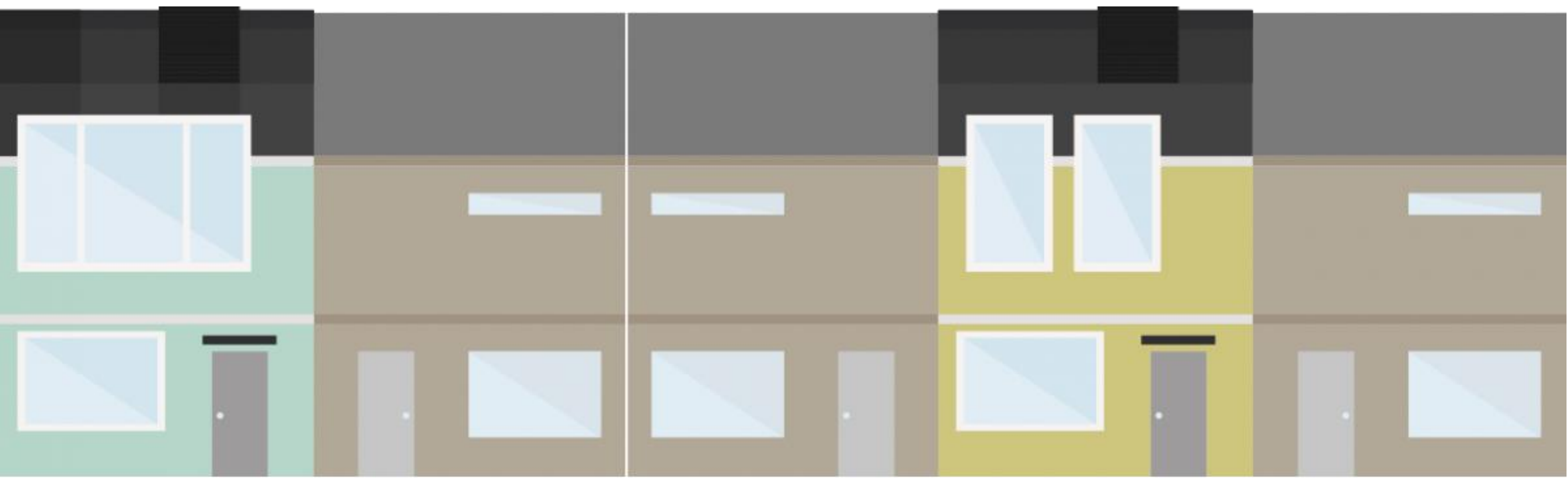
Housing typology Assessment

MORE-CONNECT WP3.1, June 2016, J.A.W.H. van Oorschot, MSc., ed.



HOUSING TYPOLOGY ASSESSMENT
MORE-CONNECT WP3.1

J.A.W.H. van Oorschot, MSc., ed.
Version 7 – June, 2016

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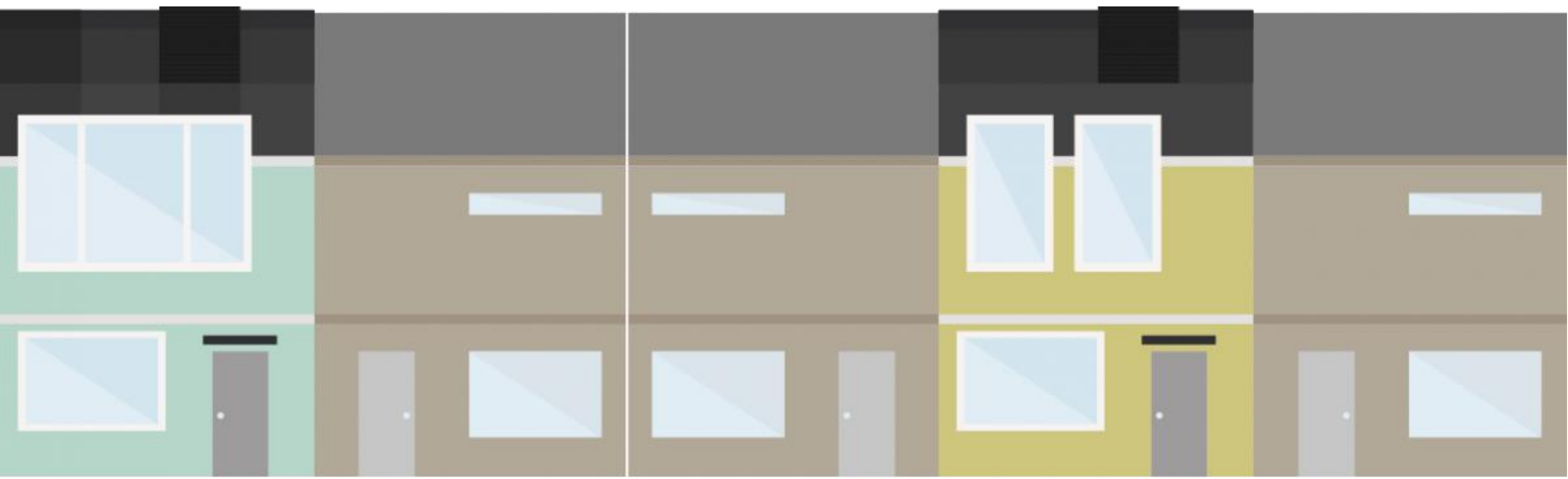

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1 INTRODUCTION

Background - The main goal of the MORE-CONNECT project is to develop a solution with respect to innovative, prefabricated building envelope elements for MOdular REtrofitting and smart CONNECTions. These building envelope elements contribute to the transformation of European housing towards near Energy Zero Buildings (nZEB). Point of departure is the assessment of European housing in order to determine which typologies are most suitable to be upgraded towards nZEB with prefabricated building envelope elements; i.e. a baseline assessment which determines which market segment MORE-CONNECT will focus on as described in task 3.1.

Task 3.1 Typology of building stock for relevant market in the Geo Clusters
Task leader: Zuyd
Other participants knowledge: RTU, TUT, CVUT, UMinho, Cenergia

In this task houses in the 4 regions will be studied and classified specifically for their suitability and adaptability for renovation elements. This will provide the basic criteria for development of the element specifications. The task will focus on the majority of buildings that in a first round might be regarded as suitable:

- Study and identify the majority of building stock potentially suitable for renovation
- Detail and classify building types according to an agreed standard approach
- Identify the basic building related specifications for element development

Deliverables
D3.1 Overview of main housing types in the addressed EU regions, classification of suitability for different prefab façade renovation configurations.

Problem definition - Within the European housing sector a diversity of housing typologies can be found which are characteristic for a specific region (for example detached housing in the Netherlands) or relatively common throughout Europe (for example apartment buildings). Preliminary national and international studies already provided meaningful insights into housing typologies. The most important publication is this respect is the TABULA report (2012) which includes an assessment of the energy performance of the European housing stock. The assessment presented in this report will build upon the Tabula report with respect to the generic building typology, the TABULA Typology Concept (Building Type Matrix). However the TABULA report provides limited detailed information about the technological conditions of the building structure and the building envelope. This information is considered detrimental to the assessment of European housing in order to determine which housing typology is most suitable to upgrade to near energy zero applying prefabricated building envelope elements.

Aim of the report - This report includes the assessment of housing typology across Europe including Czech Republic, Denmark, Estonia, Latvia, Netherlands and Portugal (alphabetic order) based on national housing statistics. Next, based on pilot residential buildings included in the MORE-CONNECT project a detailed technical assessment will be presented. The results presented in this report are considered to be necessary to determine whether and how prefabricated nZEB retrofit elements can be applied concerning a specific building typology. These insights include in particular detailed information about building geometrics, the structure of the building and the configuration of the building envelope including building service technology. Based on these insights a decision-making tool (decision-making tree) has been developed which support the assessment of housing in order to determine the applicability of the MORE-CONNECT retrofit concept.

Boundary conditions – This report has been developed taking into account several boundary conditions. First, this report will build upon the TABULA Typology Concept but will not replicate the energy performance calculations which can be found in the 'TABULA WebTool' (http://webtool.building-typology.eu/webtool/). Second, also financial aspects concerning the most cost-effective investment and the project and/or the MORE-CONNECT retrofit requirements are not considered in this report. These issues are addressed elsewhere.

Methodology – Within the participating countries, national statistics and the TABULA report were used to develop a generic Building Type Matrix. Next, national (research) reports and expert opinions were used to assess in more detail building geometrics, the structure of the building and the configuration of the building envelope. Third, the results were collected and processed within a format underlying this report (included in appendix A). For follow up this report will inform decision making which building typology or typologies will be chosen, or which market will be penetrated first, for which the nZEB retrofit elements will be developed.

Structure of the report – This report is structured as follows. In the next chapter the methodology followed to determine the EU housing typology will be addressed. In the subsequent chapters, chapters 3-8 the national housing statistics as well as exemplary case buildings from Czech Republic, Denmark, Estonia, Latvia, Netherlands and Portugal (alphabetic order) will be discussed. Based on these chapters, chapter 9 presents a decision-making tool in order to determine whether or not a residential building is suitable to be retrofitted according the MORE-CONNECT concept. Conclusions are presented in the final chapter, chapter 10.

2 Methodology: assessment building typologies in the context of modular nZEB retrofit concepts

2.1 Research approach

The primary goal of this study was to investigate the housing typology within the EU in order to determine the suitability of modular nZEB retrofit concepts (MORE-CONNECT).

2.2 Sample

The unit of analysis of this study is the housing stock of the Czech Republic, Denmark, Estonia, Latvia, The Netherlands and Portugal respectively. The housing stock of these countries are located in different geo-clusters across Europe (Northern – Denmark; Continental Northern East – Estonia and Latvia; Continental Centre – Czech Republic; Mediterranean – Portugal, and; Western Central – The Netherlands). Although climate conditions differ between countries, and thus also housing design located in these countries, this study looks for generic housing characteristics across the geo-clusters which are relevant to the development of prefabricated, multifunctional building envelope elements for modular retrofitting. Next, for each of these countries the pilot case involved in the MORE-CONNECT project will be assessed in more detail. The pilot projects are characteristic for a general typology which can be found in the specific country.

2.3 Data collection and analysis

The data collection and analysis was conducted based on a standard form which can be found in appendix A. Part 1 builds upon the TABULA's building type matrix (see box below) and national housing statistics. Part 1 provides an overview of the national housing stock and provides the data about potentially interesting housing typologies which MORE-CONNECT could (should) address. Moreover, MORE-CONNECT aims at developing one common platform for production lines (process platform), from which different solutions for each geo-cluster can be produced. Based on the statistics from part 1 the potential of the MORE-CONNECT concept and its distinct production lines can be determined. It has to be noted that the business case itself falls outside the scope of this study.

TABULA's Building Type Matrix

[TABULA, 2012, p7]: The energy performance of buildings correlates with a number of parameters including the year of construction, the building size and the neighbour situation, the type and age of the supply system and the question of already implemented energy saving measures. If these features are known for a given building it will be possible to quickly give an estimation of its energy performance. This principle can also reduce the effort for the energy assessment of a total building portfolio (municipalities, housing companies) or a national building stock, as far as typological criteria are known.

The term "building typology" refers to a systematic description of the criteria for the definition of typical buildings as well as to a set of exemplary buildings representing the building types.
In the past few decades different experiences with building typologies have been made in European countries. The idea of the IEE project TABULA was to examine them and to come to a concerted approach for the field of residential buildings. A focus was placed on the energy consumption for space heating and hot water. The overall objective was to enable an understanding of the structure and of the modernisation processes of the building sector in different countries and – in the long run – to learn from each other about successful energy saving strategies.

The residential building typologies elaborated during TABULA form a data pool of the countries' residential building stocks. They offer different opportunities of application: Single exemplary buildings can be used as showcase examples to give a first estimation of energy saving potentials of real buildings. The set of exemplary buildings – complemented with statistical data about the national building stocks – can be applied for modelling the energy demand of the countries' residential building sectors and form a basis for further scenario analyses. From a European point of view the harmonised approach of the TABULA project provides a framework for cross-country comparisons of residential building stocks against the background of energy efficiency.

[TABULA, 2012, p8]: An overview of the national building typology is given by the "Building Type Matrix". The columns of the matrix represent four building size classes (single-family houses, terraced houses, multi-family houses, apartment blocks), the rows a certain number of construction year classes. The start year and end year of the construction year classes are individually defined for each country. The single cells of the matrix form the generic "Building Types" of a country.

To each generic building type of a country (cell of the classification grid) an exemplary building is assigned which is represented by a photo and the data of the thermal envelope. This building is supposed to be a typical representative of the building type, meaning that it has features which can commonly be found in houses of the respective age and size class. The envelope area and the heat transfer coefficients of the ex-emplary building are not necessarily representative in a statistical sense.
In addition heat supply systems for space heating and domestic hot water are defined which can commonly be found in the housing stock differentiated by energy carrier, heat generator type and energy efficiency level.

Part 1 follows the general classification of the housing stock at the national and European level (Episcope project for example). From these attempts it can be learned that these assessments are to generic in nature in order to inform the development of a modular retrofit concept. What is missing is an in-depth analysis of the structural and financial characteristics of these typologies. However, it has to be emphasized that such extensive assessments are time consuming and costly and it will be challenging to meaningful classify housing based on detailed information (including geocluster (local) specific characteristics). In order to determine or a specific building is suitable to be retrofitted with MORE-CONNECT a more detailed assessment is suggested. Parts 2-6 collect case or building specific data including overall pilot building information; (architectural and geometric) design specifications; structural design specifications; building technical systems specifications, and; the building performance indicators. In more detail, according the format developed in this report supports it can be determined how many buildings can be retrofitted with a specific product-market combination following the guidelines of the MORE-CONNECT platform (advanced prefabricated, multifunctional building envelope elements for modular retrofitting). Thus, the assessment of housing typologies across Europe can be useful in order to determine which type of housing will be considered when developing the MORE-CONNECT solution.

Figure 2.1 presents the conceptual idea behind the detailed assessment: property will be assessed like the MORE-CONNECT contractor / provider would do in case of a tender. When deciding upon a nZEB retrofit approach for a specific residential building, it has first to be decided which alternative solutions to select from. Moreover, it need to be decided or the modular MORE-CONNECT concept could provide a (cost-effective) solution from a product-market combination point of view. Table 2.1 include the parameters which need to be assessed.

Figure 2.1: Conceptual idea of the housing assessment format: property will be assessed like the MORE-CONNECT contractor / provider would do in case of a tender.

Table 2.1: The housing assessment format – see appendix A for the assessment form

Parameter	Assessment
Monumental status	The building cannot be renovated with prefabricated facade elements when the building is considered monumental (major adjustments to the building (design) are prohibited.
Building aesthetics	Aesthetic building design could impede renovation when the facade is replaced with prefabricated elements
Business case	(Additional) financial slack (mortgage, income, savings from energy and maintenance cost reduction) to cover the investment, i.e. the business case for the project.
Site plan	Accessibility of the building site when considering renovation with prefabricated elements (logistics).
Legal requirements	Alterations to the building design and floor plan (increase of floor space) have consequences for the building permit.
Energy grid	Interconnectedness with energy grid: possibilities to deliver surplus of energy to the grid.
Housing typology	Assessment of housing typology including: (semi-)detached, mid-row / end-row terraced, multifamily housing with/without galleries, maissonette, other types of MFH (high-rise)
Architectural design characteristics	Assessment of the floor plan of the building: typology and dimensions (x,y)
	Assessment of the cross section of the building: dimensions (z)
	Assessment of roof design (shape, overhang): typology, U-value [W/(m2K]
	Assessment of facade design: fixed-free; open-closed; U-value [W/(m2K]
	Building extensions and complementary facade elements: bay window, France balconies, et cetera
Structural design characteristics	Loadbearing scheme: inclusion of (front-back) facade in the load bearing structure?
	Assessment of structural capabilities foundations
	Assessment of vertical structures (including openings)
	Assessment of roofing structure
Building technical system	Assessment of indoor climate systems with respect to heating/ cooling and available energy sources (district/central heating system and renewables)
	Assessment of ventilation system: inclusion in facade/roof structure
	Assessment of electrical wiring: inclusion in facade/roof structure
	Assessment of water piping: inclusion in facade/roof structure
	Assessment of drainage system: inclusion in facade/roof structure
Building performance	Assessment energy performance: costs, energy consumption
	Assessment environmental impact: CO_2 emission
	Assessment of building acoustics including noise from service systems and the acoustic performance of the building envelope and separation walls (between apartments)
	Assessment of the daylight level in the dwellings (when affected by the renovation)
	Assessment of the Air tightness
	Assessment of moisture safety / hygrothermal design

2.3.1 Assessment historical (monumental) and eastetic residential building characteristics

Assessment historical (monumental) characteristics

Residential buildings which need are considered to be renovated need to be assessed for its monumental (protected) status, given by local municipalities, provinces/regions or by the National Government. Monumental protection includes the entire property and all the parts (components) of the real estate, such as the foundation, facade and facade parts (e.g. also steps, stairs and/or landing), the supporting structure, roof, floors, floor finish and interior (e.g. ceiling, wall finishing, stairs, doors and fireplaces) are part of the protected monument. Strict codes have been developed regarding modifications which are allowed. In case of monumental residential buildings, renovation using the MORE-CONNECT principle (placing a prefabricated façade and or roof) is not possible while the building (façade) will (drastically) modified.

Example from the Netherlands
For example, in the Netherlands alone, almost 62,000 national monuments can be found which are included in a national monuments register. These buildings and other objects are identified for its national cultural-historical value and importance by the National Government and designated as protected monument.
The digital-register for historical monuments contains details on all the monuments in the Netherlands that are designated as protected monument. Monuments which are protected by municipalities and provinces are not included in this website:
http://monumentenregister.cultureelerfgoed.nl/php/main.php (figure 2.2).

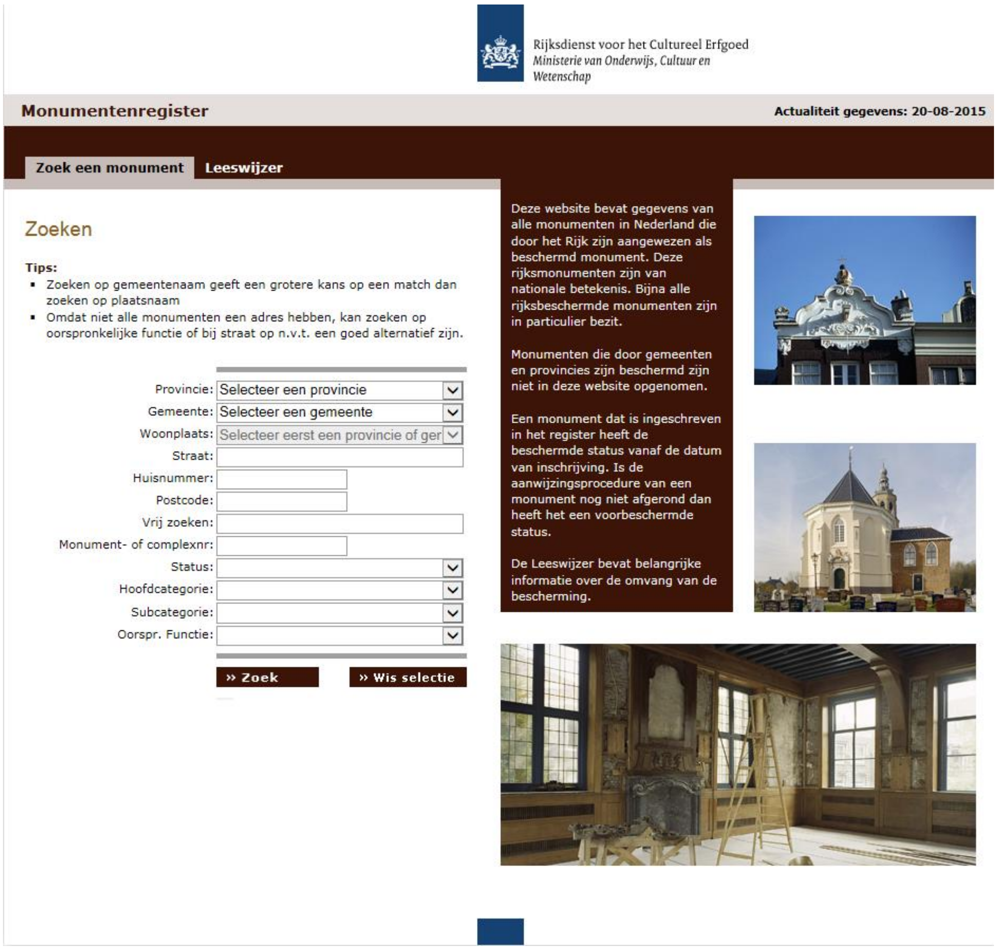


Figure 2.2: Screenshot website national service for cultural heritage (http://monumentenregister.cultureelerfgoed.nl/php/main.php)

A municipality may decide to add a particular property on the municipal monuments list. This happens when a property does not have national significance, however is of local or regional importance. The municipality states its policy for monumental properties in the municipal monumental regulation.
The Dutch provinces can also designate monumental properties. Only the North Holland and Drenthe provinces have monumental objects identified.

At the end of 2014,the Netherlands had 465 protected urban and village views.

In the Netherlands a protected village or townscape is a qualification for a building or a group of buildings that are of general interest, because of their beauty, their mutual spatial or structural cohesion. When these buildings are designated as 'protected' property, it cannot be dismantled or modified without a written permit from the college of Mayor and aldermen. This can also applies to buildings that are not monumental classified. The historical character of a village is often determined by a number of buildings, and/or the spatial structure and consistency of the buildings.

For building, re-modelling or demolition in a protected city or village different rules apply versus ‘normal’ construction or renovation plans in areas without protected designation. The requirements from the local building regulator to build in a protected village or townscape is much more impactful comparing to areas without an indication.

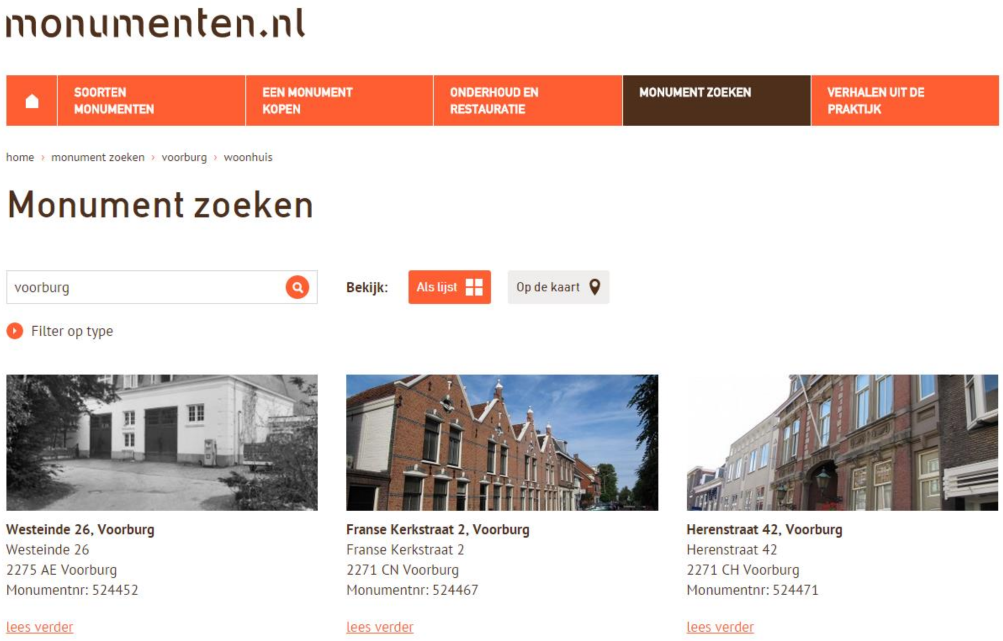


Figure 2.3: Screenshot website national service for cultural heritage (www.monumenten.nl)

Assessment aesthetic characteristics

Besides the historic characteristics it is also necessary to inventory the aesthetic characteristics with respect to the insurmountable objections against replacing the facade (and/or roof) .To replace a facade a building permit is in many cases mandatory. A permit application is important for the applicant and can also affect local residents or other interested parties.

Example from the Netherlands

A building check assures if in this particular situation a building permit is required, see also the ‘surroundings and buildings law’ website: https://www.omgevingsloket.nl/.

General provisions for Surroundings and Buildings Law (NL: Wabo)

Since 1 October 2010, the Dutch government enforced the law for general provisions surroundings and buildings (Wabo). A large number of permits, including the building permit were merged into the surroundings permit. It is now possible to apply for multiple permits at once, such as building and renovation, cutting trees, pillowcases etc. The Wabo law is intented to simplify the request for the surroundings and building permits. Permit applications including the full spectrum of building activities are comprehensive to evaluate and handled faster.

The procedure to object to planned changes of a building or new building plans can be done during the permit application procedure at the Mayor’s office and aldermen or appeal to the Court. It is strongly encouraged to get local buy in and support upfront for the planned facade renovation.

Aesthetic Committee (NL: Welstand)

If you request for a permit for construction activities, the Aesthetic Committee will review the plans. This Committee monitors the quality of the building environment, according to the building regulations regarding external appearance of buildings, which is stated for each municipality.
This regulatory note contains criteria for pre-defined objects (objects-oriented criteria) and criteria for designated areas (surroundings-oriented criteria). In practice it often means that building plans, whether

new construction or renovation, should connect to the existing environment, as pre-determined by the local government.
Part of the building permit procedure is a meeting (in principle open for public), with the opportunity to elaborate and further explain on the building plans.
Small construction plans are reviewed using quick scan criteria, which are included in the note for regulations regarding external appearance of buildings. The regulatory note can state, for example which construction materials should be used to align with to the existing buildings and surroundings. If your plans comply with the quick scan criteria, it will be relatively easy to get approval and the building permit. It is advisable to study the note for regulations regarding external appearance of buildings at the start phase of your building plans.

In two particular cases the Aesthetic Commission does not play a role, if:

- An area is designated for 'unlicensed building'
- The municipality has abolished the the note for regulations regarding external appearance of buildings for a pre-designated area.

From January 2013, a city council can determine whether the plans need to be assessed by the Aesthetic Commission or by the cities architect.

Unlicensed building
As of November 2015, different rules apply for unlicensed building. To build a dormer, an extension or a garage, in many cases this fits within the regulatory note and a permit will not be required. The building plans do not even have to comply with the zoning plan. Building without having to apply for a permit saves time and money, The 'unlicensed building regulation is designed for simple and common building plans, mostly at the back of a house, and not for the façade.
License free building plans are not assessed by the building Aesthetic Commission. However, in the event of unacceptable situations, a municipality can still intervene.

2.3.2 Assessment business case: financial issues related to energy costs

Ultimately, a solid business case has a detrimental effect on the decision to adopt MORE-CONNECT and retrofit a residential building accordingly. Therefore, the financial performance indicators of the residential building need to be assessed and in particular the energy costs. Savings on the energy cost could provide or at least contribute to the financial resources to invest in the renovation. This assessment is a first indication about the applicability of the MORE-CONNECT retrofit concept from a business case point of view. Thus, high energy cost increases the potential of the MORE-CONNECT concept while from the energy cost savings the retrofit investment can be justified. Moreover, in some countries nZEB retrofit investments are subsidized which further improves the affordability.

2.3.3 Assessment structural residential building characteristics

The assessment of step 4 includes a detailed analysis of the structural characteristics of a property. The assessment includes several data sheets which are presented below. In its essence, during this assessment it will be determined or the modular, prefabricated MORE-CONNECT elements technological 'match' with the residential building. First, table 9.2 presents some statistics about the building stock. These statistics can be used in order to determine the market potential of the product-market combination (not further assessed here, beyond the scope of this report). Second, table 9.3 provides a general description of the residential building in order to determine the potential of the building regarding the nZEB retrofit investment. Finally, table 9.4 presents the detailed technological assessment (structural characteristics) of the building.

3 Pilot Czech Republic

3.1 National housing statistics

Overview statistics of the Czech Republic housing sector with respect to building typology indicators

Statistical Table	Item	Available	Reference
S-1	Frequency of building types of the national building stock	Yes	1
S-2	Percentage of thermally refurbished envelope areas	no	
S-3	Information on insulation level and window types	Yes	1
S-4	Centralization of the heat supply (for space heating)	no	
S-5	Heat distribution and storage of space heating systems	no	
S-6	Heat generation of space heating systems	Yes	1
S-7	Heat distribution and storage of domestic hot water systems	no	
S-8	Heat generation of domestic hot water systems	no	
S-9	Solar thermal systems	no	
S-10	Ventilation systems	no	
S-11	Air-conditioning systems	no	
S-12	Control of central heating systems	no	
S-13	Domestic energy consumption	Yes	1

S-1 Frequency of building types of the national building stock

Building typology national housing stock

Number of dwellings (x 1000)	Single family housing				Multi-family housing				
	De-tached house	Semi-detached house	Terraced house, mid-row	Terraced house, end-row	MFH with common staircase and galleries	MFH with common staircase, no galleries	Maison-nette*	Other multi-family dwelling*	Total
Before 1946									
1946 to 1964									
1965 to 1974									
1975 to 1991									
1992 to 2005									
2006 to 2011									
Total									

S-3 Information on insulation level and window types

Include statistics/information about information on insulation level and window types about here

S-6 Heat generation of space heating systems

Include statistics/information about heat generation about here

Percentage of dwellings	Total
individual local heating	%
individual central heating: - non-condensing boiler - condensing boiler	 % %
district heating	%
other (delivery of warmth by third parties)	%

S-13 Domestic energy consumption

Include statistics/information about domestic energy consumption about here

Energy consumption sector private households; energy commodities		1995	2000	2005	2010	2011	2012
Total (PJ)							
	Primary coal (PJ)						
	Petroleum products (PJ)						
	Lpg (PJ)						
	Other kerosene (PJ)						
	Gas/diesel oil (PJ)						
	Natural gas (PJ)						
	Electricity (PJ)						
	Heat (PJ)						
Space Heating							
	Gas						
	Electricity (including domestic hot water)						
Domestic Hot Water							
	Gas						
	Electricity (included in space heating)						
Other Applications							
	Gas for cooling						
	Electricity for cooling						
	Electricity for cooking						
	Electricity for ICT						
	Electricity Other						
	Lighting (Electricity)						

3.2 Overall pilot Building information

MORE-CONNECT responsible partner

UCEEB CTU, CZ, Antonin Lupisek, antonin.lupisek@uceeb.cz

MORE-CONNECT industrial partner

RD Rýmařov, CZ

Building's name

Residential House "dvouletka" type in Milevsko.

Location

Jiráskova 775, 39901 Milevsko, Czech Republic

Building typology

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.

Typical problems

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. Possible overheating during winter season, insufficient thermal comfort.

3.3 Architectural design

Historical (monumental) characteristics of the property: which historical / monumental characteristics need to be taken into account when considering nZEB retrofitting?	none
Aesthetic characteristics of the property: which aesthetic characteristics need to be taken into account when considering nZEB retrofitting?	none

Site plan

Figure 3.1: Site plan pilot building

Views

Figure 3.2a: Views pilot building

Figure 3.2b: Views pilot building

Floor plans

Present state

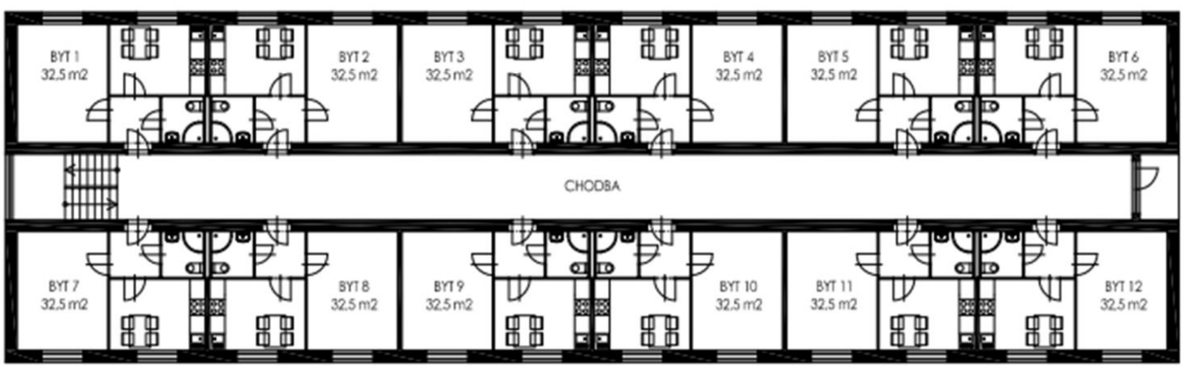


Figure 3.3: Floor plan pilot building

Design target

No significant changes 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:

Figure 3.4a: Floor plan pilot building after renovation

Figure 3.4b: Floor plan pilot building after renovation

Cross section

Present state

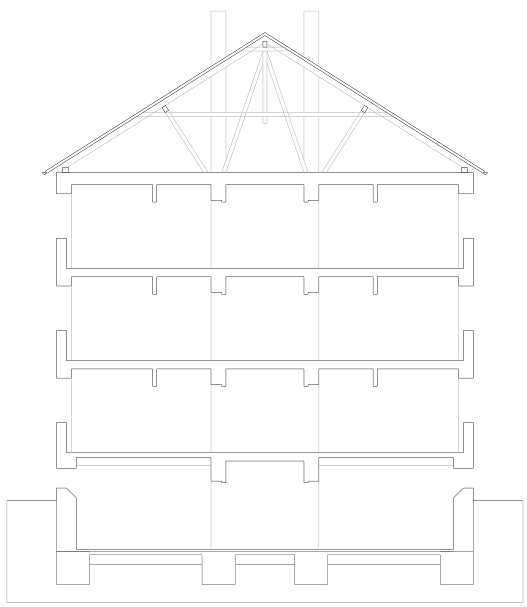


Figure 3.5: Cross section pilot building

Design target

Loft addition will be designed. A drawing will be provided later.

Façade and roof design

Present state

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.

Design target

To be further developed, depends on the architectural design of the new product. Possible design alternatives go from the basic refurbishment up to large renovation with additional balcony, reading room installation and attic utilizing.

Figure 3.6a: Façade and roof design pilot building – alternative A

Figure 3.6b: Façade and roof design pilot building – alternative B

Figure 3.6c: Façade and roof design pilot building – alternative C

Complementary façade elements

Present state
There are small balconies present in the north-west façade, one in each floor.

Design target
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. The necessary conditions for installations are described.

3.4 Structural design

Building's load-bearing scheme

The constructional system present lateral masonry bearing walls.

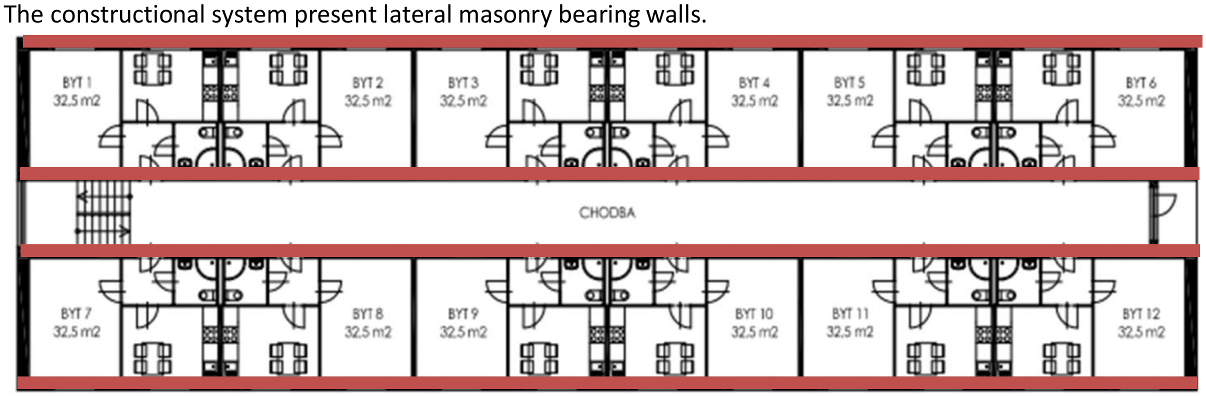


Figure 3.7: Load bearing scheme pilot building

Foundations

Present state
Monolithic reinforced concrete slab and wall footings, U = 4,0 W.m-2.K-1.

Design target
No significant changes planned for the basic solution. New additional foundations are created to support the complementary structures.

Vertical structures

Present state
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.

Design target
The interior elements without planned changes, external walls supplemented 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.

Horizontal structures, floor slabs

Present state
Precast-monolithic concrete slabs, 220 mm. U-value of the first floor above the cellar = 3.5 W.m-2.K-1.

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

Openings

Present state
Original wooden 1950s windows were replaced by plastic windows and door with assumed g-value of 0,67, Uw = 1,2 W.m-2.K-1 and Ud = 1,4 W.m-2.K-1.

Design target
Assumed g-value of 0,5; Uw = 0.7 W.m-2.K-1 and Ud = 0.8 W.m-2.K-1.

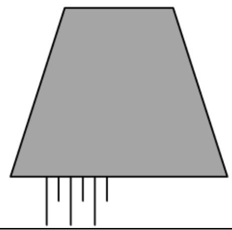
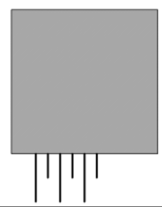
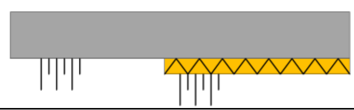
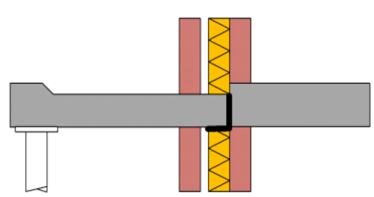
Roofing

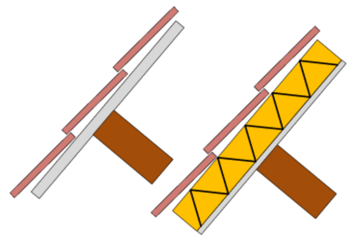
Present state
Wooden truss frame with ceramic tiles. The loft area is accessible via ladder from the last stair landing. The ceiling is insulated using slag gravel. The insulating level is not sufficient. The roof slope is 33°. Roof composition consists of asphalt waterproofing placed in between the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

Design target
Replacement of the original truss structure by new insulation, target U-value = 0,14 W.m-2.K-1. Alternatively, building up a new loft dwelling units as a part of refurbishment. In that case, roof will be newly insulated to reach the U-value of 0.11 W.m-2.K-1.

Overview structural characteristics of reference building

Structural characteristics of reference building

Element	Morphological representation	Description
(A) Foundation		Unreinforced concrete foundation beam – direct bearing foundation
		Reinforced concrete foundation beam – direct bearing foundation
(B) Ground floor		Concrete floor – direct bearing
(C) Separation and load bearing wall structures		Massive, piled – masonry – construction; load bearing
(D) Facade		Massive, piled – masonry – construction; load bearing
(E) (Second/third/..) floors		Prefabricated – hollow core – concrete floor elements
(F) Balcony / loggia / gallery		Internal balcony and loggia

Roof / top floor		Pitched roof; purlins; tiles on roof boarding; NOT/min. insulation

3.5 Building technical systems

Heating

Present state
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.

Design target
Check of current pipelines and its insulation, replacement if necessary. Replacement of original element radiators with panel radiators. Decrease of flow/return temperature associated with reduced heat loss, equithermal control implementation. To be specified later. Alternatively, warm air heating system can be used instead of traditional water-heating system; the possibility will be verified by calculations.

Cooling

Present state
Cooling system is not present. Overheating of the house was not observed.

Design target
Cooling system is not necessary to install. Thermal capacity of the building is high, so the building can absorb most of heat gains. Solar heat gains reduction by shading and increased ventilation will be used.

Ventilation

Present state
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.

Design target
New ventilation system is necessary to install because new air-tight building envelope can cause low air quality and mould growth risk or unwanted water condensation inside of the building . Pipes can be integrated in façade elements; current outlet pipes can be used in new system or removed. Assumed position of ventilation unit with heat exchanger is in the loft. Fire protection and acoustics must be taken account.

Electrical wiring

Present state
In old buildings were usually used aluminum wires. Wires are commonly beyond their life time and they can cause fire or injury by electricity.

Design target
Replace current wires by copper wires.

Water piping

Present state
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.

Design target
Connection of current water supply system to new heat source, check of insulation, replace if necessary. Circulation control implementation.

Drainage system

Present state
There are installation shafts in the middle of the buildings floor plane near the kitchen and bathroom area. No other information yet available.

Design target
No design target in sewage system. Connection piping could be replaced.

Monitoring and control

Present state
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 target
The temperature and humidity will be always monitored in each room. When air ventilation will be installed, the CO_2 will be also monitored.
In case of central heating unit, the heat in each room will be measured to split the payload.
In case of individual gas heating, the CO sensor will be placed.
If a central heating system is exploit, a control system will control the heating based on monitoring system and demands of the users. The complexity of the control system will be restricted by building owners. If more comfort solution is desired then we can offer the Individual Room Control (IRC) unit with combination of occupancy plan or temperature profile. Model predictive control can also be used.

Energy sources

Present state
The house uses block heating system with local domestic hot water preparation for the house. The exchange unit is situated in the basement of the house. The electricity is provided by standard power grid.

Design target
Central heating system, central hot water preparation, natural gas boiler. Several variants of heat sources or their combinations are possible. The choice depends on the building owners and local conditions. In case of the pilot building in Milevsko, district heating will probably be required to maintain. If not, or for other buildings, for instance biomass boiler can be used. In any case, the main heat source will be supplemented by PV and/or PT panels to increase renewable energy ratio.
The examples of installations are given in the chapter 6.

3.6 Building performance

Energy performance

Present state
The average building's U-value Uem = 1,19 W.m-2.K-1. The yearly heating demand is 634.2 GJ, which means 159 kWh.m-2.a-1. The total energy delivered to the building: 342 kWh.m-2.a-1. The heat flow (heat losses) ratio is following: external wall 43.0 %, roof: 14.6 %, floor: 14.5 % windows a doors 8.0 %, ventilation 12.5 % and heat bridges 7.4 %.

Assessment of energy use, emissions and energy costs at the starting point

Performance indicator	Unit	Performance
Energy label	(label)	G
Energy index	(-)	-
Total primary energy consumption	(MJ)	1 565 863
Gas	(m3/year)	0
Add. (sustainable) energy, lighting, PV	(kWh/year)	no production
CO2 emission	(kg/year)	10 262
Energy cost, without VAT -gas -electricity	(€/month)	approx. 60€/flat.month
Usable floor area/energy related area	(m2)	995.3/1107.3
Energy cost index	(€/m2)	to be defined later
Housing expenses -rent -mortgage	(€/month)	to be defined later

Design target

The design target is stated in the D2.1 deliverable, Table 4.7: Requirements on building envelope and ventilation to fulfil national nZEB requirements in each country.

Ventilation	
Heat/cool recovery, %	80%
Ventilation airflow, l/(s⋅m2)	0,21 ach (mean)
Renovated case represents indoor climate category II	0,3 ach at occupants presence; 0 ach at non-occupied time (approx 30 % of time)
Specific fan power, W/(l/s)	1,5
Heating syst. with its efficiency	district heating (less than 50 % of renewable energy), 0.84
Renewable energy sources	
Solar collectors for DHW, m2	0
Solar panels for electricity, m2	377
Coefficient of Performance of heat pump if it is used	-
Energy need for heating	14
Indoor temperature	
During heating period	20
During cooling period	No control

Other possible alternatives of heat source combinations and related parameters resulting in zero total primary energy consumption:

<table>
<tr><th>Var.</th><th>Heating system with its efficiency</th><th>Solar panels for electricity, m2</th><th>Solar collectors for DHW, m2</th><th>U-value [W/(m2K) walls/wind.sills ceiling/floor windows/door</th><th>g-value [-]</th><th>Energy need for heating</th></tr>
<tr><td>N2</td><td>(50–80 % of renew. energy), 0.84</td><td>160</td><td>–</td><td rowspan="6">0.12/0.13
0.3/0.138
0.7/0.8</td><td rowspan="7">0.5</td><td rowspan="5">14</td></tr>
<tr><td>N3a</td><td rowspan="2">District heating (> 80 % of renew. energy), 0.84</td><td>100</td><td>–</td></tr>
<tr><td>N3b</td><td>90</td><td>70</td></tr>
<tr><td>N4</td><td>Heat pump (air-to-water), COP 3.2</td><td>320</td><td>–</td></tr>
<tr><td>N5</td><td>Biomass boiler, 0.8</td><td>135</td><td>–</td></tr>
<tr><td>N6</td><td>Biomass boiler + warm-air heating (air flow increased to 2000 m3/h), 0.8</td><td>153</td><td>–</td><td>21</td></tr>
<tr><td>N7</td><td>Biomass boiler, 0.8</td><td>143</td><td>–</td><td>0.2/0.21
0.3/0.4
0.7/0.8</td><td>23</td></tr>
</table>

Environmental impact

Present state

Yearly nonrenewable primary energy consumption: 1 426 GJ, which means 358 kWh.m-2.a-1 Yearly CO2 emissions 10.3 tons which means 9.3 kg.m-2.a-1.

Design target
Yearly unrenewable primary energy consumption equal to zero. Yearly CO_2 emissions 10.3 tons which means 9.3 $kg.m^{-2}.a^{-1}$.
If it is not possible to reach zero yearly unrenewable primary energy consumption, for instance due to impossibility of heat source change or others and/or needed unreasonable installation of renewable energy sources, the design target will be as lowest total energy consumption and total unrenewable primary energy consumption as possible.

Acoustic

Present state
Not assessed. Possible problematic partition walls between the flats.

Design target
The national standards reported in the “Table 3.5: National design values for building acoustics in More-Connect Geo-clusters and countries.” From Deliverable 2.1 will be fulfilled

Noise from service systems LpA,eq,T ,dB(A) bedrooms living rooms LpA,max ,dB(A) bedrooms living rooms	6:00-22:00 40dB 22:00-6:00 30dB (25dB)

The maximum noise in bedrooms and living rooms due to the functioning of the building service system is considered on Portuguese acoustic regulation base on the maximum acceptable noise from service systems, LAr,nT. LAr,nT = LA,eq + K1 + K2 (K1 = 3 if the noise has tonal characteristics and ; K2 = 3 dB if the noise has impulsive characteristics). Moreover, the design will meet the requirements of a COST Action TU0901 “Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions” methodology for Class C classification at minimum.

Daylight

Present state
No problems reported. To be determined later.

Design target
The daylight level will not be influenced by the refurbishment, the similar of better daylighting will be assured during the construction process.

Air tightness

Present state
The assumed total air change is 0.3 h^{-1}, not divided into ventilation and infiltration. The airtightness is unknown but expected to be low.

Design target
The assumed total air change at 50 Pa will be 1,5 h^{-1} at maximum.

Moisture safety

Present state
Problems with the moisture in the rooms with the refurbished air-tight windows reported. Water leakages in the roof structure.

Design target
The national standards reported in the "Table 3.4: National values for hygrothermal design of building envelope in More-Connect Geo-clusters and countries." of Deliverable 2.1 will be fulfilled.

4 Pilot Denmark

4.1 National housing statistics

Overview statistics of the Danish housing sector with respect to building typology indicators

Statistical Table	Item	Available	Reference
S-1	Frequency of building types of the national building stock	Yes	1
S-2	Percentage of thermally refurbished envelope areas	no	
S-3	Information on insulation level and window types	no	
S-4	Centralization of the heat supply (for space heating)	Yes	1
S-5	Heat distribution and storage of space heating systems	no	
S-6	Heat generation of space heating systems	Yes	1
S-7	Heat distribution and storage of domestic hot water systems	no	
S-8	Heat generation of domestic hot water systems	no	
S-9	Solar thermal systems	no	
S-10	Ventilation systems	no	
S-11	Air-conditioning systems	no	
S-12	Control of central heating systems	no	
S-13	Domestic energy consumption	no	

[1] Danish Enterprise and Construction Authority, The Building Stock Register (BBR - Bygnings- og Bollgregistret), 2012

S-1 Frequency of building types of the national building stock

Building typology national housing stock

Building period	Total number of buildings. Excluded listed buildings and buildings without heating installation			Heated external area [m²]. Included heated business area. Excluded listed buildings and buildings without heating installation		
	Single-family houses	Terrace houses	Apartment Blocks	Single-family houses	Terrace houses	Apartment Blocks
For 1850	35.803	3.632	1.714	17.215.006	478.743	833.196
1851 - 1930	297.832	24.873	41.672	35.706.073	3.237.158	25.458.577
1931 - 1950	134.001	14.204	16.659	16.793.524	1.883.409	14.890.413
1951 - 1960	108.299	15.608	5.574	13.548.064	2.176.005	8.011.232
1961 - 1972	273.139	31.965	6.594	39.052.489	4.649.885	14.264.179
1973 - 1978	147.183	24.163	2.102	22.999.832	3.764.563	4.525.897
1979 - 1998	127.005	81.801	8.647	18.215.274	12.932.598	7.957.695
1999 - 2006	48.836	24.895	3.385	7.809.797	4.117.519	3.838.907
After 2007	31.525	13.531	1.642	7.342.484	2.123.698	2.620.386
Total	1.203.623	234.672	87.989	178.682.543	35.363.578	82.400.4

S-4 & S-6 Centralization of the heat supply and heat generation of space heating systems

Single-family houses

Total number of buildings
Including farmhouses and excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	2.916	3.214	15.604	5.369	6.841	1.214	368	35.526
1851 - 1930	66.137	35.173	120.088	22.477	42.489	8.022	2.269	296.655
1931 - 1950	51.703	25.320	39.992	5.248	8.735	2.198	493	133.689
1951 - 1960	47.607	26.024	25.274	3.676	3.692	1.196	210	107.679
1961 - 1972	131.414	78.902	46.066	9.546	4.246	2.987	354	273.515
1973 - 1978	68.449	37.778	20.362	17.356	1.998	1.664	187	147.794
1979 - 1998	55.955	30.089	11.831	24.125	2.367	2.519	320	127.206
1999 - 2006	23.053	16.416	4.305	1.327	1.811	1.726	252	48.890
Efter 2007	14.982	8.869	1.803	363	996	3.965	220	31.198
Total	462.216	261.785	285.325	89.487	73.175	25.491	4.673	1.202.152

Last updated: 24.10.2013

Heated external area [m²]
Including farmhouses and heated business area. Excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	430.161	516.032	2.618.304	720.330	1.145.725	231.172	68.959	5.730.683
1851 - 1930	9.728.427	5.634.140	19.612.491	3.120.719	7.249.677	1.504.847	427.978	47.278.279
1931 - 1950	6.689.575	3.427.934	5.626.435	656.125	1.360.318	365.393	81.210	18.206.990
1951 - 1960	5.782.130	3.312.007	3.237.365	413.107	514.411	177.474	30.451	13.466.945
1961 - 1972	18.941.391	11.366.339	6.605.414	1.241.665	658.154	477.394	55.007	39.345.364
1973 - 1978	10.542.169	5.764.950	3.285.613	2.500.607	369.008	288.419	35.582	22.786.348
1979 - 1998	8.030.847	4.485.950	1.979.425	3.348.487	432.547	438.261	57.488	18.773.005
1999 - 2006	3.624.960	2.585.350	773.192	176.799	352.721	293.359	43.606	7.849.987
Efter 2007	2.546.870	1.510.553	356.763	51.625	208.646	773.598	46.040	5.494.095
Total	66.316.530	38.603.255	44.095.002	12.229.464	12.291.207	4.549.917	846.321	178.931.696

Last updated: 24.10.2013

Terraced houses

Total number of buildings

Excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	1.984	320	451	566	231	40	9	3.601
1851 - 1930	16.936	1.955	2.847	1.882	870	155	25	24.670
1931 - 1950	7.201	3.849	2.454	309	150	28	5	13.996
1951 - 1960	9.146	4.056	1.696	495	94	17	2	15.506
1961 - 1972	23.642	5.561	1.571	985	37	51	6	31.853
1973 - 1978	16.767	2.856	698	3.727	12	59	40	24.159
1979 - 1998	51.645	18.252	1.525	9.728	102	308	72	81.632
1999 - 2006	15.427	8.653	384	196	16	71	5	24.752
Efter 2007	7.915	4.384	204	76	40	197	10	12.826
Total	150.663	49.886	11.830	17.964	1.552	926	174	232.995

Last updated: 24.10.2013

Heated external area [m²]

Included heated business area. Excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	245.618	50.138	71.611	59.896	33.569	7.013	3.453	471.298
1851 - 1930	2.107.117	302.969	434.545	214.601	115.285	25.402	7.607	3.207.526
1931 - 1950	1.016.456	476.619	291.018	35.027	19.841	4.108	1.389	1.844.458
1951 - 1960	1.336.452	493.266	274.239	48.441	12.511	2.299	205	2.167.413
1961 - 1972	3.498.569	739.702	263.439	121.469	5.081	7.244	779	4.636.283
1973 - 1978	2.684.731	433.173	109.412	522.144	1.780	8.013	2.907	3.762.160
1979 - 1998	8.397.726	2.951.853	230.254	1.243.149	20.904	42.493	17.431	12.903.810
1999 - 2006	2.616.958	1.343.215	73.973	41.669	4.462	11.421	551	4.092.249
Efter 2007	1.244.901	644.403	34.409	17.418	4.963	39.782	1.328	1.987.204
Total	23.148.528	7.435.338	1.782.900	2.303.814	218.396	147.775	35.650	35.072.401

Last updated: 24.10.2013

Apartment Blocks

Total number of buildings

Excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	1.171	157	177	110	79	9	4	1.707
1851 - 1930	32.697	3.271	3.882	1.088	556	82	79	41.655
1931 - 1950	13.319	1.500	1.503	214	98	16	25	16.675
1951 - 1960	4.466	603	402	45	26	8	7	5.557
1961 - 1972	5.535	564	400	47	13	7	4	6.570
1973 - 1978	1.786	129	113	61	9	2	-	2.100
1979 - 1998	7.096	1.087	150	282	9	6	20	8.650
1999 - 2006	2.808	528	16	7	6	1	2	3.368
Efter 2007	1.289	234	9	2	4	15	2	1.555
Total	70.167	8.073	6.652	1.856	800	146	143	87.837

Last updated: 24.10.2013

Heated external area [m²]

Included heated business area. Excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	523.808	52.288	75.376	35.293	26.059	3.177	2.762	718.763
1851 - 1930	22.218.593	1.103.611	1.401.534	352.349	188.912	26.398	28.942	25.320.339
1931 - 1950	13.057.176	904.195	730.503	73.948	40.011	5.142	9.393	14.820.368
1951 - 1960	6.930.392	613.930	348.138	18.410	6.371	2.285	1.980	7.921.506
1961 - 1972	12.559.708	993.293	601.852	15.562	5.039	2.463	6.459	14.184.376
1973 - 1978	4.164.596	171.555	124.157	31.212	2.248	497	-	4.494.265
1979 - 1998	6.955.160	766.257	85.418	94.772	2.460	4.282	23.665	7.932.014
1999 - 2006	3.368.305	439.310	8.138	3.025	2.025	1.510	434	3.822.747
Efter 2007	2.150.761	258.352	5.754	1.087	1.609	9.477	10.666	2.437.706
Total	71.928.499	5.302.791	3.380.870	625.658	274.734	55.231	84.301	81.652.084

4.2 Overall pilot Building information

MORE-CONNECT responsible partner

Cenergia, DK. Ove Morck, ocm@cenergia.dk

MORE-CONNECT industrial partner

Invela, DK & Innogie, DK

Building's name

Parkvænget

Location

Parlvænget, 4000 Roskilde, Denmark

Building typology

The pilot project is on social housing apartments constructed in 1967. Three blocks with a total floor area of 13472 m2 is to be renovated. There are 176 apartments of 3 sizes: 46 2-room, 98 3-room and 32 4-room. The buildings are constructed from prefabricated concrete elements.

Typical problems

The buildings are and in need for renovation – especially of the facades and change of windows. The insulation of the external walls and roof is not up to today's standard, which will be possible with an addition to the external wall and an exchange of the roof. Also the ventilation needs to be improved.

4.3 Architectural design

The aesthetic and monumental value of a property could hinder renovation according the More-Connect principle (placing a prefabricated façade and or roof). Therefore the aesthetic and historic/monumental characteristics of the property need to be assessed. In the Netherlands for example about 62,000 national monuments can be found. These buildings and other objects are valued for its national cultural-historical importance and designated as protected monument. Also local governments could designate objects to be monumental. Moreover other considerations not to change the building envelope include the aesthetic appearance or architectural design of the property. In many countries a building permit is mandatory to replace the facade of a property which often includes an aesthetic assessment of the design.

Historical (monumental) characteristics of the property: which historical / monumental characteristics need to be taken into account when considering nZEB retrofitting?	None
Aesthetic characteristics of the property: which aesthetic characteristics need to be taken into account when considering nZEB retrofitting?	None

Site plan

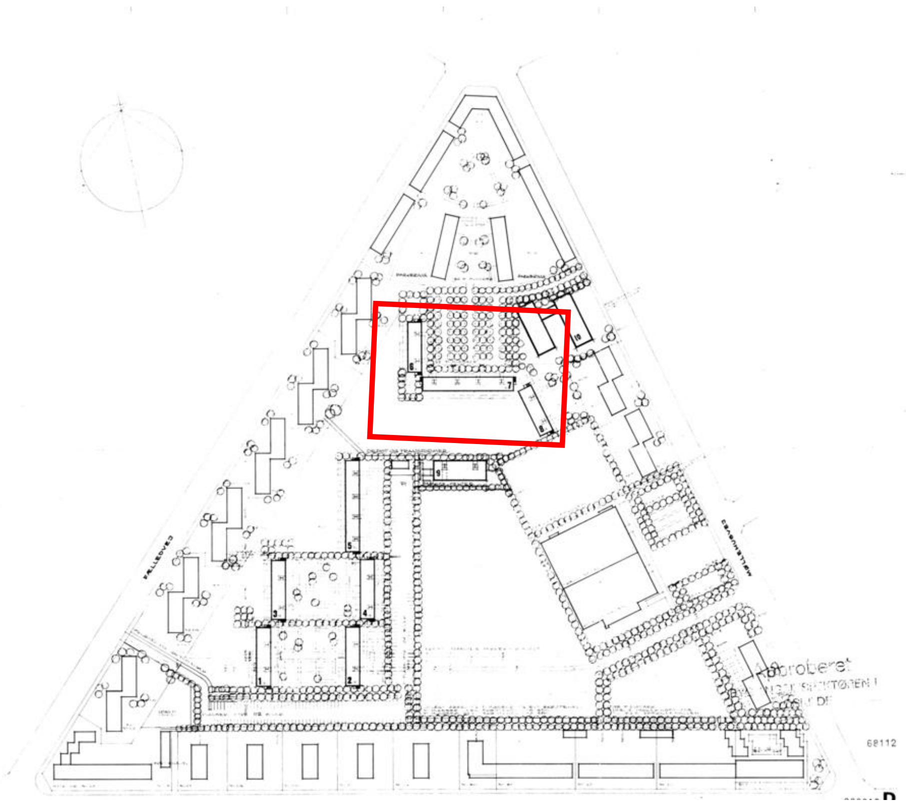


Figure 4.1a: Site plan pilot building

Figure 4.1b: Site plan pilot building

Views

Figure 4.2a: View pilot building

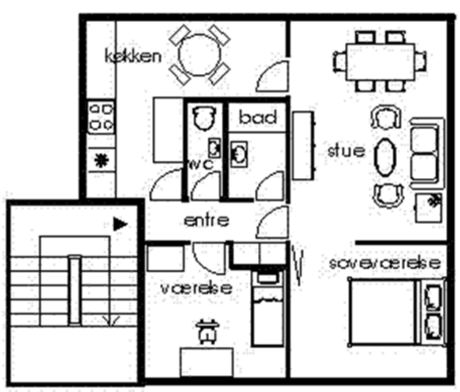
Figure 4.2b: View pilot building

Floor plans

Present state

Afd. Parkvænget 2-rum, 33 m^2

Afd. Parkvænget 2-rum, 67 m^2



Afd. Parkvænget 3-rum, 82 m^2

Afd. Parkvænget 4-rum, 91 m^2

Figure 4.3: Floor plan pilot building

Design target

No significant changes assumed in typical floor plan. A drawing will be provided later.

Cross section

Present state

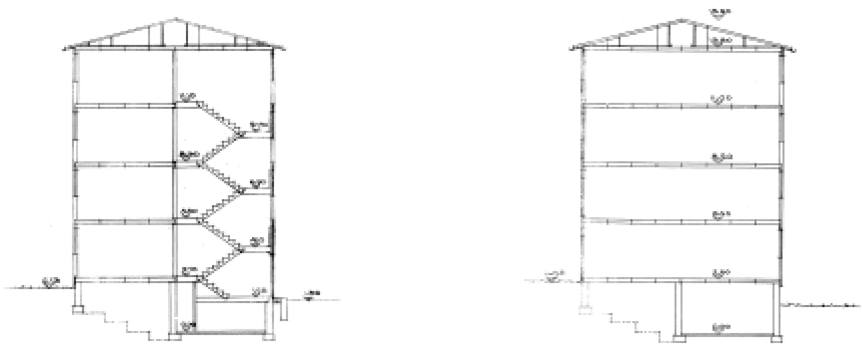


Figure 4.4: Cross section pilot building

Design target
The roof change is to be designed. A drawing will be provided later.

Façade and roof design

Present state

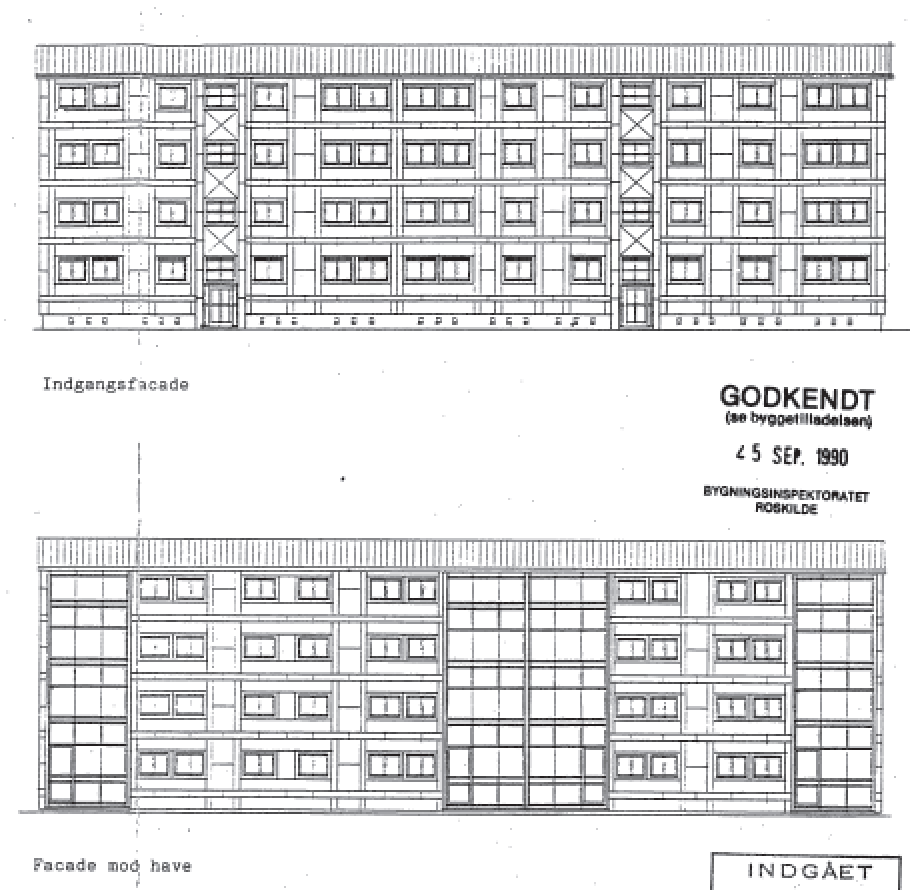


Figure 4.5: Façade and roof design pilot building

The building’s façade and gable walls were renovated in 1991. As it appear from the drawings and photos they are plane with windows placed in a fixed pattern. The three building are placed with different angles of their longitudinal axes. The balconies were glazed when the facades were renovated.

Design target
To be developed - architectural design of the new facade.

Complementary façade elements

Present state
There are quite large glazed balconies present in the façades for most apartments.

Design target
To be developed - architectural design of the new facade.

4.4 Structural design

Building’s load-bearing scheme
The constructional system presents concrete elements bearing walls.

Foundations

Present state
To be identified. Presumably concrete basement walls.

Design target
No significant changes planned.

Vertical structures

Present state
The thickness of the bearing walls is 280 mm of which app. 180 mm is concrete and 90-100 mm insulation.

Design target
The interior elements without planned changes, external walls will be stripped from insulation and app. 20 cm new integrated wall insulation and – finishing will be added by a preprogrammed robos.

Horizontal structures, floor slabs

Present state
Concrete slabs

Design target
The basement is likely to be insulated – will be decided later.

Openings

Present state
Plastic windows and doors with assumed g-value of 0,75,
Uw= 2,9 W.m-2.K-1 and Ud = 2,9 W.m-2.K-1.

Design target
Assumed g-value of 0,67; Uw = 1,0 W.m-2.K-1 and Ud = 1,0 W.m-2.K-1.

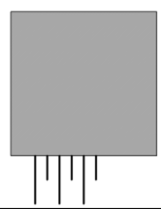
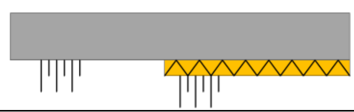
Roofing

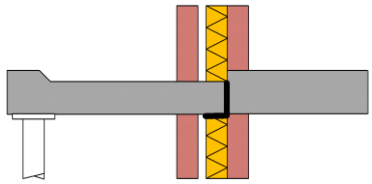
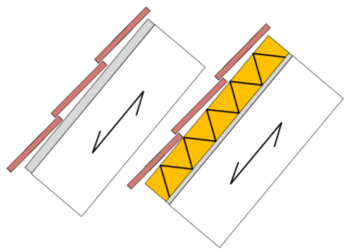
Present state
30 sloped roof – empty attic. Thickness of insulation: 10-20 cm – tbi.

Design target
Replacement and well insulated – detailed design to be made.

Overview structural characteristics of reference building

Structural characteristics of reference building

Element	Morphological representation	Description
(A) Foundation		(Reinforced concrete foundation beam – direct bearing foundation)
(B) Ground floor		Concrete floor – direct bearing (of basement)
(C) Separation and load bearing wall structures		Massive wall structure; NOT structural, prefab concrete elements
(D) Facade		Massive, piled – concrete – construction; load bearing, prefab concrete elements

(E) (Second/third/..) floors		Prefabricated concrete floor elements (not hollow core)
(F) Balcony / loggia / gallery		Internal balcony and loggia
Roof / top floor		Pitched roof; rafters; tiles on roof boarding; insulation on flat roof – not the sloped parts.

4.5 Building technical systems

Heating

Present state
The apartment blocks are connected to the local district heating system (Roskilde). The heating system is designed at flow/return temperatures 80/60°C. The radiators are mostly original from 1970s.

Design target
The heating system most probably will not need to be replaced.

Cooling

Present state
Cooling system is not present.

Design target
It is not necessary to install a cooling system.

Ventilation

Present state
The buildings are ventilated naturally/by exhaust air ventilators abducting the air from the kitchen, toilets and bathrooms.

Design target
It is necessary to install a new ventilation system, because the new air-tight building envelope can cause unwanted water condensation inside of the building and poor air quality if the air exchange is not adequate. Most probably individual mechanical ventilation systems with heat recovery will be installed, but it is still to be decided. Fire protection and acoustics must be taken account.

Electrical wiring

Present state
Existing system should be ok.

Design target
No replacement necessary.

Water piping

Present state
There are installation shafts in the middle of the buildings floor plane near the kitchen and bathroom area. Water pipes are steel…detals to be identified.

Design target
No changes planned.

Drainage system

Present state
There are installation shafts in the middle of the buildings floor plane near the kitchen and bathroom area. No other information yet available.

Design target
No design target in sewage system.

Monitoring and control

Present state
A central heat meter and an electricity meter are installed in the building. Each dwelling has radiator “meters” placed on each radiator and a separate meter for electricity use. Besides the amounts of water use – hot and cold – are metered. The supply temperature is controlled by the district heating system according to the outdoor air temperature.

Design target
Real heat meters in each apartment – to be decided.

Energy sources

Present state
District heating. Hot water is produced by a heat exchanger in the basement. The electricity is provided by standard power grid.

Design target
No changes planned as of today.

4.6 Building performance

Energy performance

Present state

The yearly heating demand is 82 kWh.m-2.a-1 The domestic hot water demand is 14 kWh.m-2.a-1
The electricity demand for fans, pumps, etc. is 1,54 kWh.m-2.a-1

Assessment financial issues related to energy costs

Performance indicator	Unit	Performance
Energy label	(label)	[X]
Energy index	(-)	[X]
Total primary energy consumption	(MJ)	[X]
Gas	(m3/year)	[X]
Add. (sustainable) energy, lighting, PV	(kWh/year)	[X]
CO2 emission	(kg/year)	[X]
Energy cost, without VAT -gas -electricity	(€/month)	[X]
Usable floor area	(m2)	[X]
Energy cost index	(€/m2)	[X]
Housing expenses -rent -mortgage	(€/month)	

Design target

The design target is stated in the D2.1 deliverable, Table 4.7: Requirements on building envelope and ventilation to fulfil national nZEB requirements in each country.

Ventilation	
Heat/cool recovery, %	90%
Ventilation airflow, l/(s⋅m2)	0,34
Renovated case represents indoor climate category II	0,5 ach
Specific fan power, W/(l/s)	1,2
Heating syst. with its efficiency	1 Radiators
Renewable energy sources	
Solar collectors for DHW, m2	0
Solar panels for electricity, m2	0
Coefficient of Performance of heat pump if it is used	-
Indoor temperature	
During heating period	20
During cooling period	23 - No control

Environmental impact

Present state

Yearly primary energy consumption (including DHW): 96 x 1 x 13472 + 1,54 x 2,5 x 13472 = 1345 MWh, which means a yearly CO_2 emissions of 96 x 13472 x 0,118 + 1,54 x 13472 x 0,377 kg.m-2.a-1. = 160,4 tons CO_2.a-1

Design target

Yearly non-renewable primary energy consumption (including DHW): 19 x 1 x 13472 + 1,59 x 2,5 x 13472 = 309,5 MWh, which means a yearly CO_2 emissions of 19 x 13472 x 0,118 + 1,59 x 13472 x 0,377 kg.m-2.a-1. = 56,7 tons CO_2.a-1.

Acoustic

Present state

Not assessed.

Design target

The national standards reported in the "Table 3.5: National design values for building acoustics in More-Connect Geo-clusters and countries." From Deliverable 2.1 will be fulfilled

Noise from service systems	
LpA,eq,T ,dB(A)	
bedrooms	30
living rooms	30
LpA,max ,dB(A)	
bedrooms	30
living rooms	30

Daylight

Present state

No problems reported. To be determined later.

Design target

The daylight level is not expected to be influenced by the refurbishment.

Air tightness

Present state

The assumed total air change is 0.5 h-1 today – this is due to a combination of infiltration and ventilation, but the airtightness hasn't been measured.

Design target

The assumed total air change at 50 Pa will be 1,5 h-1.

Moisture safety

Present state

Risk of condensation at thermal bridges in poorly insulated façade.

Design target

The national standards reported in the "Table 3.4: National values for hygrothermal design of building envelope in More-Connect Geo-clusters and countries." of Deliverable 2.1 will be fulfilled.

5 Pilot Estonia

5.1 National housing statistics

Overview statistics of the Estonian housing sector with respect to building typology indicators

Statistical Table	Item	Available	Reference
S-1	Frequency of building types of the national building stock	Yes	1
S-2	Percentage of thermally refurbished envelope areas	no	
S-3	Information on insulation level and window types	Yes	1
S-4	Centralization of the heat supply (for space heating)	no	
S-5	Heat distribution and storage of space heating systems	no	
S-6	Heat generation of space heating systems	Yes	1
S-7	Heat distribution and storage of domestic hot water systems	no	
S-8	Heat generation of domestic hot water systems	no	
S-9	Solar thermal systems	no	
S-10	Ventilation systems	no	
S-11	Air-conditioning systems	no	
S-12	Control of central heating systems	no	
S-13	Domestic energy consumption	Yes	1

S-1 Frequency of building types of the national building stock

Building typology national housing stock (amount and total are of dwellings)

	Regular multi-family (apartment) house, x1000		Other multi-family house, x1000		Single-family house, x1000		Terraced house, x1000		Dwellings total, x1000	
Year	Amount	Area, m2	Amount	Area, m2	Amount	Area, m2	Amount	Area, m2	Amount	Area, m2
< 1919	17.65	873.04	0.41	22.44	27.50	2461.94	2.43	185.65	47.98	3543.06
1919–1945	28.24	1373.62	0.24	14.19	44.37	4067.65	4.02	296.72	76.87	5752.17
1946–1960	32.68	1653.59	0.16	6.94	21.82	1969.74	2.44	165.07	57.10	3795.34
1961–1970	96.91	4254.57	0.12	5.07	17.87	1710.44	1.76	133.38	116.65	6103.46
1971–1980	116.25	6037.26	0.10	4.97	13.90	1462.78	2.35	214.57	132.60	7719.57
1981–1990	111.22	6112.21	0.14	7.50	15.48	1854.74	3.14	313.21	129.98	8287.66
1991–2000	13.56	828.70	0.09	6.49	10.19	1625.81	1.94	319.74	25.78	2780.72
2001–2005	11.04	670.82	0.04	2.64	8.52	1346.57	1.87	247.72	21.46	2267.75
2006–2011	19.59	1199.88	0.19	12.00	18.42	2940.53	3.12	413.43	41.32	4565.84
Total	447.14	23003.70	1.49	82.23	178.07	19440.18	23.05	2289.47	649.75	44815.58

S-3 Information on insulation level and window types

Statistics/information about insulation level within past 100 years

	<1920	1921-1940	1941-1970	1971-1990	1991-2010
Floor, U [W/(m2K)]	0,81	1,17	0,77	1,06*	0,35
External wall, U [W/(m2K)]	0,63	0,54	0,52	0,99	0,25
Window, U [W/(m2K)]	2,80	2,80	2,80	2,80	1,80
Door, U [W/(m2K)]	3,00	3,00	3,00	3,00	1,80
Roof, U [W/(m2K)]	0,34	0,48	0,43	0,32	0,16

S-6 Heat generation of space heating systems

Statistics/information about heat generation

Amount of dwellings, 2011	Regular multi-family house, x1000	Single-family house, x1000	Other, x1000	%%
District heating	321.38	1.48	1.43	49.9%
Local central heating	42.31	40.90	8.71	14.1%
Stove or fireplace	63.10	127.04	10.40	30.9%
Electricity	19.12	6.60	2.40	4.3%
Other	2.71	2.05	0.11	0.7%
%%	69.0%	27.4%	3.5%	

S-13 Domestic energy consumption

Statistics/information about domestic energy consumption (TJ)

Year	Coal	Peat briquette	Wood	Wood briquette	Gas	Electricity	Heat	Total, TJ
1999	996	516	13714	N/A	1997	4906	17235	39364
2000	778	447	13888	N/A	2019	5278	15752	38162
2001	674	268	13639	N/A	2037	5707	16621	38946
2002	805	286	13685	N/A	1757	5702	16465	38700
2003	510	251	14290	110	1685	5737	15623	38206
2004	898	190	14272	62	1775	5824	15551	38572
2005	771	202	12254	88	1981	5833	15801	36930
2006	622	146	11945	162	2026	6029	15643	36573
2007	271	175	15668	194	2140	6382	15174	40004
2008	233	246	15958	604	2210	6641	13979	39871
2009	197	116	16751	936	2257	6783	13842	40882
2010	209	151	16956	1490	2463	7283	14972	43524

5.2 Overall pilot Building information

MORE-CONNECT responsible partner

Tallinn University of Technology, Tallinn, Estonia, Targo Kalamees, targo.kalamees@ttu.ee

MORE-CONNECT industrial partner

Matek AS, Tallinn, Estonia, Raivo Külaots, raivo.kylaots@matek.ee

Building's name

Student's hostel at TUT campus, Tallinn

Location

Akadeemia 5a, Tallinn, Estonia

Building typology

The pilot building is a typical 5-storey house, built in 1986 and made of prefabricated concrete large panel elements. Building has a fullscale cellar. It has an insulated flat roof structure with bituminous felt cover and number of ventilation chimneys. The building has simple, rectangular floor plan. It has 2 similar wings, 2 stairways, with similarly designed flats. The net area of the building is 3824 m2 and heated area 3306 m2.

Typical problems

Unsatisfied overall present energy performance: Uwall = 1.0 W/(m2K), Uroof= 1.1 W/(m2K), Ufloor = 0.6 W/(m2K)), thermal bridges, lack or insufficient ventilation, water-proofing failures on balconies and on window drip molds. Wooden windows with high thermal transmittance (Uwindow = 1.8 W/(m2K)) has broken closing mechanisms and fixings. Failures and water leakage in the area of chimney-roof. Possible overheating during winter season, insufficient thermal comfort at southern part of living spaces on summer period.

5.3 Architectural design

The current aesthetic state is not very requiring as it represents widely used soviet-time concrete multi-storied house building traditions from last century 70's and 80's. The value of a property could be raised via renovation according the More-Connect principles (placing a prefabricated facade and roof panels).

Historical (monumental) characteristics of the property: which historical / monumental characteristics need to be taken into account when considering nZEB retrofitting?	N/A
Aesthetic characteristics of the property: which aesthetic characteristics need to be taken into account when considering nZEB retrofitting?	Compatibility with surrounding architecture has to be considered

Site plan

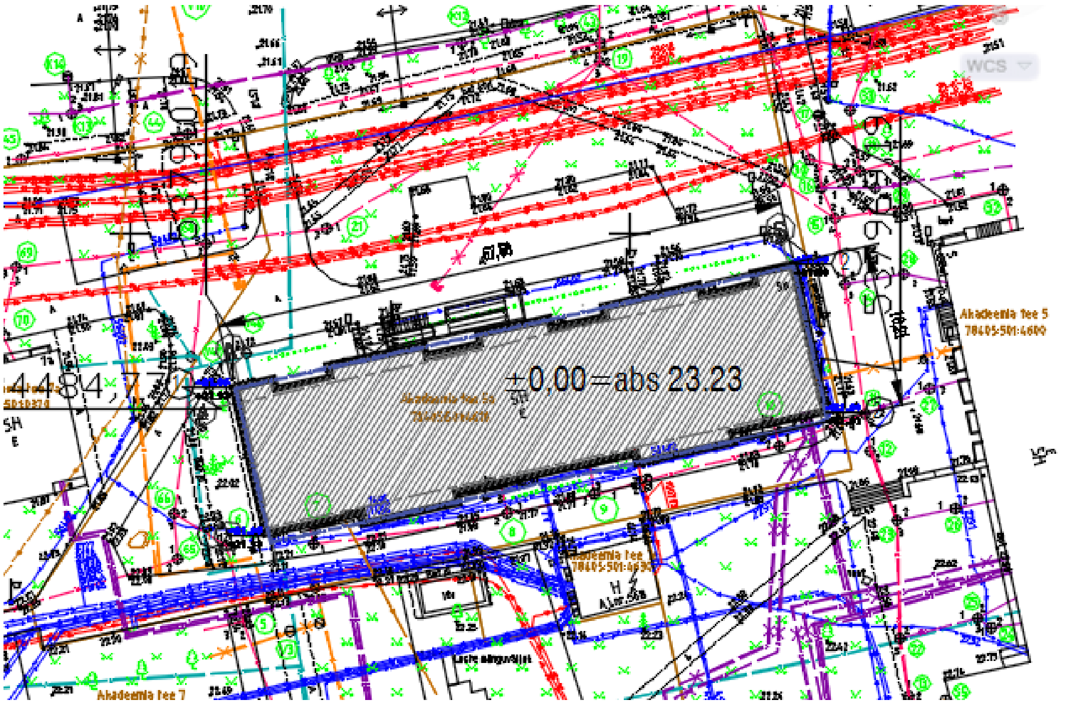


Figure 5.1a: Site plan pilot building

Figure 5.1b: Site plan pilot building

Views

Figure 5.2: Views pilot building

Floor plans

Present state

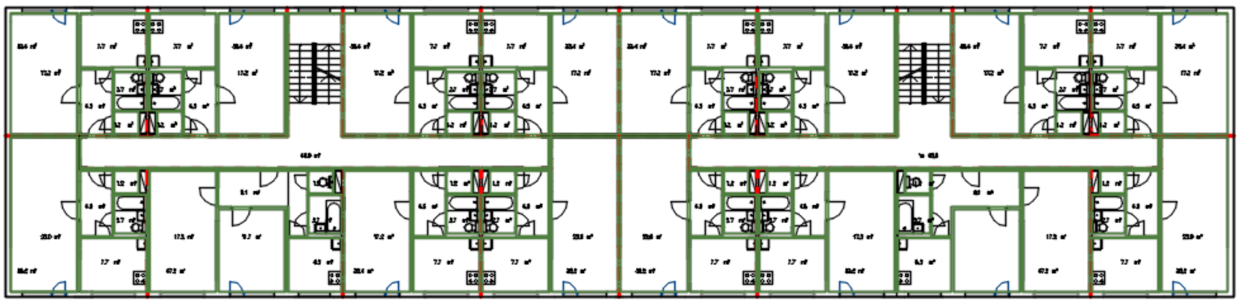


Figure 5.3: Floor plan pilot building

Design target

No major changes assumed in typical floor plan. Staircases will be re-formed in corridors and in front of the building in order to add the lift to one corridor. Open balconies on south and north longer walls will be closed with glazing.

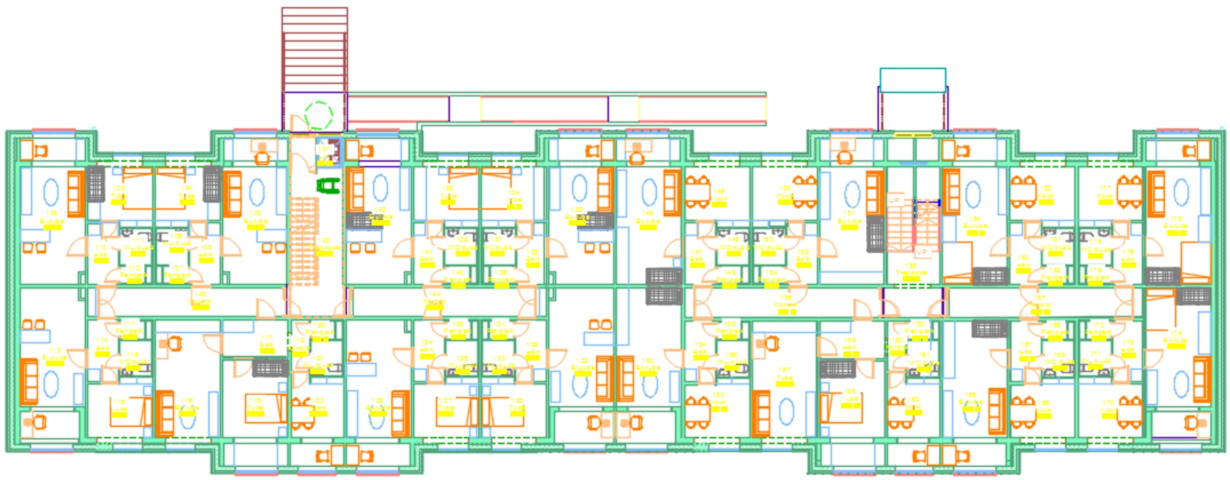


Figure 5.4: Floor plan pilot building after renovation

Cross section

Present state

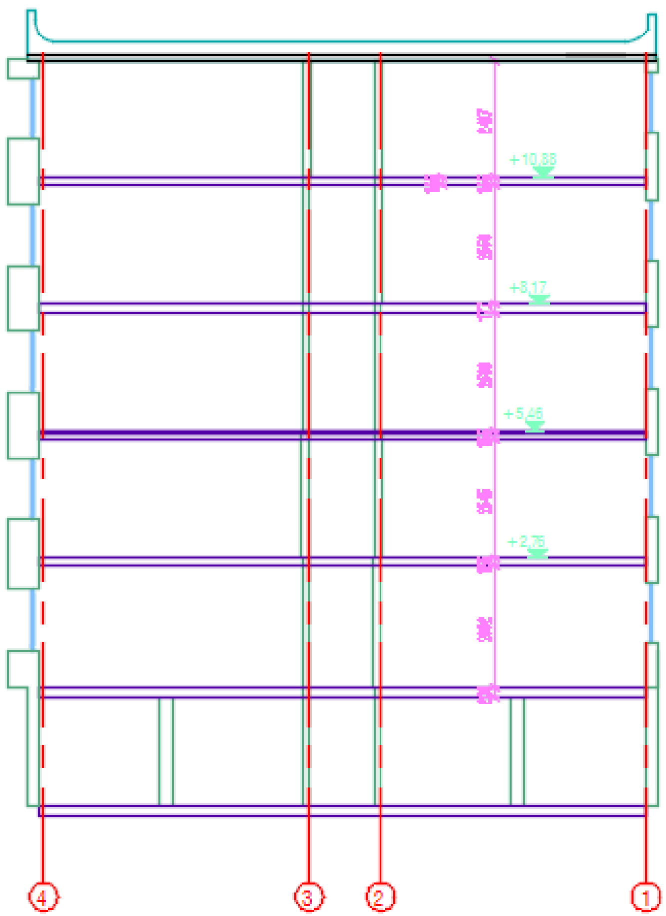


Figure 5.5: Cross section pilot building

Design target
Roof will be made with sharper slope, wider edges and wind boxes. HVAC equipment will be placed into the container on roof.

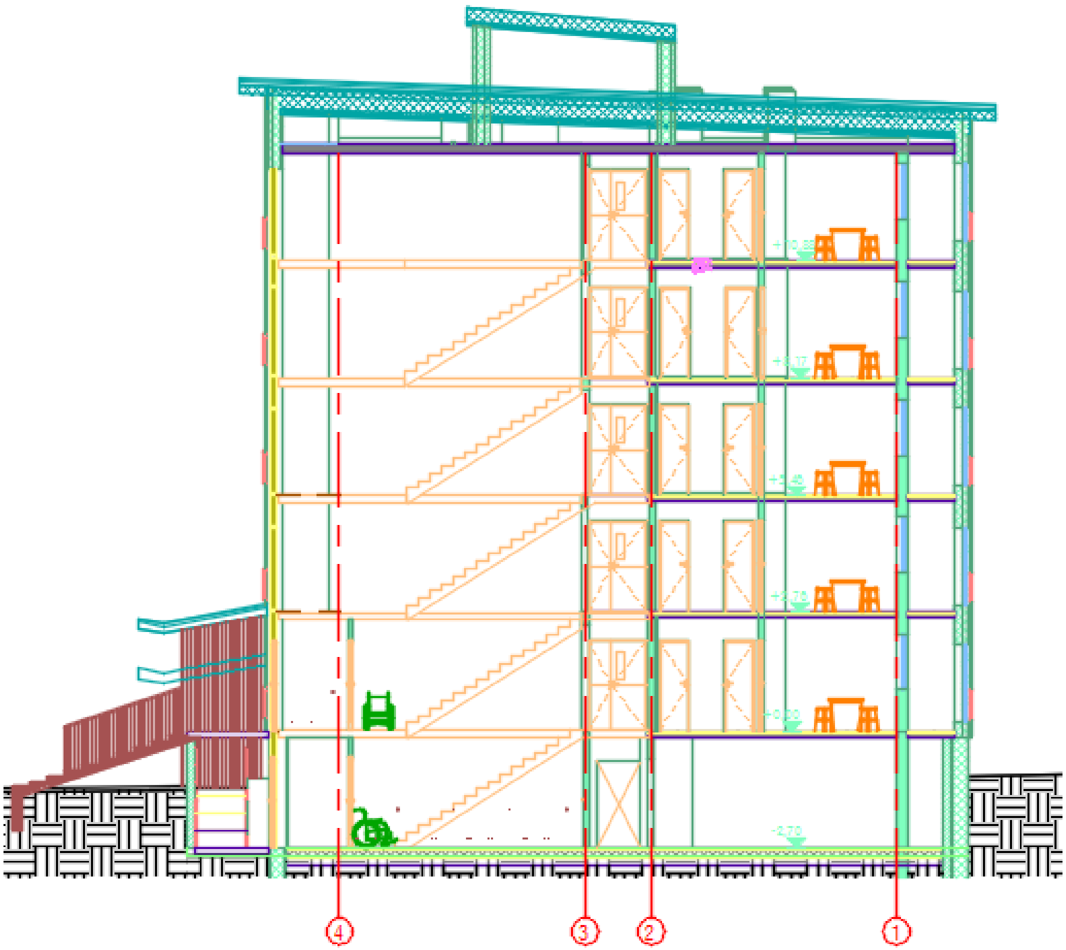


Figure 5.6: Cross section pilot building after renovation

Facade and roof design

Present state
The building's facade is plane in general, but fragmented on the balconies area. The windows are set rhythmically, repeating in the similar distances. The main entrances to the building are designed in the longer north side. The longitudinal axis orientation is north-south. The open balconies are on the both sides of the facade.

Design target
The architectural design depends on the facade panel's construction, weight and covering materials structure. The disposition of the panels with different colors will give a bright and fresh view to the whole building with wider and raised roof edges.

Figure 5.7: Façade and roof design pilot building after renovation

Complementary facade elements

Present state

There are open balconies present in the facade, one in each apartment.

Figure 5.8: Complementary façade elements pilot building

Design target

The balconies will be closed with glazing and thus will be as a part of living space.

Figure 5.9: Complementary façade elements pilot building after renovation

5.4 Structural design

Building's load-bearing scheme

The constructional system present lateral masonry bearing walls and it will remain the same after the renovation.

Foundations

Present state

Monolithic reinforced concrete slab and wall footings.

Design target

No significant changes planned.

Vertical structures

Present state

The thickness of the load bearing walls is 270 mm, partition walls 150 mm. Staircase contains two straight flights of stairs in each floor. There are 8 concrete stairs in one flight of stairs.

Design target

The load bearing external and internal walls remain the same and will be covered with prefabricated panels, Target value Uw = 0.08 W/(m2K). The stairs in one staircase will be rebuild into 1 long flight stairway, in order to place the lift in staircase corridor.

Horizontal structures, floor slabs

Present state

Precast-monolithic concrete slabs, 220…240 mm.

Design target
No significant changes planned, except more efficient noise insulation in living rooms with help of floating floors.

Openings

Present state
Original wooden windows and doors with assumed g-value of 0,75, Uw = 1.80 W/(m2K) and Ud = 2,00 W/(m2K).

Design target
Assumed g-value of 0,67; Uw = 0.60 W/(m2K) and Ud = 1.00 W/(m2K).

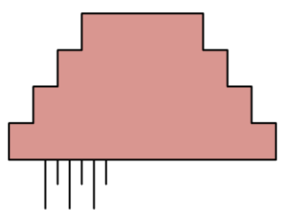
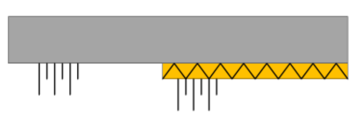
Roofing

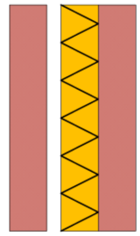
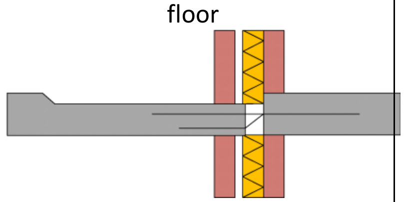
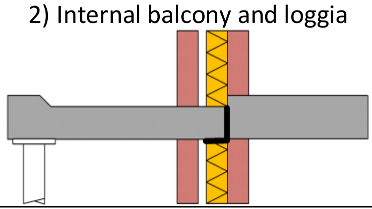
Present state
The current flat roof insulating level is not sufficient. The roof slope is 3…5°. Roof composition consists of bituminous waterproofing felt placed onto the lightweight concrete slab. Ur = 1.10 W/(m2K).

Design target
The current roof will be replaced on wooden rafters and insulated with prefabricated panels' roof with bigger slope in order to palce PV panels there. The HVAC and similar equipment will be placed on the roof container. Target value Ur = 0.06 W/(m2K).

Overview structural characteristics of reference building

Structural characteristics of reference building

Element	Morphological representation	Description
(A) Foundation		Masonry foundation – direct bearing foundation
(B) Ground floor		Concrete floor – direct bearing
(C) Separation and load bearing wall structures		Massive, poured concrete construction; load bearing

(D) Facade		Cavity wall; piled structure; insulated with 125 mm wood-chip layer between outer and inner crust, no cavity gap and/or air movement is intended
(E) (Second/third/..) floors		Massive, poured concrete floor structure – four-sided support
(F) Balcony / loggia / gallery	1) External structure connect to floor  2) Internal balcony and loggia 	
(G) Roof / top floor		Prefabricated – hollow core – concrete floor elements; ; NOT/min. insulation

5.5 Building technical systems

Heating

Present state
District heating system with pipes and radiators in each apartment is mounted. The heating one pipe system is designed at flow/return temperatures 75/60°C. The cast iron element radiators are mostly original from 1986, with thermostatic valves. Pipes are insulated using basalt wool and gypsum cover in cellar but uninsulated in flats and technical shafts.

Design target
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.

Cooling

Present state
Cooling system is not present. Massive overheating of the house was not observed.

Design target
Cooling system is not necessary to install. Thermal capacity of the building is high, so the building can absorb most of heat gains. Solar heat gains reduction by shading and increased ventilation will be used.

Ventilation

Present state
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.

Design target
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. Pipes can be integrated in facade elements; current outlet pipes can be used in new system or removed. Assumed position of ventilation units with heat exchanger is in the roof. Fire protection and acoustics will be taken account according to safety demands and rules.

Electrical wiring

Present state
In former building processes usually aluminum wires were used. They are commonly today beyond their life time and can cause fire or injury by electric shock.

Design target
Current wires will be replaced by copper wires. Also new light switches and power sockets will be installed.

Water piping

Present state
There are installation shafts nearby bathroom area of the each apartment of the building. Water pipes are steel, partly insulated. Domestic hot water temperature varies between 45°C to 60°C.

Design target
Current water supply system is intended to change to new, as heat sources, like solar panels and heat exchangers, will be installed. Circulation control implementation is designed as well.

Drainage system

Present state
There are installation shafts in the middle of the buildings floor plane near the bathroom area. The main sewage pipelines are placed in mentioned shafts.

Design target
No design target in sewage system. Connection piping could be replaced.

Monitoring and control

Present state
No central measurement control system is installed in the building.

Design target
The temperature and humidity will be always monitored in each room. When air ventilation will be installed, the CO2 will be also monitored. In case of central heating unit, the heat in each room will be measured to split the payload. In case of individual system, the CO2 sensor will be placed. If a central heating system will be exploit, a regulation system will control the heating based on monitoring system and demands of the users. The complexity of the control system will be restricted by building owners. If more comfort solution will be desired then we can offer the Individual Room Control (IRC) unit with combination of occupancy plan or temperature profile.

Energy sources

Present state
There are pipelines in the building for district heat distribution for space heating of the flats and production of domestic hot water. The electricity is provided by standard power grid.

Design target
Central heating system, central hot water preparation, individual boilers are still under consideration.
building performance

5.6 Building performance

Energy performance

Present state

The average whole building's energy performance (primary energy) value is 300 kWh/(m2a), net consumption (delivered energy) is 274 kWh/(m2a) and the heating demand is 131 kWh/(m2a). The heat flow (heat losses) ratio is following: external wall 30 %, roof: 15 %, floor: 6 %, windows a doors 24 %, ventilation and hot water heat losses 25 %.

Assessment financial issues related to energy costs

Performance indicator	Unit	Performance
Energy label	(label)	G
Energy index	(-)	-
Total primary energy consumption	(kWh/(m ^{2} a))	300
Heating	kWh/(m ^{2} a)	131
Add. (sustainable) energy, lighting, PV	(kWh/year)	-
CO2 emission	(kg/year)	To be determined later
Energy cost, without VAT -heat -electricity	(€/kWh)	 0.062 0.116
Heated floor area	(m ^{2})	3306
Energy cost index	(€/(m ^{2} a))	19.7
Housing expenses -rent -mortgage	(€/month)	To be determined later

Design target

The design target is stated in the D2.1 deliverable, Table 4.7: Requirements on building envelope and ventilation to fulfil national nZEB requirements in each country.

Ventilation	
Heat/cool recovery, %	80%
Ventilation airflow, l/(sm ^{2})	0.42
Renovated case represents indoor climate category II	
Specific fan power, kW/(m ^{3} /s)	2.0
Heating syst. with its efficiency	Hydronic radiators (efficiency 0.97)
Renewable energy sources	
Solar collectors for DHW, m ^{2}	100
Solar panels for electricity, m ^{2}	87
Coefficient of Performance of heat pump if it is used	-
Indoor temperature	
During heating period	21
During cooling period	No control

Environmental impact

Present state
Yearly nonrenewable primary energy consumption:
300 kWh/(m^2a)

Design target
Yearly unrenewable primary energy consumption:
86 kWh/(m^2a)

Acoustic

Present state
Not assessed. Possible problematic partition walls and floors between the flats.

Design target
The national standards reported in the "Table 3.5: National design values for building acoustics in More-Connect Geo-clusters and countries." From Deliverable 2.1 will be fulfilled

Noise from service systems LpA,eq,T ,dB(A) bedrooms living rooms LpA,max ,dB(A) bedrooms living rooms	6:00- 22:00 40dB 22:00- 6:00 30dB (25dB)

The maximum noise in bedrooms and living rooms due to the functioning of the building service system is considered on Portuguese acoustic regulation base on the maximum acceptable noise from service systems, LAr,nT. LAr,nT = LA,eq + K1 + K2 (K1 = 3 if the noise has tonal characteristics and ; K2 = 3 dB if the noise has impulsive characteristics).
Moreover, the design will meet the requirements of a COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions" methodology for Class C classification at minimum.

Daylight

Present state
No problems reported. To be determined later.

Design target
The daylight level will not be influenced by the refurbishment, the similar of better daylighting will be assured during the construction process.

Air tightness

Present state
The assumed total air change is 0.3 h-1, not divided into ventilation and infiltration. The airtightness is low in common areas of the house and in the flats with original wooden windows.

Design target

The assumed total air change at 50 Pa will be 1,5 h-1.

Moisture safety

Present state
Problems with the moisture in the rooms with the refurbished air-tight windows reported. Water leakages in the roof structure.

Design target
The national standards reported in the “Table 3.4: National values for hygrothermal design of building envelope in More-Connect Geo-clusters and countries.” of Deliverable 2.1 will be fulfilled. Thorough thermal and moisture performance measurements will be arranged, as a part of energy efficiency design process.

6 Pilot Latvia

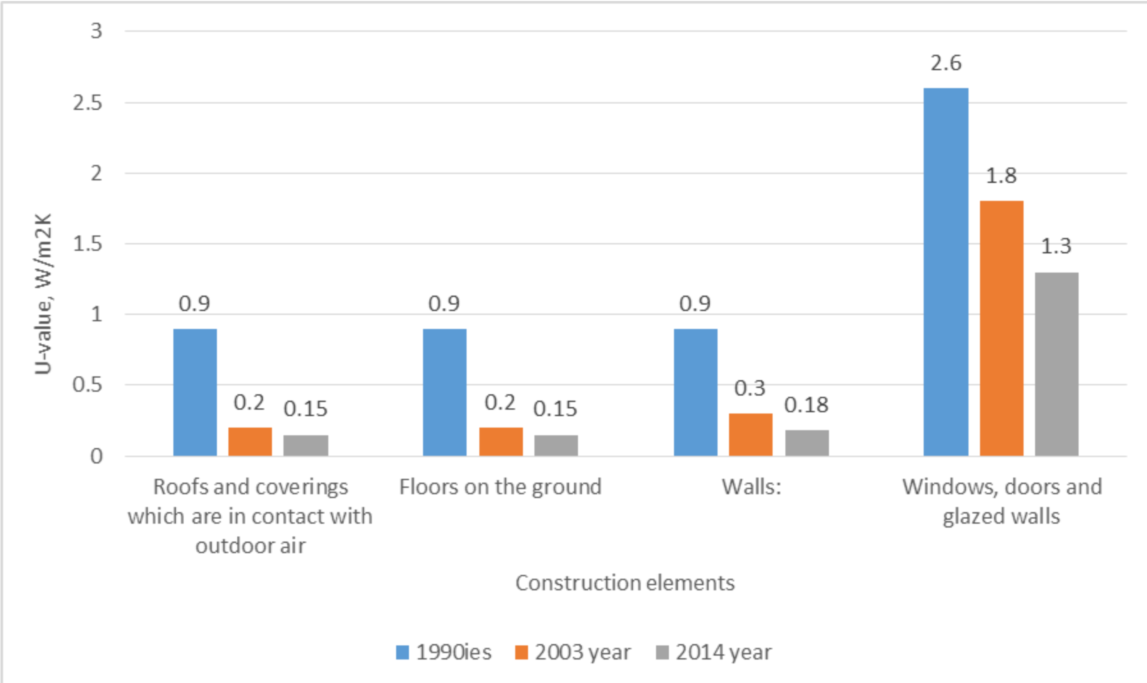
6.1 National housing statistics

Overview statistics of the Latvian housing sector with respect to building typology indicators

Statistical Table	Item	Available	Reference
S-1	Frequency of building types of the national building stock	Yes	http://www.csb.gov.lv/en/statistikas-temas/energy-database-30737.html
S-2	Percentage of thermally refurbished envelope areas	no	
S-3	Information on insulation level and window types	no	
S-4	Centralization of the heat supply (for space heating)	Yes	
S-5	Heat distribution and storage of space heating systems	no	
S-6	Heat generation of space heating systems	Yes	
S-7	Heat distribution and storage of domestic hot water systems	no	
S-8	Heat generation of domestic hot water systems	Yes	
S-9	Solar thermal systems	no	
S-10	Ventilation systems	no	
S-11	Air-conditioning systems	no	
S-12	Control of central heating systems	no	
S-13	Domestic energy consumption	no	

S-1 Frequency of building types of the national building stock

Year of construction	Single family houses	Two apartments houses	Terraced house	Multi apartment buildings
<1945	97737	3406	2278	120218
1945-1960	38047	2503	912	49248
1961-1970	26152	1081	536	141169
1971-1980	27018	1081	677	180749
1981-1990	35856	563	340	162723
>1991 (2011)	43846	1826	1509	51268



S-4 Centralization of the heat supply (for space heating)

District heating is most common heat supply source in large cities.

S-6 Heat generation of space heating systems

Heat generation of space heating systems is evaluated on the basis of ODYSSEE project report: http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-latvia.pdf

Heat generation of space heating systems for year 2010

Percentage of dwellings	Total
individual local heating	n/a
individual central heating: - non-condensing boiler - condensing boiler	73.1 n/a n/a
district heating	26.9%
other (delivery of warmth by third parties)	n/a

S-8 Heat generation of domestic hot water systems

No such detailed statistics is available. It multi apartment buildings domestic hot water mainly is prepared by district heating systems.

6.2 Overall pilot Building information

MORE-CONNECT responsible partner
RTU Anatolijs Borodinecs, Anatolijs.borodinecs@rtu.lv

MORE-CONNECT industrial partner
ZTC, Latvia

Building's name
Saules iela 4a

Location
Saules iela 4a, City of Cesis, Latvia

Building typology
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.

Typical problems
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.

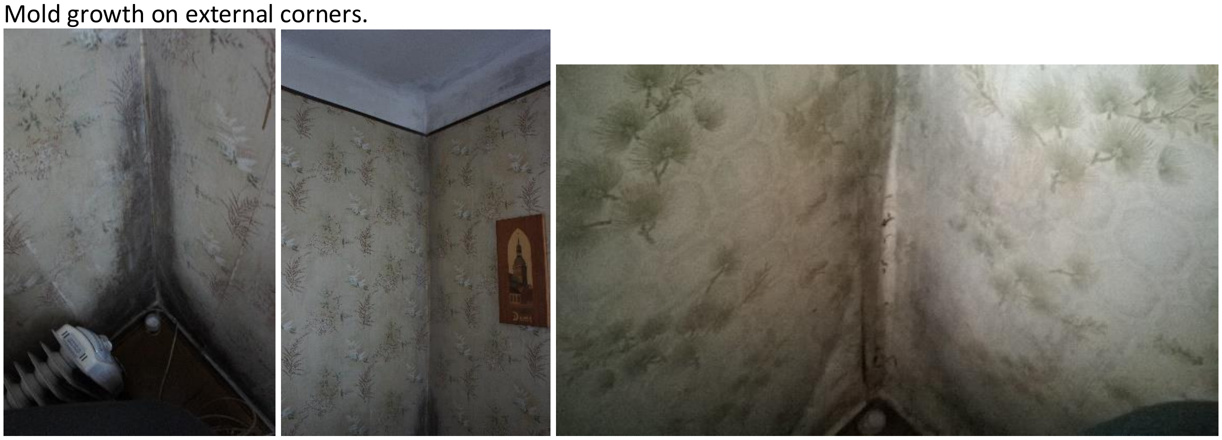


Figure 6.1: Mold growth on external walls

6.3 Architectural design
Building represents typical building constructed in 50ies – 60ies last century. This type of building is very common in rural areas and small cities.

Historical (monumental) characteristics of the property: which historical / monumental characteristics need to be taken into account when considering nZEB retrofitting?	n/a
Aesthetic characteristics of the property: which aesthetic characteristics need to be taken into account when considering nZEB retrofitting?	n/a

Site plan

Figure 6.2: Site plan pilot building

Views

Figure 6.3: Views pilot building

Floor plans

Present state

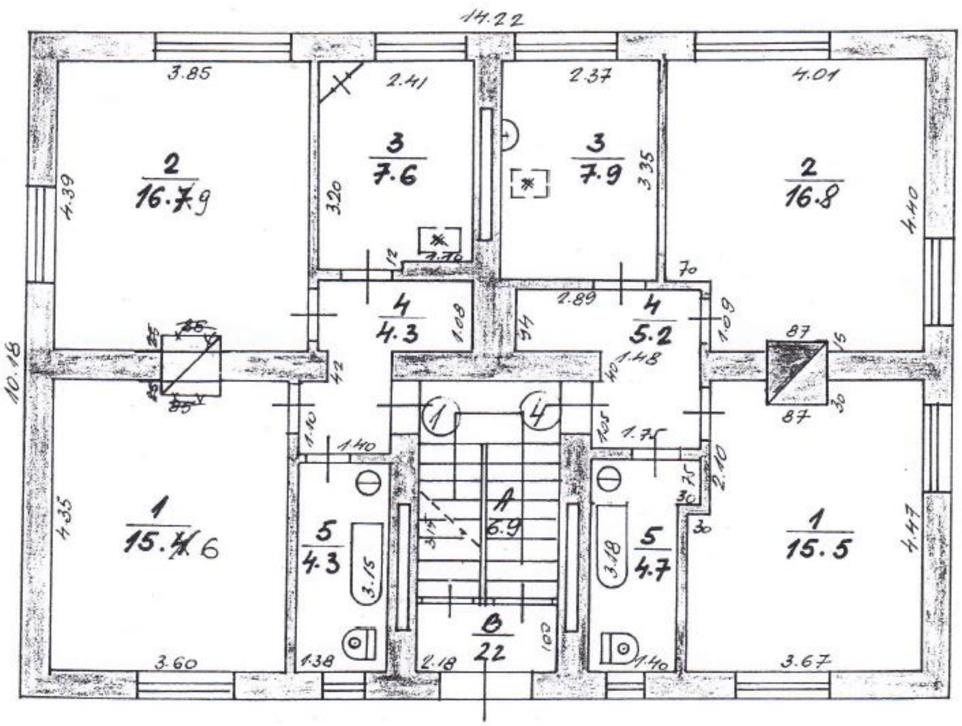


Figure 6.4: First floor plan

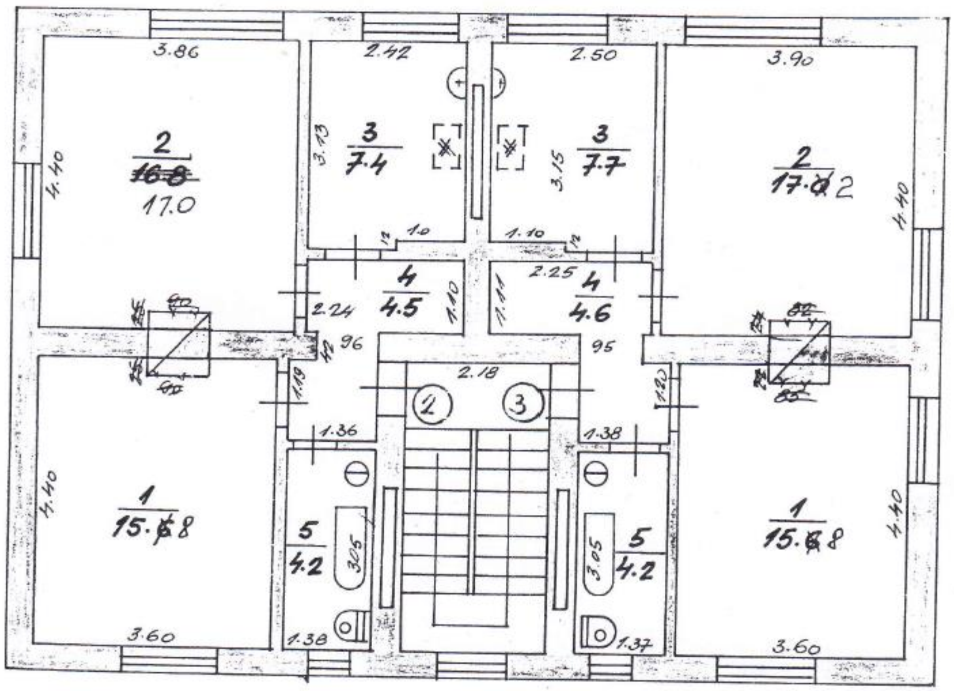


Figure 6.5: First floor plan

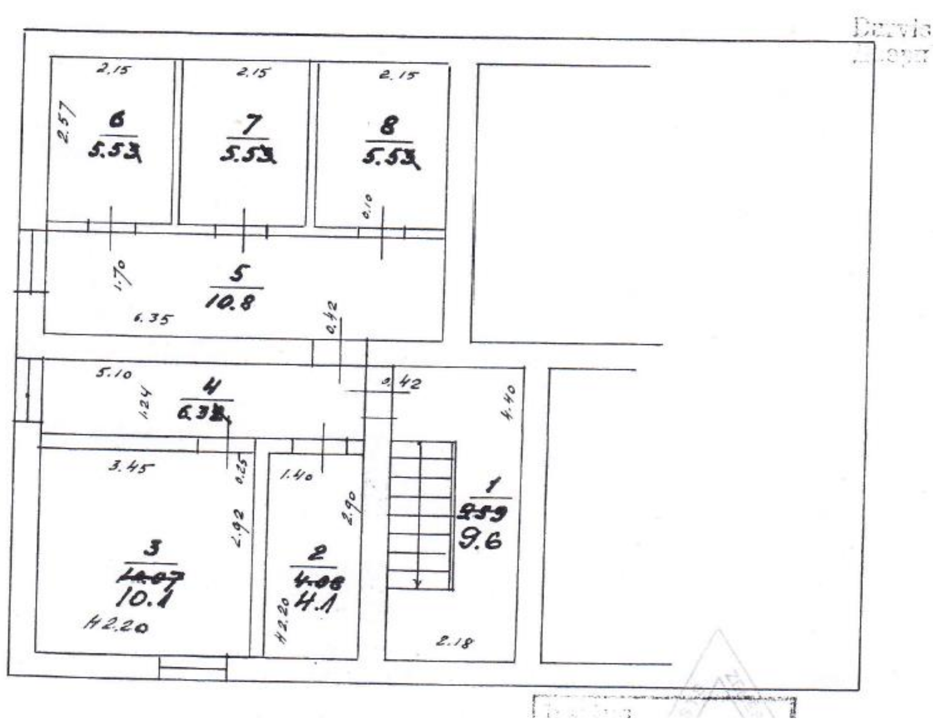


Figure 6.6: Basement floor plan

Design target

It is not planned to change floor plan

Cross section

Present state
Is not available. Will be create during the preparation of renovation project.

Design target

Façade and roof design

Present state
Facade is in poor conditions. Current color is grey. Porch construction is damaged and doesn't provide sufficient protection from rain and snow. Building socle also is not protected from rain and snow. Rain drainpipe/gutter is not connected to underground drainage

Design target
Roof overhang (eaves) should be extended in order to protect heat insulation form rain and snow.

Complementary façade elements

Present state
N/a

Design target
N/a

6.4 Structural design

Building's load-bearing scheme

The constructional system present lateral masonry bearing walls.

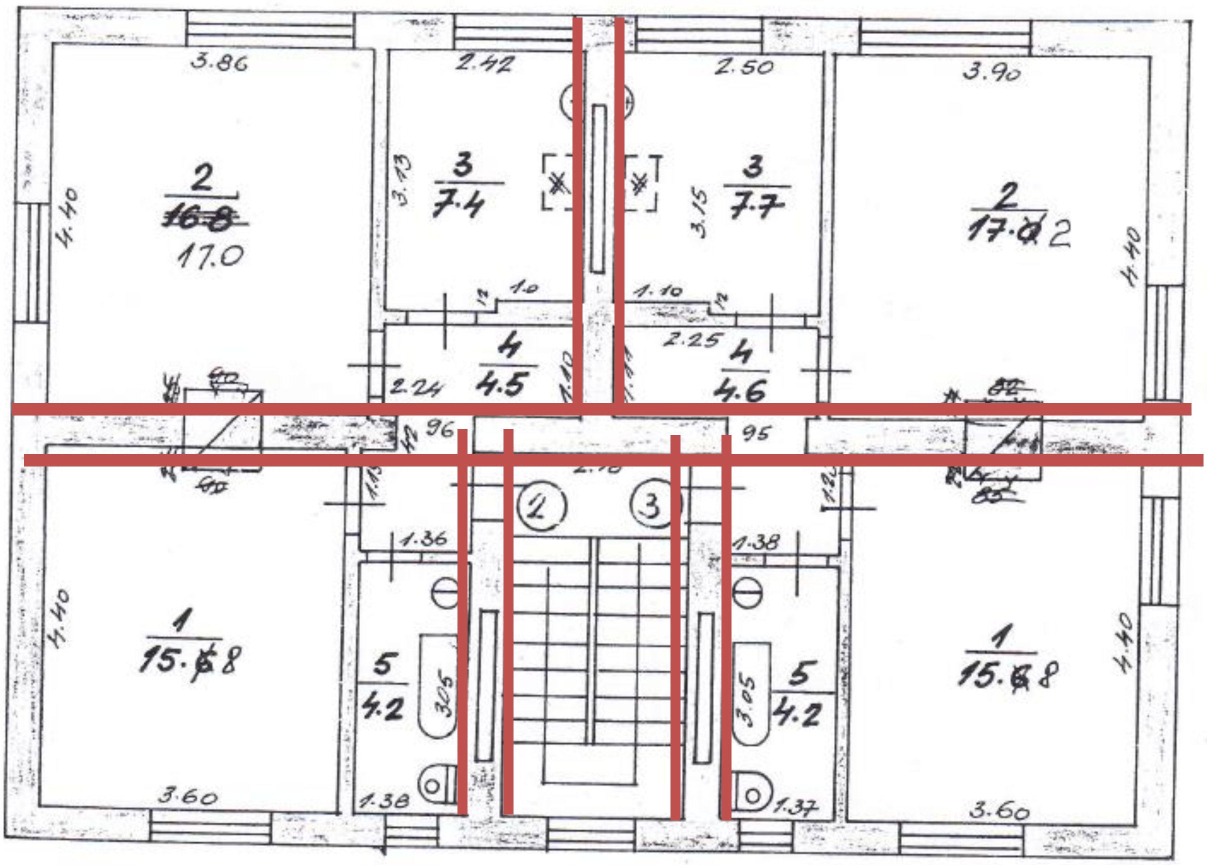


Figure 6.7: Load-bearing scheme of pilot building

Foundations

Present state

Monolithic reinforced concrete slab and wall footings.

Design target

No significant changes planned.

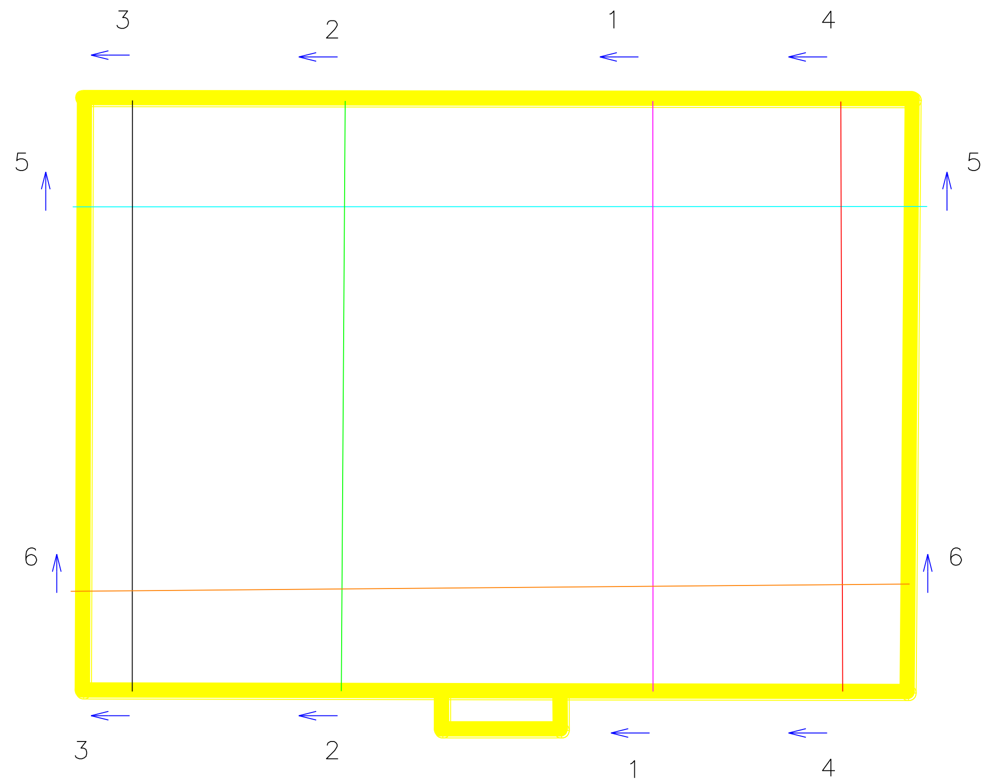
Vertical structures

Present state

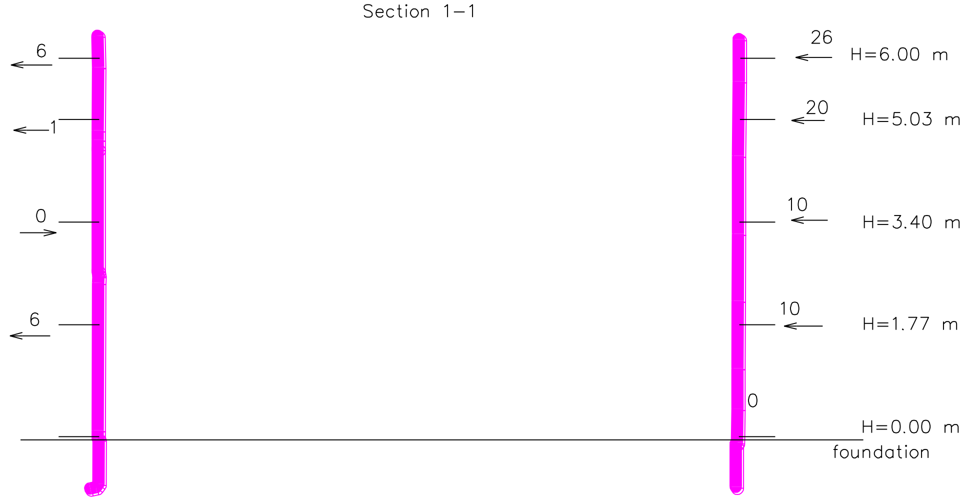
Silicate non-insulated brick wall with thickness 380mm.

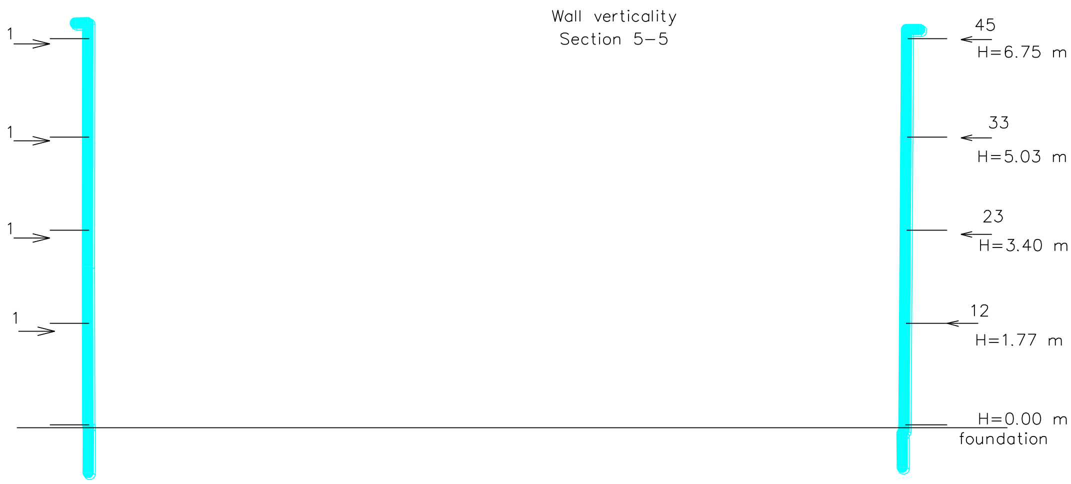
The vertical wall declination is shown in Figure 6.7

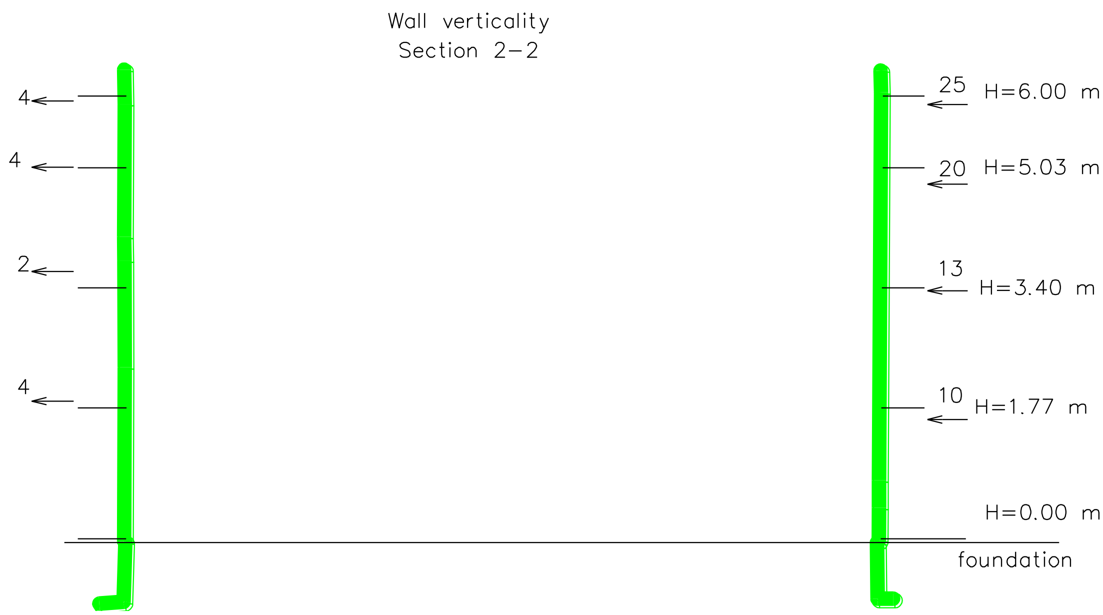
Sections placement

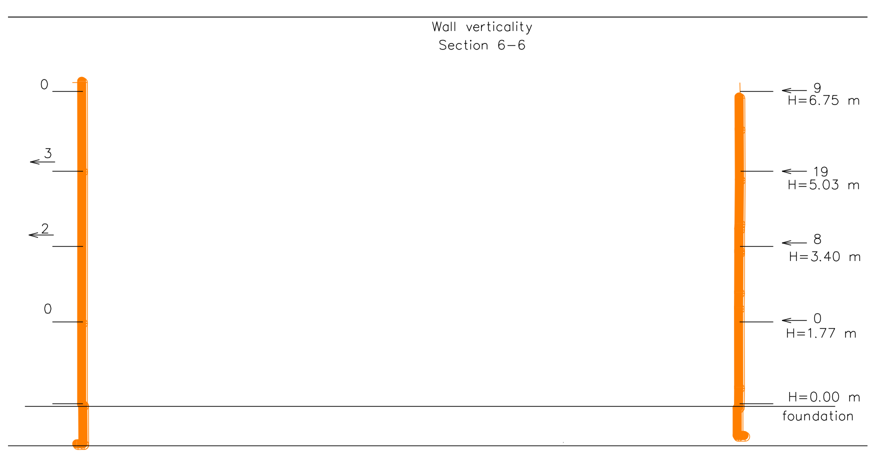


Wall verticality
Section 1–1




Wall verticality
Section 5–5
1
1
1
1
45
H=6.75 m
33
H=5.03 m
23
H=3.40 m
12
H=1.77 m
H=0.00 m
foundation


Wall verticality
Section 2–2
4
4
2
4
25
H=6.00 m
20
H=5.03 m
13
H=3.40 m
10
H=1.77 m
H=0.00 m
foundation


Wall verticality
Section 6–6
0
3
2
0
9
H=6.75 m
19
H=5.03 m
8
H=3.40 m
0
H=1.77 m
H=0.00 m
foundation

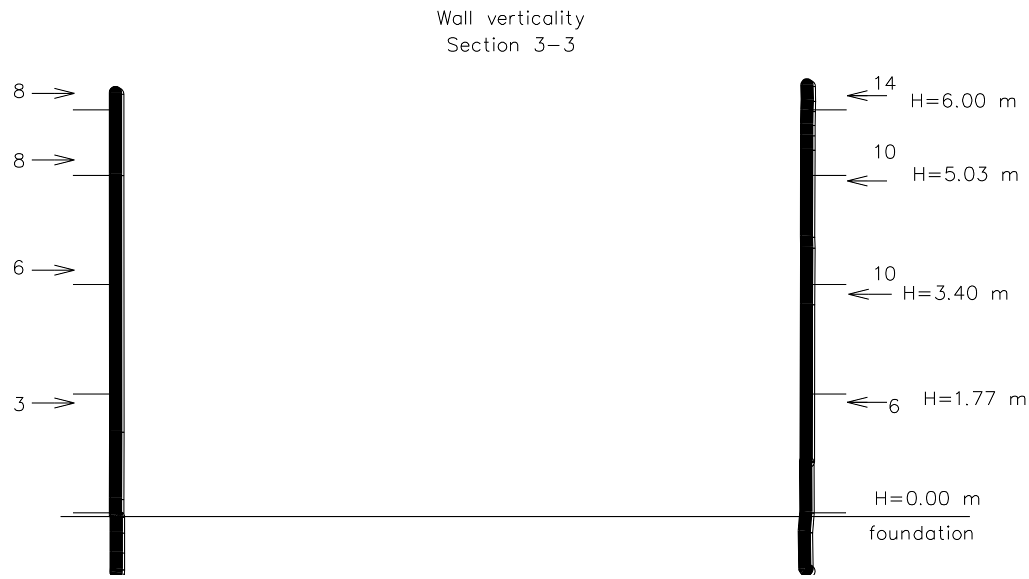


Figure 6.7: Vertical deviation of extremal walls

Design target
The external walls will be insulated to obtain a U ≤ 0,18 W.m-2.K-1. It is planned to replace existing PVC windows with new windows with U ≤ 1,1 W.m-2.K-1.

Openings

Present state
PVS windows with assumed g-value of 0,75, Uw = 1,8 W.m-2.K-1

Design target
Assumed g-value of 0,67; Uw = 1,0 W.m-2.K-1 and Ud = 1,0 W.m-2.K-1.

Roofing

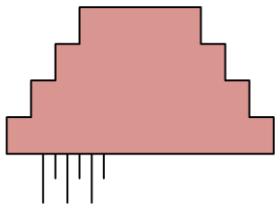
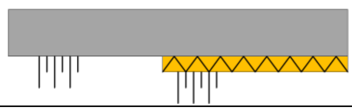
Present state
Party insulated attic slab.

Figure 6.8: Attic thermal insulation

Design target
Overview structural characteristics of reference building

Overview structural characteristics of reference building

Structural characteristics of reference building core

Element	Morphological representation	Description
(A) Foundation		Concrete foundation – direct bearing foundation]
(B) Ground floor		Concrete floor – direct bearing, without heat insulation
(C) Separation and load bearing wall structures		Massive, piled – masonry – construction; load bearing
(D) Facade		Massive, piled – masonry – construction; load bearing
(E) (Second/third/..) floors		Modular floor system
(F) Balcony / loggia / gallery	n/a	n/a
(G) Roof / top floor		Prefabricated – hollow core – concrete floor elements with minimal heat insulation d100mm

6.5 Building technical systems

Heating

Present state
Building is connected to the district heating system. Building has a single pipe heating system.

Design target
To introduce two-pipe heating systems and upgrade existing heat substation.

Cooling

Present state
N/a

Design target
Passive cooling strategy, by natural ventilation and night cooling

Ventilation

Present state
Natural ventilation with exhaust shaft without air supply vents. Some of air supply vents are sealed by inhabitant.

Design target
Hybrid ventilation. To restore existing ventilation shaft.

Electrical wiring

Present state
N/a

Design target
N/a

Water piping

Present state
N/a can be replaced by owners, during retrofitting of building envelope.

Design target
N/a

Drainage system

Present state
N/a can be replaced by owners, during retrofitting of building envelope

Design target
N/a can be replaced by owners, during retrofitting of building envelope

Monitoring and control

Present state

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 target

The temperature, humidity will be always monitored in each room. When air ventilation will be installed, the CO2 will be also monitored.
In case of central heating unit, the heat in each room will be measured to split the payload.

Energy sources

Present state

District heating

Design target

Central heating system.

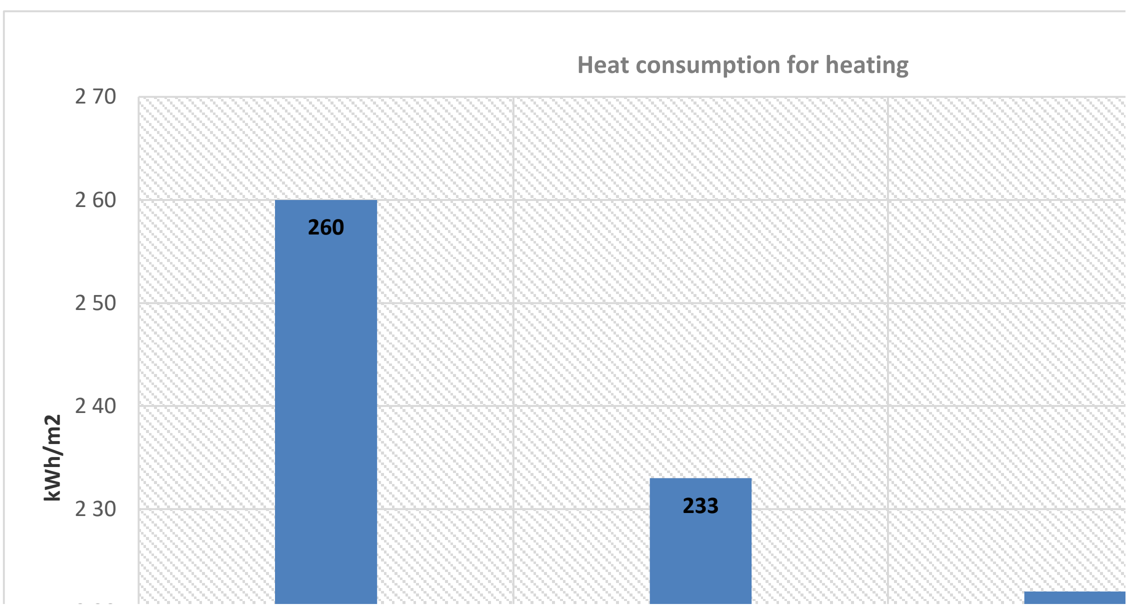
6.6 Building performance

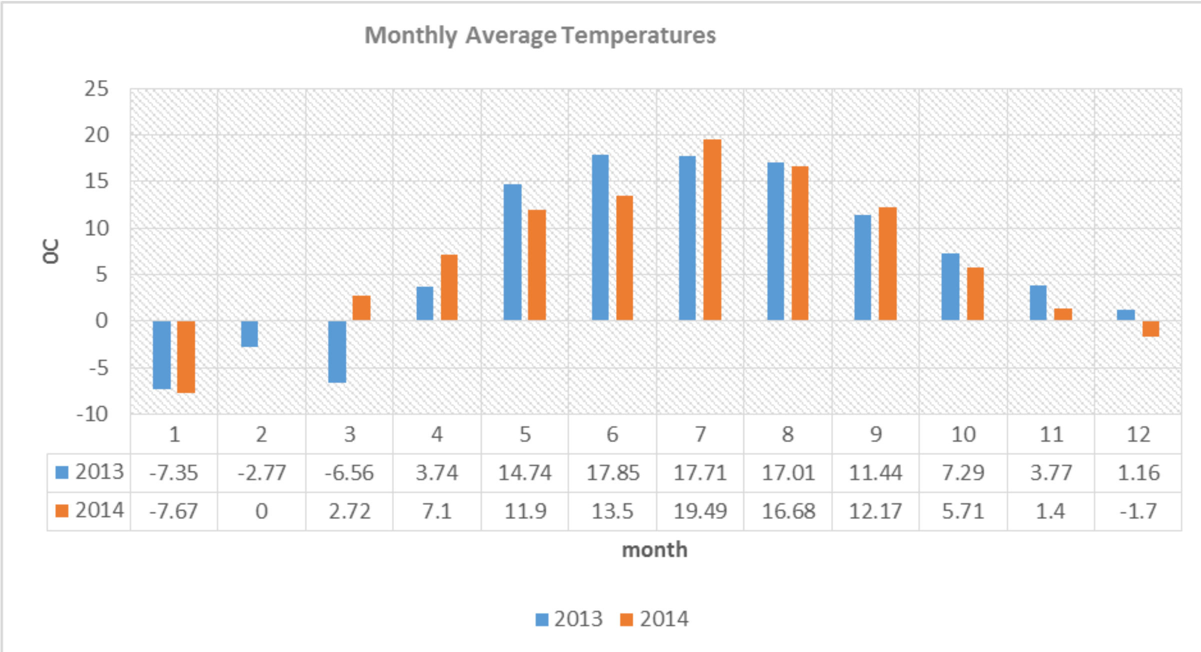
Energy performance

Present state

Assessment financial issues related to energy costs

Performance indicator	Unit	Performance
Energy label	(label)	B
Energy index	(-)	B
Total primary energy consumption	kWh/m2	31,5
Gas	(m3/year)	n/a
Add. (sustainable) energy, lighting, PV	(kWh/year)	n/a
CO2 emission	kg CO_2/m2	12
Energy cost, without VAT -gas -electricity	(€/month)	Separate data is not for individual and common electricity is not available
Usable floor area	(m2)	208
Energy cost index	(€/m2)	not used
Housing expenses -rent -mortgage	(€/month)	0





Design target
The design target is stated in the D2.1 deliverable, Table 4.7: Requirements on building envelope and ventilation to fulfil national nZEB requirements in each country.

Environmental impact

Present state
This to be précised after energy audits, which will analyzed data for last 5 years.

Acoustic

Present state
Not assessed. Possible problematic partition walls between the flats.

Design target
According to existing legislation

Noise from service systems LpA,eq,T ,dB(A) bedrooms living rooms LpA,max ,dB(A) bedrooms living rooms	 6:00- 22:00 40dB 22:00- 6:00 30dB (25dB)

The maximum noise in bedrooms and living rooms due to the functioning of the building service system is considered on Portuguese acoustic regulation base on the maximum acceptable noise from service systems,

$L_{Ar,nT}$. $L_{Ar,nT} = L_{A,eq} + K1 + K2$ (K1 = 3 if the noise has tonal characteristics and ; K2 = 3 dB if the noise has impulsive characteristics).
Moreover, the design will meet the requirements of a COST Action TU0901 “Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions” methodology for Class C classification at minimum.

Daylight

Present state
N/a

Design target
N/a

Air tightness

Present state
Existing air leakage rate of building envelope is measures as 6.5 $m^3/(m^2 \cdot h)(50Pa)$

Design target
The assumed total air leakage rate at 50 Pa will be less than 3.0 $m^3/(m^2 \cdot h)(50Pa)$

Moisture safety

Present state
N/a

Design target
N/a

7 Pilot The Netherlands

7.1 National housing statistics

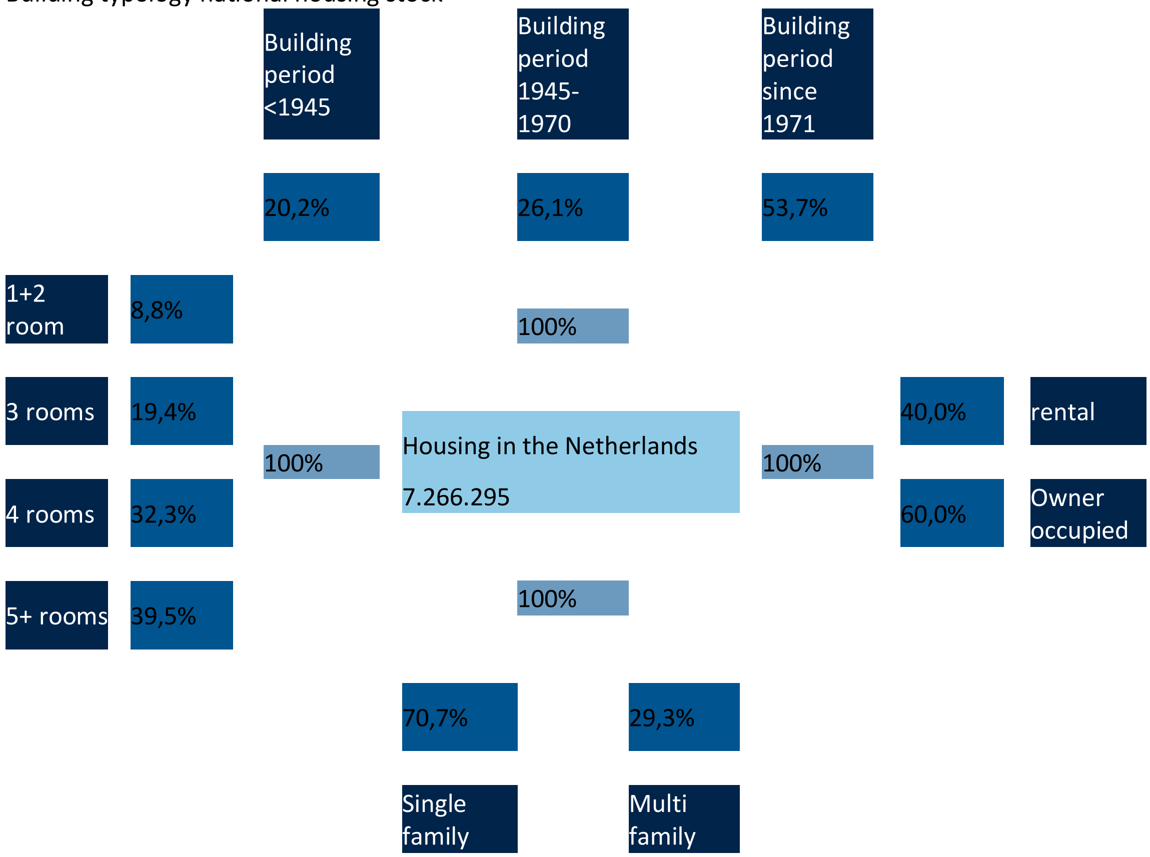
Overview statistics of the Dutch housing sector with respect to building typology indicators (http://episcope.eu/building-typology/)

Statistical Table	Item	Available	Reference
S-1	Frequency of building types of the national building stock	yes	[1]
S-2	Percentage of thermally refurbished envelope areas	yes	[2]
S-3	Information on insulation level and window types	no	
S-4	Centralization of the heat supply (for space heating)	yes	[2]
S-5	Heat distribution and storage of space heating systems	no	
S-6	Heat generation of space heating systems	yes	[2]
S-7	Heat distribution and storage of domestic hot water systems	no	
S-8	Heat generation of domestic hot water systems	yes	[2]
S-9	Solar thermal systems	no	
S-10	Ventilation systems	indication	[3]
S-11	Air-conditioning systems	no	
S-12	Control of central heating systems	no	
S-13	Domestic energy consumption	yes	[4]

[1] AgentschapNL, Voorbeeldwoningen 2011; bestaande bouw
[2] Housing Survey 2012, Energy module / Cijfers over Wonen en Bouwen 2013
[3] estimations based upon www.milieucentraal.nl/thema's/thema-1/energie-besparen/isoleren-en-besparen/ventilatie-noodzakelijk-voor-gezondheid/
[4] Sources: StatLine Statistics Netherlands (CBS) Feb. 7 2014

S-1 Frequency of building types of the national building stock

Building typology national housing stock



Overview Dutch housing stock (http://cowb.datawonen.nl/index.html)

(http://cowb.datawonen.nl/index.html)

Dutch housing stock	2006	2007	2008	2009	2010	2011	2012
	6.912.405	6.967.046	7.043.206	7.104.518	7.172.436	7.217.803	7.266.295

(http://cowb.datawonen.nl/index.html)

Building period [%]	<1945	1945-1959	1960-1970	1971-1980	1981-1990	1991-2000	>2001
	20,2	10,3	15,8	16,5	15,1	11,7	9,6

http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/woningbouw/particuliere-woningen/voorbeeldwoningen]
http://episcope.eu/building-typology/country/nl.html

Number of dwellings (x 1000) on 1-1-2012	Single family housing				Multi-family housing				
	De-tached house	Semi-detached house	Terraced house, mid-row	Terraced house, end-row	MFH with common staircase and galleries	MFH with common staircase, no galleries *	Maison-nette*	Other multi-familiy dwelling*	Total
Before 1946	441	285	337	186	69	256	226	99	2644
1946 to 1964			296	182		267			
1965 to 1974	119	142	375	231	174	112	22	125	1300
1975 to 1991	221	224	572	307	109	142	94	125	1794
1992 to 2005	178	173	241	112	113	70	40	136	1063
2006 to 2011	78	76	106	48	49	31	17	60	465
Total	1037	900	1927	1066	514	878	399	545	7266

* After 2005, the marked multi-family housing are considered as a single classification, nevertheless, the numbers of dwellings are given per building type.

Color scheme energy consumption (adjusted from Kadaster, 2013)

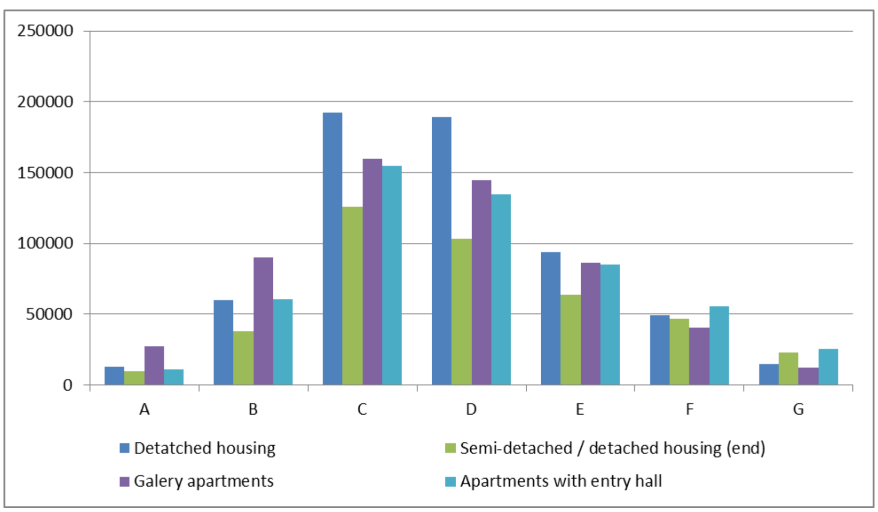
Energy label	Energy Index (EI) [MJ/m2]	Year of construction
A++	<0,50	2002>
A+	0,51-0,70	2000-2001
A	0,71-1,05	1998-1999
B	1,06-1,30	1998-1999
C	1,31-1,60	1992-1997
D	1,61-2,00	1984-1991
E	2,01-2,40	1979-1983
F	2,41-2,90	1977-1978
G	>2,90	<1976

On January 1st, 2013 2,168,687 dwellings, which equals 30% of the Dutch housing stock, are registered with an energy label (table 2).

Overview energy consumption labelling in the Dutch residential sector (adjusted from Kadaster, 2013)

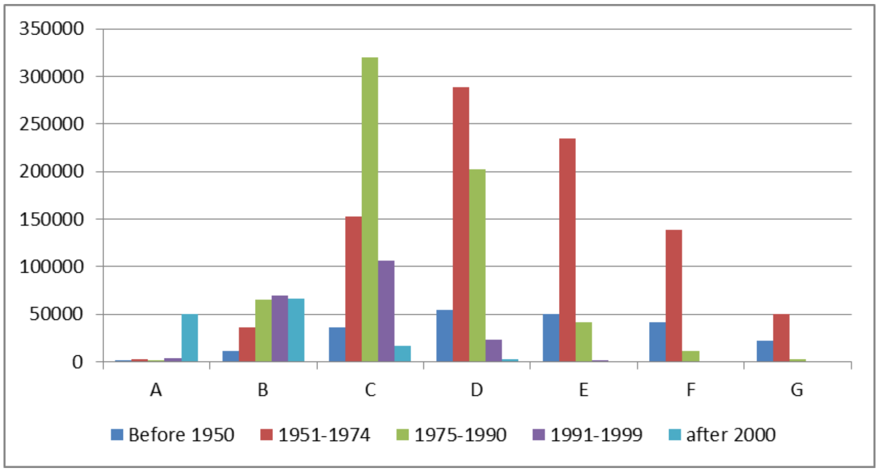
Typology	Total number of dwellings in the Dutch residential sector	Number of dwellings with an energy label	Percentage of dwellings with in the Dutch residential sector with a energy label
Apartments	1,946,055	787,572	40%
Terraced housing	2,444,436	769,850	31%
Terraced housing (end)	1,031,139	336,282	33%
Unknown	183,286	153,683	84%
Semi-detached housing	737,968	89,005	12%
Detached housing	907,916	32,295	4%
TOTAL	7,250,800	2,168,687	30%

About 1,8 million of the dwellings (83%) with an energy label are owned by housing associations with an average energy index of 1,80 which equals label D. The housing stock of Dutch social housing associations predominately consist of terraced housing and apartments. Figure 7 presents an overview of these dwellings with respect to the assigned energy label. In addition, figure 8 presents an overview of the same type of housing with respect to the year of construction. From this it can be learned that over 1,8 million dwellings with an energy label need to be upgraded to at least label B. This particularly involves dwellings constructed prior to the energy crisis of the seventies, i.e. dwellings constructed before 1975. However, upgrading these dwelling is both technological as well as financially challenging because they are poorly insulated and thus require drastic improvement (http://senternovem.databank.nl/1; Kadaster, 2013).



[1] Since January 1st, 2014 Senternovem/Agenschap NL turned into '*Rijksdienst voor Ondernemend Nederland (www.RVO.nl)*'

Energy labels classified according four housing typologies in the Dutch residential sector (adjusted from Senternovem, 2012).



Energy labels of four housing typologies classified according year of construction. Dwellings constructed before 1975; 1991; 2000 are predominately labelled as respectively D-E; C-D; B-D. The peak among label A dwellings are the result of stricter building codes introduces in 2000, 2006 and 2012 respectively (energy performance indicator) (adjusted from Senternovem, 2012).

S-2 Percentage of thermally refurbished envelope areas

Percentage of Thermally Refurbished Envelope Area
http://episcope.eu/building-typology/country/nl.html

Percentage of dwellings in 2012	Total
ground floor	56 %
wall	70 %
roof	79 %
glazing	86 %

Source: Housing Survey 2012, Energy module / Cijfers over Wonen en Bouwen 2013, p. 136

S-4 and S-6 Centralization of the heat supply and heat generation of space heating systems

Percentage of Types of Heat Supply
http://episcope.eu/building-typology/country/nl.html

Percentage of dwellings in 2012	Total
individual local heating	3 %
individual central heating: - non-condensing boiler - condensing boiler	 13 % 72 %
district heating	7 %
other (delivery of warmth by third parties)	4 %

Source: Housing Survey 2012, Energy module / Cijfers over Wonen en Bouwen 2013, p. 137-138

S-8 Heat generation of domestic hot water systems

Heat Generation of Domestic Hot Water Systems
http://episcope.eu/building-typology/country/nl.html

Percentage of dwellings in 2012	Total
kitchen geyser	5 %
bath geyser	3 %
gas boiler	1 %
electric boiler	4 %
common boiler for heating and dhw	80 %
solar boiler	0 %
individual heat pump	1 %
collective facility	3 %
other (delivery of warmth by third parties)	4 %

Source: Housing Survey 2012, Energy module / Cijfers over Wonen en Bouwen 2013, p. 139

S-10 Ventilation systems

Ventilation Systems
http://episcope.eu/building-typology/country/nl.html

Percentage of dwellings in 2012	Total
natural ventilation	± 67 %
exhaust air ventilation	± 30 %
balanced ventilation	± 3 %

Source (notes: numbers are derived by estimation)
www.milieucentraal.nl/thema's/thema-1/energie-besparen/isoleren-en-besparen/ventilatie-noodzakelijk-voor-gezondheid/

S-13 Domestic energy consumption

Domestic energy consumption
http://episcope.eu/building-typology/country/nl.html

Energy consumption sector private households; energy commodities		1995	2000	2005	2010	2011	2012
Total (PJ)		454,94	432,35	424,61	478,84	404,72	429,25
	Primary coal (PJ)	0,23	0,20	0,2	0,23	0,16	0,2
	Petroleum products (PJ)	6,17	3,65	3,79	4,37	3,08	3,68
	Lpg (PJ)	1,42	0,94	1	1,15	0,82	0,97
	Other kerosene (PJ)	0,69	0,56	0,58	0,67	0,45	0,56
	Gas/diesel oil (PJ)	4,06	2,15	2,21	2,55	1,81	2,15
	Natural gas (PJ)	360,81	333,59	314,92	361,76	294,35	312,54
	Electricity (PJ)	70,92	78,48	87,12	88,76	85,06	89,46
	Heat (PJ)	6,89	6,07	7,81	11,36	9,64	10,5
Space Heating		295,68	275,31	261,85	299,10	245,30	260,33
	Gas	285,04	263,54	248,79	285,79	232,54	246,91
	Electricity (including domestic hot water)	10,64	11,77	13,07	13,31	12,76	13,42
Domestic Hot Water		68,55	63,38	59,83	68,73	55,93	59,38
	Gas	68,55	63,38	59,83	68,73	55,93	59,38
	Electricity (included in space heating)	-	-	-	-	-	-
Other Applications		37,00	39,63	42,89	44,51	41,61	43,82
	Gas for cooling	7,22	6,67	6,30	7,24	5,89	6,25
	Electricity for cooling	12,06	13,34	14,81	15,09	14,46	15,21
	Electricity for cooking	3,55	3,92	4,36	4,44	4,25	4,47
	Electricity for ICT	10,64	11,77	13,07	13,31	12,76	13,42
	Electricity Other	3,55	3,92	4,36	4,44	4,25	4,47
	Lighting (Electricity)	11,35	12,56	13,94	14,20	13,61	14,31

Derived from: http://www.government.nl/issues/energy/energy-and-the-economy
StatLine Statistics Netherlands (CBS) Feb. 7 2014

7.2 Overall pilot Building information

MORE-CONNECT responsible partner

WEBO, Willem Haase, whaase@webo.nl
BJW, Jan Kamphuis, jankamphuis@bjwwonen.nl

MORE-CONNECT industrial partner

WEBO, Willem Haase, whaase@webo.nl
BJW, Jan Kamphuis, jankamphuis@bjwwonen.nl

Building's name

Terraced dwelling Zoetermeer

Location

Zoetermeer, the Netherlands

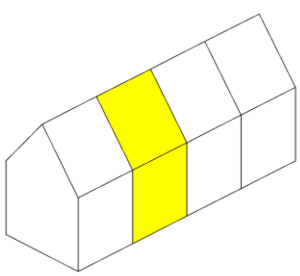
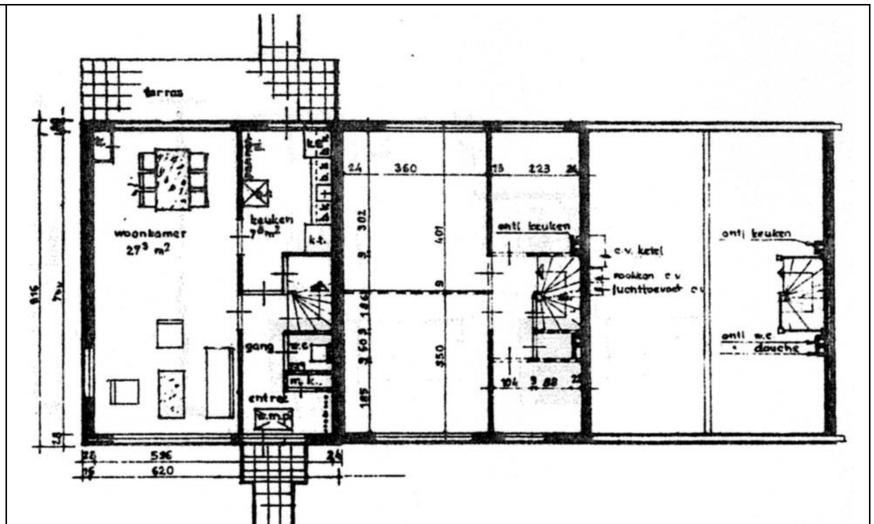
Building typology

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.

Typical problems

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. Possible overheating during winter season, insufficient thermal comfort.

7.3 Architectural design

Typology reference building: Terraced house, block-by-block. NL – Zoetermeer, occupied by a family (3) 	
Construction period	1965 to 1974
Statistics	375.000
Year of construction reference building	1973

Previous nZEB investments	Single glazing replaced by double glazing; improved heating system
Number of housing units	1
Number of floors	3
Usable floor space (per unit)	+/- 140 m2
General description reference building	The row houses that were built in the period 1965-1974, represented by 606,000 dwellings (9%). Almost half (47%) of these dwellings are owned by a private homeowners. An equal portion is owned by social housing associations and about 6% is rented in the private sector. The homes included in this category often have four to 5 rooms spread over three floors. The reference dwellings involves a mid-row dwelling in the city of Zoetermeer and is still occupied. Characteristic for this dwelling is the panelized façade of the dwelling. Across 3 floors, the lay-out includes a living room, kitchen, two private rooms, single bathroom and there are two bedrooms. Characteristic of this building period is that several housing systems have been developed. This is especially evident in the floor structures, which are made of concrete, and panelized façade structures with sandwich panels. Both systems can be found in the reference dwelling. Since 1965, the building code provide energy performance requirements. Nevertheless, the homes were to current construction standards, not very well insulated. Double glazing was hardly used. Many homes were at that time both local gas heaters, where central heating was on the rise. A portion of this housing is energetically in the course of the years improved. Almost all houses have central heating. The high efficiency-combi boiler is most common used. Besides combi boilers, especially kitchen geysers are used for the preparation of (locally at the kitchen for example) domestic hot water supply. With respect to improving energy efficiency, the emphasis is on placing double glazing. However, insulation of the 'closed' wall sections lag behind. It is expected that 35% of the closed wall; 8% of the floor area of 8%; 17% of the inclined roof and 26% of the flat roof have been insulated. The major part of the housing is provided with natural ventilation (82%). The remaining part has mechanical extraction. Some of the homes features air tightness measures (35%).

The aesthetic and monumental value of a property could hinder renovation according the More-Connect principle (placing a prefabricated façade and or roof). Therefore the aesthetic and historic/monumental characteristics of the property need to be assessed. In the Netherlands for example about 62,000 national monuments can be found. These buildings and other objects are valued for its national cultural-historical importance and designated as protected monument. Also local governments could designate objects to be monumental. Moreover other considerations not to change the building envelope include the aesthetic appearance or architectural design of the property. In many countries a building permit is mandatory to replace the facade of a property which often includes an aesthetic assessment of the design.

Historical (monumental) characteristics of the property: which historical / monumental characteristics need to be taken into account when considering nZEB retrofitting?	None
Aesthetic characteristics of the property: which aesthetic characteristics need to be taken into account when considering nZEB retrofitting?	None

Site plan

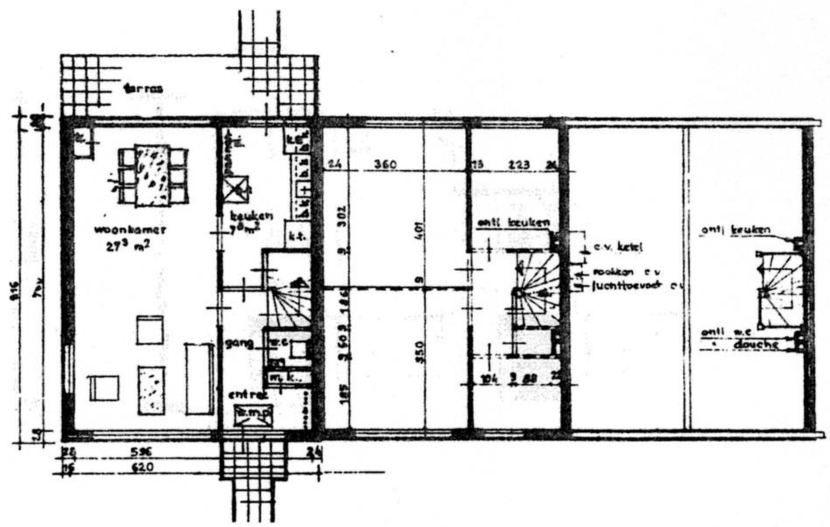
A drawing will be provided later.

Views

A drawing/picture will be provided later.

Floor plans

Present state



A more accurate drawing will be provided later.

Design target
No significant changes assumed in typical floor plan.

Cross section

Present state
A drawing will be provided later.

Design target
Minimum loss of floor space.

Façade and roof design

Present state
A drawing/picture will be provided later.

Design target
To be developed, depends on the architectural design of the new product.

Complementary façade elements

Present state
None.

Design target
To be developed, depends on the architectural design of the new product.

7.4 Structural design

Building's load-bearing scheme

The constructional system present lateral masonry bearing walls (separation walls in between dwellings within housing block (see floor plan, section 3.3.1).

Foundations

Present state
Reinforced concrete pile foundation with monolithic reinforced concrete slabs, U = ??? W.m-2.K-1. The ground floor near the entry and kitchen consists of a concrete ground floor – direct bearing (no/minimum insulation). A wooden ground floor including crawl space can be found at the living (no/minimum insulation).

Design target
To be determined.

Vertical structures

Present state
The separation walls consist of a massive, poured structure (load bearing). The building façade consists of a cavity wall; piled – masonry – outer layer; no/minimum insulation; NOT structural. Integration facade with load bearing structure (thermal bridges): there is an opportunity to remove outer skin. HVAC system integration with building façade: The pipes of the installation run through the facade. U = ??? W.m-2.K-1.

Design target
The interior elements without planned changes, external walls supplemented by M-C modules, the parapet area possibly removed for system connections etc. U ≤ 0,21 W.m-2.K-1, will be defined later.

Horizontal structures, floor slabs

Present state
Massive, poured concrete floor structure – two-sided support by separation walls. Load bearing capacity building structure: tension test required to assess structural connection retrofit element – building.

Design target
None.

Openings

Present state
(Original) wooden window frames, Uw = 2,90 W.m-2.K-1 and Ud = 2,90 W.m-2.K-1.

Design target
Assumed g-value of 0,67; Uw = 1,0 W.m-2.K-1 and Ud = 1,0 W.m-2.K-1.

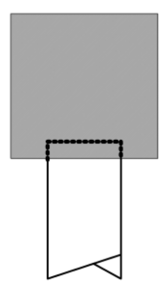
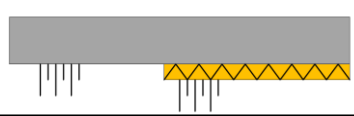
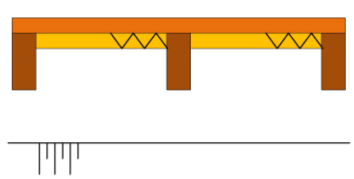
Roofing

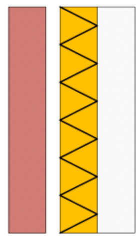
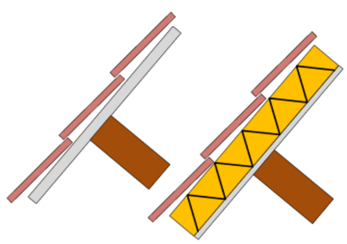
Present state
Pitched roof; purlins; tiles on roof boarding; no/minimum insulation. The roof slope between 40-50°. U = ??? W.m-2.K-1.

Design target
Target value U ≤ 0,15 W.m-2.K-1, will be defined later.

Overview structural characteristics of reference building

Structural characteristics of reference building

Element	Morphological representation	Description
(A) Foundation		Reinforced concrete foundation – pile foundation
(B1) Ground floor entry and kitchen		Concrete ground floor – direct bearing at the entry and kitchen (no/minimum insulation)
(B2) Ground floor living		Wooden ground floor including crawl space at the living (no/minimum insulation)

(C) Separation and load bearing wall structures		The separation walls consist of a massive, poured structure (load bearing.
(D) Facade		Cavity wall; piled – masonry – outer layer; no/minimum insulation; NOT structural. Integration facade with load bearing structure (thermal bridges): there is an opportunity to remove outer skin. HVAC system integration with building façade: The pipes of the installation run through the facade.
(E) (Second/third/..) floors		Massive, poured concrete floor structure – two-sided support. Load bearing capacity building structure: tension test required to assess structural connection retrofit element – building.
(F) Balcony / loggia / gallery	N/a	N/a
Roof / top floor		Pitched roof; purlins; tiles on roof boarding; no/minimum insulation

7.5 Building technical systems

Heating

Present state
Need to be included here.

Design target
Need to be included here.

Cooling

Present state
Cooling system is not present. Overheating of the house was not observed.

Design target
Cooling system is not necessary to install. Thermal capacity of the building is high, so the building can absorb most of heat gains. Solar heat gains reduction by shading and increased ventilation will be used.

Ventilation

Present state
The common areas in the house are ventilated naturally. Most frequently, air ventilation is present (suction boxes included in windows) and air abducting from the toilets and bathrooms.

Design target
New ventilation system is necessary to install because new air-tight building envelope can cause unwanted water condensation inside of the building and low air quality. Pipes can be integrated in façade elements; current outlet pipes can be used in new system or removed. Assumed position of ventilation unit with heat exchanger is in the loft. Fire protection and acoustics must be taken account.

Electrical wiring

Present state
Expected to be of sufficient quality.

Design target
No design target with respect to electrical wiring.

Water piping

Present state
Expected to be of sufficient quality.

Design target
No design target with respect to water piping.

Drainage system

Present state
Expected to be of sufficient quality

Design target
No design target in sewage system.

Monitoring and control

Present state
Need to be included here.

Design target
Need to be included here.

Energy sources

Present state
There are individual gas boilers for space heating and production of domestic hot water. The electricity is provided by standard power grid.

Design target
Need to be included here.

7.6 Building performance

Energy performance

Present state

Assessment financial issues related to energy costs.

Performance indicator	Unit	Performance
Energy label	(label)	E
Energy index	(-)	2,08
Total primary energy consumption	(MJ)	91.097
Gas	(m3/year)	2.030
Add. (sustainable) energy, lighting, PV	(kWh/year)	924
CO2 emission	(kg/year)	4.136
Energy cost, without VAT	(€)	1.416
Usable floor area	(m2)	140
Energy cost index	(€/m2)	10,11
Rc façade	(m2 K/W)	0,43
Rc Roof	(m2 K/W)	0,86
Rc ground floor	(m2 K/W)	0,17
U-Window	(W/M2 K)	2,90
U-Entry	(W/M2 K)	2,9
Orientation towards sun (front building)	(orientation)	North

Agentschap NL, Voorbeeldwoningen 2011, Bestaande bouw, 2011

Design target

The design target is stated in the D2.1 deliverable, Table 4.7: Requirements on building envelope and ventilation to fulfil national nZEB requirements in each country.

Ventilation	
Heat/cool recovery, %	Need yet to be determined
Ventilation airflow, l/(s·m2)	Need yet to be determined
Renovated case represents indoor climate category II	Need yet to be determined
Specific fan power, W/(l/s)	Need yet to be determined
Heating syst. with its efficiency	
Renewable energy sources	
Solar collectors for DHW, m2	Need yet to be determined
Solar panels for electricity, m2	Need yet to be determined
Coefficient of Performance of heat pump if it is used	Need yet to be determined
Indoor temperature	
During heating period	Need yet to be determined
During cooling period	Need yet to be detemined

Environmental impact

Present state

Need to be included here.

Design target

Need yet to be determined

Acoustic

Present state

Not assessed. Possible problematic partition walls between the dwellings.

Design target

According (Dutch) national standard.

Daylight

Present state

No problems reported. To be determined later.

Design target

The daylight level will not be influenced by the refurbishment, the similar of better daylighting will be assured during the construction process.

Air tightness

Present state

Need to be included here.

Design target
Need yet to be determined

Moisture safety

Present state
Need to be included here.

Design target
Need yet to be determined

8 CASE STUDY: PORTUGAL

8.1 National housing statistics

Overview statistics of the Portugese housing sector with respect to building typology indicators

Statistical Table	Item	Available	Reference
S-1	Frequency of building types of the national building stock	Yes	[1] [2] [3]
S-2	Percentage of thermally refurbished envelope areas	No	-
S-3	Information on insulation level and window types	Yes	[2]
S-4	Centralization of the heat supply (for space heating)	No	-
S-5	Heat distribution and storage of space heating systems	No	-
S-6	Heat generation of space heating systems	Yes	[1] [2]
S-7	Heat distribution and storage of domestic hot water systems	No	-
S-8	Heat generation of domestic hot water systems	Yes	[2]
S-9	Solar thermal systems	Yes	[2]
S-10	Ventilation systems	No	-
S-11	Air-conditioning systems	Yes	[1] [2]
S-12	Control of central heating systems	No	-
S-13	Domestic energy consumption	Yes	[2]

[1] Censos 2011, Final results. Statistics Portugal
[2] Survey on Energy Consumption in Households 2010 (2011). Statistics Portugal and DGEG.
[3] Energy Label Statistics (2012). ADENE. Available from: http://www2.adene.pt/pt-pt/SubPortais/SCE/EdificiosCertificados/Paginas/default.aspx

S-1 Frequency of building types of the national building stock

Building typology national housing stock; number of buildings by typology:

Number of buildings	Single family housing			Multi-family housing		Non classic family housing	Total
	Detached House	Semi-Detached House	Terraced House	Multi-family housing	Other multi-family dwelling		
	1 202 897	340 226	401 913	1 467 685	21 396	110272	3 544 389

Number of buildings by year of construction:

Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2011	Total
206 343	305 696	387 340	408 831	588 858	578 845	558 471	510 005	3 544 389

Until 2012, only 10% of the building stock had been certified. Energy efficiency label statistics:

Energy label	Existing Buildings
A++	
A+	3,3%
A	12,9%
B	21,6%
B-	15,1%
C	23,6%
D	10,7%
E	6,1%
F	1,9%
G	4,8%
Representativity	10%

Label according to energy performance in Portugal:

Energy label	Energy Index (EI) [MJ/m2]
A++	<0,50
A+	<0,50
A	0,50-0,25
B	0,75-0,50
B-	1,00-0,75
C	1,50-1,00
D	2,00-1,50
E	2,50-2,00
F	3,00-2,50
G	>3,00

S-3 Information on insulation level and window types

Insulation level of the building elements by construction period:

Building characteristics				
Construction period	Before 1960	1960-1990	1990-2013	After 2013[2]
U façade (W/m2.K)	2.00	1.76	0.92	I1-0.40 I2-0.35 I3-0.30
U roof (W/m2.K)	2.80	2.80	0.94	I1-0.35 I2-0.30 I3-0.25
U ground floor (W/m2.K)	2.10	2.10	0.78	I1-0.35 I2-0.30 I3-0.25
U-window (W/m2.K)	4.40	4.30	3.30	I1-2.80 I2-2.40 I3-2.20

[2] Depends on the climatic zone (I1, I2 or I3). The pilot building is located in I2 V2.

Only 21.1% of households have insulation in exterior walls.
Among single family houses and multi-family houses located on the top floor, only 17% have roof insulation.
More than 70% of households have single glazed windows.

S-6 Heat generation of space heating systems

Regarding heat generation sources: 45.9% of dwellings use electricity, 29.3% use solid fuels (e.g. wood, coal), 7.4% use natural gas and 3.2% use liquid fuels and 0.2% use other sources (e.g. solar, geothermal, etc). 14% of dwellings do not have space heating system available.

Type of equipment	% of dwellings that used the equipment (2010)
Open fireplace	24
Fireplace with heat recovery	11,1
Salamander (wood)	7,2
Boiler	10,5
Individual electric heater	61,2
Individual GPL heater	7,1
Heat pump	7,3

Note: District heating is only available in Portugal in a neighborhood in Lisbon. It was an isolated experience installed 15 years ago that it is still in full operation. Nevertheless, it is not significant for the statistics of the building stock. Website: http://www.climaespaco.pt/index.html

S-8 Heat generation of domestic hot water systems

Statistics/information about heat generation of domestic hot water systems:

Percentage of dwellings	Total
Gas heater	78.6 %
Electric heater	11.2 %
Boiler3	11.9 %
Solar thermal energy	1.8 %

S-9 Solar thermal systems

In 2010, only 2% of dwellings used solar thermal energy. The average size of installed panels by dwelling was 3.8 m2. However, it is important to point out that this percentage will increase gradually due to the European Directive on the Energy Performance of Buildings which compels new buildings and major renovations to install solar thermal systems (since 2006).

S-11 Air-conditioning systems

In 2010, the majority of dwellings did not have an air-conditioning system. Only 7.2% of dwellings (mostly recent buildings located on the South of Portugal) presented this type of equipment. The majority of dwellings (69.5%) use a fan for cooling and 26% use heat pumps.

[3] 56.8% of dwellings use them as common boilers for heating and DHW

S-13 Domestic energy consumption

Statistics/information about domestic energy consumption in 2010:

Energy consumption sector private households; energy commodities		2010
Total (tep[4])		2 916 026
	Primary coal	6 404
	LPG - piped	70 625
	LPG – Butane canister	396 115
	LPG – Propane canister	87 738
	Diesel oil	124 636
	Natural gas	263 507
	Electricity	1 242 021
	Wood	705 875
	Solar thermal	19 105
Space Heating (tep)		533 892
	Primary coal	192
	LPG - piped	2 899
	LPG – Butane canister	10 085
	LPG – Propane canister	318
	Diesel oil	75 445
	Natural gas	8 231
	Wood	360 828
	Solar thermal	1 546
	Electricity (including domestic hot water)	93 987
Domestic Hot Water (tep)		583 040
	LPG - piped	43 396
	LPG – Butane canister	201 173
	LPG – Propane canister	48 284
	Diesel oil	49 191
	Natural gas	162 782
	Wood	41 016
	Solar thermal	17 559
	Electricity (included in space heating)	19 639
Other Applications (tep)		1 366 043
	Electricity for cooling	13 107
	Electricity for cooking	332 557
	Wood for cooking	292 347
	LPG - piped for cooking	24 330
	LPG – Butane canister for cooking	184 857
	LPG – Propane canister for cooking	39 136
	Natural gas for cooking	92 494
	Primary coal for cooking	6 212
	Electricity for electrical equipment	269 694
	Lighting (Electricity)	111 309

[4] 1 tep = 41,868 GJ (except for electricity in which 1 tep = 41,86047 GJ)

8.2 Overall pilot Building information

MORE-CONNECT responsible partner

UMinho, PT, Manuela Almeida, malmeida@civil.uminho.pt

MORE-CONNECT industrial partner

Dark Globe, PT

Building's name

Edifício Professor Doutor Mota Pinto.

Location

Rua do Bom Samaritano, Pedroso, Vila Nova de Gaia, Portugal

Building typology

The Portuguese pilot building is a social housing multifamily building constructed in 1997. It has three floors and 18 apartments: nine two-bedroom dwellings (T2) and nine three-bedroom dwellings (T3). The building has simple, rectangular floor plan with an underground basement for parking. There are three entrances, each one giving access to 6 apartments, one T2 and one T3 per floor. In each entrance, there is a corridor and a hall on the first floor that connects to a staircase with a fire door on each floor. The building implantation area is 600 m2. The building has a pitched roof with ceramic tiles, double pane masonry walls without thermal insulation and aluminium frames with double glazing.

Typical problems

The low level of thermal insulation of the envelop leads to thermal discomfort, condensation and mould growth and low energy efficiency. Additionally there are also some acoustic problems.

8.3 Architectural design

The aesthetic and monumental value of a property could hinder renovation according the More-Connect principle (placing a prefabricated façade and or roof). Therefore the aesthetic and historic/monumental characteristics of the property need to be assessed. In the Netherlands for example about 62,000 national monuments can be found. These buildings and other objects are valued for its national cultural-historical importance and designated as protected monument. Also local governments could designate objects to be monumental. Moreover other considerations not to change the building envelope include the aesthetic appearance or architectural design of the property. In many countries a building permit is mandatory to replace the facade of a property which often includes an aesthetic assessment of the design.

Historical (monumental) characteristics of the property: which historical / monumental characteristics need to be taken into account when considering nZEB retrofitting?	None
Aesthetic characteristics of the property: which aesthetic characteristics need to be taken into account when considering nZEB retrofitting?	None

Site plan

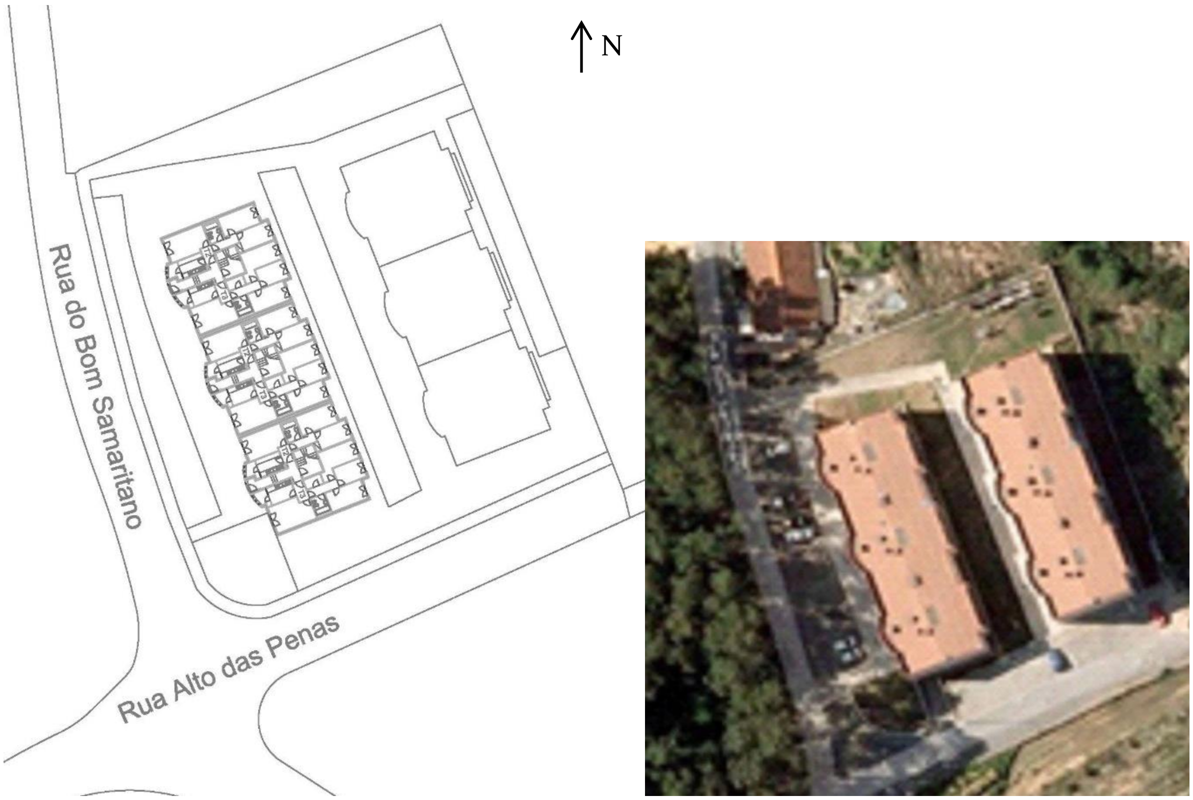


Figure 8.1: Site plan pilot building

Views

Figure 8.2: Views pilot building

Floor plans

Present state

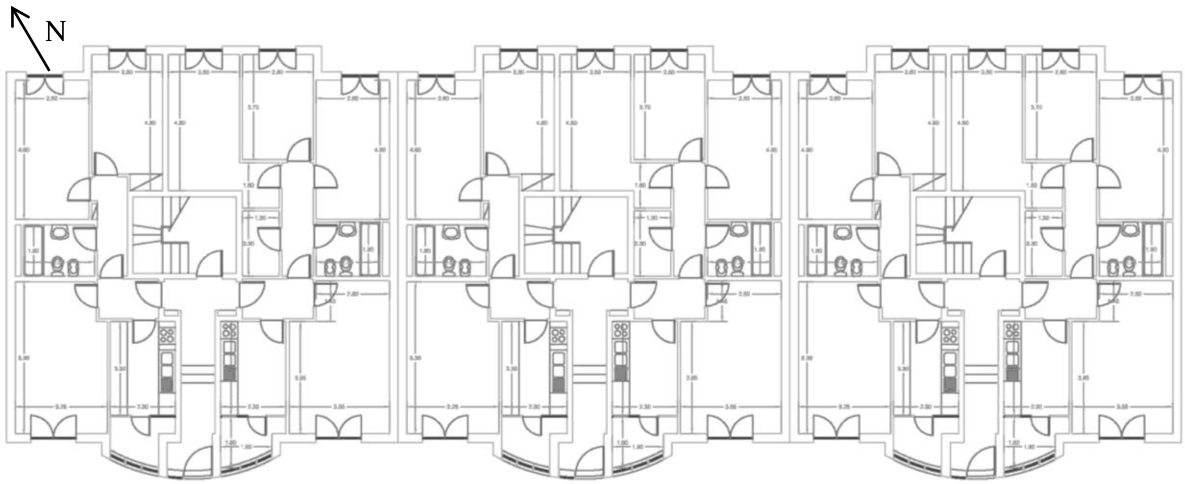


Figure 8.3a: First floor plan pilot building

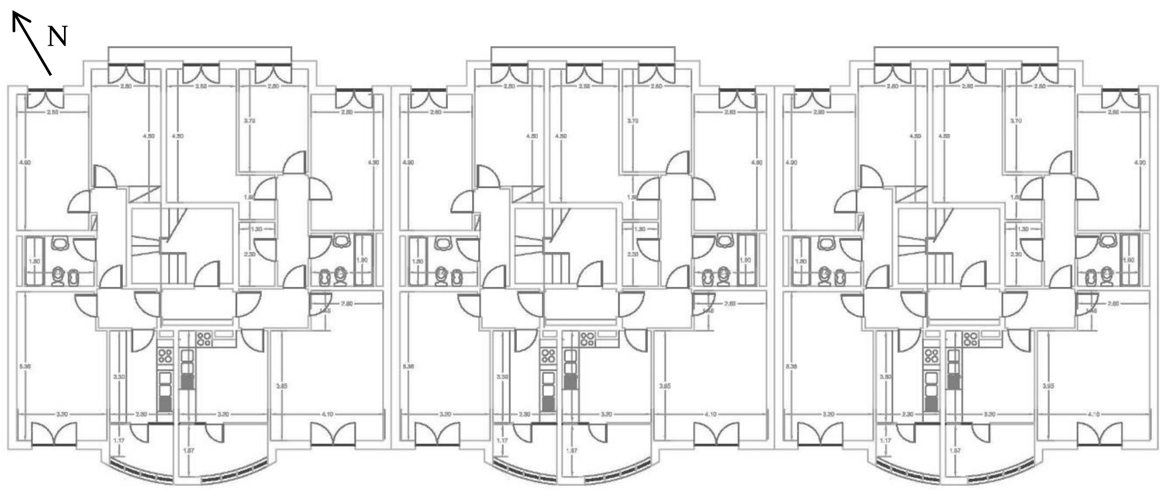


Figure 8.3b: Second and third floor plan pilot building

Design target

No significant changes assumed in typical floor plan. If necessary a drawing will be provided later.

Cross section

Present state

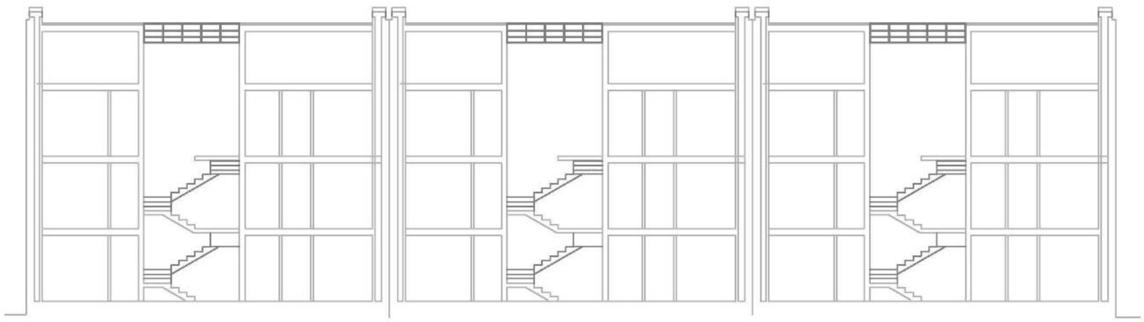


Figure 8.4a: Longitudinal section view pilot building

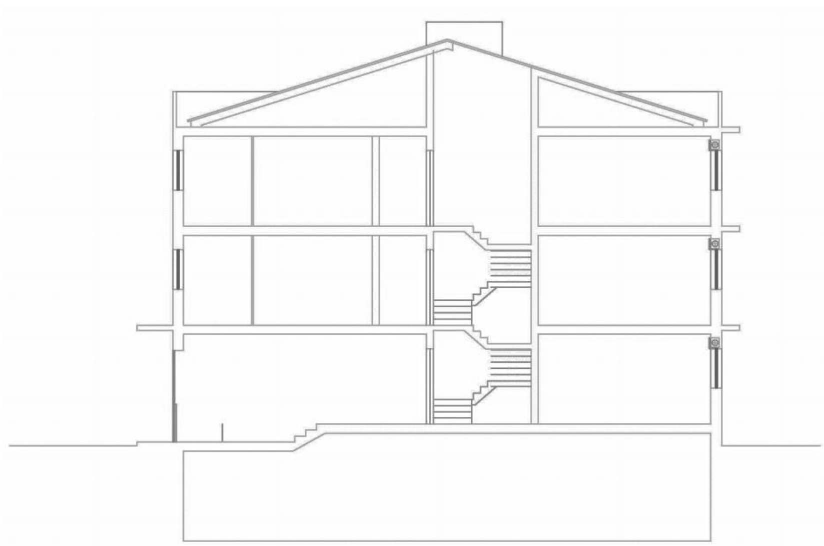


Figure 8.4b: Transversal section view pilot building

Design target

No significant changes assumed in typical floor plan. If necessary a drawing will be provided later.

Façade and roof design

Present state

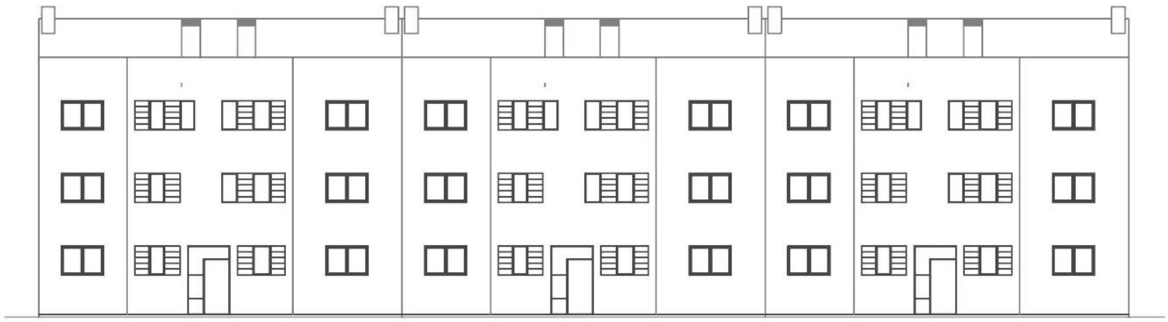


Figure 8.5a: Front view pilot building

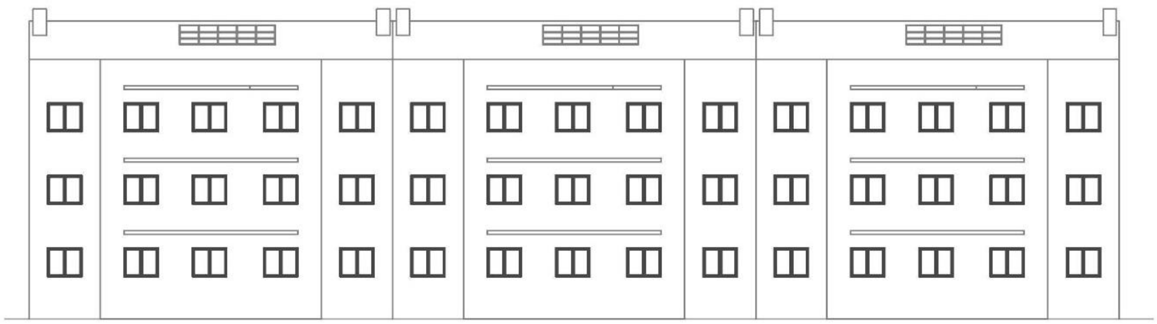


Figure 8.5b: Rear view pilot building

Design target
To be developed, depends on the architectural design of the new product.

Complementary façade elements

Present state
The entrance and laundry wall (south-east façade) have a round shape.

Design target
To be developed, depends on the architectural design of the new product.

8.4 Structural design

Building's load-bearing scheme

This building is composed by a pillars and beam structure with hollow brick masonry walls and beam and pot slabs.

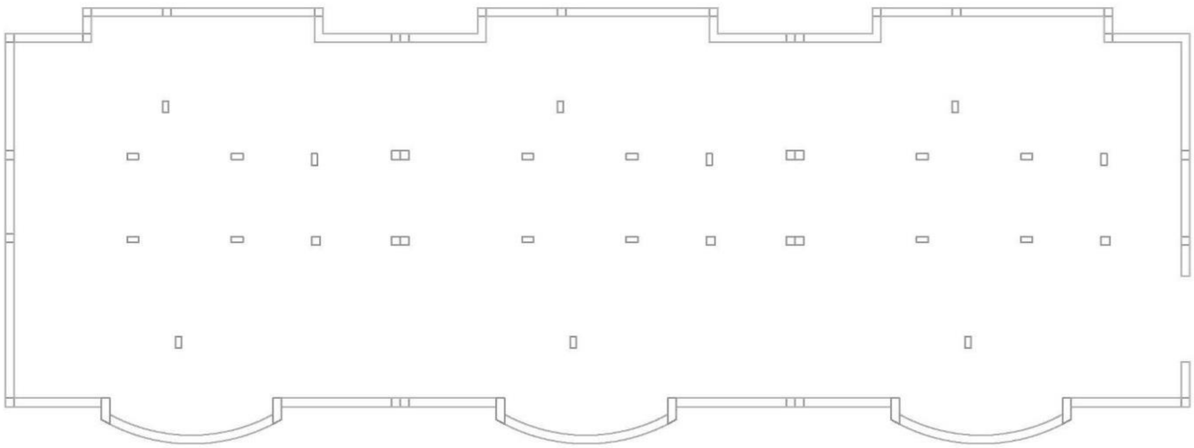


Figure 8.6: Load bearing scheme pilot building

Foundations

Present state
Foundations with overspans in connection with the pillars.

Design target
No significant changes planned.

Vertical structures

Present state
The pillars have a 30 cm by 20 cm section.

Design target
The interior elements without planned changes, external walls supplemented by M-C modules defined later.

Horizontal structures, floor slabs

Present state
Beam and pot slabs, 30 cm. U = 0.78 W/(m2·K)

Design target
The insulation level of the first floor slab, above the common garage (basement), will be improved. The insulation level of the last slab (roof) will be increased. Target: U $\leq$ 0.30 W/(m2·K).

Openings

Present state
Original windows with aluminium frames and double glazing, with roller shutters. U = 3.10 W/(m2·K).

Design target
Improved thermal behaviour of the windows (frames with thermal cut), roller shutters and roller shutter box.
Target: U ≤ 2.40 W/(m2·K).

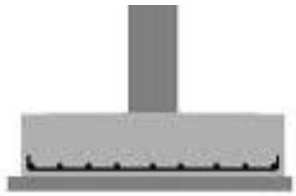
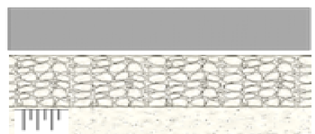
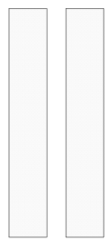
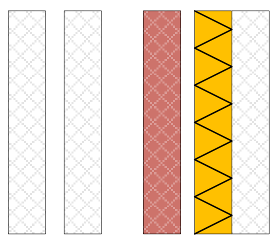
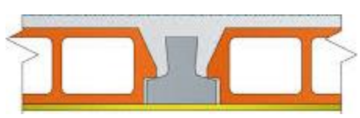
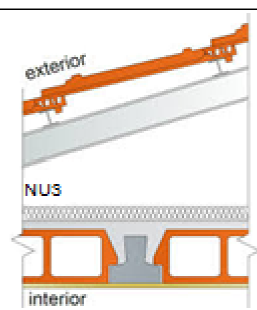
Roofing

Present state
Reinforced concrete truss frame with ceramic tiles. Skylights over the staircases, with double glass and aluminium frame. The ceiling is insulated with 2 cm of mineral wool. The insulating level is not sufficient. The roof slope is 33°.
U = 0.94 W/(m2·K).

Design target
Improvement of the ceiling thermal insulation level. Target value U ≤ 0.32 W.m-2.K-1, will be defined later.
Overview structural characteristics of reference building

Overview structural characteristics of reference building

Structural characteristics of reference building

Element	Morphological representation	Description
(A) Foundation		Reinforced concrete foundation overspan – direct bearing foundation in connection with the pillars
(B) Ground floor		Concrete ground floor – direct bearing (without insulation (does not contact a useful area
(C) Separation and load bearing wall structures		Walls separating flats: double pane hollow brick wall (11 cm + 11cm) Partition walls: single pane hollow brick walls (11 cm)
(D) Facade		Double pane hollow brick wall without insulation (15 cm + 11 cm) (U = 0.92 W/m2.ºC)
(E) (Second/third/..) floors		Beam and pot slabs with 30 cm (U = 0.78 W/m2.ºC)
(F) Balcony / loggia / gallery	-	-
Roof / top floor		Beam and pot slabs with 30 cm and 2 cm of mineral wool, attic (non useful space) and pitched roof with concrete truss and ceramic tiles. (U = 0.94 W/m2.ºC)

8.5 Building technical systems

Heating

Present state
The buildings does not have heating systems. The flats have electric radiators.
Heating needs ≤ 33.9 kWh/(m2·a)

Design target
To be defined later. Target: Heating needs ≤ 16.1 kWh/(m2·a)

Cooling

Present state
Cooling system is not present. Overheating of the flats only occurs for short periods when the night temperature is higher than 25ºC.

Design target
Cooling system: probably it is not necessary to install one. Thermal capacity of the building is high so the building can absorb most of heat gains. The building has shading systems and it is common to use night ventilation.

Ventilation

Present state
The common areas in the flats are ventilated naturally. There are extractors in the kitchen and ventilators in toilets and bathrooms.

Design target
To be defined later. It will probably be necessary to install new ventilation systems because new air-tight building envelope can cause low air quality. Pipes can be integrated in façade elements. Fire protection and acoustics must be taken account.

Electrical wiring

Present state
In these type of buildings were usually used copper wires. Existing system should be ok.

Design target
No replacement of current wires is foreseen.

Water piping

Present state
There are installation shafts in the middle of the buildings floor plane near the kitchen and bathroom area. Water pipes are plastic, without insulation.

Design target
No replacement foreseen. Connection of current water supply system to solar thermal system and new backup heat source might be necessary.

Drainage system

Present state
There are installation shafts in the middle of the buildings floor plane near the kitchen and bathroom area. No other information yet available.

Design target
No design target in sewage system.

Monitoring and control

Present state
None.

Design target
The temperature, humidity and CO_2 concentration will be will be monitored in the main rooms during the assessment period.

Energy sources

Present state
There are individual gas heaters for domestic hot water (DHW) production and electric radiators for space heating of the flats. The electricity is provided by standard power grid.

Design target
HVAC system (COP of 4.1), natural gas heater for DHW preparation.

8.6 Building performance

Energy performance

Present state
The average building's U-value are:
Façade: U = 0.92 W/m2.K.
Windows: U = 3.10 W/m2.K.
Roof: U = 0.94 W/m2.K.
Floor (over garage): U = 0.78 W/m2.K.
The yearly energy demand is 179 kWh/m2.a.

Assessment financial issues related to energy costs

Performance indicator	Unit	Performance
Energy label	(label)	C
Energy index	(-)	1.3
Total primary energy consumption	(MJ)	[X]
Gas	(m3/year)	[X]
Add. (sustainable) energy, lighting, PV	(kWh/year)	[X]
CO2 emission	(kg/year)	[X]
Energy cost, without VAT -gas -electricity	(€/month)	[X]
Usable floor area	(m2)	[X]
Energy cost index	(€/m2)	[X]
Housing expenses -rent -mortgage	(€/month)	[X]

Design target
The design target is stated in the D2.1 deliverable, Table 4.7: Requirements on building envelope and ventilation to fulfil national nZEB requirements in each country.

Ventilation	
Heat/cool recovery, %	-
Ventilation airflow, l/(s.m2) Renovated case represents indoor climate category II	0.55 ach in winter 0.6 ach in summer
Specific fan power, W/(l/s)	-
Heating syst. with its efficiency	HVAC; 410%
Renewable energy sources	
Solar collectors for DHW, m2	66
Solar panels for electricity, m2	0
Coefficient of Performance of heat pump if it is used	4.1
Indoor temperature	
During heating period	18 ºC
During cooling period	25 ºC

Environmental impact

Present state
Yearly non-renewable primary energy consumption: 179 kWh/m2.a (including DHW)
Yearly CO2 emissions 144.9 t/m2.a (2.0 t/a).

Design target
Yearly non-renewable primary energy consumption: 55 kWh/m2.a (including DHW)
Yearly CO2 emissions 98.7 t/m2.a (1.4 t/a).

Acoustic

Present state
Not assessed. Possible problems in the façade walls, elements separating the flats (walls and floor), and the staircase, and the flats.

Design target
The national standards reported in the "Table 3.5: National design values for building acoustics in More-Connect Geo-clusters and countries." From Deliverable 2.1 will be fulfilled

Noise from service systems: The maximum noise in bedrooms and living rooms due to the functioning of the building service system is considered on Portuguese acoustic regulation base on the maximum acceptable noise from service systems, LAr,nT. LAr,nT = LA,eq + K1 + K2 (K1 = 3 if the noise has tonal characteristics and ; K2 = 3 dB if the noise has impulsive characteristics).	LAr,nT ≤ 27 Continuous work LAr,nT ≤ 32 Intermittent

Moreover, the design will meet the requirements of a COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions" methodology for Class C classification at minimum.

Daylight

Present state
No problems reported. To be determined later.

Design target
The daylight level will not be influenced by the refurbishment, the similar of better daylighting will be assured during the construction process.

Air tightness

Present state
The assumed total air change is 0.94 h-1, not divided into ventilation and infiltration.

Design target
The assumed air change rate is of 0.55 ach in winter and 0.6 ach in summer

Moisture safety

Present state
Problems with the moisture in some rooms due to the low indoor temperature and high relative humidity.

Design target
The national standards reported in the "Table 3.4: National values for hygrothermal design of building envelope in More-Connect Geo-clusters and countries." of Deliverable 2.1 will be fulfilled.

9 CONCLUSION AND IMPLICATIONS

This report presents the results of task 3.1 of the MORE-CONNECT project.

Task 3.1 Typology of building stock for relevant market in the Geo Clusters
Task leader: Zuyd
Other participants knowledge: RTU, TUT, CVUT, UMinho, Cenergia

In this task houses in the 4 regions will be studied and classified specifically for their suitability and adaptability for renovation elements. This will provide the basic criteria for development of the element specifications. The task will focus on the majority of buildings that in a first round might be regarded as suitable:

- Study and identify the majority of building stock potentially suitable for renovation
- Detail and classify building types according to an agreed standard approach
- Identify the basic building related specifications for element development

Deliverables
D3.1 Overview of main housing types in the addressed EU regions, classification of suitability for different prefab façade renovation configurations.

It was learned that the assessment of housing typologies across Europe can be useful in order to determine which type of housing will be considered when developing the MORE-CONNECT solution and moreover, to determine the market potential of MORE-CONNECT. Early attempts to classify the housing stock have been made at the national and European level (Tabula/Episcope project for example). However, these attempts are to generic in nature in order to inform the development of a modular retrofit concept. What is missing is an in-depth analysis of the (structural) building and financial characteristics (rent and energy costs for example) of these typologies. Therefore an assessment framework have been developed to determine the applicability of the MORE-CONNECT concept with respect to deep-renovation of residential buildings (Appendix A). The framework encompass several aspects to be assessed, including: the historical (monumental) characteristics; aesthetic characteristics; financial issues related to energy costs, and; the structural characteristics of the property. Tools have been developed for each aspect to the support the assessment.
The approach taken here suggests a standardized approach to assess the applicability of the MORE-CONNECT concept across Europe. Insights from the progress of other work packages part of the MORE-CONNECT project could result in the adjustment of the decision-making tool and morphological overviews presented in this report.

References

AgentschapNL (2011), Voorbeeldwoningen 2011: Bestaande bouw [in Dutch], report (http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/woningbouw/particuliere-woningen/voorbeeldwoningen)

AgentschapNL (2011), Voorbeeldwoningen 2011: Onderzoeksverantwoording [in Dutch], report (http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/woningbouw/particuliere-woningen/voorbeeldwoningen)

Liebregts, M. & Van Nunen, H. (2014), Essay de toekomst van de woningvoorraad, ISBN978-94-6104-034-3

Tabula/Episcope (October 2014), Inclusion of New Buildings in Residential Building Typologies: Steps Towards NZEBs Exemplified for Different European Countries, Episcope Synthesis Report No.1 (Deliverable D2.4) (http://webtool.building-typology.eu/webtool/

Not complete yet!

APPENDIX A: ASSESSMENT FORM

To be included!