ZenN

Nearly Zero energy Neighborhoods

Common barriers and challenges in current nZEB practice in Europe

D.1.1. Report

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ZenN – Nearly Zero energy Neighborhoods

Authors
Anja Karlsson (IVL Swedish Research Institute), Carmel Lindkvist (NTNU), Ewa Wojtczak (ASM), Katarzyna Stachurska-Kadziak (ASM), Daniel Holm (IVL Swedish Environmental Research Institute), Kari Sornes (Sintef), Patrice Schneuwly (CEA), Nagore Tellado (Tecnalia), Francisco Rodríguez (Tecnalia).

Editors

Anja Karlsson (IVL Swedish Environmental Research Institute) and Carmel Lindkvist (NTNU)

Layout

IVL Swedish Environmental Research Institute

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Further information

ZenN website: http://www.zenn-fp7.eu/

Anna Jarnehammar (IVL Swedish Environmental Research Institute): anna.jarnehammar@ivl.se

Francisco Rodríguez (Tecnalia): francisco.rodriguez@tecnalia.com

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Executive Summary

This report is part of the project Nearly Zero energy Neighbourhoods (ZenN). The project is being implemented 2013 – 2017 and is funded through EU's Seventh Framework Programme (FP7). In total, 12 partners from five countries are involved in the project: Tecnalia (Spain), CEA (France), IVL Swedish Environmental Research Institute (Sweden), SINTEF (Norway), ASM (Poland), NTNU (Norway), The municipality of Oslo (Norway), Debegesa (Spain), City of Eibar (Spain), Ville de Grenoble (France) EJ-GV (Spain) and the City of Malmö (Sweden).[1] The aim of ZenN is to reduce energy use in existing residential buildings and neighbourhoods.

In the ZenN- project, residential areas in Sweden, Norway, Spain and France will function as nearly Zero energy building (nZEB) renovation demonstration projects where a number of measures will be implemented in connection with renovations. The general objectives of the project are to demonstrate the feasibility (technical, financial and social) of innovative low energy renovation processes for buildings at the neighbourhood scale; identify and disseminate promising management and financial schemes to facilitate large scale replication and launch ambitious replication plans at several scales (local, regional etc.) with the participation of local administrations. As a first task, in order to optimize the long term results and efficiency of the project, the current building renovation practices and main challenges around Europe regarding residential nZEB renovations has been analysed in this report.

The objectives of this study are two-fold:

1) Identification of *barriers* at the decision-making level in renovation projects which did not have high energy efficiency improvement goals;

2) Identification of *challenges* in practice of retrofitting processes, in the renovation projects with high energy efficiency goals.

There are also five major challenges/barriers considered within these objectives that were defined within the proposal for this work which are technical, financial, social, environmental/health and organizational/legal.

The report is divided into several chapters in considering the above objectives within the five major pre-identified challenges. There is a literature review (Chapter 3) of recent project/program reports based within Europe in terms of how low energy and high performance building is being currently addressed in terms of technical, financial, social, environmental/health and organizational/legal. The literature review highlights the following challenges:

[1] For more information on the ZenN-project, visit the project website: http://www.zenn-fp7.eu/

- Disconnection between developing innovative technologies for the building industry and the lack of take up.
- Budgets within the industry and the distribution of savings and costs amongst the different stakeholders.
- End user awareness of how they are using energy in residential buildings.
- Energy targets are challenging for cultural and historic significant buildings.
- Policy, regulation and standards are not established and are still developing across a number of countries
- Lack of understanding of what low energy building means in legislation for the actual building process.

In the analysis of financial challenges, incentives and business models for nZEB renovation (Chapter 4) it is recognised that there are financial challenges for nZEB but there are also a number of fiscal incentives and business models available. There are a number of challenges emphasised which are as follows:

- There is a long payback period taking between 15-30 years and residents do not stay long enough in a house to benefit from this payback period.
- There are issues where the landlord cannot raise rents.
- There are very little financial instruments available in the EU that are aimed directly and exclusively at supporting nZEB renovations.

Chapter 6 is the main contribution of this study which outlines individual country reports from Sweden, Poland, France, Spain and Norway. These countries present an overview of experiences concerning barriers and challenges in relation to residential nZEB renovations and in some cases new builds. Many barriers and challenges in connection to realizing residential nZEB renovations are similar between the countries but there are also other, just as important, challenges and barriers that are more country-specific. Below the main common barriers and challenges in current practice in Europe are outlined.

Barriers in the decision making process

- *Technical barriers*: Existing building structure and technical system limit the choice of technical solutions that can be used but where technical solutions can be found, they are often costly and not financially viable.
- *Financial barriers*: Investment cost too high
- *Social barriers*: Lack of knowledge and/or interest for energy efficiency among residents and building owners, often due to lack of awareness combined with challenges with architectural and cultural values
- *Environmental/health barriers*: No common environmental/health barriers were highlighted

- *Organisational/legal barriers*: The ownership structure and need for consensus among several homeowners can hinder a nZEB renovations

Challenges of the retrofitting process

- *Technical challenges*: Existing building structure and technical systems limit the choice of technical solutions possible for nZEB renovations.
- *Financial challenges:* Building owners are unlikely to make a return on investment
- Social challenges: The need for communication and information early in the renovation process to increase acceptance among residents
- *Environmental/health challenges*: The risk of moisture must be taken into consideration when making a building more airtight
- *Organisational/legal challenges:* The need for an extensive communication between involved organisations and actors early in the process

Below are short country specific summaries of the *barriers* in the decision making process and *challenges* of the retrofitting process from Sweden, Spain, France, Poland and Norway.

Sweden

Barriers in the decision making process

- *Technical barriers:* Existing technical systems combined with the structure and condition of the building have significant impact on the choice of technical solutions and possibility for nZEB renovation.
- *Financial barriers:* Budgetary constraints for renovations which are financed by maintenance budget and/or the energy savings limit the scope of renovation and possibility for nZEB renovation.
- *Social barriers*: Historical and cultural values of a building have an impact on renovation.
- *Environmental/health barriers:* These areas were not an issues as they are already considered in common practice in renovations
- *Organizational and legal barriers*: Different number of contracts to choose from and technical knowledge is different between property owners.

Challenges in the retrofitting process

- *Technical challenges*: Existing technical systems combined with the structure and condition of the building have significant impact on the choice of technical solutions.
- *Financial challenges:* Uncertain profitability in nZEB renovation as it depends, amongst other things, on the requirements of yields and return of the investment by

the building owner. There is also a loss of revenue through loss of income from rents when large-scale renovations are being conducted as tenants need to be evacuated.

- *Social challenges*: Initial worries from tenants but, in the nZEB projects studied, these worries were resolved through a high degree of communication.
- *Environmental/ Health challenges*: No different in environmental/health criteria in nZEB compared to traditional renovation, however, the risk of moisture must be considered when changing the building envelope and airtightness.
- *Organisational and legal challenges*: When carrying out large-scale nZEB renovations, the organization and staff need to adapt to new working processes and work tasks.

Spain

Barriers in the decision making process

- *Technical barriers*: Some solutions cannot be implemented in building retrofitting due to a lack of space and common rooms for equipment installation or when the compatibility with existing system is a requirement.
- *Finance barriers*: The main financial barriers are the investment cost and the access to finance due to a lack of long term credit from banks.
- *Social barriers:* There is a work to do in the involvement and awareness rising of building owners. The benefits of building energy efficient renovation should be explained with data including payback periods and reduction of energy bills.
- *Organisational and legal challenges:* Historic buildings have special regulations and the aesthetics cannot be changed which means that many market solutions cannot be implemented.

Challenges in the retrofitting process (based on best practice rather than nZEB)

- *Technical challenges*: Innovative technical solutions are not well accepted by the building owners or construction companies. “Proven solutions” locally available and with maintenance and warranty are required.
- *Financial challenges*: Public funding for retrofitting is necessary for building owners, as without it they would not be able to afford to do retrofitting. The challenge is to retrofit with nZEB criteria without any public funding.
- *Social challenge:* The involvement of owners is a main challenge as they are the final decision-makers in the retrofitting process.
- *Environmental/ health challenges*: These areas were not seen as highly problematic.
- *Organisational and legal challenges*: Dialog and communication is needed with building owners to achieve agreements and look for common benefits above of the personal preferences. In this sense distrust to common equipment has been identified. Also, the Spanish draft law of electrical energy, if approved, will reduce

drastically the use of PV panels in Spain because it will be economically of no interest to install PV panels.

France

Barriers in the decision making process

- *Technical barriers/Financial barriers*: It is not the technical which limits the energy performance level but it is the economy which limits the technical.
- *Social barriers*: Changing the behavior of residents for energy efficient housing and their resistance to change.
- *Environmental/health barriers*: The use of insulation with respect to criteria of eco-labels in the renovation of social housing is rare as they are usually quite expensive. Also waste management is difficult during a management of an occupied construction site.
- *Organizational and legal barriers*: "Bailleur social" report that the statutory requirements on processing of asbestos on construction site are difficult, if not impossible, the removal or the processing of the technical structure concerned on an occupied site.

Challenges in the retrofitting process

- *Technical challenges*: There are challenges in the air tightness of building which requires many technical adjustments connected to the execution.
- *Financial challenges*: The energy renovation is usually accompanied by other works: upgrading housing (technical equipment (kitchen, bathroom, WC) and embellishment (painting, flooring)). So in general, for 100 euros invested on the energy renovation, there are 75 - 80 euros invested on the rest of the works, allowing to maintain housing at a good level.
- *Social challenges*: Follow-up with tenants is essential after the renovation. There is a turnover of about 10 to 12 % of tenants annually who take up social housing. It is thus essential to inform, to follow and to train tenants before and after the works.
- *Environmental/health challenges*: There are challenges in conducting renovation on an occupied site, e.g. removal of asbestos. In terms of health, it is necessary to verify good ventilation of housing as well as the acoustic comfort.
- *Organizational and legal challenges*: Considering works in an occupied site, the preparation period must be long so as to reduce the duration of the works. For example for the building site of one renovation (example of the operation managed by the company GFC), the preparation period has duration 6 months and the works 11 months with a gain of one month on the total duration.

Poland

Barriers in the decision making process

- *Technical barriers*: A significant technical barrier hindering nZEB renovations is usually the lack of sufficient knowledge on nearly zero energy building renovations/solutions among investors, contractors, designers and other professionals. The mentioned deficiencies in awareness together with lack of good practices are the reasons why investors do not consider implementing nZEB renovations.
- *Financial barriers*: nZEB renovations are more expensive than standard thermo-modernisations and neither residents nor building owners can afford such investments. There are no complex financial models supporting exclusively nZEB renovations. There are subsidies devoted to residential buildings in nearly zero energy consuming standard, however, the subsidies concern only new buildings, renovations are not included in it.
- *Social barriers*: Awareness of the importance of energy efficiency among residents is very low. Therefore there are usually no demands regarding deep/innovative energy efficiency solutions and standard thermo-modernisations are implemented throughout Poland. There is deficiency of promotional or educational actions explaining the advantages and benefits of nZEB renovations
- *Organizational and legal barriers:* Polish regulations do not encourage implementing nZEB renovations. For example, in order to apply for grants that are part of the program of thermo renovations, energy consumption must be reduced only by 10, 15, 20 or 25 % (depending on the date of construction and other factors), which does not make the buildings nearly zero energy consuming (residential buildings in Poland are very energy intensive – the ones built before 1985 consume even up to 300 kwh/m2/y). This is an indirect barrier hindering nZEB renovations. Investors are not motivated enough to realize such thorough renovations, and therefore only fulfil the lowest requirements in order to get the grant.

Challenges in the retrofitting process

- No (residential) nZEB renovation projects have been identified in Poland.

Norway

Barriers in the decision making process

- *Technical barriers*: Knowledge not spread out amongst professionals
- Financial barriers: There is no return on investment. Short time period to invest in renovations as extensive renovation occurs every 15-30 years. Also energy prices in

Norway are low and do not rationalise in investing in more expensive nZEB renovation as compared to non-nZEB

- *Social barriers*: Lack of knowledge amongst end users as well as the high technical systems for nZEB means residential 'Do it yourself' approaches are not possible.
- *Environmental/health barriers*: Quality of dwelling is good but improvement can be done in using non-toxic materials and improving energy efficient ventilation systems. Also improving the market perspective that energy efficient homes can also be comfortable.
- *Organizational and legal barriers*: There can be unambitious energy performance targets but this is also caused by the poor demand from the market for nZEB renovations as well as a lack of regulation.

Challenges in the retrofitting process

- *Technical challenges*: Attaining knowledgeable experts for nZEB renovation is necessary for successful projects
- *Financial challenges*: Cost is not always considered upfront in projects but should be part of the business model to avoid surprises. Fiscal incentives are used but could go further.
- *Social challenges:* Communication with end users is recognised as key during the renovation but very little projects referred to follow up communication after a project is complete. This follow up is necessary to understand how energy performance targets have been met.
- *Environmental/ Health challenges:* Norway has high performance targets that are part of the norm of standard projects but project could set higher performance targets.
- *Organisational and legal challenges:* Communication, commitment and cooperation across project teams are difficult to achieve but are necessary for successful projects. Currently in Norway there is debate on the energy distribution and ventilation regulatory requirements.

Contents

List of abbreviations

BEA	Berlin Energy Agency
BPIE	Buildings Performance Institute Europe
CMV	Controlled Mechanical Ventilation
CPH	Combined Heat & Power (boilers)
DHW	Domestic Hot Water
EPBD	European Energy Performance of Buildings Directive
EPC	Energy Performance Contracting
ESCO	Energy Saving Company/Energy Service Company
EU	European Union
FP7	EU's Seventh Framework Programme
IEA	International Energy Agency
IPR	intellectual property rights
KfW	German Bank for Reconstruction
LCA	Life-Cycle Analysis
LCC	Lice-Cycle Costs
nZEB	Nearly Zero Energy Building
PACE	Property Assessed Clean Energy
PV	Photovoltaic
TBS	Public Building Societies
TPF	Third Party Financing
VOC	Volatile Organic Compounds

1 Introduction

This report is part of the project Nearly Zero energy Neighbourhoods (ZenN). The project is being implemented 2013 – 2017 and is funded through EU's Seventh Framework Programme (FP7). In total, 12 partners from five countries are involved in the project: Tecnalia (Spain), CEA (France), IVL Swedish Environmental Research Institute (IVL)(Sweden), SINTEF (Norway), ASM (Poland), NTNU (Norway), The municipality of Oslo (Norway), Debegesa (Spain), City of Eibar (Spain), Ville de Grenoble (France) EJ-GV (Spain) and the City of Malmö (Sweden).[2]

The aim of ZenN project is to reduce energy use in existing residential buildings and neighbourhoods. Today, buildings account for the main source of energy use in Europe (Directive 2010/31/EU) and a majority of the European building stock that will exist in 2050 has already been built (Buildings Performance Institute Europe BPIE, 2011b), most of which suffers from poor energy performance (Meijet et.al, 2010). In order to achieve EU's current target for energy use and reduced emissions, dramatic improvements in energy efficiency and renewable energy use are required, but making older residential areas more energy efficient poses some major challenges.

In the ZenN- project, residential areas in Sweden, Norway, Spain and France will function as nearly Zero energy building (nZEB) renovation demonstration projects where a number of measures will be implemented in connection with renovations. The European Energy Performance of Buildings Directive (EPBD) defines a nearly Zero-Energy Building as "*a building that has a very high energy performance...The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby*" (Directive 2010/31/EU Article 2). The general objectives of the ZenN - project are to demonstrate the feasibility (technical, financial and social) of innovative low energy renovation processes for buildings at the neighbourhood scale; identify and disseminate promising management and financial schemes to facilitate large scale replication and launch ambitious replication plans at several scales (local, regional etc.) with the participation of local administrations.

As a first task, in order to optimize the long term results and efficiency of the project, the current building renovation practices and main barriers and challenges around Europe regarding residential nZEB renovations have been analysed with the aim to form a framework for a useful retrofitting process of existing residential buildings with high energy efficiency goals.

The objectives of this study are two-fold:

1) Identification of *barriers* at the decision-making level in renovation projects which did not have high energy efficiency improvement goals

[2] For more information on the ZenN-project, visit the project website: http://www.zenn-fp7.eu/

2) Identification of *challenges* in practice of retrofitting processes, in the renovation projects with high energy efficiency goals:

In order to achieve the objectives, this study includes a literature review on barriers and challenges in current practice, an in-depth analysis of financial challenges, incentives and business models for nZEB renovation as well as country studies based on interviews and workshops with key persons involved in renovation projects in five countries: Sweden, Norway, Poland, France and Spain. A methodology (chapter 5) has been developed for identifying common barriers and challenges concerning residential nZEB renovation in the specific countries. Both *barriers* for taking the decision for nZEB renovation and *challenges* in the planning and implementation phases of nZEB renovation have been addressed.

Five major barriers/challenges – technical, financial, social, environmental/health and organizational/legal – have been pre-identified which provides the delimitation in this study of common barriers and challenges in current practice.

This report – *Common barriers and challenges in current practice in Europe* – presents the results and conclusions from the study. The target groups for the report are actors involved in renovations of existing building stock as well as decision-makers on national and local levels.

2 Outline and responsible contributors

In the next chapter, the results from the literature study on barriers and challenges in current retrofitting practice are presented, followed by an in-depth analysis of financial challenges, incentives and business models for nZEB renovation in chapter 4. In chapter 5, the methodology for identifying common barriers and challenges concerning nZEB renovation is outlined. The summaries from the studies carried out in Sweden, Norway, Poland, France and Spain are presented in chapter 6. Each country section in chapter 6 is concluded with a discussion and conclusions. Finally, in the last chapter, the results from the literature studies and country studies are summarized and discussed.

Several organizations and individuals have been involved in carrying out the study and writing the report. Main responsible authors in this report are as follows:

Chapter 3: NTNU
Chapter 4: ASM
Chapter 5: IVL /NTNU
Chapter 6.1: IVL
Chapter 6.2: Tecnalia
Chapter 6.3: CEA
Chapter 6.4: ASM
Chapter 6.5: NTNU
Chapter 7: IVL/NTNU

3 Barriers and challenges in current practice – literature study

The objectives of this chapter is to identify and discuss in detail the common barriers and challenges of renovation projects as already identified in reports from forerunning retrofitting/renovation projects and programs in terms of technical, financial, social, environmental and health, and organization. While these are broad in definition, the table below identifies the main areas that will be focused on as identified as being five major challenges and barriers for projects.

Table 1: Five major challenges and barriers in the literature study

Barriers and Challenges	**Main issues**
Technical	Technologies and innovative solutions
Financial	Schemes and financial incentives, balance between cost and solution
Social	Engagement, awareness, behaviour of all stakeholders, architectural and cultural heritage
Environmental and health	Life cycle perspective in design; quality of the indoor environment
Organisational/legal	Legislation, governance and policy; Project management; Stakeholder/ Ownership structure

Initial search for reports is based on the established projects\ programs of SECURE, E2Rebuild, NorthPass and BarEnergy. Further reports were accessed through the snowball effect of the initial search and examining conference papers associated with projects\programs. Reports in the time period of 2010-2013 were examined as this reflects the time period since the recast of the European Energy Performance of Buildings Directive (EPBD) in 2010 that all new buildings in Europe will have to be “nearly zero energy” by 2020. The aim of this literature review is to outline what work has been done in these exemplar projects\ programs and the gaps that can be addressed within the work of ZenN.

3.1 Technical barriers and challenges

Technologies and innovative solutions

Reports emphasize the need to develop technologies and innovative solutions as being key to address new approaches for low energy efficient building. Tools have been developed to

visualize performance for retrofitting process in the Building Energy Efficiency for Massive Market (EeB\PPP 2012). One project developed a technical solution to measure the quality of daylight and artificial light for planning interventions in cultural heritage sites which allow for alternative lighting solutions to be explored as well as enabling a reduction of operating cost and electric energy demand for the future (Pfuger, Werner et al. 2011). However, it is not necessary for all technology solution to be new. E2Rebuild builds on existing technological solutions to come such as metering for monitoring energy and 3D models for planning and production to develop new methods and approaches in retrofitting design that can incorporate all stakeholders as well as reduce building and energy costs (EeB\PPP 2012). While there are a large number of solutions being developed, this in itself is perceived as confusing. The SuPerBuilding project found that there was a lack of standard solutions and technology components as well as initiative and innovation from the construction industry (SuPerBuilding 2012). The above indicates a certain disconnection within the construction industry as while there are technical solution for energy efficient building and retrofitting developments – there may be a challenge in terms of take-up within the industry. While the industry has been criticized within reports for lack of skills and knowledge (NorthPass 2012, SuPerBuilding 2012), this industry is not known for being open to change and more known for being quite traditional. However there is also a challenge of when to engage with industry on innovative solutions as there is a risk for the supplier in terms of loss of intellectual property rights (IPR) which might be overcome with legislation to protect suppliers IPR to innovation tools (SCI-Network 2012a). The challenge is how technical innovative solutions coming out of the above projects can become engaged and become part of common practice within the industry.

Overarching challenge

- Disconnection between developing innovative technologies for the building industry and the lack of take up.

3.2 Financial barriers and challenges

Schemes and incentives

There are a number of schemes and incentives that are used across Europe, e.g. CONCERTO (SERVE 2011) which are considered critical to the success to energy efficient renovations (IEA\SHC 2010). But subsidies also present challenges such as addressing increased equipment and budgetary constraints (SuPerBuilding 2012). These schemes are further discussed in chapter 4.

Balance between cost and solution

There is an established approach to budgets of building projects that do not meet the business model of viewing the building as a life-cycle from design to demolition. There is a separation of budget costs between construction and operations so little incentive to take in

operation costs (SCI-Network 2012a, SCI-Network 2012b). Fear of investment costs upfront combined with unforeseen costs and problems with financing an energy efficient building project are viewed as barriers as the current business model does not consider cost saving during operations that is beneficial to building owners and it is considered that this is not adequately communicated to a wider audience (SuPerBuilding 2012). There is an initial outlay of costs on low energy renovations (IEA\SHC 2010) but initial investment costs are quite small when the overall operational costs are considered by a ratio 1:5 (SCI-Network 2012a). Taking a building life-cycle perspective is important for energy efficient building but this also needs to be considered in budgetary decisions rather than having construction cost and operational cost in individual silos. Cost optimal delegated regulation, which is a legal document for EU member states (Atanasiu and Kouloumpi 2013), is used to get a holistic view of the cost of renovation. Cost optimal levels define the energy performance level of a building that takes into account investment cost as well as operational, maintenance, disposal and energy saving cost of buildings (Atanasiu and Kouloumpi 2013, Buildings Performance Institute Europe, 2013). The value of conducting such life cycle cost analysis is to move away from cost being a perceived problem and viewing the cost in the reality of the construction and the operations of the building (NorthPass 2012). However such life-cycle costing methods have been criticized for being overly flexible in data input and cost optimal calculation with methodological limitations, ignoring items such as the natural environments and the costs and benefit being attached to an array of individual owners and users (SuPerBuilding 2012, Atanasiu and Kouloumpi 2013). While cost optimal levels consider the whole life-cycle costing of a building/renovation, there are wider issues on how to share costs for low energy houses between developers, owners, buyers, tenants etc. (NorthPass 2012). Taking a life-cycle approach in budgets for projects is a step forward in examining the real cost of construction and operations but more needs to be done as highlighted with the challenges of understanding the distribution of costs and savings across the different stakeholders.

Overarching challenge

- Budgets within the building industry are divided between design/construction and operation. Also there is a challenge in the distribution of savings and costs amongst the different stakeholders.

3.3 Social barriers and challenges

Engagement, awareness, behaviour of all stakeholders

Engagement of all stakeholders of an energy efficient renovation has been considered through information dissemination. Identifying relevant networks and communication channels is highlighted as necessary for engagement (SCI-Network 2012a, SCI-Network 2012b). Other work emphasizes the need to develop end-users awareness in renovation projects through:

- Informing end-users of renovations at the initial stage and emphasizing that residents will receive a new quality house at the later stages of a project (IEA\SHC 2010).
- BEEM-UP project used a tenant involvement strategy that included workshops to evaluate tenants priorities and interests (EeB\PPP 2012).
- E2Rebuild developed walkthroughs of pre-construction sites for tenant\owner input (EeB\PPP 2012).
- Considering user behaviour where in SEAI project developed a website called *The power of one street* which allowed residents to monitor and modify their own behaviour in their dwelling to save energy (SEAI, 16 September, 2013).

Client demand and willingness is deemed to determine development (SuPerBuilding 2012), but this decision is influenced through dissemination of knowledge and publicity of positive projects (IEA\SHC 2010). The building industry is often reluctant to take on change and bad examples of poorly renovated energy efficient projects can confirm prejudices where there should be promotion of good examples (IEA\SHC 2010, NorthPass 2012). The above indicate that having the appropriate knowledge and examples of positive projects will aid in the decision making process for clients and building owners in taking on low energy building.

Architectural and cultural heritage

Areas of architectural and cultural heritage while important are particularly challenging for the purposes of renovation. Historic building are an area of energy inefficiency contributing to the release of greenhouse gas emissions and it is therefore necessary to have an improved approach to their refurbishment (EeB\PPP 2012). Projects such as 3ENCLUT bridges the gap between conservation of historic building and climate protection (EeB\PPP 2012). Energy refurbishment of historic buildings can reduce CO2 emissions as well as increase indoor comfort which can result in higher surrounding temperatures and less draughts and energy cost decrease (Troi 2011). The primary challenge is merging energy efficient targets with maintaining the historical/cultural heritage value of these types of buildings.

Overarching challenge

- Need for more knowledge on energy efficient projects as well as positive examples to feed into decisions for energy efficient projects
- Energy targets are challenging for cultural and historic significant building.

3.4 Environmental and health barriers and challenges

Life cycle perspective in design; quality of the indoor environment

Developing a life-cycle perspective means changing the organisation of building projects to include operational use. This encourages projects to think about environmental challenges for the life-cycle and not just for the project by setting energy performance targets for the

whole life-cycle with minimum requirements as well as aspirational requirements (SCI-Network 2012a). E2ReBuild has achieved monitoring guidelines for measuring buildings energy performance (EeB\PPP 2012). Building technology tools such as Building Information Modelling (BIM) can be used for developing performance and indicators (SCI-Network 2012a, SuPerBuilding 2012). The European SuPerBuildings project approached meeting targets by setting sustainable indicators in relation to environmental, social and economic performance at the different stages of the building processes in connection with building information models and with different instruments (SuPerBuilding 2012). However, inhabitants are a challenge in ensuring their behaviour supports the design of the building. Problems related to user behaviour are related to indoor environment, inadequate operation and use of the building and missing information e.g. no dialogue between the developers and the users/tenants to result in functioning low energy buildings (NorthPass 2012). There is a comfort level that needs to be considered for residential building because while inhabitants may have aspirations to live in an environmental way, they may return to old habits which is the 'rebound effect' (IEA\SHC 2010). The above indicates that energy, social and economic performance life-cycle targets needs to be considered alongside the use of the building by the tenant or owner.

Overarching challenge

- End user awareness of how they are using energy in residential buildings

3.5 Organisational barriers and challenges

Legislation, governance and policy

Legislation, governance and policy are an integral catalyst for bringing low energy building to the forefront of the building industry. The EPBD introduced, in Article 9, nZEB is a future requirement to be implemented from 2019 onwards for public buildings and from 2021 onwards for all new buildings (BPIE, 2011). Legislation is moving towards implementing targets for low energy or nZEB for the building industry to react to e.g. building quality legislation (SERVE 2011). However there is also the case that the legislation is in a mode of development which is evident within the inconsistencies continuously referred to in reports.

- Policy is referred to as being inconsistent which has been a deterrent to the industry to engage (IEA\SHC 2010).
- Regulation is seen as inadequate or lacking across European countries that necessitate a new kind of building authorities and public actors (SuPerBuilding 2012).
- Standards that have been developed around low energy building in countries that include Denmark, Norway, Sweden and Finland can be ambiguous within the industry and a common specification for low energy houses ideally for Europe but at least within individual countries is called for (NorthPass 2012).

Governments have a key role in promoting energy efficient building types. Government initiated projects, thus leading by example with projects such as Schools for the Future

projects which create the opportunity to show case high performance retrofit approaches (IEA\SHC 2010, EeB\PPP 2012). There are comprehensive planning being conducted from national and local authorities as well as the implementation of energy labelling quality assurance which should be further supported through long term ambitions and time schedules from authorities (IEA\SHC 2010) . While there is a mix of government initiatives that highlight good examples of nZEB, there is a need that legislation should reflect and go further in policy, regulation and standards to incorporate the changes on what low energy building means in the actual building process.

Project management/ Stakeholder/Ownership structure

Present construction environment is characterized by complex supply chain with various players and competing interests (SuPerBuilding 2012). The type of projects that have been considered in these reports are in the format of a separation of design and build or combined design and build or design, build and operate, energy performance contracting, design competitions (SCI-Network 2012a, SCI-Network 2012b, SuPerBuilding, 2012). The project management of a low energy building project needs engagement with the market before procurement with cooperation and communication across teams during the project (SCI-Network 2012a, SuPerBuilding, 2012). There are challenges in the ownership structure of projects in terms of separating project by design and build and then operations. One such approach to overcome this challenge is to have contracts as building/facility operation where an innovative pot is used which allows saving to be generated by an innovation to be shared by owner and operator (SCI-Network 2012a). However, financial savings in terms of ownership are not the only issue as the information generated in the project is not always used in operations. There is a lack of information management across the building life cycle that needs to be addressed across the different actors of design, construction and operations (SuPerBuilding 2012) as well as perceived problems that could be overcome with information and good dialogue (NorthPass 2012). Soft-landings approach in the UK is one way that communication and information is continued in operations after a project is complete (SCI-Network 2012a). However, further education is needed amongst professionals managing projects to take a life-cycle view point early (NorthPass 2012). Ensuring that information is being utilized across the life-cycle means that energy efficient buildings can be utilized in operations as they were designed.

Overarching challenge

- Policy, regulation and standards are not established and are still developing across a number of countries
- Need to understand what low energy building means in legislation for the actual building process.
- Need to ensure that information is being used across the building life-cycle.

3.6 Discussion and conclusion

The above highlights that there are projects trying to address barriers and challenges under technical, financial, social, environment and health and organizational perspectives but there are ongoing barriers and challenges that these projects have not been able to address:

- Budgets within the building industry are divided between design/construction and operation. Also there is a challenge in the distribution of savings and costs amongst the different stakeholders.
- Need for more knowledge on energy efficient projects as well as positive examples to feed into decisions for energy efficient projects
- Energy targets are challenging for cultural and historic significant buildings.
- End user awareness of how they are using energy in residential buildings
- Policy, regulation and standards are not established and are still developing across a number of countries
- Need to understand what low energy building means in legislation for the actual building process.
- Need to ensure that information is being used across the building life-cycle.

This literature review of reports has incorporated the perspectives of technical, financial, social, environment and health and organizational a separate areas. In reality they are not as each perspective as an overlapping influence on the project that they are prominent within. Sometimes the challenge is based on a mix of these perspectives. For example in the report of SCI-Network, certain projects were discussed in having a contract that is building/facilities management (organizational) but is contradicted by a budget which separates finances of building the structure from the finances of operations (financial). The next chapter takes a closer look at the financial barriers and challenges for nZEB renovations and analyses current incentives and business models for nZEB renovations.

4 Analysis of financial challenges, incentives and business models for nZEB renovation

4.1 Introduction

This chapter has been developed in order to gain a general overview of financial challenges, incentives and business models for nZEB renovation in Europe. Main financial challenges for nZEB renovation, such as high investment cost of deep renovation, long payback time or split incentives, are indicated in this report. Furthermore, financial instruments that are available throughout Europe have been analysed, and some evidence and examples in particular countries have been provided. This information gives a general view of financial support for encouraging nZEB renovations. In order to present good practices of financial schemes, this chapter also includes an analysis of successful schemes that have been implemented in particular countries. Focus has been put on Germany (soft loans), United Kingdom (The Green Deal) and USA (PACE) funding mechanisms. The mentioned countries have developed policies and financial schemes that stimulate energy efficient renovation of their housing stock and other buildings.

4.2 Financial challenges regarding nZEB renovation

When considering implementing a nZEB renovation the main barrier connected with it is not, as many may think, the technical barrier but the financial one. The Buildings Performance Institute Europe (BPIE) report - *Energy efficiency policies in buildings – the use of financial instruments at Member State Level* - presents that financial barriers are one of the highest ranking barrier category when it comes to deep retrofits in a majority of EU countries. 21 of them gave it a high priority (Buildings Performance Institute Europe, 2012).

Nearly ZEB renovations require high level of investment costs. Most house owners cannot afford such expensive renovations. Many households have limited resources and limited access to credit and this situation had even become worse by the current economic and financial crisis. The financial crisis is visible in all countries (for some more than others) and the lending markets have also been affected. Additionally, consumers are not willing to take the risks that come with a credit. Moreover, high uncertainty surrounding energy savings measures and difficult replication of projects increases concern about such renovations. The information failure is also present in the financial sector. The absence of awareness and knowledge among financiers is still an important barrier to increased energy efficiency investments. There is still a dependency on grants and a lack of a systematic approach to pushing energy efficiency investments into complex packages (and thereby gaining economies of scale and reduction of relative administrative costs and technical risks).

Certainly implementing energy saving solutions is financially rational. However, regarding nZEB renovations, the time taken for return of the money invested becomes a barrier. What

is more, for many house owners, energy bills are not a major concern because they account for 3-4% of house budget, therefore, long payback time is a more crucial barrier.

Most building owners and investors across Europe, in particular in the eastern part, tend to focus on solutions with short or medium payback periods (less than 10 years) which usually generate less than 30% energy savings. However in order to achieve the European Union's energy and climate objectives for 2020 and 2050 the energy savings should be higher. Ambitious energy and climate policies require savings up to 80% energy in buildings, which can only be reached through nZEB renovations. nZEB renovation's payback time is between 15 to 30 years (depending on energy prices) and it is often not appreciated by most property owners. Usually many householders keep in mind that they can move to another house in a couple of years. For example, the average Poles change homes two times in life compared to the average American who moves out every six to nine years. Implementing nZEB renovation would mean that they would have to stay in the house for about 20 years in order to get a return on their invested money. This aspect might be discouraging implementing deep retrofits.

The split incentives barrier is sometimes considered as a financial barrier and it is not a mistake because there are financial implications. The problem forms when one person or organization owns a building and someone else uses it. As for the owner, any investment has to bring a benefit which is not necessarily through energy savings, unless it is a situation where the landlord pays the energy bills. Since the tenant does not own the facility, any investment in lowering energy bills has to be seen as financially beneficial for both parties. This often leads to a point where nothing is happening and the investor does not want to invest his own money if he/she is not the one who will benefit from it. Moreover, it can happen (as noticed in Poland) that the value of the building after renovation does not go along with the market price. If the investor was to sell the renovated building he/she would have to put up a high price for it in order to get a return on his/her money. It would probably be so expensive that a problem with selling it in near future could occur.

There are many examples where the party investing in a building may not be the party benefiting from the investment. These situations can occur when e.g. the landlord invests in a property where tenants pay the energy bill or the landlord cannot raise the rents in order to get a return the money invested because there are some legislative restrictions.

This is one of the most relevant barriers for renovating to nZEB levels needing increased attention, particularly since many rents include heating charges and so the actual consumer has no understanding of actual energy consumption. Moreover, as it has been shown in the example of Poland actual consumers/residents lack awareness about energy efficiency and the benefits of nZEB renovations. A comprehensive analysis on split incentives undertaken by the International Energy Agency (IEA) showed that this barrier accounts for about 30% of sectorial energy use, which is highly significant. Neither regulatory mechanisms, (e.g. minimum energy performance standards, or regulated contract design), nor information-

based instruments (i.e. awareness campaigns) alone will resolve this issue. Instead, governments should help design well-targeted policy packages to address Principal-Agent problems in their specific national contexts, and within the particular constraints of a given sector. These packages should include measures to (Buildings Performance Institute Europe, 2011b):

a. address contract design to ensure end-users face energy prices,

b. regulate the level of energy efficiency in appliances and buildings,

c. improve access to information about energy efficiency performance.

The barrier of split incentives has been more or less touched in United Kingdom's G*reen Deal scheme* for financing energy efficiency investments in buildings, which is analysed later in this chapter.

4.3 Review of available financial instruments for energy efficiency improvements

A great variety of financial instruments are available throughout Europe to support the improvement of the energy performance of buildings. These instruments are variously used in different countries pending on the political context.

Most of the instruments mentioned below are funded by public authorities at the national/federal level or regional/local level. EU structural funds and resources from other EU and international sources for renovations are also available. This is usually addressed to Central and Eastern region countries.

Categories of financial instruments that are used throughout Europe can be divided into (Buildings Performance Institute Europe, 2012):

- Grants/subsidies
- Soft loans
- Tax/VAT incentives
- Energy Supplier Obligations (White Certificates)
- Third Party Financing/Energy Performance Contracting

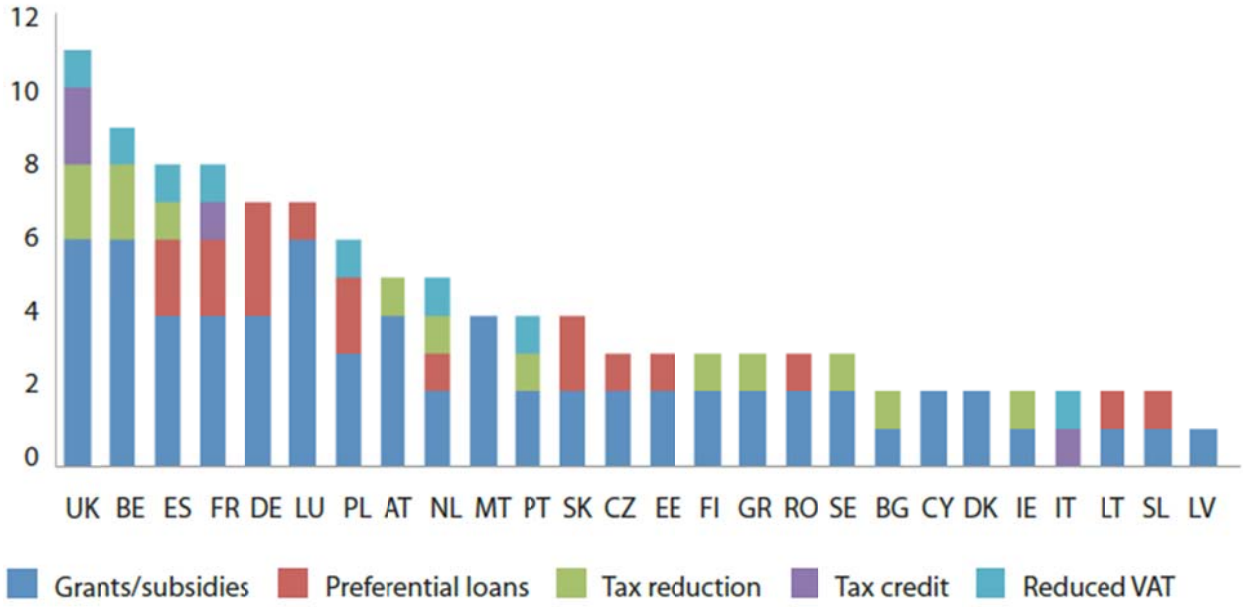

Figure 1: Number of financial instruments by country (Buildings Performance Institute Europe, 2012)

According to BPIE study, there are 68 grants and subsides schemes, 18 preferential loans and 25 tax related instruments. 10 programs were implemented together with more than one type of instrument in place. The most popular types of instruments are grants and subsidies schemes followed by preferential loans.

In many EU countries the listed instruments provide technical and financial support to projects aimed at increasing energy efficiency of buildings, but unfortunately only a few is aimed directly and exclusively at supporting nZEB renovations. Many countries support residential and non-residential buildings, both new and existing, while others focus only on renovating existing building stock. Many schemes target specific technologies, renewables. Funding a deep retrofit strategy requires the use and possible bundling of all of the financial instruments available because of the overall cost of an ambitious retrofit.

4.3.1 Grants/subsidies

Grants and subsidies are the most popular financial instruments in European countries. Nonetheless, they usually have limited resources, and depend on public priorities, budgetary margins. Public subsidies often give only a partial answer to the needs of potential investors. Such needs often consist of technical and financial assistance for the project.

Examples of financial support for energy efficient investments in chosen EU countries

Grants and subsidies are available in all European countries. Unfortunately not many of them encourage nZEB renovation. Most of them are aimed at supporting energy efficiency improvements. However, when looking deeper into the building sector of each country, it can be seen that reducing energy consumption by 20% is not enough to achieve nZEB standard. Therefore, the key concern is the level of ambition that can be attained from

financial programs to motivate consumers to invest in nZEB renovation. It is most common that grants and subsidies are combined with preferential/soft loans and tax reduction with the tax credit measure. Some examples of financial supports in chosen countries are presented below.

In Bulgaria, a National Program for Renovation of Residential Buildings has been implemented. The priority of this program is the multifamily residential buildings. Within the program direct subsidy of 20 % from the renovation total value is provided, with a limit that increases steadily from 13 000 thousand BGN in 2006, to 130 000 thousand BGN in 2020. This subsidy is aimed at common renovation works, isolation and strengthening of social housing stock.

A National Environment Fund Green Savings has been launched in Czech Republic. It provides subsidies for thermal insulation of apartment houses, non –panel technology and the installation of sustainable power resources for the production of heat, such as solar collectors, heat pumps or biomass boilers. The government contributes with about 40 % to 50 % of the funds. The banks also provide commercial credits for financing the remaining costs. There is also Panel Program in Czech Republic, which is directed at owners of high-rise blocks or flats and it provides subsidies for complex reconstruction or modernization of such constructions. There are also preferential credits subsidized by the government with a special focus on thermal insulation.

In Denmark there is a Renovation Fund, it grants for 40% of wages up to a maximum of DKK 15 000 for general home renovation, and 20% of material costs (only if they involve energy efficiency measures) up to maximum of DKK 10 000.

Energy grants for residential buildings have also been implemented in Finland. They are aimed at funding reparation and improvement of residential buildings regarding energy efficiency and greenhouse emissions. The grants cover 40 % of the actual costs of the audit and 10-15% of costs of other solutions.

France is realizing low energy consumption buildings within the AAP PREBAT program. Grants possible to obtain are mainly from 40 to 80 EUR/m² in new buildings and 50 to 100 EUR/m² in retrofits.

In Spain, there is a Support of Energy Effectiveness Performance of Buildings, which aims to encourage high energy class (A or B) for buildings. The objectives of the program are: modernization of the building envelope, improving heating, ventilation and cooling systems, increase in effectiveness of the internal lighting and the promotion of new and existing nZEB (European Alliance of Companies for Energy Efficiency in Buildings, 2009).

In Poland, two grants are available within the Thermo-modernisation Program: (1) renovation grant and (2) thermo-modernisation grant. The renovation grant is a financial assistance for the investors to repay part of the loan drawn for the renovation project. In

order to receive the grant the project must lead to a reduction in annual demand for energy by 10 %, 15 % or 25 % depending on the construction date and other factors. The condition of the grant is that the renovation be a residential building, consisting of more than two flats, which was constructed before 14 August 1961. The thermo-modernisation grant is granted on proof (disclosed in an audit) that the results of the project will be:

1. reduction of annual energy consumption: in buildings where upgrading only the heating system: at least 10 %, in buildings in which after 1984 had upgraded heating systems – at least 15 %, in other buildings the reduction of annual energy consumption by at least 25 %;

2. or reduction of annual costs of heating by at least 20 %;

3. or conversion of energy sources to renewable sources or the use of high-efficiency cogeneration – with obligation specified in the act for energy savings.

Both of these grants are addressed to owners or managers of residential buildings, public buildings used by local governments, direct heating, local source heat and accommodation buildings such as: social care workers' hostel, dormitory and school dormitory, retiree and pensioner's home, homes for homeless and other buildings used for similar purposes.

When it comes to schemes that target specific technologies, in Poland, the National Fund for Environmental Protection and Water economy offers subsidies for partial repayment of bank loans for the purchase and installation of solar collectors for individuals and housing cooperatives. There is also possibility to get support for purchasing heat pumps but not in all regions in Poland. The realization of a project including the installation of a heat pump must take place in one of the regions in which The Regional Fund offers such contribution, these are: Łódzki region, Małopolski region, Pomorski region, Mazowiecki region.

4.3.2 Soft loans

As mentioned above, some countries in the EU have developed policies and targeted funding mechanisms to stimulate the renovation of their housing stock and other buildings such as soft loans. Soft loan schemes are mechanisms where public funding decreases the cost of loans which are usually distributed by private banks. Banks have access to low cost capital which is required by the investor. Those banks can distribute that capital to the end customer, and the government, as it has been successfully proved in case of Germany, can stand behind the banks and allow them to have access to certain poles of low cost capital that makes sense for the national interest.

Example of good practices in Germany

Germany, with an annual renovation objective of 2% and an objective to reduce building energy demand by 80% before 2050, has been one of the most successful European countries in terms of stimulating energy renovation.

All government's funding are managed by the Bank for Reconstruction (KfW, a non-profit banking group owned by the government (80%) and the Laender (20%).. KfW funding programs target 95% of existing buildings in Germany. KfW does not grant loans or other financial support directly to the investor, but to commercial banks.

KfW working with private sector banks has been able to provide low cost capital roughly at 2.7% to encourage energy efficient renovations through various programs. KfW raises funds from the financial markets and transfers this capital (by the use of private banks) to program applicants in the form of lower interest loans. Since 2005 additional subsidies from federal government are used by the KfW both to improve the financial conditions of the programs and to expand their volume. Grants of 5 – 17.5% of investment are commonly available with soft loans because they reduce the first costs for the building owner.

As mentioned above, KfW has launched several programs such as Housing Modernisation Program, Ecological Construction Program or Municipal Loan Program. All of them are aimed at energy efficient improvements for new or existing buildings.

The Housing Modernisation Program is directed at existing residential buildings. The investor receives a long-term-low-interest loan specifically targeted at energy efficiency (eco-plus measures; thermal insulation and heating modernisation on basis of renewable energy) with a fixed interest rate and repayment-free start-up years.

Since 2006, each Euro that the German government has invested as a capital contribution to the state bank KfW has resulted in four Euros invested by the markets and by building owners. Within recent years, that ratio has increased up to 9 times. This cascade effect was generated thanks to, among other things, the participation of private banks.

Soft loans are attractive for building owners as they make the investments more bearable. They are a very efficient way of financing nZEB renovations especially in the housing sector, although house owners still have to bear the costs and risk that come with debts.

4.3.3 Tax/VAT incentives

In order to achieve an nZEB standard, the renovation must include energy efficient technologies using renewables. Such technologies, as it is known, are expensive. This is why, in order to minimize the initial cost of the investment in some countries, fiscal measures such as tax incentives are a form of direct subsidy to renewable energy and energy efficiency. These are directed at actors in the energy field such as manufacturers, generators, distributors etc. Fiscal measures include tax reductions (individual, corporate and on properties), tax credit and reduced Value Added Tax (VAT). The main difference among tax credit and tax reduction is the direct or indirect incidence in the amount payable to the state. The tax reduction is an amount subtracted from the payable income tax that does not generate reimbursement to the taxpayer, i.e. if the payable income tax is less than the tax deduction the net value in favour of the taxpayer is not going to be reimbursed by the tax authority. The tax credit is an amount to be reimbursed to the taxpayer against the

payable income tax. VAT is a general tax on consumption applied to commercial activities involving the production and distribution of goods and the provision of services.

In 2011, 14 EU Member States out of 27 had fiscal incentives related to investments for increasing energy efficiency in buildings. In these 14 countries, there were 25 fiscal measures: 13 tax reductions, 8 reduced VAT and 4 tax credits. Most of these incentives were focused on existing, residential buildings (Buildings Performance Institute Europe, 2012).

For example, the energy efficiency tax credit in France was launched in 2005. The government has introduced tax credit for expanses for the most energy efficient equipment and equipment using renewable energies. This tax incentive encourages investors/house owners to invest in equipment eligible for tax credit which satisfies high performance criteria. For equipment such as condensing boilers the tax credit is 25%, whereas 40% tax credit for isolation materials when buying a house which was built before 1977 and the work must be done in less than 2 years (25% for the installation of these materials). Tax credit for production of renewable energy for solar is 50%, wood 25%, heat pumps 40% (European Alliance of Companies for Energy Efficiency in Buildings, 2009).

The level of support for tax credit in Italy it is 36/55% for envelope and equipment. It the case of United Kingdom, the level of support for tax credit is 100% tax relief on the cost of equipment.

The level of support for tax reduction also varies throughout countries. In Austria, the level of support on individual/households income is 25% for equipment and envelope, whereas in Belgium it is 40%, in Estonia only 10%.

Reduced VAT rate for equipment or envelope, or both, depends on country. There are 8 countries in which reduction of VAT rate was noticed. The highest level of ambition was observed in United Kingdom – 5% instead of normal VAT rate of 20%. The reduced rate covers all insulation, draught stripping, hot water and central heating controls, installations of solar panels, wind and water turbines, ground-source and air-source heat pumps and micro CHP and wood/straw/similar vegetal matter-fuelled boilers. In France, VAT rate is decreased to 7% instead of normal rate of 19.60%. The reduction is related to promotion of heating networks. France has also introduces a reduced rate of VAT on the supply of heat if it is produced from at least 60% biomass, geothermal energy from waste and recovered energy. In Belgium VAT rate is 6% and in Italy VAT is reduced to 10% instead of normal 21% rate. In Portugal, a VAT rate of 13% is used instead of 23% for appliances, machinery and other equipment designed mainly for the following purposes: collection and use of solar energy, wind energy or geothermal energy, collection and use of other forms of alternative energy, production of energy by the incineration or modification of detritus, garbage and other waste.

4.3.4 Energy Supplier Obligations (White certificates)

The system of white certificates is a tool, which uses market mechanisms, to promote energy efficiency. White certificates are documents that attest saving a certain amount of energy as a result of investments in improved energy efficiency. They have property rights and are traded on a commodity exchange of energy.

The essential element of White Certificates is imposing an obligation on a group of entities that operate in the energy market (e.g. energy companies selling electricity, heat, gas and operators of distribution, transmission system) in regard to attaining certain amount of energy savings as a result of measures taken to improve energy efficiency or payment of so-called substitute fee when the energy savings are not implemented/achieved.

Fulfilment of the obligations to obtain a certain amount of energy savings is presented by redemption of particular amount of white certificates (which amount to the required energy savings). In most countries, this settlement of obligations is performed by established regulator of the energy market.[3] The entities required to redeem a specific number of white certificates or pay the substitute fee may obtain white certificates by implementing projects aimed at improving energy efficiency or may buy white certificates on the commodity exchange of energy.

According to experts, the advantage of white certificates system over other solutions operating in European countries regarding the promotion of energy efficiency, such as soft loans, tax incentives grants and subsidies in various forms, is its market character. This system is to become a self-perpetuating mechanism, strongly focused on the competitiveness of the ideas that will be forced by tenders.

White Certificates have been used in several EU countries. United Kingdom (Great Britain only) has a variation of this policy mix scheme since 2002, although, there is limited trading. Tradable certificates have been introduced in Italy since 2005 and in France since mid-2006. Savings obligations have been imposed on electricity distributors in Flanders (region of Belgium) however, without certificate trading option (Bertoldi, 2011).

The first French Energy Savings Certificates scheme for improving energy efficiency in the period of 2006-2009 assumed 54 TWh of final energy. The entities that were obliged to present redeem of white certificates (in France called Energy Savings Certificates- CEE) were suppliers of electricity, gas and heating and oil distributors. In order to apply for white certificates the saving measures must be in compliance with the indicators included in the catalogue of eligible activities. The measures include projects in the construction sector (insulation of building, installation of solar panels ect.), in the transport sector (eg, application intermodal transport unit) and in industry sector (e.g. installation of high efficiency motors).

[3] Regulator of the market is an institution established by the state to supervise particulars markets.

The calculation unit is CUMAC. This term contains the information that "saved" energy is calculated for the entire duration of the energy efficiency project. Due to the aging of the properties under improvements and associated loss of anticipated savings an update rate has been adopted. The update rate includes the loss of saving benefits due to their aging. This ratio for the period of the program was adopted at 4% (European Council for Energy Efficient Economy, 2012).

Obliged energy suppliers have a variety of options for meeting their commitments. They may implement energy saving programs, buy certificates on the Energy Saving Certificate market, pay the penalty or some combination of the above.

Almost 90% of received certificates in France are a result of improvements related to exchange of heat source and insulation of buildings and all come from the residential sector. It was announced that during the whole program, 2100 certificates were issued to 251 recipients. The amount of energy saved was 98.2 TWh. Savings achieved so far correspond to the annual electricity consumption in Paris.

4.3.5 Participation of third-party / Energy Performance Contracting

The structure of financing the energy efficiency improvements and the type of parties engaged in financing is influenced by the risk sharing, type of business and other external conditions.

Classical and widely used method of financing the investment lies in the fact that the investor's own financial resources are involved, or he/she takes a loan from the bank for a maximum of 70 - 80% of investment value. In this case it is required by the investor to have knowledge about what to do and how to achieve the planned results.

The other option is based on using the services offered by companies with technical and financial back up, prepared to invest in projects that reduce energy consumption and energy costs in return for a share in energy savings that will be ensured by this investment.

This investing company is the Energy Saving Company (ESCO). ESCO usually receives additional financial support from an external third party financial institution and this method is called Third Party Financing (TPF). Here several possible funding sources should be investigated: private banks and lending institutions; venture capital companies; equity funds; strategic partners (e.g., utilities and engineering companies); leasing companies and equipment manufacturers.

In the ESCO type project three parties are being involved: the owner/customer (his/her role is defining the goals of the project, identification of available financial resources and understanding of the various possibilities arising from the hidden potential of rational energy use), an expert who makes money on "energy costs reduction" service (in this case ESCO – it is responsible for project performance according to the previously signed agreement) and the financial institution that provides money for the investment.

Energy Saving Company

Energy Saving Company (ESCO)[4] is a company that provides energy services to energy users, including the supply and installation of energy-efficient equipment, the supply of energy, and/or building refurbishment, maintenance and operation, facility management, and the supply of energy (including heat).

The three main characteristics of an ESCO are:

- ESCO guarantees the energy savings and/or provision of the same level of energy service at lower cost;
- The remuneration of ESCO is directly connected to the energy savings achieved;
- ESCO can either finance, or assist in arranging financing for the installation of an energy project.

The ESCO sign with the customer an agreement, so called Energy Performance Contracting (EPC). With EPC, ESCO develops, implements and finances (or arranges financing of) an energy efficiency project or a renewable energy project, and uses the incomes from the cost savings to repay the costs of the project, including the costs of the investment. ESCO will only recover its costs if the project delivers all of the energy savings guaranteed (Bertoldi & Rezessy, 2005).

Third Party Financing

In TPF projects, financing comes from a third party, e.g. a finance institution, and not from equity of the ESCO or of the investor. Depending on which party (the ESCO or the investor) borrows the money we could have two different TPF arrangements within Energy Performance Contracting.

In the first option the ESCO borrows the money necessary for cost-effective project implementation whereas in the second option the energy-user/house owner takes a loan from a bank. In the second option the energy savings guarantee is still on the ESCO side, the investor takes only financial risk. The savings guarantee is especially important for the bank which requires assurance that the project for which the customer takes a loan will generate a positive cash flow and the debt repayment will be covered. When the ESCO is the borrower it takes both financial and technical risks related to the project performance. The figures below show the relations between ESCO and the energy-user/customer depending on which party borrows the money.

[4] Energy Saving Company can also be called Energy Service Company, and can go both under acronym ESCO and ESCo.

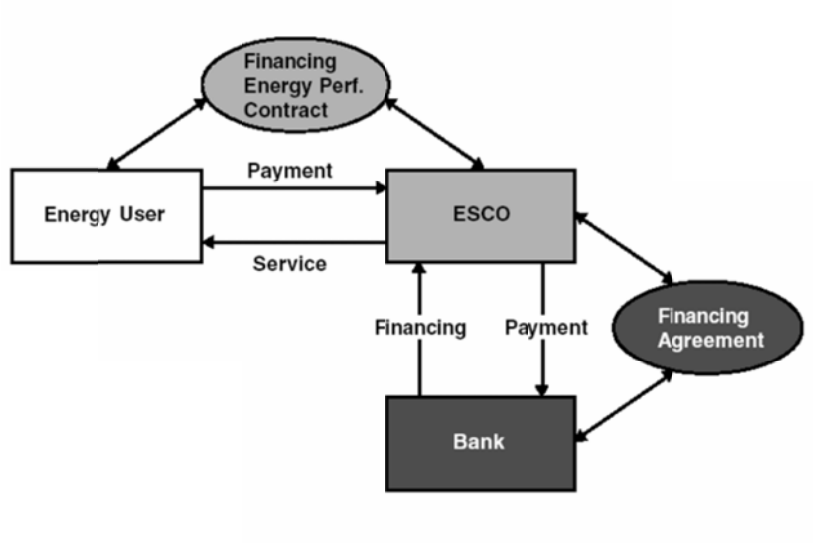

Figure 2: Third Party Financing (TPF) with ESCO borrowing (Dreessen, 2003).

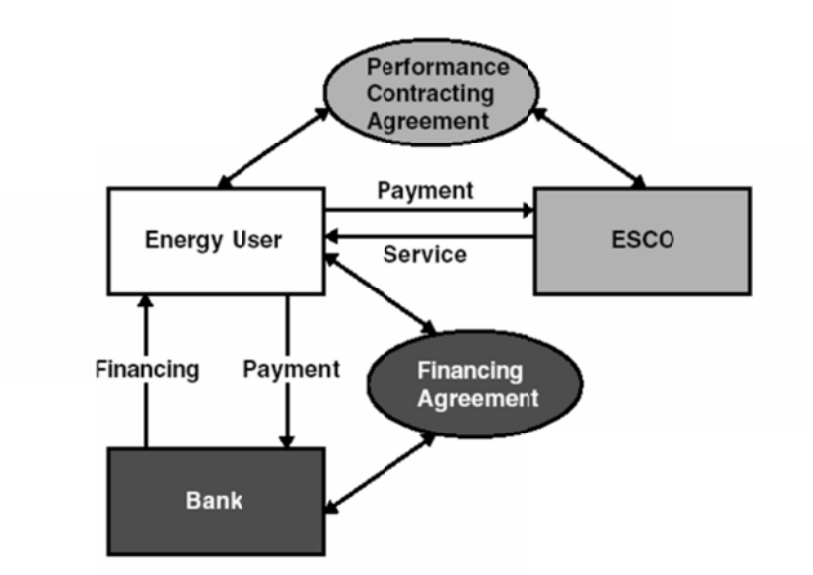

Figure 3: Third Party Financing (TPF) with energy user/customer borrow (Dreessen, 2003)

Energy Performance Contracting

Energy Performance Contracting (EPC) is a contract that guaranties to the customer achievement of savings declared by ESCO. An amount of the achieved savings in the energy costs is used for the reimbursement of the investment of the ESCO. After the end of the contractual period, where the ESCO has achieved the amortization of its capital and earned the corresponding commercial profit, it backs away and the outcome of the refurbishment of the building is for the benefit of the building users. If the project does not provide returns on the investment, the ESCO is often responsible to pay the difference. The approach of the EPC

is based on the transfer of technical risks from the customer to the ESCO based on performance guarantees given by the ESCO.

There are several schemes for the return on the investment (EPC types):

1. First out – the whole amount of the income is granted to the ESCO until full reimbursement or until the end of the contracting period (reducing to a minimum repayment period). The duration of the contract depends on the level of savings achieved: the greater the savings, the shorter the contract. Typically the contract is signed for up to 5 years.

2. Shared savings – the income of the energy saving or energy sales is shared (50/50, 80/20) between the ESCO and the customer for agreed length of time. The split depends on the cost of the project, the length of the contract and the risks taken by the ESCO and the customer. The contracting period is usually between 5 and 10 years.

3. Guaranteed savings – the customer pays regularly an agreed amount to the ESCO, who guarantees the performance of the installation (and a certain level of energy savings). The ground difference between guaranteed and shared savings is that in the first case the performance guarantee is the level of energy saved, while in the second scheme this is the cost of energy saved.

Under a guaranteed savings contract, the ESCO assumes the entire design, installation and savings performance risks, but does not assume financial risks. The investment is financed by the customer's equity capital or by funds obtained from banks or other financing agency. The key advantage of this model is that it provides the lowest financing costs.

Under a shared savings the ESCO assumes both performance and credit risk. The customer takes over some performance risk but assume no financial risk. This scheme functions properly only in countries with an established banking structure, high degree of familiarity with project financing and sufficient technical expertise, also within the banking sector, to understand energy efficiency projects (Bertoldi & Rezessy, 2005).

As every financial scheme, Third Party Financing (TPF) also has advantages as well as disadvantages. The main benefits of using TPF are that the investor/homeowner does not have to provide up-front capital. Moreover, it is the provider who takes all the risk both technical and financial and the investor is not required to have technical expertise by its own. The investor becomes the owner of the equipment at the end of the contractual period. However, this means that the investor is the one who is responsible for the service of the equipment and its maintenance. To the disadvantages of TPF scheme added can be the unawareness of users about the possibilities offer by TPF as well as lack or shortage of capital in general and unwillingness of banks and financing institutions.

EPC is not currently used as a business model for the private sector. Projects carried out with the use of EPC business model are performed mainly in the public sector. The public sector drives the EPC market and so far it is not pushing for high levels of savings in the EPCs which are tendered. Public contracts are chosen by the requirements of public procurement rules. In order to procure an EPC, a traditional call for tenders is not adapted due to the impossibility for the client to define the technical solutions, the duration of the contract and the level of savings beforehand.

Example of supporting EPC markets

Berlin Energy Agency (Berliner Energieagentur)

A number of measures can be implemented to increase the impact of EPC and its use for nZEB renovation. In order to structure the demand for EPC in the public sector, the existence of market facilitators acting as mediators between ESCOs and their clients has proved to be a successful approach. The "Energy Saving Partnership", developed by the Berlin Energy Agency (BEA) and Berlin's Senate Department for Urban Development, is a model for efficient energy saving contracting where private funding is involved in order to ensure energy efficient investments in public buildings. The aim is to tap the potential for saving energy existing in a pool of buildings ranging from 4 to 400, depending on the level of expected energy savings and construction date. BEA, which is a leading energy consultancy partly owned by the government of Berlin, manages projects (till EPC is signed by the cooperating partners) and prepares tenders for public and private buildings for work that will guarantee reductions in emissions.

BEA organizes retrofits for large government and commercial buildings by setting up EPCs between public buildings' owners and ESCOs. It is required that ESCOs which apply for the retrofit tenders must agree to obtain energy savings of around 26%. They can gain it by installing heating control systems, lights, insulation etc. The annual energy savings of 26% covers the cost of retrofit. BEA helps building owners and ESCOs to decide how the money will be paid back to the ESCO. The average payback periods are 8 to 12 years. BEA's energy partnerships are highly successful –they cost the building owner nothing and immediately deliver savings (C40 Cities – Climate Leadership Group, 2013).

The "Energy Savings Partnerships" have been the catalyst for EPC market in Germany. BEA developed a model that allows German municipalities to replicate the experience at national level. BEA was so successful that it turned the attention of the private sector which is now a competition for BEA activity of supporting public clients in the EPC signature process.

Energy Savings Partnerships are effective because the savings are guaranteed by contract. The energy investment is refinanced through the energy savings and the building owner also participates in the saved costs.

So far, ESCOs have invested EUR 43,125,882 in light retrofitting, energy control system, insulation etc. in 1,400 buildings. These buildings have made total guaranteed savings of EUR 10, 164,848 or 26% of the energy bills (Berliner Energieagentur, 2007).

4.4 Examples of innovative financial schemes for energy efficiency improvements

4.4.1 The Green Deal – UK

In the UK, since the beginning of 2013, The Green Deal has been launched. The Green Deal is a framework to enable private firms to offer consumers energy efficiency improvements to their homes and businesses at no upfront cost, and where payments are returned through a charge of instalments on their energy bills.

The program is intended to encourage house owners and owners of companies to use energy efficient technologies/solutions such as insulation of walls, exchange of windows, insulation of doors, installation of smart meters and installation of heat sources such solar collectors, heat pumps and biomass systems. Under the Green Deal, building owners and the tenants are able to order an energy efficient refurbishment of their property from a Green Deal Provider and fund it with a new type of loan.

The difference between The Green Deal and a conventional loan is that the bill is attached to the building where the savings come from, and not the payer of the bill. In addition, when the resident moves out of the building, he stops paying the energy bill (in addition the loan). This idea is based on the thought that people are less likely to stop paying energy bills then unsecured loans. It is expected that 26 million buildings will be renovated over the next 25 years, and buildings built before 1920' will benefit from the program the most.

How does The Green Deal work?

The initial steps of the program are individual meetings with Green Deal Advisers. Based on a visit to the property and interviews carried out with the owners of the building, the Adviser produces a Green Deal Adviser Report which recommends a solution suitable for the particular building and an estimates payback time. The Green Deal Adviser prepares and offers a valuation of recommended solutions. Both the choice of the offer as well as the decision on the number of implemented solutions depends on the property owner.

The Provider then prepares an action plan, within which the subject of the order and the payment system is described. The Green Deal Providers are approved by an supervisory body and are required to operate in line with a robust "Code of Practice". After the approval and signing of the plan by the owner of the property, the Provider arranges work for the installer, whose job is to implement the chosen solutions.

The loan repayments are not made directly to the lender but will instead be added to the property's electricity bill as a separate item. The loan is therefore repaid by the person

responsible for the energy bills, who will also benefit from the improved energy efficiency of the property. The energy supplier company then passes on the money to the Green Deal Provider. Because the loan runs with the property, not the person, the loan will continue to be paid even if the original owner or tenant who organized the refurbishment leaves the property. Of course, it is this mechanism which makes the scheme applicable to the rental sector (private or commercial) as it is the occupiers of the property (who of course could be tenants) who pay off the loan. The Green Deal process is illustrated in Figure 4 below.

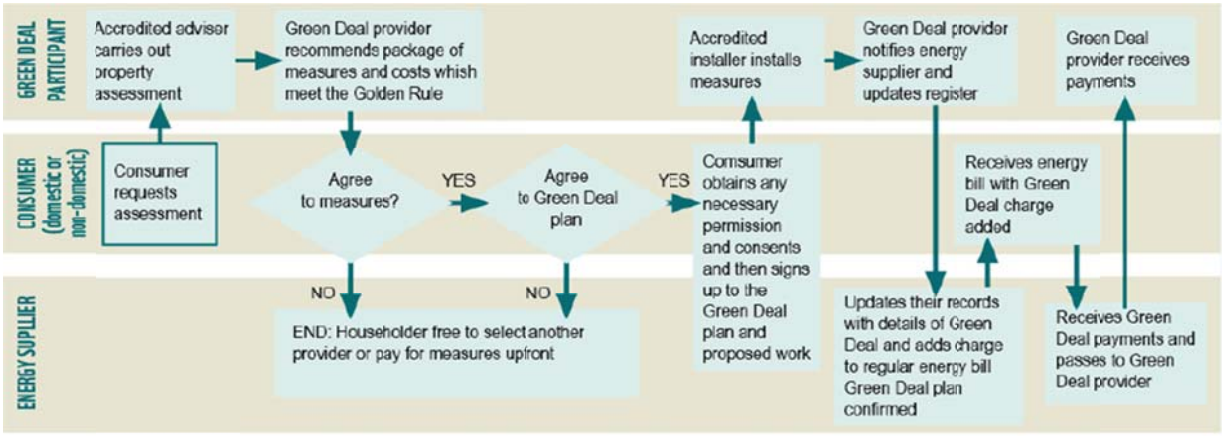

Figure 4: The Green Deal process (WWF Spain, 2012)

The Green Deal addresses some key barriers hindering very energy efficient retrofits. First of all, the Green Deal removes the requirement for upfront payment so neither owners nor tenants have to provide the money for the renovation. The Green Deal also recognizes that the building occupants may change – the person benefiting from the lower energy use is the person responsible for paying for the improvements. The split incentives barrier is also addressed in this scheme. Under The Green Deal, however, the tenants are the ones who will repay the loan (through energy bills) since it is attached to the property and it does not matter if new tenants move in every few months.

The program assumes that, by investing in energy efficiency solutions, households in England and Wales can apply for a partial refund (depending on the scope of solutions implemented) of the cost of investment under the "*Green Deal Cashback Scheme*". Since the beginning of 2013, more than 44 000 British households had met *with Green Deal Advisers*. Until the end of August 2013, 8 404 vouchers entitling for a partial return for investments were issued under the "Green Deal Cashback Scheme". 5 733 of them, with total value of 1.6 million pounds, has already been paid.

Much worse is the situation associated with the start-ups of loans, which were to be repaid by savings resulting from lower energy bills. At the end of August 2013, only 677 action plans for owners of households were prepared. This shows that relatively small numbers of Britons are interested in financing investments from the government program loans. However, it is still considerable progress since the end of May only 100 action plans were prepared.

One of the main objections to the Green Deal is high interest rate (7%), which, according to experts, discourages the use of credit. Interest rate of more than 7 % is significantly higher than available high street loans. This has led to some Green Deal Providers raising concerns about the high rates and that, unless they were brought down, the scheme would fail. The high interest rate has also raised concerns that the Green Deal will not meet its golden rule. The Golden Rule is a limitation that comes with the loan. Under this rule, the annual cost of any loan repayments must not exceed the anticipated annual saving in energy costs. Another limitation is that only certain measures are eligible for financing with Green Deal.

4.4.2 PACE – Property Assessed Clean Energy Program (USA)

United States have launched a program aimed at decreasing energy consumption in buildings. Property Assessed Clean Energy (PACE) programs are used by local governments to finance renewable energy and energy efficiency projects on residential, commercial and industrial properties. PACE programs allow property owners to avoid the high upfront cost of clean energy installations, such as solar panels, and other energy-saving retrofits by paying for these improvements over time through an addition to their property taxes (loans can be repaid up to 15-20 years). Under these programs, in general, a local government designates an improvement district and issues a bond secured by real property within the district. This district may follow municipal boundaries, but only those property owners who opt in PACE are subjected to financing.

Low interest, long-term loans are available for energy saving measures, which property owners are able to pay back while saving on their energy bills. The PACE model addresses the barrier regarding the return of money invested when the building is sold. Under the PACE plan, there is no up-front cost to the property owner and, generally, when the property is sold before the end of the repayment period the new owner takes over the remaining special tax payments as part of the property's annual tax bill. Four steps in the PACE program are illustrated below.

Figure 5: PACE process

The PACE concept was first introduced in Berkeley, CA, where a pilot program was approved in September 2008. Since then, PACE financing has been specifically authorized through legislation in 26 states, while 2 additional states were able to implement PACE programs without additional legislation. The state legislation that authorizes PACE may include residential PACE programs, non-residential programs (including commercial, industrial, and agriculture), or a combination of both residential and non-residential programs.

Developing PACE program brings benefits for the city such as promotion of energy efficiency improvements in buildings and reduction of energy costs for residents and businesses or stimulation of local job creation. It is also not a burden for the city's general fund. Moreover, the city can launch a clean energy financing program and recoup most of the costs of running the program through a pass-through to participating property owners. PACE can also develop the economy of the region. Local solar installers and renewable energy companies can be integrated as partners in the program (U.S. Department of Energy Clean Energy Finance guide, 2013).

The benefits of PACE for building owners are crucial. The key benefit is that the PACE program neither includes taking a loan nor relies on or draws down a property owner's available credit line. Another advantage of PACE is that the repayment of the investment is attached to the building and not the owner of the building (the same solution as in The Green Deal). This solution solves the barrier such as long payback time for energy efficient renovation investment. As it has already been mentioned, longer payback time hinders the implementation of nZEB renovation. Many investors/house owners would rather invest in short payback time investments because they bear in mind that they might move out of the house and they would never get a return on the money they invested for the renovation. The average Americans move out of their home every six to nine years while the repayment for energy efficient retrofits and solar investments will probably take much longer (depending on energy price, about 15-30 years). This is why seamless transferability of financial obligation is a crucial benefit of the PACE program. Unfortunately, a drawback of PACE is that it is directed at house owners only, renters cannot participate in the program.

4.5 Conclusion

Many countries face similar challenges when it comes to financing nZEB renovations. Some of them have adopted a series of measures to resolve the key financial barriers hindering more energy efficient renovation of residential buildings. There are many financial instruments/schemes that have been implemented in different countries either on national or local level. However, the problem is not the lack of financial instruments but the level of energy efficiency ambition associated with available instruments.

The mentioned financial schemes launched in Germany, United Kingdom and USA can be set as examples of financing energy efficient retrofits. However, these mechanisms also have drawbacks. It seems that the political willingness to make very energy efficient renovations a common practice is important. nZEB retrofits should be a central objective and the requirements for obtaining the financial support should be more ambitious. For now, nZEB renovations are just an option.

In many countries, in order to benefit from the grants only 20 or 30% of energy reduction is required. Unfortunately, this does not make the buildings nearly zero energy consuming in a majority of cases. Many investors fulfil the lowest requirements in order to receive the financial support. This is not a bad thing as every energy efficiency improvement is needed.

However, higher level of ambition is possible and most of all needed in order to reach EU objectives. The level of ambition of financial programs needs to rise in order to have greater impact and unlock further private investment for nZEB renovation.

Public authorities, above all local and regional authorities, have a leading role to play in setting up financing schemes. They need to be able to identify the schemes which are adapted to their objectives and to their local context, and to understand the overall process to implement them.

This input provides a general overview of possible solutions which can be used to finance energy efficient renovations in buildings. Although there is not any perfect nZEB renovation financial scheme, the existing instruments could be consolidated in order to make one. The coming years should concentrate on the replication and multiplication of innovative financing schemes in order to create clear business cases understood by both public authorities and the financial community. Therefore, the adaptation of the legal and policy frameworks to allow the development of those schemes is needed.

5 Methodology

The methodology for identifying the common barriers and challenges in the participating countries - Sweden, Spain, France, Norway and Poland - is based on qualitative techniques consisting of workshops and/or semi-structured interviews with key stakeholders involved in renovation projects, which may consist of architects, building owners, residents or construction contractors. The Interviews and workshops have been adjusted to the stakeholder groups depending on the type and quality of information that they are expected to provide in identified projects.

The methodology addresses the objectives of this study by focusing on 1) identifying common *barriers* at the decision-making level in the renovation projects which did *not* have high energy efficiency improvement goals, that is, why not higher energy efficiency goals were adopted, and 2) identifying common *challenges* in current practice of retrofitting processes, in the renovation projects with high energy efficiency goals.

The pre-identified five major challenges/barriers – technical, financial, social, environmental/health and organizational/legal –provides the delimitation in this study of common barriers and challenges in current nZEB practice.

5.1 Selection of renovation projects

A number of projects, based on the objective of the study, have been selected in each participating country. The selection of projects was based on the following criteria's:

1. Non-nZEB renovation projects – where energy efficiency was discussed and carried out but not at the level of nZEB renovation. The projects are in their final stages or completed.
2. nZEB renovation projects – where high energy efficiency goals were set (nZEB, passive house level or low energy building level). The projects are in their final stages or completed.

For non-nZEB renovation projects, between 2 – 8 projects have been selected in each country (the number depending on the availability of projects in each country). For nZEB renovation projects, between 0 - 5 have been selected (the number depending on the availability of projects in each country).

For all renovation projects, key persons, i.e. for the renovation project central individuals with good insight to the decision-making process or renovation process, have been identified.

5.2 Workshops and interviews

The collection of empirical information have been carried out in two forms, workshops and/or semi-structured interviews, which was adjusted to key persons and the expected information received as a result. The collection of data has either been based on a

combination of workshops (for identifying barriers in decision-making) and interviews (for identifying challenges in the retrofitting process) or solely on interviews, depending on the availability and geographical spread of key persons in each country.

In total, 35 interviews[5] have been carried out with key persons from nZEB and non-nZEB renovation projects. Each interview has taken approximately one hour and the interviews have been carried out both face-to-face and by telephone. Furthermore, one workshop with 13 participants has been carried out in France, in addition to interviews.

To enable comparability of the results as well as to simplify the reporting of the findings by different interviewers, a flexible interview framework and tool has been used for the workshops and interviews and the summary and analysis of the same (see 5.3. Interview Framework and Appendix 1. Interview Framework Tool). Suggested workshop/interview guides have also been developed (see Appendix 2 and Appendix 3) and adapted and used by each partner. The framework and guides are structured around the five pre-identified challenges/barriers as previously described

5.3 Interview framework

In total there are five pre-defined challenges/barriers regarding nZEB renovation. For each challenge/barrier a flexible checklist with clarification has been created to ensure the usability by all participants/interviewers and comparability of the results (see Table 2). A more comprehensive interview guide for guiding the semi-structured interviews and workshop is available in the Appendix 2 and Appendix 3.

[5] Sweden: 10 interviews, Spain: 11 interviews, France: 4 interviews, Poland: 3 interviews and Norway: 7 interviews.

Table 2: Interview framework

Barriers & Challenges	Content (example)
Technical	• Performance level • Applicability of the technical solutions • Compatibility between different technical solutions • Availability and quality of technological solutions for energy efficient retrofitting of buildings and districts • Maintenance , durability and warranty • Level of knowledge
Financial	• Investment cost • Access to financing • Business models and financial schemes • Payback period/profit • Financial incentives • Energy price
Social	• Involvement of residents • Acceptance among residents • Level of knowledge among residents • Living conditions during the renovation process • Change in quality of life after the renovation • Added costs to the residents • Energy use behaviour of residents • Cultural values
Environmental and health	• Optimisation of the building envelope and technical systems (heating and ventilation system) • Integration of the building energy systems with the district level • Building materials and waste (chemical content, emissions, recycling) • Life cycle perspective in design • Quality of the indoor environment (light, thermal comfort, air, noise) • Noise and dust during the renovation process
Organisational and Legal	• Renovation steps • Time plan • Business agreements • Communication between partners • Laws and regulations

5.4 Summary and analysis of the results

The workshops and interviews, based on the Interview framework and interview/workshop guides, have been performed in the respective language of each country by an individual interviewer selected by a partner in each partner country. In order not to lose important information during the semi-structured interviews, the interviews/workshops were recorded

and/or detailed minutes were taken. With help from the Interview Framework Tool (see Appendix 1), the results from the workshops and interviews were then summarised and analysed and the results presented per country in a report (in English). These country reports are found in chapter 6 below.

6 Barriers and challenges in current practice in Europe

6.1 Barriers and challenges in current practice in Sweden

6.1.1 Introduction

In Sweden, several residential renovation projects with very high energy efficiency goals (nZEB) as well as projects with energy efficiency goals not reaching nZEB levels (non-nZEB) were identified[6]. Many of the renovation projects have included several buildings, i.e. neighbourhood renovations, whilst others have focused on one building. In total, 10 interviews over telephone have been carried out with key persons in 4 non-nZEB and 5 nZEB renovations[7] in order to identify and discuss challenges and barriers regarding residential nZEB renovation. The summary from the interview below reflects the answers given by the individuals interviewed in respective projects, and do not represent all nZEB or non-nZEB renovations in general in Sweden.

Concerning renovation projects with high energy efficiency goals (nZEB renovations), six projects were identified and contacted of which five[8] agreed to participate in the study. All nZEB renovation projects included have a measured or expected energy use of between 50 – 65 kWh/m2 (A_{temp})[9] after the renovations. Four of the renovation projects have included several buildings (between 150 – 550 apartments) and one included one building (90 apartments). The ownership structure of the included projects are both public housing and private property companies (rental apartments), but with a majority of public housing.

For renovation projects with energy efficiency goals not reaching nZEB levels (non-nZEB renovations), five projects were identified and contacted of which four[10] agreed to be part of the study. All non-nZEB renovations projects included have achieved or expect a reduction of energy use between 35 – 50%. However, all of the projects have or will have an energy use higher than 80 kWh/m^2 (A_{temp}) after the renovation. Three of the projects included more than one building. The ownership structure of the non-nZEB renovation projects are both public housing and private property companies (rental apartments), but with a majority of public housing.

6.1.2 Barriers in the decision-making process

The respondents from non-nZEB renovation projects all state to have different focuses for their renovation which provide different conditions regarding economy and implementation.

[6] For this study in Sweden, energy consumption under 70 kWh/m2 (Atemp) has been the definition for nZEB renovation. Levels above 70kWh/m2 (Atemp) are seen as non-nZEB renovations.
[7] For one nZEB-project, two key persons were interviewed.
[8] nZEB renovation projects included in the study is Gröna Gatan (Uppsalahem), Brogården (Alingsåshem), Maratonvägen (Halmstad Fastighets), Giganten 1 och 7 (Apartment Bostad), Katjas gata (Poseidon).
[9] Including: heating, hot-water, building services energy and comfort cooling. Household electricity is not included.
[10] Non-nZEB renovation projects included in the study are Pilothus Ålidhem (AB Bostaden), Orrholmen (Karlstad Bostäder AB), Kvarteret Örnen (Akelius Fastigheter AB) and Klackvägen Solberga (Stockholmshem AB).

The different focuses are exterior maintenance, energy efficiency measures and new plumbing.

Technical barriers

The availability of technical solutions on the market was in general not seen as a barrier for energy efficiency renovations as the technical solutions exist on the market and the, often vague, energy saving goals have been possible to reach without greater technical challenge. Only one respondent from one non-nZEB renovation project, carried out around 10 years ago, experienced that the availability of technical solutions was a problem as the range of technical solutions was limited at that time. Since then, the development of technical solutions on the market has been fast.

The measures implemented in the non-nZEB renovation projects have been based on today's knowledge on energy-efficient buildings and available technical solutions, which means that relatively simple actions can have large impact on the buildings' energy performance resulting in a reduction of energy use with up to 50%. However, for the interviewed non-nZEB renovation projects put together, a 50 % reduction of energy use would still mean that the actual energy consumption will be around 100 kWh/m^2 (A_{temp}) after the renovations.

The existing technical systems as well as the structure and condition of the building renovated have had significant impact on the choice of technical solution for the non-nZEB renovation projects as well as the possibility for an nZEB renovation. For many of the projects, given the existing technical systems and the building's structure it would have required such extensive and expensive measures to reach nZEB levels that an nZEB renovation would have been unrealistic. Overall, in order for the non n-ZEB renovation projects to reach nZEB renovation levels more comprehensive actions are required which is expressed by the respondents as a costly technical barrier that has not been possible within the financial framework the projects.

Financial barriers

The non-nZEB renovation projects have different focuses for their renovations and the financial decision-making process also differs. For example, the project focusing on exterior maintenance with added energy saving measures had to implement measures within the budget for maintenance. For the projects with focus on energy saving, the measures had to be funded with the reduction of costs as a result of the future savings. These measures were implemented without any substantial increase of rents after the renovation, which has limited the scope of the projects and represented a major challenges regarding profitability.

The public housings are legally operated businesses meaning that the renovation measures must be economically viable in the same way as for private property companies. However, public housing also has an explicit social responsibility to provide residents with affordable

housing. For one of the non-nZEB renovation projects, a management directive had been adopted by the board saying that renovations could only result in a maximum of 10% increase in rent.

The often vague goals for energy efficiency measures mean that the selected measures are based on economic conditions rather than efficiency goals. Therefore, no need to develop new profitability- or financial models was expressed by the respondents. Also, as energy efficiency measures were not the first priority future energy prices were not of highest concern for most of the projects.

For two of the non-nZEB renovation projects, Project Partnering[11] has been used as business-model. One respondent underlined that this way of working was successful as all partners strive towards the same goal resulting in all involved partners benefiting from the best possible result since the model is based on shared responsibility for the outcome.

Two of the public housing non-nZEB renovation projects were pilots for the subsequent renovation of a larger area. Various technical solutions were tested to see results in energy saving and economy. For one of the projects, the measures tested in the pilot would have resulted in increased rental costs up to 50 %. As a result, the respondent told that measures had to be removed from the list of actions to be performed in the subsequent large-scale renovation resulting in lower energy efficiency goals. The extensive work undertaken in the pilot house was only profitable thanks to grants from a government initiative.

In general, finance has been a major challenge in the non-nZEB projects. The technical solutions implemented are evaluated and compared in order to achieve maximum benefit for the money, i.e. the choices of technical solutions are based on the best economic yield. One respondent emphasized the need for government loans with favourable terms which would help to take a more comprehensive approach in energy efficient renovation of a building.

Social barriers

None of the projects experienced any social challenges regarding the renovations which may relate to the fact that the tenants had the opportunity, in all projects, to remain in the apartment during the renovation. The involvement of tenants early in the process is expressed by the respondents to be a key factor to success. The level of involvement depend on how affected the tenants were of the measures. In most cases only a few measures were undertaken inside the apartments which meant that the effect on people's everyday life was limited. In the case where extensive measures were implemented indoors the respondent

[11] Project Partnering is a business model where the building owner and entrepreneurs go into a form a partnership with common goals in which all aspects of the project are shared between the organizations involved in the project, often also the economy. All partners are involved already from the design phase and a lot of effort is put into communication and dialogue between project partners.

underlined the importance of comprehensive information to the residents about the renovations impact on the living environment.

As only small or no increase in rent was one basic prerequisite in the majority of the projects, hence, increased rents was not a social barrier.

The historical and cultural value classification of certain areas and buildings, decided by the municipalities, has affected all of the renovation projects in various degrees. For one project, the cultural value of the exterior façade made it impossible to add insulation to the exterior building envelop, and as an interior insulation was not profitable, the project could not lower the energy use by adding insulation which affected the buildings energy performance after the renovations.

Environmental/ health barriers

In general, the non-nZEB renovations projects in Sweden have high environmental criteria's for materials and waste, but this does not differ from other renovation projects.

The interviewees underlined that the environmental assessment methods that were introduced to the market around 2008 has simplified the work to choose materials with low environmental impact significantly. Today it is industry standard for contractors to choose materials from these databases when performing renovation projects and it often causes no additional cost.

In some cases, an improved indoor environment has been one of the factors deemed important by the project decision-makers and highlighted early in the decision-making process. In other cases, the respondents state that it has been a positive consequence of the measures undertaken.

Organizational and legal barriers

The projects have used different kinds of contract forms; general contract, all-in contract and divided contract. Respondents have underlined the benefits of all-in contract where all participants work together early in the process. This has had large impact on the decision-making process when all partners experience is shared before any decisions are made.

The technical knowledge differs between the different property owners; the public housing companies possess their own technical expertise within the organization while the private property company does not have this expertise. It is unclear whether this has affected the decision making process in the projects but for the public housing companies this is emphasized as a safety in achieving good results.

6.1.3 Challenges in the retrofitting process

Technical challenges

The existing technical systems as well as the condition and structure of the building prior to the renovations have significant impact on the choice of technical solution (given that the existing systems are not fully replaced). A considerable technical challenge highlighted by most respondents has been to find the technical solutions compatible with the existing building and its technical systems, and to adapt the solutions to the particular building.

The technical solutions needed are in general available on the market but many respondents expressed a need for more easily accessible and cost-effective solutions on the market with better performance levels, for example regarding additional insulation. At the same time, the fast development of technical solutions in connection to nZEB renovations on the market was also underlined; solutions are quickly becoming better and cheaper, with the implication that new calculation and decision on technical solutions often needs to be made for each new building in large –scale neighbourhood nZEB renovation projects.

Another factor with significant impact on the choice of technical solution was the maintenance of the technical solution. Reduced maintenance needs and decreased maintenance costs were important aspect of most projects' profitability. Also, most projects are carried out by public housing or private property companies that have a long-term ownership perspective for their apartments why it has been important that the technical solutions chosen are sustainable and durable.

The lack of comprehensive understanding among contractors of the overall technical systems and how to adapt them to the particular building was also highlighted by several respondents as a major technical challenge. Most contractors are very good at their particular area, respondents put forward, but lack the overall understanding of the technical systems and building. This was especially evident in connection to the commissioning of the technical systems where several projects experienced a low level of knowledge among the appointed contractors on how to make the different technical systems and solutions to work together in the particular building. This had the implication that the commissioning of the technical systems was more time-consuming than anticipated. As the choice and combination of solutions are often unique between projects and nZEB renovations are still relatively uncommon, most contractors have had little prior experience of such renovations. However, with the increasing number of nZEB renovations projects, the knowledge and competence of contractors are increasing.

In general, the respondents emphasized that all actors involved in the nZEB renovation projects have increased their competence and knowledge regarding energy efficient renovations during the renovation process. The lack of knowledge among involved partners initially concerning issues related to energy efficiency was often overcome by early common educations and communication due to the use of Project Partnering business-model.

Financial challenges

The nZEB renovation projects included in this study were all carried out by larger public housing or property companies with good economy and customer base in metropolitan areas, why access to finance has not been a challenge.

The main financial challenge for nZEB renovations, expressed by all respondents, has been the profitability of the projects, i.e. to make the project financially justified. The profitability depends according to the respondents on, among other things, the requirements of yields and return of the investment by the public housing or property company in question but also on the building's prior condition and extent of renovation needs. The nZEB renovation projects included here have solved the issue of profitability in different ways, for example, by using "total renovation" where non-profitable solutions have been financed by more profitable solutions, by developing new financial- or profitability models and ways of calculating the return of the investment that is more compatible with the current long-term renovation needs, or justified the added costs with reference to e.g. social sustainability and/or improved indoor air quality and climate. In the end, not all nZEB renovation projects turned out to be profitable. However, the respondents of those nZEB renovation projects pointed out that the experiences and lessons learned have been used for subsequent renovations that in turn have become more profitable while maintaining the high energy efficiency goals.

One respondent also experienced that they had to put a lot of effort in justifying the investment costs and the choice of technical solutions, especially when added costs have been justified with non-financial benefits, such as social sustainability.

In three of the large-scale nZEB renovation projects, the tenants did not stay in their apartments during the renovation. A financial challenges underlined in relation to the evacuation of tenants was the loss of revenue from rents. Large-scale renovations are often preceded by a letting stop or use of temporary contracts several years before the start of the renovation as apartments need to be emptied for the renovations and evacuations.

Project Partnering[12] was used as business-model for carrying out the renovations in most of the selected nZEB renovations. The use of Project Partnering was described by the respondents as a very good business model where partners strive towards the same goal, however, it was also pointed out that Project partnering is more time-consuming than traditional business models, especially in the design phases of the project. One respondent expressed a considerable challenge in justifying the use of Project Partnering.

[12] Project Partnering is a business model where the building owner and entrepreneurs go into a form a partnership with common goals in which all aspects of the project are shared between the organizations involved in the project, often also the economy. All partners are involved already from the design phase and a lot of effort is put into communication and dialogue between project partners.

The impact of current and future energy prices differs between projects. One respondent state that increase in expected future energy price was the main reason for carrying out a very energy efficient renovation, in order to "build away" economic risks. Other projects had other driving forces for the high energy efficiency goals.

Moreover, there is a lack of financial incentives in Sweden for choosing higher energy efficiency goals. Many of the interviewed project, however, have joined EU or/and national initiatives, that often provide financial incentives (such as BEBO, Beem-up and E2rebuild).

Social challenges

For all nZEB renovation projects, the acceptance among the tenants for carrying out the renovation was expressed as unproblematic. However, initial worries among the tenants in the start-up phase of the renovations were reported. Respondents underlined that communication and information is a key success factor for increasing the acceptance for the renovations among the residents. All respondents reported that the projects all worked with communication and increasing the acceptance but in different ways, e.g. by having dialogues meetings, sending out periodical newsletter, having specially appointed contact persons (so called "Renovations hosts" or "Renovation coordinators") or by illustrating the new standard using demo-apartments. To use a pilot project as the starting point for a neighbourhood renovation was also expressed to be efficient way to communicate the renovations to the larger group of residents in the area.

The nZEB renovations have implied an increase in rents for the tenants, however, this is not seen as a barrier for nZEB renovations by the projects. The Swedish Tenant Act limits the increase of rents after the renovation and the rents are often negotiated with the Association for Tenants that represents the tenants. Often, the tenants also need to approve the renovation before it is carried out, i.e. the acceptance for the renovations needs to be high from the start. Again, the necessity of information and communication was underlined by the respondents. If the tenants have an understanding of the project and the reason for increased rents, they often accept the new rents. In one project, economists were used to discuss the impact of higher rent on private economy with each household in the affected houses. In some project, a rent-free month or phased rents were used to lower the impact of increased rents. However, it should be noted that not all tenants chose to move back to their apartment after the renovation for different reasons, including that they could not afford the increased rent, and that disputes occasionally are dealt with by the Regional Rent and Tenancies Tribunals.

For the nZEB renovation projects where the tenants stayed in their apartments during the renovations, one of the greatest social challenges expressed was the careful planning for how the renovation process impacts the tenants. On the other hand, the long evacuations for the tenants on up to 10 months in the other projects were also explained as a challenge needing careful considerations.

The energy use behaviour of the tenants have, in many cases, significant impact on building energy performance, an impact that often increases the more energy efficient the building. In several projects, individual meters have been installed and debiting for hot water established after the renovations to reduce energy use, with an initial decrease of hot water use between 25 – 50%.

Depending on the regulations in the specific area and for the specific building(s), cultural conservation values can be a limiting factor with impact on the choice of technical solutions, especially regarding changes to the outside structure of the buildings. For example, one project was unable to install planned ventilations shaft on the roof of the building as the silhouette and façade of the building could not be changed due to conservation values.

Environmental/Health challenges

In general, the nZEB renovations projects in Sweden have high environmental criteria's for materials and waste, but this does not differ from other renovation projects.

All respondents point out the improvement in indoor air quality and environment after the renovation as an important aspect also for the choices of technical solutions. In one of the nZEB renovation projects, however, the renovation increased the risk of damages due to damp as a result of low level of knowledge about the effect on indoor humidity when changing the building envelope. Actions were taken after the renovation to deal with the increased risk.

Aspects such as noise and dust are underlined by respondents as important to be considered during the renovation process, especially when tenants remain in the apartments during the renovation.

One challenge, highlighted by one of the respondents, was the difficult environmental balance between generating waste and increasing energy performance. For example, to replace the windows of the building (instead of, for example, adding insulation) increases the energy performance of the building but also generates more waste with an environmental impact. Which aspect is more important?

Organizational and legal challenges

The Swedish Tenancy Act limits the number of years an apartment can be used for temporary tenants (with no permanent contracts) e.g. to be used as evacuation apartments. The upper limit is 4 years, which can become an obstacle for large scale nZEB neighbourhood renovations as the same apartments might need to be used as evacuation apartments or be rented with only temporary contracts for a longer period than 4 years. The Swedish Tenancy Act also limits the possible increase in rents after the renovations which can influence the projects' profitability.

The conservation value classification of certain areas and buildings, decided by the municipalities, can also be seen as a legal barrier as it limited the possible solutions for energy efficiency.

An organizational challenge expressed concerns the internal organization of the public housing or Property Company. When carrying out large-scale nZEB renovations, the organization and staff need to adapt to new working processes and work tasks. For example, additional administrative pressure can put on the unit in charge of rental as tenants need to be evacuated.

6.1.4 Discussion and conclusions

In Sweden, several nZEB renovations on both building and neighbourhood level can be found and more are underway. Many renovation projects with energy efficiency goals not reaching nZEB levels (non-nZEB) were also identified.

The main barriers raised by respondents for taking a decision on carrying out nZEB renovations are mainly financial. For the interviewed non-nZEB projects, the renovations had to be financed within the budget for maintenance and/or by the energy savings which limited the scope of the renovation and the possibility for nZEB renovation. To have higher energy efficiency goals would have been too costly given the existing technical systems and building structure. A considerable increase in rents was not, for different reasons, an option for the non-nZEB projects in order to further increase the energy performance after the renovation. This differs from the nZEB renovation project, where increased rents have been an important condition in order to achieve higher energy performance levels. Furthermore, the lack of financial incentives in Sweden for choosing higher energy efficiency goals was highlighted by both the non-nZEB and nZEB renovation projects.

For the retrofitting process of nZEB renovation projects, several challenges were highlighted by the respondents related to technical, financial, social, and environmental/health and organisational aspects. Technical challenges include finding technical solutions compatible with the buildings' existing technical systems and structure, and to adapt the technical solutions to the particular buildings. In general, the technical solutions are available on the market but more cost-effective solutions with better performance level are requested. Furthermore, the lack of knowledge within the construction sector, especially regarding how to commission and optimize the technical systems as a whole, was identified. Similarly to non-nZEB renovations, the profitability has been a considerable financial challenge for the nZEB renovation projects. Increased rents have been a part of all nZEB renovations to be able to proceed with the renovations, but the nZEB renovation projects have also, for example, further developed their profitability models to take into account the current long-term renovation needs, or justified the added costs with reference to e.g. social sustainability. The loss of revenue from rents due to long evacuations in connection to large scale nZEB renovations was also identified by the respondents as a challenge. Concerning social challenges, the acceptance among tenants for the renovations and increased rents has

been seen as relatively unproblematic, often as an effect of extensive information campaigns and dialogue meetings. However, it should be noted that far from all tenants decide to move back or stay after renovations for different reasons, including that they could not afford the increased rent, which should be seen as a social dilemma. Another limiting factor for both nZEB renovation projects and non-nZEB renovations is the demand to conserve historical and cultural values which especially affects choice of technical solutions effecting the exterior façade.

To sum up, Sweden has started a development towards nZEB renovation both on neighbourhood level and on building level. The fast development of more cost-efficient technical solutions with better performance levels on the market as well as increase of knowledge in the construction sector as nZEB renovations are becoming more and more frequent is encouraging. However, several barriers and challenges need to be overcome in order for more widespread nZEB renovations. The financial challenges and barriers are particularly important to address. One important challenge is how to deal with the increase of rents. Today, it seems that the attitude towards increased rents after the renovation for better energy performance levels is dividing the non-nZEB and nZEB renovation projects. Increased rents can facilitate nZEB renovations but should also be seen as an important social challenge.

6.2 Barriers and challenges in current practice in Spain

6.2.1 Introduction

During the identification process in Spanish retrofitting projects, no nZEB-renovation was identified. The identified more effective renovation were A and B type certifications, so the *Interview to nZEB-renovation* was made to the identified national best practices.

Three best practice interventions were identified, the three of them with strong public funding (from European projects and public administration). The expected heating energy consumptions after renovation (there aren't cooling systems in the buildings) were: 40 KWh/m2 year in Bilbao (calle Cortes 32); 25.2 kWh/m2 year in san Joan de Malta (Barcelona) and 28.7 kWh/m2 year in Sestao Berri (Bizkaia).

For the non nZEB-renovations, eight interviews were fulfilled, two of them in Zaragoza and six more in the Basque Country. The usual energy efficient renovations (non-nZEB) in Spain implement the following energy efficiency solutions:

- Renovation of the passive aspects: envelop insulation, improvement of glazing.
- Implementation of efficient equipment: condensing boilers (for the community or independent) and solar thermal panels for DHW.

The performance of the buildings and comfort conditions increased drastically after renovation but they are still far from being an nZEB –renovation.

In interventions carried out in have led to reductions environ 50%-70% in heating. The high value of the reduction percentage is due to the initial very bad conditions of the Buildings. The average final heating energy consumptions is environ 75-85 kWh/m2 year. Only two of the eight buildings (located in Zaragoza) have cooling system. The initial cooling energy consumption was unknown but after renovation cooling energy consumption was of 2,2 kWh/m2 year.

6.2.2 Barriers in the decision-making process

From the interviews of non-nZEB projects the main barriers for deeper retrofitting have been identified.

The main barrier for the retrofitting with nZEB criteria are clearly the *financial barriers*. The main financial barriers are two: on the one hand the *investment cost*, and on the other hand the *access to finance* due to a lack of long term credit from banks.

The investment cost has been a clear barrier for more ambitious retrofitting and has determined the depth of the renovations. From the data we have, the investment cost for a nZEB-renovation is environ 40.000-50.000 EUR per dwelling. Without public funding this is not in general affordable for building owners, so long term credit from banks should be available to afford such an investment. But the access to these credits is very limited and no other business models are implemented to finance the investment costs.

The pay-back period is the second indicator that building owners take into consideration for the decision making about the implemented retrofitting solutions. Solutions with payback periods higher than 10 years are not considered interesting.

In the second place the most relevant barrier was the involvement of the residents or building owners. When retrofitting, the residents are concerned by accessibility aspects (architectural barriers, elevators, etc), habitability (moisture due to thermal bridges) or the aesthetics of the building. The improvement of the mentioned aspects is the main reason why they take the decision of retrofitting. The energy efficiency and the performance of the building are secondary aspects. There is a lack of involvement with energy efficiency issues from the owners. This is more accentuated when it comes to holiday apartments, and not to the principal residences.

The lack of involvement is linked with the lack of knowledge and awareness, because in general the residents don't see clear benefit in the investment, so the cost-effectiveness of the intervention should be very well proved.

Other types of barriers are also present but are secondary, such as the technical barriers. Within the technical barriers must be mentioned that some solutions can’t be implemented in building retrofitting due to a lack of space and common rooms for equipments’ installation (for example biomass, heat recovery systems or CHP systems) or when the compatibility with existing system is a requirement.

The historic buildings have their own difficulties, as they have special regulations and the aesthetic can't be changed, so many market solutions can't be implemented in this type of buildings.

6.2.3 Challenges in the retrofitting process

The summary of the findings from the interviews of nZEB projects concerning the faced challenges are described divided into the five identified aspects: technical, financial, social, environmental/health and organizational/legal challenges.

Technical challenges

Technical challenges are not a main issue in general when aiming to retrofitting with nZEB criteria.

The main technical challenge is the compatibility with the building existing structure and existing systems. When an integral retrofitting is planned the compatibility aspects are not a main challenge, because all systems can be changed and the structure can be adapted to introduce different systems. But when the structure is maintained, the existing structure and systems force to discard some performing solutions.

In Spain there are very few systems at district level, so the compatibility at district level is not usually a problem, as there aren't connections at district level.

The problem of compatibility is even higher with buildings with historical value, in which the structure and aesthetic of the façade can't be changed. So solutions specially developed for this type of buildings should be developed.

When energy efficiency solutions are selected "proven solutions" are required. The investment is high and the investors don't want to take any risk. So well-known solutions, with proven performance, locally available and with maintenance and warranty service are requested. State of the art solutions are not accepted by the market. The commitment of the technology provider is considered very important moreover with innovative solutions to be implemented.

Only research projects funded by public administration (typically European Projects) implement new and innovative solutions, so the role of these projects is critical to prove new solutions.

Another challenge is the level of knowledge of the construction professionals. They are used to place usually the same solutions. Solutions they know and feel comfortable with. So when a new solution is proposed, the construction planning is usually delayed and training of professionals is needed during the renovation process. Research projects also allow training the construction professionals in new products and techniques, but the impact is very low.

Finally in the cases of whole building retrofitting the bad state of the structure and foundation have had as consequence the need of higher investment and a delay in the planning.

Financial challenges

The nZEB-renovations carried out in Spain have had a strong public funding behind, so the investment cost hasn't been a barrier, and the renovation solutions have been selected based on the improvement of energy efficiency achieved with them.

But without public funding the retrofitting wouldn't be affordable for the building owners. So, the challenge is to retrofit with nZEB criteria without any public funding, with the investment of the building owners. As the long term credit is not currently available, innovative business models are required to finance these retrofitting.

The payback period is also relevant, but only if the investment money is available. If the investment money is available, the payback period is in many cases the indicator used to select one or other solution. So technologies or solutions with smaller payback period will have higher market penetration. As a consequence, technologies like PV integrated in façade, green roofs or façades, co-generation systems, etc. are more unlikely to be implemented.

The future energy price is uncertain but it will increase with certainty. Currently is not a main concern for the society, but it is an argument that helps to convince building owners in the investment.

In Spain there aren't fiscal incentives (such as tax reductions or exemptions) for energy efficient retrofitting or living in energy efficient buildings.

Social challenges

The involvement of the owners is a main challenge as they are the final decision-makers in the retrofitting process. The payback periods and the reduction of the energy bill are very relevant aspects to involve the building owners.

The lack of knowledge was one main challenge as it created a climate of distrust on the retrofitting solutions. Moreover during the last years the trend has been to have individual systems and to pay only for the self-consumption. The return to community systems has been a challenge, as many people didn't want to pay the common part. So raising awareness on the benefits of the common systems has been necessary.

In the Spanish renovations there weren't residents before retrofitting, so the living conditions weren't a problem. Only in one case there were residents but they were relocated by the administration. Nevertheless if the administration is not involved, we

foresee a real big challenge if the families have to be relocated. The acceptance of the retrofitting will be very low in this case due to the added cost.

For the same reason the quality of life was not a problem in the Spanish cases. In general, when the works are made from the outside, they are well accepted, even if they suffer noise and dust, because it is considered necessary. But when the works are made from the inside the acceptance is reduced.

In general the satisfaction of the residents after renovation was a success.

In one building renovation building owners have individual energy consumption meters and they have been trained in energy efficient habits (relevance of temperature set-points; turning off appliances instead of leaving them in *stand-by*; etc). They can monitor their energy consumption, what allows raising awareness on the benefits of energy efficiency systems and habits.

Environmental/health challenges

There weren't many challenges concerning the environment or health.

In the case of nZEB retrofitting, they were projects with high public funding and the energy performance of the building was an initial requirement. The design of the building was made considering it a whole system, and an integral solution was proposed in order to achieve the established goals with the most cost-effective solutions. The life cycle of the building was also considered in some cases to define the retrofitting solutions.

Different retrofitting approaches, lead to different solutions. In some cases energy efficiency is the most relevant aspect while in others, the sustainability is considered when designing the retrofitting. When the sustainability is considered then selection of construction materials acquire high relevance, and environmentally friendly materials are selected. The management of waste material is regulated by Spanish laws and the construction companies comply with regulation. But when the retrofitting is more oriented to sustainability the reuse and recycling of the material is prioritized.

The quality of indoor environment is oriented to the installation of low consumption equipment and appliances. During the renovation process the noise and dust of works imply to have the windows closed, so during the day the dwelling can't be ventilated, which is very common in Spain.

Organizational/Legal challenges

The main critical aspect is the dialog and communication with building owners. They are the final decision makers, and the negotiation is not collective but one by one. So dialogue and awareness-raising on the benefits of the nZEB is crucial for acceptance because new technologies cause distrust among residents. The interlocutor must have technical

knowledge but also communication skills. On the other hand the communication and dialogue among the professionals involved in the project has been fluent due to common interests and commitment with the research projects.

In parallel the business agreements have been complicated due to the current economic crisis because some tenants have mortgages higher than the market price of their dwellings, and they cannot afford the retrofitting.

Laws and regulations also have big effect on the renovation possibilities. In historic areas of the city the intervention possibilities are much reduced. And in the case of Spain a new draft law of electric energy is being prepared where PV technologies won't be cost-effective any more due to a strong tax load. The approval of the law (currently under discussion) would reduce drastically the implementation of PV technologies in Spanish buildings.

6.2.4 Discussion and conclusions

The most important findings with the Interviews are the following:

- In order to finance the nZEB –renovations, long term credits from banks should be available or innovative business models developed, because without any of them building owners can't afford the investment cost.
- There is a work to do in the involvement and awareness rising of building owners. The benefits of building energy efficient renovation should be explained with data including payback periods and reduction of energy bills.
- Moreover dialog and communication is needed with building owners to achieve agreements and to look for the common benefit above of the personal preferences. In this sense distrust to common equipment has been identified. The residents are reluctant to pay for common equipment because they are used to pay only for their energy consumption, so the benefits of common systems and solutions implementations have to be addressed.
- Innovative technical solutions are not well accepted by the building owners or construction companies. "Proven solutions" locally available and with maintenance and warranty are required. So in order to introduce new solutions in the market the public administration should play an important role of demonstration of the performance and reliability of the solutions.
- The Spanish draft law of electrical energy, if approved, will reduce drastically the use of PV panels in Spain because it will be economically of no interest to install PV panels.

6.3 Barriers and challenges in current practice in France

6.3.1 Introduction

During September and October, 2013, a workshop and four interviews were conducted. The group was recorded with the authorization of the participants.

The workshop lasted three and half hours and the interviews were on average one hour. There were 13 participants in the workshop who came from the following organizations:

- "bailleur social"[13] and the department of "bailleur social"
- City of Grenoble
- Local agency for energy and climate
- Energy advice to the city of Grenoble
- Two offices of Energy and Environmental Engineering
- CEA-INES

The four interviewees are contracted by the "bailleur social" and the architect department of 40 Arlequin as well as the "bailleur social" and the proxy company of design/building of 50 Arlequin.

There were a number of projects discussed in the workshop and interviews which are outlined in the below table as well as a description of the energy level before and after the renovation in each project.

[13] In the strict sense of the building code and housing, the bodies of "bailleur social" are builders who approval in conformance with the service of general interests defined mainly as:
- The construction, the acquisition, the improvement, the attribution, the management and the assignment of renting housing with put an upper limit rents,
- The realisation of operations of ownership access intended for persons whose income is lower than certain ceilings.

Table 3: Renovation projects in France

Company	District	Original building	Renovation	Energy levels before renovation	Energy levels after renovation
OPAC 38	Henri Wallon to Saint Martin d'Hères	1960s	2006 till 2009 - 354 renovated housing	Consumption heating and DHW (in 2003 - 2543 DJU) = 198 kWhep / m²shon / year	Consumption heating and DHW (in 2007 - 2495 DJU) = 109 kWhep / m²shon / year [45 %], actual consumption (observatory of rental expense)
ACTIS	Block of buildings and two towers of the Olympic Village to Grenoble	1968	2010 till 2013 - 500 renovated housing	190 kWh / m ².an (consumptions)	96 kWh / m ².an in objective[14]
SDH	Several towers and blocks of buildings of Village 2 to Echirolles	1968s / 1970s	2009 till 2012 - 642 renovated housing, and 211 demolish	150 kWh / m ².an (initial calculation)	96 kWh / m ².an in objective 76 kWh / m ².an measured
Agency Pierre BERNE and OPAC 38	Stendhal neigbourhood to Voiron	1955s	2011 till 2013 - 72 housing	245 kWh / m ².an (initial calculation)	96 kWh / m ².an in objective
GFC and OPAC 71	Aubépins to Chalon-sur-Saône	1950s	2011 till 2013 - Initial renovation of the 197 housing consisted of a tower and two building blocks	200 kWh / m ².an (initial calculation	96 kWh / m ².an in objective

6.3.2 Barriers in the decision-making process

Summary of findings from the workshop/interviews of non-nZEB projects are divided into the five identified aspects specified within this report:

[14] 96 kWh/m² correspond with Effinergie BBC Renovation label

Technical barriers

- The improvement of the natural ventilation by humidity sensitive air inlets, works well on towers of 9 floors. On the other hand, it works with difficulty on the buildings from 3 to 5 floors, because buildings lack of height.
- Unchanged outside joineries prevent insulation around bay windows and therefore, thermal bridges remained.
- There were challenges in processing airtightness as a result to the installation of joineries in the renovation which had kept the frames of existing joineries.
- Monitoring the installation of thermal solar energy shows that the installation works but there are challenges, e.g. poor maintenance.
- The humidity sensitive ventilation with air inlets and extract is to be removed if the "bailleur social" does not take a maintenance contract. By experience the tenants do not clean the air inlets and as a result the renewal of air in housing is reduced.

Financial barriers

- In 2009, the renovation cost on average 15 000 EUR by housing, today this cost has doubled. The impact of this increase in cost is that in the past the "bailleur social", for example, renovated a 1000 housing units a year, today it will renovate 450 to 500 housing units.
- Generally, when the "bailleur social" invests in renovation, it is the tenants who gain the financial benefits. This is part of the social mission of the "bailleur social".
- Concerning the grey energy[15], the renovation of buildings is very interesting. On the other hand for the "bailleur social", except operations ANRU[16] (State subsidy), and other subsidies, renovation is not funded unlike new construction.
- The thermal retrofit must be accompanied by an upgrading of technical equipment. This upgrading can include plumbing (for example, pipes as waste water soil stack-up) and electricity for safety and such bathrooms up to standard. Thus thermal retrofitting of social housing as well as in private housing has to be made with an upgrade of other housing technical equipment to maintain a real estate property at market level compared to new housing. Otherwise, the gap between old and new housing will widen between too new housing BBC (low-energy buildings) and existing housing, depreciating de facto the existing housing and risking to cause the increase of the vacancy of these, or outright their demolition.
- The budget does not still take into account the embellishment of the building and visible investment levels implemented for renovation are not necessarily included, what the tenant does not understand considering the global cost of works

[15] Grey energy is the energy hidden in a product, i.e. the amount of energy required to extract that product from nature, or to cultivate, manufacture, package and transport it. Objects can conceal very different levels of grey energy: for example an apple that is grown locally or one that is shipped from New Zealand to Europe.
[16] National agency for the Urban Renovation (specific operations for urban renewal)

- The overall cost in the residential building for the building owner is by many parameters which have to be taken into account. The complexity of these parameters which overlap into each other prevents the consideration of this overall cost.
- The approach of life cycle is made by taking into account a life span. It is necessary to be careful on this life span, because other criteria can appear such as trends ("outdated" materials), use, evolution of regulations, safety, etc.

Social barriers

- The general consensus was that as sometimes tenant of these social housing have difficulty paying rent it is better that fees (heating, DHW, electricity, etc.) for tenants decrease.
- In the public sector (e.g. social housing), the increase of rent after renovation is limited and regulated. In contrast, in the private sector (housing in co-ownership), the lessor[17] can significantly increase rents to recover part of their investment.
- There is a challenge in changing the behavior of residents for energy efficient housing and their resistance to change. The question is how to change the behavior?

Environmental/health barriers

- To date, the examples of energy renovations do not take into account the LCA tool.
- The use of insulation with respect to criteria of eco-labels in the renovation of social housing is rare as they are usually quite expensive.
- The waste management of construction is a function of aimed targets which follows the criteria requested by the contracting authority. Sorting waste is difficult during a management of the construction site. Certain contracting authorities require an individual management of waste where every company removes its own construction waste.
- The "bailleur social" generally limits the humidity-sensitive ventilation to type A (which is the amount of specific extractions) because the levels of ventilation of type B are too low and thus lead to hygiene problems in housing.
- The "bailleur social" complains about a lack of technical solutions available to solve problems of acoustics between housings which arise as a result of treating the building envelope better (especially when changing joinery).

Organizational/Legal barriers

- In France, the thermal regulation does not exist. This requires political will and workable business models.

[17] In France the 'lessor' is the individual who leases the property (housing, house)

- “Bailleur social” report that the statutory requirements on processing of asbestos on construction site are difficult, if not impossible, the removal or the processing of the technical structure concerned on an occupied site.

6.3.3 Challenges in the retrofitting process

Summary of findings from the workshop/interviews of nZEB projects are divided into the five identified aspects:

Technical challenges

- There are challenges in the air tightness of building which requires many technical adjustments connected to the execution. Housing showcases provide a place where numerous tests can be done to explore what works which is essential to obtain the desired result.
- The contracting authority tends to have a high level of control of tasks without considering the true cost (time, travel, etc.).

Solutions to some technical challenges

- There are a number of ways of getting systems to work together to avoid wasted energy within singular solutions. The terraces of buildings can accommodate thermal solar energy for the production of domestic hot water as well as preheating housing. The resource in solar energy that is not used by the production of hot water is reusable because of the substantial reduction in thermal losses due to the reinforced insulation. The new conditions allow lowering appreciably heating curves and enabling preheating returns to the secondary network with a temperature between 25 ° and 35 °C. The control system must be adapted to optimize the operation.
- The creation of verandas in place of old balconies on buildings can feed into new architectural image of facades and can provide additional living space.
- The bioclimatic approach through passive solar verandas is an additional solution to insulation which is strengthened by the outside walls and improves natural ventilation.
- The waterproof flat roofs of building must be renovated with the implementation of a strengthened insulation.
- The experience of the contracting authorities, architects, engineering consulting, show that it is essential to plan:
    - simple, practicable design,
    - implement a prototype,
    - develop satisfactory prototype implementation of a series, with occasional or systematic testing,
    - provide good supervision of the construction site by the project management (that considers the true cost) and by contractor for self-compliance.

Financial challenges

- There is legislation not to increase rents for houses that are under the “bailleur social”. This is done so that the tenant saves on fees (heating, DHW, electricity, etc.). The savings are calculated by the “bailleur social” every year and half and the tenant is billed monthly on a separate line. This contributes to tenants shared savings.
- The global investment cost of a renovation is to a large extent supported by the “bailleur social”. The subsidies from Europe, regions within France, the community of municipalities, the municipality and others who contribute such as those regions and ADEME which support conducting a renovation with a BBC renovation label for low-energy buildings or a lower energy grade(BBC renovation +).
- Heating production is always collectively done in social housing in order to give some tenant an equal share of the heating charges m² of housing. This is done to avoid the overconsumption of certain housing and the "theft" of calories, for example, certain housing can be warmed by those surrounding it.
- The payback period for renovations is generally 40 to 50 years which does not allow for time for return on investment. On the other hand, it is always necessary to subtract before dividing to the real understanding of payback on improving energy performance. So, the works of embellishment must be removed from the global amount of the total cost of work before speaking about time of return on work related to energy.
- In general, the return on investment is difficult to achieve in a time period of 7 - 8 years. On the other hand, it is better to address the energy cost coming from sources such as gas and heating oil today rather than in the coming years.

Social challenges

- In the social housing, the support of the tenants is necessary however sometimes there is not sufficient support for energy retrofit projects. Information, dialogue and raising awareness is conducted with tenants at an early point of the project. Identifying “pain point” (tenants against the works, social problems) can be addressed during the renovation but the bottom line is education of tenants and training them on the basis of energy conservation.
- Generally, a meeting for the purposes to inform and raise awareness is done with tenants before renovation works begin. At the kick-off meeting, a tenant booklet is distributed and explained to tenant what is involved in the renovation operation. The project management is associated with the writing of this booklet.
- Tenant group meetings are conducted right up until works begin as well as during the renovation works. Large renovation projects are managed by the headquarters of the “bailleur social” with the support of their local agency. The resources that are made available take into account the demands of the inhabitants as well as liaising with stakeholders who are active in the renovation (e.g. contracting authority, project

management, building contractor). This support generally is called social project management of the renovation process.

- Before the launch of the project, the “bailleur social” asks tenants to designate a referent person from different climbing staircases of the building. This referent will be the person who will participate in choices related to the design phase and to the works.
- Follow-up with tenants is essential after the renovation. There is a turnover of about 10 to 12 % of tenants annually who take up social housing. It is thus essential to inform, to follow and to train the tenants before and after the works. An exchange between tenants and stakeholders is to be planned during the renovation works to establish and\or strengthen the link within neighborhoods.
- Mostly, the works of energy renovation are welcomed. There is a stumbling block as a result of the works take place on an occupied site, where the tenant stays in their dwelling during the renovation ("We're going household") and therefore their private life is disturbed. Social support is essential to the success of the renovation project.
- The renovation project must be prepared well, both from the point of view of design and in terms of construction, so that the work site is occupied for as short a time as possible in the apartments.
- User behavior cannot be relied on to reduce energy consumption and technical systems have to be simple. Safeguards exist to avoid waste, such as cutting off the heating in a room when the window remains open in winter and meters which monitors energy consumption remotely and is not accessible to the tenants
- It is difficult to get inhabitants to understand the regulation of systems – which does not imply necessarily a hot radiator though it may be 5°C outside.
- From an architectural view, the original “modénature” facades that were not necessarily respected in the life of the building can be restored at the energy renovation.

Environmental/health challenges

- The inhabitants first gain from the results of the renovation work on thermal comfort. Then, other comforts can be improved or degraded following systems such as acoustics, air quality and day-lighting.
- During the construction site of renovation, tenants are informed about the constraints and nuisances of the work.
- The environmental criteria at the level of the choice of materials are for the most part respected for painted walls through the “bailleur social” that have been less wear resistant.
- Attention is given to the chemical contents of the implemented materials in terms of constraints to construction (for example, smell of painting in an occupied site) or on statutory aspects (for example, fire resistance). In order to avoid pollution in housing, excluding the aforementioned painted walls without Volatile Organic Compounds

(COV), the distribution of heating can be made using multiple pipes with crimping and without soldering.

- The consideration of the chemical contents of the original material is made through diagnosis - diagnosis of the presence or absence of asbestos, lead, etc. in buildings required within French regulations.
- The attention of the “bailleur social” in the renovation operations concern firstly, good ventilation of housing. So, all the systems containing filters inside housing are excluded. For example, ventilations in dual-flow are reserved for high-performance building airtightness and are implemented collectively to avoid the maintenance in housing. There is no example of renovation with dual-flow for Controlled Mechanical Ventilation (CMV).

Organizational/Legal challenges

- The implementation of a blog where tenants inquire and exchange is a good means of communication. The complaints made by the tenants on this blog or in person are recorded and followed-up on.
- The participation of the state, the local and the territorial authorities in funding the work of energy renovation has to be done in cooperation with energy performance obligations. Certain operations which are 60 % subsidized have to have measurable result on the expected energy performance which are controlled by monitoring.
- Responsibilities resulting from strong requirement of a high performing renovated building neglect separate building contractors. The contracting authority solicits mostly a leader of the consortium or to a general contractor.

6.3.4 Discussion and conclusions

Conclusion of the most important findings:

- Currently, it is not the technical which limits the energy performance level; it is the economy which limits the technical.
- In the building, the works constitute a complex assembly of simple things (such as the implementation of a window with outside insulation) and what is limiting is the assembly of companies and their control over the works.
- For “bailleur social”, it is very important to balance the levels of old housing compared to new housing in order to limit the number of empty dwellings which can be expensive. This is essential in the asset management of a “bailleur social”.
- The positive vision of the medium and long-term future energy prices produced from district heating networks influence the choices of this type of energy.
- Three major success factors for a nZEB renovation are:
    - A simple design which is technically feasible on the construction site.

- A rigorous follow-up of works with contracts which are not pulled downward, with project management and companies that are structured, organized and have quality management competences.
- A follow-up after works validating the successful completion with an obligation to measure results.

6.4 Barriers and challenges in current practice in Poland

6.4.1 Introduction

Based on analysis of extensive data and opinions gathered from Polish experts, companies, organizations focusing on energy efficiency, renovated residential buildings that gained the characteristics of an nZEB have not been found in Poland. Therefore, this section focuses on identification of barriers at the decision-making level in the renovation projects which did not reach high energy efficiency improvement goals. Moreover, this section will answer the question why nZEB renovations and adaptation of residential buildings to zero or nearly zero energy consumption is difficult to achieve and not practiced in Poland. In order to collect the required information, key actors involved in the selected renovation projects were interviewed.

Interviews were conducted with two representatives of two Public Building Societies Ltd. and one representative of Establishment of Municipal Housing Resources. All of the interviewees were Directors of departments of investments.

Both of the Public Building Societies manage particular housing communities (to whom belong the renovated projects). The responsibility of Public Building Societies is to run all the technical documentation, outsourcing the development of an audit, choosing a contractor by tender, and supervising the construction works. Therefore, the interviewed directors have crucial knowledge on the barriers for not implementing nZEB renovations in Poland. Moreover, they manage more than 200 residential buildings each, this is why they have great experience regarding renovation of residential buildings. All the interviews were based on projects that were renovated but not to the level of nZEB.

During the decision making process, the investors of all mentioned projects did not take into account implementing an nZEB renovation. Additionally, such ambitious decisions were not taken in regard to other renovated buildings managed by the Public Building Societies. All investments implemented in the projects included into this analysis were standard thermo-modernisations. This is the general practice in Poland according to the opinions of consulted experts. These thermo-modernisations usually include, among others, insulation of exterior walls, roof and sometimes replacement of windows. Such thermo renovation usually reduces about 30% of energy consumption, and does not make the building an nZEB. All respondents agree that the reason for not taking into account an nZEB renovation is the higher cost of such investment and lack of knowledge about nZEB renovations. The main reason for implementing a standard thermo renovation was the reduction of energy

consumption of buildings which was very high because the buildings were very old not insulated and heat was escaping in large quantities.

6.4.2 Barriers in the decision-making process

Ownership structure of residential buildings in Poland

In order to understand who has influence on the decision making process a brief statement of ownership structure of residential buildings in Poland is needed. Illustrated below is the ownership structure of dwellings in Poland which is based on six main ownerships:

Table 4: Ownership structure of dwellings in Poland

Ownership	Influence on the decision making
Municipality	Dwellings owned by municipality and allocated to those people who request it as a specific form of social assistance. The decisions about renovation of the building are taken only by the particular municipality.
Housing co-operatives	Privately-owned dwellings or tenancy dwellings located in buildings constituting the property or the joint property of housing cooperatives. Decisions concerning renovations of the buildings are taken by particular residents who live in a building belonging to particular housing cooperative. The residents can submit a proposal for renovation, however, the decision process is multistage and the final decision is taken by the management of the housing cooperative.
State Treasury	Dwellings which are the property of public enterprises e.g. public scientific and research institutes, public higher education institutes (excluding catholic universities), art institute etc.
Supported Employment Enterprises	Dwellings staying as part of resources of Agricultural Property Agency, the Military Housing Agency under management of entities subordinate to ministers.
Public Building Societies (TBS)	Dwellings in buildings being property of legal entities having in their name „public building society" or the Polish abbreviation „TBS". The residents of buildings belonging to public building societies have little influence on decision making process because they are not the ones who choose the management of public building societies. Public building societies as a service company are very often hired by e.g. housing communities, as managers of their buildings.
Housing communities	Multi dwelling building or several buildings, in which part of or all dwellings represent separate ownership of each resident, confirmed by a relevant entry in the land and mortgage register. A housing community comprises of all owners of the premises. The decision about renovation in such buildings is taken by all residents. It often happens that housing communities hire private companies (TBS) which manage the building.

According to the report Housing economy in 2011, published by Central Statistical Office in Poland, the share of dwellings by forms of ownerships presents as follow: housing cooperatives dwellings - 40,1%, dwellings of private people in buildings belonging to housing communities 38,3%, municipal dwellings – 16,7%, supported employment enterprise – 2,1%, public building societies dwellings – 1.5%, the State Treasury – 0.8% , other – 0.5%.

Technical barriers

Respondents agree that the availability of technology on Polish market is not a barrier. For every year, producers operating in the construction sector expand their offer by including more energy efficient, passive materials and technologies. However, such materials and technologies are still very expensive. The problematic issue is the fact that there is no complex offer on nZEB solutions and technologies. There are individual producers of solar panels, heating pumps, photovoltaic panels but not as a complex offer.

The barrier that might be perceived as a technical, according to the respondents, is lack of sufficient knowledge about nZEB renovations among professionals: designers, developers and contractors. It is believed that this is an important aspect when talking about such renovations. There should be some promotional and educational actions intensified in order to publicize such renovations. It is expressed that most Polish designers are not qualified enough in preparing project documentation for nZEB renovation. Furthermore, problems occur when it comes to the practical application of theoretical solutions. The ability to use such solutions in practice is also important. There are also many negative opinions about the constructors. An nZEB renovation requires very specific and thorough construction works. In order to perform a good nZEB renovation, the employees must be well trained and educated so they would not make simple mistakes which could squander the energy efficiency of the building.

Experts in field of low energy building confirm that lack of knowledge, not only among investors but also constructors and designers, is one of the barriers hindering nZEB renovations in Poland. Many investors lack awareness and information about passive construction. Additionally, even the designers are still not persuaded to passive building and there is lack of education and training courses concerning nZEB renovations. Moreover, many constructors are reluctant to changing their technology. Also, lack of free training courses organized by technology providers hinders the realization of nZEB renovations in Poland.

Another technical barrier that hinders the implementation of nZEB renovation, mentioned by respondents, concerns the insulation of the basements. In Poland, traditional foundations of buildings are made from insulated footings with walls above the ground. In the old buildings, the layer of insulation on the ground floor or the ceiling of the basement was

usually 5 to 10 cm of Styrofoam or mineral wool. This insulation thickness and numerous thermal bridges caused during the construction of the building are the reasons for the heat escape. This is why, during the potential nZEB renovation, the ceiling of the basements would have to be insulated with at least a 10-20 cm layer. However, in many Polish residential buildings it is not possible because there are national technical regulations indicating the required height of the basement premises. There are many residential buildings in Poland with very low basements and it is sometimes impossible to add a 3 cm or 10 cm insulation to the ceiling. It is known that in order to gain a nZEB standard, the insulation of the basements is absolutely necessary. This is a very important technical barrier that might hinder nZEB renovations of residential buildings in Poland.

Another technical barrier that was repeatedly mentioned by the respondents would be the historic value of the buildings, particularly the front facades, especially in tenement houses which are numerous in Poland. Such buildings' front facades cannot be insulated from the outside. It would have to be insulated from inside of the dwellings and it is not as effective, not to mention the fact that this solution reduces the usable area of the flats. Moreover, the cost of interior insulation would be higher and it would not be possible with the residents living in the building during the renovation time. As a consequence the residents would have to be relocated for the time of renovation. In the view of respondents, the residents would not have easily agreed to it.

Financial barriers

The financial barriers are the main barriers that hinder realization of nZEB renovations in Poland. The main barrier is the high investment cost which is about 30% or even 40% higher compering to a standard thermo-modernisation. According to the respondents, the implementation of the idea of zero energy buildings is an extremely expensive investment mainly due to the need for costly technologies using renewable energy sources. Not only have the materials/technologies made such renovations more expensive, but also the project documentation. In experts' opinion, many Polish investors try to save money on project documentation, which is a wrong habit. It is known that buildings design and implementation documentation should be as accurate as possible in order to meet technical requirements. All respondents agreed that most Polish potential investors (building owners/residents) are not able to afford an nZEB renovation.

It should be indicated that there are no financial models or schemes supporting exclusively nZEB renovations in Poland. Within the on-going Thermo-modernisation Program two grants (financial support for projects aimed at increasing energy efficiency of buildings) are available: renovation grant and thermo-modernisation grants. In order to benefit from the Thermo-modernisation Program energy consumption must be reduced by 10 %, 15 %, 20 % or 25 % depending on the construction date and some other factors. However, the energy consumption of Polish residential buildings is very high compering to the western countries

of Europe. It ranges from 90 kWh/m2/year (for buildings built after 1998) to 350 kWh/m2/year (for buildings built before 1985).

Hence, reducing energy consumption of buildings by even 25% in order to benefit from the grants does not make the buildings nZEB and they are still very energy intensive. Most investors adapt easily to the conditions required to receive the mentioned support in Poland. Additionally, the amount of renovation/thermo-modernisation grant does not depend on the results gained in decreasing energy consumption, therefore most investors fulfil the lowest requirements and such ambitious goals as nZEB renovations are not practiced in Poland. Consequently, standard thermo modernisations are conducted most frequently in Poland. Due to lack of money (on all levels), the renovated buildings are usually very old buildings, which in autumn and winter lose significant amount of energy. In respondents view, the existing financial models for improving energy efficiency of buildings in Poland does not encourage implementing nZEB renovations. Much more ambitious requirements should be implemented.

Many experts think that the financing offered by Thermo-modernisation Program is not profitable for the future. In their opinion a thermo-modernisation of a building should cover all aspects related to its energy consumption. Unfortunately, in practice, thermo-modernisation is limited to improving thermal insulation of external walls, and in some cases, replacement of windows, very often without interfering with the heat source and the installation of central heating. From an energy saving point of view, these actions are incorrect. These buildings will still need renovation in a couple of years because, even after thermo-modernisation, as they still consume too much energy, much more than an average residential building in Germany or Denmark etc.

When it comes to housing communities the decision about renovation and its extent is taken by particular owners of the dwellings in a building or buildings. All residents pay an agreed amount for the renovation fund each month. If all the owners of dwellings feel the need to renovate the building, the money from renovation fund is taken along with a loan because it is usually not enough to cover the whole investment only from the fund. When the residents, as a housing community, take a credit for the renovation, the rise of fund rate acceptable for residents is no more then 2-5 zł/m2. This means that in most housing communities their members would never agree to perform a nZEB renovation because the loan would have to be higher, and the fund contribution would be higher in order to pay the loan back. Most residents cannot afford it. Respondents representing one of the housing communities confirm that it is already hard to persuade residents to a standard thermo-modernisation which is cheaper than a nZEB renovation. Many residents cannot afford to pay a higher contribution for the renovation fund.

A nZEB renovation would be even more difficult to realize when it comes to municipal buildings. The owner of them is the municipality. Therefore it is only municipality's decision whether to have a renovation of its residential buildings and to what extent. The cost of such

renovations is covered by the budget of the municipality. It is known that municipalities' budgets in Poland are not over flowing with money, hence, expensive nZEB renovations would be a challenge for them. In contrast to housing cooperatives or housing communities, it would not be possible to increase the rent rates in order to compensate the high investment cost because in municipal buildings the rent cannot be higher than defined by law. NZEB renovation's payback time would also be too long, even tens of years. The commune has to invest very carefully and try not to locate too much money in an investment, which will pay back in tens of years.

According to respondents, payback time for nZEB renovations can also be a hinder. When it comes to standard thermo-modernisations practiced in Poland, the payback time is usually about 10 years, whereas payback time of nZEB renovations extends to 20 years or more. When looking from an economic point of view, this is not encouraging.

Split incentives can also be a barrier especially in the case of municipal dwellings. The municipality covers all the costs of investments in this case, and the one who benefits from it is not the municipality, but the residents because they pay their individual energy bills themselves. In effect of the renovation the residents will pay lower energy bills and the municipality will be waiting tens of years for the return of the investment. In case of housing communities and housing cooperatives the investors are all the residents of the building and they would be the ones who benefit from it.

Most of the respondents think that energy price is burdensome for all residents. Moreover, it is expected that energy prices in Poland will increase in the coming years. The actions of the legislator and the energy market situation show that, in Poland, construction should be better, wiser and more energy efficient to the benefit of natural resources. Taking everything into account, Polish people see the rationale for investing in standard thermo-modernisation of buildings. Such investments are expensive but not as expensive as nZEB renovations, and bring energy savings.

The LCC/LCA analyses were not carried out in the projects investigated. In order to receive the grants mentioned, investors must only carry out an energy audit. The energy audit is a study on the basis of which defined is the scope of the development, technical and economic parameters of thermo-modernization project. The aim is to identify optimal solutions in the building, which will increase its energy efficiency and thus energy savings. Such thorough analyses as LCC/LCA are not required by law and, additionally, they are more expensive. Therefore, they are not applied commonly in Poland.

Social barriers

It is generally thought that lack of information and knowledge about nZEB solutions is one of the reasons for not implementing such renovations in Poland. The respondents are unanimous that there should be some promotional and educational activities which would

inform the society – residents of the buildings as well as investors - about the benefits that come with nZEB renovations.

The main social barrier that has been brought up by all respondents is lack of awareness of residents about energy efficiency. There is still a great deal of work needed in Poland in regard to promotion and dissemination the importance and benefits of energy efficient solutions. When residents hear about possible solutions such as e.g. the installation of heating pumps or solar panels which can lower their energy bills they seem interested. However there come the costs, and questions concerning living in such a nZEB: would it be comfortable, would there be problems with operating these new technology solutions? People are not familiar with it because there are not many good practices concerning nZEB renovations of residential buildings in Poland. There should be some intensive activities taken in order to publicize such renovations. Currently, there are no examples of nZEB renovations of residential buildings in Poland. The important role of the state in initiating programs and educational and informational campaigns aimed at raising public awareness of low-energy buildings has been pointed out by the interviewees. Many Polish residents do not realize that they live in uninsulated buildings, losing a significant amount of energy during autumn and winter. In the study of „Energy efficiency of my home", conducted in early 2013, more than half of Poles (53%) who were asked to assess the size of energy consumed for heating the house or apartment, has determined it is "normal". 15% of respondents considered it to be "low" or "very low". Only 29% of Polish people think that heating energy consumption is "high" or "very high". The authors of the report mention that currently 75% of flats and houses in Poland are not insulated, and their thermo renovation would reduce heat loss, which could result in a threefold decrease in the demand for energy needed to heat an average square meter apartment.

Potential lack of consent for nZEB renovations from the residents would be connected mostly, if not always, to the financial matters. If an investment such as nZEB renovation would cause the high increase of the contribution for renovation fund, most residents would not allow it. However, if the residents, potentially, would be able to afford an nZEB renovation they would probably agree to it, even if they would have to suffer from uncomfortable renovation conditions such as dust and noise etc. Unfortunately, there are a lot of problems with persuading residents to agree to a standard, cheaper thermo-modernisation. Nonetheless, the main barrier is the financial one.

Organizational and legal barriers

In respondents' view, there are many barriers regarding the structure of ownership of particular dwellings. Particular flats in buildings, that are part of housing communities or housing cooperatives, were sold to private people at different time. In consequence the owners of the flats had renovated their flats in different times. Particular house owners have the heating system which they chose when renovating the apartment while the others still use heating system that has been installed there since the beginning of the construction. In

consequence each flat in one building might have different heating systems. For e.g. in tenement houses, which were built before the war, there can be coal stoves in some dwellings and gas or electric heating in others. If particular residents renovate their own dwellings, it is hard later on to persuade them to renovate their heating systems again, especially if he/she has to cover the cost of it (even partially).

Respondents point out that, unfortunately, the same situation is when it comes to the exchange of windows and doors in particular flats. It is known that in order to gain a nZEB all of the windows in a building have to fulfil special, technical requirements, not to mention that they are much more expensive than normal PVC windows. Unfortunately, as already said, particular flats in a building belonging to housing communities or housing cooperatives are sold to private people at different times. Each owner exchanged the windows in his flat at different time. Some flat owners did not decide to exchange the windows at all. As a result, in one building some dwellings have new exchanged windows and in other dwellings the windows are old. It rarely happens that the exchange of windows in each dwelling of a building, belonging to either housing community or housing cooperative, takes place at the same time as a thermo renovation is planned. Frequently, windows and doors are exchanged only in the common areas of the building. Usually by the time when the housing community starts the renovation most of the windows in the private flats are exchanged already. However, the quality of these windows varies and the windows were exchanged in different years. The owners of flats that have not exchanged the windows and do not intend to exchange them, because e.g. they cannot afford it, cannot be forced to do so. As a consequence, many buildings in Poland still have windows of various qualities after a standard thermo renovation, and some of them are so old and cause heat loss, that a question about the meaning of such renovations rises.

If an nZEB renovation was to be planned, all the windows would need to be exchanged, even the ones which were newly replaced because most residents exchange original windows with PVC ones. These are, as it is known, not energy efficient enough to make the building nearly zero energy. Respondents pointed out that residents would not agree to exchange the windows when for e.g. they were replaced only a couple of years ago. Moreover, the cost of changing of the windows was covered by each flat owner. It is known that exchanging windows is connected with renovation of the apartment, especially, the walls around the windows in the inside of the flat. This would also discourage making a decision to implement a nZEB renovation.

When speaking of organizational and legal barriers, the respondents mentioned the current process of tendering procedures as a probable barrier when it comes to renovation of municipal buildings. The contractors of standard thermo renovations that are being implemented in Poland are typically selected by the way of tender procedure. It usually happens that the contractor who wins the tender is the one who offered the lowest price of the investment. In order to realize the investment as cheap as possible many Polish

construction companies hire uneducated and unqualified employees. Very often they are random people without any construction education or experience, who e.g. works on building site during vacation time or simply due to high unemployment in Poland, cannot find any other job. They are not qualified and certainly not educated specifically on nZEB technologies or solutions and are not fully familiar with the technology used in nZEB renovations. Taking everything into account, there are already problems even with proper realization of standard thermo renovations.

6.4.3 Challenges in the retrofitting process

No (residential) nZEB renovation projects have been identified in Poland.

6.4.4 Discussion and conclusions

Undoubtedly, the main barrier hindering nZEB renovations in Poland is the financial barrier. Such renovations are more expensive than standard thermo-modernisations and neither residents nor building owners can afford such investments in Poland. Moreover, Polish regulations do not encourage implementing nZEB renovations. There are no complex financial models supporting nZEB renovations. For example, in order to apply for grants that are part of the program of thermo renovations, energy consumption must be reduced only by 25 %, which does not make the buildings nearly zero energy consuming. This is an indirect barrier hindering nZEB renovations. Investors are not motivated enough to realize such thorough renovations, and therefore only fulfil the lowest requirements in order to get the grant. There are subsidies devoted to residential buildings in nearly zero energy consuming standard, however, the subsidies concern only new buildings, renovations are not included in it. Another significant barrier hindering nZEB renovations is the lack of knowledge on energy efficiency solution of: investors, contractors, designers and residents. The mentioned deficiencies in awareness together with lack of good practices are the reasons why investors do not consider implementing nZEB renovations. There are no promotional or educational actions explaining the advantages and benefits of such renovations. The government should focus on publicizing nZEB renovations in Poland and offer advantageous subsidies for implementing them, taking as an example countries like Germany or United Kingdom. These countries offer favourable loans and grants for the construction of nZEB as well as nZEB renovations.

6.5 Barriers and challenges in current practice in Norway

6.5.1 Introduction

Interviews were conducted in Norway with seven individuals from different backgrounds - finance, end user perspective, architectural and construction industry – all of who have backgrounds involved in nZEB. Findings for representatives from finance and end-user perspectives focus on the objectives within the decision making process to conduct renovation projects while findings from four architectural firms and one construction firm focuses on the retrofitting process in practice. There were challenges within the research sample to find completed renovation projects. The three architecture firms who were

interviewed referred primarily to projects that had energy efficient and high performance targets for new builds. Insights were drawn from these interviews where new builds appeared to overlap with challenges in renovation of nZEB renovation projects. Two researchers from NTNU and SINTEF arranged and conducted the interviews which were open ended but focused on the five major challenges identified in the methodology - technical, financial, social, environmental/health and organizational/legal. The interviews were analysed by each researcher and then recombined into this report. The table below highlights the main challenges which are further elaborated in each section on barriers in the decision making process and challenges in the retrofitting process.

Table 5: Main barriers and challenges in Norway

	Barriers in the decision making process	**Challenges in the retrofitting process**
Technical	Knowledge not spread out amongst professionals Private home owners not technically aware Reluctance to interfere with the internal structure of the home Restrictions based on regulations and wider environment	Knowledge and expertise of renovation for nZEB is necessary for successful projects Expertise enables related technical solutions to work together New technical systems for low energy targets Meeting performance targets
Financial	Short-time period to invest in renovation – The renovation window No return on investment Fiscal incentive do not focus enough on existing building and impact on project energy efficiency ambitions Energy prices low and building prices high	Fiscal incentives are used in choosing a high performing solutions Fiscal incentives could go further Cost is not always considered in business models but should be
Social	Lack of knowledge Not possible for “do it yourself” approaches Fear of the unfamiliar amongst end users Not just one solution for all endusers Balancing nZEB aspirations with cultural and historic values	Communication with end users is key both during and after a project Residential involvement is essential Relocate residents depends on whether renovation is internal or external Cultural historical values can prevent certain aspects of a renovation occurring
Environmental/ health	Non-toxic materials Feeling of plastic box Living energy efficiently vs living comfortable	High performance ambitions Building as a system that impact other systems Building energy system with local district level Environmental criteria – BREEAM and LCA tools
Organisational/ Legal	Unambitious project energy targets Contractors involvement Undemanding market Lack of regulations	Communication, commitment and cooperation – workshops required Energy distribution and ventilation requirements are debated

6.5.2 Barriers in the decision-making process

Two representatives from finance and research organizations were interviewed in relation to barriers in the decision making process for residential nZEB renovation projects. One individual was part of the organizing process for financial support for building projects and the other individual had involvement with end-users of renovation projects. While they did not speak about specific projects, both individuals had a good general knowledge of the building industry within nZEB based on their experiences across a number of energy efficient projects. They therefore represented and had experience of the decision making process from an end user as well as the wider building industry.

Technical barriers

Both representatives from finance and end users agreed that the products and skills are present to conduct zero energy renovation but this knowledge unevenly distributed. The representative from the financial organization thought that there is knowledge available on the technical solutions for big renovations but the knowledge is not spread out enough particular in not knowing enough about the details on what are cost optimum solutions.

However, residential renovations in Norway are not just done by large building owners but are also done by individual homeowners. Individual homeowners tend to have a limited degree of knowledge on general renovations and even less knowledge on the technical aspects of an energy efficient renovation. Within the end user perspective, there was a challenge in the way that Norway has a lot of private home-owners who are not necessarily technically aware of what they need to do to renovate in an energy efficient way and therefore are not necessarily aware of the consequences of their decisions. There is a reluctance to interfere with the home through attempting to do work with what is already inside a home.

There are restrictions on the technical solutions that can be installed into a home which can be based on fire regulations to considering that impact of the renovation for neighbours. For example, where a position of windows could be changed for solar gains but is not feasible as a neighbour may see through the window. Therefore, if the technical solution is for high performance, it also must fit the surrounding area and adhere to regulations.

Financial barriers

Investments occur in renovations in Norway within short amount of time, every 20-30 years for the exterior. This is referred to as the renovation window where calculations can be based on results from the Life Cycle Costs tool. The renovation window is short and if investment on a renovation was done 10 years ago, an nZEB renovation is unlikely to happen for another 10 or 20 years.

The representative from finance organization spoke about how municipalities often have different budgets which does not take into account the life-cycle perspective of buildings.

For example, in the renovation of a building where access for disabled people is necessary might save money on the health budget but there is no incentive for the housing budget to invest. However, such a situation is more common in an office building. The initial investment from the end user perspective in individual homes is that they tend to have no budget for maintenance activities and there is a tendency to use savings. The individual home owners tend to not see the investment for the long term as they often sell their house after 6 years so do not see the return on investment.

Housing cooperatives in Norway are quite different to individual home owners and companies. Housing cooperatives tend to have association that serve members by acting as property developers and housing managers. There is a board of management that are representative from the residential area. Both representatives from finance and end user spoke about the housing cooperative. The financial representative spoke how there is a requirement in the business model of housing cooperative to have all owners informed of any change in the property including renovation where two-thirds have to agree to the change. Within the business model of housing cooperative, the upfront payment for the renovation may result in an increase in pay for the loan for the renovation but this can be spread over a number of years and across a number of owners. There are challenges in getting two thirds of home owners to agree on an investment on a low energy renovation and sometimes requires ambassadors for low energy renovations to liaise between homeowners and project contractors as well as other stakeholders. These ambassadors have been from the financial organisation and also from researchers that represent the end-user perspective. Within the end user perspective, it was highlighted that there is a need to speak one to one to residents in detail on the consequences of the renovation and build up information with them so they can agree on a cost optimal way to do a renovation.

Building companies who own flats and rent them afterwards to residents also face the challenge in competing with non nZEB buildings where flats may look the same but one is more energy efficient than the other which will benefit residents energy bills. However, tenants do not consider bills when renting but upfront costs and there is a higher likelihood they would choose a less expensive non nZEB flat than a more expensive nZEB flat.

Both representatives referred to fiscal incentives which are directed at ambitions in low energy building projects in Norway but may demand only slightly more energy efficiency than the building regulations. Such regulations tend to aim at new buildings rather than renovation projects though there has recently been a limited shift in focus on existing buildings. There are incentives in the form of grants from Husbanken and ENOVA for projects with high energy efficiency standards for nZEB projects. Both representatives interviewed also agreed that there is a challenge in energy prices. In Norway there are low energy costs and high building costs which reduce incentives to invest in low energy building as there is likely to be little to no return which means that energy efficient renovations do not have a payback period.

Social barriers

Both representatives from the finance and end user representative referred a lot to the social aspects in terms of a lack of knowledge and awareness of nZEB renovations. End users have a lack of knowledge on the possibility of nZEB and they do not know how to do low energy renovations. This lack of knowledge also impacts on owners who like to do renovations themselves through DIY (Do it yourself) approaches. They do not want to hire professionals and want to manage the task themselves as it gives them a sense of achievement. However, nZEB renovation is highly skilled so it is not possible for a DIY approach. The solutions are unfamiliar to the end user and there is a perception among homeowners that they do not understand them. One example of this which both representatives referred to was the ventilation system which resulted in a fear to live in a plastic bag and rely on a ventilation system to help you breathe. To overcome this fear, there is a need to understand how things work. There is not just one solution that is suitable for all demographics and interests. One suggestion from the end user representative was to have a basic solution for all renovations and the differences where you can have the user influencing.

Spreading knowledge and having good examples from successful nZEB renovation projects is necessary which also aids in overcoming the fear of the unfamiliar. There were different views as to whether the renovation should result in residents leaving their homes based on context. If the renovation was done primarily externally, there should be no necessity for residents to leave however, internal renovation are highly disruptive for the living conditions of the resident and the benefit of the resident leaving for a short period may speed up the internal renovation and save money.

There are challenges in balancing nZEB aspirations with maintaining what makes a building special for culture and historic reasons as well as the pride that residents may have toward a building in their area. There are possibilities with cultural and historic buildings of importance to look at producing energy and energy efficient products such as having an extra window on the inside and improving roof or floor and using heat-pumps.

Environmental and Health barriers

The quality of dwellings in Norway is good but there are improvements that can be made. The use of non-toxic materials is moving forward but what is considered as non-toxic today may be considered less so in the future. As mentioned earlier, there is a perception that having energy efficient ventilation may result in a feeling that people are living in a plastic box. This is concerned with what is known as the ‘sick building’ where there can be a tight building with no air exchange or not dealing with the moisture on the inside and the outside of the building.

Both representatives referred to comfort as being more important than energy prices in terms of what increase of quality of life can be gained from nZEB. This attitude was captured

within the marketing strategy of one building company where originally the company marketed energy efficient apartments in terms of energy savings and environmental advantages but they changed to the more established marketing strategy of how an apartment can be lived in comfortably.

Organizational and legal barriers

In terms of organization and legal, the financial representative referred to Energy Performance Contracting (EPC)[18] that is currently being considered in his organization but the problem with this may be that contractors are likely to "pick low hanging fruit" and therefore may not be ambitious enough in their energy targets. One approach that this individual spoke about in relation to a new building was the use of a workshop with building contractors at an early stage of the project. They discussed what energy efficient levels should be targeted for in the building which gave the contractors a sense of ownership and responsibility to meet these targets. The building industry also needs to invest in skills for energy efficient building.

Some large companies are moving forward with energy efficient building with the knowledge that they may not get a return but want to develop skills that will be required in the future plus do gain from positive publicity from building energy efficiently. But smaller building companies do not have the same incentives to up skill as their market is not demanding energy efficient building.

Lack of regulation that manage to transform the market into energy efficiency are needed but there is a need for a more defined regulation for nearly zero energy building. Regulations are not mutually exclusive as there is an issue if the market is not demanding low energy buildings it is difficult to develop new regulations.

6.5.3 Challenges in the retrofitting process

There were five firms interviewed to discuss the challenges in the retrofitting process in relation to nZEB. Four firms were architecture and one was a construction firm. One architectural firm and the construction firm-*+ referred to renovations in building offices. Three of the architectural firms who were interviewed spoke in relation to energy efficient and high performing new builds rather than specific renovations. These new builds were for residential, publicly military building and an office building.

Technical challenges

There was a mixed perspective of what are the main technical challenges in retrofitting amongst those interviewed. One perspective was that proven solutions do not always work for low energy retrofitting. In some projects proven solutions were not deemed as appropriate for the choice of technical systems. Within one architectural firm, new solutions

[18] Please refer to section 4.3.5 of this report for more information on Energy Performance Contracting.

were developed and tested and then implemented in order to find alternatives to proven solutions. In the construction firm, the project had high energy performance ambitions and new solutions had to be developed. The other perspective is that there is a general technical solution for most things, challenges occur when there has not been enough organisation early in the project. One way in which this can be managed is by having an experienced and knowledgeable team in a project. Such teams can understand how systems work together. In one new build project, there were low ZEB ambitions and existing technical solutions for heating ventilation and cooling, lights and the solar energy system were used but the challenge was to implement these technologies in an optimal way so that they worked together.

Performance is a key decision factor in renovation projects interviewees referred to the objective of each project was to reduce energy and at the same time increase performance level. However, only one individual spoke about monitoring performance after a project was complete and the building has been used for a period of time. This was in a residential new build where there were technical systems implemented that included heating, daylight and water solutions. While there were predicted estimates conducted on how these systems would be used in which monitoring highlighted that estimates were relative close to reality. However, where there were variations between user habits and the set-up of the technical systems, the technical systems were readjusted to suit the living habits of the residents. These readjustments to systems were planned in the project so there was flexibility built into how the systems were implemented.

The local market where renovation projects were conducted had little influence on the availability and quality of technical solutions chosen. In two of the firms doing renovations, they referred to ventilation concepts that had to be developed. One firm developed the concept to reduce energy used for getting air around the building and exposing thermal mass in order to even out temperature as well as please the acoustics. The second firm used what was already in existence in the building for a new ventilation concept which made use of the floor area. This second firm illustrated how the existing building technical systems can be combined with the new building system while the second firm chose to renew everything during the renovation. The level of information and knowledge among involved actors has had a positive effect on technical solutions where the share of project partners involved in the design process and level of expertise was a deciding factor in all projects.

Financial challenges

There are economic incentives in choosing high performing renovations. The Norwegian energy agency Enova which is a public enterprise that is owned by the Ministry of Petroleum and Energy, gives support to especially ambitious energy efficient projects. While life cycle costs can be done for the new builds, the budget is often divided between capital expenditure for the project and operations expenditure for once the building is complete. This approach to budgeting in new building projects means that the upfront investment is

limited by the capital expenditure as the long term financial benefits in operations are not accounted for. This was also highlighted as a problem in the decision making process in doing renovation projects in the previous section. However, one individual spoke about a project supported by Norwegian and EU funding in which apartments in a new residential building were sold at the equivalent price as those that did not have high performance targets but funding closed the gap on the losses being made by the building company. Another approach is to make the issue of high cost in low energy efficient building part of the business plan. One individual speaking, in relation to a new build, referred to how one of their clients incorporated costs into the business plan at the early stages so that there were no surprises further down the line.

Social challenges

Communication is important in developing a renovation and ensuring everyone understands what is required to achieve an innovative project. Residents were involved in both renovation projects from an early stage and throughout the process. In the architectural firm some residents had a dual role as both users and consultants in order to try to get residents ideas and wishes met as far as within the capability of the project which resulted in a mostly positive acceptance response from residents. However, the high involvement of residents in the project involving the renovation project of another architectural firm was reflective of the professional background of the tenants who were from a firm of consultant engineers whose knowledge of this field is generally quite good. In one new build, it was seen as important to involve residents in the design stage and end users of the building were informed about the ZEB approach to the build from the client's website and internal magazine. The designers of this new build worked with the end users on how the heating and ventilation system would be used to ensure their comfortable use of the building. They did this by having hot air pumped during the night and as the building had good insulation, the heat would be retained and no hot air would be pumped during the day. However, most interviewed spoke in relation of communicating to residents during the renovation. Only one individual highlighted the need to communicate to residents after a project is complete in relation to a new build. For this particular new building project, residents received a manual on how the building was intended to be used according to the design in which case they have access to information of the optimal way to live in their dwelling.

In both renovation projects, the residents did not stay in the building. The construction firm focused more on the financial impact on residents rather than their knowledge of the project. The rents of the building were going to increase but this was acceptable to them due to the benefits gained through a sustainable working environment. In both projects there were challenges in maintaining cultural-historical values around the external expression as well as the form and height of the building.

Environmental and Health challenges

There were specific criteria for energy performance for the building in both renovation projects while one new build designed for the lowest ambitions of ZEB definitions. In the renovation projects, the construction firm's ambitions was to have net positive energy with additional limitations that included minimum passive-house requirements and the architectural firm aimed to have more energy in its lifetime than it used, excluding user equipment. One new build project had a goal to achieve BREEAM outstanding and therefore had high targets led by this standard in terms of materials and management of waste. BREEAM was useful for this project as it is well known while some other environmental standards can be vague.

Both renovation projects viewed the building as a system with the construction firm specifying that everything affected everything and complex design process initiated at an early stage made this possible. Environmental criteria were used for the material during the renovation. In the construction firm, they aimed to reduce environmental impact from new materials and to make use of current material in the building while the architectural firm calculated embodied energy for every material introduced but also had the objective of meeting requirement of BREEAM Outstanding which in turn meant that materials had to be environmental friendly. The construction firm also used the strict requirements of BREEAM to consider chemical content in the building material and waste when retrofitting. LCA tools were also used in the renovation project of the construction firm.

The construction firm referred to different areas of indoor environmental project that were addressed in terms of indoor temperature, daylight conditions, sound the increase of quality of daylight versus artificial light compared to before the renovation. The thermal comfort also influenced the choices of material, components or technical systems in the retrofitted building with, exposed concrete in ceiling combined with sound absorbing solutions. In both renovations the quality of sound in the indoor environment influenced the renovation process particular in the choices of materials and ventilation strategy.

Organization and legal challenges

The common organization denominator for all projects was having a good level of communication with all participants. A number of architects referred to the use of workshops at the early stage of the project which involved the diverse construction industry disciplines i.e. architects, engineers, clients, contractors, material designers and researchers. Such workshops were used to set project goals and building performance targets which enabled everyone to have a voice in these decisions. This workshop approach at an early point in the project made the ongoing process within project smoother and also saved time within the overall project as problems could be managed at an early point.

In terms of organization of the renovation project in the construction firm, the business agreement was different compared to traditional renovation as there was an alliance sharing

all risk which was formed up front. There was ongoing communication between different partners through intensive workshops at an early stage of the project. However despite ongoing communication there were challenges based on trust and openness between partners.

One individual indicated how Norway have tight regulations in relation to energy efficient buildings and low energy projects are moving toward what should be the standard project. However there are still issues being debated in Norway in terms of distributing ventilation and cooling design in the building and energy supply. Requirements for ventilation in terms of volumes for air are higher in Norway than other countries but there are people questioning the necessity of these requirements. For the construction firm, there were challenges in integrating the building energy systems on the district level in terms of exporting the energy to the electrical grid which had some legal barriers which was also referred to in a new build project.

The success factors of the renovation in the construction firm was based on early involvement, intensive cooperation in design and close follow up throughout the whole project. In the architecture success factors were having high commitment to a high ambition, support from the top level in each company involved and cooperation with all involved from day one. Both renovation projects indicate that communication, commitment and cooperation on an organizational front are necessary for success.

6.5.4 Discussion and conclusions

There are barriers to the decision making processes and challenges in the retrofitting process for renovating existing building which relate to technical, financial, social, environmental and health and organisational. The barriers to the decision-making process relate to lack of knowledge within technical solutions and social understanding of what energy efficiency means to the home owner; technical restrictions from current regulation but also not having clear regulations for zero energy building. The technical problem of end users not wanting their homes interfered is associated with the issue of having to leave their home if the renovation is primarily internal. In terms of financial, there is a short window to invest in extensive renovations which happens every 20-30 years; the focus on upfront cost overshadows the benefits on how an energy efficient renovation impacts on a building and while fiscal incentives are useful, they could go further for renovating in existing buildings. However, one of the main financial barriers in Norway is the low energy prices compared to the large labour costs for investing in renovation which makes a return unlikely. The social barriers are related to the technical barriers to some degree in terms that the technical solution for renovation require professionals which makes the traditional do it yourself approaches to home renovation obsolete as well as developing a fear of the unknown. In terms of culture and historical values there is a need to balance these building that are significant with nZEB aspirations by working within the building structure. Norway has a good tradition of building for positive environment and health conditions but more needs to

be done in using non-toxic material and overcoming the problems of the sick building. There is also a balance that should be addressed in terms of communicating houses as environmentally friendly dwelling in relation to houses being places where people live. In terms of organization, more needs to be done to develop the market through regulation but also up skilling of the building industry professionals and being more ambitious in energy efficient projects.

The challenges related to nZEB renovations were related to needing to develop solutions as the proven solutions were not seen as sufficient, however this was viewed differently in new builds where the technical solutions were always fixable and for the most part already in existence. What was deemed as key in all related nZEB projects was having a project team made up of knowledgeable actors. There were fiscal incentives used in the renovation projects that were referred to, but it was recommended that the overall costs should become part of the business model in projects rather than seen as an ongoing challenge. In terms of overcoming the social barriers, communication is key and there was a necessity to involve residents during the project. Only one individual referred to keeping in touch with end users after a project is complete through monitoring the performance of buildings but also providing residents with a manual. There are some challenges in the exterior façade for maintaining cultural and historic values. The projects that were considered here for the retrofitting process had high performance ambitions but faced challenges with the current technical building systems in the building as well as exporting to the local grid. Another issue here were related to debates on the high requirement in ventilation systems. Well known environmental tools were used in projects, specifically BREEAM and LCA tools. For the purposes of organization, a different business agreement was necessary that involved alliance sharing and trust in at least one renovation project. The key to organization of the projects required ongoing communication, commitment and cooperation which were often done through workshops early in the project.

Norway has come a long way in nZEB renovation and projects and decision makers are clearly considering carefully how they develop for nZEB. While technical, financial, social, environmental and health and organizational were discussed here as distinct issues, each issue does overlap as reflected in the barrier to decision making and challenges in the retrofitting process. They cannot be considered as being mutually exclusive in addressing the identified barriers and challenges.

7 Barriers and challenges in current practice in Europe - discussion and conclusions

7.1 Common barriers and challenges in current practice

The countries in this study (Sweden, Norway, Spain, France and Poland), together with the literature studies, present an overview of experiences concerning residential nZEB renovations and in some cases new builds. These countries face many similar barriers and challenges in connection to realizing residential nZEB renovations but there are also other, just as important, challenges and barriers that are more country-specific.

The report shows that the countries are at different stages when it comes to residential nZEB renovations. One of the challenges in conducting this study is that nearly Zero-Energy Building still is an undefined term in the building industry. While member states in the EU must provide a definition of nearly Zero Energy Building adapted to their national conditions by 2014 (according to EEPBD), this is still in development. Also, as many of the studies indicate, there are challenges in how nZEB currently affect renovations and retrofit projects. In Poland, for example, no residential nZEB renovations have been carried out and there is still a long way to go in order to make nZEB renovations possible. This also applies to Spain and Norway where renovation projects included refer to more energy efficient building with high performance (best practice) or nZEB new builds rather than nZEB renovations. In Sweden and France, several residential nZEB renovation projects[19] can be found and more are underway. Clearly, there are many barriers and challenges to be overcome in order for widespread nZEB renovations in Europe.

While there are a large amount of issues associated with nZEB renovations, this report addresses five major aspects in terms of barriers and challenges associated with technical, financial, social, environmental/health and organizational/legal issues.

In the table below, the main common barriers and challenges in current practice have been summarized based on the individual country reports. Both *barriers* for taking a decision for a residential nZEB renovation as well as *challenges* during the retrofitting process are being addressed. These common barriers and challenges have been highlighted in the country reports of most of the participating countries. The barriers in decision-making in the table is based on the reports from Sweden (SE), Norway (NO), Poland (PL), Spain (ES) and France (FR). Concerning challenges in the nZEB retrofitting process, Poland is not included (as already stated no residential nZEB renovation projects could be found in Poland). Spain and Norway are included in the table for challenges in retrofitting processes but these challenges refer to best practice concerning energy efficient retrofitting rather than nZEB renovations or nZEB new builds rather than renovations.

[19] Note that Sweden and France have different limits for nZEB renovations in this study (in Sweden: 70 kWh/m2 (Atemp) and for France: 96 kWh/m2)

Table 6: Summary of main common barriers and challenges in current practice

Barriers and Challenges	Barriers in decision-making process (SE, NO, PL, ES, FR)	Challenges in nZEB retrofitting process (SE,NO, ES, FR)
Technical	• Existing building structure and technical system limit the choice of technical solutions and possibility for nZEB renovation (ES, SE, NO, PL, FR). • Technical solution exists but are costly and not financially viable (SE, PL, ES, FR, NO) • No "packages" of solutions available for nZEB renovations but solutions specific to the building being renovated are required (NO ,PL , SE) • High energy consumption as a baseline makes it more difficult to reach nZEB levels (PL, SE, ES) • Low level of knowledge about nZEB renovations among (some) professionals concerning nZEB renovations (PL, NO).	• Existing building structure and technical systems limit the choice of technical solutions possible for nZEB renovations (ES, SE, NO, FR). • Lack of "proven solutions" and cost efficient solutions for nZEB renovation which e.g. increases the sense of risk and/or puts more pressure on the skills of professionals (ES, NO, SE). • Low level of knowledge about nZEB renovation processes and new technical solutions among (some) construction professionals (ES, SE, NO)
Financial	• The investment cost is too high (ES,PL,SE,FR,NO) • Payback period is too long and/or requires a long-term ownership perspective which is not always possible (FR, NO, ES, PL, SE). • Lack of financial incentives for higher energy efficiency goals (PL, SE, ES, NO, FR) • Limited access to finance due to e.g. lack of long-term credits and/or innovative business/financial models (ES, PL,SE, FR) • Ownership structure of the building limits the possibility to finance nZEB renovations (PL, NO, SE, FR) • Risk for split-incentives i.e. the actor that has to make the investment is not always the actor that would benefit from it (PL, FR)	• Building owners are not likely to make money from investment (SE, NO,FR) • Profitability, i.e. to make the projects financially justified, without public funding (SE, ES)
Social	• Lack of knowledge and/or interest for energy efficiency among residents and building owners, often due to lack of awareness (ES, PL, NO, FR) • No wish or possibility to increase rents/mortgages for a more energy efficient renovation (SE, FR, PL) • Architectural and cultural values limit the choice of technical solutions and possibility for nZEB renovation (NO, ES, PL, SE, FR).	• The need for communication and information early in the renovation process to increase acceptance among residents (ES, NO, SE, FR). • Impact of end user energy use behaviour (NO, FR, SE) • Architectural and cultural values limit the choice of technical solutions and measures (ES, SE, NO).
Environmental/health	• No common environmental/health barriers were highlighted	• When residents stay in their apartment during the renovation, issues such as noise, dust and removal of dangerous materials (e.g. asbestos) needs to be carefully considered (SE, FR). • The risk of moisture must be taken into consideration when making a building more airtight (FR, SE,NO).

Organizational	• The ownership structure and need for consensus among several homeowners can hinder a nZEB renovations (PL, ES, NO, FR)	• Careful planning and preparation needed for reduce the impact of the renovation process on residents (SE, FR) • The need for an extensive communication between involved organisations and actors early in the process (SE, NO, FR).

The table outlines the main common barriers in the decision making process and challenges in the retrofitting identified in the reports across all five countries. What is clear from the above table is that some of the barriers addressed in decision-making process and challenges in the retrofitting process overlap. This may be indicative that what is happening during the retrofit process in having an impact and being considered in the decision making process. The literature review emphasized the need for good examples (IEA\SHC 2010, NorthPass, 2012) and clearly the overlapping of common barriers and challenges in each process are having an impact on each other.

In both decision-making process and retrofitting process there is an acknowledgement that technical solutions exist but the **existing building structure and technical system** sets limits to what extent these solutions can be implemented, which in the end also can affect the possibility for an nZEB renovation. This limitation is especially evident where **architectural and cultural values** of the buildings needs to be conserved, making the decision-making and retrofitting processes even more challenging. This is different to what can be faced in new builds.

Furthermore, existing technical solutions for nZEB were viewed as expensive adding to the main financial challenge of having **high investment** in nZEB renovation projects which overlapped as a barrier in the decision making process and a challenge in the retrofit process. In the review of the literature, the savings are done through the life-cycle of the building i.e. initial investment costs being small when compared to the overall operational cost by a ratio 1:5 (SCI-Network 2012a). However, those conducting the renovation are often unlikely to see a **return of the investment**.

The rationale behind attaining little return on investment is often related to social aspects identified as barriers in the decision making process of this study. In chapter 4, it was emphasised that the payback period for nZEB renovation is long, taking between 15-30 years, and residents do not stay long enough in a house to benefit from this payback period. This was also highlight for single family homes in the report from Norway. Also discussed in chapter 4 are the issues where the landlord cannot, or do not want to, raise rents as was illustrated in the case of France where there was regulation and limitations for the increase of rents in certain publicly owned buildings. Related to the issue of rising rents was becoming uncompetitive in the marked as referred to in Norway and Spain. Rents tended not to increase as the residential market do not consider the difference between non-nZEB and nZEB buildings so therefore do not understand the rationale behind increased rents.

While also identified in chapter 4 that there are financial instruments available in EU countries that provide technical and financial support to projects aimed at increasing energy efficiency of buildings, only a few are aimed directly and exclusively at supporting nZEB renovations.

Lack of knowledge regarding nZEB renovations **among professionals** was also highlighted in both processes and was also addressed in the literature review (NorthPass 2012, SuPerBuilding 2012). However, within some projects this was not just in relation to the industry's skill set but also in relation to attaining experienced teams who are familiar with nZEB in renovation projects and know how to make different technical systems and solutions work together. Knowledgeable professionals were emphasized in contributing to successful projects.

While a **lack of knowledge and awareness amongst residents** was identified as a challenge in both the decision making process and the retrofit process, the need for communication with residents was especially emphasized during the retrofit process after the decision is taken. Communicating with residents and end-users has also been identified as necessary in the literature study (SEAI, EeB\PP, 2012, IEA\SHC 2010). End-user behavior after a completed renovation is also a challenge in the retrofitting process as it is indicative of the impact of the project. While in some cases in this report there is a suggestion to train people to behave more energy efficient (France) or reduce residents energy use by installing individual meters and debiting (Sweden), another proposal is to monitor the building energy use after the residents have been living in the building for a period of time and change the system in place to be more compatible with user behavior (Norway). Therefore, there is an issue of whether the technical solution should influence the end user or whether the end user should influence the technical solution that needs to be resolved.

In the literature review there was an emphasis of actors from Design, Build and Operation (SCI-Network 2012a, SuPerBuilding, 2012) that involving end users adds another complexity into the organization of renovation projects. End-users in many of the residential projects are involved in the decision as to whether they will renovate or not which is related to the ownership structure in different renovation projects. While the **ownership structure** is viewed as a barrier in the decision making process, both as an organizational barrier and financial barrier, ongoing communication with end users (which was identified within the social aspects) as well as communication with and between wider project partners was acknowledged as important throughout the retrofit process.

Environmental and health issues are neither seen as a main barrier for taking a decision for nZEB renovation or a challenge during the renovation process. Rather, aspects such as improved indoor air quality and environment are seen as drivers for residential nZEB renovations. However, issues such as change in moisture content when making the building more airtight and the consideration of dust, noise and removal of health hazardous materials during the renovations was mentioned in relation to the retrofitting process.

The above highlights that there are a number of issues related to common barriers of the decision making process and challenges to the retrofit process that overlap but also interact with the diverse aspects of technical, financial, social, environmental/health and organizational/legal. These aspects are not distinct issues or mutually exclusive which adds to the complexity of the barriers and challenges facing residential nZEB renovations.

In order to summarise the above, the list below identifies five main *barriers* in the decision making process to nZEB and five main *challenges* of the retrofitting process based on their frequency of reference in the country by country reports:

Main barriers in the decision making process

- *Technical*: Existing building structure and technical system limit the choice of technical solutions that can be used but where technical solutions can be found, they are often costly and not financially viable.
- *Financial*: Investment cost too high
- *Social*: Lack of knowledge and/or interest for energy efficiency among residents and building owners, often due to lack of awareness combined with challenges with architectural and cultural values
- *Environmental/health*: No common environmental/health barriers were highlighted
- *Organisational*: The ownership structure and need for consensus among several homeowners can hinder a nZEB renovations

Main challenges of the retrofitting process

- *Technical*: Existing building structure and technical systems limit the choice of technical solutions possible for nZEB renovations.
- *Financial*: Building owners are unlikely to make a return on investment
- *Social*: The need for communication and information early in the renovation process to increase acceptance among residents
- *Environmental/health*: The risk of moisture must be taken into consideration when making a building more airtight
- *Organisational*: The need for an extensive communication between involved organisations and actors early in the process

While the discussion so far has focused on *common* barriers and challenges in nZEB renovation practice, it should again be noted that many other barriers and challenges have also been highlighted in the individual country reports and these are equally important in order to facilitate more residential nZEB renovations across Europe. These barriers and challenges include loss of revenue from rents in large-scale neighbourhood nZEB renovation as residents need to be evacuated (SE), lack of knowledge among residents regarding new technologies creating a climate of distrust for a common energy system (ES) and hinders to

nZEB renovations due to tendering procedures for renovation of municipality buildings (PL). More barriers and challenges can be found under each country reports in chapter 6.

7.2 Success factors

Although this study focuses on common barriers and challenges in nZEB renovation practices, we would like to emphasise that the report also highlighted some success factors for residential nZEB renovations. The below points are not comprehensive and but were common in many of the projects discussed in the country but country reports.

- Early communication, dialogue and information both between involved actors and organizations of the renovation project as well as with the residents are seen as key for a successful nZEB renovation.
- A follow-up after projects is important to validate nZEB targets set within the project and to ensure that residents are using building as designed or that any alternations of technical system are done to suit living habits.
- The use of good examples in nZEB renovations is needed to increase the knowledge among both professionals and general public about energy efficient renovations and technical solutions.
- For some projects, a successful organisation required ongoing communication, commitment and cooperation where workshops proved fruitful in setting targets and goals that were agreed on and implemented by all members of the project.
- The main challenge for ZEB renovations around Europe are financial ones. However, as chapter 4 illustrates, there are working financial instruments/schemes that have been implemented in countries around Europe, either on national or local level, to try to overcome the key financial barriers. Although there is not any perfect nZEB renovation financial scheme, the existing instruments could be consolidated in order to make one. Public authorities, above all local and national authorities, have a leading role to play in setting up financing schemes which works in relation to the national or local contexts. It is also important that the level of ambition of financial programs rises in order to have greater impact and unlock further private investment for nZEB renovation.

7.3 Concluding remarks

The study indicates that the barriers to the decision making processes and the challenges to the retrofit process are related as in some areas, the barriers and the challenge were the same across a number of reports. Each country in this report is individual as some barriers and challenges were unique to specific countries particular in terms of legislation. For example, in Spain there is legislation where there is a draft law on of electrical energy, if approved, will reduce the use of PV panels and in Poland there are thermo-modernisation grants to incentivize energy efficient renovations. Clearly, legislation and financial incentives has a strong influence in developing approaches for nZEB within countries. There are also common barriers and challenges that can be addressed within the building industry. In

particular, as highlighted in all reports in the area of social and organizational, that communication within the project for developing goals and targets was necessary as well as communicating with end users of the residential dwelling. Uniquely, environmental and health challenges/barriers were not deemed as highly problematic which may be seen as a positive within the industry as this perspective is already considered within common practice across countries in the building industry. Overall it is clear that there are progressive steps being taken across Europe in terms of nZEB renovation. Recognizing the barriers and challenges provides lessons that can be learnt for ongoing and upcoming nZEB projects.

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10 Appendix

Appendix 1: Interview Framework Tool

Topics	Challenges to retrofitting (nZEBr)	Barriers to decision making (non-nZEBr)
Technical		
Performance		
Compatibility/Applicability		
Availability tech. Solution		
Maintenance and warranty		
Level of knowledge		
Financial		
Investment cost		
Access to finance		
Business models		
Payback period		
Fiscal incentives		
Energy price		
Low demand from residents		
Social		
Involvement		
Acceptance		
Lack of knowledge and awareness		
Living conditions		
Quality of life		
Added costs		
Energy use		
Cultural values		
Environment and Health		
Optimisation		
Technical system		
Integration		
Material		
Waste		
Quality of indoor env.		
Noise/dust		
Organisational and legal		
Renovation steps		
Laws and regulations		
Time plan		
Business agreement		
Dialog/Communication		

Appendix 2: Interview guide nZEB renovations

Aim of the interview: To identify and understand the challenges that renovation projects with high energy efficiency goals face during the project.

General questions

Name of the interviewee:
Role of the interviewee:
Name of the project:
Energy use before renovation:
Energy use after renovation (measured or expected):

Technical

- What, in your experience, are/has been the main technical barriers during the renovation process?

Performance level and applicability/compatibility

- What were the driving forces for choosing the technical solutions for the renovation project?
- How much did/do the existing technical system influence the choice of the new technical solutions (*For example, connection to the district heating system, individual boilers, mechanical ventilation, and available space)?*
- How much did the desired performance level of the technical solutions influence the choice of the systems, compared to other aspects like financial or social?
- Did/Do you have any challenges in finding the technical solution with desired performance level for the renovation project? *If yes, what challenges?*
- How much did/do the "proven solution" aspect influence the choice of the technical systems?

Availability of technological solutions

- How did/do the availability and quality of technical solutions on the local market affect the renovation process and the choice of systems?

Maintenance and warranty

- How much did/do the need for maintenance of the technical system and warranty time by the producer influence the choice of the system?

Level of knowledge

- Has the level of information and knowledge among involved actors affected the technical solutions chosen (*for example, personal know-how, business community acceptance, corporate conviction and personal commitment*?)

Financial

- What, in your experience, are/has been the main financial barriers during the renovation process?

Investment cost

- What was/is the overall investment cost of the renovation? *How is the overall investment cost different compared to non nZEB (or similar) renovation?*
- How much did/do the cost of the renovation solutions for improving energy efficiency influence the decision for one or the other solution?
- What financial model did/do you use as decision support for different renovation options (*for example Life-cycle-costs (LCC)*)?

Access to financing and business models

- Has/Is access to financing been a challenge in the renovation process? *If yes, how?*
- Have/Are any innovative business models or financial models been used to facilitate the renovation? *If yes, which business model/financial scheme?*

Payback period/profit

- What is the payback period of the investments?
  How is the payback period different compared to non nZEB (or similar) renovation?
- How did/do the payback period influence the project (*for example, choice of the technical system solutions and level of renovation*)?
- Do you expect an impact on the property value as a result of the energy efficiency measures? *If yes, what impact?*

Fiscal incentives

- Did/Do you have any fiscal incentives (subsidies, tax reduction etc.) for choosing a better performing solution that can result in higher energy savings? *If yes, how has/does that influenced the renovation? If no, how has/does that influenced the renovation?*
- Do you expect an impact on the property taxes as a result of the renovation?
  If yes, what impact?

Energy price

- How has energy prices affected the choices made for nZEB (or similar) renovation?
- How much did the expected future energy prices influence the decisions on improving building's energy performance?

Social

- What, in your experience, are/has been the main social barriers during the renovation process? (*for example, involvement of residents, acceptance, resident energy use behaviour etc.*)

Acceptance and involvement of residents

- How and when were/are the residents involved in the renovation process? To what extent were the resident's ideas and wishes fulfilled? *Did you experience any difficulties or challenges when involving residents?*

- How was/are the acceptance among the residents for the renovation process? *Did the level of acceptance affect the renovation process?*
- How was/are the level of awareness and knowledge about energy efficiency and nZEB (or similar) among the residents? *Did the level of knowledge or awareness affect the renovation process?*

Living conditions during the renovation process

- Did/Do the residents stay in the building or did they have to be relocated during the renovation process? *Was the procedure different from traditional renovation?*

Quality of life

- Have any change of the quality of life been registered that were due to the improved energy efficiency of the building? *If yes, what?*

Added costs to residents

- What kind of impact did/will the renovation costs have on the rent paid by residents? *Is the impact different from traditional renovation?*
- How was/is the potential impact of increased costs on rents received by residents and solved?

Energy use behaviour of residents

- To what extent does the residents' energy use behaviour influence the energy performance of the building?
- Has/Will the energy use behaviour been/be improved after the renovation? *If yes, how? If no, why not?*
- Has/will residential energy use behaviour been/be a barrier for achieving modelled energy savings and cost-effectiveness of investment? *If yes, how?*

Cultural values

- Did/Do you have to consider any culture-historical values of the building during the renovation process? *Is yes, how did/do that affect the renovation?*

Environment and health

- What, in your experience, are/has been the main challenges concerning the environment/health during the renovation process?

Optimisation of the building envelope and technical systems

- Did you have any specific criteria for energy performance for the building as a whole?
- Did you have energy performance criteria's or specific demand for the building envelope (window, walls, floor, roof), the heat and ventilation system, household appliances, hot water? *If yes why? If no why not?*
- Did you think of the building as a system and did that influence the choice of material, components and technical systems? *If yes, why? If no, why not?*

Integration of the building energy systems with the district level

- Did the overall energy system on district level influence the choices for the building systems? Was there an integration of the building energy systems with the district level?

Material and waste

- Did you have any specific environmental criteria for the material used during the renovation? *If yes, how did that affect the renovation process and choice of technical solutions? If no, why not?*
- Have you used the LCA tool to analyse the environmental impacts of the renovation? *If yes, how did that affect the renovation process and choice of technical solutions?*
- How did you handle construction waste *(For example, recycling waste as material or re-used materials in the renovation process or in another construction project*)? *Was the procedure different from traditional renovation?*
- Did you consider chemical content in building material or waste when retrofitting? *If yes, how? If no, why not?*

Quality of indoor environment

- Were there any indoor environmental problems that where addressed during the renovation process?
- Have/Will any changes been/be made regarding the quality of light, daylight vs. choice of artificial light (*like low energy bulbs with UV filter*)? *If yes, how has that affected the quality of light?*
- Did/Do thermal comfort influence the choices of material, components or technical systems in the retrofitted building? *If yes, how?*
- Did/Do the quality of sound in the indoor environment influence the renovation process? *If yes, how?*
- Was indoor air quality before and after the renovation assessed?*If yes, what were the results?*

Noise and dust during the renovation

- Have you had/do you have specific criteria for noise and dust pollution during the renovation? *Are the criteria's different from traditional renovation?*
- How does/did noise and dust pollution impact the residents (especially if the inhabitants remain living in the apartments during the renovation process)? *Was the impact different from traditional renovation?*

Organisational and legal

- What, according to your experience, are/has been the main challenge concerning the organization and legal aspects? *(For example, renovation steps, time plan, communication between actors, laws and regulations etc.)*

Renovation steps

- Which were the critical points during the renovation process that you would like to point out *(both positive and negative that could be improved in future projects*)?
- Have you implemented any innovative steps in the retrofitting process due to the high energy goals *(such as better coordination between different construction moments*)?

Time plan

- How did the nZEB (or similar) renovation affect the time frame for the renovation process? *Was time a barrier for a successful renovation?*

Business agreement

- Was the business agreement different compared to tradition renovation? *If yes, state good and bad differences*.

Communication and dialogue between partners

- How did the dialogue/communication between different partners look like? *Was the dialogue/communication different from traditional renovation?*
- What are/were the main barriers for a successful dialogue and understanding between partners?

Laws and regulations

- Did you experience any legal barriers (e.g. uncertainties, unclear legal requirements etc.) in relation to the high energy goals? *If yes, which legal barriers?*

Concluding question

- What were/are the three mayor success factors for your nZEB (or similar) renovation?

Appendix 3: Interview/Workshop guide non-nZEB renovations

Aim of the interview/workshop: To identify barriers for taking the decision to go through with a nZEB renovation. Discuss about the reasons why not higher ambitions were made for improving energy efficiency of the renovation buildings.

General questions

Name of the interviewee:
Role of the interviewee:
Name of the project:
Energy use before renovation:
Energy use after renovation (measured or expected):

Technical

- What, if any, were the main technical barriers for renovating nZEB (or similar)?
  Lack of technology (solutions) or quality of technology on the local market?
  Lack of compatibility between existing technical system and new technology?
  Lack of information and limited knowledge about technology and measures?
  etc…

Financial

- What, if any, were the main financial barriers for renovating nZEB (or similar)?
  Investment cost?
  No access to financing or innovative business models/financial schemes?
  Payback period?
  Lack of financial or other incentives (subsidies, tax reduction etc.)?
  Level of Energy-price?
  Split-incentives (the actor who makes the investment is not the one who benefits from it)?
  Low demand from current/future residents?
  etc…
- Was Life-cycle-costs/overall total cost taken into consideration for decision-making? *If no, why not?*

Social

- What, if any, were the main social barriers for renovating nZEB (or similar)?
  Lack of acceptance for from residents?
  Lack of knowledge and awareness from residents about energy efficiency?
  Level of added costs (rents) for residents?
  Change in quality of life for residents?
  Energy use behavior of residents?
  Cultural-historical values of the building?
  etc…

Environment and health

- What, if any, were the main environmental/health barriers for renovating nZEB (or similar)?
  Building material, components and technical systems in the building or energy system on district level?
  Indoor environment?
  Waste?
  Noise and dust during the renovation?
  etc….

Organisation and legal

- What, if any, were the main organizational/legal barriers foreseen for renovating nZEB?