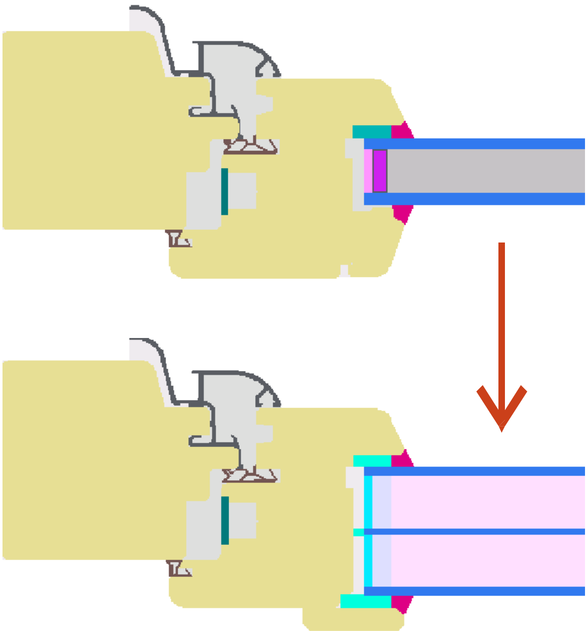
EuroPHit



D5.1.4_Improving_existing_windows

INTELLIGENT ENERGY – EUROPE II

Energy efficiency and renewable energy in buildings

IEE/12/070

EuroPHit

[Improving the energy performance of step-by-step refurbishment and integration of renewable energies]

Contract N°: SI2.645928

Co-funded by the Intelligent Energy Europe Programme of the European Union

Technical References

Project Acronym	EuroPHit
Project Title	Improving the energy performance of step-by-step refurbishment and integration of renewable energies
Project Coordinator	Jan Steiger Passive House Institute, Dr. Wolfgang Feist Rheinstrasse 44/46 D 64283 Darmstadt jan.steiger@passiv.de
Project Duration	1 April 2013 – 31 March 2016 (36 Months)

Deliverable No.	D5.1.4
Dissemination Level	PU
Work Package	WP5_Product Development
Lead beneficiary	05_iEPD
Contributing beneficiary(ies)	01_PHI
Author(s)	Dr.-Ing. Benjamin Krick
Co-author(s)	
Date	27.01.2016
File Name	EuroPHit_D5.1.4_Improving_existing_windows_PHI

Table of Contents

List of figures and tables

Co-funded by the Intelligent Energy Europe Programme of the European Union

Abstract

Often especially wooden windows have a much longer service life, than predicted. Is a window in a good condition, its thermal properties might be improved by replacing the glazing and by covering the frame and the sash with insulation. The later one could best be done in one step with a wall insulation.

In doing so, passive house quality could be achieved even with old window frames.

1 Passive House suitable windows

In a step-by-step retrofit where the windows are replaced first, and the insulation layer is added at a later stage, there are special considerations regarding the window connections. The new windows should work well both in the first stage, when they are installed in the old wall, and afterwards, when the insulation is added to the envelope.

Passive House suitability is verified using the U-value of the installed/uninstalled components and the temperature factor at the glazing edge or the installation situation as the coldest point of the component. These requirements are directly derived from Passive House criteria for hygiene and comfort as well as from feasibility studies.

1.1 Requirements

The requirements for transparent components are set according to the climate zone for which the component is designed. The criteria is included in Table 1.

The basis of this criteria, in terms of the functional requirement for hygiene is:

- **Maximum water activity (interior building components): $a_w \leq 0.80$**

  Water activity is the relative humidity either in a material's pores or directly on its surface. This requirement restricts the minimum temperature at the window surface for health reasons. Mould growth may occur if water activity exceeds 0.80. Such conditions should therefore be consistently avoided.

  The $f_{Rsi=0.25}$ temperature factors given in Table 1 result as acceptable certification criteria for different climates. This f_{Rsi} is the temperature factor at the coldest point of the window frame. Criteria for other climate zones are currently being determined.

Regarding comfort, the functional requirement is the following:

- **Minimum temperature of volume enclosing surfaces: $|\theta_{si}-\theta_{op}| \leq 4.2K$**

  This temperature difference requirement limits the minimum average temperature of a window for reasons of comfort; it may deviate by a maximum of 4.2K. A greater difference may lead to unpleasant cold air descent and perceptible radiant heat deprivation.

  The maximum thermal transmittance coefficients (U-values) of installed certified transparent Passive House building components under heating dominated situations are calculated from this temperature difference criterion. The heat transfer coefficients given in Table 1 result as acceptable certification criteria for different climates.

- **Limiting the risk of draughts: $v_{Air} \leq$ 0.1 m/s**

  The air velocity in the living area must be less than 0.1m/s. This requirement restricts the air permeability of a building component as well as cold air descent.

Table 1: Adequate certification criteria and U-values of the reference glazing

Climate zone	Hygiene criterion $f_{Rsi=0.25\ m^2K/W} \geq$	Orientation	Component U-value [W/(m²K)]	U-value installed [W/(m²K)]	Recommended glazing (low-e-coated)
1 Arctic	0.80	**Vertical**	**0.40**	**0.45**	High end quadruple
		Inclined (45°)	0.50	0.50	
		Horizontal	0.60	0.60	
2 Cold	0.75	**Vertical**	**0.60**	**0.65**	High end triple or quadruple
		Inclined (45°)	0.70	0.70	
		Horizontal	0.80	0.80	
3 Cool-temperate	0.70	**Vertical**	**0.80**	**0.85**	Triple
		Inclined (45°)	1.00	1.00	
		Horizontal	1.10	1.10	
4 Warm-temperate	0.65	**Vertical**	**1.00**	**1.05**	Triple
		Inclined (45°)	1.10	1.10	
		Horizontal	1.20	1.20	
5 Warm	0.55	**Vertical**	**1.20**	**1.25**	Double
		Inclined (45°)	1.30	1.30	
		Horizontal	1.40	1.40	
6 Hot	none	**Vertical**	**1.20**	**1.25**	Double anti sun
		Inclined (45°)	1.30	1.30	
		Horizontal	1.40	1.40	
7 Very hot	none	**Vertical**	**1.00**	**1.05**	Triple anti sun
		Inclined (45°)	1.10	1.10	
		Horizontal	1.20	1.20	

1.2 Calculation method

The thermal transmittance coefficients (U-values) and the thermal bridge loss coefficients (ψ-values) are determined based on DIN EN ISO 10077, EN 673 and DIN EN 12631. Passive House suitability should be determined for the specified dimensions of the products to be certified. Verification of the hygiene criterion is provided using 2-dimensional heat flow calculations of the standard cross-sections.

The detailed information on the requirements and calculation can be found in the criteria for certified Passive House transparent components (click here).

Co-funded by the Intelligent Energy Europe
Programme of the European Union

2 Design principles

Is the window in a good condition, it might be worth to keep and improve it. This measure might save investment costs and of cause will lower the heating energy demand and by that the energy costs. So the solution of improving the window might be the solution of the economic optimum.

At the same time, the temperature at the glass edge will be improved towards achieving the hygiene criterion as well as the improving of the U-value of the window for keeping the comfort criterion

2.1 Starting point

The starting point is a double glazed (U_g = 2.8 W/(m²K) g = 78%, aluminium edge bond standard wooden IV68 frame in a good condition. The u-value of the window is 2.46 W/(m²K). The window is installed in an uninsulated wall with a U-value of 1.4 W/(m²K). This is resulting in an $U_{W,\ installed}$ –value of 2.94 W/(m²K). High losses are causing high energy costs. Low temperature factors at both, installation situation and glazing edge (glazing: 0,39) causing highest risk of mould and condensation, see Figure 1, left

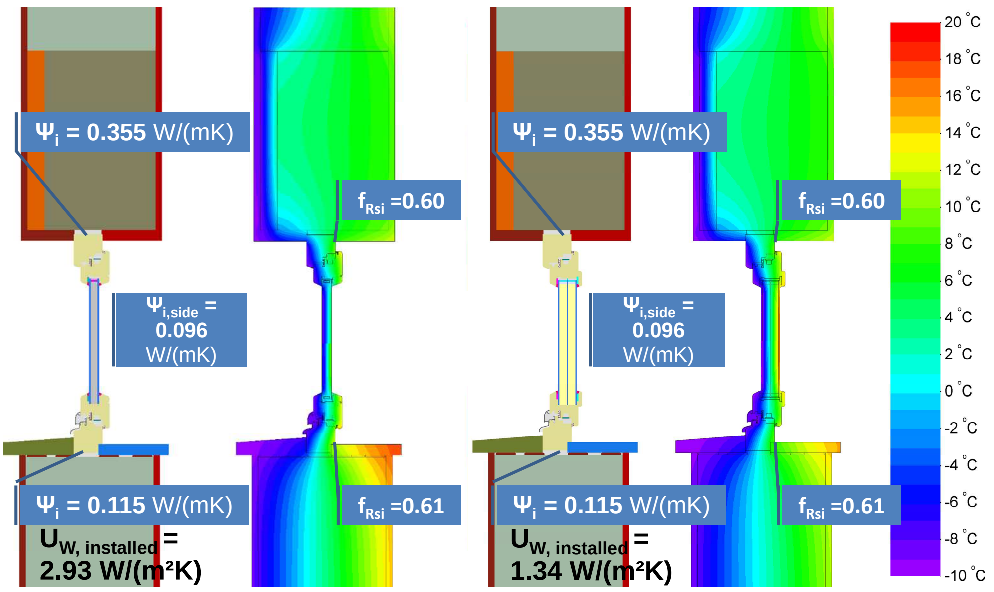


Figure 1: Left: Initial situation: Old window in not refurbished facade. Bottom, side and top section of the window: Very high window U-values and thermal bridges are causing inacceptable high thermal losses as well as low temperature factors creating high risk of mould and condensation. Right: The replacement of the glazing is reducing the thermal losses, but not the low temperature factors.

2.2 Replacing the glazing

To reduce weight and avoid unnecessarily putting an additional load on the frame, pre-tightened thin-layered panes should be used. A 3/x/2/x/3 (3 mm of glass outside, 2 mm inside) pane design is recommended. The new glass will then be exactly as heavy as the old. The old glass generally has two panes with a thickness of about 4 mm each; along with 16 mm of space between the two panes, the total is 24 mm. In terms of thermal quality, the optimum for glazing filled with krypton is 8 mm of glass + 2 x 12 mm of space between the panes for a total of 32 mm. Generally, this should be possible if the old window's pane-holding strip is reduced. Krypton, however, is much more expensive than argon, and also the losses at the glass edges are much lower if the gaps between the window panes are larger. The optimum for argon-filled glazing 2 gaps of 18 mm between the panes for a total of 44 mm (with 8 mm of glass). A typical U-value of such a glazing is around 0.53 W/(m²k) at a g-value in the same height. For such glazing for a standard IV 68 window, the pane-holding strip should be reworked as shown in Figure 1, right. The airtight connection between the old frame and the new glass should be made by using an adhesive tape that is as diffusion-tight as possible so that condensation does not build up as so often happens with these old windows, thereby preventing the frame from rotting and extending the window's service life. When the glass is renewed, old gaskets should also be replaced.

Figure 1, right shows that the U-value of the window is improved significantly, but it is not even suitable for the warm temperate climate! The temperature factors at the glazing edge are now at a state, suitable for the cool, temperate climate. Not so the temperature factors of the installation situation, which only achieve "warm".

The change of the only the glazing does not lead to a solution suitable for passive houses.

2.3 Additional reveal insulation

An additional reveal insulation (including a new window sill with additional insulation) is able to improve the situation, see Figure 2, left. The installed U-value is now at 1.01 W/(m²K), that means, the Passive House comfort criterion for the warm, temperate climate is achieved. For the top- and side sections is the hygiene criterion even for the cool, temperate climate zone reached, only the sill section is lacking that.

Regarding the U-value, the requirement for the warm, temperate climate zone is fulfilled with the improved window including reveal insulation. The temperature factor at the sill is not achieved.

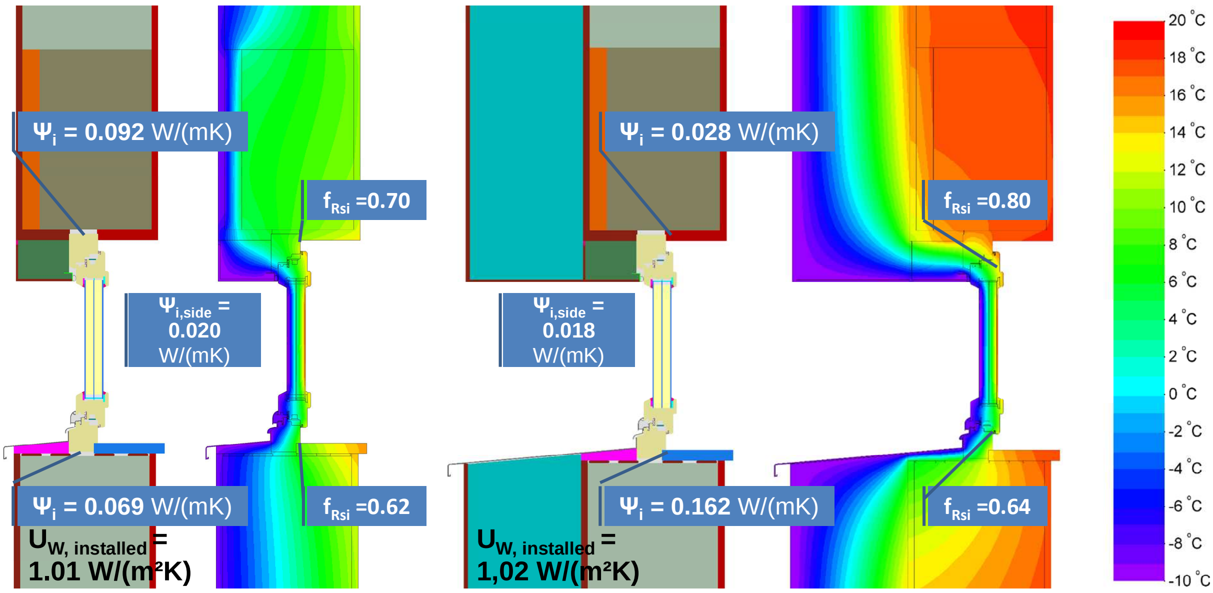


Figure 2: Left: With reveal insulation: Significant improvement of both, thermal bridges and temperature factors. Temperature factor at the sill section is still only suitable for warm climate. Right: With reveal insulation and exterior insulation: No changes regarding the U-value of the installed window. Slightly improved temperature factor at the sill profile. Now nearly suitable for the warm, temperate climate.

2.4 Final state with exterior insulation

Will the old wall be insulated with exterior insulation at a final stage, including reveal insulation will not change the results regarding the installed U-value, Figure 2, right. The thermal bridge of the top section is improved by the measure, because the week point where the concrete lintel and the wall is connecting, is over covered by insulation. On the other hand, the sill section is now a new week point, the thermal bridge is much higher, than before. But never the less, the temperature factor is improved. And of cause, where whole building will be improved by the external insulation.

With an exterior insulation, the comfort requirements, as well as the hygiene criterion can be fulfilled by improved windows for the warm, temperate climate zone.

2.5 Energy- and cost savings

Table 2 shows all thermal data as well as solar gains, the energy balance and the annual energy costs for a cool, temperate climate. It can be seen, that the cost reductions are very high. Comparing the starting point with double glazing and the improved window with reveal insulation, the difference is 22 € per year, not included the benefits of a prolonged life of the window by the measures. Again not included the longer life of the improved window, this will (with a real interest rate of 2%) sum up to a present value of round about 500 € over 20 years. If this is taken into account as the lifespan of both, the enhanced and the not enhanced window, someone may spent this 500 € to improve the window and the money will be completely paid back over the 20 years.

Looking at the final state and comparing the measures with a new phA-class window, the difference in energy cost is some 8 € per year. That means some 200 € over an assumed service life of the new window of 40 years, not taken into account the lover remaining service life of the old window. In addition to the lower energy costs of the new window, the much higher thermal quality, the smaller hygienic risks, more light and view as well as an assumable longer (remaining) service are counting for the new window.

Table 2: Thermal data, energy and costs

	Starting point		**Inproved by triple glazing**			**New phA-class window**	
	double glazing	double low-e glazing		+ reveal insulation	final stage		
$f_{RSi,min}$	0,39	0,39	0,62	0,62	0,64	0,7	[-]
U_g	2,8	1,3	0,52				[W/(m²K)]
g	0,78	0,60	0,52				[-]
U_W	2,46	1,47	0,87			0,64	[W/(m²K)]
$U_{W,installed}$	2,93	1,94	1,34	1,01	1,02	0,70	[W/(m²K)]
Solar gains	139	107	93	90	64	99	kWh/a
U wall	1,40				0,12	0,12	[W/(m²K)]
Transm. losses	801	663	580	534	175	131	kWh/a
Balance	662	556	487	444	111	32	kWh/a
Annual energy costs	66	56	49	44	11	3	[€/a]

Solar gains: West oriented including 20% shading and shading by reveal+ overhang. Transmission losses: Window + 0.5 m wall arround the window, calculated @ 76 kKh/a. Annual energy costs: Calculated @ 0.1 €/kWh heating energy

Co-funded by the Intelligent Energy Europe Programme of the European Union

3 Conclusion

In terms of the passive house hygiene- and comfort criteria, the discussed measures are not suitable for the cool, temperate climate. Improving of windows only by using new glazing should be avoided. Only if the reveal is insulated too, acceptable hygienic conditions are the result.

If the measures are better than a new window from the economic side of few, should be considered case by case. This can be for instance done by PHPP, especially with version 9.0 or higher.