MORE-CONNECT: SPECIFICATIONS DEMONSTRATION PROJECTS

D 3.3 PRODUCTION AND CONSTRUCTION SPECIFICATIONS: BUILDING BLOCKS OF DEEP RETROFITTING

MORE-CONNECT, November 2017, J.A.W.H. van Oorschot, MSc., ed.

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BUILDING BLOCKS OF DEEP RETROFITTING

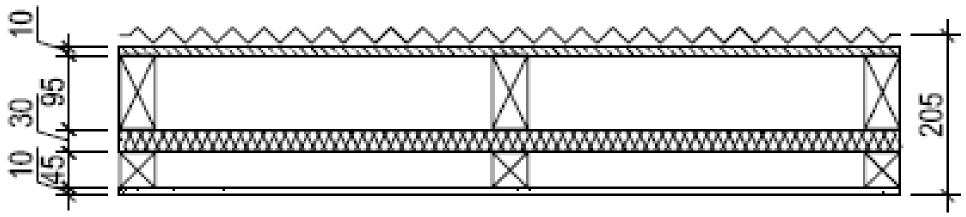
J.A.W.H. van Oorschot, MSc., ed.
November, 2017

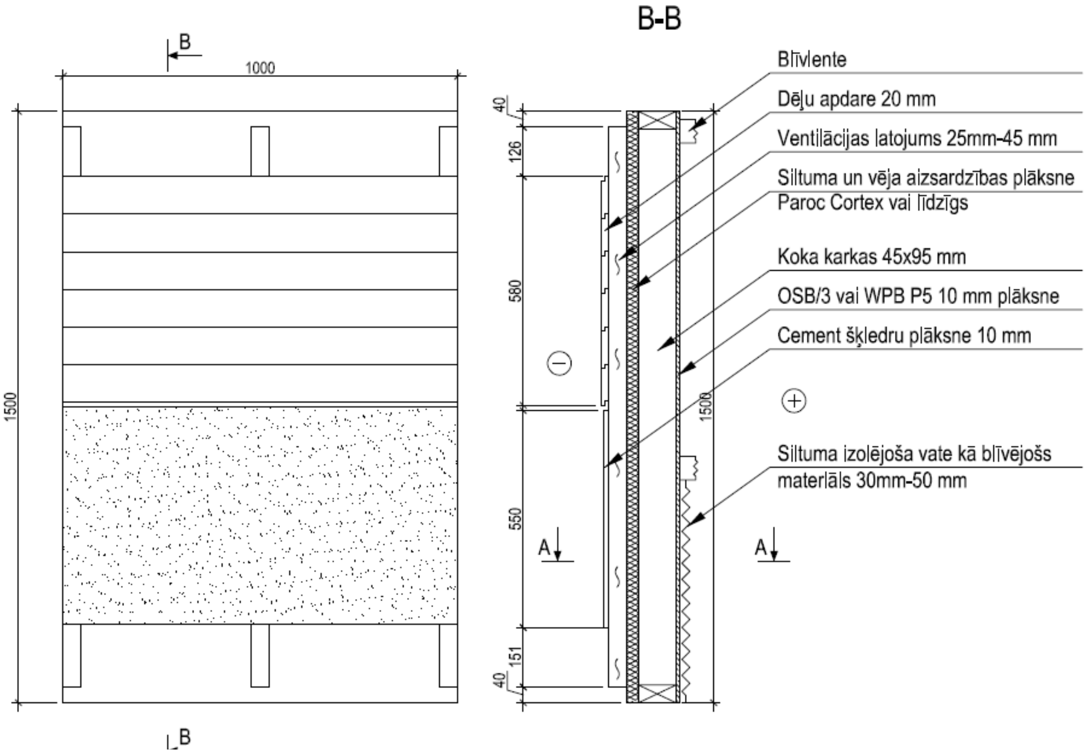
List of Contributing Authors:

Author	Abb	Affiliation	Located
(John) J.A.W.H. van Oorschot, MSc. (ed.)	ZUYD	ZUYD University of Applied Science	Heerlen, The Netherlands
Bart Voortkamp	WEBO	WEBO	Rijssen, The Netherlands
Targo Kalamees, PhD	TUT	Tallinn University of Technology	Tallinn, Estonia
Kalle Kuusk, PhD	TUT	Tallinn University of Technology	Tallinn, Estonia
Peep Pihelo, MSc	TUT	Tallinn University of Technology	Tallinn, Estonia
Raivo Külaots, MSc		Matek AS	Tallinn, Estonia Pärnu, Estonia
Manuela Almeida, Associated Professor	UMinho	University of Minho	Guimarães, Portugal
Ricardo Barbosa, PhD	UMinho	University of Minho	Guimarães, Portugal
Ana Rodrigues, MSc	UMinho	University of Minho	Guimarães, Portugal
Ove Christen Mørck, PhD	Kuben	Kuben Management A/S	Kopenhagen, Denmark
Ing. Martin Volf	CVUT	Czech Technical University in Prague, UCEEB	Prague, Czechia
Ing. Kateřina Sojková, Ph.D.	CVUT	Czech Technical University in Prague, UCEEB	Prague, Czechia

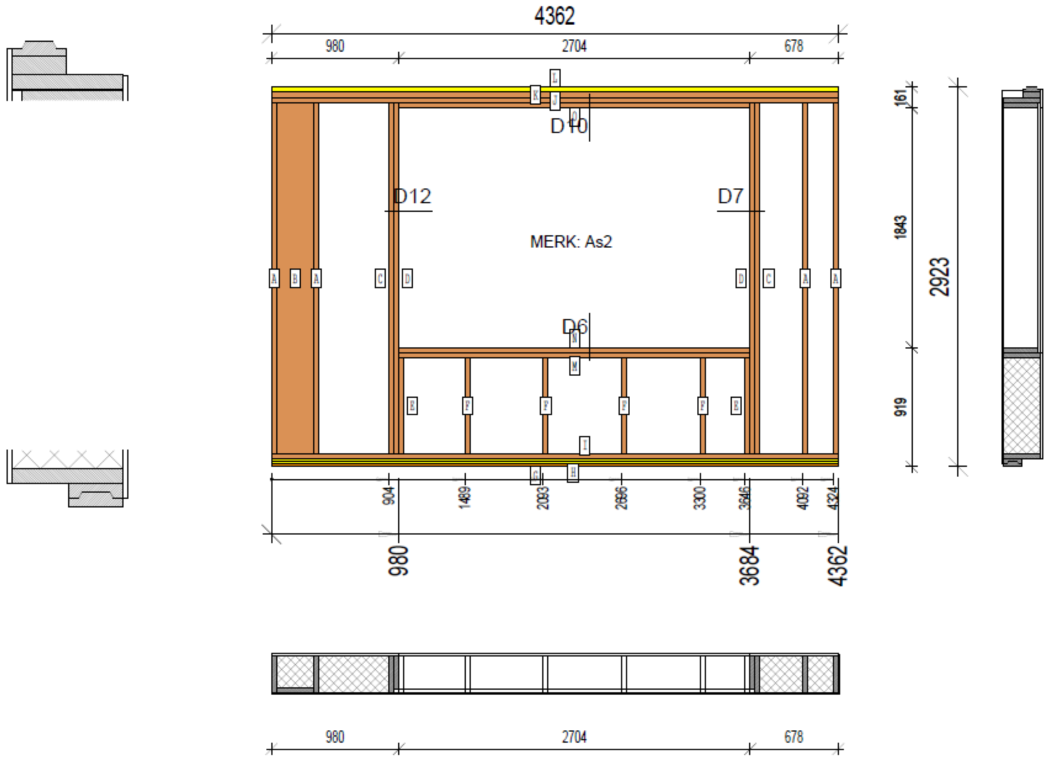
TABLE OF CONTENT

Basic module applied in Latvia

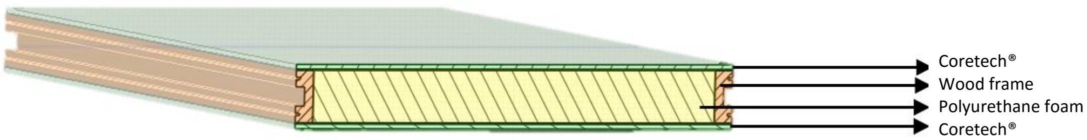




Basic module applied in The Netherlands

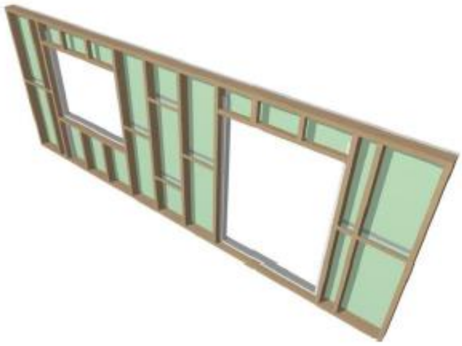
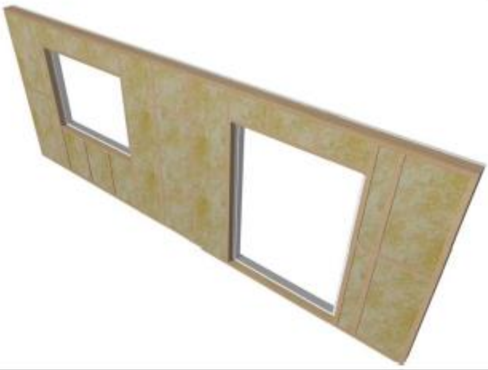


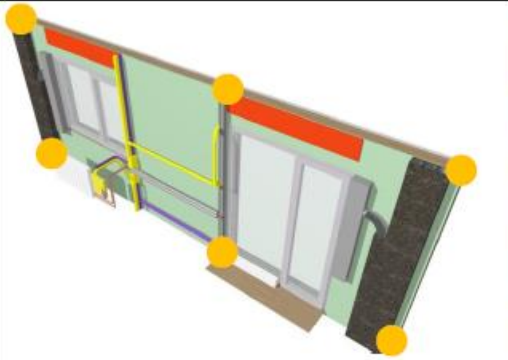
Basic module applied in Portugal



Basic module applied in Czech Republic

Table 5.4: Commented visualization of the standard wall module (from exterior to interior)

Construction stage / layer	Description
	The main bearing structure presents wooden or wood-based frame with high density mineral wool boards. The boards can be provided with a precast basic plaster, the final surface will be created in situ. The frame thickness is 120 mm.
	The frame is filled with thermal insulating material, generally mineral wool.

Construction stage / layer	Description
	The module's core is closed up by stiff, bracing boards, e.g. cement fibre boards. The installations (electrical wires in yellow and heating loop pipes in purple, insulated ventilation pipes and distribution elements in brown and grey) are fixed to the bracing board. The high-performance insulation (in red) is placed in the thermally weakest detail of the module – behind the electric shading device. *The module can be connected by 6 anchoring elements, shared with neighbouring elements (orange circles, not visualised, developed in Task 2.6).*
	*The integrated systems are covered with soft, compressible insulating layer.*

Construction stage / layer	Description
	The window siding boards will be applied after the installation of the panel to the existing structure. The control elements and electrical junction boxes can be covered by those.
	*Final setting – the wall module mounted on existing wall.*

EXPERIENCES FROM DENMARK

CASE STUDY: KLOSTERPARKEN 34.6, ODENSE, DENMARK

4.1 General project description

Multi apartment building built in Odense

PROJECT CHARACTERISTICS	KEY TECHNOLOGIES
Owner: Fyens Social Housing Association Architect: n/a Consultant: Rambøll Contractor / key suppliers: Several contractors Location: Odense, Denmark Number of housing units: 1 block, 166 apartments Under construction: 2017-2018	• Added insulation to part of the external walls - the gable walls (*) • Additional insulation of the roof • New windows • New mechanical ventilation systems with heat recovery • PV-system on part of the roof (*)

DESIGN DATA (before renovation)
Number of housing units [#]: Before renovation: 170
After renovation: 166
Heated floor area [m^2]: 13685

Energy consumption (heating + DHW) per housing unit per year [kWh]: 8900 (108 kWh/y/m^2)

Electricity consumption per housing unit per year (excl. heating) [kWh/y] (excluding household electricity): 370 (4.5 kWh/y/m^2)

Korsløkkeparken consist of seven apartment blocks in total in Odense the centre town of the island Fyen. All the seven blocks are being renovated as part of a total renovation plan for the area. The blocks were originally constructed in the years 1961-1981. The apartments are administered by Building association Fyen (FAB), which refer to them as department 34. One of the seven buildings have been selected for the MORE-CONNECT pilot project. This is referred to a building 34.6 – see photo to the right. It has 170 apartments and after the renovation this will be changed to 166 apartments. The building is 205 m long and 13,6 m broad and has 5 stories. The total living area is 13685 m² and the basement area is 2737 m². See an illustration on figure 1. This building was constructed in 1961.

Figure 1 General view of the building

Poorly-insulated building envelope. Natural ventilation without regulation possibilities.

4.2 Renovation concept and notable features

The energy renovation encompass the following measures:
Added insulation to part of the external walls - the gable walls (*)
Additional insulation of the roof
New windows
New mechanical ventilation systems with heat recovery
PV-system on part of the roof (*)

DESIGN DATA (after renovation)
Number of housing units [#]: 166
Heated floor area [m²]: 13685
Average size of unit [m²]: 82.4
Energy consumption (heating) per housing unit per year [kWh]: 3873 (47 kWh/y/m²)

Electricity consumption per housing unit/year
(excl. heating and household) [kWh/y]: 420 (5 kWh/y/m²)

Rent [€/month/unit]: 510
Rent increase per month [€/unit]: 115
Reduction energy costs per year [€]: 295 (heating savings + PV production

4.3 Energy related indicators

Characteristics Retrofit projects:

Thermal insulation: -Roof -Facade -Floor/foundation	Rc 1,0 – 2,5 ○ ○ ○	Rc 2,5 – 4,0 ○ ○ ○	Rc 4,0 – 5,5 ○ ○ ○	Rc 5,5 – 7,0 ○ ● ○	Rc 7,0 – 12,0 ● ○ ○
Measures airtightness	Present ●	Not present ○			
Glazing	Double ○	Triple ●			
PV panels (m2 PV / dwelling)	2 - 5 ●	15 - 20 ○	20 - 30 ○	30 - 40 ○	>40 ○
Heating	Gas-fired boiler (HR-107) ○	Heat pump (water) ○	Heat pump (air) ○	Hybrid ○	External source –district heating ●
Domestic hot water	Gas-fired boiler (HR-107) ○	Heat pump ○	External source ○	Shower heat recovery ○	External source –district heating ●
Ventilation system	Natural (C) ○	Natural-controlled (C+) ○	Mechanical (D) ●	Mechanical-controlled (D+) ○	
Energy supply	Gas + Electric ○	Electric ○	External source (district heating) ●	None (all-electric) ○	

4.4 Technological design – retrofit design details

Façade solutions

Roof solutions

Floor solutions

4.5 Construction process

EXPERIENCES FROM ESTONIA

CASE STUDY: AKADEEMIA 5A, TALLINN, ESTONIA

General project description

PROJECT CHARACTERISTICS
Owner:
TUT Campus
Architect:
SIRKEL & MALL OÜ
Consultant:
TUT
Contractor / key supplier:
Oma Ehitaja AS / Matek AS
Location:
Akadeemia 5A, Tallinn, Estonia
Number of housing units:
80
Under construction/renovation:
2017

KEY TECHNOLOGIES / PRINCIPLES

- Prefabricated modules for the facade;
- Prefabricated modules for the roof;
- Heat recovery ventilation
- PV panels
- Solar thermal collectors
- Sewerage heat recovery

The pilot building, located at Tallinn University of Technology campus and functioning as a student hostel, is a typical 5-storey building, built in 1986 and made of prefabricated concrete large panel elements. Building has a full-scale cellar and it has an insulated flat roof structure with bituminous felt cover and number of natural ventilation chimneys. The building has simple, rectangular floor plan. It has 2 similar wings, 2 staircases, with similarly designed 80 flats. The net area of the building is 3824 m^2 and heated area 3306 m^2.

Overall present energy performance of the pilot building: U_{wall} = 1.0 W/(m^{2}K), U_{roof}= 1.1 W/(m^{2}K), U_{floor} = 0.6 W/(m^{2}K)). It has serious thermal bridges, lack or insufficient ventilation, water-proofing failures on balconies and on window drip molds. Windows with plastic frames have high thermal transmittance (U_{window} = 1.8 W/(m$_2$K)) and broken closing mechanisms and fixings. Calculated according to measurements temperature factor f_{Rsi}<0.80, which is under the accepted limit (required for this type of buildings f_{Rsi}>0.80 according to national annex of EN ISO 13788). Because of serious thermal bridges in these type of buildings, mould growths on interior surface, especially in the corners of exterior walls and roof.

The pilot building has similar problems typical to many other older buildings in Estonia: high energy consumption, insufficient ventilation, overheating during winter, unsatisfactory thermal comfort. Fresh air inlet was initially designed through the slits around untightened window wooden-frames and natural exhaust via kitchen and sanitary rooms to central shaft. The building has a one-pipe radiator heating system without thermostats and the room temperature for the whole building is regulated by a heat substation depending on the outdoor temperature.

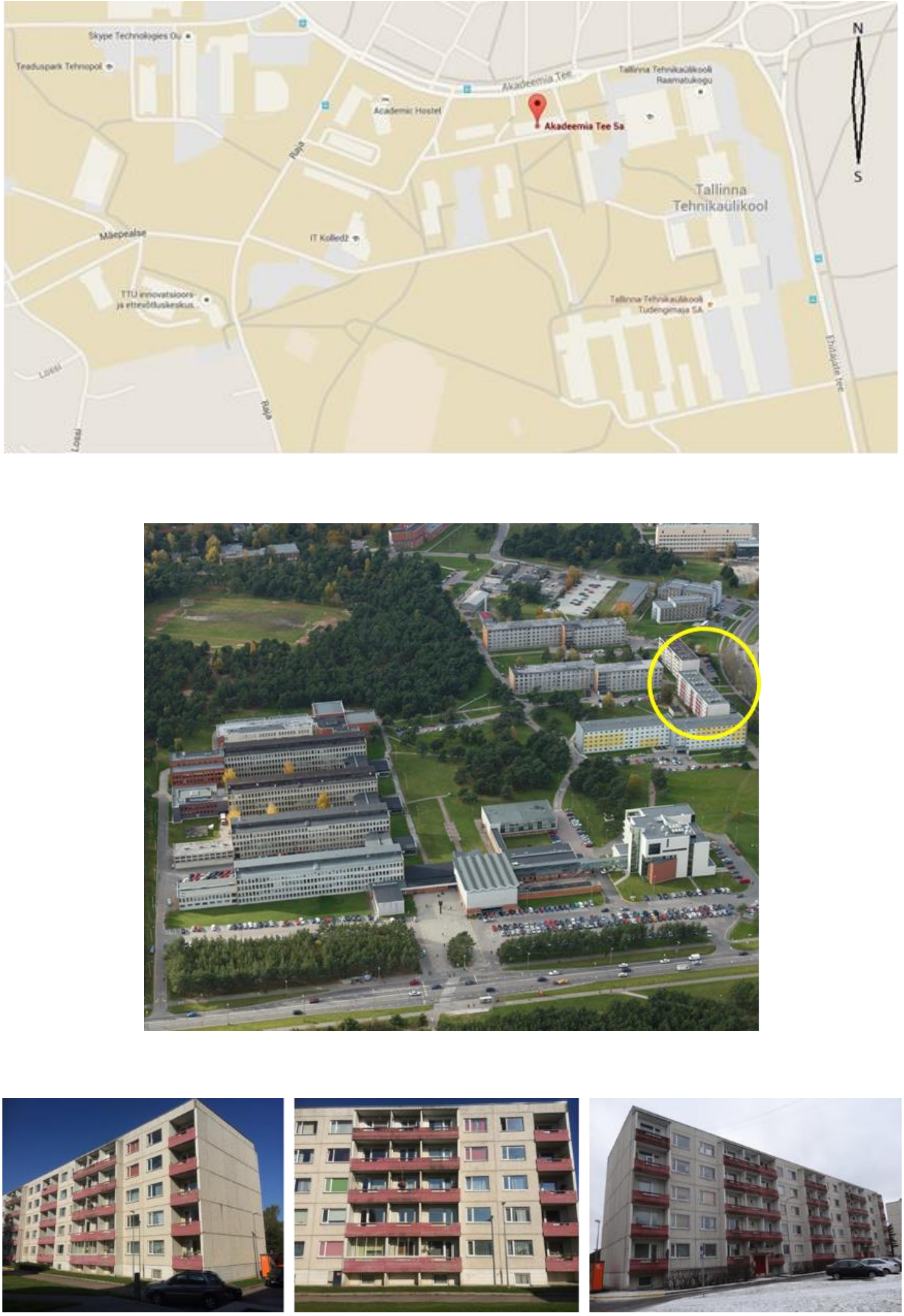


Figure 2 Location and overview of pilot building at TUT campus, Tallinn

DESIGN DATA (before renovation)
Number of housing units [#]: 80
Heated floor area [m^2]: 3306
Energy consumption (heating and ventilation) per housing unit per year [kWh]: 6157 (149 kWh/m^2)
Energy consumption (DHW) per housing unit per year [kWh]: 1240 (30 kWh/m^2)
Air tightness qv; 10 [dm^3/s] per m^2 floor space: N/A
Installed heating capacity per housing unit [kW]: N/A (N/A W/m^2)
Electricity consumption per housing unit per year (excl. heating) [kWh]: 1240 (30 kWh/m^2)

Renovation concept and notable features

The owner of the building has decided to make a deep renovation of the whole building to solve the aforementioned problems.
In the framework of the MORE-CONNECT project, beside the anyway renovation of the building interior premises and technical appliances, there is designed a solution of insulation of building envelope with prefabricated roof and wall modules.
Correspondingly, the monitored and automated heat and ventilation systems with mechanical inlet and exhaust systems, PV panels, thermal solar collectors and sewerage heat recovery systems are part of the innovative and energy efficient solution of the nZEB renovation of the pilot building. All the technical systems and module structures will be monitored with sensors and logged data will be analysed periodically. Special attention is paid to the airtightness and hygrothermal performance of the building envelope as a one of the key factors of sustainable nZEB project.

The main technological aspects of nZEB renovation of the pilot building in Estonia:

- Prefabricated timber frame modular panels for facades and roofs
- Preinstalled into the wall modules double glazed windows
- Embedded into the modular panels ventilation ducts
- Heat recovery ventilation
- Sewerage heat recovery
- Solar thermal collectors
- PV panels

DESIGN DATA (after renovation)

Number of housing units [#]: 80

Heated floor area [m^2]: 3562

Energy consumption (heating and ventilation) per housing unit per year [kWh]: 445 (10 kWh/m^2)

Energy consumption (DHW) per housing unit per year [kWh]: 1336 (30 kWh/m^2)

Air tightness q_{50} [m^3/(m^{2}h)]: < 2

Installed heating capacity per housing unit [kW]: 5.1 (115 W/m^2)

Electricity consumption per housing unit per year (excl. heating) [kWh]: 1336 (30 kWh/m^2)

Heat production on site (solar panels and sewerage heat recovery) per housing unit per year [kW]: -1024 (-23 kWh/m^2)

Rent [€]: N/A

Rent increase per month [€]: N/A

Reduction of energy costs per year [€]: N/A

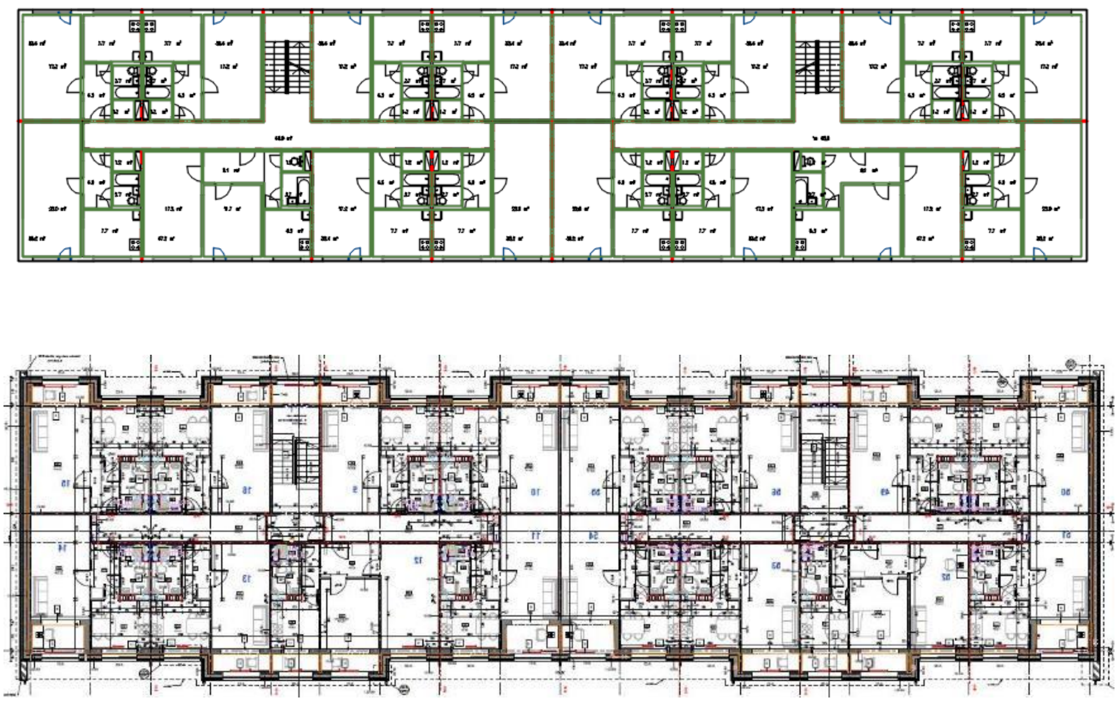


Figure 3 General floor plan of the pilot building before (above) and after (below) nZEB renovation

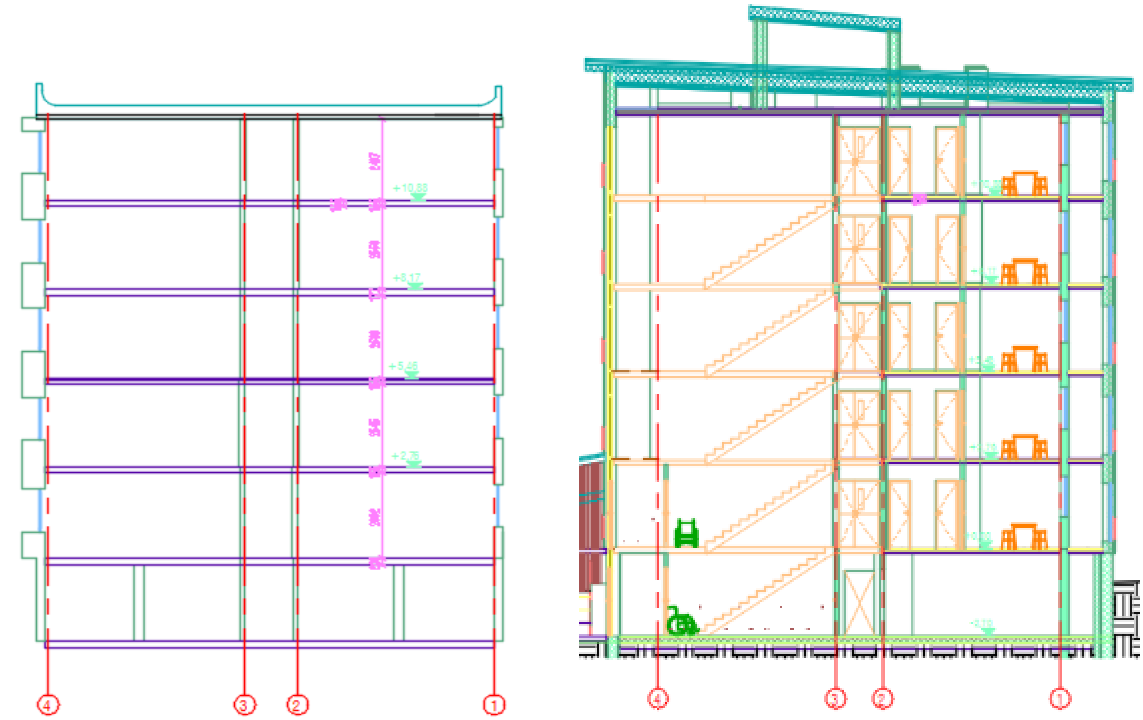


Figure 4 Cross section of the pilot building before (left) and after (right) nZEB renovation

Energy related indicators

Characteristics of retrofit projects:

Thermal insulation:	Rc 1,0 – 2,5	Rc 2,5 – 4,0	Rc 4,0 – 5,5	Rc 5,5 – 7,0	Rc 7,0 – 12,0
-Roof	○	○	○	○	●
-Facade	○	○	○	○	●
-Floor/foundation	○	○	○	○	●
Measured airtightness	Present ●	Not present ○			
Glazing	Double ●	Triple ○			
PV panels (m2 PV / dwelling)	10 - 15 ●	15 - 20 ○	20 - 30 ○	30 - 40 ○	>40 ○
Heating	Gas-fired boiler (HR-107 ○	Heat pump (water) ○	Heat pump (air) ○	Hybrid ●	External source ●
Domestic hot water	Gas-fired boiler (HR-107 ○	Heat pump ○	External source ○	Shower heat recovery ●	Thermal solar boiler ●
Ventilation system	Natural (C) ○	Natural-controlled (C+) ○	Mechanical (D) ○	Mechanical-controlled (D+) ●	
Energy supply	Gas + Electric ●	Electric ○	External source (district heating) ●	None (all-electric) ○	

nZEB is defined in Estonia as a numeric indicator, Energy Performance Value (EPV), of primary energy use, considering energy for indoor climate (heating, cooling, ventilation, lighting), DHW and appliances. For nZEB apartment buildings EPV<100 kWh/(m^2·a). Ventilation airflow after renovation should represent a normal level of expectation for the II indoor climate category (ICC II) with ventilation airflow 0.42 l/(s·m^2).

The calculated primary energy use of nZEB renovation shows a 2/3 reduction compared to pre-renovation state. The heating system will be replaced with a two-pipe system with hydronic radiators and thermostats. The building's initial passive stack ventilation system will be replaced with a mechanical supply and exhaust ventilation with heat recovery. The deficit of places for ventilation ducts in this project design will be solved with the integration of preheated air supply ducts into the renovation module panels. Solar collectors and PV panels will be installed onto the roof, ventilation and sewerage heat recovery is applied.

Heating & ventilation

New ventilation system will be installed. In one wing of the building is planned to use individual room/apartment based and controlled system. In another wing will be installed central inlet and outlet ventilation system with local room based semiautomatic valves. The both systems will have efficient warm exhaust air collectors and heat exchangers. Ventilation ducts are embedded into the wall module elements. Assumed position of ventilation units with heat exchanger is in the roof. Fire protection and acoustics will be taken into account according to safety rules.

Heating system will be replaced in one wing of building to individually adjustable two-pipe system with radiators and valves. Pipelines will be replaced and insulated as much as aesthetically possible. Original element radiators will be replaced with panel radiators, with flow/return temperature 70/55°C. Decrease of flow/return temperature associated with reduced heat loss, equithermal control implementation.

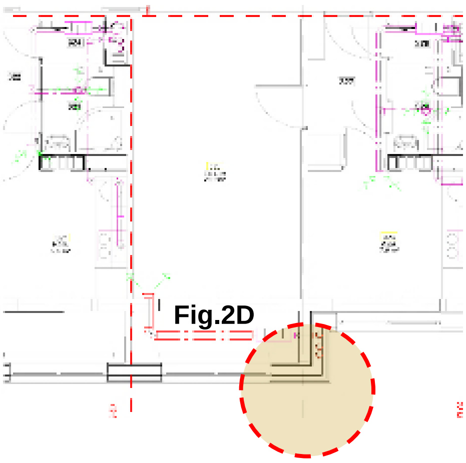
Figure 5 Building based balanced ventilation units with VHR and embedded ventilation ducts into the wall module (left) and apartment based balanced ventilation units with VHR (right) in different wings of the pilot building

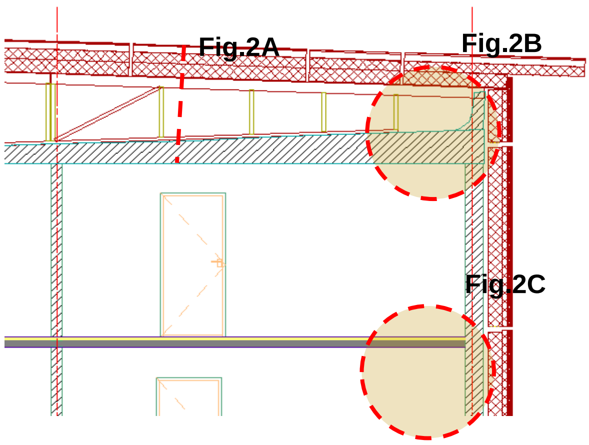
Figure 6 Designed solution (above) and installed (below) solar and PV panels on the roof of the pilot building

Facade solutions

The building envelope above ground is planned to be insulated with prefabricated modular panels. Basement walls are planned to be insulated with an external thermal insulation composite system. Prefabricated modular panels consist of a timber frame structure filled with mineral wool. To get accurate information about the unevenness and roughness of the existing surfaces and inhomogeneity of windows location, 3D laser scanning of the envelope was conducted before the design.

The total thickness of designed modular wall elements is 340-380mm, depending on the surface flatness of the existing wall. The total thickness of the thermal insulation in wall panels is 305-345mm: 30mm wind barrier, 70+195mm insulation between timber frames and 10-50mm light elastic mineral wool to fill the unevenness and roughness of the existing surfaces, U_{wall}=0.11W/(m^2·K). In the wall panel with dimensions ≈2.7×9m, installed in horizontal direction, are up to three preinstalled windows. To minimize joints between the modules and connections of pipes on site, the panels with ventilation ducts will be installed in vertical direction. According to the structural design of the pilot building, there is no need for additional foundation for the wall module panels. Self-supporting modules will be hanged onto the existing wall surface with the help of designed fixings, allowing adjustment of modules in all directions.





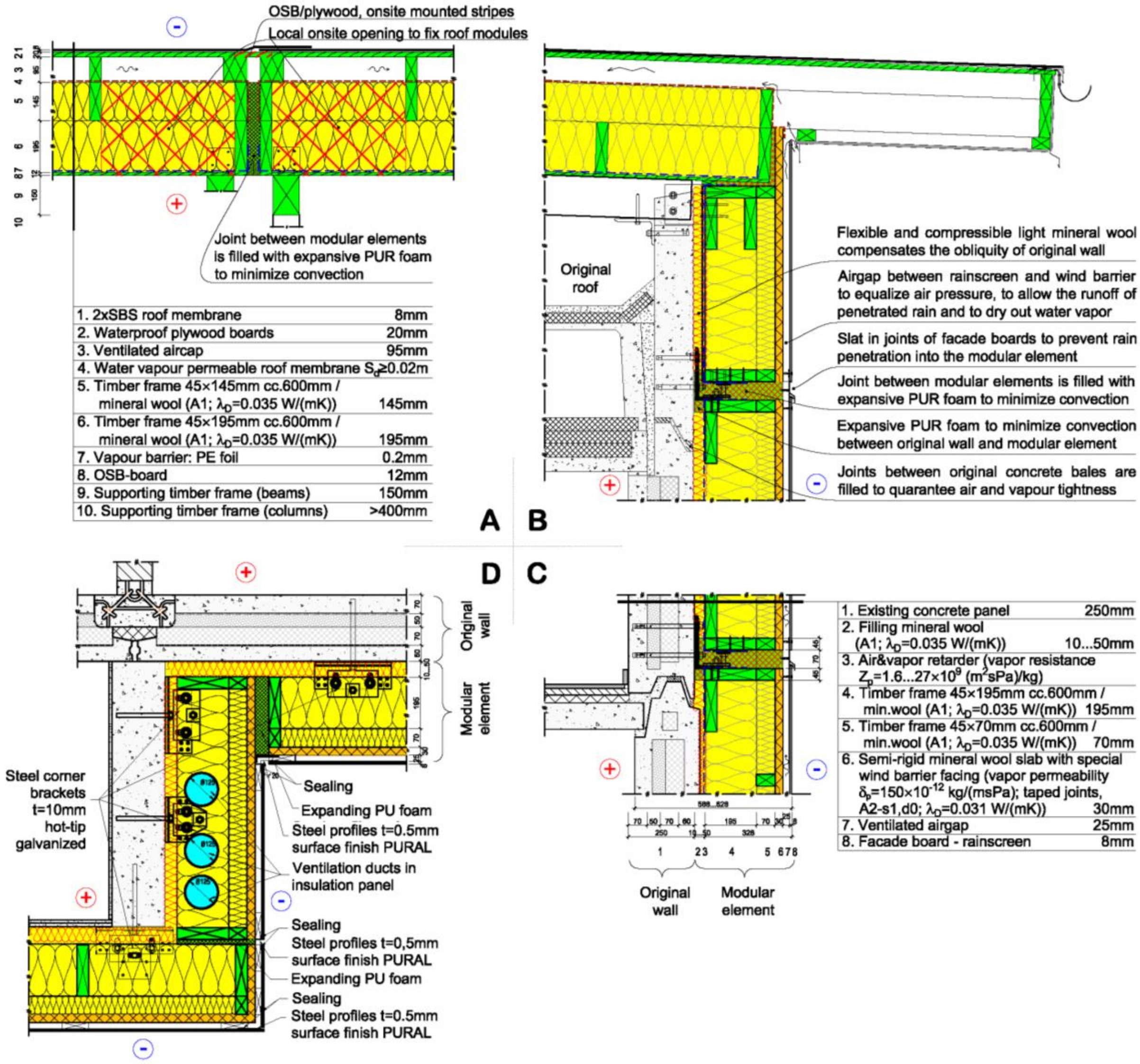


Figure 7 Designed solutions of the wall and roof modules of the pilot building

Roof solutions

Designed roof elements will be installed on the specially built timber frame because the original roof has an inward slope and parapet. Therefore, under the formed slope roof, in 0.6-1.2m high attic between old and new roof technical appliances are planned to be placed (e.g. heat exchangers, duct dispensers, automatics etc.). The total thickness of the thermal insulation in the roof modules is 340mm, U_{roof}=0.10W/(m²·K).

Figure 8 Roof constructions before (left) and during the renovation (right) of the pilot building

Floors and foundation solutions

The ground floor concrete slab is insulated with EPS boards in thickness 150mm. The foundation walls are insulated with EPS boards in thickness 340mm and rendered (plastered) above the ground level. Intermediate floors in the living spaces are insulated with 30mm rigid mineral wool slabs against impact noise and covered with HD wooden chips boards and parquet (in wet rooms with glued PVC).

Balcony solutions

The existing balconies will be demolished and rebuilt as an additional space for living rooms, therefore the module panels are used in front of former balconies spaces.

Figure 9 Balconies before (left) and after (right) renovation of the pilot building

Production and construction processes

The main construction elements of current pilot project – wall and roof module elements – were produced and assembled in the factory by Estonian producer Matek AS. The fully equipped elements of modules were transported by trucks in forehand scheduled way onto the building site and installed with help of cranes and lifters. The joints between the panels were after the installation filled with PU-foam to guarantee the airtightness of the envelope and covered with wind barrier and steel bands against rainwater penetration into the structures.

Figure 10 Production of the module panels in the factory of producer Matek AS (April – May 2017)

Figure 11 Fixings (hangers) of wall module panels before (left) and after (right) installation of the wall module panels

Figure 12 Installation of the wall module panels on the building site of the pilot building (May 2017)

EXPERIENCES FROM LATVIA

CASE STUDY: CĒSIS SAULES_IELA 4A, LATVIA

4.1 General project description

Multi apartment building built in

PROJECT CHARACTERISTICS
Owner:
Private ownership
Architect:
n/a
Consultant:
Dr.sc.ing. Anatolijs Borodinecs
Contractor / key suppliers:
LTD PRIME SERVICE

DESIGN DATA (before renovation)
Number of housing units [#]: 134
Heated floor area [m2]: 120
Energy consumption (heating + DHW) per housing unit per year [kWh]: 16500 (137kWh/m2)
Air tightness qv;10 [dm3/s] per m2 floor space: -
Installed heating capacity per housing unit [kW]: 20 (160W/m2)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]: 3500 (29kWh/m2)

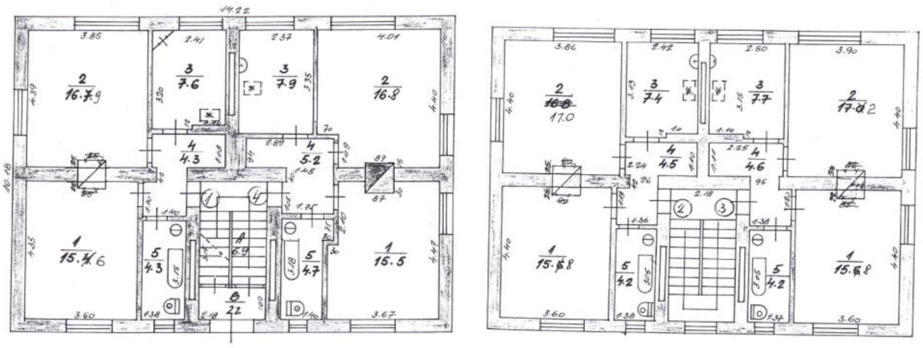
KEY TECHNOLOGIES

- Prefabricated timber facades and roofs;

Building represents typical building constructed in 50ies – 60ies last century. This type of building is very common in rural areas and small cities. The pilot building is silicate brick residential house with a lateral bearing system. The house has a wooden roof structure with slate covering. The building has simple, rectangular floor plan. It has two floors with similarly designed flats. The house has a hip roof with a number of chimneys. All old wooden windows are replaced by PVC windows 7 – 10 year ago.

Figure 13 General view of the building

Non-insulated building envelope and heating system distribution pipe. High air leakage rate of building envelope. Low thermal comfort in winter cause by low temperature of internal surfaces as well as overheating in summer. Insufficient ventilation rate. Natural ventilation without regulation possibilities Mold growth on external corners was observed during energy audit.



1st floor 2nd floor

Figure 14 Floor plans

4.2 Renovation concept and notable features

The passive house renovation technology have been tested in a single test dwelling. It has been demonstrated how a dwelling can be insulated using a 350 mm timber frame element with cellulose insulation, with triple glazed passive house window frames, and prefabricated timber roof elements, filled with 350 mm insulation. For the external façade cladding natural slates have been applied. This approach has been implemented in 134 dwellings in area 505 in the 'Kroeven' district.

Key technologies for the 134 houses using prefab renovation elements:

- Prefabricated timber facades and roofs
- Triple glazed windows
- Prefabricated timber roofs
- Heat recovery ventilation
- Condensing gas boiler
- Solar thermal collectors

DESIGN DATA (after renovation)
Number of housing units [#]: 4
Heated floor area [m2]: 208
Energy consumption (heating) per housing unit per year [kWh]: 18720 (90kWh/m2)
Air tightness qv; m^3/(h*m^2) per m2 external building envelope: <1.5
Installed heating capacity per housing unit [kW]: 3,5 (30W/m2)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]: n/a
Rent [€]: n/a
Rent increase per month [€]: n/a
Reduction energy costs per year [€]:

4.3 Energy related indicators

Characteristics Retrofit projects:

Thermal insulation:	Rc 1,0 – 2,5	Rc 2,5 – 4,0	Rc 4,0 – 5,5	Rc 5,5 – 7,0	Rc 7,0 – 12,0
-Roof	○	○	○	●	○
-Facade	○	○	○	●	○
-Floor/foundation	○	○	○	○	○
Measures airtightness	Present ●	Not present ○			
Glazing	Double ●	Triple ○			
PV panels (m2 PV / dwelling)	10 - 15 ○	15 - 20 ○	20 - 30 ○	30 - 40 ○	>40 ○
Heating	Gas-fired boiler (HR-107) ○	Heat pump (water) ○	Heat pump (air) ○	Hybrid ○	External source ○
Domestic hot water	Gas-fired boiler (HR-107) ○	Heat pump ○	External source ○	Shower heat recovery ○	Thermal solar boiler ○
Ventilation system	Natural (C) ●	Natural-controlled (C+) ○	Mechanical (D) ○	Mechanical-controlled (D+) ○	
Energy supply	Gas + Electric ○	Electric ○	External source (district heating) ●	None (all-electric) ○	

Heating, ventilation

Heating & ventilation –

Domesitic hot water –

4.4 Technological design – retrofit design details

Façade solutions

For the renovation of area 505 first the outer layer of the cavity wall was demolished. The next step was to insulate the perimeter (foundation) of the dwelling with EPS insulation, and to adjust the foundation for the installation of the timber frame panels. The new prefabricated timber frame modules (360 mm wide) are insulated with cellulose fibre with an U-value of 0.11 W/(m²·K). Moreover, triple glazed windows were already installed in the factory (U-value frame of about 0.87 W/(m²·K), U-value glass of about 0.5 W /(m²·K) with a g-value of 0.47). The new cavity between the inner leaf and the timber element is sealed around the window frames. The finishing of the prefab timber frames was installed on-site (slate tiles).

Roof solutions

Floor solutions

4.5 Construction process

The prefabricated elements have been produced by VDM, a company that is based 250 km away from the

EXPERIENCES FROM THE NETHERLANDS

CASE STUDY PRESIKHAAF, ARHNEM, THE NETHERLANDS

General project description

Deep renovation apartment block Floriszstraat, Presikhaaf, Arhnem, The Netherlands:

PROJECT CHARACTERISTICS
Owner:
Housing association (Volkshuisvesting Arhnem)
Architect/Consultant:
Bouwnext, Ede
Contractor / key suppliers:
Vastbouw, WEBO
Location:
Presikhaaf (district), Arhnem (NL)
Number of housing units:
64
Under construction:
2015

KEY TECHNOLOGIES
- Prefabricated timber facades
- Triple glazed windows
- Heat recovery ventilation
- Condensing gas boiler??

Social housing association Volkshuisvesting Arhnem owns more than 700 housing units in Presikhaaf, Arhnem. Part of these 700 housing units consist of 64 apartments, constructed in 1963, located in the Stellingwerfstraat, Floriszstraat, Van Galenstraat and Hudsonstraat. These outdated and energy consuming housing units, are still heated by gas-fired boilers, and will be renovated towards Label A++. The energy efficiency improvement measures include triple glazing, a heat recovery system and mechanical ventilation.
The front and back balconies are partially added to the house, the facade is packed with 25 centimetre insulation and gives a fresh and fresh look. The entrees are also improved and residents get a new front door and videophone. Residents do not pay a rent increase for these improvements, and will subsequently save significantly on the energy costs. The relatively low housing costs will ultimately be even lower and the comfort increases. In addition, residents can choose extras for a rent increase, such as a soundproofing wall between the home and the neighbours. The 16 homes on the Hudson Street turn in 2016.
Due to the investments that can be made, the homes can be back in 50 years. The energy label makes multiple jumps to level A with several plus points! We will consult with a Soundboard group of six residents about the upcoming maintenance plan.

DESIGN DATA (before renovation)
Number of housing units [#]: 64
Heated floor area [m2]: xx
Energy consumption (heating + DHW) per housing unit per year [kWh]: xx (xxkWh/m2)
Air tightness qv;10 [dm3/s] per m2 floor space: xx
Installed heating capacity per housing unit [kW]: xx (xxW/m2)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]: xx (xxkWh/m2)

The first step of the deep renovation project was the demolishing (of parts) of parts of the facade. The next step was to insulate the outer wall at the ground floor level (storage rooms of the apartments) with EPS insulation blocks. The prefab elements were made out of softwood and contain glass wool insulation. The triple glazed windows with wooden frames were factory mounted in the prefab façade elements. The finishing of the elements consist of brick slips (off-site) or plaster (on-site) installed on 60mm XPS added to the prefab element. The R_c value of the façade is 7,51 $m^2 \cdot K/W$. For the roof an on-site system was applied by adding a layer of insulation on top of the existing roof.
The building services systems consists of several components. The HR100 condensing boiler was replaced by a new HR107 condensing boiler?? The original radiator system was adjusted to a smaller heat demand. Ventilation is provided by balance ventilation with heat recovery.

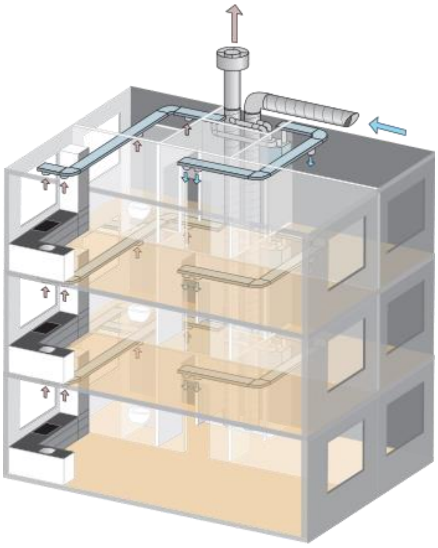
Energy performance
The energy index calculated with is 0.xx resulting in energy xx label. The total annual primary energy use is xx MJPrim.

Renovation concept and notable features

Characteristics Retrofit projects:

Thermal insulation:	Rc 1,0 – 2,5	Rc 2,5 – 4,0	Rc 4,0 – 5,5	Rc 5,5 – 7,0	Rc 7,0 – 12,0
-Roof	○	○	○	○	○
-Facade	○	○	○	○	●
-Floor/foundation	○	○	○	○	●
Measures airtightness	Present ●	Not present ○			
Glazing	Double ○	Triple ●			
PV panels (m2 PV / dwelling)	10 - 15 ○	15 - 20 ○	20 - 30 ○	30 - 40 ○	>40 ○
Heating	Gas-fired boiler (HR-107) ●	Heat pump (water) ○	Heat pump (air) ○	Hybrid ○	External source ○
Domestic hot water	Gas-fired boiler (HR-107) ●	Heat pump ○	External source ○	Shower heat recovery ○	Thermal solar boiler ●
Ventilation system	Natural (C) ○	Natural-controlled (C+) ○	Mechanical (D) ●	Mechanical-controlled (D+) ○	
Energy supply	Gas + Electric ●	Electric ○	External source (district heating) ○	None (all-electric) ○	

- 3d design of renovation:
  - Removing front and back facade (inner and outer layer of the cavity wall)
  - Installing prefabricated façade modules front and back facade (new aesthetic façade design)
  - Adding insulation and new finishing (brick-like tiles) to left and right facing facades
- Specifications design:
  - Certificated design approach: Zero-on-the-Meter deep-retrofitting concept (certificate of right design methodology and application)
  - Heat resistance R_c 6 $W/m^2 \cdot K$, Qv;10 value of 0,25 $dm^3/(s \cdot m^2$ Ag)
  - Windows triple glazed
  - New ventilation system with heat exchange (efficiency >74%)



DESIGN DATA (after renovation)
Number of housing units [#]: 64
Heated floor area [m2]: ??
Energy consumption (heating + DHW) per housing unit per year [kWh]: ?? (??kWh/m2)
Air tightness qv;10 [dm3/s] per m2 floor space: 0,25
Installed heating capacity per housing unit [kW]: ?? (??W/m2)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]: ?? (??kWh/m2)
Rent [€]: ??
Rent increase per month [€]: none
Reduction energy costs per year [€]: ??

Energy related indicators

The energy consumption of the houses is expected to change significantly. Space heating demand will reduce to a calculated figure of around xx kWh/(m^2·y) for a mid-terrace and around xx kWh /(m^2·y) for an end terrace. These figures are xx% better than the current performance. Hot water demand will reduce by xx% to xx% due to the installed solar thermal collectors and the high efficiency of hot water production by the compact system. Highly efficient fans are part of the compact system. But otherwise there are no building related electricity savings in the units.
The building related energy bill is expected to reduce by xx%, whereas the full bill for additional costs reduces by xx%, at constant energy prices. The significantly lower heating bills make the houses future proof and affordable, even if energy prices keep rising.

Key technologies:

- Prefabricated timber facades
- Triple glazed windows
- Heat recovery ventilation

The heating energy demand is expected to reduce by xx. The hot water demand decreases with xx%, thus resulting in a xx% lower building related energy demand. The significantly lower heating bills make the houses future proof and affordable, even if energy prices keep rising.
At completion of the renovation works blower door tests have been made resulting in an airtightness figure qv;10 of 0,25 dm3/s per m2. Infrared imaging of the units did not show any anomalies.

Heating, ventilation

***Heating & ventilation* -** Heating and ventilation is provided by a compact heating system, consisting of:

- Mechanical heat recovery ventilation
- Condensing gas boiler

The heating system has been installed on the top floor. The original radiator system has been adjusted to the smaller heat demand. This include xx. Fresh air is provided by the ventilation unit to the habitable spaces, i.e. living room and bedrooms, and exhausted via toilet, bathroom and kitchen.

***Domesitic hot water* -** xx

Technological design – retrofit design details

Façade solutions

First, parts of the façade was demolished. The next step was to insulate the perimeter, the façade at the ground floor level were the storage rooms are located, around the apartment block with EPS insulation. The new prefabricated timber elements are 270 mm wide and contain glass wool insulation (Rc value of 7.51 m2 ▪ K/W). The single story high prefab elements, are installed on a steel structure at the first floor level. The prefab elements on top are connected to the building structure (floors) with plug-and-play connectors.

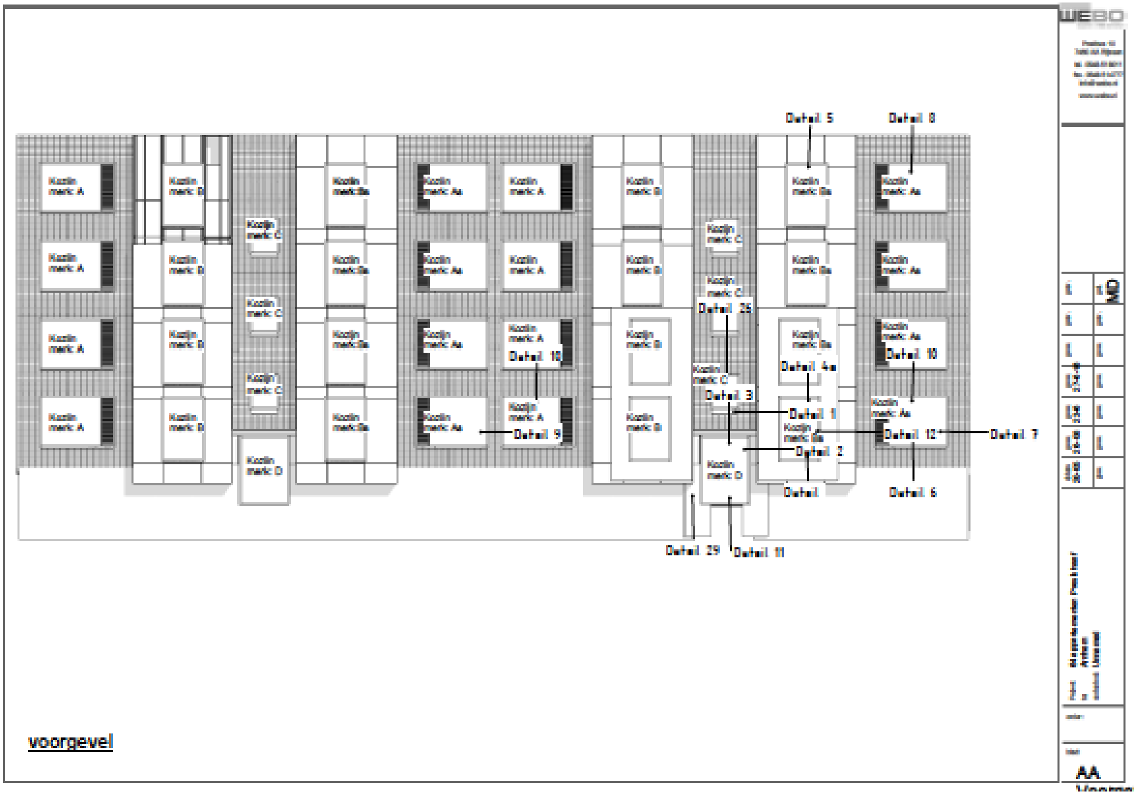
Roof solutions

For the roof an on-site system was applied by adding a layer of insulation on top of the existing roof.

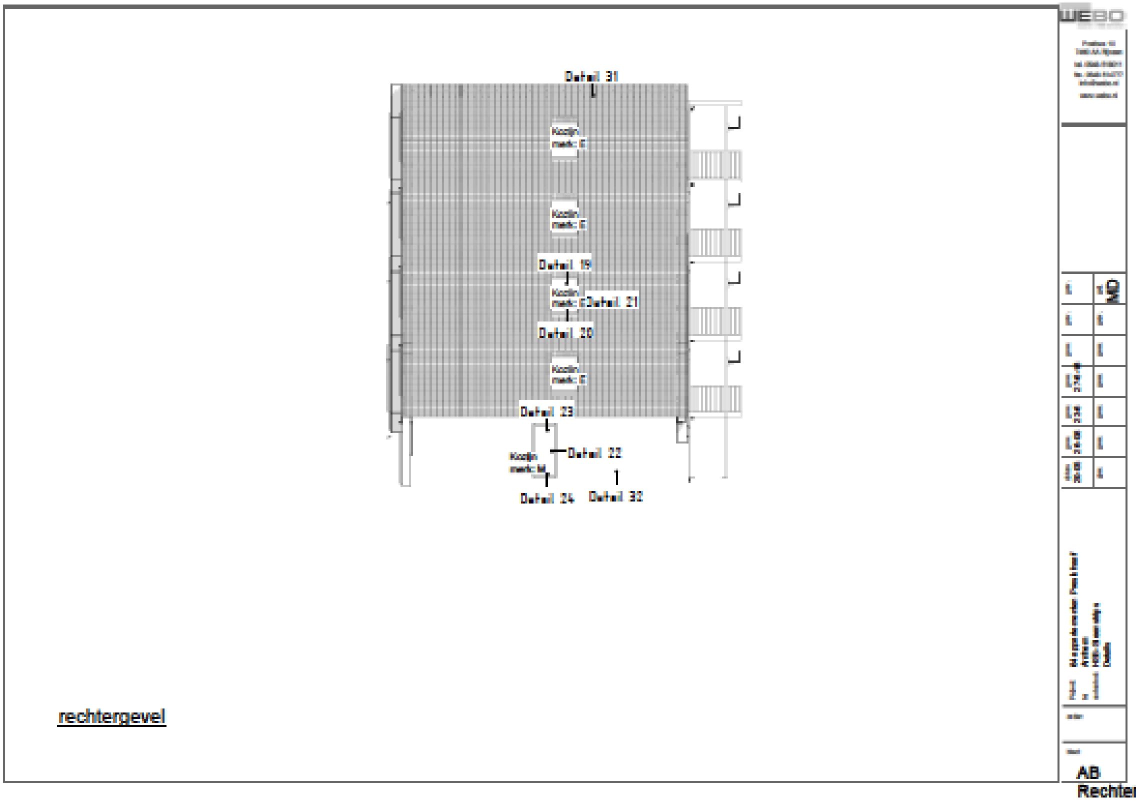
(Ground) floor solutions

The façade at the ground floor level is insulated using EPS.

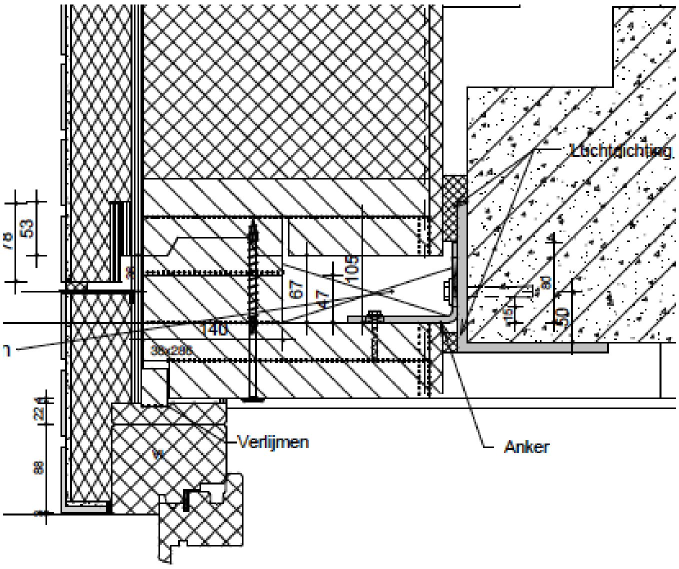
Demands met on insulation and airtightness (thermo pictures and blower test)



Overview of details front

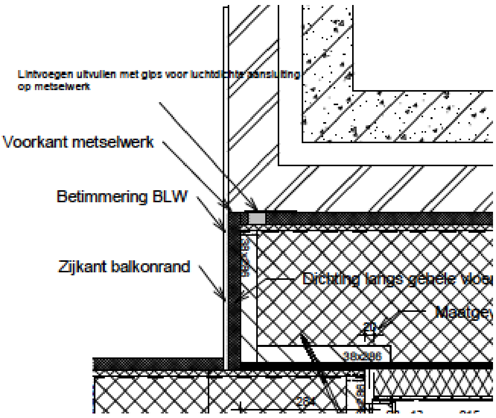


Overview of details side and back

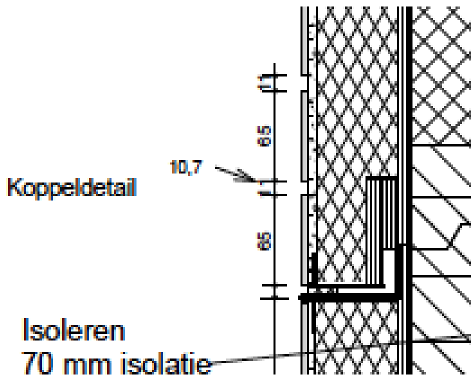


Improvements compared to previous project (project completed in the city of Zoetermeer);

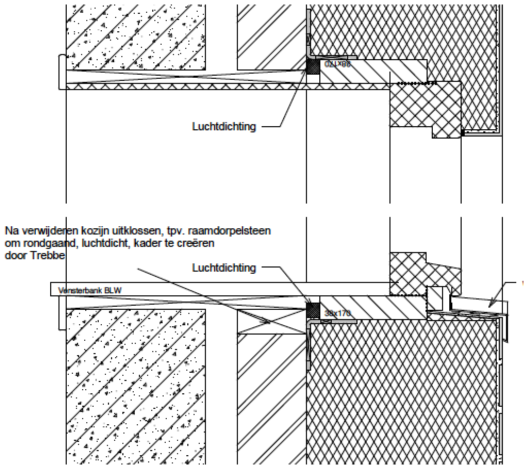
- Airtightness still organised on new elements
- Airtightness different types of compressed band used
    - Klick & Span plug-and-play mounting system applied; mounting from within the building (no scaffold needed)
- Connection between elements; different types of compressible band used (water tightness)



Some preparation work done on the existing wall to ensure airtightness. Compressible band all around the existing floor edge.

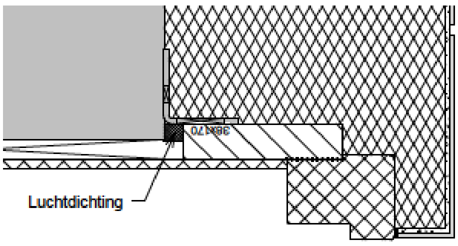


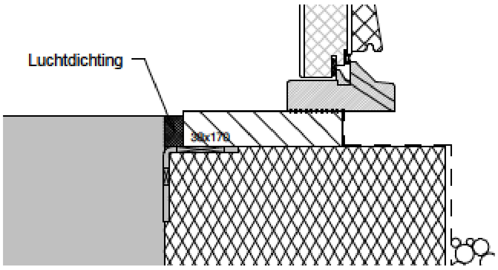
Connection detail; foil on both edges combined with compressible band.



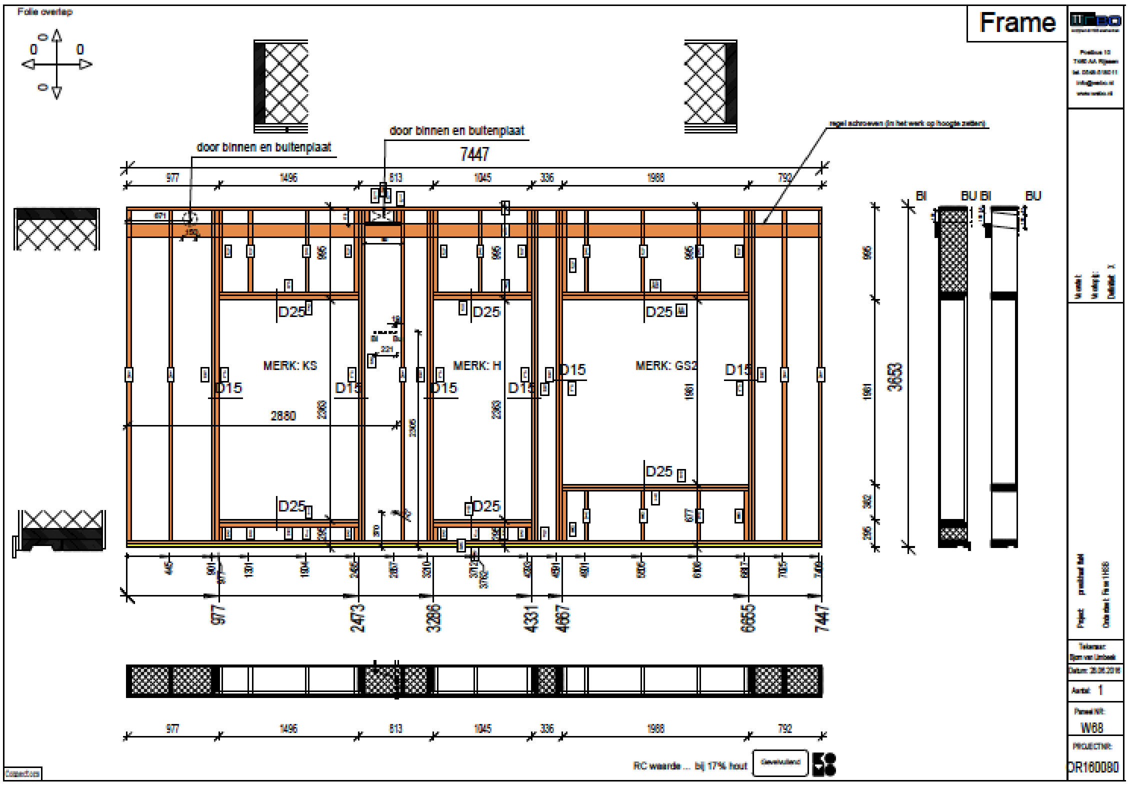
Connections detail window frames

- Old window frames removed
- New window frames installed in the façade module
- Airtightness around existing window openings





Steel bearing of walls; all weight directly to the foundation.



Construction process

The prefabricated elements have been produced by WEBO, a company that is based 75 km away from the renovation site in Presikhaaf, Arhnem. The elements are transported to the construction site by type (and thus not on based on the order of assembly). The window frames and outer finishing (brick slips) are already installed in the factory. Next the prefab façade elements are installed on site. An innovative connector has been developed to ease the mounting process. By applying the click-and-span connector, a typical plug-and-play solution, the prefab elements can be installed without scaffolding. After the installation of the elements the main contractor completed the internal finishing of the apartments. Notably, during construction period the apartments remained occupied.

EXPERIENCES FROM PORTUGAL

CASE STUDY: [EDIFÍCIO MOTA PINTO, VILA NOVA DE GAIA, PORTUGAL]

General project description

PROJECT CHARACTERISTICS
Owner:
Gaiurb
Architect:
n.a.
Consultant:
n.a.
Contractor / key suppliers:
Eletrofer
Location:
Rua do Bom Samaritano, Pedroso, Vila Nova de Gaia, Portugal
Number of housing units:
18
Under construction:
0

KEY TECHNOLOGIES / PRINCIPLES

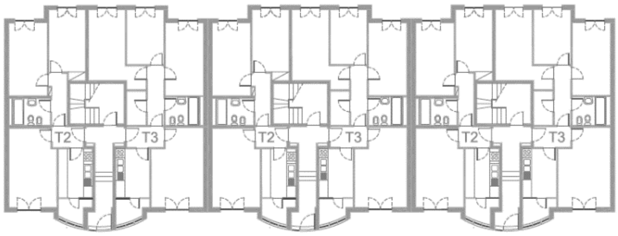
- Prefabricated module for the façade;
- Insulation on the roof and in the cellar ceiling;
- Biomass boiler for DHW and Heating

The building into analysis consists of a multi-family building with three blocks, each with three floors, corresponding to six apartments per block. The building has two types of dwellings - two bedrooms apartment and three bedrooms apartment. It was built in 1997 under a cost-control regime for social housing and is owned by the municipality of Vila Nova de Gaia.

Figure 15 General view of the building

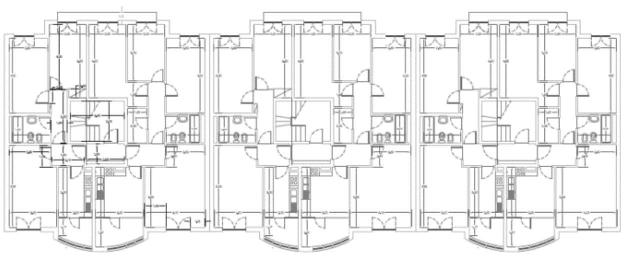
The municipality has decided to make an intervention on both buildings to solve some problems related to humidity and mould. In particular, inside the apartments, mould is visible near a significant number of windows and in some of the corners. It was decided to intervene distinctively in both buildings, to allow comparisons between a traditional renovation and an innovative proposal using a prefabricated solution.

The building selected to be intervened using the prefabricated solution (indicated in Figure 1) presents low energy performance and low levels of insulation. Besides, it has no integrated building technical systems for heating and cooling. Portable electric heaters and fans are used when necessary. A gas heater provides the DHW, in each apartment.
The renovation will affect mainly the exterior walls, roof and floor. Thus, the renovation concept for the selected building consists of improving the external walls with a prefabricated panel (developed within the scope of the project) and implementation of cellar and roof insulation (as well as consequential work such as replacement of the rainwater system). It is not foreseen any intervention in the windows. Additionally, after the renovation, as part of a second phase, a biomass boiler is planned to be implemented, improving significantly the building systems for both heating and domestic hot water (DHW).
Figure 16 shows the general aspect of the building and the floor plans. To help characterizing the building, Table 1 presents a summary of the building's main characteristics, including the most important dimensions and U-values. Details of this intervention are explained below.



Floor plan

Front façade



1st and 2nd-floor plan

Figure 16 General aspect of the building and typical floor plans

Table 1 Building' main characteristics

Parameter	Unit	Data
Building period	year	1997
Gross heated floor area	m^2	1265
Wall area (excl. windows)	m^2	2712.2
Roof area (pitched)	m^2	622.12
Attic floor	m^2	514
Area of ceiling of cellar	m^2	514
U-value wall	$W/(m^2*K)$	0.96

U-value attic floor	$W/(m^2*K)$	0.91
U-value ceiling of cellar	$W/(m^2*K)$	0.78
U-value windows	$W/(m^2*K)$	3.60
g-value windows	Factor	0.78
Airflow rate	h^{-1}	0.4-0.6*[1]

DESIGN DATA (before renovation)*[2]
Number of housing units [#]:
18
Heated floor area [m2]: 1264.50
Energy consumption (heating) per housing unit per year [kWh]: 67478
($53\ kWh/m^2$)
Energy consumption (DHW) per housing unit per year [kWh]: 52510
($42\ kWh/m^2$)
Air tightness qv; 10 [dm3/s] per m^2 floor space: 110.8 dm^3/s

Installed heating capacity per housing unit [kW]: 1.5
($21.35\ W/m^2$)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]:
n.a.

*[1] Minimum limit values for winter and summer conditions according to the Portuguese legislation
*[2] Energy consumption values are obtained through numerical simulation

Renovation concept and notable features

The most important concept behind the renovation of the selected building consists of a modular approach regarding the improvement of the exterior walls. The walls will be renovated with the prefabricated module developed within the MORE-CONNECT context. The module consists of different layers, as shown in Figure 17:

- 8 mm of Coretech;
- Wood frame;
- 100 mm of Polyurethane foam;
- 8 mm of Coretech.

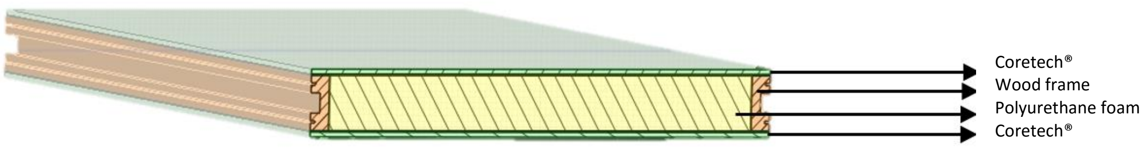


Figure 17 Illustration of the prefabricated module

The Coretech panels result from the reutilization of material from the automotive industry, which helps reducing the amount of waste. The dimensions of the panel can be adjusted, to allow adapting it to the conditions of each building.
The fixation consists of anchors, attached to the existing surface, including metal pieces in corners and joints, to promote stability. The external layer of the Coretech can be painted with the desired colour. Between the panel and the existing support, a layer of flexible mineral wool (or other similar insulation material) will be applied to better promote the link between the two surfaces and, this way, to minimize the thermal bridges of the panel joints.
This solution presents a very low thermal transmittance coefficient, that may vary according to the type and thickness of the material placed between the panel and the existing exterior wall. In multifamily buildings, the exterior wall is the constructive element that affects more directly the energy performance of all apartments. In most cases, it is the element that presents higher thermal exchanges with the surrounding environment, depending on the solar orientation and area.

Key technologies for the project using prefabricated renovation elements:

- Prefabricated module for the façades that will be attached to the existing exterior wall.

DESIGN DATA (after renovation)*3
Number of housing units [#]: 18
Heated floor area [m2]: 1264.50
Energy consumption (heating) per housing unit per year [kWh]: 34141.50 (27 kWh/m2)**
Energy consumption (DHW) per housing unit per year [kWh]: 37441.85 (29.61 kWh/m2)*4
Air tightness qv;10 [dm3/s] per m2 floor space: 110.8 dm3/s
Installed heating capacity per housing unit [kW]: 64 (51 W/m2)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]: n.a.

Rent [€]: n.a.
Rent increase per month [€]: 0
Reduction energy costs per year [€]: 7364.73

*3Energy consumption values are obtained through numerical simulation

*4This building is a social housing and thus, the energy costs are subsidized. However, for the calculations, typical costs for Kwh were considered.

4.3 Energy related indicators

Characteristics of the Retrofit projects:

Thermal insulation:	Rc 1,0 – 2,5	Rc 2,5 – 4,0	Rc 4,0 – 5,5	Rc 5,5 – 7,0	Rc 7,0 – 12,0
-Roof	○	●	○	○	○
-Facade	○	○	○	●	○
-Floor/foundation	○	●	○	○	○
Measures airtightness	Present ○	Not present ●			
Glazing	Double ●	Triple ○			
PV panels (m2 PV / dwelling)	10 - 15 ○	15 - 20 ○	20 - 30 ○	30 - 40 ○	>40 ○
Heating	Gas-fired boiler (HR-107) ○	Heat pump (water) ○	Heat pump (air) ○	Hybrid ○	Biomass ●
Domestic hot water	Gas-fired boiler (HR-107) ○	Heat pump ○	External source ○	Thermal solar boiler ○	Biomass ●
Ventilation system	Natural (C) ●	Natural-controlled (C+) ○	Mechanical (D) ○	Mechanical-controlled (D+) ○	
Energy supply	Gas + Electric ○	Electric ○	External source (district heating) ○	None (all-electric) ○	Pellets ●

Energy efficiency is expected to be improved in a significant manner with the conclusion of the project. Space heating demand in the apartments will decrease in average 26.42 Kwh/(m^2.y), which corresponds to a reduction in energy expenses around 82%. In the context of the renovation, the following systems will be installed:

Heating & ventilation – Currently the building does not have a heating system installed, apart from portable electric heaters. In a later stage, after the renovation, a biomass boiler is expected to be implemented.
Domestic hot water – Currently the building has a gas heater in each apartment. After the renovation, the DHW will also be prepared by the biomass boiler.

The calculations performed showed that it is possible to avoid the use of a system just to deal with cooling energy needs. The cooling energy needs are very low and the Portuguese thermal regulation has an expeditious method to evaluate the risks of overheating by calculating a heat gains utilization factor, which depends on the thermal mass and on the balance between heat gains and heat losses throughout the envelope. When this factor is higher than the reference value, the overheating risks are considered inexistent and the cooling needs are not accounted for the energy performance of the building avoiding using a system just for cooling. After applying this methodology to this pilot building, it was decided that a cooling system would not be considered because in this case, the overheating risks are nil

Technological design – retrofit design details

Façade solutions

For the façade, the renovation solution consists of the prefabricated module. For this building, the panels will be applied over a layer of 10cm of mineral wool. This layer intends to absorb the irregularities of the wall and deal with the thermal bridges from the joints of the panels, as presented in Figure 18 . The fixation of the panels consists of injectable adhesive anchors and metal pieces to promote stability, attached to the existing wall. Figure 19 and Figure 20 show some details of the fixation system.
The external layer of the Coretech surface will be painted.
This solution presents a very low coefficient of thermal transmittance (weighted U-value = 0.17W/m².°C), which will reduce significantly the thermal bridges, where normally occurs mould and humidity.

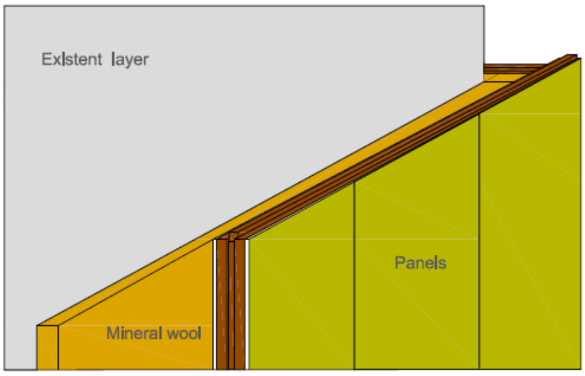


Figure 18 Representation of the application of prefabricated panel

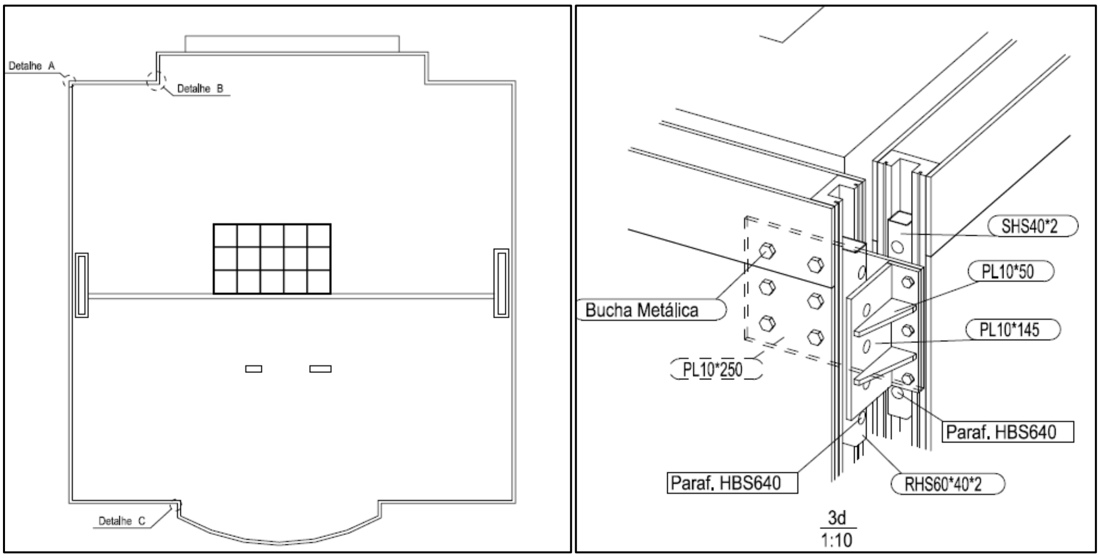


Figure 19 Roof plan and Details of the fixation of the panels in the existing wall. Detail A is relative to a protunding corner.

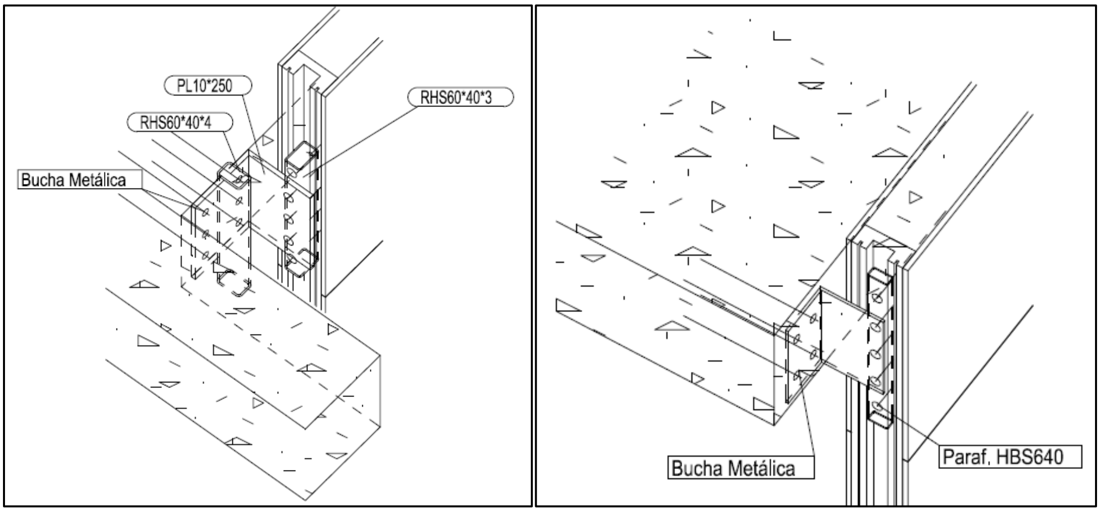


Figure 20 Details of the fixation B and C.

Roof solutions

The roof is a crucial element to avoid water infiltration and humidity. Besides, for the apartments that are beneath it, the roof is another important element, once it also allows significant heat exchanges with the environment. Thus, to reduce the heat exchanges, a 6cm layer of projected polyurethane will be applied in the attic, to increase the insulation of the existing slab (see Figure 21). The rainwater system will also be replaced. The final U-value is expected to be reduced from 0.91 to 0.40 W/m².°C.

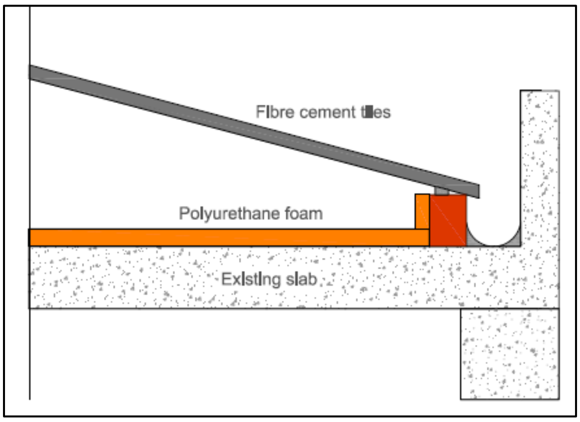


Figure 21 Application of insulation on the roof

Floor solutions

Concerning the ground floor, insulation boards will be applied underneath the floor slab, directly in contact with the cellar. The insulation consists of boards with 6 cm of extruded polystyrene attached directly to the slab. This slab is very easy to access from the cellar and being so, the renovation solution does not present any special specificity, besides the necessary surface homogeneity. The transmittance of the final solution is expected to be U=0.34 W/m².°C. Figure 22 shows an illustration of the application of the insulation boards.

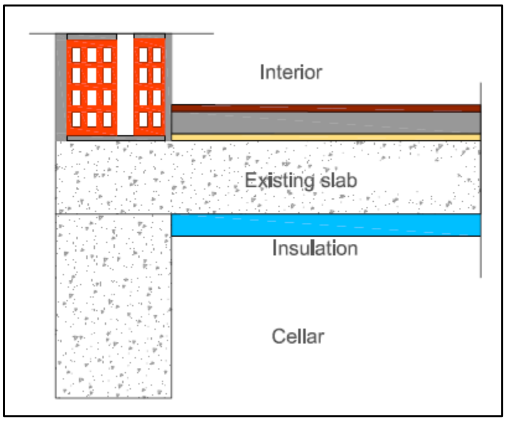


Figure 22 Application of insulation in cellar ceiling

4.5 Construction process

The intervention intends to interfere as little as possible with the daily routine of the users. Thus, the solution for the façade consists of applying a layer of flexible mineral wool (low density) between the existing wall and the prefabricated module. The module will be fixed with anchors and metallic pieces to provide resistance in the corners and joints.
The application of the panels requires the use of lifting platforms and a mobile crane.
It will be necessary to replace the window sills, adapting it to the new thickness of the wall.
Concerning the roof, the height of the attic does not allow a person to stand up in the whole area, which is a constraint to the application of some insulation solutions. In this sense, the insulation is going to be projected, which also reduces the time for its application.
The intervention on the floor is going to be performed inside the cellar bellow the ground-floor level. The insulation will be attached to the ceiling, with mechanical anchorages.

EXPERIENCES FROM Czech Republic

CASE STUDY: RESIDENTIAL BUILDING, JIRÁSKOVA 775, MILEVSKO

General project description

PROJECT CHARACTERISTICS
Owner:
Town Council of Milevsko
Architect:
unknown
Consultant:
unknown
Contractor / key suppliers:
unknown
Location:
Jiráskova 775, Milevsko, CZ
Number of flats:
36
Under construction:
1958

KEY TECHNOLOGIES / PRINCIPLES
- masonry wall system
- district heating system

The pilot building is masonry/brick residential house with a lateral bearing system. The house has a wooden roof structure with ceramic tiles, house is partly provided with cellar. The building has simple, rectangular floor plan. It has three floors with similarly designed flats. The house has a hip roof with a number of chimneys.


The building's façade is plane, split by colour changes. The windows are set rhythmically, repeating in the similar distances. The main entrances to the building are designed in the shorter side of the house from the street Karla Čapka. The longitudinal axis orientation is east-west. The fronts of house is divided by broad double front door and large windows above the staircase. The recessed balconies are on the other side of the short façade situated in the axis of the view. Simple white and brown stucco façade was renewed in the beginning of 1990's.

Its typical problems are old-fashion appearance, devastated common areas, unsatisfied overall energy performance, insufficient ventilation, mould growth in the basement floor, water-proofing failures, ruptures in plaster, badly insulating original wooden windows with loose closing mechanism, condensation and mould growth in the flats with replaced wooden windows for the new "euro" standards. Failures and water leakage in the area of chimney-roof run through. Overheating problem may occur during winter season bringing insufficient thermal comfort to the building users.

The thickness of the bearing walls is 450 mm, the staircase surrounding walls have thickness of 300 mm, partition walls 100 mm or 150 mm. Dextral staircase contains two straight flight of stairs in each floor. There are 7 stairs made of stone in one flight of stairs. U-value of external walls 450 mm = 1,35 $W.m^{-2}.K^{-1}$, U-value of window sills (thickness 300 mm) = 1.77 $W.m^{-2}.K^{-1}$. The floor slabs are precast-monolithic concrete, 220 mm thick. U-value of the first floor above the cellar = 3.5 $W.m^{-2}.K^{-1}$.

Original wooden 1950s windows were already replaced by plastic windows and door with assumed g-value of 0,67, U_w = 1,2 $W.m^{-2}.K^{-1}$ and U_d = 1,4 $W.m^{-2}.K^{-1}$.

The roofing consist of wooden truss frame with ceramic tiles. The loft area is accessible via ladder from the last stair landing. The ceiling is insulated using slag gravel. The insulating level is not sufficient. The roof slope is 33°. Roof composition consists of asphalt waterproofing placed in between the wooden laths and covered by ceramic tiles. $U_{ceiling}$ = 3.58 $W.m^{-2}.K^{-1}$.

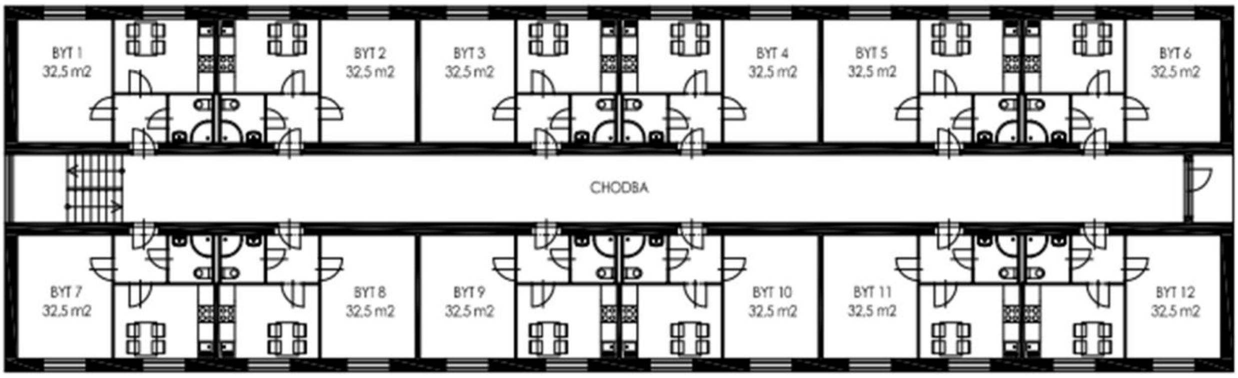
The heating source is district heating with in-house DHW preparation. The system is designed at flow/return temperatures 80/60°C, double steel pipes with pump. Horizontal piping is mounted under cellar's ceiling. The radiators are mostly original from 1950s, cast iron element radiators with thermostatic valves – these are not present in common areas. Pipes are insulated using basalt wool with gypsum layer or mineral wool with aluminum foil. The heat consumption is measured individually in each apartment.

Cooling system is not present. Overheating of the house was not observed. The common areas in the house are ventilated naturally. Most frequently, air ventilation is present in the form of suction boxes in the kitchens and axial ventilators abducting the air from the toilets and bathrooms.

There are installation shafts in the middle of the buildings floor plan near the kitchen and bathroom area. Water pipes are plastic, partly insulated by “Mirelon” insulation. Domestic hot water temperature varies between 45°C to 60°C.

There are individual measurement and control system in each flat depending on the heat source. No central measurement control system is installed in the building.

DESIGN DATA (before renovation)
Number of flats (units) [#]: 36
Heated floor area [m2]: 1107
Energy consumption (heating + DHW) per unit per year [kWh]: 378 594
(342 kWh/m2)
Air tightness qv;10 [dm3/s] per m2 floor space: unknown
Installed heating capacity per unit [kW]: unknown
(- W/m2)
Electricity consumption per unit per year (excl. heating) [kWh/y]: approx. 55 350
(50 kWh/m2)



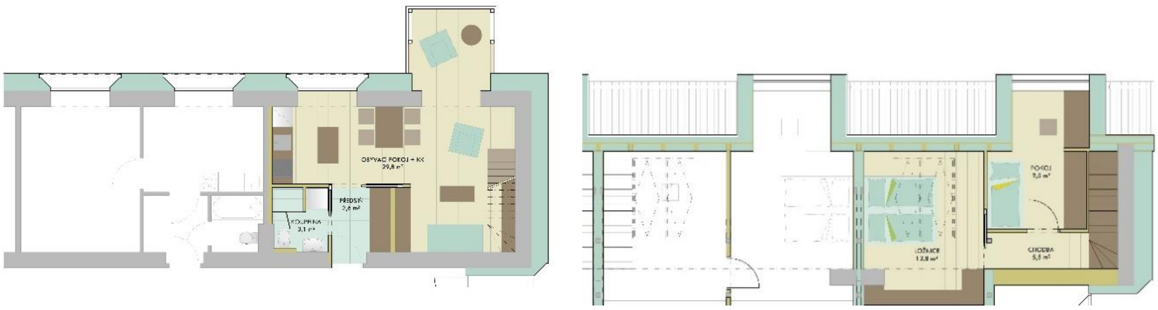
Renovation concept and notable features

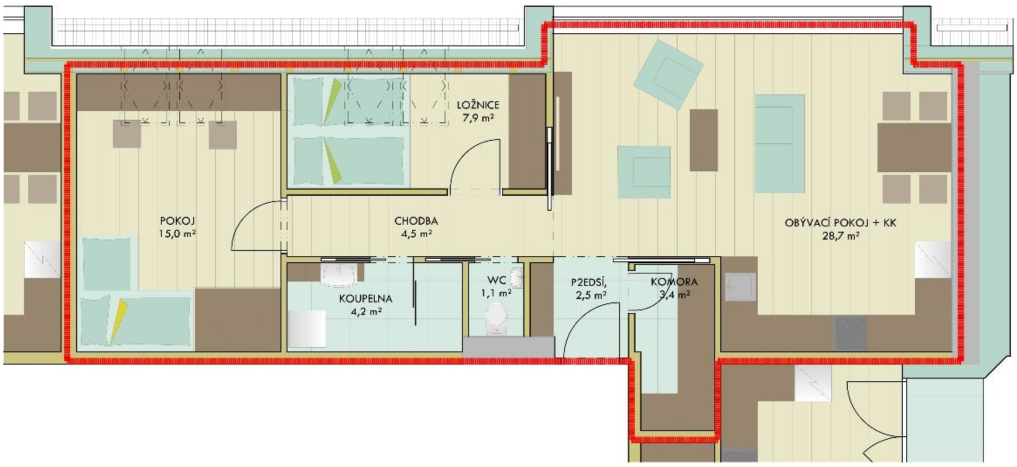
The renovation scenario was not set as the real building will not be refurbished within the project. The possibilities are tested in widest possible scale in real life laboratory setting.

The interior building elements stay without planned changes, external walls s will be upplemented by M-C modules, the parapet area possibly removed for system connections etc. $U_{walls,450}$ = 0,12 W.m^{-2}.K^{-1}, $U_{window\ sill}$ = 0.13 W.m^{-2}.K^{-1}. The first floor above the cellar will be insulated to obtain a U = 0,32 W.m^{-2}.K^{-1}.

No significant changes are necessary in typical floor plan. Possible disposition changes can be following:

When loft addition applies, a new staircase in the top floor will be designed:





The newly built structures will be offered for the owners:

- balconies,
- reading rooms,
- attic dormer windows.

The additional structures are designed in the compatible way with the basic modules.

Key technologies for the project using prefab renovation elements:

- Prefabricated timber facades and roofs
- Double glazed windows
- Prefabricated roof modules
- Heat recovery ventilation

DESIGN DATA (after renovation)
Number of flats (units) [#]: 36
Heated floor area [m2]: 1189
Energy consumption (heating + DHW) per housing unit per year [kWh]: 73 122 (62 kWh/m2)
Air tightness: 0,21 V.h^{-1}
Installed heating capacity per unit [kW]: 1,1 (28 W/m2)
Electricity consumption per housing unit per year (excl. heating) [kWh/y]: approx. 61 828 (52 kWh/m2)
Rent [€]: -
Rent increase per month [€]: -
Reduction energy costs per year [€]: -

4.3 Energy related indicators

Characteristics Retrofit projects:

	Thermal insulation: -Roof -Facade -Floor/foundation	Rc 1,0 – 2,5 ○ ○ ○	Rc 2,5 – 4,0 ○ ○ ●	Rc 4,0 – 5,5 ○ ○ ○	Rc 5,5 – 7,0 ○ ○ ○	Rc 7,0 – 12,0 ● ● ○
	Measures airtightness	Present ●	Not present ○			
	Glazing	Double ●	Triple ○			
	PV panels (m2 PV / house)	10 - 15 ○	15 - 20 ○	20 - 30 ○	30 - 40 ○	>40 ●
	Heating	Gas-fired boiler (HR-107) ○	Heat pump (water) ○	Heat pump (air) ○	Hybrid ○	External source ●
	Domestic hot water	Gas-fired boiler (HR-107) ○	Heat pump ○	External source ●	Shower heat recovery ○	Thermal solar boiler ○
	Ventilation system	Natural (C) ○	Natural-controlled (C+) ○	Mechanical (D) ○	Mechanical-controlled (D+) ●	
	Energy supply	Gas + Electric ○	Electric ○	External source (district heating) ●	None (all-electric) ○	

Heating, ventilation

Heating & ventilation

Check of current pipelines and its insulation will be done, replacement if necessary. Warm air heating system with heat recovery may be used instead of original water-heating system and it will be connected to original heating source (district heating)

Domestic hot water

Hot water preparation will be without changes.

Technological design – retrofit design details

Façade solutions

The external walls supplemented by refurbishment modules, half of the parapet walls are removed. $U_{walls,450}$ = 0,12 $W.m^{-2}.K^{-1}$, $U_{window\ sill}$ = 0.13 $W.m^{-2}.K^{-1}$.

Roof solutions

In most probable case, the roof would not be refurbished, the most upper ceiling will be insulated from above to reach the target U-value = 0,14 $W.m^{-2}.K^{-1.}$

However, a replacement of the original truss structure can be also done and a new insulation will be provided. Alternatively, building up a new loft dwelling units as a part of refurbishment is also possible. In that case, roof will be newly insulated to reach the U-value of 0.11 $W.m^{-2}.K^{-1}$.

Floor solutions

The first floor above the cellar will be insulated to obtain a U = 0,32 $W.m^{-2}.K^{-1}$.

4.5 Construction process

The modules would be produced in RDR company. The original windows and parapet walls will be removed and the openings for the ventilation must be created (to the corridors and to the gable façade). The roof floor and cellar ceiling will be additionally insulated.
The overhang of the original roof will be removed and the timber elements shortened.
The steel anchors will be mounted on the original façade. Later on, the modules will be installed and mounted to the anchors. The roof will be extended and finished.
The interior ventilation will be installed and covered by textile hanging coverings. The final plaster will be applied on the façade as the final step.