Renovation of Housing using a glass skin 
extra space, more comfort, better energy performance and an 
extended life span

M. Ham, R. Craenmehr, R. Driessen,  
Eindhoven University of Technology, TU/e,  
Faculty of Architecture, Building and Planning  
Vertigo Building, PO Box 513  
5600 MB Eindhoven, The Netherlands  
m.ham@bwk.tue.nl  

ABSTRACT

In almost every European country a large stock of houses exists. Many houses are outdated in respect to the space offered to the occupants, the general level of comfort and the energy performance. In the Netherlands some 1,300,000 post war houses built in the 1946 - 1965 period are now outdated and are facing either renovation or demolition. Row houses consist of some 50% of the total housing stock (fig 1)

Fig. 1 Typical outdated row housing in the Netherlands (1953)

In this research a method of renovation using a greenhouse like skin is presented. The glass skin is placed over an existing house giving space for additions and creating a thermal buffer. It is more or less like fruits and vegetables being preserved in glass. The consequences regarding ventilation, occupant requirements and build ability are discussed. The result of this approach is prevention of demolition of outdated houses and enabling the occupants to stay in their dwellings. The occupants will enjoy more space, more comfort and an improved energy performance.

KEYWORDS

Housing, Durable Renovation, Energy performance

TT8-159, Renovation of Housing using a glass skin extra space, more comfort, better energy performance and an extended life span, M. Ham, R. Craenmehr, R. Driessen
1 INTRODUCTION

After World War II in the Netherlands some 30% of the existing housing stock was damaged or demolished. In the 1946 – 1965 period in the Netherlands an enormous effort has been effected in building over 1.300.000 new homes.

These houses are now (2004) considered small, poor energy performers and of only limited comfort. It must be emphasized that in those days these houses formed the perfect answer to the need of the people and most people were really happy to live in these houses.

A closer look at the typical post war houses shows a two story pitched roof row-house with a small garden in the front and a slightly bigger garden at the back. (Fig 1)
Usually the lot measures some 6 x 25 meters, (150 m² or 1612 square feet) the ground floor generally consists of an entrance, a living room, a small kitchen, a toilet and a staircase. The first floor has two bedrooms, a small bedroom and a bathroom. Under the pitched roof there is an attic only for storage due to the low height and often only accessible by a folding stair. The ground floor plan makes clear that space is very limited [fig 2]

![Row house ground floor plan](image)

Fig 2 Row house ground floor plan.

Over the past 50 years many changes have taken place in society. Regarding housing the most significant changes are space requirement per person, energy performance and level of comfort.

The space requirement per person has gone up from 21 m² in 1947 to 50 m² in 2000. The number of persons per dwelling has gone down from 4.6 persons in 1947 to 2.3 persons per dwelling in 2000. [NVTB, 2001]
Not only space requirements and comfort requirements have changed, also energy performance has become an important issue. The old fashioned row houses with old fashioned façade details consume a lot of energy according to today’s standards and need improvements in order to stretch the life span. Single pane windows and cavity walls without thermal insulation do not meet today’s requirements.

2 APPROACH

This study focuses on the renovation of outdated housing in order to stretch the life span. In this specific case the possibilities of a glass skin over an existing dwelling are analyzed. The dwelling is more or less “preserved” like fruits and vegetables in a glass jar. The glass skin gives the opportunity to add space to the dwelling. Using the results of an occupants survey, [Dogge et al, 1996] the occupants’ requirements are determined and the extra space is filled in. The energy performance of the existing house is determined according to the existing Dutch standard.

3 ANALYSES

Postwar row housing in the Netherlands can be characterized as being of an extremely time-related design. After the Second World War there was a lack of houses, material, equipment and skilled labor. With great effort a large number of houses have been built in unprecedented quantities. [table1]

<table>
<thead>
<tr>
<th>year</th>
<th>Number of houses built</th>
<th>Year</th>
<th>Number of houses built</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>800</td>
<td>1956</td>
<td>68000</td>
</tr>
<tr>
<td>1947</td>
<td>8000</td>
<td>1957</td>
<td>87000</td>
</tr>
<tr>
<td>1948</td>
<td>36000</td>
<td>1958</td>
<td>87500</td>
</tr>
<tr>
<td>1949</td>
<td>42000</td>
<td>1959</td>
<td>82000</td>
</tr>
<tr>
<td>1950</td>
<td>44000</td>
<td>1960</td>
<td>82000</td>
</tr>
<tr>
<td>1951</td>
<td>59000</td>
<td>1961</td>
<td>81500</td>
</tr>
<tr>
<td>1952</td>
<td>56000</td>
<td>1962</td>
<td>79500</td>
</tr>
<tr>
<td>1953</td>
<td>60000</td>
<td>1963</td>
<td>97500</td>
</tr>
<tr>
<td>1954</td>
<td>68000</td>
<td>1964</td>
<td>100000</td>
</tr>
<tr>
<td>1955</td>
<td>60000</td>
<td>1965</td>
<td>115000</td>
</tr>
</tbody>
</table>

Table 1 Number of houses built in the 1946 – 1965 period in the Netherlands. [Tellinga, 2004]

In the Netherlands over 600.000 outdated post war row houses exist while only some 60.000 new houses being built per year. The old row houses are considered too small, offering only very limited comfort and the energy performance is low. In fact already many these outdated houses have been demolished in order to create space for new houses. If all 600.000 outdated row houses are demolished this will represent an enormous amount of debris, as on house alone represents some 140 to 150 tons of material. For comparison, the empty weight of a Boeing 747 SP is 147 tons.
New dwellings have been constructed with a greenhouse like skin over the entire house. This has resulted in comfortable houses with a good energy performance [Karsenberg, 2002] fig. 4

Fig 4 New row houses under a glass skin being built in Culemborg, Netherlands (2001)

Combining the greenhouse like skin with the existing houses is a new concept. The greenhouse skin offers the occupant more space and also creates new possibilities, like flexible space: in the summertime the entire space under the glass skin can be used, in the winter time the space between the existing house and the glass functions as a thermal buffer, improving the energy performance. The useable living area changes with the season.

Analyses has been carried out regarding occupant requirements and offered space. Extra space is required, on the ground floor the hall, living room and kitchen are considered being too small. On the first floor the bath room is considered to small and an extra room on the attic is wanted in order to have a possibility for a home office.
4 DESIGN

The design consists of two elements: The placing of a glass skin over the existing house and the addition of elements in order to fill up the required extra space.

The basic design concept is given in Fig 5.

Fig 5 The existing structure, the glass skin and the addition in vertical section.

The advantages of the design can be seen in both the ground floor plan and the first floor plan. With only a small addition in the space provided by the glass skin the kitchen is moved from the back to the front of the house, enlarging the living room. Also the toilet is moved enlarging the hall. (Fig 6)

Fig 6 The ground floor plan under the glass skin (left) and in the existing situation (right)
On the first floor only a small extension is placed above the extension on the ground floor, enabling the bathroom to be increased in size. The bedrooms all have a balcony covered by the glass skin. At the outside of the front and back façade a services duct is added giving space for ventilation shafts, a central vacuum cleaning system and other services. (Fig 7)

Fig 7 First floor in the new situation (left) and in the existing situation (right).
5 RESULTS

The glass skin over the existing dwelling will create a buffer space between the outside climate and the climate in the house. During winter this phenomena will reduce the energy demand of the house for heating. In the summer period overheating of the greenhouse is to be prevented. Large openings for ventilation are necessary. Using a computer simulation with a ventilation factor of 10 the temperature in the dwelling will rise approximately 2°C above standard has been calculated. The question is if additional ventilation is needed. If necessary there is space for extra ducts available in the services shafts. During winter the extra area between the existing house and the glass skin is not to be used and acts only as a temperature buffer. The space should not be heated, as this will result in higher energy losses.

The glass skin building structure is an existing product in the agricultural greenhouse building sector. The structure is able to carry snow loads according to the Dutch standards. Also sufficient detailing is provided to cope with condensation and ventilation.

The services shaft mounted at both front and back façade enables placing of large piping for a forced heat exchange ventilation system and also enables accessibility for maintenance of this system. This maintenance is extremely important as all ventilation is provided by the heat exchanger system and “sick building syndrome” symptoms are to be avoided.

The occupant will receive in this concept extra space and extra comfort, the operating cost will be reduced significantly.

Using and adding to an existing structure will reduce demolition cost and disposal of waste. The energy incorporated in the material will not be lost, only limited material is needed for the proposed retrofit again reducing the energy needed to create and transport this material.

The average yearly consumption of natural gas for a Dutch dwelling is 2087 m³, representing an emission of some 3715 kg CO₂. With the glass skin the natural gas consumption is reduced to 625 m³ natural gas, representing an emission of 1112.5 kg CO₂. The reduction of CO₂ emission is 2600 kg. The Dutch aim of CO₂ reduction is some 2.0 Mton for the year 2010. If it would be possible to realize the 2.6 ton CO₂ reduction over 600,000 houses a CO₂ reduction of 1.56 Mton CO₂ would be achieved, a quite remarkable conclusion.

In respect to the CO₂ emissions it should be mentioned that the emissions due to heating purposes still are very limited. The family car is producing much more emissions, at an average 16,330 km/year and a consumption of 1 liter to 10 km the family car consumes 1.633 liters of petrol. The CO₂ emission of petrol is 2.2 kg/liter, thus the CO₂ emission of only the family car is 3600 kg.

6 DISCUSSION

The final question is will the occupant accept this concept or not. The extra space in summer will be appreciated, but will the occupant also accept the smaller area in winter? Will the occupant accept the heat recovery system as main source of ventilation, being used to the so called natural ventilation concept, which is nothing but simply opening a window. In this design the glass skin covers the entire dwelling. The question is the use of the skin at the north side (in the drawings the entrance), as the buffer here will almost not be heated by the sun. Another aspect to be dealt with is cleaning. A glass cover will allow dust to build up. Not all places are easily accessible or can be cleaned easily.
7 ACKNOWLEDGMENTS

The author wish to thank collaborating researches and industry representatives who were willing to give their time and expertise.

8 REFERENCES

NVTB, 2001, Consument gericht toeleveren in de 21 st eeuw.
Dogge, Pott, Smeets, 1996, Dynamics, Housing preferences and appreciation.
ISBN 90-6814-064-7 (in Dutch only)
Tellinga, 2004, De grote verbouwing. Verandering van naoorlogse wijken
Karsenberg, Wienberg, 1999-2002, Housing Lanxmeer, Culemborg. (interview)