Semi-detached house in De Pinte, Belgium

PROJECT SUMMARY
Retrofit of a semi-detached house from the 50's approaching Passive House Standard.

SPECIAL FEATURES
Passive House constructions
Ecological design

ARCHITECT
Alexis Versele Architecten vennootschap

OWNER
Huyghe-Van Steeland

SHC 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 house from the 50's wanted a healthy and low-energy house with daylit, open space. It was decided to renovate to near Passive House Standard but stay close to budget. The design focused on sufficient insulation and airtight construction. Since the party wall faces south, windows were designed to make the best of available passive solar gains.

New construction or renovation?

The decision was renovate because.

- the structure of the existing dwelling was sound, consisting of 19cm thick concrete blocks (providing good thermal inertia).

- this minimize waste and materials were even reused wherever possible.

- the reduced VAT rate for retrofit of 6%, compared to 21% rate for new construction.

The original house

The existing dwelling consisted of a main volume with a pitched roof, to which different past additions had been made. The common wall facing south made it challenging to reach the Passive House Standard.

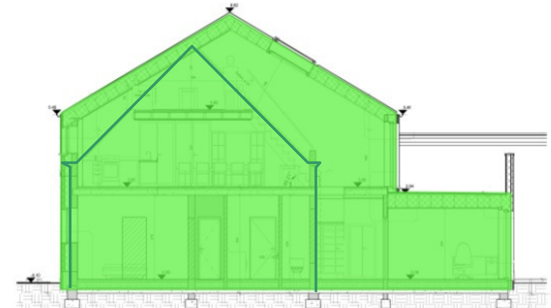
The owners wanted a house with a ‘lofty feeling’, with a well daylit, open space. This inspired the placement of the rooms. Bedrooms are at ground level, where natural light is less abundant. The living space and kitchen were moved to the first floor. By raising the eaves and changing the pitch of the new roof, one big open space was created here, including a new mezzanine.

Before

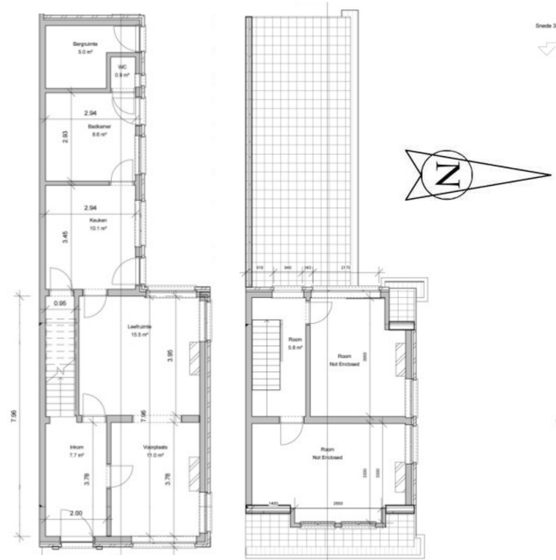
After

SUMMARY OF THE RENOVATION

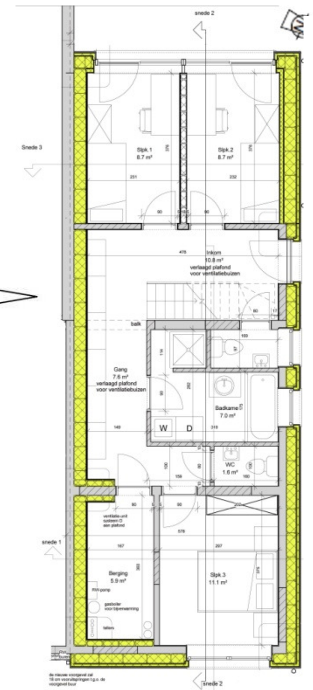
- Replacing past additions by a new addition (improved compactness from 1.73m to 2.16 m^3/m^2)
- Replacing the worn out roof construction.
- New room layout and the circulation
- Replacing the exterior brick facade by a timber frame construction filled with cellulose
- Air tightness of 0.56 h^{-1}
- Mechanical ventilation with counter-flow heat exchanger
- Ground/water heat exchanger
- Flat plate solar collector



Cross section with old and new volumes marked

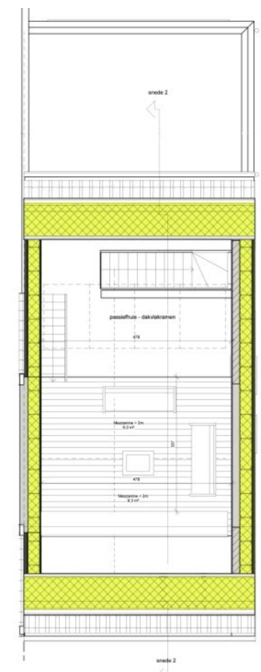


Original plans of the dwelling



Ground floor

first floor



Mezzanine

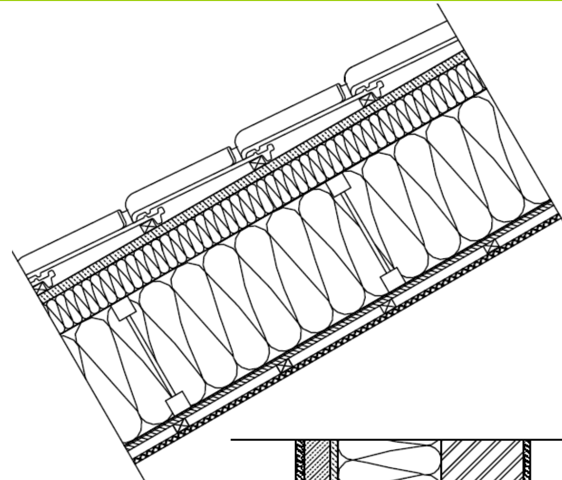
Timber frame construction fixed to the existing wall. The originally wall was erected with concrete blocks, but during the retrofit and the adaptation of the windows some clay tile blocks were build in.

CONSTRUCTION

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

(top down)

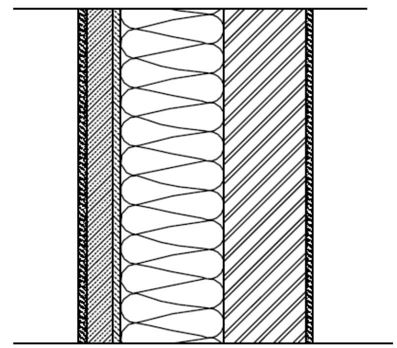
- Roof tiles	50 mm
- Wood-fiber board	22 mm
- Rafter + cellulose	82 mm
- Wooden I-beams + cellulose	300 mm
- OSB	15 mm
- Lathwork	22 mm
- Gypsum Fibreboard	12,5 mm
Total	503,5 mm



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

(interior to exterior)

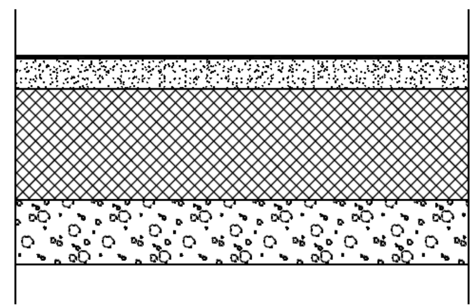
- Interior plaster	15 mm
- Concrete blocks	190 mm
- Wooden I-beams + cellulose (new)	240 mm
- Wood-fibre board (hardboard) (new)	18 mm
- Wood-fibre board (soft board) (new)	60 mm
- Exterior stucco (new)	20 mm
Total	543 mm



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, uninsulated cavity wall construction. The exterior brick facing was replaced by a timber frame construction fixed to the inner walls. The cavity was insulated. During construction, it became clear that the inner wall was far from straight. In places a difference of 7 cm had to be gapped.

REACHING PASSIVE HOUSE STANDARD

The first calculation (PHPP) of the project made evident the challenge to reach Passive House Standard. Following changes were made to the original design achieve the standard:

- The wall insulation was increased.
- The window size was optimized, with bigger windows to the rear (west-side).
- The forseen skylights and light tunnel on the east side were omitted because their solar gains wouldn't offset heat losses.
- The type of floor insulation was changed towards a less ecological but higher performance material (26 cm Phenolic rigid board instead of cellulose)

ENSURING AIR TIGHTNESS

Connections between the masonry and timber constructions were critical. 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 the roof penetration of solar collector pipes (even thought they were taped), the penetration 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 facade.

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

Thermal break at the base of the walls

Connection treshold with frontdoor.

THERMAL BRIDGES AND SOLUTIONS

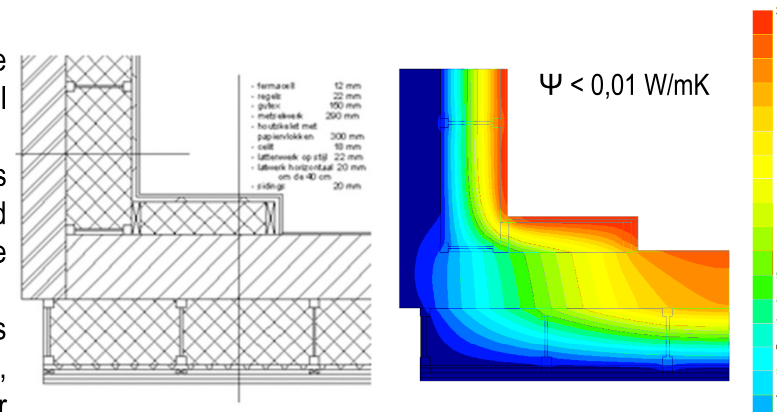
Resolving thermal bridges was difficult because the starting point was an existing structure. Critical connections were simulated.

A common, major thermal bridge in renovations is the base of the wall. Because a moisture barrier had to be installed anyway, it was decided to replace the first layer of bricks by cellular concrete.

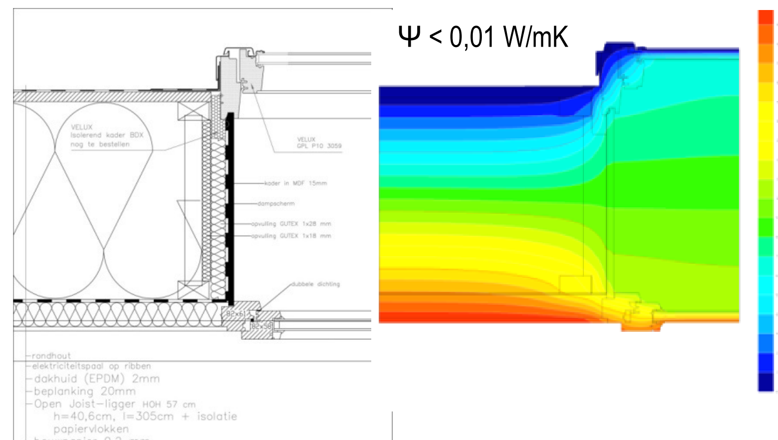
The joint between the facade and common wall was another problem. Here, no real solution was found, but adding an additional insulation layer on the inner wall greatly reduced the thermal bridging effect.

Finally, installation of the skylights 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 skylight.

The roof windows and the solar thermal collector.



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



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

Mechanical ventilation unit.

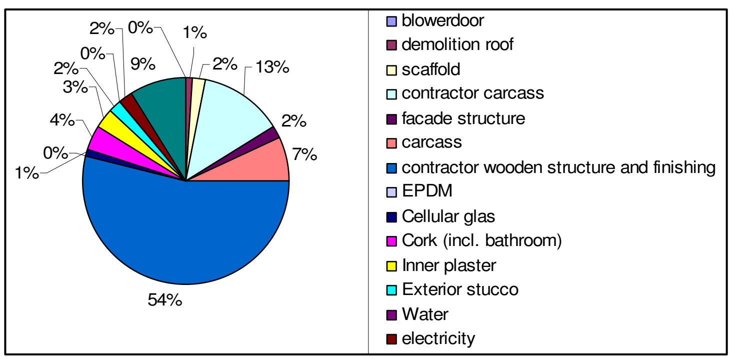
An electrical resistance for post heating the living areas.

SUSTAINABLE MATERIALS

The ecological value of building materials was a selection criterion. FSC labeled timber was used for the frame construction. Cellulose insulation was used for the walls and roof. Only in the floor was a chemical insulation material used (Fenol-insulation).

Interior plaster based on natural gypsum was used on masonry walls. Cork and linoleum were applied as flooring. A mineral stucco applied on a wood fiber insulation plate was used as an exterior finish.

A final aspect of sustainability is reuse of rainwater, a 5000l cistern was placed in front of the house, supplying two toilets and a washing machine and reducing tap water use.



Cost diagram

COST ANALISYS

The renovation to Passive House Standard was not easily to be reached, within budget. The unfavorable orientation of the dwelling had to be compensated with additional insulation. On the other hand, the reduced VAT rate, various grants and a federal tax deduction for retrofitting to this standard, made it economically viable in times of high energy prices.

CONCLUSIONS

When the owners first formulated their dream of an ecological new home, their first architect failed to meet their expectations. A new architect committed to these goals was able to fulfill these dreams for a sustainable and ecological passive house retrofit. The project fully capitalizes on the existing potential of the building, and changes compensate some of its limitations. The process was not easy and solving thermal bridges, tightening difficult connections, designing an efficient ventilation system and last but not least, keeping the budget reasonable.

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 air supply to the living room. Additional electric heaters can heat the air supply to the bedrooms as desired. In the bathroom an extra electrical heater is installed to meet higher comfort temperatures there.
To prevent summer overheating, screens are installed on all roof windows, as well as on the back windows on the first floor. Two trees shade ground floor windows.
A compact unit with heat pump is connected to the solar collectors via a 300l buffer tank used for domestic hot water.

RENEWABLE ENERGY USE

Solar collectors: 8m²
storage tank: 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

Alexis Versele Architecten, PHP vzw

Brochure authors

Wouter.Hilderson@passiefhuisplatform.be
Johan.Cre@passiefhuisplatform.be

This research was executed within the framework of the LEHR project (www.lehr.be), grouping three research teams (PHP/PMP, Architecture et Climat – UCL, BBRI), on account of the Belgian Federal Science Policy, executing the “Programme to stimulate knowledge transfer in areas of strategic importance”.