A: Design & technology
A.1. Human centred design solutions

RENOVATION OF A SINGLE FAMILY HOUSE IN A SOCIAL HOUSING GARDEN CITY IN BRUSSELS AS PRIVATE-PUBLIC COLLABORATION: AMBITIOUS TARGETS FOR ENERGY, INDOOR CLIMATE AND POST-OCCUPANCY MONITORING

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SUMMARY

RenovActive is a renovation project in Brussels based on the concept of Climate Renovation that implies achieving an excellent indoor climate as well as energy performance. The house is part of a social housing association, and is renovated within the financial frame for social housing, and renovated using standard solutions and products to facilitate future replications of the result. The different renovation scenarios have been analysed with dynamic simulation and daylight analyses, and the Active House specification has been used to evaluate the scenarios. The house will be equipped with balanced mechanical ventilation for winter use, and demand-controlled natural ventilation. When building works have been completed, the house will be occupied by a family, and physical measurements as well as social scientific enquiries will be carried out.

INTRODUCTION

RenovActive House is a single family house of the social housing company Foyer Anderlechtois, located in Brussels, in the garden city 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 considered, their performance was analysed according to the Active House specifications.

RenovActive follows the Model Home 2020 project: During 2009-2011, a demonstration project programme of five model homes were built in Denmark (Home for Life, HFL, 2009), Austria (Sunlighthosue, SLH, 2010), Germany (LichtAktiv Haus, LAH, 2010), France (Maison Air et Lumière, MAL, 2011) and United Kingdom (CarbonLight Homes, CLH, 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 these 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 and can be easily reproduced.

The projects has several specific targets:

- Ambitious energy performance for a renovation case with net energy demand for heating and a primary energy use that complies with the Flemish EPB legislation until 2021 and the Walloon EPB legislation until 2017 for new built
- Excellent indoor climate with a particular focus on high daylight levels, prevention of overheating and good indoor air quality through demand-control
- Affordability, as the renovation incl. all technical equipment must be executed within the financial frame given by the social housing company of Brussels
- Reproducibility, using a scenario approach to determine the best set up according to priorities and technical choices, in order to make the concept reproducible for the Foyer Anderlechtois (3.600 dwellings in Brussels area), on a larger scale in other housing communities as well as for private building owners.

The house from the mid-1920s is compact, semi-detached and in a very bad condition. An architecture competition was organised to generate new ideas and innovative concepts for the climate renovation. The Antwerp-based architecture office ONO architectuur won the competition and is developing the project.

Figure 1. The existing house is a semi-detached house. The house unit to the right will be renovated. Photo of the present state (above) and the architect’s proposal (below).

METHODOLOGIES

Design targets

The design targets for indoor climate, energy and environmental impact are based on the Active House Specification (Active House, 2011). As there is a clear financial frame for the house, the approach in the design process was to evaluate different scenarios that combined different technical solutions. Each scenario was evaluated according to the Active House radar diagram. The scenario that was chosen as the scenario that will be realised is the scenario that provided the best overall performance in the three aspects and meets the construction cost and reproducibility requirements.

Daylight performance

The daylight performance is improved by adding and enlarging the windows in the existing house, see Figure 2.

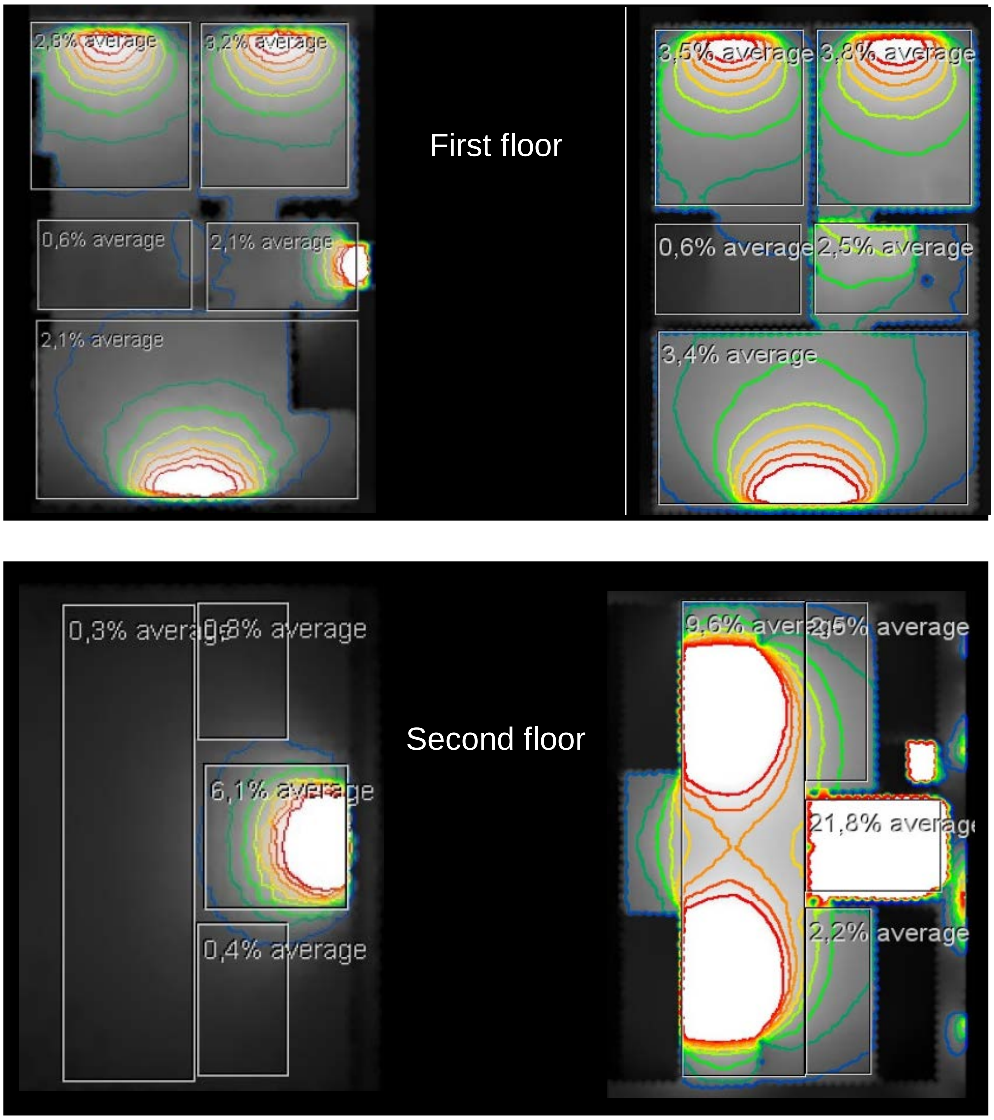
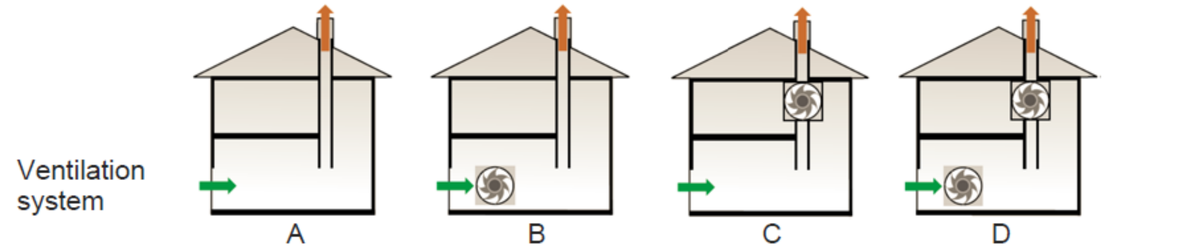


Figure 2. Daylight performance (daylight factor) for the room on first and second floor in the existing (left) and renovated (right) situation.

Ventilation system

The window design has been optimised for daylight and natural ventilation. The staircase window e.g. functions as an extract for natural ventilation that helps prevent overheating. In Belgium, ventilation systems are categorised in four categories, as illustrated in Figure 3. To minimise energy consumption during winter, the evaluation focused on system C (possibly in combination with a heat pump in the extract air duct) and system D in combination with heat recovery.



	A	B	C	D
supply	natural	mechanical	natural	mechanical
exhaust	natural	natural	mechanical	mechanical

Figure 3. Categorization of domestic ventilation system types in Belgium.

To minimise energy consumption and to maximise thermal comfort during summer, natural ventilation was identified as the best solution when there was no need for heat recovery. Supported by a study by Holzer et al. (2014), the outdoor temperature will be used to identify the most favourable mode of ventilation. The constant-flow mechanical ventilation system D with heat recovery will be used when the outdoor temperature is below 14°C.

Next to this, CO_2-controlled natural ventilation is running all year; as peak ventilation during cold periods and as the only ventilation as soon as the outside temperature exceeds 14°C. The air in- and out-flow happens through automatic opening of the windows, profiting from the stack effect. The system will therefore be a hybrid ventilation system, combining the benefits of mechanical and natural ventilation. The switching between natural and mechanical ventilation mode will be limited to maximum once per morning and evening.

External, dynamic and automatically operated solar shading is foreseen on façade and roof windows facing south and west.

To ensure a simple and affordable control solution, the windows and solar shading is controlled by room units without a central computer. The room units use CO_2 and possible temperature to control window openings, and in addition external solar radiation is used to control shading. In addition to the sensor-based control, timer based control may be used in rooms with a predictable usage pattern.

RESULTS

The different potential design scenarios for the house were evaluated according to Active House Specification; 10+ scenarios were evaluated in total. Dynamic thermal simulation and daylight simulations were used in addition to the Belgian EPBD energy performance tool. Figure 4 illustrates the performance of the unrenovated house. The house is leaky, which results in the best score (1) for indoor air quality, but in combination with poor insulation, a bad score for thermal comfort (3,5).

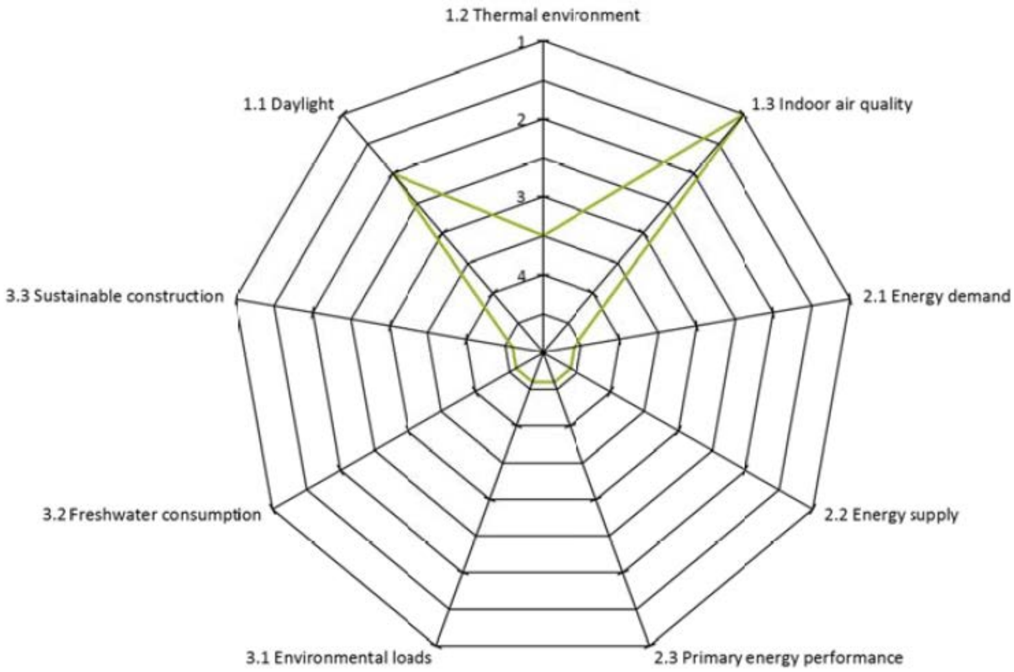


Figure 4. Performance of the unrenovated house according to the Active House Specification.

Figure 5 illustrates two renovation scenarios. On the left is scenario 1b, which meets the anticipated 2015 Brussels energy requirements as well as the NZEB requirements for the region of Flanders. It uses a geothermal heat pump, solar collectors and additional insulation (compared to 2a) to achieve this. However, scenario 1b cannot be achieved within the financial frame.

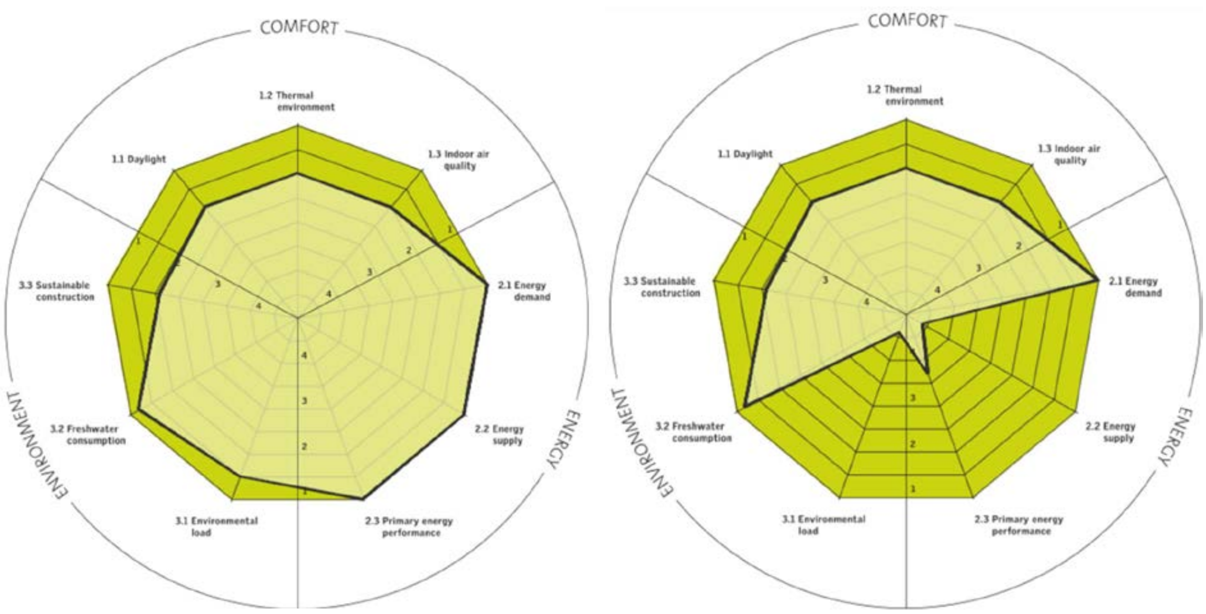


Figure 5. Scenario 1b (left) and scenario 2a (right) according to the Active House Specification.

In scenario 2a, the house is connected to the gas grid and uses a condensing gas boiler. There are no solar collectors, and slightly less insulation. The energy design of this scenario fits better to the local area and is easily reproducible for other housing units in Foyer Anderlechtois. The energy performance meet Flemish EPB legislation until 2021 and the Walloon EPB legislation until 2017 for new built.

In both scenarios, the indoor climate performs well, achieving a score of 2 in the main categories daylight, thermal comfort and indoor air quality. This is a big improvement from the unrenovated situation, and is considered a very satisfying result.

OCCUPATION AND POST-OCCUPANCY EVALUATION

After completion of the renovation works (foreseen in the end of 2015), the house will be open for visits during 1 year. After this, it will be handed to the Foyer Anderlechtois and inhabited by a social housing beneficiary. During the first 2 years of occupation, the performance of the house will be monitored; technically by measuring indoor climate parameters and energy performance, and also by psycho-social techniques like questionnaires.

The technical monitoring will be made with a room-based system, e.g. *NetAtmo*, which stores data in the cloud.

CONCLUSIONS

The project is an example of affordable and replicable renovation techniques that not only improves the energy efficiency of the dwelling but perhaps more importantly, focuses on providing the best possible indoor environment.

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