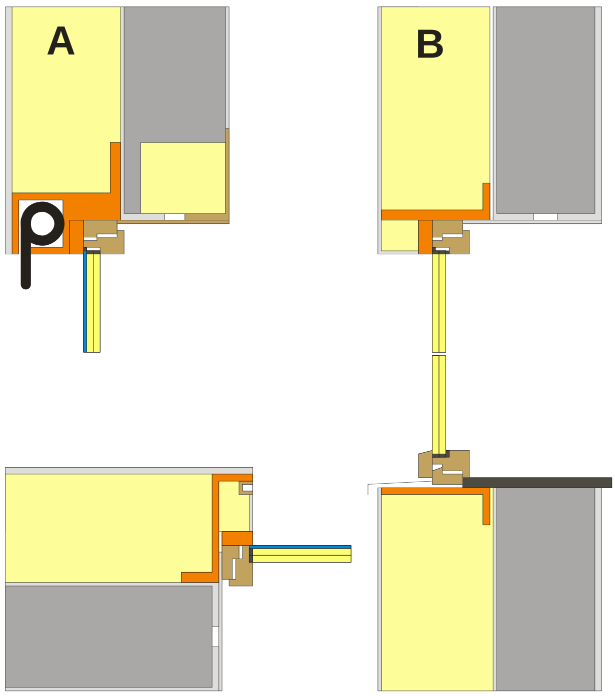

Final stage

# D5.1.1b_Window_connections_/_Insulation first

**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<br>Passive House Institute, Dr. Wolfgang Feist<br>Rheinstrasse 44/46<br>D 64283 Darmstadt<br>jan.steiger@passiv.de |
| Project Duration | 1 April 2013 – 31 March 2016 (36 Months) |

| | |
|---|---|
| Deliverable No. | D5.1.1b |
| 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_D5.1.1a_WindowConnection_WindowFirst_PHI |

## Table of Contents

Abstract 4
1 Passive House suitable windows 5
1.1 Requirements 5
1.2 Calculation method 6
2 Design principles 7
2.1 Starting point 7
2.2 Proposed solution 8
2.3 Shading/Blinds 9
3 Exemplary solution: smartshell reno 11

## List of figures and tables

Figure 1: Initial situation. 7
Figure 2: Interstage 8
Figure 3: Insulating sash and reveal 9
Figure 4: Window installation situation 9
Figure 5: Initial state with a wooden window frame and a double glazing 11
Figure 6: Step 1: Wall is insulated, window frame is covered by insulation 12
Figure 7: Step 2: The old window as well as the interim insulation is taken away. 12

Table 1: Adequate certification criteria and U-values of the reference glazing 6

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

# Abstract

Often, windows and walls are retrofitted separately. Nonetheless, good overall results are possible.

If the wall is insulated first, previsions should be made for a new window, such as by using front-wall mounting systems. Care should be taken to cover the reveal with insulation, best up to the glazing including the sash.

Raff-stores, shutters or roller shutters should be replaced in the first step with applying the insulation, to avoid high thermal bridges, cold spots at the inner surface drafts and convective losses.

# 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).

# 2 Design principles

In practice, windows and façades are seldom retrofitted at the same time, even though doing so would save costs, reduce thermal bridges and optimise solar gains. There are many reasons why retrofits are done step by step. Often, new windows are put in between tenants, or a window may be in such bad shape that it cannot wait. If a façade is renovated, any windows renewed “in the meantime” will still be in good shape and not need retrofitting. In addition, building users may not wish to be bothered further. Often, there simply is not enough money to do both things at once. Sometimes, the ownership community can only reach a minimal consensus.

## 2.1 Starting point

If the façade is retrofitted, insulation is added to the reveals up to the window frame at its best. Often, however, the reveals are not insulated, especially when roller blinds are used. The result is a massive thermal bridge. If the window is to be renewed in a second step, it is installed where the old window was so that the new plaster and insulation are not damaged. The situation is hardly improved; the installation thermal bridge remains large, as does reveal shading.

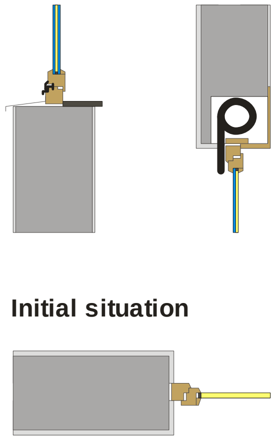


**Figure 1:** Initial situation: Old window in not refurbished facade. Bottom, side and top section of the window with roller shutter box.

## 2.2 Proposed solution

Provisions should be made so that the new windows can be installed in the new insulation layer. Front-wall mounting systems can be used for this purpose, such as those from Iso Chemie, Hanno and Illbruck. Another option is self-made hidden parts of the frame made of timber or hard insulation materials (such as CompacFoam, Purenit and similar products/ materials). The Passive House Institute is currently working on a certification scheme for such products.

The front-wall mounting system is attached to the exterior wall and connected to the insulation. Then, insulation is applied to the reveal up to the old window. At the position of the new window, a plaster strip is used, and the reveal insulation is redone. When the window is replaced, the interior part of the insulation over the reveal can be taken off up to the plaster slat and the new window placed in the planned position without requiring any other work on the thermal insulation composite system.

Covering the casement with insulation is an especially good way of reducing the installation thermal bridge. The reveal insulation can be used to close gaps; at the end where it meets the casement, a hose seal can be used to connect it to the casement. This approach considerably improves the thermal situation; in addition, the old window frame is now optimally protected from the weather, which can increase its service life considerably. This approach is only easy to implement on the side and top connections, however, because rainwater has to drain off the balustrades.

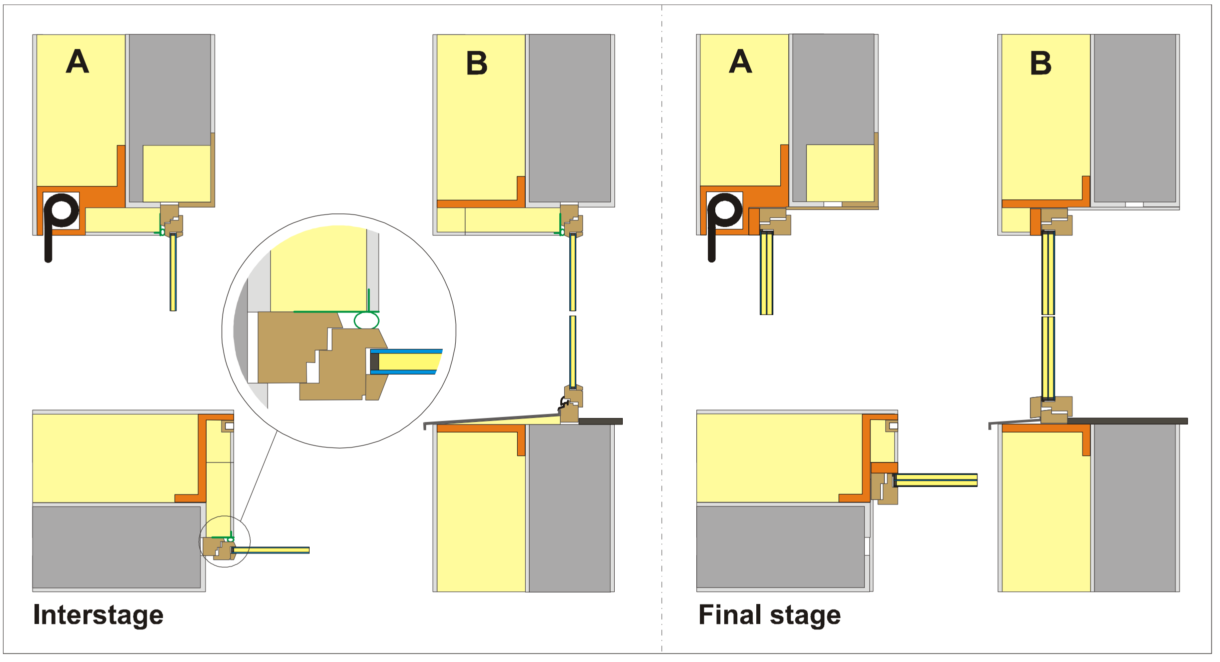


**Figure 2:** Interstage (left): Solutions for the bottom, side and top section with- and without shading elements, Installation situation is prepared for the later mounting of the window frame by kind of a insulating blind frame. The reveal insulation is fitted in a way, that it can be taken off for the installation of the new window without destroying the finishing (i.e. plaster) of the insulation. A: With shading: Old shutter box filled with insulation and sealed airtight right in the first step. The new shutter box is located in flush with the new plaster to minimize thermal bridges and mounted to the insulating plind frame. B: Without shading.

Final state: The prepared part of the reveal will be removed together with the old window. The new window is fitted in. The inside reveal is repaired and a new window sill is mounted, or the old one is covered by a new finish.


**Figure 3:** Insulating sash and reveal: a) XPS board notched to size; b) PVC profile inserted with hose gasket glued on; c) inserted in the reveal; d) interior view; e) exterior view after plastering

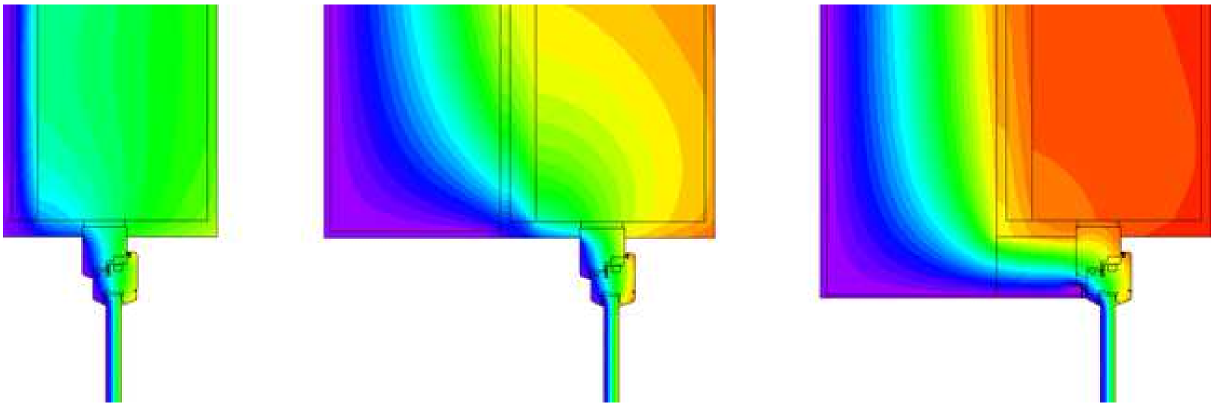

**Figure 4:** Window installation situation at the top with reinforced concrete lintel (U-value of the wall: 1.4 W/(m²K), double-glazed IV68 wood frame. Left: initial situation ($\Psi_{installation}$ = 0.34 W/(mK)). Middle: with insulated wall ($U_{Wall}$ = 0.12 W/(m²K), $\Psi_{installation}$ = 0.60 W/(mK)). Right: With insulated reveal and sash $\Psi_{installation}$ = –0.35 W/(mK): The temperatures remain uncritical everywhere around the installation area; condensate and mould are reliably avoided here, but the edge of the glass remains problematic.

## 2.3 Shading/Blinds

Roller shutter boxes are one of the major weak points in a building envelope. Generally, roller shutter boxes are not airtight, and it is hard to make them so in existing buildings. The result is high heat losses, even when the roller shutter box is insulated. Because the roller shutter box contains more or less cold outdoor air, insulating the box in the outside does not have a significant effect.

It is therefore recommended that the old roller shutter be removed along with the window; the roller shutter box should then be filled with insulation, made airtight and a new darkening/shading option should be provided. A in flush with the new plaster located and at the blind frame mounted box or blinds are a good option. It is a good idea to have the slats roll to the outside; the guide rails are then farther out and do not have any significant thermal bridge effect. As much insulation as possible should be used between the roller shutter box and the window to reduce the thermal bridge.

An even better option shown at the 2015 Component Award is shading in an air gap between an exterior single window pane and interior insulating glazing unit. The award showed that the investment costs for such shading are less than half those of blinds. Additional benefits include weather protection for shading/ darkening, lower thermal bridges and simpler, faster installation. The drawback is that the slats or the screen can slightly enlarge the visible frame width at the top, and dirt may collect on the panes in the air gap, which would then require cleaning. If this additional cleaning is to be avoided, filters can be used. This solution, called “composite windows”, is generally only offered operable

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

windows. However, some manufacturers are working on solutions for stationary glazing as well (see also Design Brief D5.1.3 Glazing Integrated Shading).

# 3 Exemplary solution: smartshell reno

Smartshell reno is a timber based renovation system, partly developed in EuroPHit. The system was certified as a wall and construction system for the cool, temperate climate by the Passive House Institute. Main developer of the system is the window-cooperative pro Passivhausfenster, see www.smatrwin.eu.

In the position of the ceiling, planks will be fitted to the existing wall all around the building. Than vertically planks will be mounted and cladded by a special rigid wood fibre board. The gap between the old wall and the new cladding will be filled by cellulose.

**Step one:** The windows reveal will be made by those planks too. The fibre board will extend the planks bit and will be specially carved to serve as a part of the new window later. The emerging gap between the old window and the new fire board will be filled with an other piece of wood fibre board, leading to acceptable thermal bridges and hygienic conditions, see

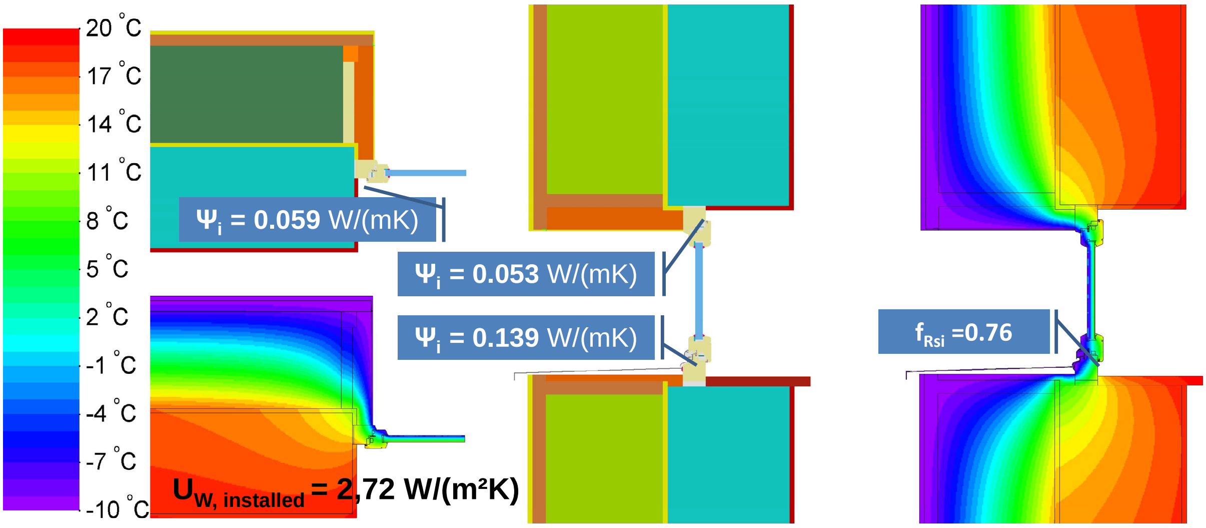


Figure 6.

**Step two:** The fibre board and the window is taken away and the new window is mounted at the very edge of the construction, see Figure 7

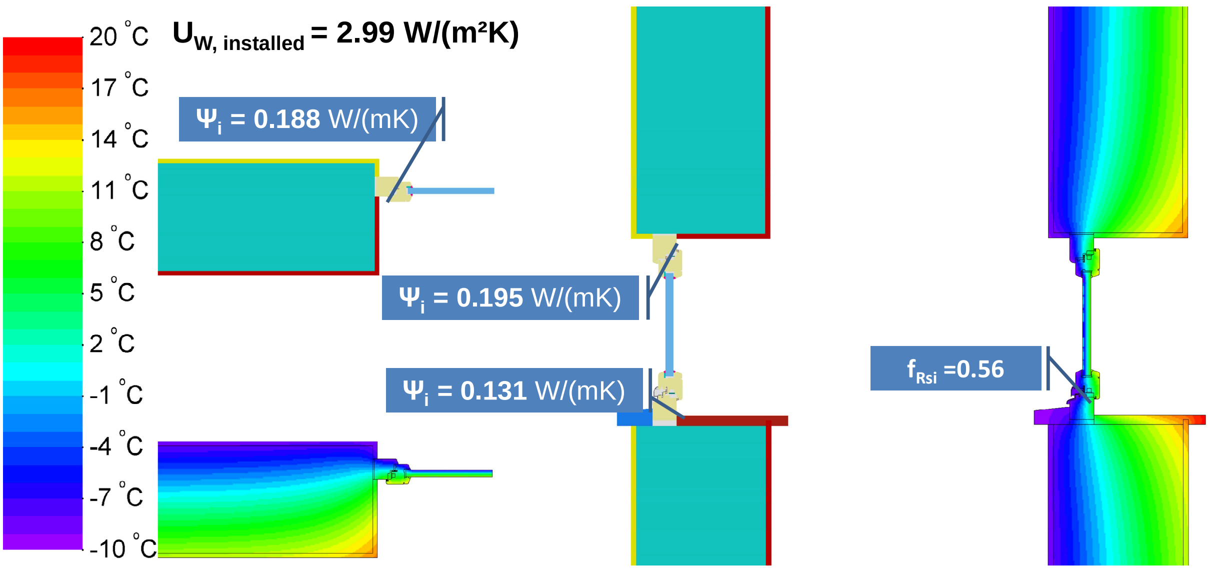


**Figure 5:** Initial state with a wooden window frame and a double glazing. Thermal bridges are very high and there is an extremely high risk of mould as well as condensation.

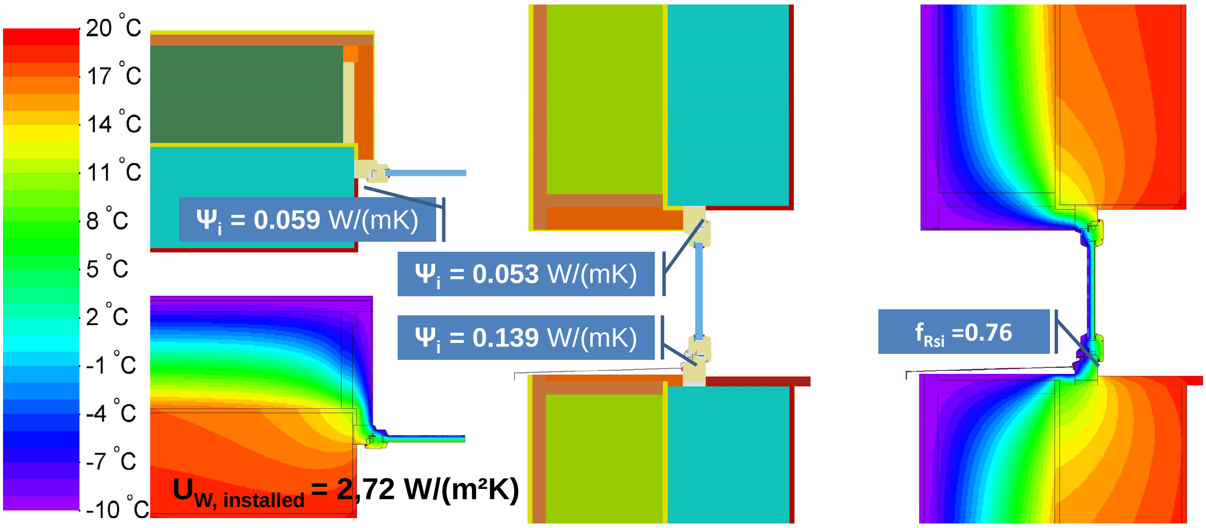


**Figure 6:** Step 1: Wall is insulated, window frame is covered by insulation. The thermal bridges are significantly lower and the hygienic risk at the window junction is reduced by far.

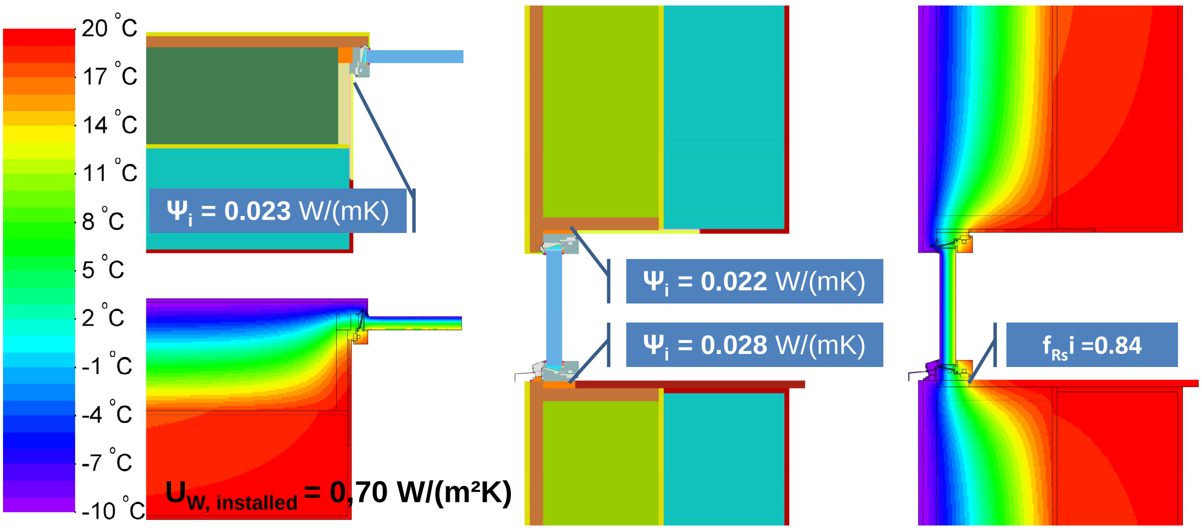


**Figure 7:** Step 2: The old window as well as the interim insulation is taken away, the new window is mounted at the very edge of the new insulation layer. The results are low thermal bridges and perfect hygienic conditions. Because of the position of the window at the very edge of the insulation layer, there is nearly no shading by the wall or insulation itself.

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