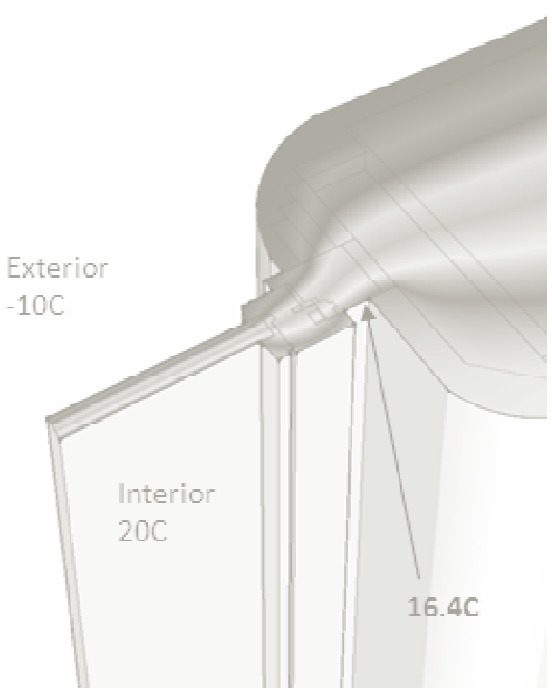
The Influence of a Window's Installation on the Window's U-value

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 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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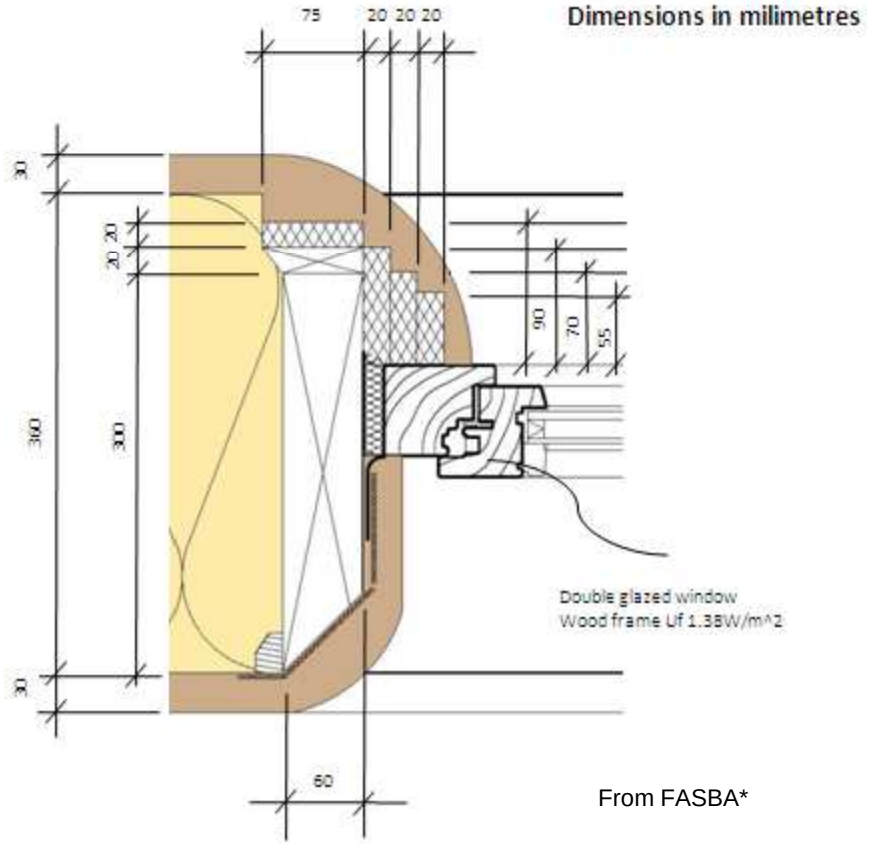
Modelled Detail

The detail originally developed
By FASBA

Window jamb - fitting into a
420 mm thick strawbale wall



From FASBA*

* Model geometry based on a bitmap underlay; reference point for dimensioning - straw Bale Layer thickness = 360mm

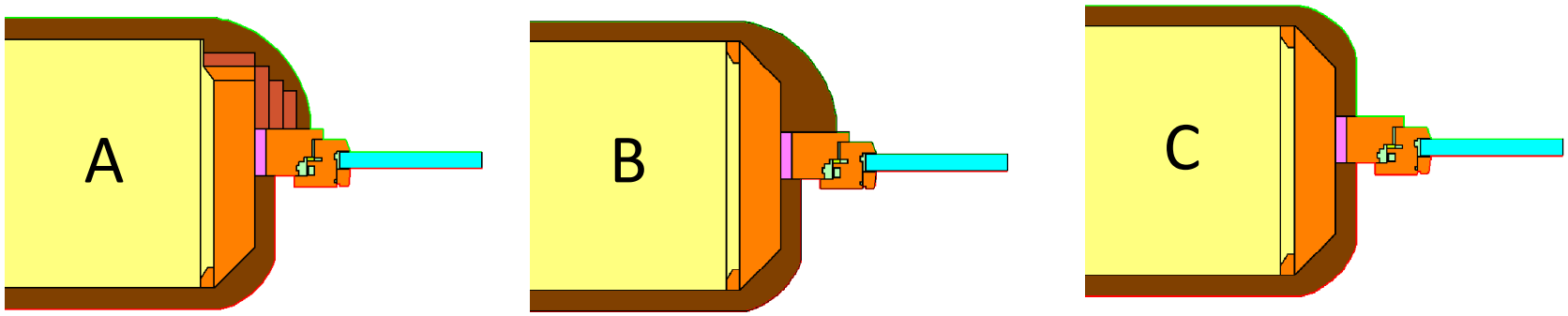
Modelled Scenarios

The difference between three methods of window installation:

A - Window jamb protected by wood fiber boards (original FASBA detail)

B - Window jamb covered by plaster only

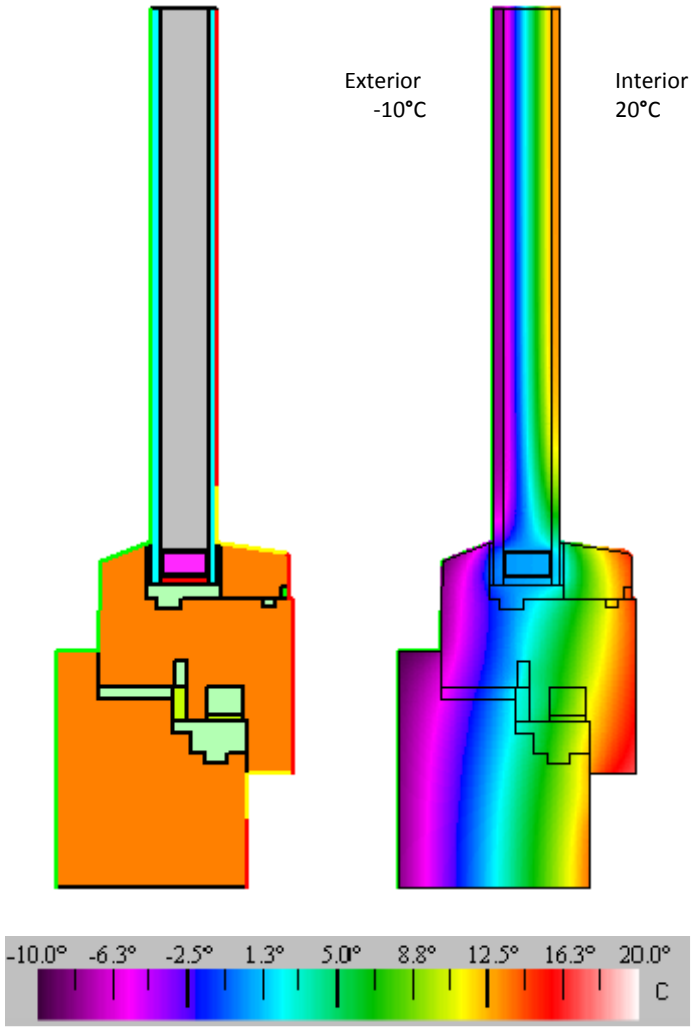
C - Window jamb completely exposed



Simulation software

The THERM 6.3 and WINDOW 6.3 software packages from LBLN

Sample Window



Window

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

Uw = 1.816 W/m^2K

Ug = 1.78 W/m^2K

Uf = 1.37 W/m^2K

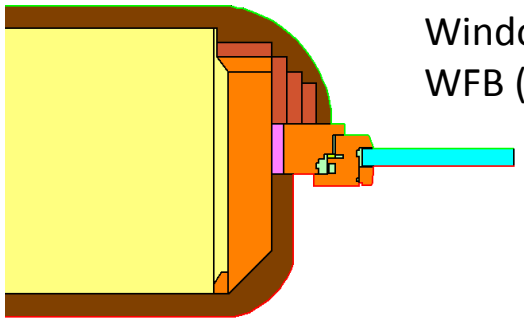
Ψg = 0.068 W/mK

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

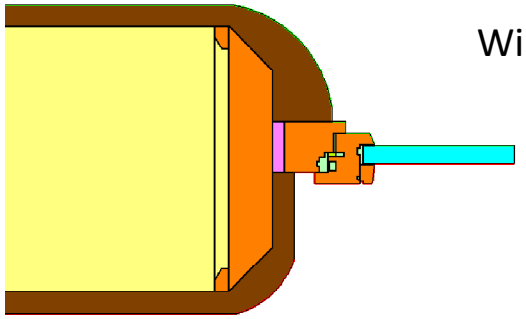
Geometry, Materials and Simulation Conditions

A



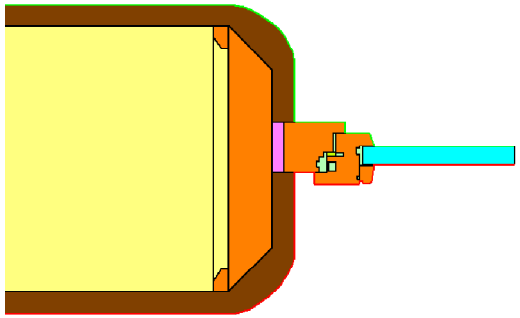
Window jamb protected by WFB (original FASBA detail)

B



Window jamb covered by plaster only

C



Window jamb completely exposed

Materials	λ[W/(mK)]
Compriband 0.048	0.048
EPDM 0.25	0.250
Earth plaster 0.95	0.950
Spurce 0.13	0.130
Straw perp 0.052	0.052
WFB 0.042	0.042
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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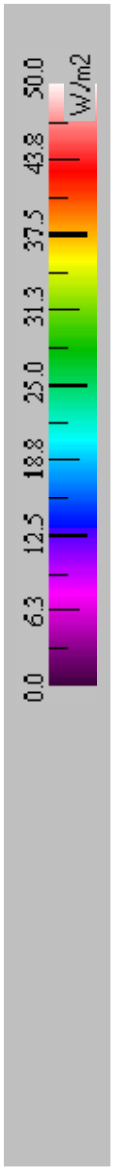
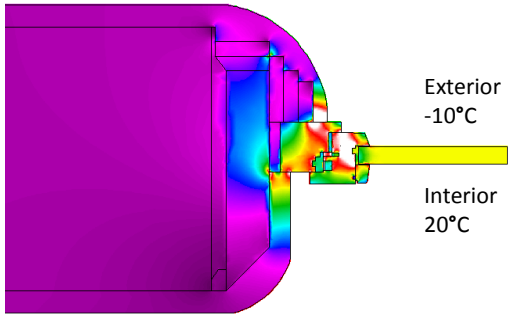
Simulation – Heat Flux



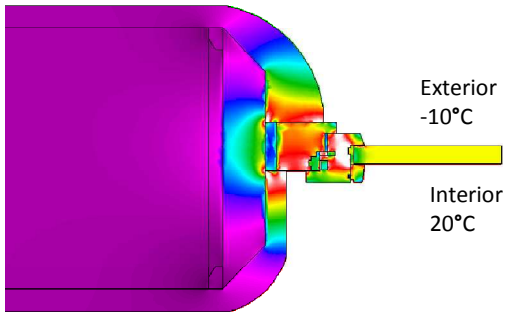
A



Heat Flux at ΔT = 30°C

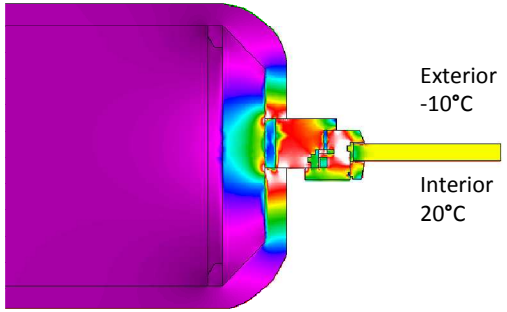
Window jamb protected by WFB (original FASBA detail)

B



Window jamb covered by plaster only

C



Window jamb completely exposed

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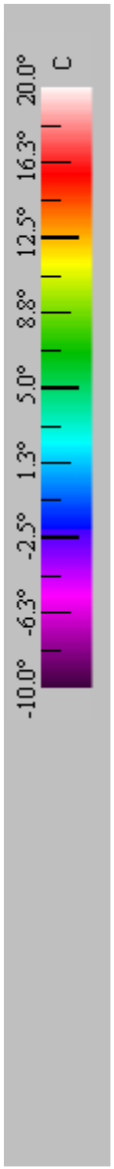
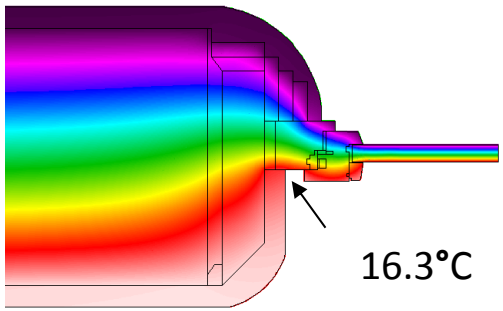
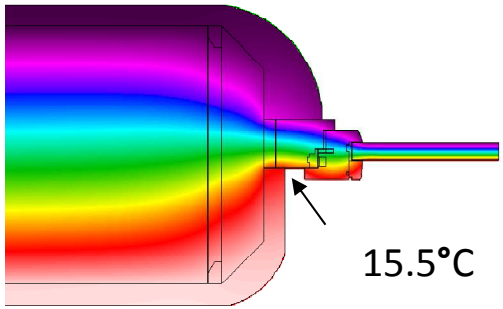
Simulation – Junction Surface Temperature



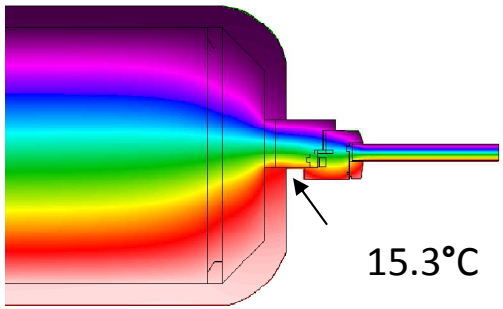
A



B



C



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

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

The minimal permissible internal surface temperatures are country dependant. Check with your national guidelines

Boundary conditions for the assessment of surface temperatures*

Rse = 0.04 W/m^2K
Rsi horizontal = 0.13 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

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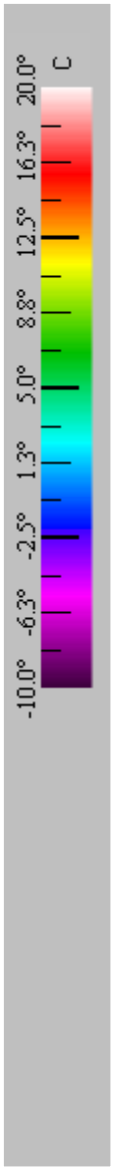
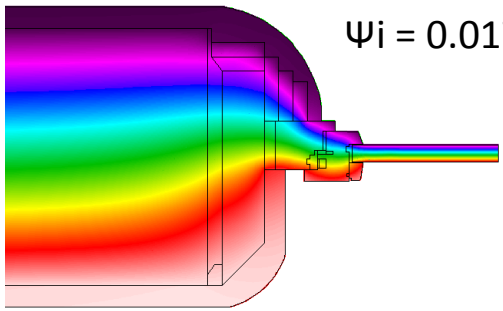
Simulation – Ψi-value

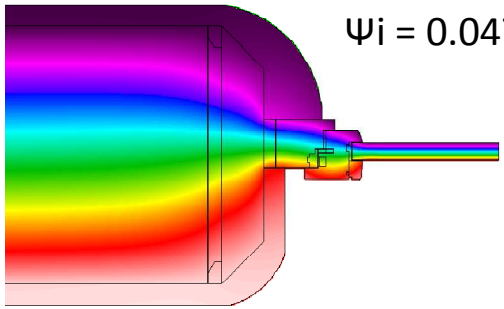


A



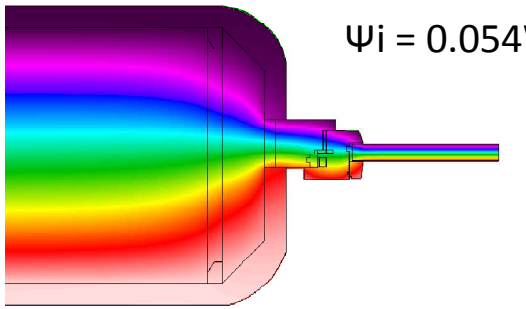
Ψi = 0.017W/mK

B



Ψi = 0.047W/mK

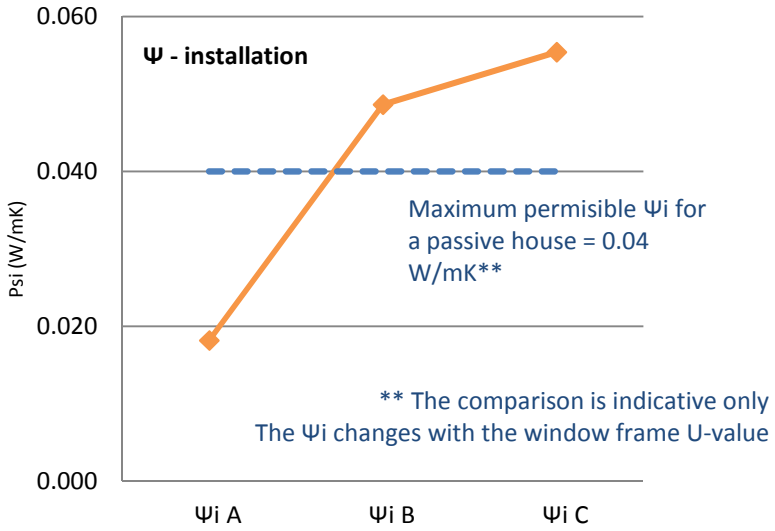
C



Ψi = 0.054W/mK

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

$$\Psi_{i} = \frac{Q_{\text{total inst}}}{\Delta T} - (U_{\text{wall}}l_{\text{wall}} + U_{f}l_{f} + U_{p}L_{p}) \quad *$$



NOTE – the Ψi is calculated following the PHI convention (length of the wall up to the edge of the window frame)

* For details of the calculation 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 Equation adapted for the ins panel

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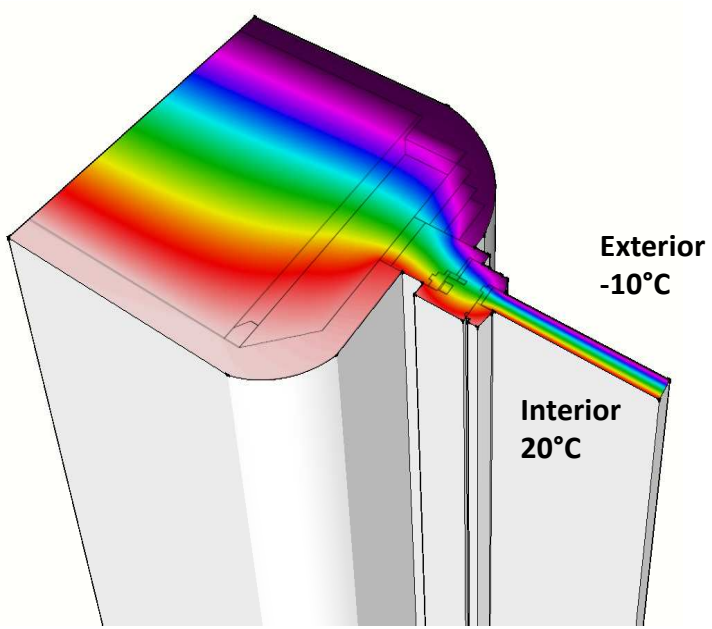
U-value of the Installed Window

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 sill and head fitted in the same way as jambs

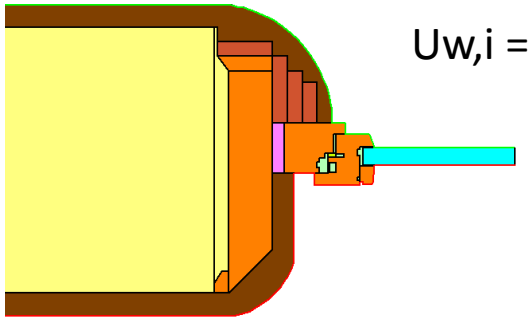
	Uw W/m^2K	**Aw** m^2	**li** m	**Ψi**** W/mK	**Uw,i** W/m^2K	**Increase** %
Uninst	1.816	1.820	-	-	**1.816**	-
A	1.816	1.820	5.420	0.017	**1.867**	3
B	1.816	1.820	5.420	0.047	**1.958**	8
C	1.816	1.820	5.420	0.054	**1.978**	9

* 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

U-value of the Installed Window – Three Scenarios

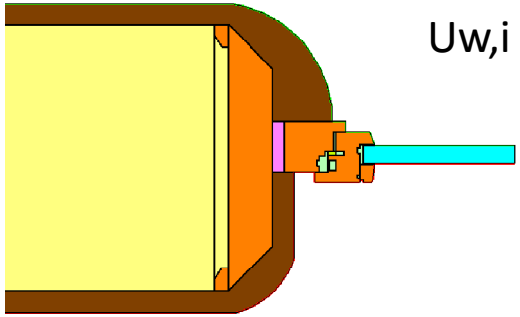
A



Uw,i = 1.87 W/m^2K

Increase 3%

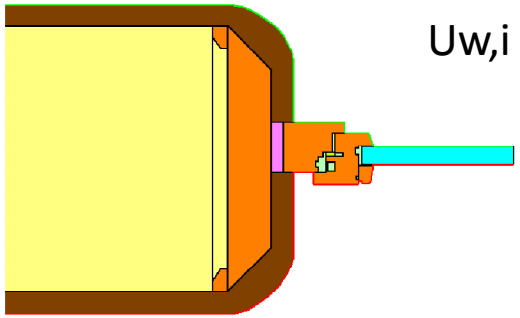
B



Uw,i = 1.96 W/m^2K

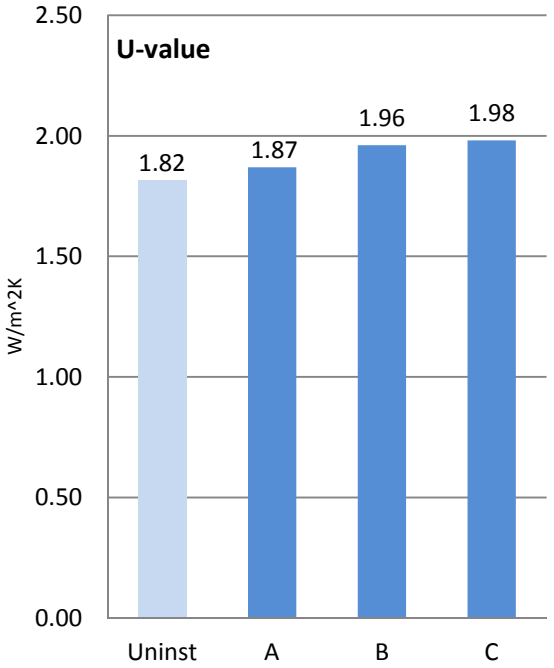
Increase 8%

C



Uw,i = 1.98 W/m^2K

Increase 9%



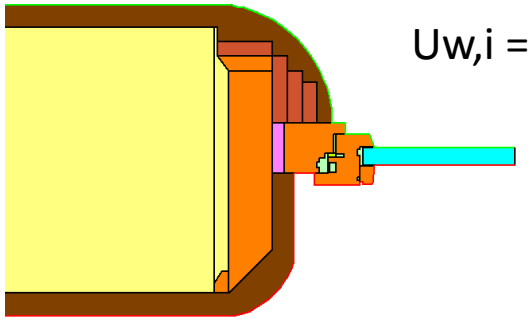
A Window jamb protected by WFB (FASBA)

B Window jamb covered by plaster only

C Window jamb completely exposed

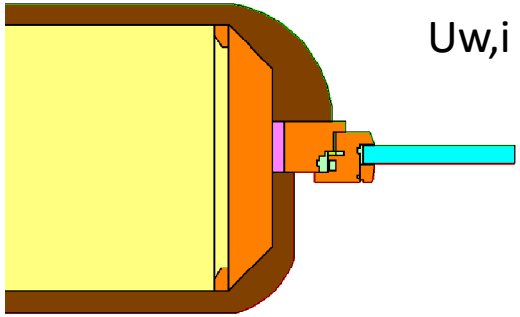
U-value of the Installed Window – Wider Context

A



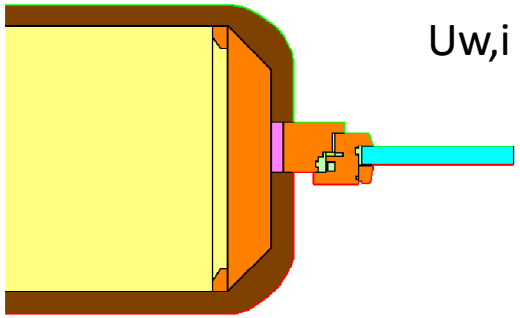
Uw,i = 1.87 W/m^2K

B



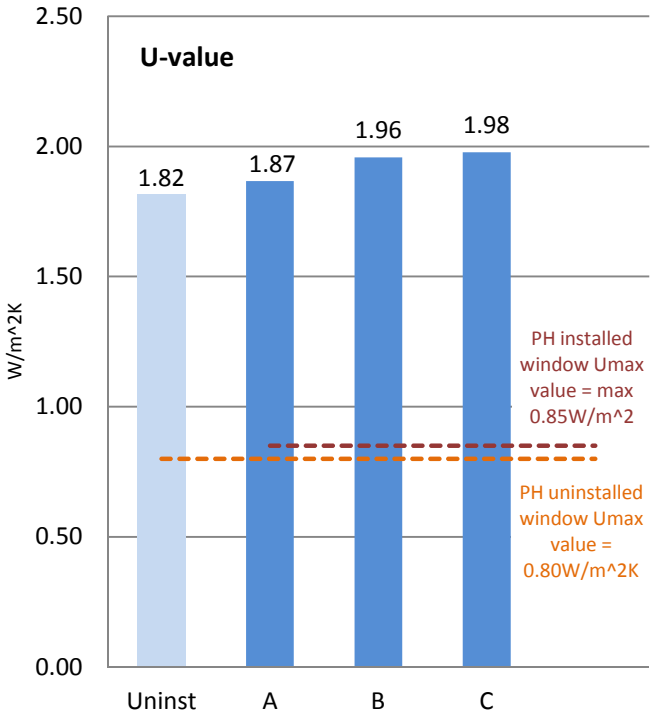
Uw,i = 1.96 W/m^2K

C



Uw,i = 1.98 W/m^2K

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 use of wood fiber boards (case A) limits the increase of the installed window U-value to 3% on the uninstalled window U-value
- The replacement of the wood fiber boards by earth plaster (case B) increases the installed window U-value by 8% on the uninstalled window U-value. The removal of any protection (case C) increases the installed window U-value by 9% on the uninstalled window U-value.
- With decrease in the window U-value, the importance of good installation increases. What would the situation be for a high performance (i.e. PHI certified) window?
- As well as improving thermal performance, it might be assumed that the additional protection to the frame provides higher durability against water ingress through the wall / window junction. This might further improve real-world performance. The significance of this could be assessed through hygrothermal simulation (e.g. WUFI)

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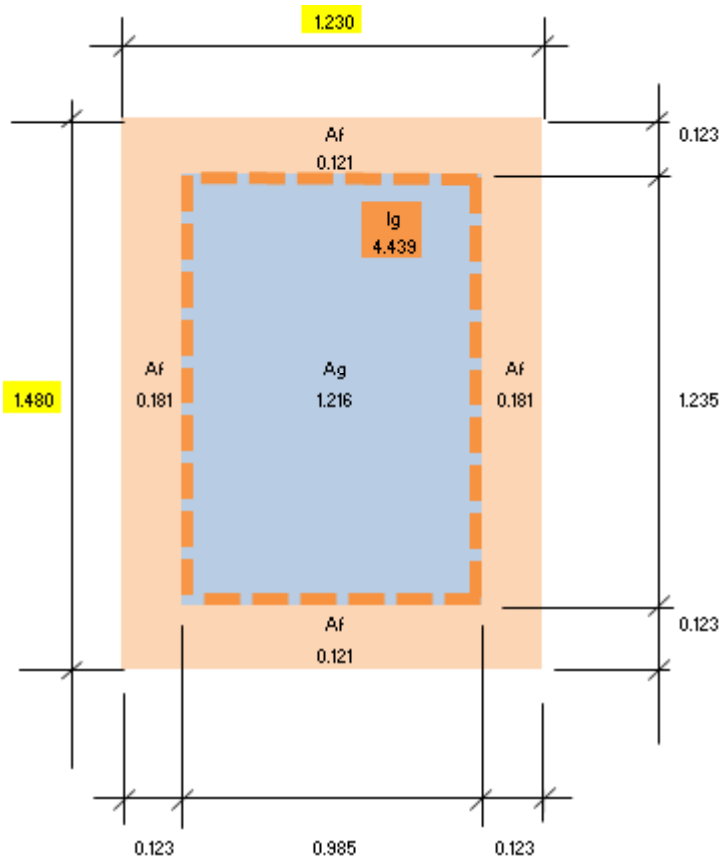
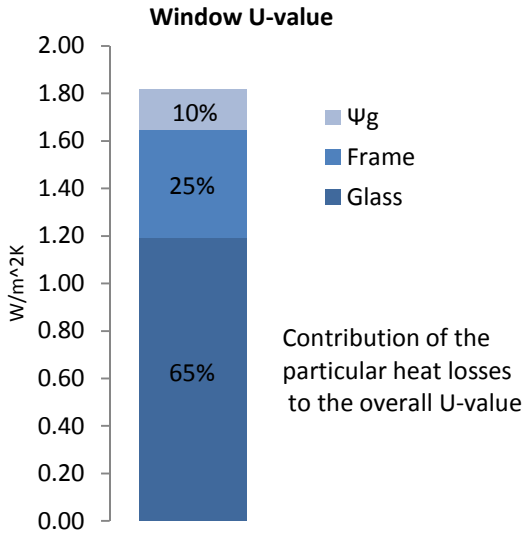
Q & A

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		