A flexible and upgradeable facade concept for refurbishment

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ABSTRACT: A large percentage of offices in Europe is outdated on technical and design aspects. Different promising facade and climate concepts exist for new construction. The presented research aims to derive from these systems a high potential flexible and upgradeable façade concept suitable for renovation of office buildings. For a case study a concept has been developed which provides connections and installation space. Different levels and means of installations are just as possible as an easy change of cladding material or building physical standards. As such system can supply the necessary installations appropriate to every individual room it prevents the production and mounting of excessive components. Being upgradeable it combines the interests of sustainability and an economics to extend the life cycle of building stock.

1 INTRODUCTION

Two thirds of the office buildings in Europe are outdated. This means that façade and installations are older than 30 years (Russig). The average renovation interval for the interior is seven years. Design fashion changes rapidly. The supporting structure on the contrary can last very much longer. Dealing with a decreasing market for office real estate and thus falling rental rates, while user demands enlarge, building owners face the question of how to treat their office stock.

Demolition of technically good buildings leads to unnecessary waste, emission of CO2, energy consumption both in construction, as well as in form of grey energy bound in the material and processes. It also is a question of destruction of capital and on the social level a loss of architectonic identity in successively grown city centers.The research project “Systems in Façade refurbishment” aims to analyse common problems and to proof that renovation of offices can be a feasible solution helping to extend the life cycle of buildings.

2 DEMANDS FOR FAÇADES

To be able to deal with current and future demands for a building envelope one has to take many different aspects into account during the design process. Those aspects can be sorted into the categories: Architectural design, building construction, installation and financial aspects (Figure 01). The importance of economic aspects in the planning and design process is often underestimated, as ultimately, every concept has to prove it’s feasibility to be realized.

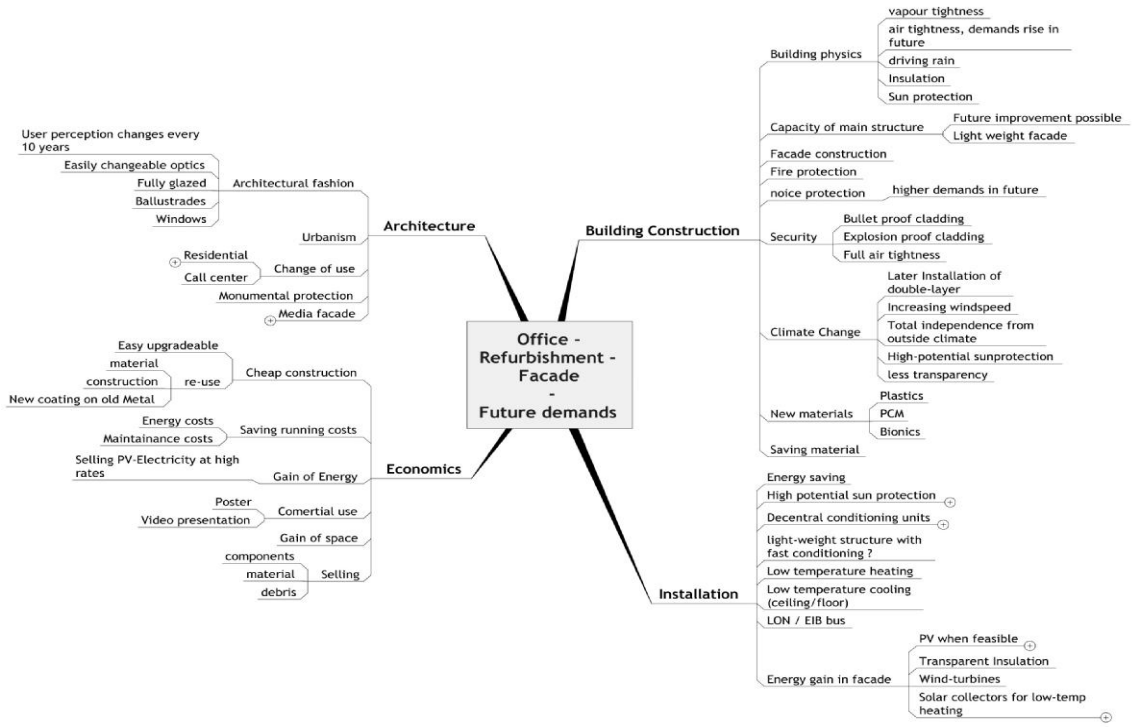

Figure 01: Overview of future demands for office facades

2.1 *Architectural design:*

- The architectural fashion is subject to constant change. To maintain a building, the outer appearance should be possible to be changed easily. New materials will provide properties and functions not yet known. Media installations may become a more important feature.
- On the contrary to constant change, more and more buildings are subject to monumental protection. In such case an upgrade may only take place without changing the outer appearance and will thus interfere with the interior.
- The use of the building may change. The tendency to work from home and not in a physical office, for example, already leads to an oversupply of office space. This situation will probably get worse in the future. To deal with it, the option to change the use of the building, e. g. to residential use, must be considered.

2.2 *Building construction*

- The supporting structure of a building limits the possibilities in façade renovation. Particularly steel structures are often not capable of extra loads. In such case the use of light weight materials can be considered.
- Fire protection has shown to be one of the biggest issues and motivations for renovation.
- While upgrading the façade all aspects of building physics, such as insulation, and vapour impermeability have to be brought to actual standards. A further future update should be kept possible.
- Global climate change will most likely cause a demand for future upgrade. While today's standards meet current needs, in the future higher temperatures, greater wind loads and stronger rainstorms are expected. (Stock)
- The requirements for security are likely to be higher in the future.

2.3 *Installations*

- Climate, electric and IT-installations are subject to constant development, thus a chance for upgrade must be provided to easily maintain or replace components. Furthermore the complete HVAC concept may be altered, e.g. to low temperature heating and cooling.
- The gain of energy within the façade is another topic of interest. Large surfaces of buildings can be equipped with PV or other means to produce energy which can be used or sold.
- Sun protection is most important in office buildings. Buildings with more than 55% of glassed surface tend to overheat (Hausladen) et al. Modern sun blinds installed outside prevent excessive heat input while allowing indirect natural lighting.
- Decentralized installations provide a large potential in renovation, as every need for ventilation and air condoning is met in the façade without the demand for ducts inside the building.
- The recent development in BUS systems makes control and maintenance of many data-points possible. Modern climate concepts demand a facility management system that allows for both individual and central control.
- The users' demands on their work environment change often. In northern Europe, for example people ask for individual climate control and operable windows for direct connection to the outside, while in other countries office staff relies more on central air conditioning.

2.4 *Economic aspects*

- The expense of building process and construction is only one part of the financial plan
- Re-use and re-cycling of material saves costs, selling of used material, is an option
- Very important for the users of a building are running and maintenance costs. With the introduction of the European Energy passport (EU) a tool is introduced which makes these costs more transparent to tenants and thus influences their decision for a property.
- Energy gained in the building envelope can be used or sold, often to very good conditions, depending on political guidelines.
- By renewing the façade and installation concept extra space can be gained due to smaller components or by transferring installation space into rental space by replacement of central air conditioning systems with decentralized façade-bound components.

3 LATEST DEVELOPMENTS IN FAÇADE CONCETS

3.1 *Service integrated façade systems*

Various façade system producers and architects have recently developed service integrated facades. These are composed of parts with fixed glazing, operable windows and decentralized HVAC service installations. In the development process facility managers, climate designers and the manufacturers of HVAC components are integrated.

Such systems are designed as element facades which can be installed in floor-high components. Decentralized heating-, cooling and ventilation units provide all necessary installations with minimized dimensions. They include mechanical ventilation with heat recovery and a heat exchanger for air conditioning. Air is taken in and brought out directly through the façade in every element. Thus no central mechanical ventilation and air ducts need to be installed.

Due to these short distances, such units provide a high efficiency in air conditioning and heat recovery. As every façade element is equipped with HVAC installations, it is easy to provide individual comfort control for every office space. Disadvantages of such systems lie in the lack of compatibility with operable windows and mainly in a large number of maintenance points like filters. A well administered facility management system is essential for this façade type. BUS installations with many data-points help solve the mentioned disadvantages. Two examples for modern, integrated façade systems are shown in Figure 2 (TEMotion) and Figure 3 (Capricorn):

Figure 02: Facade system TEMotion

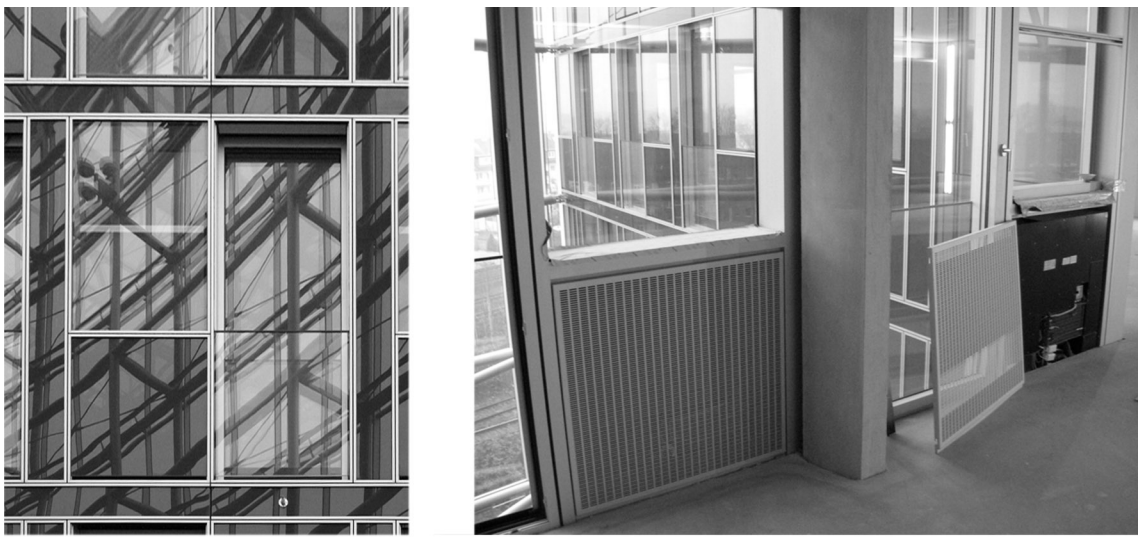

Figure 03: Facade system Capricorn building, Düsseldorf, Germany

3.2 *Fibre concrete façade, a development at University of applied science, Detmold, Germany*

Within the course program on glass construction a modular façade with integrated building services has been developed. This façade concept uses fibre reinforced concrete for the framework of the façade element.

The development of fibre reinforced concrete makes it possible to produce slim profiles and frames that have nearly the same dimensions as those manufactured from aluminium or steel. With such dimension the profiles are capable of carrying structural loads. Thus in a new construction of pre-fabricated elements this façade-concept makes load bearing columns redundant. At the end of the life span of a building made of prefabricated elements, the components, made from long-lasting material, can be re-used either directly or after being overworked in the factory.

The installation space provided within the façade element is dimensioned in a way that it can take in different installation components from a simple radiator heating up to an installation unit correspondent to those mentioned above. Operable windows provide natural ventilation, which, in northern Europe, makes mechanical ventilation unnecessary in spring and autumn.

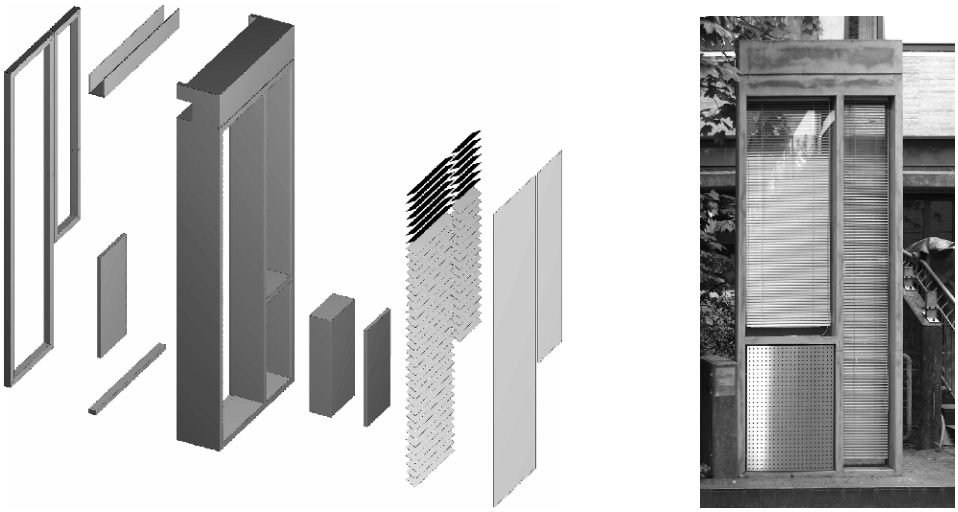

Figure 04: Fibre Reinforced façade module

4 THE REFURBISHMENT ENVELOPE THAT CHANGES WITH THE USE

All the service integrated façade systems on the market have been designed for new construction and thus plan to be equipped with complete installation units in minimized dimensions. For the task of refurbishment special matters have to be taken into account. During a case study analysis within the research program “Façade systems for refurbishment” at Delft Technical University a renovation façade concept has been developed which is suitable for renovation of different building types. Within the case study it has been designed for a building with concrete balustrades. This is reasonable, as fire regulations in Germany, where the case study building is located, demand a vertical barrier of one meter for high rise buildings.

The façade is composed of five components: A non transparent balustrade, a fixed glazing, an operable window, vertical connection elements and integrated space for installation units. For the case study the façade has been constructed as a ventilated façade, which can be cladded with different materials such as metal, glass, natural stone or wood panels. Further advantages of the ventilated façade lie in the flexibility for exchange of elements and insulation as well as in the good heat protection in summer due to the shading effect. The complete façade structure is mounted from the outside, which causes little interference with the interior. While connection details stay the same, the façade grid is adjustable both horizontally and vertically to different office grids.

Operable windows contribute to energy saving in spring and autumn. They provide the user with a desired connection to the outside and serve for maintenance and cleaning as the dimension of the fixed glazing permits to be reached from the window openings.

Horizontal adjustable sun blinds are installed outside the façade. These provide an efficient sun protection combined with relatively low costs and individual control. Depending on wind loads the installation of an additional glass pane for protection of the blinds can be considered.

Vertical connections between the floors of the building provide the option to install new tubing, electric cabling and IT installations within the façade. This prevents interference with the interior of the building, as no installations need to be installed in rooms or hallways. Existing installations can either continue to be used or set out of service depending on the climate concept. Old tubing can later be removed, when the next renovation of the interior is due. Horizontal distribution of media is realized within the balustrade space of the façade system. The installations are brought into the building either through the balustrade or at the connection points to vertical elements. Installation space is generously dimensioned to allow adding or replacing of ducts in the future.

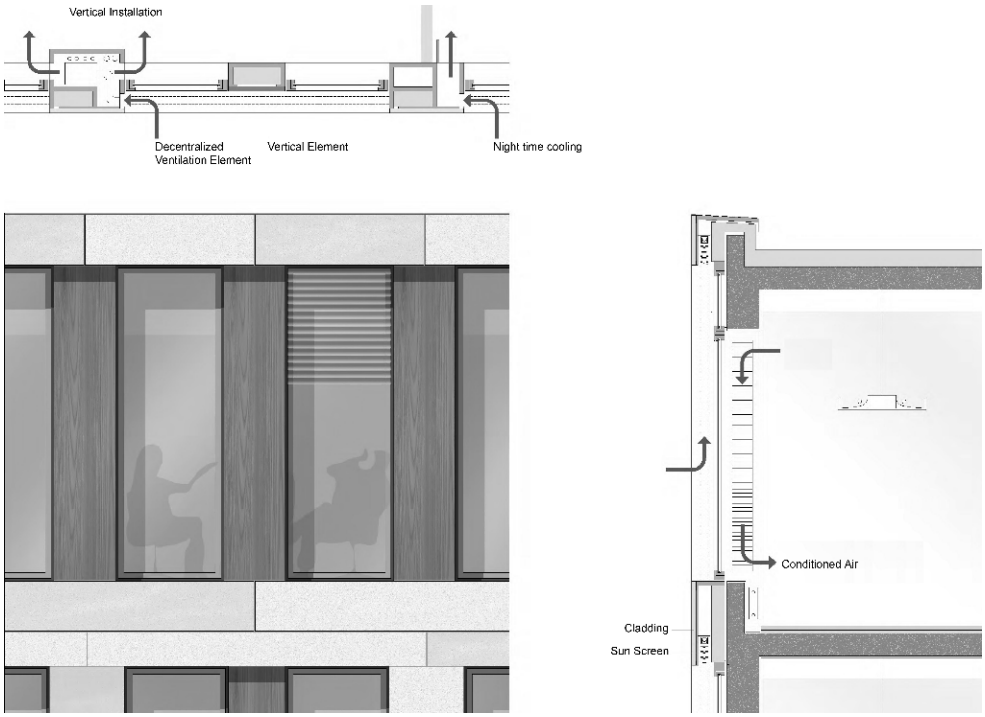

Figure 05: Concept for upgradeable refurbishment façade

The installation units integrated into the façade can be placed horizontally at balustrade level, where fire protection demands and given circumstances allow. Alternatively they can be installed vertically, in addition to or as a substitute for the connection elements.

The climate concept is based on the idea of de-centralized installations and full flexibility for upgrade and change. Following this, the installation "box" can be filled with different components or left empty. During the life cycle of the building different demands occur for different rooms (north- or south side; many electric appliances; high air exchange rates; etc.). With a flexible system rooms can individually and successively be up- or downgraded depending on the use. The following installation concepts are imaginable:

1. A minimal solution
   The building is equipped with high insulation and a ventilated façade. Thus it does not need any cooling and only minimal heating. Existing radiators (often installed in northern European office buildings) will be kept in use. Operable windows supply ventilation.
   This concept demands "smart users" able and willing to adjust their own office climate. Window contacts, thermostats and a central override control for heating and windows would allow saving energy or open designated windows for natural night time cooling.

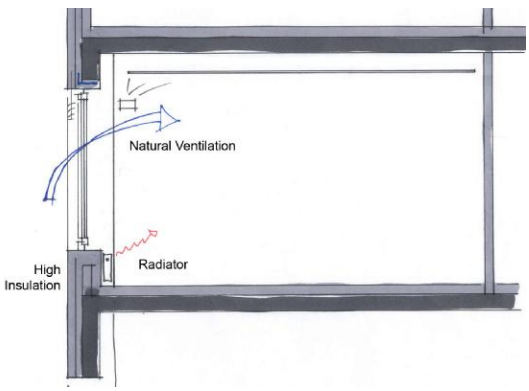

Figure 06: Minimal solution

2. Improved energy performance through heat exchangers
   As natural ventilation may lead to higher energy demands in extreme weather conditions (summer, winter, climate change) due to the direct exchange of air of different temperature levels, mechanical ventilation with heat recovery is a common option. Small individual ventilation units can be installed in the climate-boxes and thus provide fresh air without the loss of thermal energy. Such small decentralized fans with heat exchanger provide a high efficiency, as no ducts are needed to transport conditioned air.

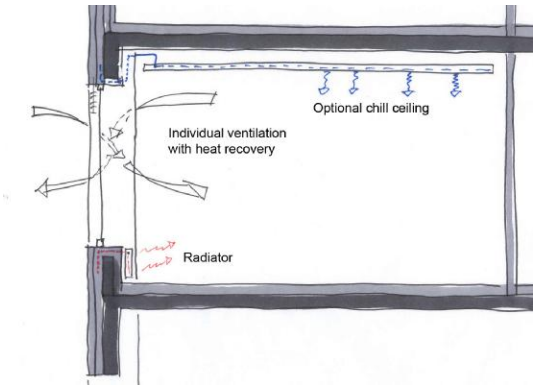

Figure 07: Improvement by heat exchanger

3. The all-in-one solution
   Climate installation devices which provide ventilation with heat recovery and air conditioning by heat exchangers can be placed into the installation space provided. These are connected to hot water and cooling liquid circuits, are controlled individually and provide full climate conditioning with a high efficiency. This is due to direct air supply through the façade and small, energy efficient fans.

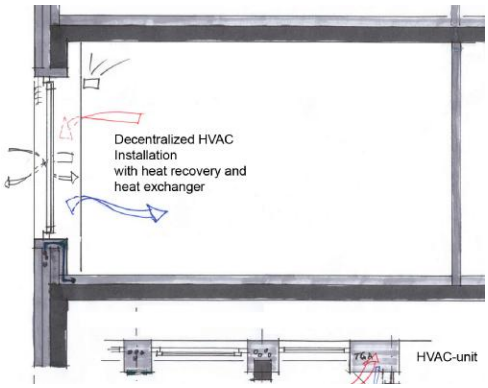

Figure 08: Decentralized HVAC units

4. Low temperature heating/cooling
   Alternatively to active air conditioning, the installation of low temperature systems can be considered. A chill ceiling provides comfortable cooling in summer by transporting water of a temperature slightly below room temperature through small tubes within a suspended ceiling. In a highly insulated office building heating is only rarely necessary, thus the ceiling can also be used for heating in winter. For a surface heating the temperature of the water only needs to be around 25 °C instead of the 70°C hot water needed for radiator heating. The changing of the climate installations to such a low temperature system makes the old machinery redundant and opens the field for sustainable solutions. The desired temperature level can e.g. be reached by geo thermal energy and heat pumps.

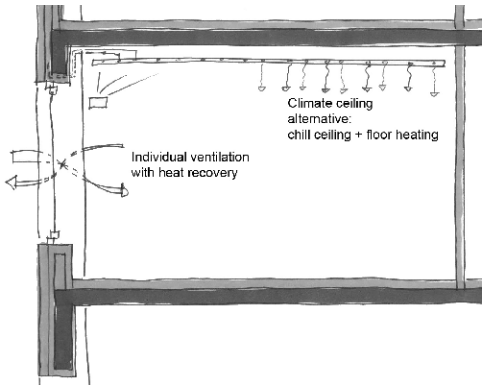

Figure 09: Low temperature heating and cooling

As long as installation space is provided and easily accessible changing of installations can be done with minimal interference with running work. An important task not yet solved lies in the easy possibility to combine and connect components. While electric and IT installations are equipped with common connectors, the topic of easy (de-) connection of water-, heating and cooling liquid tubing is new in the building process.

For future buildings it is imagined to be an interesting marketing concept to offer “Facades for rent”. Users rent façade components or installation parts according to their need. When they are not needed any more, the supplier takes them back into stock to rent them out to other clients. This extends not only they life cycle of the building, but also the one of every component and prevents an overproduction.

5 SUMMARY AND CONCLUSION

There is a big market for refurbishment of office buildings. Many interesting façade systems and components are already available for new construction. To transfer those for the task of renovation, various special aspects have to be taken into account. New developments particularly have to deal with the demands of the user and a big flexibility in construction, installation and design. To achieve flexibility and upgradeability of the building envelope a standard is needed for dimension and connection of various installation components. New business-concepts may turn up in which a tenant of a building can rent installation components to be installed into his façade system according to his needs and return them for re-use. New materials and technical innovations will contribute to more sustainable and material saving constructions.

Finally it can be concluded, that refurbishment of office buildings by means of smart façade and installation concepts extends the life span of buildings significantly and thus supports both feasibility and sustainability.

6 REFERENCES

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