Semi-detached house in De Pinte, Belgium

PROJECT SUMMARY
Retrofit of a semi-detached house from the 50's towards passive house standard.

SPECIAL FEATURES
Passive house standard
Ecological design

ARCHITECT
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OWNER
Huyghe-Van Steeland

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

IEA – SHC Task 37
Advanced Housing Renovation with Solar & Conservation

The original front view of the dwelling

The original back view of the dwelling

BACKGROUND

The owners of this half-open house from the 50ies wanted a healthy and low-energy house with lots of light and open space. But the search for an architect who could realize their dream house turned out to be difficult. When their first architect presented them the preliminary sketches of the future house, the design was severely over budget, while not fully taking into account a low-energy concept.

So the owners decided to search an architect who already had experience with energy efficient buildings, and found this person in Alexis Versele Architects. After an initial interview and a visit to the house, the decision was made to renovate the property towards passive standard, and close to the postulated budget. The new design focused on sufficient insulation and airtight construction. Since the orientation of the building was far from ideal, the common wall being oriented south, window surfaces were designed to maximize the possible passive solar gains.

New construction or renovation?

One could argue that new construction towards passive house standards would have been preferred. Still, the decision was made to retrofit the building, because of:

- the excellent structure of the existing dwelling, consisting of 19cm thick concrete blocks which were still in excellent condition. Their thermal inertia was another plus.
- waste reduction, by reusing the existing materials. This was clearly a sustainable decision.
- the reduced VAT rate for retrofit of 6%, compared to the 21% rate for new construction.

The original house

The existing dwelling consisted of a main volume with a pitched roof, to which different constructions had been added according to the needs of the former inhabitants. As the common wall was almost perfectly oriented towards the south, this provided an extra challenge to reach passive house standard.

The owners wanted a house with a 'lofty feeling', with lots of light and an open plan. This inspired the organization of the different functions: the bedrooms were placed on the ground floor, where natural light was less abundant.

The living space and kitchen would take up the first floor. By raising the eaves and changing the pitch of the new roof, one big open space was created here, including a new mezzanine.

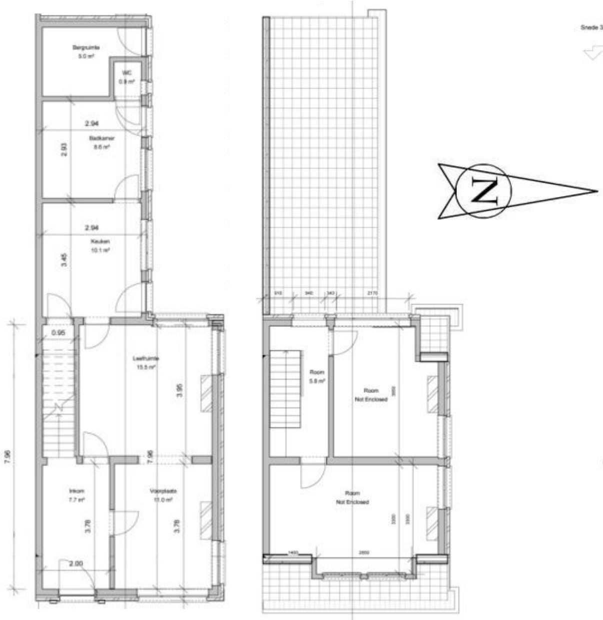
Before

After

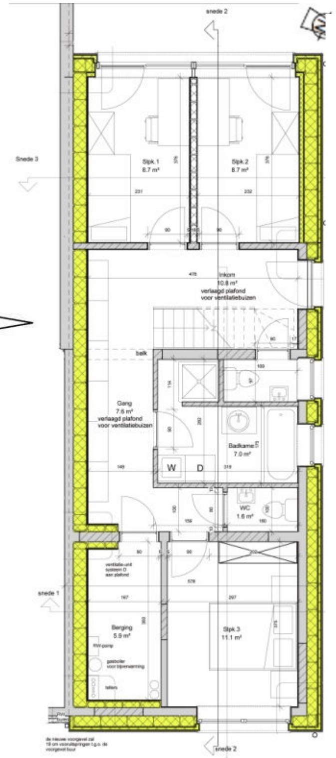
SUMMARY OF THE RENOVATION

- Replacing the existing annexes by a new one resulting in an improved compactness (from 1,73m to 2,16m).
- Replacement of the worn out roof construction.
- Redesign of the layout and the circulation of the house.
- Removal of the exterior brick façade, replaced by a timber frame construction and filled with cellulose.
- Air tightness of 0,56 h^{-1}.
- Mechanical ventilation with counter-flow heat exchanger.
- Ground/water heat exchanger.
- Flat plate solar collector.

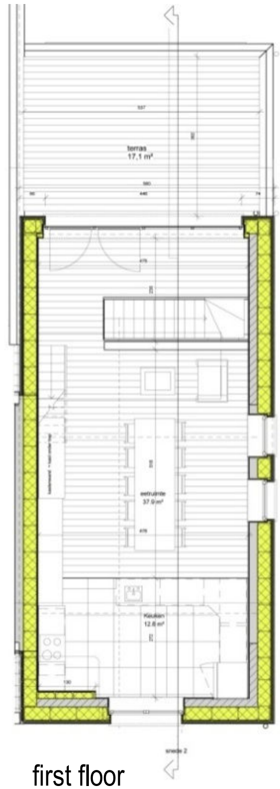
cross section, with old volume marked



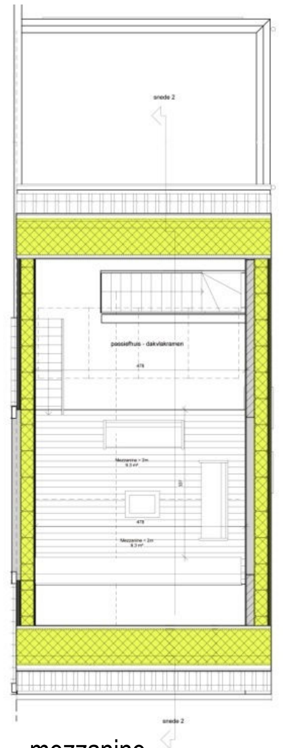
The original plans of the dwelling



ground floor



first floor



mezzanine

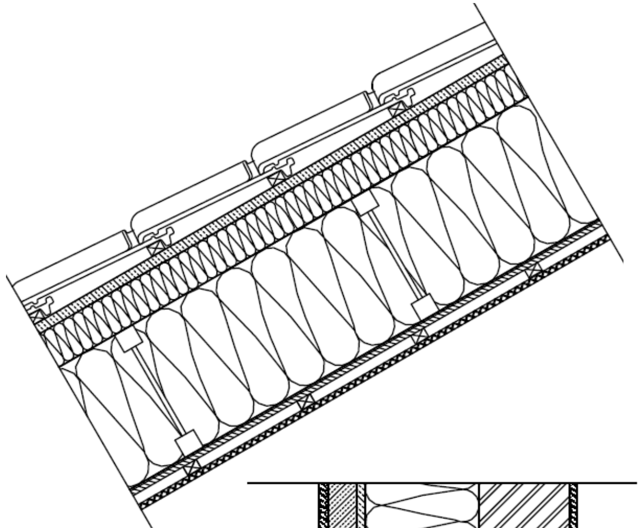
Timber frame construction fixed to the existing wall. The originally wall was erected with concrete blocks, but during the retrofit and the adaptation of the windows some clay tile blocks were build in.

CONSTRUCTION

Roof construction (new) *U-value: 0,12 W/(m²·K)*

(top down)

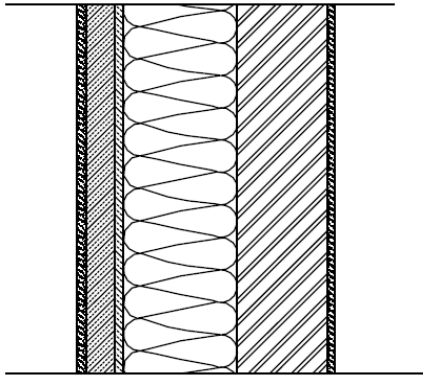
- Roof tiles	50 mm
- Wood-fiber board	22 mm
- Rafter + cellulose	82 mm
- Wooden I-beams + cellulose	300 mm
- OSB	15 mm
- Lathwork	22 mm
- Gypsum Fibreboard	12,5 mm
Total	503,5 mm



Wall construction *U-value: 0,126 W/(m²·K)*

(interior to exterior)

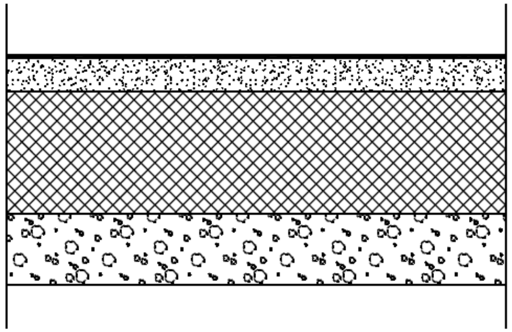
- Interior plaster	15 mm
- Concrete blocks	190 mm
- Wooden I-beams + cellulose (new)	240 mm
- Wood-fibre board (hardboard) (new)	18 mm
- Wood-fibre board (soft board) (new)	60 mm
- Exterior stucco (new)	20 mm
Total	543 mm



Floor construction *U-value: 0,086 W/(m²·K)*

(top down)

- Linoleum (new)	6 mm
- Screed (new)	70 mm
- Phenolic rigid board insulation (new)	260 mm
- Concrete slab	150 mm
Total	486 mm




The house after dismantling the walls


The construction of the common wall

REPLACING THE OUTSIDE BRICK FACADE

The old house was built with a traditional cavity wall construction, without insulation. After consultation with the contractor, the outside wall was removed, to be replaced by a timber frame construction fixed to the inner walls, containing the insulation layer.

During construction, it became clear that the inner wall was far from straight. In some places a difference of 7 cm had to be gapped.

REACHING PASSIVE HOUSE STANDARD

The first PHPP calculation of the project underlined how big the challenge would be to reach passive standard. Following changes were made to the original design, in order to reach the target standard:

- The insulation layer in the walls was increased.
- The size of the windows was optimized, allowing for bigger windows at the back (west-side).
- The skylights and light tunnel on the east, originally planned, were deleted because they wouldn't deliver enough solar gains.
- The floor insulation type was changed towards a less ecological but higher performance material (26cm Phenolic rigid board in stead of cellulose)

ENSURING AIR TIGHTNESS

Because of the mixed structure of solid and timber construction, the connections between them were critical points. Special bands that can be plastered were used to make this connection.

A first air tightness test showed an infiltration rate of 0,56 h-1 at 50 Pa pressure difference (n_{50}). The big leaks that remained were situated at the passage of the solar collector pipes through the roof (even thought they were taped off as good as possible), the passage of an old electricity cable in the old floor and the interruption of the stucco at the base of the wall in the corner between common wall and façade.



Taping off the OSB boards, and connection between OSB and plaster on the brick walls (the white band in the upper photo)

THERMAL BRIDGES AND SOLUTIONS

Resolving the thermal bridges became an additional challenge, mainly because the starting point was an already existing structure. The most important connections were simulated.

A classic thermal bridge when retrofitting is the base of the wall. Calculations showed its' great impact. Because a moisture resisting barrier had to be installed anyway, it was decided to replace the first layer of bricks by cellular concrete.

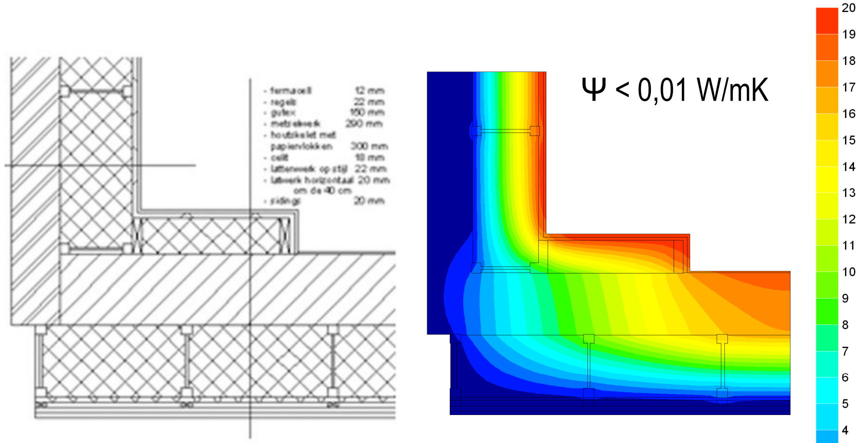
The joint between façade and common wall was another problematic connection. Here, no real solution was found, but adding an additional insulation layer on the inner wall at least greatly reduced the thermal bridging effect.

Finally, the installation of the roof windows was studied. Because of their positioning outside of the roof construction, the thermal bridging effect was even greater. To reduce this, a second window was placed underneath the roof window.

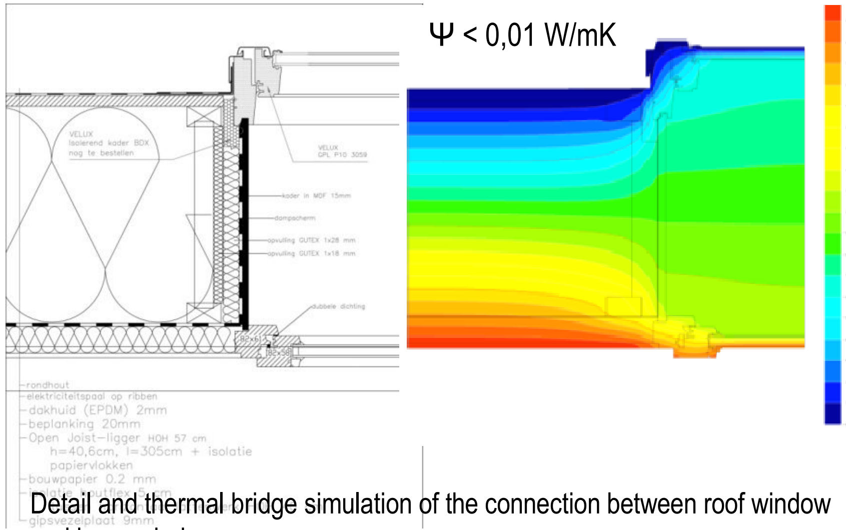
Thermal break at the base of the walls


Connection treshold with frontdoor.


The roof windows and the solar thermal collector.



Detail and thermal bridge simulation of the connection between façade and common wall



Detail and thermal bridge simulation of the connection between roof window and inner window.

Mechanical ventilation unit.

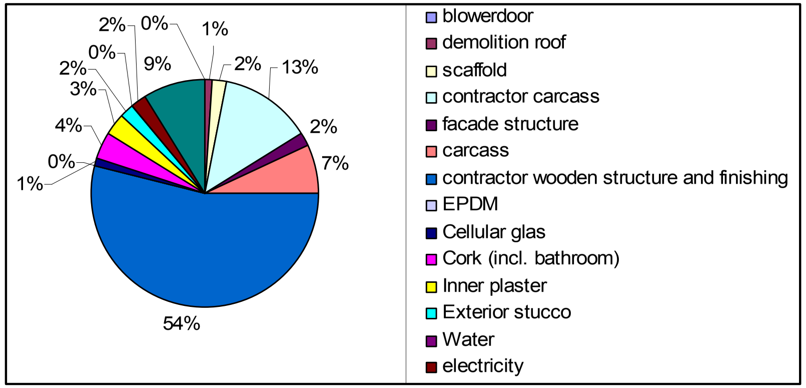
An electrical resistance for post heating the living areas.

SUSTAINABLE MATERIALS

For choosing the building materials, their ecological value was taken into account. FSC labeled timber was used for the timber frame construction. Cellulose insulation was used for the walls and roof. Only in the floor a chemical insulation material was used (Fenol-insulation).

An interior plaster based on natural gypsum was used for the masonry walls. Cork and linoleum were applied as floor decking. A mineral stucco applied on a wood fiber insulation plate was used as an exterior finishing.

A final aspect of sustainability is the reuse of rainwater. In front of the house a rain water tank of 5000l is placed. 2 toilets and a washing machine are connected to it. This way the use of tap water is reduced to a minimum.



Cost diagram

COST ANALISYS

The renovation to passive house standard was not evident. This translates into the cost of the project. This also reflects the unfavorable orientation of the dwelling, therefore additional insulation was needed. On the other hand, the reduced VAT rate, various grants and a federal tax deduction for retrofitting to passive house standard, make it all economically viable in times of high energy prices.

CONCLUSIONS

When the owners first formulated their dream of an ecological new home, their wishes were far from met. After having found an experienced architect, eager to realize their dream, the end result was a sustainable and ecological passive house retrofit. The project fully uses the existing potential of the building, and changes the rest for the better.

The process was not an easy one though. Solving thermal bridges, incorporating air tightness solutions, developing an efficient ventilation strategy and last but not least keeping the budget within reasonable margins, required commitment and study work.

Front and rear view of the house; trees for natural shading

Summary of U-values W/(m²·K)

	Before	After
Roof	5,5	0,12
Walls	1,9	0,126
Basement ceiling	2,7	0,086
Windows*	5	0,74

BUILDING SERVICES

Mechanical ventilation system with a counter flow heat exchanger (η=84%).
An electrical decentral post-heater (1200W) warms the ventilation air going to the living room. Additional electric heaters can heat the air going to the bedrooms as desired. In the bathroom an extra electrical heater is installed because of the higher comfort temperatures that are required there.
To prevent overheating during the summer, screens are installed on all roof windows, as well as on the back windows on the first floor. 2 trees in front of the windows will provide sufficient shadow on the ground floor.
Compact unit with heat pump and connected to the solar thermal collector, via a 300l buffer tank. This is used for the domestic warm water.

RENEWABLE ENERGY USE

Solar heating collector: flat plate collector, 8m²
storage volume 300l

ENERGY PERFORMANCE

Space + water heating (primary energy)*
Before: 450 kWh/m².a
After: 67 kWh/m².a
Reduction: 85 %
* Flemish implementation of EPBD

INFORMATION SOURCES

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