

Prefabricated window with integrated technology for refurbishments “Window Machine”

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Authors:

Christian Bodensteiner, Dipl.-Ing. (FH) Architekt, TUM (Project leader)
Prof. Dipl. Ing. Florian Musso
Arnulf Dinkel, Dipl.-Ing. Architekt, ISE
Fabien Coydon, Dipl.-Ing., ISE
Atilla Akarcay, Dipl.-Ing., B+H
Frank Liedloff, M.Sc. Dipl.-Ing. (FH), B+H

Technical University Munich
Department of Architecture
Institute of Design and Construction
Chair of Building Construction and Material Science
Arcisstraße 21
80333 München
+49. (0)89. 289-22353
christian.bodensteiner@tum.de
www.ebb.ar.tum.de

Project partners:

Fraunhofer-Institute for Solar Energy Systems ISE
Heidenhofstraße 2, 79110 Freiburg

Beck+Heun GmbH
Stotternheimer Straße 10, 99086 Erfurt

Heroal GmbH & Co. KG
Österwieher Straße 80, 33415 Verl





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Starting point

Exterior wall and thermal glazing constructions have today reached sophisticated levels of energy efficiency and quality. The weak point of a façade with many individual windows is the connection of the window frame and the wall, where design, constructional, structural, functional and organizational problems are concentrated in one place. Complaints in this area are one of the most common grounds for legal disputes in the construction industry.

Overview & objectives

“Prefabricated window with integrated technology for refurbishments”, a research project from TUM’s Chair of Building Construction and Material Science, seeks to discover how as many requirements as possible can be incorporated into a functionally expanded prefabricated window element for use in energy-saving renovation works. The majority of such renovation needs in Germany are presented in buildings of the 1950s to 1970s. The unadorned, ‘standardized’ façades of this era are predestined for the application of industrial prefabricated solutions. This research project focuses on buildings typical of their generation in which no energy-saving improvements have yet been carried out.

Focus of the project

The installation of conventional window replacements is complicated by the involvement of many trades and numerous interfaces at geometrically and structurally challenging places. Through the integration of sun, glare and insect protection in an elegant prefabricated quality element – the “window machine” – the user will profit from a less intrusive construction process, lower costs as well as higher construction quality. Alongside typical window functionality, the inclusion of building services such as ventilation/heat exchanger, electrification/building automation will be studied as additional components in the window element. Thus, additional otherwise laborious renovation measures can be carried out as part of the window replacement with minimal intrusion into the building fabric.

The many potential solutions identified at the start of the project were further investigated according to the following parameters: Design quality, modular



Fig.1 3D prints of the investigated variants, Photo: EBB



Fig. 2 Production of prototypes at B+H works, Photo: EBB

construction, simplified construction process, maintenance and dismantling, reduction of interfaces and associated trades, integration of functions, degree of tolerance, connection to surrounding building elements, daylight, sun protection, insect protection, heat protection, isothermal characteristics. The advantages and disadvantages of each construction were compared and analyzed. Proposals were developed over several selection rounds resulting in three prototype variants. Meanwhile, three proposals for integrated ventilation were chosen and assigned to the prototypes.

In accordance with idea of prefabrication, the window is conceived as an integral component of the element. Following the same principles as a car production series, the form is governed by the installation of the maximum range of features, with individual components incorporated as desired in a given project.

Variant 1

The outward tilting 'frameless' window is mounted flush with the plaster. In this case the window frame can be larger than the existing window opening. Daylight is thus able to penetrate the building through almost the entire structural opening, such that from the inside no frame can be seen. This means an increase in daylight penetration of about 30% for a window of 1.25 × 1.5 m. Room ventilation inlets and outlets are accommodated in channels within the insulation layer. A central ventilation plant can service multiple rooms or several dwellings. The pre-assembled base frame allows the window to be installed as a last step in the construction process and also permits easy maintenance or repair without impacting the surrounding works.

Variant 2

The volume available for integrated services, installation and maintenance is increased by way of an additional metal frame. The visible window casing integrates (amongst other features) an innovative decentralized ventilation unit based on an existing product from an industry partner. By using ducts in the frame as conduits for ventilation, previously necessary interventions in the building structure can be avoided. Maintenance is effected from the outside.

Variant 3

The further development of an industry partner's renovation element integrates all the new window's technical components in the insulation layer. Ventilation is facilitated by way of a newly designed decentralized unit based on a regener-

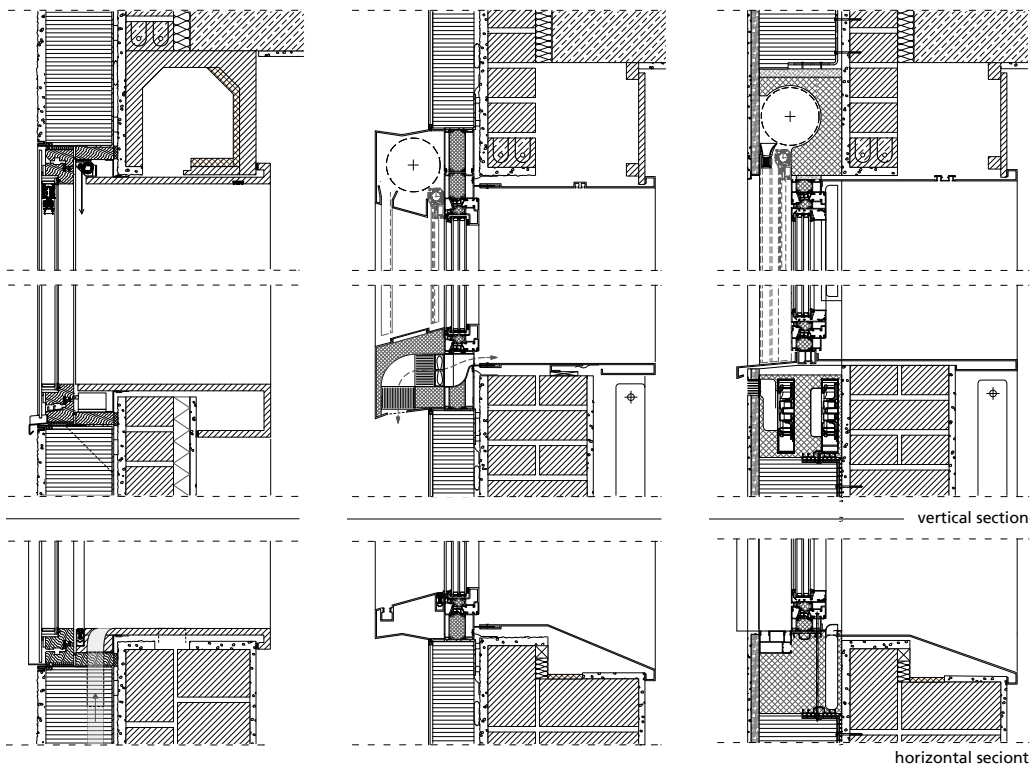


Fig. 3 Sectional drawings: left Variant 1, middle Variant 2, right Variant 3, EBB

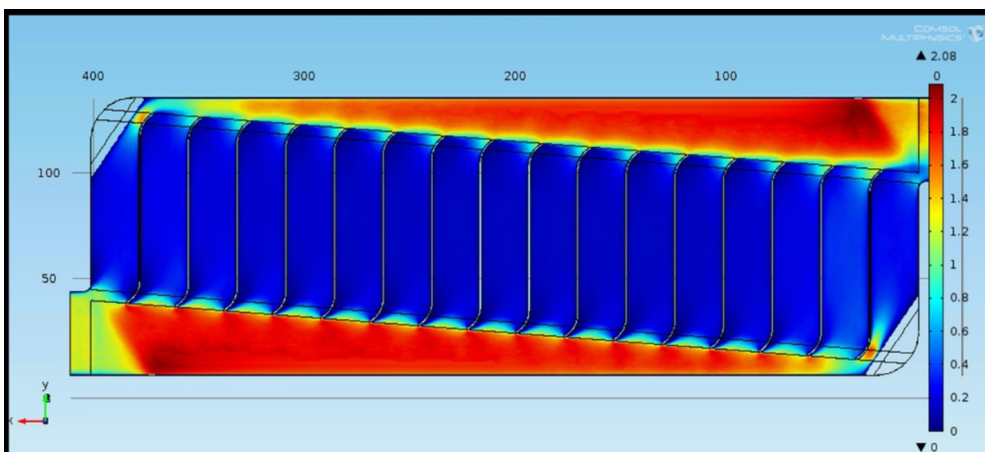


Fig. 4 CFD-Simulation results of the enthalpy heat exchanger in Variant 3, Source: ISE

ative enthalpy heat exchanger (comprising about 90 separate airstreams) with heat and moisture recovery which offers many advantages: In winter, increased comfort is achieved thanks to moister air and no need to remove condensate. The window is delivered to the site for installation as a completely prefabricated element.

The presentation of the research project at the 2015 Munich construction fair (Detail research lab, Fraunhofer Institut, Zukunft Bau) and bautec 2016 in Berlin (Zukunft Bau) attracted considerable interest. In the next phase of the project it is planned to test one of the variants in a demonstration building.

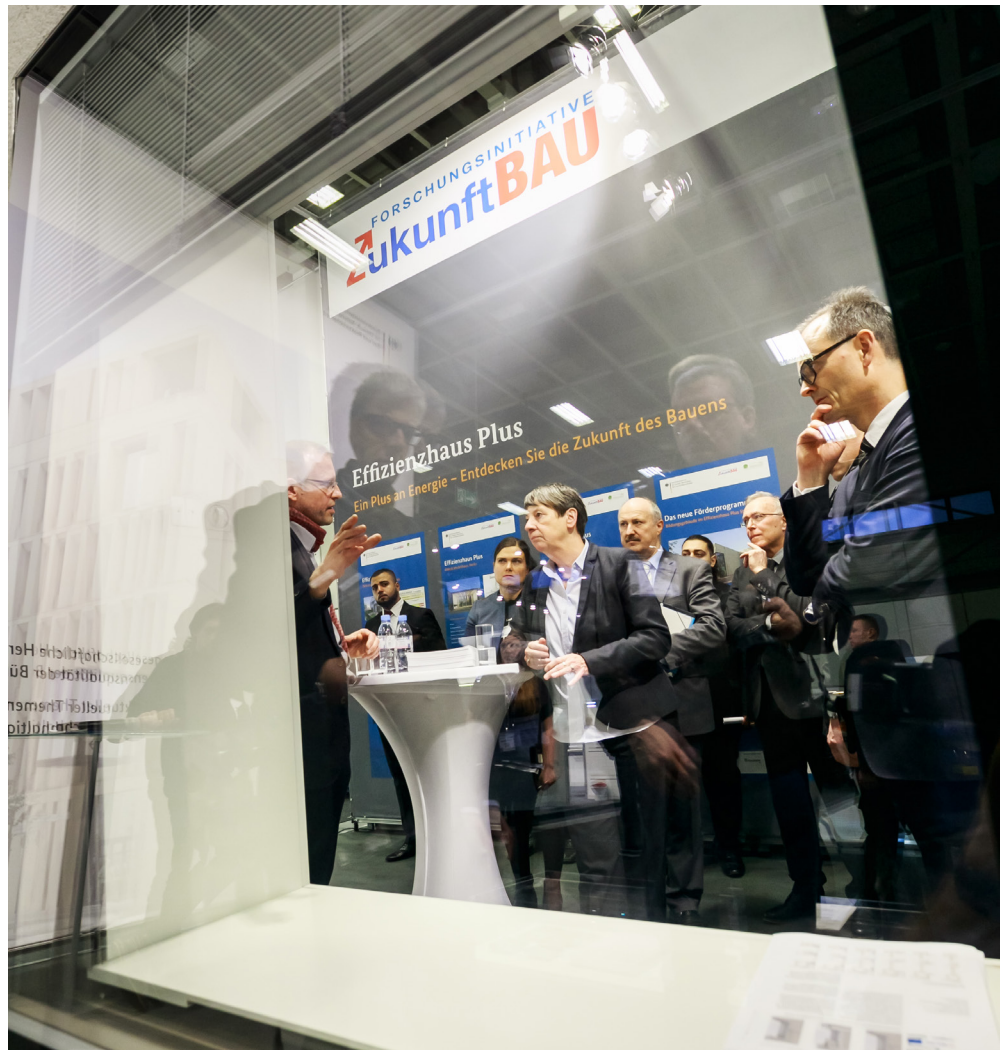


Fig.5 Presentation of the model to Federal Minister Dr. Barbara Hendricks during her visit to the fair bautech in Berlin 2016. Source: BBSR

Conclusion

A substantial amount of time is lost on site due to the interdependency of the various trades involved in the construction. The “window machine” will be produced by a single company and saves on plastering, painting and sun protection works and their coordination. Technical trades simply have to make the final connections to the unit.

The economic efficiency of the window module is a function of the technologies integrated. The greater the number of services accommodated in the window element, the more worthwhile the additional expense as compared to a conventional window replacement. In addition, savings in maintenance must be included in a long-term view of the costs.

Where additional building services are incorporated into the window element in addition to the typical window features, interventions into the building fabric and their associated disruption to residents can be further reduced.

The simplification and speeding up of the construction process requires a precise building survey and more in depth planning. Thus the focus of effort shifts from the construction itself to the planning and production processes.

Prefabrication offers new possibilities in the reduction of different materials and their correct separation for recycling (recyclability).

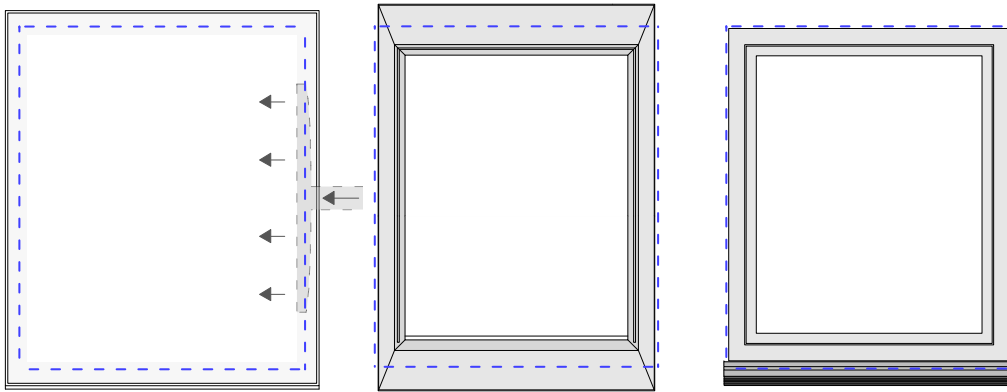


Fig.6 Elevations of variants left to right: 1,2,3, dashed blue line: structural opening; Source: EBB

The deep reveals of retro-fitted façade insulation massively limit the penetration of daylight into the buildings. The narrow consideration of heat losses through transmission neglects other aspects of the transmittance of solar radiation and the positive psychological impact of sunlight. The outward opening window of variant 1 enables a major gain in daylight. While the frame is invisible from the inside, the elements exposed to weathering are almost completely reduced to glass. (Reduction of building elements).

Further study of hardware fittings is required for the outward opening window of variant 1, such as are widely found in Scandinavia, in terms of large-size solutions and new opening combinations.

With respect to the daylight autonomy of the rooms the window size can be ignored.

The surrounding casing of variant 2 offers plenty of flexibility for the integration of additional components, also with regard to future customization. By activating the structural capacity of the individual pieces, additional material usage can be minimized. In design terms the surrounding frame is a given, nevertheless the form offers a wide range of possible variations.

Variant 3 has the advantage of easy handling thanks to the light weight of the insulation module. The integrated ventilation system could not yet be fully resolved in the project.

The potential to speed up construction processes and avoid defects make the "window machine" an especially interesting solution for new build projects, as well.

Key data

Short title: Window machine

Research / Project leader:

Dipl. Ing. Architekt (FH) Christian Bodensteiner

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