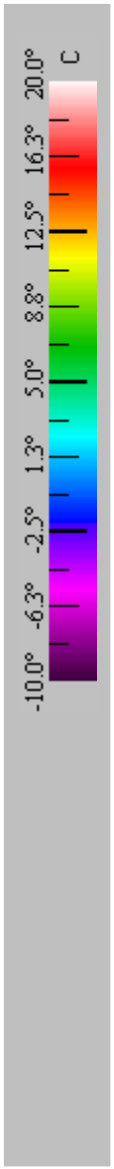
The minimum permissible internal surface temperatures are country dependant. Check national guidelines for values

Boundary conditions for the assessment of the junction surface temperatures*

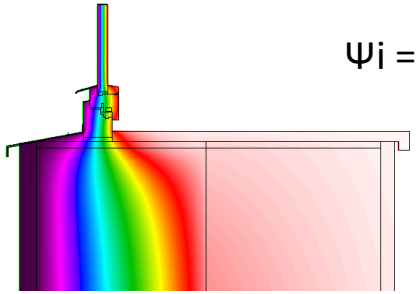
Rse = 0.04 W/m^2K
Rsi horizontal = 0.13 W/m^2K
Rsi down = 0.17 W/m^2K
Rsi increased = 0.20 W/m^2K as per the ISO 10077-2 2012

* Boundary conditions for the assessment of surface temperatures as per the BR497

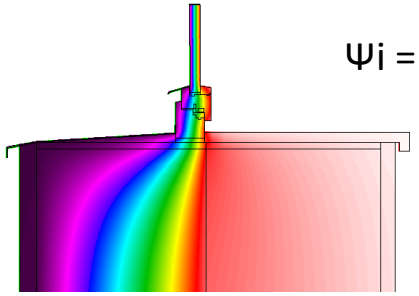
Simulation – Ψi-value



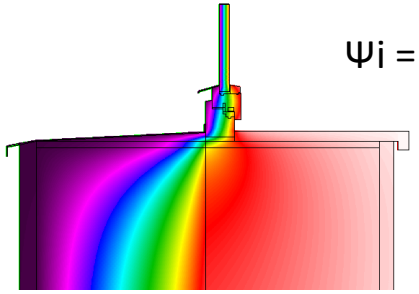
A Ψi = 0.029W/mK



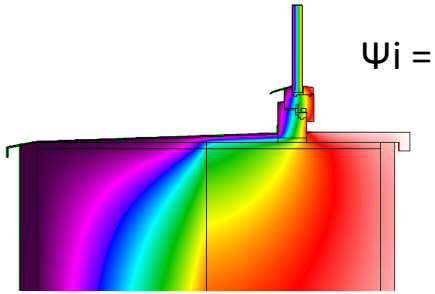
B Ψi = 0.046W/mK



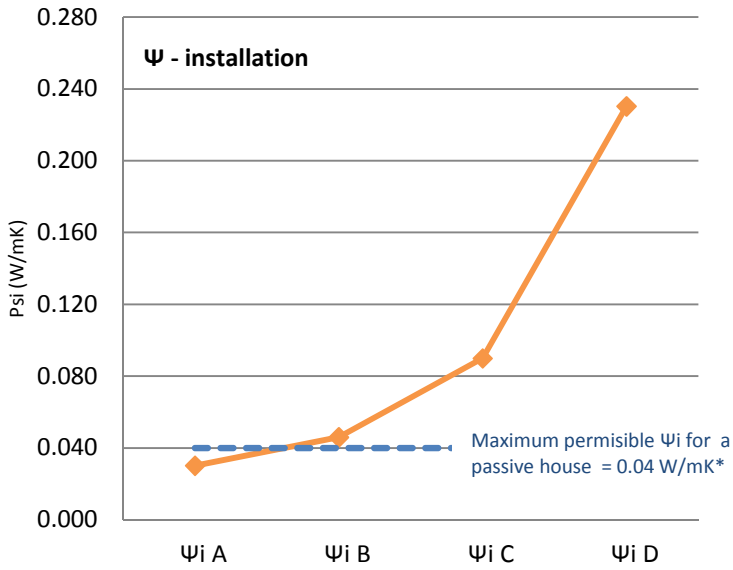
C Ψi = 0.091W/mK



D Ψi = 0.231W/mK



Ψi-value tells us how much heat flows through the window / wall junction:



A Window in the middle of insulation

B Window at the inner edge of insulation

C Window at the outer edge of masonry

D Window in the middle of masonry

* NOTE – the comparison is indicative only
The Ψi changes with the window frame U-value

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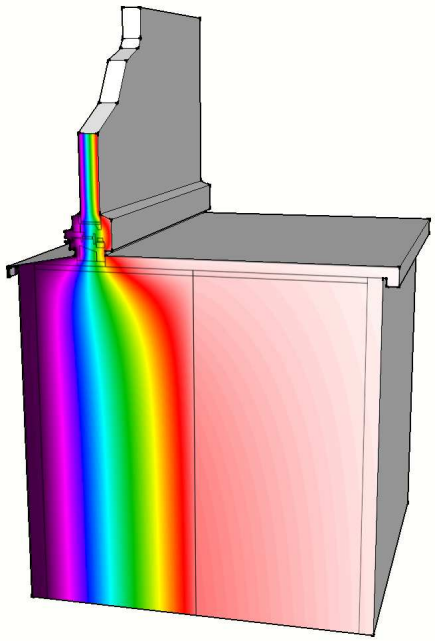
U-value of the Installed Window

Calculation of the window U-value in an installed condition

$$U_{w,\,installed} = \frac{U_w A_w + \sum l_i \Psi_i}{A_w} \quad *$$



Calculation assumptions

- Window size 1.23 x 1.48 m
- Window jambs and head fitted in the same way as sill

	Uw	**Aw**	**li**	**Ψi****	**Uw,i**	**Increase**
	W/m^2K	m^2	m	W/mK	W/m^2K	%
Uninst	1.816	1.820	-	-	**1.816**	-
Case A	1.816	1.820	5.420	0.029	**1.904**	5
Case B	1.816	1.820	5.420	0.045	**1.951**	7
Case C	1.816	1.820	5.420	0.089	**2.082**	15
Case C	1.816	1.820	5.420	0.230	**2.500**	38

* For details of the calculation see the *Certification criteria for Certified Passive House Glazing and Transparent Components* Available from http://passiv.de/downloads/03_certification_criteria_transparent_components_en.pdf

** Averaged value for the sill, head and jambs

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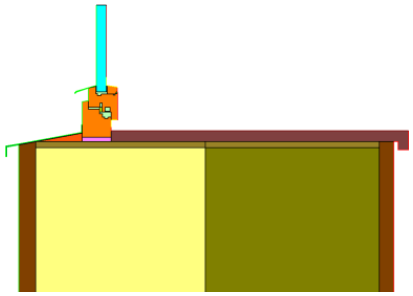
U-value of the Installed Window – Four Scenarios

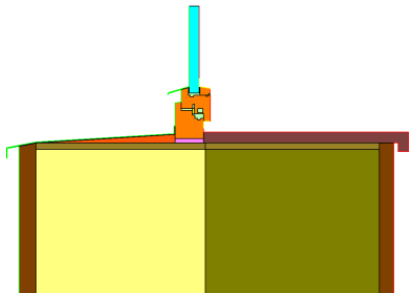
A



Uw,i = 1.90 W/m^2K

Increase 5%

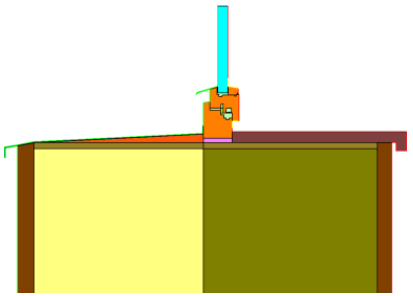
B



Uw,i = 1.95 W/m^2K

Increase 7%

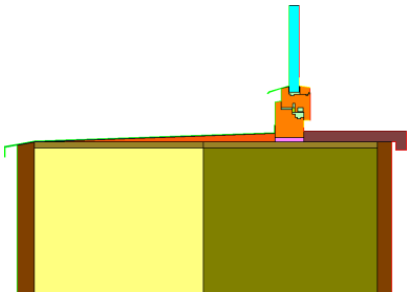
C



Uw,i = 2.08 W/m^2K

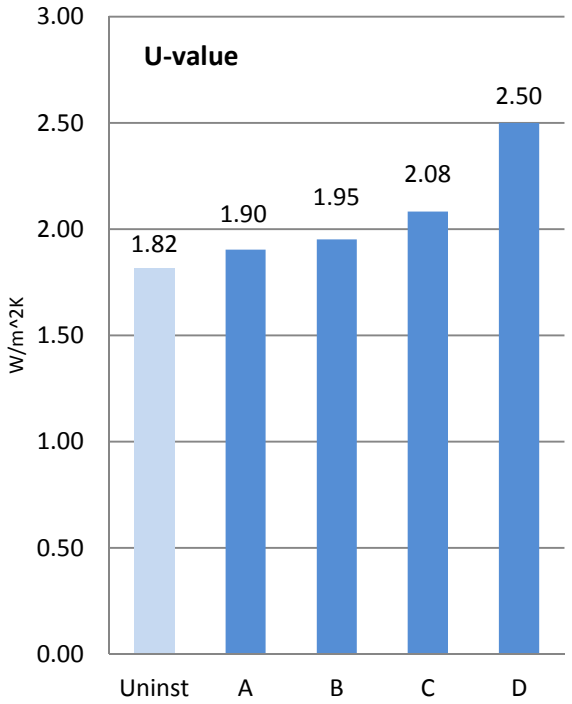
Increase 15%

D



Uw,i = 2.50 W/m^2K

Increase 38%



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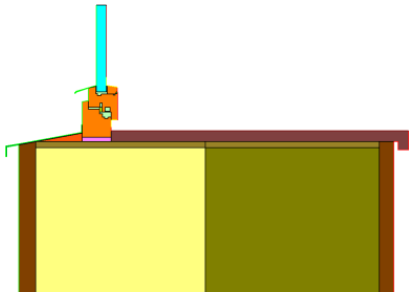
U-value of the Installed Window – Wider Context

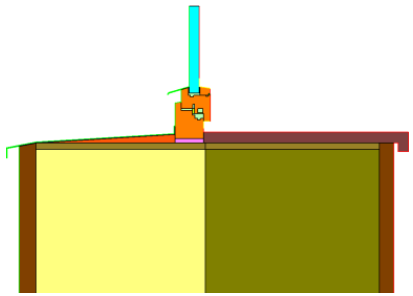
A



Uw,i = 1.90 W/m^2K

Increase 5%

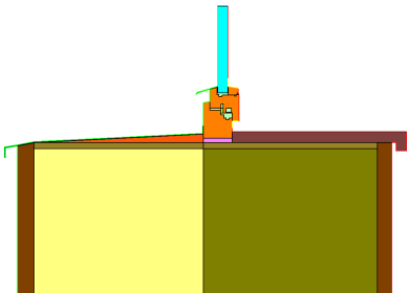
B



Uw,i = 1.95 W/m^2K

Increase 7%

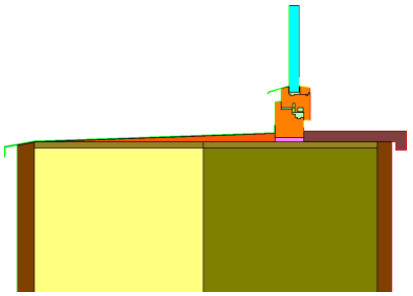
C



Uw,i = 2.08 W/m^2K

Increase 15%

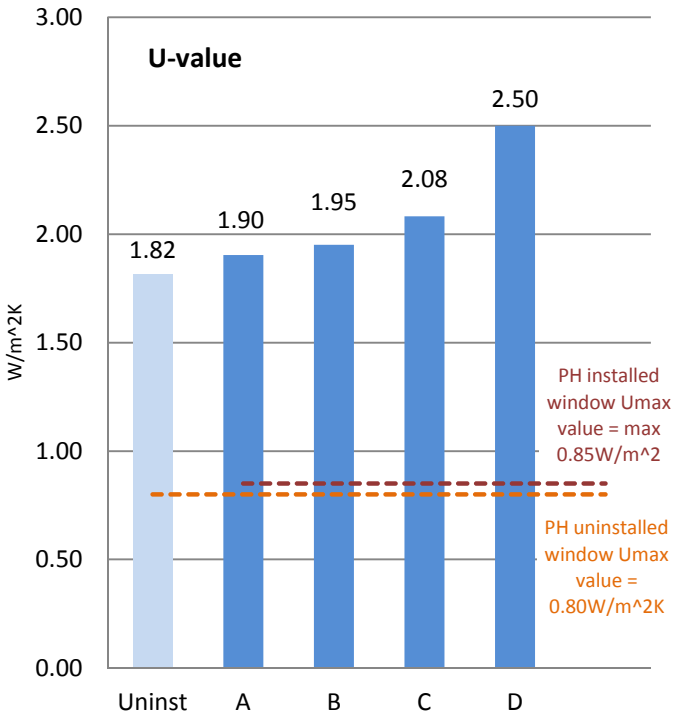
D



Uw,i = 2.50 W/m^2K

Increase 38%

How far are we from a Passive House?



PHI criteria for U-values of an installed and uninstalled window *:

Uw = max 0.80 W/m^2K

Uw,i = max 0.85 W/m^2K

* For details see the *Window Frame Certification Schedule (PHI)*, Available from http://www.passiv.de/old/07_eng/03_cert/Komp/Anford_e/F_Anfor_e/F_Roadmap.pdf

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Conclusions and Future Work

- The position of the window in the wall can make a significant difference to the installed window U-value
- From the thermal performance point of view, windows should be placed in the insulation layer
- Higher $\Psi_{installation}$ value does not necessarily mean lower surface temperature of the junction
- With decrease in the window U-value, the importance of a good installation increases. What would the situation be for a high performance (i.e. PHI certified) window?
- Next to improving performance from thermal point of view, it can be assumed that with the window being closer to the external face of the wall, there is less water entering the wall. This can further improve the real world performance. The significance could be assessed by a hygrothermal simulation (i.e. WUFI)

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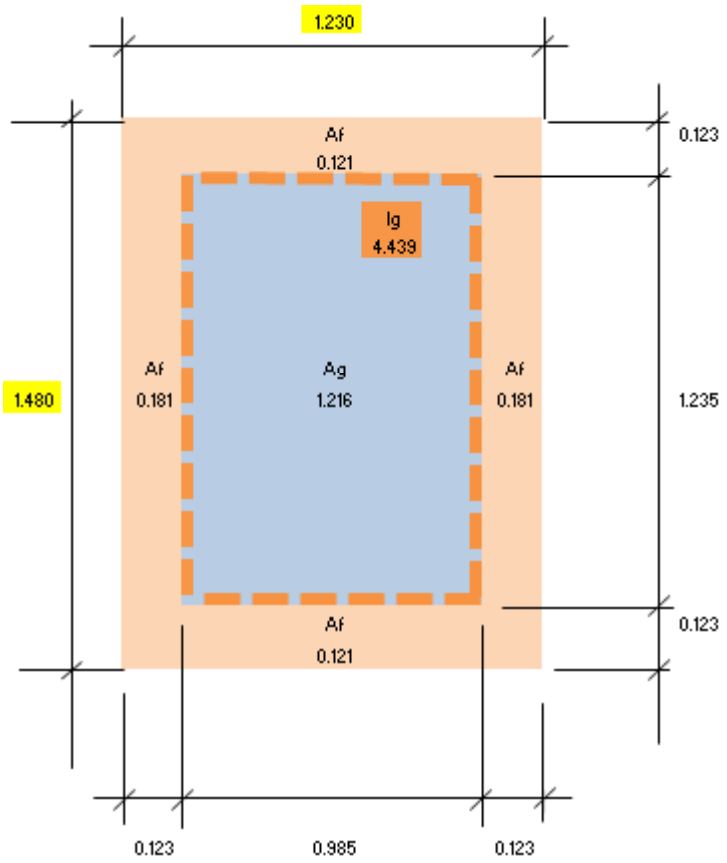
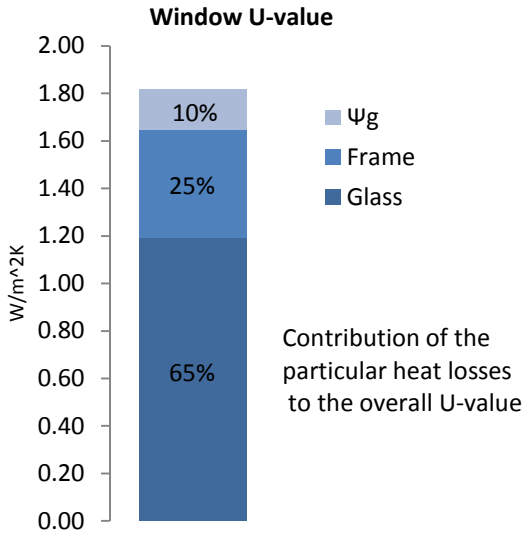
Q & A

Appendix A

Window U-value calculation – uninstalled condition

$$U_w = \frac{\sum A_g U_g + \sum A_f U_f + \sum l_g \Psi_g}{A_t}$$





	Ag	Ug	Af	U_f	lg	Ψg	At	Uw
	m2	W/m2K	m2	W/m2K	m	W/mK	m2	W/m2K
Overall	1.216	1.781	0.6044		4.439		1.820	**1.816**
Head			0.1207	1.367	0.985	0.068		
Sill			0.1207	1.365	0.985	0.083		
Jamb-L			0.1814	1.367	1.235	0.068		
Jamb-R			0.1814	1.367	1.235	0.068		