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A New Façade Concept

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This paper is focussing on the development and opportunities for new façade concepts. In a survey on the possibilities for energy saving in the supply chain of the Dutch glass industry it appeared that there are major opportunities for applications of glass in the European building stock. The integral application of several glass products was the basis for the development of a new façade concept. Apart from saving energy this concept also solves some major problems in the construction industry and the refurbishment of the European building stock. Therefore this paper also contains information about shortcomings and developments in the European construction industry as well as the scale and characteristics of the European building stock suitable for the application of the new concept.

Keywords: glass application, energy saving, façade concept, building process, building stock

1. Introduction

This paper is a follow up on a survey [1] carried out by Moonen Consultancy in collaboration with Lichtenberg Consultancy and TNO in commission of SenterNovem. The objective of that survey was to make an inventory of the opportunities for energy reduction in the production and application of products manufactured by the Dutch glass industry. This work was carried out in the frame of a possible commitment between the Dutch Government and the Dutch industry. The production of the Dutch glass industry includes among others: float glass, fibreglass for reinforcement, fibreglass insulation and lighting glass.

Especially the reduction of energy consumption regarding heating, cooling and lighting in the European buildings stock appeared to be interesting for (an increase of) glass applications. Regarding the opportunities of a joint action of the Dutch glass industry, it was suggested to develop a new façade concept with an integral application of float glass, fibreglass reinforced composites and fibreglass insulation. New on this concept is the ability of pulling out the 3D-façade parts comparable with a drawer and by that expanding the floor area. Apart from flexibility, the benefits of this concept are: low U-values, integration of window frames suitable for multilayer windows and an improved air-tightness, more opportunities for free form design enabling improving shading, industrial and adaptable potentials based on off-site production, extension of the inner space and an improved panorama view.

Why a façade? The façade is a substantial element in the architecture of a building and divides the inner and outer space concerning noise, light, heat, air, moist, security and privacy. Beyond any doubt the façade herewith is the most complex and expensive building part. The building industry with its one-of-a-kind projects, on site production, temporary organization and many small enterprises, is not able to offer proper solutions on a conceptual level, especially for refurbishment. In order to develop and provide such products an industrial infrastructure comparable with the automotive industry, is required. The glass industry probably has the competences to fulfil this role. This downstream integration of the glass industry in its supply chain will create more turn over with much better margins. Research is needed in order to prove this thesis, possibly in the frame of a PhD-research.

2. The glass survey

2.1. Approach of the survey

The survey was carried out in collaboration with the Dutch glass industry. Interviews were taken with employees responsible for the production, development, purchase and sales. These employees were considered to be informed about the interests and requirements within their companies. With the exception of table glass the entire Dutch glass industry was involved. The interviews were prepared by desk research and the involvement of glass expert prof.dr.ir.R.Beerkens from TNO.

2.2. Results of the survey

As a result of the survey 55 possible actions to improve energy efficiency were identified. These actions are related to research, regulation, finance and knowledge transfer. Related to the supply chain efficiency in total 30 actions for energy efficiency were identified and confirmed by the Dutch glass industry. In order to get a clear image of the impact on energy savings and on reduction of carbon emission of these projects an overview was composed, see table 1.

Regarding the possibilities of saving energy by the smart application of solar glazing, lighting and insulation in the European building stock it was proposed as a joint action to develop a new facade concept and to start with a feasibility study. The proposed façade concept will be based on an industrial production and market approach. The unique characteristics compared to the usual façade concepts are as follows:

- Reduces U-values;
- Integration of window frames including multi glass layers and a high level air tightness;
- Planned shading by free form design;
- Flexibility and adaptability;
- Extending the floor area;
- Improving the view;
- Free façade design per orientation, floor and building user.

This concept has the potential to create value and herewith substantially improving the margin of the glass industry. In the Dutch glass industry the margin is usually based on cost effectiveness.

Table 1: expected energy savings and carbon reductions in Europe related to some actions of the survey

Issue	Energy saving/production	CO2 reduction*	Reference
Solar Control Glazing	Till 1 million TJ in 2020 in 25 EU states	Till 80 Mton per annum in 2020	4 major European float glass manufacturers (GEPVP)
Lighting Office lighting Public lighting	50 million barrels oil per annum in EU 25 million barrels 12-14 miljon barrel	28 Mton per annum 8 Mton 3.5 Mton	Philips Lighting
PV	150 - 300 GWp PV-facilities in the OECD countries		The Photon Consulting report "The True Cost of Solar Power"
Insulation	1.2 biljon barrels per annum in EU	460 Mton per annum	European Insulation Manufacturers Association (EURIMA)
Wind	230 GW capacity in 2020 in EU	338 Mton per annum	European Wind Energy Association (EWEA)

* To compare: the carbon emission of the total Dutch glass industry related to the production is 0.65 Mton/a

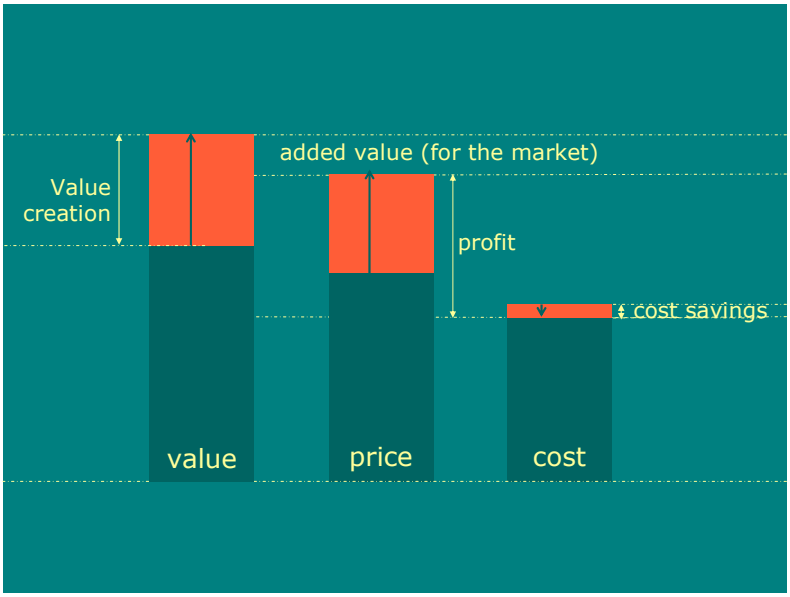

Figure 1: improving margins by creating value in the supply chain provide better opportunities than cost reduction.

The possible commitment between the Dutch Government and the Dutch industry concerning energy saving is still in discussion. So up till now the next step of the survey is uncertain.

3. The construction industry

3.1. Shortcomings

From the point of view of the consumer, the construction industry and the society the shortcomings of the construction industry can summarized as follows.

For the consumer the building offers a controlled environment where he lives, works, stays and moves. An adequate build environment is therefore of a crucial meaning for the economy and general well being [2], [3]. From the perspective of the consumer the shortcomings in the building environment are in the performance, affordability and availability [2], [3]. The terms of references for building projects are beyond the influence of the consumer [4]. The existing building stock does in general not meet the to days technical requirements [5], [6], [7], [8]. By the lacking availability, prices are extremely high and procedures and contracts are extremely complex [2], [3].

The position and organisation of the construction industry is among many others elaborated in the publications [21], [22]). An analysis of the market structure clearly shows that a lot of stakeholders are involved in establishing building projects. Among others architects, several consultants, the mean contractors, the subcontractors, the supplying industry, authorities, developers, estate agents and financial services. In general a major part of the construction work is carried out on site by quiet a number of subcontractors and suppliers who usually cooperate on an incidental bases. In such case the construction process is an addition of activities rather than a balanced result of a close cooperation ("working apart together"). Nobody seems to be the owner of the problem as a whole. In general the subcontractors are small and medium sized enterprises and are therefore not used to new developments especially for developments concerning the end product [3]. New developments are usually limited to sub optimizations, called innovation by addition [9]. Especially issues like health, energy, resources, emissions and safety are provoking change. However these changes are not initiated by the industry itself but in general by governmental institutions. The result is an increase of the price of the end product. An integral approach concerning the price and performance of the total product is failing.

Because of the importance of a well build environment and the impact of the construction industry on the economy and environment, governments and municipalities are strongly involved in the planning, realisation and exploitation of real estate. This is accomplished by research, regulations, subsidies, taxes and control.

3.2. Neutralization off shortcomings

To eliminate shortcomings a lot of attention is paid on:

- Radical process innovation like Open Building [10], industrialised construction [26], [11], [23], [24], [12], Slimbouwen [9] and new forms of procurement [13].

- Improving the management of the building process using the experiences from other industries like mass production, lean production, agile production, value generation, performance based production en mass customization [14], [15], [16].
- New tools to support the building process. Especially ICT becomes a lot of attention [17], [18], [19], [20], [25].

An alternative approach of the building process is in general aiming at reduction of weather dependency and to stimulate the application of industrial designed, produced and distributed products. To realise all this, a division between "support" and "infill" is a proven strategy. This division enables the flexible use of the building and the anticipation on new building codes, notions, materials and technologies.

To improve the management of the building process experiences from the automotive industry serve as a model. At first there were the experiences of Henri Ford regarding mass production and later those of Toyota concerning lean production.

Considering the complexity of the building process as a whole, from planning to delivery, and the large number of stakeholders much support is expected to be found in ICT. Among others ICT can be extremely important in the communication between the stakeholders and the communication about the building as a whole. The programs Performance Based Building (PeBBu), Bestfacade, EuroAce, Eurima en SUREURO pay a lot of attention to comfort, energy and environment and the tools that are needed to deal with this in the right way.

4. The façade concept

4.1. Starting points and benefits

The concept consist of a three dimensional façade element including i.e. glass fibre reinforced polymers and a steel or aluminium frame. The storey high elements are prefabricated and on site mounted in the building structure. By the drawer principle an elevated floor and suspended ceiling are introduced. The plenum can be used for ventilation with heat recovery and the elevated floor contains all kind of services and the possibility of floor heating. Special attention has to be paid to the required storey height.

By combining the variety of façade elements the architect is free to articulate each individual apartment. The design can also be the result of planned shading. The drawer principle provides extra floor area. The prefab façade elements can be combined with other prefab units like kitchens, entrees, bathrooms etc. In high-rise residential buildings the façade element can also be used to create covered galleries.

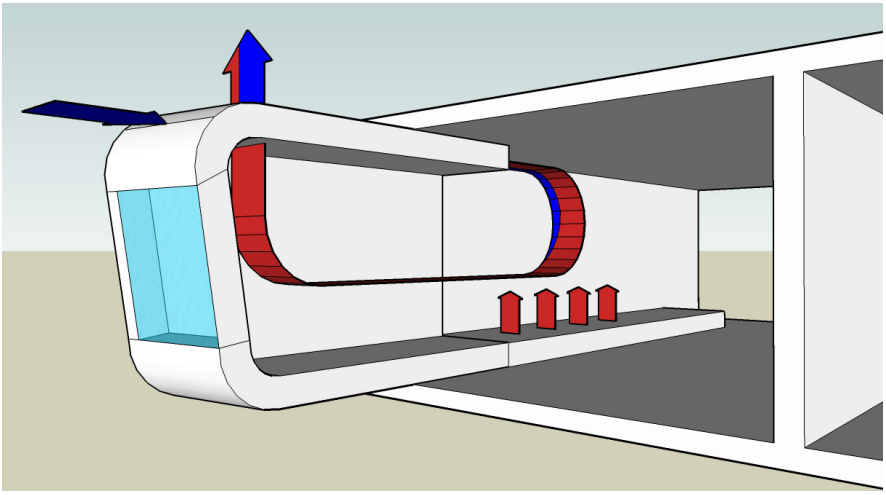

Figure 2: Sketch up of the drawer façade element.

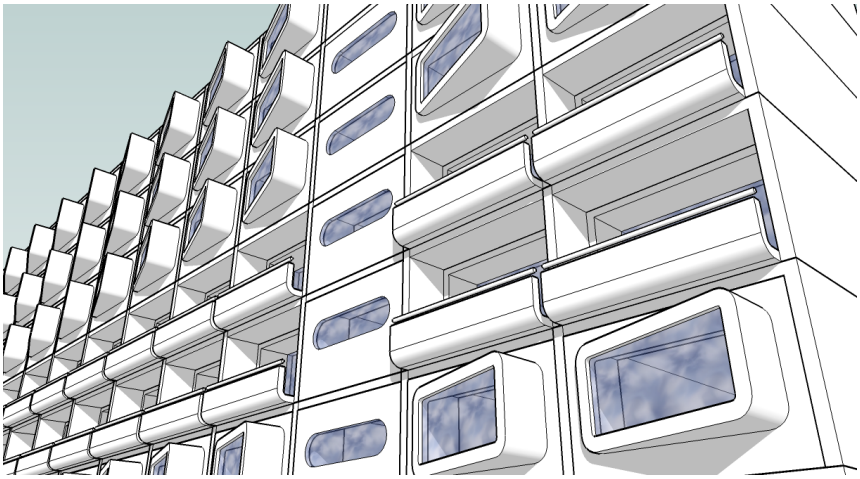

Figure 3: Example of the variety of design and shading.

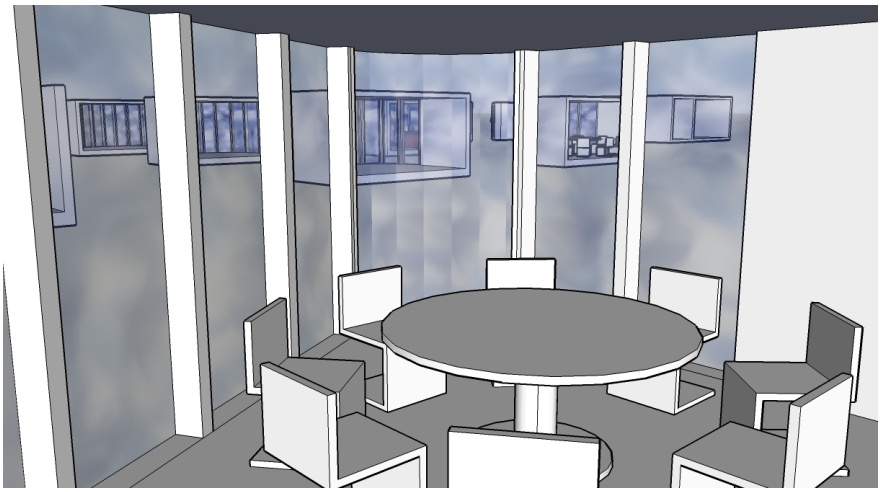

Figure 4: Extending floor area and improving view.

4.2. Market potentials

The idea about market potentials starts with the question is application of the new façade concept possible in new housing and in refurbishment? Application requires a building structure composed by floors, load-bearing walls or columns. In this way application is possible in residential and non-residential buildings, in new housing and especially in refurbishment of the building stock. Besides the application of the new concept isn't reduced by national cultures, boundaries or building codes and can be produced and distributed in every European country. High-rise residential and office buildings offer the best opportunities. An accurate refurbishment of the building stock leads also to a better balance in the housing supply which implies a better quality and better prices.

To get an impression of the market potentials the report for European housing ministers' was used [6]. According to this report there are over 100 million multi-family dwellings in Europe.

Table 2: Involved EU countries in 2004.

EU15=old EU member states	Austria, Belgium, Denmark, Finland, Portugal, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, United Kingdom
EU10=new EU member states	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia
AS4=accession states	Bulgaria, Romania, Turkey, Croatia

Over one-third of the multi-family dwellings are high-rise with more than 4 floors. Roughly calculated, there are 35 million high-rise dwellings. High-rise dwellings count for an average of 17.3% of the total housing stock in the EU countries. The percentage of high-rise dwellings in the EU10 is higher (in average 34.1% of total housing stock), compared to the EU15 (14.7%).

Over 65% of the dwellings in Europe are built between 1945 and 1990. In this period, most of the high-rise dwellings were built. This situation is similar across Europe. In the EU15, most high-rise dwellings were built in the 60's/70's; as in the EU10 and AS4 these were mostly built in the 70's/80's.

The living area of the most high-rise dwellings ranges between 20 and 100 m² and consist of 2 to 4 rooms. The size of high-rise dwellings in the EU15 is usually bigger than in the EU10. Almost 70% consists of apartments with 3 rooms or more. In EU10 almost 60% has less than 3 rooms. In Romania and Bulgaria, the multi-family and high-rise dwellings are substantially smaller than in the other European countries, as the living area of most dwellings, is less than 60 m².

The percentage of household income used for housing expenditures is about 25% both in EU15 and EU10. In AS4 it is about 10%. In EU15 most expenditures are allocated for paying rent or mortgage (approx. 70%), while in EU10 and AS4 the same percentage is needed to cover the costs of energy and other utilities. This fact also indicates that there is not much of a margin within the household budget to invest in maintenance and repair. Investment in the increase of energy efficiency combined with repair seems to be the most realistic option.

The owner occupies sector dominates the tenure structure of high-rise dwellings all over Europe, though there is distinction between the regions.

Table 3: the tenure structure in EU countries in 2004.

	EU15	EU10	AS4
Owner occupied	55.3%	35.5%	83.4%
Private rental	10.8	10.2	12.8
Cooperative	1.4	31.2	0
Public/social rental	12.4	20.8	3.8
Other	24.5	2.3	0

The major problems in the EU29 in general are: income segregation, unemployment segregation and housing affordability. The major problems in the EU15 in general are: ethnic / cultural segregation. The major problems in the EU10/AS4 in general are: building maintenance aspects, need for modernisation, payment arrears, parking, management and energy efficiency.

In the EU10, building with large prefabricated panels is the dominant construction method for high-rise dwellings, especially for the post World War II buildings. Due the mass production in a relatively short time span and due to the homogeneity in technology it can be assumed that technical and maintenance problems are quite similar in large parts of these panel buildings across a country and even across the whole region. One of the consequences may be that in the same time a large number of buildings need to be refurbished or come to an end of their life-cycles. In the EU15, the construction methods are very diverse, even though mostly in situ concrete is applied.

The energy consumption per household in multi-family dwellings in EU15 is approx. 50% higher compared to EU10/AS4. The potential energy saving resulting from refurbishment in EU15 is estimated at 20-40% and in EU 10/AS4 at 30-50%.

It is hard to make an exact calculation of the total investment needed for refurbishment of high-rise residential buildings. Nevertheless, when projecting the available information on the total multi-family stock, it is possible to get at least an indication of the total need for investment.

Table 4: need for investment in housing refurbishment in 2004

*)	total MF dwellings	Need for refurbishment	Average investment	Total investment in euro
EU15	80.566.630	15%	20.794	251.295.375.633
EU10	14.544.684	60%	9.950	86.831.763.480
AS4	4.985.900	80%	2.500	9.971.800.000
Total				348.098.939.113

*) excl. Croatia and Turkey.

The total (direct) employment involved in the actual realisation of the investment needed is almost as large as the current total employment in the sector in the respective countries.

5. Concluding remarks

This paper is not a report of a finished process but a follow up on a survey in the glass industry. The survey clearly shows the problem in designing products with high added value. On one hand there is a glass industry that is strongly focused on production. On the other hand a building industry suffering from shortcomings of all kind. By bringing these parties together there are a lot of possibilities for the development of products with enormous added values for both parties. In this case by developing a new façade concept. The state of the art technology with respect to façades is that they are carried out as an envelope mounted outside the building structure. The presented façade concept is based on three dimensional elements that are mounted like a drawer in between two floors. As such it is possible to design, produce and distribute these products in a way that is comparable with the automotive industry. That means efficient and consumer minded. That also means the creation of a product that contributes to flexible and sustainable building in Europe. This complies with the Slimbouwen vision. The ambition is to elaborate this façade concept possibly in the frame of a PhD thesis at the University of Eindhoven.

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