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# Short report

based on research project

# - Interface -

## „Multifunctional Element Façades for the Energy Efficient Refurbishment of Non-Residential Buildings“

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“The authors take sole responsibility for the content of this report”

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This research project will be fund by the Federal Ministry of Transport, Building and Urban Affairs in the context of the research initiative “future building“

## Goal of the research project

State of the technology

Today's office work stations deviate explicitly from those of the fifties and seventies. Function and ergonomics of office equipment as well as mode of information flow based on technical innovation and operational procedures have changed essentially.

In addition to flexible design of office work stations and (modern/electronic) ways of communication, a good indoor climate is acknowledged as significant factor for the high efficiency of employees. Basis for an increase of user's contentedness and productivity is the "renovation" of office work places into a new modern working environment in which users themselves can regulate the climate in their immediate surrounding. Operating costs are directly influence by improved comfort. A higher acceptance of the working environment reduces sick leave and unproductiveness and thus minimizes overall cost.

Precondition for a good indoor climate is good air quality as well as good acoustical, thermal and visual comfort. A one percent decrease of the added value of a workplace caused by bad indoor climate sums up to more than the total annual costs of internal air conditioning and heating. The comprehensive understanding and consideration of these effects reveal the great potential of the reconstruction of non-residential buildings from the fifties and seventies.

Research Project

The potentials of refurbishing building shell and technical building equipment with a local system repair will be analyzed in the research project "Multifunctional Element Façades for the Energy Efficient Refurbishment of Non-residential Buildings" (Interface). Multi-functional element façades are a new type of curtain wall that integrate ventilation systems for supply and exhaust air and air conditioning. They promise highly flexible technical solutions with a minimum of used space. The project analyses installation details and the systems ability to provide a good indoor air climate. In order to analyze the system performance in regard to indoor comfort a mockup of the façade consisting of two elements is being set up in the test bed of the IGS laboratory. Compared to central air conditioning systems, local systems have significant advantages. Interface research project contributes consolidated findings on their performance especially as alternatives for refurbishment of non-residential buildings.



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## Procedure of the research project

Preliminary studies and procedure

The project is based on two recently concluded projects carried out by IGS. Typical types of refurbishment for office buildings have been developed within the project “PROsab - Refurbishment of Office Buildings of the 50ties and 70ties under Energy efficient and Comfort oriented Aspects”. The second project “DeAL” focused on a field study evaluating the performance of façade integrated ventilation systems in new office buildings in Germany. Both projects considered architectural, functional and economic aspects as well as building physics and indoor climate.

Literature Review and Test Bed

An in-depth potential analysis is drawn from results of above mentioned preliminary studies and findings gained from theoretical research of “Interface”. Crucial basic conditions and future demands on a building are being evaluated focusing mainly on implementation of local building services systems integrated in multifunctional element façades. A test bed consisting of sample façade and climate-chamber is set up in the laboratory of IGS in addition to literature research determining the current state of knowledge.

The E²-façade is a modular system of Schüco International KG, a leading manufacturer of façade systems in Germany, and is being installed in the test bed with different functional modules. Main feature of this multifunctional façade is the combination of building shell with an integrated local air handling unit. Through several components the E²-façade is supposed to provide high energy efficiency and a high standard of user comfort. The façade can be controlled by an electronic management system that automatically reacts to weather conditions or user behavior. The system controls ventilation rates, supply air temperature, blinds and further features and can be integrated into any building management system.

**Figure 1 Elevation $E^2$-Facade**

**Figure 2 Detail $E^2$-Facade**



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Experimental assembly

In order to simulate a practical location the analyzed façade module is installed in the climatic chamber as shown in figure 3. The room is divided so that the warm side imitates the office room whereas the outside temperature is being simulated on the cold side. The “office inside“ has a size of 11m² and is fitted with a 160 Watt electric heater to simulate heat sources equal to two people. A humidifier maintains the relative interior humidity at 40 percent. The set room temperature is 20°C.

Outside temperatures in the chamber are set as follows:

- Heating: **-10°C, -5°C and 0°C**
- Cooling: **26°C, 29°C and 32°C**

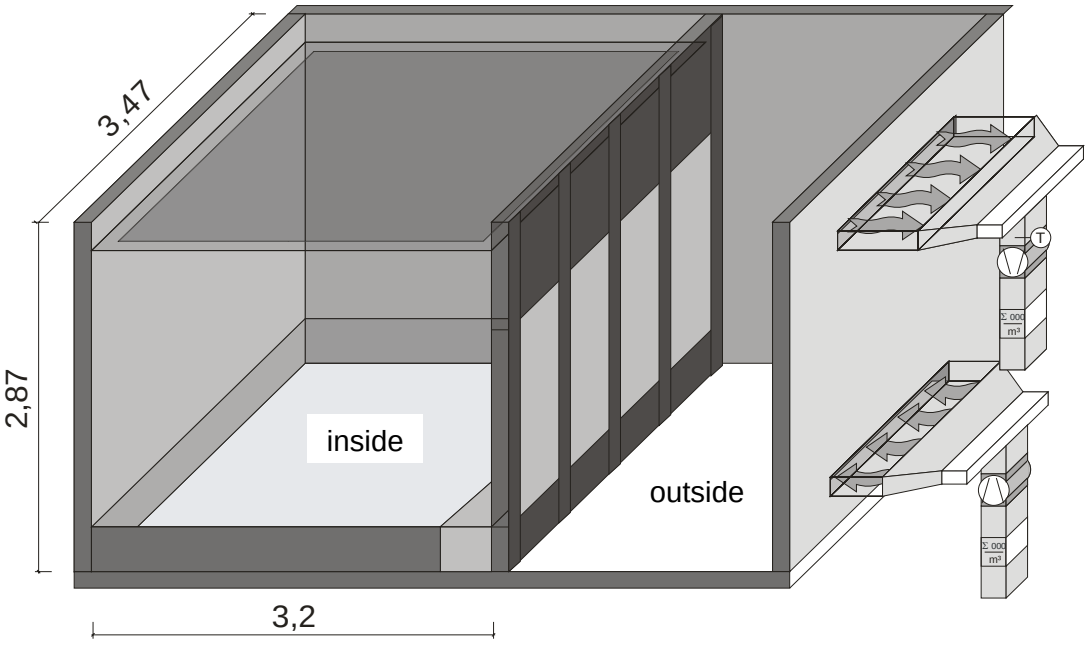


**Figure 3 schematic experimental set up in the climatic chamber**

The test bed façade has integrated air handling units in the double floor as well as units attached to the ceiling. Heating, cooling and ventilation is thus provided locally via simulated outer façade. Different ventilation strategies are being analyzed in order to gain an optimized operation mode with special emphasis on improved energy efficiency. Furthermore, façade and air handling units will be tested for their capability to ensure comfortable indoor temperatures and increase user comfort.

Productivity and capacity of local devices is being analyzed and evaluated under various conditions.



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Following parameters of comfort are crucial to research work in the climatic chamber:

- Room air temperature / global temperature
- Surface temperature
- Surface temperature of the window
- Relative Humidity of the room
- Air distribution and cruise of room air
- Measurement of noise level
- Characteristics during wind attack

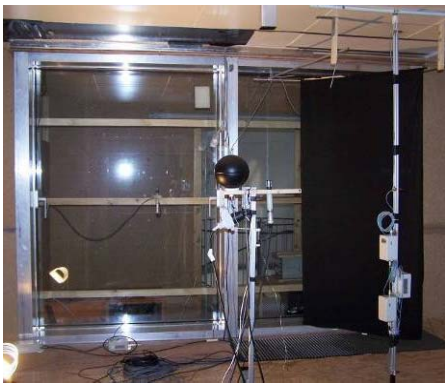
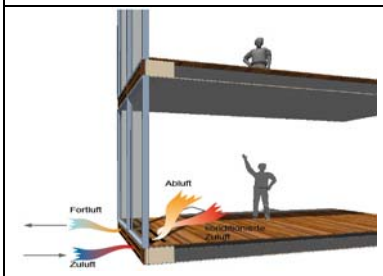
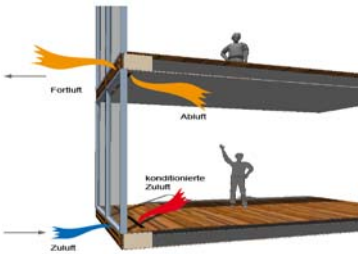
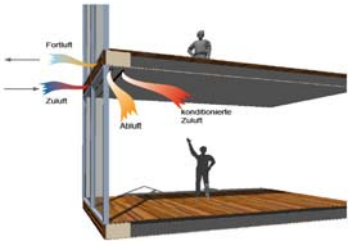


**Figure 4 Arrangement of measurement techniques**

This experimental assembly analyzes three functional ventilation strategy of the facade:

| **Option of the equipment 1** | **Option of the equipment 2** | **Option of the equipment 3** |
|---|---|---|
|  |  |  |
| Subsurface air conditioning appliance with heat recovery (Schüco IFV 120 GH) | Subsurface air conditioning appliance and under ceiling air conditioning appliance (Schüco IFV 120 GI and Schüco IFV 120 CE) | Under ceiling air conditioning appliance with heat recovery and bypass (Schüco IFV 120 CB) |

**Chapter 1 Option of the equipment / Ventilation strategies**



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Following advantages and disadvantages of the above described local ventilation strategies have been discovered:

### Option of the equipment / Ventilation strategy 1:

Subsurface air conditioning appliance with heat recovery (Schüco IFV 120 GH)

| *Advantages:* | *Disadvantages:* |
|---|---|
| • Application possible for big power ratings, saving of energy with heat recovery<br>• Simple maintenance with filter change and cleaning<br>• warm air current in front of façade during heating caused by vertical ascent of warm air<br>• Good air distribution during cooling: equal distribution in the room<br>• Good/satisfying air distribution during heating | • air distribution overbearing in axis of convector<br>• Drafts occur during temporary Boost-level (Boost-level via GLT after period of use)<br>• Higher equipment costs caused by heat recovery<br>• Air conditioning appliance on the floor can not be covered |

**Chapter 2 Option of the equipment / Ventilation strategy 1**

### Option of the equipment / Ventilation strategy 2:

Subsurface air conditioning appliance and under ceiling air conditioning appliance (Schüco IFV 120 GI und Schüco IFV 120 CE)

| *Advantages:* | *Disadvantages:* |
|---|---|
| • Application possible for lower power ratings<br>• Air conditioning appliance quieter than appliance with heat recovery (lower falls of pressure)<br>• Excellent air distribution during cooling: equal distribution in the room<br>• Good/satisfying air distribution during heating<br>• warm air current in front of façade during heating caused by vertical ascent of warm air<br>• higher costs for appliances with heat recovery<br>• Simple maintenance with filter change and cleaning (only for supply air unit) | • decreased energy efficiency because of missing heat recovery<br>• Draft possible during higher ventilation level<br>• More space required (ceiling and floor)<br>• Air conditioning appliance on the floor can not be covered |

**Chapter 3 Option of the equipment / Ventilation strategy 2**



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**Option of the equipment / Ventilation strategy 3:**

Under ceiling air conditioning appliance with heat recovery and bypass (Schüco IFV 120 CB)

| *Advantages:* | *Disadvantages:* |
|---|---|
| • Good air distribution during cooling: equal distribution in the room<br>• Application possible for big power ratings, energy savings via heat recovery<br>• With horizontal air exhaust: no draft at office place<br>• Easy handling of exhaust slats at air conditioning appliance<br>• Less space requirements on floor level | • air distribution overbearing in axis of convector<br>• Satisfying air distribution during heating: horizontal air exhaust causes lower air movement at the office place<br>• Time consuming maintenance (requires a ladder - working overhead) |

**Chapter 4 Option of the equipment / Ventilation strategy 3**

## Summary of goals

Conclusions of “Interface” reached with façade testing of various ventilation strategies in regard to user comfort, comfort at work station, energy efficiency and space efficiency may be summed as follows:

- Desired room temperatures have been maintained at any of the analyzed outside air temperature levels in summer case as well as winter case
- Good comfort at the work place can be gained through room conditioning with local ventilation appliances
- Criteria of comfort (DIN EN ISO 7730 (Class A and B) are met in regard to temperature, indoor air humidity and air speed.
- Integration of a heat recovery considerably minimizes heat demands.
- Capital costs for realization of local ventilation concepts are comparable to those of central ventilation system.
- Capacities of air volume can be individually adjusted to user needs via regulation of power levels.
- Local air conditioning appliances can be easily adjusted based on presence of employees. Considerable energy savings can thus be reached during operation.
- A higher volume efficiency can be reached for new builds with local air conditioning concepts. The integration of technical equipment in the façade (element façade) can diminish construction heights of ceilings and floors.



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- A high level of pre-fabrication of local element façades with integrated technique is specially qualified for refurbishment. Various sections of refurbishment can thus be enabled.

Following chart shows the advantages and disadvantages of local and central air conditioning concepts:

| Local technique: | Central technique: |
|---|---|
| • Removal of suspended ceilings - greater freedom of design – optional activation of thermal mass<br>• Possible improvement of comfort by users<br>• Building refurbishment possible in various sections<br>• Smaller control rooms<br>• Lower place requirement<br>• Lower energy costs<br>• Flexible use of space<br>• Direct influence of users on indoor climate with individual comfort<br>• Saving of electric energy fo airlift (lower fall of pressure)<br>• No necessity for sealing of air ducts<br>• bigger benefit of floor space due to location of ventilation systems<br>• cause related possibility to charge waste producer<br>• operation only during presence of users in particular room | • Lower effort of maintenance<br>• shorter media lines<br>• humidification and dehumidification of ambient air easy to realize<br>• Air conditioning of rooms with large spatial depth is possible<br>• Higher rates of waste heat recovery<br>• Entire system has to be deactivated for maintenance, even though it takes place in separate room.<br>• Refurbishment during operation is hard to realize<br>• Long and lossy supply channels are complex in construction and have inert modes of distribution<br>• Difficult registration of individual consumption leads to less comprehensibility and comparability<br>• Lack of possibilities to inspect channel system can lead to disturbance of rooms during operation. |

**Chapter 5 Advantages and disadvantages of local and central ventilation systems**

<u>Forecast/Perspectives</u>

Possibilities of integrating local technologies to multifunctional element façades open new design alternatives to architects and engineers in regard to energetic refurbishment of non-residential buildings. This leads to the point where necessary media devices for local ventilation systems can be integrated into refurbished façade or building shell and thus be prefabricated by assigned façade company. The multifunctional façade element can then be delivered to the construction site and mounted to the building. Merely final fittings are necessary and take place on site in terms of “plug and play”. A custom-fit prefabrication in the factory considering all components of the outer shell and building services is thus



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ensured. Due to the multifunctional element construction there is the possibility to renovate a building step-by-step without mayor influences on rentable floor space. The dismantling of old façades and so called “refurbishment during operation” as well as affiliated strengthening of building stock occur quick and smooth in most cases. With the use of multifunctional element facades a non-residential building from the 50ties and 70ties can achieves high energetic standard in all aspects of architecture, building physics and building services. Both, users individual needs and the resulting demands on comfort are thus being considered. The integration of sustainable local components for energy production (e.g. photovoltaic) to the façade allow additional functions within the modular system. An interdisciplinary team of architects, structural engineers and specialized engineers works together from early planning stage and thus involves all different approaches and building needs to the design of the multifunctional element façade. A top level building standard can be reached due to a high level of prefabrication in the factory and a coordinated involvement of different building trades during installation. The fabrication of the elements in the company is closely monitored and controlled before they are approved for construction site. Detailed coordination of all building components is required for prefabrication and leads to high fitting accuracy and high quality of contact details. A cost efficient and smooth installation on site is thus accomplished. In case of refurbishment it is possible to remove overage components of ventilation systems from inside the building. With the application and integration of the entire building services to the façade, a new, flexible and architectural high-class office structure can be realized inside buildings. The same goes for buildings, that have previously been fitted with low technical equipment and used free ventilation via windows.

The knowledge gained from this research project gives an overview of possible values and potentials of using multifunctional element façades in case of refurbishment. Due to the option of step-by-step refurbishment of sections or individual parts of the building the element façade has a great potential for refurbishment during building operation. Furthermore the individual controlling of small service units in order to reduce energy consumption can simultaneously lead to an improvement of user comfort.



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