Affordable and replicable renovation of social housing fulfilling indoor climate and energy targets thanks to seven replicable renovation elements

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ABSTRACT

RenovActive is a renovation project which took place in Brussels based on the concept of Climate Renovation that implies achieving an excellent indoor climate as well as a high energy performance. The house belongs to a social housing association and is renovated within the financial frame for social housing in Brussels, and renovated using standard solutions and products to facilitate future replications of the result. Seven generic replicable elements were applied; these elements can be used in other renovation projects and are described in the paper. The house is equipped with a mechanical extract ventilation system for winter use, and demand-controlled natural ventilation for warm periods and peak loads during winter. The house is occupied by a family, and physical measurements as well as social scientific enquiries are carried out during a two-year period from June 2017.

KEYWORDS

Renovation; indoor climate; ventilation; replicability, affordability

1 INTRODUCTION

RenovActive House is a single family house of the social housing company Foyer Anderlechtois, located in Brussels, in the garden city of Bon Air in Anderlecht. The renovation is based on the concept of “Climate Renovation”: to renovate houses to create an excellent indoor climate with a good energy performance. Several renovation scenarios were generated and the performance was analysed according to the Active House specifications.
RenovActive follows the Model Home 2020 project, for which five single-family houses were built during 2009-2011. The Model Home 2020 project demonstrated that 2020 building performance targets can be achieved with today’s solutions (Feifer et al, 2014). It has previously been found that the Model Home 2020 houses provide good daylight conditions without compromising thermal comfort (Foldbjerg et al., 2014). It is the aim of the present project to extend the good performance in a renovation case that is affordable by using existing standard products and solutions.
A particular focus of the renovation was to identify generic elements that can be replicated in other renovation projects on a large scale. The renovation was completed in May 2016, and was

followed by an open house period for academic and professional studies and visits. Since June 2017 a family has moved in, and the performance of the house is monitored for 2 years.

2 METHODS

The design targets for indoor climate, energy and environmental impact are based on the Active House Specifications (Active House Alliance, 2011). As there was a strict financial frame for the renovation, different renovation scenarios were evaluated according to the Active House radar diagram. The scenario that was selected provided the best overall performance under the three Active House principles and fulfilled the financial frame for social housing in Brussels as well as the requirements for replicability.

2.1 Demand-controlled ventilation system and sun screening

To minimize energy consumption and to maximize thermal comfort during summer, a hybrid ventilation system was developed using both a mechanical ventilation system and natural ventilation with automated window opening. Supported by a study by Holzer (2014), the outdoor temperature is used to identify the most favourable mode of ventilation. Natural ventilation has been identified as the best solution when the climate is mild. During cold periods, the ventilation is a mechanical extract system (type C+). The "+" indicates demand-control based on sensors, a solution based on a product by the company Renson. The house is divided into different zones, each with dedicated sensors of temperature, humidity, CO_2 and VOC installed in the extract ducts.

When the outside temperature exceeds approximately 14°C, the flow through the C+ system is reduced to 25% to minimize electricity use although the sensors are still active. The control system then uses automated windows in each zone to maintain the target of CO_2 levels and prevent overheating thanks to the stack effect. Therefore, the system is a "hybrid" ventilation system, combining the benefits of both mechanical and natural ventilation. The switching between natural and mechanical ventilation modes is limited to once per morning and per evening.

External automatic solar shading is installed on façade and roof windows facing south and west. To ensure a simple and affordable control solution, the solar shading is controlled by pads in each room providing manual control and timer-based control.

3 RESULTS

3.1 Replicable elements

The seven generic replicable elements have been identified as the following:

3.1.1 Attic conversion: Growing from within

Utilizing the upper floor's potential; this first densification element identifies idle areas and converts them into first class living areas. For an attic conversion the space is designed with daylight in mind, creating more space with plenty of natural lighting, improved ventilation and heat control. From an energy perspective, an attic conversion is more energy efficient than a building extension, as the attic conversion provides more living area with less building envelope and thus less thermal transmission losses, as seen in Table 1. It is also the cost-optimum solution.

Table 1: Energy performance of different renovation scenarios

	No attic conversion	**Attic converted**	**Extension added**	**Attic converted + extension**
Index of primary energy consumption	100	90	115	104
Primary energy consumption for heating [kWh/m2]	34	31	39	36

3.1.2 Staircase shaft for daylight & ventilation: Respiratory channel

An open stairwell provides enhanced daylight distribution and efficient airing via the stack effect. Daylight is distributed to all floors and central rooms of the home. The stack effect helps to expel humid exhaust air through the roof windows at the top of the staircase, while clean air enters the building via open doors and windows.

3.1.3 Increased window area: Daylight treatment

Large façade and roof windows increase the level, and in particular the quality, of daylight. A balanced distribution of windows ensures a pleasant and bright indoor environment with plenty of daylight in every room and on every floor. Good daylighting results in less hours of artificial lighting (Christoffersen et al., 2014).

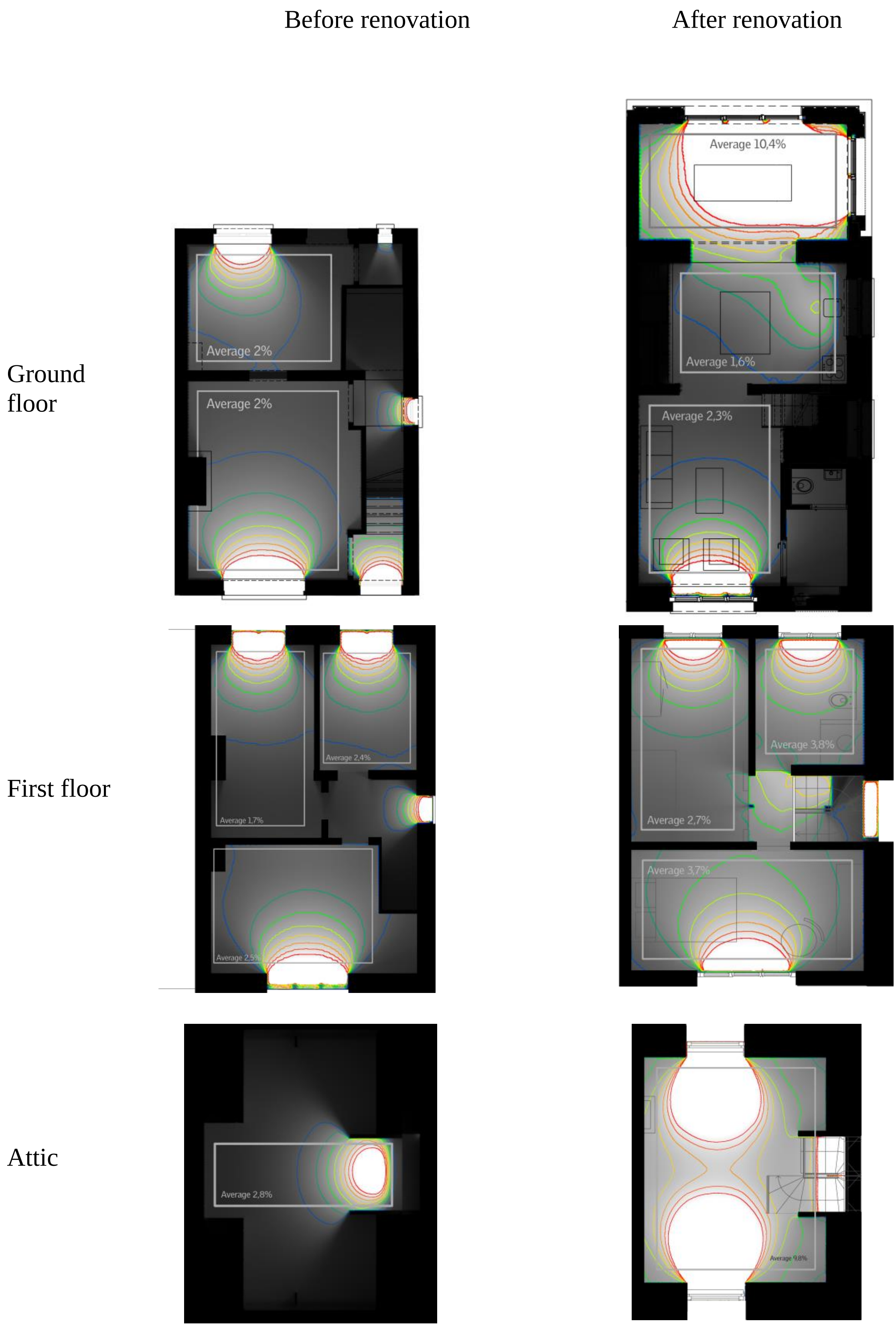

Figure 1. Daylight performance (average daylight factor) for the room on first and second floor in the existing (left) and renovated (right) situations.

3.1.4 Building extension: new life space

Building an extension adds precious square meters to the home and creates room for extra people. An extension is subject to the size of the plot and surrounding terrain. A well-daylit extension gives also access to a new living experience and to a space with longer days with daylight and better connected to the outdoor (e.g. to a garden).

3.1.5 Dynamic sunscreening: third skin

A dynamic envelope is vital to ensure good indoor comfort with pleasant temperatures day and night as well as during all seasons, particularly in the shoulder seasons. Dynamic external sun screening, e.g. awning blinds, reduces overheating during summer.

3.1.6 Hybrid ventilation system: hybrid breathing

The hybrid ventilation system combines mechanical and natural ventilation with automated windows and heating. During the summer, windows and stairwell are used to provide natural cooling in the building, e.g. using the stack effect for efficient air replacement. Natural ventilation can provide high ventilation rates, which results in low CO_2-concentration in the house, with no use of electricity for fan operation. During the winter, mechanical ventilation helps to maintain good indoor air quality and reduce the risk of draught.

3.1.7 Improved thermal envelope

The thermal envelope consists of a façade climate shield and a modern heating system, optimizing energy performance and thermal indoor comfort. Work on the façade comprises extra surface insulation, a new roof construction and new windows. The upgraded heating system includes a new boiler, a floor heating as well as modern radiators on upstairs levels.

The energy cost for heating and ventilating the house would be reduced by 85% after the energy renovation of the house for the same comfort level. But a higher comfort level is expected after renovation, as occupants of poorly insulated houses often reduce the temperature to reduce the energy cost (lower heating set point, only heating of living room, temporary heating of bathroom). After renovation, a “rebound effect” is expected, which could mean that the real energy cost reduction will be in the order of 40–50%. Table 2 presents the indoor climate and energy performance before and after renovation, calculated according to the Belgian PEB software. The energy performance before renovation is a theoretical energy consumption calculated for a whole house at a yearly average temperature of 19°C, and not the measured energy performance.

Table 2. Indoor climate and energy performance before and after renovation

	Before renovation	**After renovation**
U-values	no thermal insulation double glazing	Improved thermal insulation low-e double glazing, triple glazing on north
Net energy demand for heating	700 kWh/m²	25 kWh/m²
Primary energy consumption	1300 kWh/m²	82 kWh/m²
Ventilation	Not ok	Ok
Thermal comfort winter	Not ok	Ok
Thermal comfort summer	Ok	Ok
Energy class	G	B
Energy cost for building services (excluding light and plug loads)	5,000 €/year	800 €/year

Figure 2 illustrates the performance of the house prior to renovation as well as the calculated performance for the renovated house according to Active House specifications.

Figure 2. Performance of the non-renovated house according to the Active House Specification.

The active House Radar shown in Figure 2 is a good tool for displaying the ambition reached before and after renovation. The radar can be a useful tool for monitoring, evaluating and improving the renovation scenarios generated during the design. As communication tool, it can provide clarity and tare combinations of three principles: comfort, energy and environment. The comfort principle sits for the indoor air quality, the thermal comfort and daylighting quality. The energy principle includes the energy demand, the energy supply and the primary energy performance. Last but not least the environment principle includes the sustainable construction dimension, the consumption of fresh water and the environmental load for which life cycle assessments of different scenarios are made.

3.2 Occupation and post-occupancy evaluation

Since June 2017 the house has been be handed to the Foyer Anderlechtois and inhabited by a social housing beneficiary. During the first two years of occupation, the performance of the house is monitored; technically by measuring indoor climate parameters and energy performance, and also by psycho-social techniques including questionnaires and time diary. The monitoring is carried out by researchers from Humboldt University Berlin, Vreie University Brussels and Daidalos Brussels. The technical indoor climate monitoring is undertaken thanks to a room-based system.

4 CONCLUSIONS

The project is an example of an affordable and replicable renovation that not only improves the energy performance of the dwelling and perhaps more importantly, focuses on providing the best possible indoor environment. The seven replicable elements that have been applied are generic and can be replicated easily on a large scale.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

Active House Alliance (2011) Active House Specification, Active House Alliance, activehouse.info

Feifer, L, Foldbjerg, P, Asmussen, TF and Andersen, PA. 2014. Tomorrows buildings today – results, conclusions and learnings from a cross-european demonstration programme. Proceedings of World Sustainable Buildings 2014, Barcelona.

Foldbjerg, P, Asmussen, TF and Holzer, P, 2014. Ventilative Cooling of Residential Buildings - Strategies, Measurements results and lessons learned from three Active Houses in Austria, Germany and Denmark, International Journal of Ventilation, September 2014.

Holzer, P and Foldbjerg, P. 2014. Control of Indoor Climate Systems in Active Houses. Proceedings of World Sustainable Buildings 2014, Barcelona.

Christoffersen, J.and Foldbjerg, P, 2015. Results from Post-occupancy evaluation in four Single-family Houses. Healthy Buildings Europe 2015, Eindhoven.