ZenN

Nearly Zero energy Neighborhoods

Barriers and Key Success Factors for future replicability

D6.1/ T6.1. Report (WP 6)

Publisher

ZenN – Nearly Zero energy Neighborhoods

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Disclaimer

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Contents

List of abbreviations

ANRU	National Agency for Urban Renewal
BEMS	Building Energy Management System
DHW	Domestic Hot Water
ESX	Exhaust and supply air ventilation with heat recovery
EU	European Union
FP7	EU's Seventh Framework Programme
LCC	Life-Cycle Costs
LVR	Loan to Value Ratio
nZEB	Nearly Zero Energy Building
PACE	Property Assessed Clean Energy Program
PNRU	National Programme for Urban Renewal
PV	Photovoltaic
WP	Work Package
ZenN	Nearly Zero Energy Neighbourhoods

1 Introduction

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.

The aim of *Nearly Zero Energy Neighbourhoods* (ZenN)[1] project is to reduce energy use in existing residential buildings and neighbourhoods. With this purpose a number of measures have been implemented in connection with renovations of residential areas in Sweden, Norway, Spain and France, which are intended to function as nearly zero energy neighbourhoods. A consortium of 12 partners from five countries is involved in ZenN 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).

The general objectives of 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.

The ZenN - project running from 2013 has already achieved some of the above mentioned objectives through the work carried out in the demonstrators and the additional scientific and technical associated work:

- establishing a common understanding and a common approach to the nearly zero-energy building (nZEB) renovation in the demonstrators (WP1: common framework for nZEB renovation)
- validating the energy saving measures (WP2: Demonstration of near zero energy districts and WP3: *Validation and monitoring*[2])

In addition, critical success factors for nZEB renovation actions in four non-technical domains have been identified and improved thought the work carried out in WP4: Non-Technical Drivers. Those domains are:

1. Architectural and cultural heritage;
2. Stakeholder awareness and behaviour;

[1] For more information on the ZenN-project, visit the project website: http://www.zenn-fp7.eu/
[2] D3.3 *Monitoring Performance* currently under development

3. Economic and ownership structures;
4. Legislation, Governance and Policies.

Currently in WP6 *Replication and Exploitation*, the main aim is to leverage the knowledge of the project in order to identify key success factors for future replicability (both technical and non-technical), and exploit nZEB renovation demonstration results.

Based on all this generated knowledge, this report D6.1 *Barriers and Key Success Factors for future replicability* intends to bundle main outcomes of research and local demonstration activities developed in the project following the format of barriers and key success factors identification, extracting main conclusions of the retrofitting process to be borne in mind in future retrofitting projects. Replication of measures may seem quite straightforward for same location and building typology, but there is a need to study the potential extension of the local answer to further environments, where solutions can be applied to a wider range of buildings and contexts.

2 Objectives, outline and responsible contributors

The main objective of WP6, as aforementioned, is to identify key success factors for future replicability and to exploit nZEB renovation demonstration results.

Replicability means repeatability or 'reproducibility' of solutions. The replication potential is one of the key elements of this project; therefore this report D6.1 deals with the analysis of barriers and succcess factors which have to be taken into account for effective replication of ZenN concept, as stated in D1.2: “*A nearly zero energy neighbourhood is a cluster of residential units where the overall energy demand is low and partly met by renewable energy self-produced within the neighbourhood.*”

The main content of this report starts in chapter 3 with the knowledge-flow description of the project, and the way all generated knowledge in ZenN project has been bundled in several categories in order to identify main barriers and KSFs for future replicability. Chapter 4 presents summarising tables of KSFs and barriers identified on each demonstrator of the project. Finally, chapter 5 elaborates on a more detailed description of all barriers and KSFs identified, followed by a brief wrapping-up *Conclusions* section.

Main contributors of this deliverable have been:

- TECNALIA: overall coordination and chapters 1, 2, and 3
- IVL: sections 5.1, 5.2.3, and input for chapter 4
- NTNU: sections 5.2.2, 5.2.4 and input for chapter 4
- ASM: 5.2.1 and input for chapter 4
- SINTEF: External review

3 KSFs and barriers categorisation

This brief chapter provides an overview of ZenN project's knowledge flow, intending to drive key points of generated knowledge towards the identification of barriers and KSFs for future replicability of solutions. Accordingly, this categorisation intends to bundle all that knowledge into different packages, presenting key lessons learnt during the project. Besides taking into consideration external inputs, already submitted deliverables and demonstrators of the project have become the most relevant knowledge sources for the identification of barriers and KSFs for future replicabililty of ZenN solutions:

- D1.1 Final Report on common challenges in current practice.
- D1.2 Final Report on common definition for nZEB renovation.
- D2.1-D2.6 Design plans for nZEBR demonstrators in Malmo, Eibar, Grenoble, and Oslo.
- D3.1 Technical evaluation and general recommendations on retrofitting measures.
- D3.3 Results monitoring.
- D4.1 Taxonomy of near-zero energy renovation options and their influence on architectural and cultural heritage.
- D4.2 Stakeholder awareness and behaviour.
- D4.3 Economic and ownership structures.
- D4.4 Legislation, Governance and Policy.
- D4.5 Holistic design kit for nZEB renovation.

This set of documents represents a comprehensive catalogue of issues to be borne in mind when facing low-energy buildings renovation processes at a neighbourhood scale. After processing all that data, and in order to provide an intuitive access to main barriers and KSFs, the content has been divided into two main sections: technical and non-technical drivers.

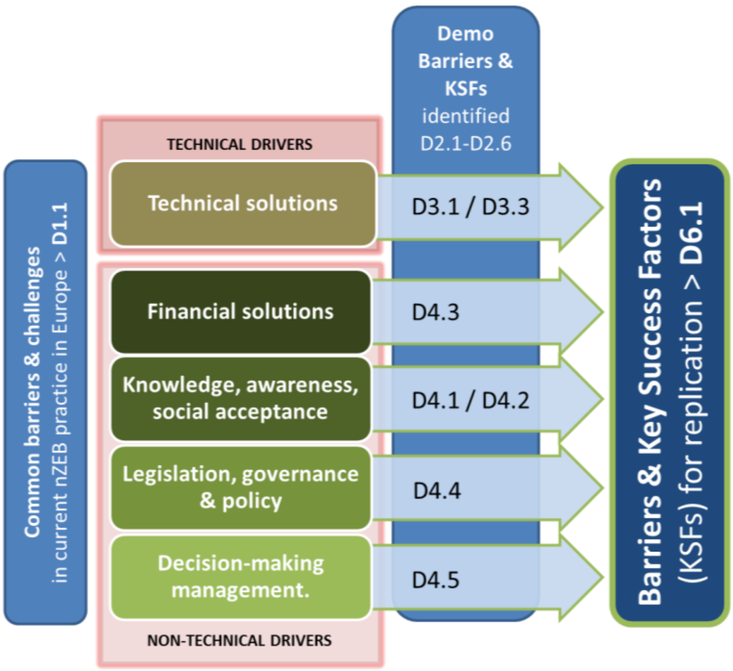

Figure 1: ZenN knowledge flow to identify barriers and Key Success Factors for replication.

As Figure 2 shows, *Common barriers & challenges in current nZEB practice in Europe* have been taken as a starting point (D1.1). After this overall mapping, a number of documents have deepened in specific issues in order to provide solutions within the different fields of nZEB practice, both regarding technical and non-technical aspects. As the figure presents, technical solutions' section bundles deliverables D3.1 and D3.3, regarding technical issues and demonstrators' monitoring results respectively. On the other hand, non-technical factors' section intends to pack generated knowledge in WP4 under 4 sub-categories: *Financial solutions*; *knowledge, awareness & social acceptance*; *legislation, governance & policy*; and *decision-making management*. All these inputs have then been contrasted by the demonstrators' supervisors of each city in order to incorporate practical experiences to the results, finally generating the main outcome of this deliverable: main barriers and KSFs for future replicability of Nearly Zero energy Neighbourhoods.

The description of each category of KSFs and barriers provided in the following sections of this report is intended to bring valuable insights and share the experiences of ZenN stakeholders with all owners and organizations willing to engage in similar projects in the future. It is probable that some of the recently encountered challenges, as well as many of the available solutions will be faced again in the future.

4 Main KSFs and barriers identification by demonstrator

4.1 Main Key Success Factors identified by demonstrator

Demonst.	Technical factors	Non-technical factors			
		Financial	Knowledge, awareness, social acceptance	Legislation, governance & policy	Decision-making management
Lindangen (Malmö):	• Excluding an overall facade renovation (due to good condition before project) has increased the economic viability of the full retrofitting project. • Exhaust air heat recovery systems are generally cost-effective. A careful assessment is needed of its impact on primary energy consumption and greenhouse gas emissions, for which savings are not granted[3].	• The owner's business approach - according to the building owner the investment would be recouped purely by the rise of the property value. • The possibility of obtaining ZenN grant dedicated directly to the deep renovation. Although it constituted only 1/6 of the total investment in the project, it has been an important motivator. • The availability of relatively high amount of own resources that helped to obtain the bank loan.	• Use of photovoltaics as an architectural expression as well as an energy performance measure • Testing window exchange using a test montage, before wider implementation • Use of a liaison person who was of similar social/cultural background of tenants to give them information of the renovation process and help with access to apartments.	• High focus on assessing and proposing new economic policy instrument (E.g. tax-free retrofitting funds, credit-guarantees and grant support to tenants). • Swedish renewable energy share target for 2020 slightly higher than the commitment towards EU. • Many policy measure suggestions to solve knowledge problems (Information centre, improvements of tenant dialogue etc.).	• PV panels were used as a symbol of architectural value for energy efficiency • Employing residents to inform other residents to make the renovation acceptable • Having a low LVR to obtain loan from bank • Viewing total renovation in terms of increased value of the properties rather than seeking return on investment from energy solutions
L'Arlequin (Grenoble)	• A partial window replacement (keeping 20 year old windows) should give almost the same energy savings as a complete replacement, and increase the cost-efficiency.	• The financing model applied in the case of Grenoble demonstration site has been assessed by the investors as rewarding and worth recommending to other developers. All the financing sources were essential to achieve the goals established in the project. • ZenN subsidy assessed as the financing instrument that allowed conducting more intensive, deeper energy efficient renovation. • Win over the problem of split incentives - the owners gain financial benefits from raised rents, while tenants pay less in total as the energy bills are lower.	• Using sufficient time to develop a deep understanding of design details to meet the required air-tightness for the demonstration: prototyping several façade modules, with an airtightness test, to retain the most efficient solutions • Hiring a liaison person living in the same area as the residents. This person knew the culture and was able to communicate the positive impacts of the renovation. The liaison person worked closely with the project coordinator.	• Research and information centre for low-energy construction, retrofitting and urban renewal is implemented. • High awareness on problems engaging private building owners and on lacking sanctions when legal objectives are not fulfilled.	• Using compatible technical solutions to preserve architectural value and cultural heritage. • Use of a liaison person to ensure positive communication between project team and residents • Having support from Grenoble municipality and French government • Developing split incentives to increase rents while tenant benefit from reduced energy bills and low operational costs • The collective feeling in the project team
Økern (Oslo)	• Focusing on technical detail improvements (of thermal bridges, heat exchanger efficiency, PV area etc.) retains fairly similar life cycle costs, implying that reducing energy is economically sustainable.	• The financing model (city budget, ZenN, Enova) applied in the case of the Økern demonstration site has been assessed by the building owners as rewarding and worth recommending to other developers. • Win over the problem of split incentives - green lease contract;	• Step wise approach to incorporating solar power. The long terms objective is to take lessons forward to increase the amount of solar power in future projects. • Ensuring energy performance measures were sustainable for the long term functional purpose of the nursing home • Manager who can intermediate between staff/residents and	• Research and information centre for low-energy construction, retrofitting and urban renewal is implemented. • Good awareness of the current construction industry focus towards minimizing building costs and the too low focus at full lifetime costs.	• Prioritizing architectural value and cultural heritage of a listed neighbouring building by ensuring complementary energy solutions on façade. • Involving facilities managers and building users. • Project manager was a positive link between building users and project

[3] The exhaust air heat pump solution decreases the district heating demand, but at the same time increases the property electricity demand. Often the ratio of decreased district heating demand and the electricity consumption of the heat pumps is approximately 3:1 or 4:1. This means that, depending on the energy supply systems, primary energy savings and greenhouse gas emission savings are not granted although the delivered energy decreases.

			project contractors • Obtaining technical knowledge to meet energy performance targets • Økern renovation complemented the design of the neighbouring listed building.		team • Managing misconceptions on energy solutions • Good access to funding opportunities
Mogel (Eibar)	• Prioritizing neighbourhood level solutions above building level solutions successful out of a cost-efficiency and resource-efficiency perspective. This has enabled implementation of new systems and technologies. • A large reduction in heating demand is obtained with the implemented thermal insulation of facades and better thermal performance of windows.	• Additional financial sources from ZenN project that allowed to bring to the retrofitting project an added value (more ambitious energy targets) with the same costs. • Support from professional parties - DEBEGESA and construction company • Subsidized interest rate provided by the Basque government • Connection of the energy efficient renovations with other previously requested installations and modifications of the buildings (e.g. lifts).	• Ensuring the final renovation project should not exceed a maximum budget in order for the neighbours to have "more" for approximately the same budget. • The Neighbourhood Committee is a group spontaneously formed by some residents who want to push the renovation initiative and who took the role to coordinate between residents and other stakeholders. • The involvment of the public service company for economic and sustainable development, Debegesa, developed a building maintenance guide for Mogels' residents, which includes information on for instance ventilation to prevent humidity, behavioural changes and aesthetic measures.	• High research awareness on barriers of low retrofitting interest, lacking level of knowledge, financing and profitability difficulties • Benefits of combining energy efficiency and tenant convenience measures demonstrated through projects such as ZenN (elevator installation in Mogel).	• Knowing when to prioritise energy solutions over well liked characteristics of the building • Developing energy solutions which do not impact resident's behaviour • Having a neighbourhood committee to aid decision making • Local drivers that support communities to include energy efficiency measures for residential building renovation.

Table 1 Main KSFs identified by demonstrator

4.2 Main barriers identified by demonstrator

Demonst.	Technical factors	Non-technical factors			
		Financial	**Knowledge, awareness, social acceptance**	**Legislation, governance & policy**	**Decision-making management**
Lindangen (Malmö):	• Mechanical exhaust - and supply air ventilation with heat recovery (ESX) include high investment costs and disturbances for residents. (Not applied in Lindängen.) • Solutions for heat recovery from grey water – which decreases thermal energy demand – not proven to be economically viable yet.	• The difficulties in estimation of the payback time (the owner considers the increases in property value in the category of the return of investment rather than analysing calculation based solely on energy savings from the equipment installed).	• Uncertainty of energy calculations budget constraints did not for sub-transmitters on energy equipment in apartments, which led to energy calculations being based on estimates. • Conveying decisions to cultural diverse residents.	• The building permit need for the PV system has been an obstacle for the building owner (ways to simplify the application is advocated). • General profitability insecurity and lack of financing possibilities in Sweden (even despite anticipated profitability) one of the main barriers described. • General interest conflicts occur between several legislative fields (see Barriers in Chapter 5.2.3)	• Logistical access to tenant's apartments • Managing budget to include energy performance measure when project has started.
L'Arlequin (Grenoble)	• Two main obstacles are seen for installing PVs: - A return time of approx. 40 years in the best case, at the level of the repurchase rate of the electricity. - A risk of roof occupation by young inhabitants - in spite of metallic doors limiting the access. • Solutions for heat recovery from grey water – which decreases thermal energy demand – not proven to be economically viable yet.	• The lack of sustainability of the financing over the time - the ANRU convention was signed for a defined period of time. It is now finished and still the new National Program of Urban Renewal (NPNRU) is not yet operational and is also limited in time. • Unexpected cost of the retrofitting (the increased VAT level and the new regulations on asbestos complicating the intervention of the workers).	• Residents living in apartments during renovation being disturbed and uncomfortable due to chaos caused by renovation and erratic time schedules • Managing the various objectives of a complex project	• Private residential buildings owners often lack interest and knowledge (best practice information needed) • A lack of sanctions has been displayed for when legally defined objectives are not reached.	• Concern of project team on introducing energy measure to project • Unexpected costs • Gaining return on investment due to the fragmentation of ownership
Økern (Oslo)	• General uncertainties in forecasting electricity generation for PVs are a barrier for PV system investments (uncertainties of energy import savings and energy export to grid etc.).	• Unexpected costs: tightening of the previous legislation TEK-10 that sets some minimum energy-efficiency requirements of particular building components.	• Extended commissioning period into operations meant that end users comfort was affected to some degree for the initial months of operations while defects were addressed.	• Lack of knowledge and technical performance uncertainty. • Energy efficiency standards/ requirements have been assessed as too low.	• Building users unnecessarily changing behaviour • Unexpected costs primarily due to more asbestos being discovered than expected
Mogel (Eibar)	• A demanding holistic approach and knowledge needed to optimize solutions of tight building envelopes and good indoor air quality. • Technical solutions that have to be applied at a neighbourhood level require a large consensus within the group of interest. • A demanding holistic approach and knowledge necessary to optimize solutions of tight building envelopes and good indoor air quality. • Technical solutions that have to be applied at a neighbourhood level require a large consensus within the group of interest.	• The individual owners' resources were the biggest contribution to the overall budget of the retrofitting -there were a few cases where the financial situation was difficult due to the unemployment; there were some owners with fewer resources, who were unable to take a loan due to their financial situation. • Long return of investment / payback time - it may be possible that the financial benefit will occur for future generations • Little engagement in the project from the banks - many of them did not provide competitive offers with low interest rates; the banks assessed the project from a more traditional standpoint rather than looking at the market position and image incentive that came along with participation in such projects.	• Renovation of the building without moving of the residents. • Some residents showed a lack of interest in the energy measures (insulation, solar panels water heating installation, etc.) at the early stages of the project and did not understand the added benefits of the energy measures	• General lack of financing possibilities - policy measures for financing insufficient. • Grant applications to finance rehabilitation actions are too complicated if not managed by technicians or experts. • For multi-owner buildings (as in Eibar), the decision process for retrofitting is difficult. This pinpoints the need to improve general knowledge and policy measures.	• Discovering misconceptions of building users • Access to financing • Need to set agreement with residents not to commercially profit from renovation as Basque government partially funded it.

Table 2 Main barriers identified by demonstrator

5 KSFs and barriers detailed description

In this section, a brief analysis on each category is developed, introducing the description of main KSFs and barriers identified in the demonstrators of ZenN project, classified under the aforementioned categorisation:

Figure 2: Categories of barriers and Key Success Factors in ZenN project.

5.1 Technical drivers

5.1.1 Range of applicable technical solutions analysis

A wide range of retrofitting measures and technical solutions have been applied at the four ZenN demonstration sites, including building envelope refurbishment, energy recovery measures and local energy generation units etc.. Depending on the geographical location, the building condition before project as well as differing national market, economical and other prerequisites, the solutions applied have differed significantly. For example, in Mogel, an overall significant facade refurbishment has been carried out, including both exterior additional insulation both for walls and roof, while in Lindängen window replacement has been the sole energy efficiency measure carried out for the facade. The Lindängen approach was connected to the rather good facade conditions before the project, while, still, the windows had reached their technical life span. For Lindängen, Ökern and Grenoble, a PV solution has been applied, while a solar heating solution has been applied in Eibar. Furtherly, energy recovery systems (exhaust air heat recovery) were applied in Lindängen and Ökern with a foreseen good recoupment of the investment, while not being implemented in Grenoble and Mogel. The overall view of these technical solutions and the balances considered for the different demo sites to reach the final decisions is summarized below per technical solution.

Window replacement and facade retrofitting

Window replacement has been performed in every of the four ZenN demonstration sites, and should be commonly performed in similar projects ahead. Where buildings have been operated for approximately 40 years having an old and worn set of windows approaching its technical life span, the investment should always be profitable. The energy savings purely due to window replacement could not be monitored, but all sites have considered the investment as a beneficial investment. Careful considerations should always be made, and have been done in Grenoble, whether a complete replacement should be made if parts of the window stock have been replaced a few years earlier. In Grenoble, the windows installed 20 years before the project were kept due to insignificant energy savings.

The viability of facade refurbishment depends largely on the pre-project condition of the facade. Also, the scale of the facade retrofitting and ambition to decrease air infiltration depend on the ventilation solution, how a good indoor climate can be maintained and how condensation problems can be avoided. In Mogel, these considerations have been essential (see Technical barriers below). In Lindängen on the other hand, no facade retrofitting accept for the window replacement has been performed, partially since the facade was in good condition already before the project and a foreseen lack of profitability of the investment.

Energy recovery system of exhaust air

Energy recovery solutions for exhaust air have been applied for the sites in Lindängen and Ökern where profitable investments have been anticipated.

The investment in Lindängen (exhaust air heat pumps recovering heat for heating system) results in a decreased heating supply but simultanously cause an increased electricity consumption by approximately ¼ of the decreased heating. The profitability foreseen at Lindängen depend on the overall cost relation between the electricity and district heating supply. D3.3 will give sharp results on the energy and environmental efficiency of this measure.

With an ESX solution, as installed in Ökern, the electricity use increase is small, ensuring primary energy and environmental benefits of the measure. At the same time, it includes difficulties in implementation for residential buildings since disturbances for residents are higher than when installing a heat pump solution and since there could be a lack of space for air intake ducts (see Technical barriers below).

Individual metering of domestic hot water

Individual metering and billing (IMD) of domestic hot water has been applied in the Lindängen site. The anticipated DHW savings after renovation is 27 %; the monitoring report of D3.3 finalized upcoming September, will provide the real results on this from the first year of monitoring.

The cost-effectiveness of the technique is naturally dependent on which energy savings that are achieved. Individual billing is not legally mandatory in Sweden, due to the conclusion that it is not cost-efficient compared to a collective bill (Boverket, 2015[4]), for which costs are distributed between the tenants based on their rental area. There is often a doubt among building owners on which energy savings that will be achieved from applying IMD, and often the real savings could not be proved, due to a lack of sub-metering of domestic hot water before IMD is implemented. A problem often mentioned in similar projects previously is that the will to save energy can be hindered by the insight given to the tenants that the domestic hot water costs often are not considerably high compared to other everyday costs (in Sweden). The effect of implementing IMD should therefore probably be largest for households with more limited incomes and a previously squandering behaviour in domestic hot water use.

New control systems for heating

A well-functioning control system for heating is important to avoid over-heating in apartments and making sure that a good indoor comfort is maintained. In Grenoble, a system of regulating heating temperature in every house has been implemented and in in Lindängen heating adjustments have been performed with the goal to maintain indoor temperatures of 21°C during heating season. The double benefit of trying to equalize the indoor comfort between apartments and to avoid over-heating and inefficiency should be acknowledged.

Photovoltaics

Photovoltaics are the local energy generation facility implemented in the sites of Lindängen, Ökern and Grenoble. The PV facilities in each of the sites are foreseen to bring a significant reduction in delivered property electricity. They constitute interesting examples in how to achieve a higher self-supply of energy for residential buildings and nursing homes, and interesting results on their real performance compared to calculation will be presented in D3.3.

Solar thermal system

Mogel have implemented a local solar thermal system complementing the heat supply from natural gas boiler. The generation system is foreseen to provide approximately 20 % of the yearly thermal energy need. The first year of monitoring, to be presented in D3.3, will give good insights to the real performance.

Solar thermal solutions have in previous cases demonstrated a low applicability under Nordic circumstances; the systems could be complex to adjust into an as efficient operation as having been foreseen. In a demonstration building included in the EU-financed BuildSmart

[4] Boverket (National Board of Housing, Building and Planning), 2015, *Individuell mätning och debitering i befintlig bebyggelse*, RAPPORT 2015:34, REGERINGSUPPDRAG

project, an adjustment period of up to 2 years has been needed for the solar thermal facility, and the investment has been considered as overall unprofitable (BuildSmart, 2016[5]).

Low energy light fittings

Measures of installing low energy light fittings have been performed in each of the demonstration sites in Lindängen, Mogel, Ökern and Grenoble, and should be a common measure to include for future similar retrofitting projects. A large reduction in energy use is foreseen e.g. at the Lindängen site where the sub-metering system installed for the property electricity will give an overview of the performance of the light fittings presented in D3.3.

5.1.2 Technical KSFs description

KSF headline
1. **Prioritizing neighbourhood level solutions above individual building level solutions is successful** out of a cost-efficiency and resource-efficiency perspective.
2. Fairly similar life cycle costs are remained when making technical details improvements, implying that **reducing energy is sustainable not only in environmental terms, but also economically**.
3. **Exhaust air heat recovery systems**, as installed at Lindängen, **are generally cost-effective**.
4. **A large reduction in heating demand is obtained with the implemented thermal insulation on facades and better thermal performance of windows** in Mogel. Corresponding solutions should be cost-effective in many similar neighbourhoods.

1. Prioritizing neighbourhood level solutions above individual building level solutions is successful out of a cost-efficiency and resource-efficiency perspective.

D3.1 confirmed that the neighbourhood approach in the Mogel demo allowed the proposal and integration of new systems and technologies for rehabilitation that would not be feasible if just a smaller scale (building level) had been considered. This has made it easier to include more sustainable energy management strategies in a cost-efficient way. The results suggest that generally, neighbourhood level solutions should be prioritized over individual solutions at building level, as these are more cost-effective and more resource efficient.

2. Fairly similar life cycle costs are remained when making technical details improvements, implying that reducing energy is sustainable not only in environmental terms, but also economically:

The general impression from the Økern demo site is that extended energy reductions by focusing on detail improvements do not increase the life cycle costs significantly. E.g.,

[5] BuildSmart, 2016, EU project, Deliverable 5.3, *Report on observed challenges and obstacles during development, installation, and operational stages of advanced ICT Systems*

reducing thermal bridges and increasing the airtightness further, increasing heat exchanger efficiency, improving performance of demand controlled ventilation and increasing PV area were included in the scenarios where the costs were assessed. The scenarios focusing on technical details gave between 24-43 % energy savings compared to the final energy performance of the real scenario implemented without significantly changed life cycle costs. This is an important perspective on the cost-efficiency of a high energy saving ambition.

3. Exhaust air heat recovery systems, as installed at Lindängen, are generally cost-effective:

It has been concluded in D3.1 as generally cost-efficient to install heat pumps for local heat recovery in exhaust air flows, and a solution that always should be considered, especially in Northern Europe where heat losses in ventilation represent a significant part of the energy demand. The installed system in Lindängen has during the 2016-2017 season had a COP (coefficient of performance) of approximately 4. This implies that for every kWh electricity consumed by the pumps, 4 kWh heat has been recovered to the heating system, partly replacing the district heating deliverance. The total cost relation between electricity and district heating makes this investment recoupable. Out of a final energy perspective the solution should be as large-scale as possible, but out of a total environmental perspective, the scale might have to be different, since primary energy consumption and greenhouse gas emission might increase despite the final energy savings.

4. A large reduction in heating demand is obtained with the implemented thermal insulation on facades and better thermal performance of windows in Mogel. Corresponding solutions should be cost-effective in many similar neighbourhoods:

It was included in D3.1 that the rehabilitation of facades and the associated replacement of windows frames leads to an increase of the tightness of the envelope, and as a result a reduction of air infiltration rates with a very positive impact from the point of view of energy efficiency. Several blower door tests carried out in Mogel have concluded that a reduction of nearly 33% in air leakage can be reached after a correct execution of the retrofitting works. This also reduces the thermal bridges contributing to a further reduce of the envelope thermal losses. The implemented solution should be considered as a possible long-term beneficial solution also in many similar neighborhoods.

5.1.3 Technical barriers description

Barrier headline
1. **Complex and demanding to find a balanced facade retrofitting solution** considering both energy efficiency, indoor air quality and avoiding condensation risks.
2. A **technically holistic perspective is needed**; sometimes one measure makes another necessary.
3. Many solutions require access to apartments (requiring extensive communication,

	sometimes evacuation apartments...)
4.	**Practical difficulties implementing ESX solution for heat recovery** (disturbances for residents, lack of space for air intake ducts etc.)

1. <u>Complex and demanding to find a balanced facade retrofitting solution considering both energy efficiency, indoor air quality and avoiding condensation risks:</u>

Facade retrofitting is a holistically complex measure to improve energy efficiency. The main actions in Mogel are related to reducing heat losses through the building envelope, by applying additional insulation in facades and roofs as well as a window replacement. These solutions decrease the air infiltrations in the building and are foreseen to give a large reduction in heating demand and an overall 55 % primary energy reduction. A complexity lies in the connection to indoor air quality, and the solution required an extensive risk analysis to avoid condensation and air turnover problems. One conclusion was that if the only mechanism available for ventilation is the infiltration through the envelope, this may result in an insufficient level of air turnover to ensure acceptable levels of indoor air quality inside the flats when having full occupancy. The difficulties and the necessary analysis to carry out display the importance of a holistic balance in the design of facade retrofitting solution.

2. <u>A technically holistic perspective is needed; sometimes one measure makes another necessary:</u>

A holistic technical perspective must be kept in the decision process of the complete retrofitting measure package. As an example, the sensibility studies of the construction in Grenoble showed that insulation of the outside of the facades without reducing the thermal bridges can bring real problems of condensation and of mould. The renovation of buildings thus required studying the singular points, and not only the common sections, and the implementation of a certain energy efficiency measure could make another measure necessary in a holistic perspective.

3. <u>Many solutions require access to apartments (requiring extensive communication, sometimes evacuation apartments...):</u>

An overall difficulty for many retrofitting measures, compared to new building projects, is that they require access to inhabited apartments. Examples are facade retrofitting, window replacement, ESX ventilation installations and individual metering solutions, for which these challenges are a significant factors in the decision process. The need for access requires an extensive communication with tenants and, in cases, consent agreements, evacuation apartments and rent adjustments. For the least possible disturbance for the tenants, different measures should be coordinated and performed simultaneously. In Lindängen, a comprehensive scheme for window replacement was made a largely communicated with help from engaged tenants in the neighbourhood. The goal for Lindängen of making the complete replacement in one apartment a day was mostly possible to achieve. For avoiding technical difficulties, also the opportunity to perform test montages in empty apartments for these measures has been very well advocated by the engaged contractors.

4. <u>Practical difficulties implementing ESX solution for heat recovery (disturbances for residents, lack of space for air intake ducts etc.):</u>

ESX ventilation solutions involve certain technical and practical problems which e.g. could be avoided if a heat recovery system for radiator heat is applied, as in Lindängen. For example, the disturbances for residents are higher with an ESX solution, since access to apartments is necessary. Furthermore, it can be challenging to find or create space for shafts for the additional air intake ducts inside the buildings. New technologies are though under development where supply air ducts can be placed on the outside of the existing building in combination with additional insulation. These solutions should facilitate implementation of ESX, thereby simplifying the implementation of heat recovery systems with an ensured environmental benefit, compared to exhaust air heat pump solutions.

5.2 Non-technical drivers

5.2.1 Financial aspects analysis

During the project, a study on economic and ownership structures of ZenN demonstration buildings has been carried out. The aim of the study was to analyse different financial schemes that were implemented within the ZenN project, and propose efficient solutions for energy-efficient retrofitting.

In general, the main challenge concerning energy-efficient renovations is associated with a short time horizon, in economic science known as high time preference. The point is that many investors or property owners are not willing to invest in nZEB renovation because of the long payback time of such investment. Another challenge of such investments is the lack of capital needed to implement nZEB refurbishments, as well as reluctance of real estate owners to take high credits. It is also connected with some hesitation or lack of knowledge whether new, ecological solutions are indeed as profitable as it is being said.

Among promising financing models that make it possible to handle the aforementioned challenges are Third Party Financing and the Energy Savings Performance Contracting (with participation of Energy Saving Company – ESCO).

The ZenN project provided in the report *D4.3 economic and ownership structures* the following conclusions, recommendations and respondents' (owners, managers, residents' representatives etc.) suggestions:

- **It may be considered as a problematic situation when an owner of a building does not inhabit it**. It can raise problems when an owner of a building is not its user. Expenses are made by an owner, while incentives and utility upgrades are used by tenants. Thus, owners can be discouraged to invest in energy-efficient renovations. However, some solutions of this problem can be proposed.

- **It is a good idea to combine energetic renovations with other renovation goals**. In case of the renovation performed in Spanish demonstration case (Eibar, Mogel), many of the dwellers were mostly interested in acquiring lifts in their buildings. It was an important investment for them. Thus, it was the strategy promoted by Debegesa and the Basque Government to try to connect the energy efficient renovations with other previously requested installations and modifications of the buildings. It is advisable to use such a combined investment approach in order to encourage owners to involve energy efficiency measures in other types of projects.
- **Low percentage of funds should be kept as a cash reserve in case of additional costs required**. An initial budget of renovations should be slightly expanded in order to give financial security for project implementers. Additional money would allow to omit any challenges related to unexpected expenses that would arise due to new, unforeseen and necessary construction work. Taking into account a complexity of deep energy efficient renovation, a possibility of being faced with some unscheduled renovation may occur.
- **An important issue is the sustainability of financing**. There is a need for a different approach to financing nZEB renovations in terms of the duration of the subsidies. The ZenN project partners mentioned the importance of continuity of the financing programs or instruments. In the case of projects coordinated by public entities there is a strong need for a financing source that would go on for a longer period of time, without interrupting the continuity of financing options. This would pave the way for more extensive projects, involving a renovation of greater number of building. Considering that a financing source would not change, the formalities required to obtain the funds would also be identical. This would enable investors to use the financing options more effectively and efficiently for future projects.
- **There are some very promising new mechanisms that can be applied in nZEB renovations**. There are some innovative instruments for financing energy improvements that have been applied in a couple of countries. The financing models for nZEB renovations can be improved in particular by attaching loans to properties rather than owners or tenants and making loans flexible to the changing users or property rights, including the loan instalments in utility bills or deducting the loaned money from property tax bills. Among these instruments are: The Green Deal (the UK); Property Assessed Clean Energy Program (PACE, the USA) , Public Third Party Investor (France) .
- **Owners were pretty satisfied with the financing scheme applied in the ZenN project, some that are replicable**. Majority of the ZenN project partners indicated they would either use the same financial model again in future projects or would be willing to recommend the solution to other building owners. Although in the case of the Spanish demo site the model also had been a great success, the owners of the Eibar properties had certain doubts concerning the replicability of the investment. They were implied inter alia by the fact that the project was strongly dependent on public support that as mentioned above is not stable enough (both in timeframe and structure). Moreover, the ownership structure was very fragmented in this case and required individual approach to some of the residents. This challenge, however, was overcome with success. On top of that, residents of other buildings who at first did not agree with the renovation have contacted Degebesa and expressed their

great interest in such renovation. The key issue here is to show the residents that in reality they will gain great benefits of such investment.

- **Banks consider loans for nZEB in a rigorous and unified way**. One of the conclusions of the financial barriers analysis is the fact that banks treat finances in rigorous, traditional and unified way. The fact that the funds are required for energy-efficient retrofitting on a large scale does not change the approach of financial institutions. Many banks are quite cautious when it comes to financing investments with relatively high risk. This may result in difficulties when some of the co-owners of a retrofitted property are denied financing and cannot participate in the refurbishment project. Naturally, most of banks are not willing to offer much lower interest rates for their clients when it is not in their best financial interest.
- **Subsidies were important incentives for deciding to take part in retrofitting**. In all the ZenN demonstration cases the subsidies were assessed as very important and necessary sources of funds for the planned refurbishments. In most cases, the grants were a big element of motivation for engaging in such a venture. It is sometimes hard to encourage building owners to invest in energy-efficient technologies. This phenomenon is well documented in the case of the Spanish demo site in Eibar.
- **Financial incentives were essential motivation for tenants**. Without the financial incentive, the environmental benefits alone are not enough to convince an average user of a dwelling to invest in retrofitting, even if it arrives with an opportunity for a subsidy. The regional and local governments are aware of that; that is why they are placing their attention on providing financing for these types of projects and providing support tools that will enable the owners to approach energy efficient retrofitting more successfully.
- **There is a big difference in the specificity and motivation in case of commercial and municipal entities**. There is a large difference in the specificity and motivation for retrofitting between commercial and municipal properties. Apart from trying to generate financial and energy savings, the public entities are also interested in improving energy performance due to ideological causes. Setting good examples and disseminating the idea of nZEB renovation may be more important in case of public buildings than any financial gain that may arise in the process.
- **There is a need for flexible approach to finance and technologies in grant awarding procedure**. The building owners pointed out it is important to have a surplus of funds when performing ambitious energy-efficient renovation, since additional needs may arise if difficulties appear along the way of the refit. Second, it is important for owners not to be limited by financing entity to using technologies that are not the best to perform a given refit.

5.2.1.1 Financial KSFs description

KSF headline
1. **Financing instruments** allow conducting more intensive and **deeper energy-efficient renovation** (e.g. ZenN subsidy)
2. Win over the problem of split incentives - implementation of **solutions that deal with the problem of fragmented ownership and building use structure** (Oslo: green lease contract; Malmo: increased property value as the owner’s main motivator; Grenoble: the owners

gain financial benefits from raised rents, while tenants pay less in total as the energy bills are lower)
3. Encouragement and support for inexperienced investors dealing with pioneering projects (complicated technically and financially, burdened with significant risk) – Eibar case: involvement of professional party experienced in energy efficient renovation, e.g. DEBEGESA, connection of the energy efficient renovations with other previously requested installations and modifications of the buildings, e.g. lifts installation;

Commonly identified barriers to energy efficient renovations relate to finances. Empirical findings from studies on energy efficient renovations, including ZenN analysis (see D.1.1 Common barriers and challenges in current nZEB practice in Europe, and D4.3 economic and ovnership structures) show that especially nZEB renovations are perceived as expensive, and for sure are more expensive than standard energy efficient renovations, and neither residents nor building owners can easily afford such investments without any external supprt. Thus, the key success factor is to guarantee a complex financial model supporting not only the renovations aimed at energy efficiency increase, but to provide financial instruments supporting exclusively nZEB renovations. It was commonly agreed by the ZenN demonstrators that the possibility and high probability of gaining external funds for the renovation works mobilised and prompted them to take a decision on the investment project implementation.

There were three main sources of financing for retrofitting in Oslo demo. The investment was funded from the following sources: the municipality's budget, the ZenN project funds and the national fund for energy efficient buildings called ENOVA. ENOVA SF is a Norwegian National Energy Agency owned by the Royal Norwegian Ministry of Petroleum and Energy (MPE), established in 2001 with headquarters in Trondheim and a total staff of 60 employees. Enova SF works with a broad network of players in all sectors of the economy, including decision makers in commerce and industry, end-users, municipalities and other public sector and regulatory bodies. Enova's role is to strengthen the links between the various groups of actors, to coordinate project development and to improve the effectiveness of public action in the energy area. Enova's vision is an energy-efficient and renewable Norway. Its primary objective is to promote environmentally friendly restructuring of energy end-use and energy production. The energy restructuring is a long-term initiative to develop the market for efficient and environmentally friendly energy solutions that contribute to strengthening the security of supply for energy and reduce the emissions of greenhouse gases. ENOVA contributed 450 NOK[6] per square meter, namely 4,4 million NOK[7]. The payments per square meters were made accordingly to the surface stated in the application: 9357 meters. The payback time for the investment, with the help of

[6] Exchange Rates: 1 Euro = 9.3138 Norwegian Krone (04.11.2015; http://themoneyconverter.com/)
[7] Ibidem

ENOVA is 7.5 years. Without the ENOVA's funds it would have been 13 years. The investment support from Zen-N amounted to 50 euros per square meter. The total investment cost for the renovation was just under 215 million NOK[8] (approximately 18 000 000 €).

Demonstrators from Grenoble received financial support from subsidies/grants under National Programme for Urban Renewal (PNRU) coordinated by National Agency for Urban Renewal (ANRU). The first National Program for Urban Renovation (PNRU1) was carried out from the year 2003 to 2013. Urban renovation projects were done in working-class neighbourhoods in order to trigger their development. A second National Program (PNRU2) started in 2014. As part of the National Programme for Urban Renewal the National Agency for Urban Renewal (ANRU) was created in 2003. It controls the development of urban renewal projects. The ANRU's goal is to simplify and speed up the control of urban renewal projects on the part of local collectives and rented social housing management bodies that wish to undertake urban renewal projects in priority areas. The ANRU finances urban project with public and private funds. These projects have to take place in neighbourhood classified as sensible urban zone (ZUS), meaning neighbourhood with social and economic problems. In addition, the French demonstrators benefited from loans dedicated to building renovations: Urban Renewal AMALLIA loan, PAM loan (refurbishment loan), Anti-asbestos loan. Obviously, the renovation works were also supported by the ZenN grant.

In Eibar, there were four financing sources of the investment:

- Basque Government;
- Eibar City Council;
- European programme (ZenN project);
- Residents' funds.

All of them were direct grants. Apart from that, the Basque government provided a subsidized interest rate. Depending on the beneficiary's income the government offers additional funds used in order to lower the interest rates by a decimal point. The bank then adjusts the rates, taking into account the money received from this subsidy. It is important to point out that the funds were not strictly and exclusively for energy efficiency reform.

In Lindängen demo site (Malmo), the budget used for retrofitting included building owner's own sources + bank loan and ZenN project subsidies.

All interviewed representatives of ZenN demo cases were satisfied with the applied financing scheme and would in general recommend it to the next similar projects. What is important to stress, in each out of the four demo cases the financial support received from ZenN project was especially appreciated. Despite the fact that ZenN financing was not the major part of the retrofitting budget in any case, it guaranteed financial sources to perform deeper,

[8] Ibidem

more intensive and ambitious renovations targeting at better levels of buildings energy performance. It was expressed that the additional financial sources from ZenN project were the main motivator to implement more ambitious retrofitting works as they allowed bringing an added value with the same costs. Thus, the external financing support, especially such dedicated directly to nZEB renovations should be considered as the main key success factor in case of energy efficient retrofitting.

One of the most important barrier hindering energy efficient renovations is the problem of split incentives - it concerns the lack of appropriate incentives to implement energy efficiency measures in housing sector resulting from fragmented building ownership and use schemes (party financing the investment and taking the investment risk is not the one who obtain the financial benefits from reduced energy use). It was also the case of majority of ZenN demonstrators. In each case the involved parties implement solutions dealing with the problem of split incentives and those solutions were assessed by the demonstrators as the key success factors.

A green leasing contract was applied in Økern. A green leasing contract governs the relationship between the landlord and tenant through an environmental lens. Among its main principles are:

- The landlord should operate the building and the tenant should operate its premises as efficiently as possible;
- The responsibility for the capital expense of an installation or piece of equipment and the benefit of savings should reside with the same entity. Alternatively, all of the savings achieved by virtue of a system improvement should be available to pay for the improvement;
- Both consumption and demand for resources throughout the building should be measurable and transparent to both the landlord and the tenants.

A green lease is either a new lease or a modification to an existing lease. It has an additional set of schedules compared to a 'normal' lease contract. A green lease includes a contractual basis for monitoring and improving energy performance, mutual obligations for both tenants and owners to achieve resource efficiency targets (e.g. energy, water, waste) and minimize environmental impacts. This ensures that the rented space operates at an agreed level through regular monitoring and ensures issues can be addressed as they arise. Green leases help to ensure that leases are structured to create compulsion and to create incentive for both parties. In a result tenants pay a slightly increased rent, however the final expenditure for the accommodation expenses will be lower than before the retrofitting due to reduced costs in energy bills. The additional rent money will be used in order to assure the return of the owner's investment.

In Grenoble, rental costs were made higher in order to generate the return of the investment: the price increase mustn't exceed 10% according to the agreement made with the CSF (Confédération Syndicale des Familles) which is a neighborhood tenants association. A maximum 10% increase of rents (excluding the bill charges) has been established and introduced not sooner than the time the refurbishment is completed. The level of costs to be experienced by the residents will not be affected because the operational cost of the dwelling will be lower (the overall costs of living will still be lower or exactly the same considering the energy efficiency savings + remodelling of the dwellings into smaller sizes).

Apart from the direct financial savings, the owners benefited from increased building value due to the renovation process, while tenants from improved quality of life and better living conditions inside the building (e.g. better insulation resulting in more comfortable temperatures inside). The residents benefit from the implementation of the renovations. The value of the property is now greater due to its integral rehabilitation and above all because of the installation of the lifts. The property is also far more energetically secured, which also translates into its value.

It might seem that the issue of split incentives was also an important obstacle in the Malmo case, as the sole owner of the Lindängen demo site property is real estate company Trianon, and dwellings in Lindängen site consist solely of rental apartments. However, due to the business approach performed by the Trianon (owner) the problem of split incentives is not the issue in Malmo case. Although the tenants will benefit from the lower energy bills, it will be Trianon and its shareholders who are the most important financial beneficiaries of the nZEB renovation according to the owner company. The owner did not divide costs in terms of his company's investment into energy saving equipment and the savings his occupants could potentially obtain through their energy bills. Instead, he considered payback in terms of the increased value of the property after renovation. Malmo demonstration owner might be characterized as having a strong business approach as he claims that successful endeavours in retrofitting result in profits and "make good businesses". The business owner approach of examining property value within the calculation of payback removes the complexities of considering the in-balance of investment to energy measure and tenants who benefit through reduced energy bills.

When the split incentives is not the issue as the building owner who invest money in the energy efficient renovation is also the one who will benefit from lower energy bills, there is often another obstacle – individual building owners are usually inexperienced in dealing with such demanding projects. Deep energy efficient renovation is a challenge complicated technically and financially, burdened with significant risk, especially when the owners private financing sources are needed in order to perform the energy efficient renovation. It was the case of Eibar demonstration - part of the investment was financed by the residents. Not surprisingly, fears and scepticism were expressed by them.

Thus, the successful strategy applied in the Eibar demo was the connection of the energy efficient renovations with other previously requested and highly needed installations and modifications of the buildings (in Eibar case many of the dwellers were mostly interested in acquiring the lifts in their buildings). It is advisable to use such a combined investment approach in order to encourage owners to involve energy efficiency measures in other types of projects. In this way it is possible to achieve a good added value for a similar price of the work and omit additional construction works in the property. All refits are performed jointly at the same time, minimizing the impact and the inconvenience for the residents.

Another successful factor supporting the non-professional investors dealing with energy efficient renovations is the involvement in projects professional parties experienced in energy efficient renovation – in case of Eibar it was the involvement of DEBEGESA and construction comany who supported the residents in decision making process as well as during the works were performed. Debegesa is the Local Development Agency of Lower Deba region who offers housing renovation services to assist individuals and residential communities, as well as developers of renovation works.

Debegesa supported residents at the stage of applying for funds for renovation together (from the Basque Government, the City Council and the European Commission) – in a result of its mediations residents gathered all the support in one package, which has made the procedures and formalities much easier. In addition, the involved construction company negotiated with bank better financial terms that allowed for longer repayment period (5 to 10 years) and resulted in lowering instalments to about 200€ – 300€ a month, which made it easier to participate for the owners with fewer financial resources, who were unable to take a loan due to their financial situation.

5.2.1.2 Financial barriers description

Barrier headline
1. **Long and /or difficult to predict payback time / return of investment**
2. **Fragmented building ownership and use schemes** (party who finances the investment and takes the investment risk is not going to obtain the financial benefits from reduced energy use)
3. **Risk assessment for loans from banks not always suitable for ZenN renovation** (banks manage finances in rigorous, traditional and unified way
4. **Unexpected costs** exceeding the fixed project budget

One of the most important barrier hindering energy efficient renovations is the problem of split incentives - it concerns the lack of appropriate incentives to implement energy efficiency measures in housing sector resulting from fragmented building ownership and use schemes. In practice, this means that party financing the investment and taking the investment risk is not the one who obtain the financial benefits from the reduced energy use. Thus, owners don't make efficiency investments because it's the renters who pay the energy bills. And renters don't make investments in property they don't own. This problem is called ”split incentives” which are defined as a circumstance in which the flow of investments and benefits are not properly rationed among the parties to a transaction, impairing investment decisions. It was also the case of majority of ZenN demonstrators.

In Oslo the party financing the investment and taking the investment risk (Omsorgsbygg – a municipal enterprise and property managers) is not the one obtaining the financial benefits through lower energy bills (building operator - Sykehjemsetaten). There was a similar situation in Grenoble - the parties financing the investment and taking the investment risk (owners: social housing associations SDH and ACTIS) are not the same who benefit from improved energy efficiency (residents). Naturally, the issue of split incentives might be also perceived as an important obstacle in the Malmo case, as the sole owner of the Lindängen demo site property is real estate company Trianon (decision maker and investor), and dwellings in Lindängen site consist solely of rental apartments. However, thanks to the business approach of Trianon Company, the problem of split incentives did not exist in Malmo case despite the fact that they will be the tenants who benefit from the lower energy bills. Trianon considered payback in terms of the increased value of the property after the renovation, thus adopting such an approach the problem of split incentives does not exist in this case. In Mogel the situation was less complicated as the dwellings owners are their users in majority of cases.

Another significant problem to overcome is long / difficult to predict payback period/ return of investment. Payback period refers to the period of time required to recoup the funds expended in an investment, or to reach the break-even point.

There is a long payback period in energy efficient renovations (especially in nZEB retrofitting). Certainly, implementing energy saving solutions is financially rational and people are getting more and more aware of it. However, regarding nZEB renovations, the time taken for return of the money invested is a significant 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 even a more crucial issue. 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 hindering the implementiation of deep retrofits. Another limitation of payback period is its calculation burdened with errors - basic payback period ignores the time value of money and therefore may not present the true picture when it comes to evaluating cash flows of a project. Additionally, payback period does not take into account the level of cash flows of an investment after the payback period. In other words, payback period ignores the overall profitability of investments. These were also the challenges that ZenN demonstrators faced.

The estimated payback time for the investment in Økern (Oslo) is approximate 7.5 years. It is relatively short due to the involvement of ENOVA funds (without the funds, it would have been around 13 years). However, the final calculation will be available after the monitoring period. Another factor shortening the period needed for the return of investment is the green lease solution implemented by the owner of Økern Sykehjem (Omsorgsbygg). This lease ensures a pay back from the investment in energy efficiency measures as the tenants will pay a slightly increased rent to the owner. The tenants benefit as their final expenditure for the accommodation expenses will be lesser than the previous one due to much lower energy bills. Although exact figures on what the energy bill amounts to after the renovation are not available yet, the owner is confident that the retrofitting will result in at least a 68% reduction in energy expense.

In Malmo case, one of the greatest challenges was the estimation of the payback time. The owner considers the increases in property value in the category of the return of investment rather than analysing calculation based solely on energy savings from the equipment installed. This means that if the property valuation increases by more than 50 million SEK[9] (the amount invested in the retrofitting), there is no need to examine the payback time according to the owner. A higher net operating income will result in higher property assessment. The increased net operating income has not been noticed yet, but due to the changes in the market situation the property has already generated 50 million SEK[10] of revenue due to the rise of its value. When this effect coincides with the net operating income increase, the company will earn more than it has invested.

In Eibar, the period needed to gain the direct return of investment (not understood as the property value) was foreseen to be very long and linked to the use of utilities. It may be even possible that the financial benefit will occur for future generations.

In order to compensate this drawback, the apartment's owners were encouraged with improvements like better quality of living conditions and home comfort related to the accessibility measures (the lifts). The energy efficiency measures were treated as a kind of unexpected result that was appreciated only after the refurbishment was finished. Currently, the residents benefit from the implementation of the renovations. The value of the property is now greater due to its integral rehabilitation, and above all, because of the installation of the lifts. The property is in addition far more energetically secured, which also translates into its value.

[9] Exchange Rates: 1 Euro = 9.3224 Swedish Krona (19.01.2015; http://themoneyconverter.com/)
[10] Ibidem.

In the last ZenN demo site - Grenoble, the payback time was not calculated at all. According to the interview with SDH representative: *in 20 years, the exploitation simulation shows that the operation of the 40 Arlequin is still not going to be balanced. The SDH will still be losing 44 000 € per year in 2036.*

Another important problematic issue is the banks' attitude towards nZEB projects. The representatives of ZenN demonstration buildings complained that in general, banks manage finances in rigorous, traditional and unified way. The fact that the target use of borrowed funds is potentially the energy-efficient retrofitting on a large scale does not change the approach of financial institutions. Overall, the risk **assessment for loans from banks is not always suitable for ZenN renovation.** For example, in order to receive funds from the bank in Sweden it is important to have a low LVR (Loan to Value Ratio). Banks do not finance uncertain investments with high risks and low LVR. This means that the value of borrower's resources must be high in comparison to the amount of money to be borrowed. Fortunately, Trianon had no problems in getting a loan from the bank as their own resources were relatively high when compared to the amount to be borrowed (LVR for the property was around 60%, which was lower than the maximum of around 75% allowed by bank). However the typical situation is opposite – in many cases people are not able to get loans for such expensive investments as the calculated LVR is too high.

Mogel demonstration participants complained that there had been little engagement in the project from the banks. Many of them did not provide competitive offers with low interest rates. The banks viewed the project from a more traditional standpoint - they examined the clients from the perspective of the financial risk. As a result, there were some residents who did not receive loans.

It seems that some global top-down mechanism should have worked there. Banks should be encouraged to follow individual and flexible approach towards such pioneering projects as their participation in such projects should be perceived as an occasion to upgrade their market position and image, etc. Such self-regulating market mechanisms might be complemented by the public authorities whose role is to create relevant legislation requirements, incentives, and other forms of support for banks. It was too late to introduce such an approach in Mogel demonstration case it but can be carried forward to other similar projects in the future.

Last but not least barrier is the unexpected cost exceeding the project budget fixed at the preparatory stage. Nearly zero energy renovations are still specific type of pioneering projects - complicated technically and financially, burdened with significant risk. Thus, it is not surprising that in the course of the project implementation some unexpected circumstances requiring the involvement of additional financial resources might occur.

For example, in Oslo case during the process of retrofitting some parts of the property were demolished which led to discovering additional areas of the building which required renovation. As the property is an old facility the level of costs increased during the progress of the retrofitting. Moreover, the modified area turned out to be larger than initially expected. The increased weight of the new ventilation system led to an expanded technical room on the roof to manage the increased load bearing on the building. These additional works for the renovation were not included in the original calculated subsidy.

Similar challenge was also faced by the demonstrators from Grenoble case; however, the reasons for the emergence of unplanned expenses were different. According to the SDH representative the state regulatory interventions influenced the investment in a negative way – these interventions included increased VAT level from 1st January 2015 and new regulations on asbestos complicating the intervention of the works (including the investor costs).

This might lead to the conclusions that the estimated budget of the renovations should be slightly expanded in order to give the financial security for project implementers. There may be additional or hidden expenses required for the construction that project financers may not be able to predict at the beginning. It may be hard to finance such additional expenses in some cases without having surplus funds. Additional money would allow omitting any barriers related to unexpected expenses that would arise due to new, unforeseen and necessary construction work. Taking into account the complexity of deep energy efficient renovation, the possibility of being faced with some unscheduled renovation work is quite high. These additional funds might be used only in special circumstances and returned to the financing bodies in case there was no need to use them during the project.

5.2.2 Awareness, social acceptance, knowledge and training implications

The initiative to renovate emerged differently for demonstrators in ZenN. The motivations to renovate include a need for updating building(s) to meet maintenance demands (Økern, Lindängen), improvement of a run-down neighbourhood (L'Arlequin) or an accessibility need (Mogel). For Økern and L'Arlequin demonstrations, the reduction of energy demand was always on the agenda but the introduction of ZenN increased targets to reduce energy demand. Mogel was the only demonstrator where the building owners were the residents so they were involved in the decision making process. The energy efficiency targets in the demonstration projects were part of a stipulation to receive funding from the government. In L'Arlequin the energy efficiency targets were part of a strategy for social improvements. The table below indicates the backgrounds of each of the demonstrations.

	Økern	**Lindängen**	**Eibar**	**Grenoble**
Building owner	Public owned	Real estate agent	Private (at least 10 owners per building)	Public owned
End users	Building owner, Facilities managers, nursing home	Building owners, facilities managers, janitors and	Residents who are also building owners	Residents who rent from building owner

	staff and elderly residents	renters		
Motivation for original renovation	Necessary upgrading and building required as temporary nursing home	Necessary upgrading	Accessibility issues	Improving the district's image, identity and quality of life.
Occupation during renovation	Empty building	Residents in building	Residents in building	1/3 of building occupied

Table 3 Background of demonstrators

5.2.2.1 Social KSFs description

KSF headline
1. **Expertise for energy performance solutions, which complement user functionality**
2. Long-term focus in renovation through **building user involvement**
3. Knowing the **optimal compromise between energy performance measures and architectural value and cultural heritage**

1. Expertise for energy performance solutions, which complement user functionality

In the earlier report of ZenN D1.1 (Karlsson et al., 2013), gaining access to knowledge for energy performance solutions was problematic. Demonstration projects considered this access to knowledge within the context and goals of the renovation. Demonstrators were reluctant to change original renovation goals due to the introduction of ZenN, which increased energy performance ambitions. Therefore, demonstrators aligned the increased energy performance measures using different approaches and knowledge sources. Some of these approaches and knowledge sources include; examining design detailing, value adding on a functional need and being realistic on energy measures by considering available knowledge and budgets. In this way, the underlying reason for the renovation was improved by the introduction of energy performance measures.

The demonstrators of ZenN provided different ways on the access and the development of knowledge. A well-formed project team helps openness of communication when there is uncertainty about implementing energy measures and gaining support for renovation energy performance goals. Økern demonstration held workshops and several meetings to address concerns of the project team, particularly on the installation of the solar PV system. Lindängen tested the window exchange on one apartment before installation to the entire building to increase confidence of the solution and detect errors early. Mogel project team needed to address user misconceptions about the technical energy performance system as such misconceptions led to unnecessary changes in behaviour. Grenoble held early discussions with the project team at the design phase to find solutions to reduce energy efficiency without innovative technology or material, which resulted in focusing on the design detailing and air tightness. Learning was therefore an on-going process in the demonstration projects.

2. Long-term focus in renovation through building user involvement

In all demonstration projects, the building design teams needed to consider long-term functionality of the building. This often meant obtaining input from building users or their representatives in order to ensure energy performance solutions complemented the functionality of the building. Much of this interaction happened during the renovation process and into operations, which increased the likelihood of meeting energy performance targets. One way in which the demonstrators engaged with end users was intermediation. Intermediators had a broad understanding of the need required to meet project goals and the functional needs to the building. Økern had a project coordinator who was quick to address end user concerns directly with those who were responsible on the project team. L'Arlequin and Lindängen demonstrators used a mediator to communicate between the building project teams and residents. There were different names for these mediators – "animator" (L'Arlequin) and "informer" (Lindängen). Both L'Arlequin and Lindängen used individual(s) who were on the same social level as residents with the expectation that they would be viewed as approachable by residents. The animator's and informer's main role was to address any concerns emerging by residents and inform them on developments of the project. In Mogel, the Neighbourhood committee represented residential owners and were the intermediators of decision making between residents and the project.

In addition to this engagement, strategic thinking often obtained optimal approaches to having support from residents. Examples were:

- In Mogel, a group of residents, who initially opposed the renovation, started to support it when they saw the initial work done in another neighbouring building
- In Lindängen, information provided to residents by other residents who shared similar cultural backgrounds was believed by the project team to help acceptability of the project.
- In Økern and Grenoble, when project coordinators actively listened and followed up decisions or inquiries with project teams and residents

3. Knowing the optimal compromise between energy performance measures and architectural value and cultural heritage

Integration of renewable solutions into existing building structure needed to consider architectural value and cultural heritage. Sometimes, there was seemingly, a negotiation process between optimal energy performance solutions and architectural value and cultural heritage. This negotiation process involved weighing up options by prioritising one over the other and considering how the chosen option would affect the final output of the renovation. The priority of these aspects depended on the context of the project. Creative solutions were core to this negotiating process. For example, the use of colour or considering ways to complement surrounding listed buildings. The most optimal energy performing solutions were not always chosen, instead the optimal compromise between energy performance and architectural value and cultural heritage. The optimal compromise required awareness of architectural value and cultural heritage of the buildings and neighbourhood, in order to design energy performance solutions, which would complement the neighbourhood.

Reviewing designs and architecture of building in the renovation aided in the integration of high energy performance solutions. Project teams in Grenoble, examined the design details to see where energy efficiencies could be gained. This involved more time on the project side but provided a way of thinking through potential problems in the project. In Mogel, examining the design of the building helped when energy insulation reduced the size of balconies and minimized the area in order to hang washed clothes. A relook of the material used for balconies led to the use of a thinner panel for balconies in order for the size of space to remain the same and washing could be hung. In Lindängen the PV solar panels were used for energy performance and as a symbolic expression of a high energy performance well designed building. In Økern, the decision of sunscreens prioritised architectural value and cultural heritage to complement the architectural award winning listed neighbouring building. Sunscreens laid in the façade and behind plates, which was not optimal but still reduced energy demand of the building.

5.2.2.2 Social barriers description

Barrier headline
1. **Lack of knowledge or awareness of energy behaviour by residents**
2. Comfort and **access to residents living in apartments during/after renovation**
3. **Not always possible to balance architecture value and cultural heritage with energy efficiency**

1. <u>Lack of knowledge or awareness of energy behaviour by residents</u>:

The ability to meet high-energy performance targets is reliant on the behaviour of residents. Optimum energy performing behaviour is challenging to achieve due to issues such as the rebound effect and reluctance of residents to be energy conscious in their home (Lindkvist et al., 2014). In the demonstrations, there was evidence that residents did not necessarily understand the technical solutions installed in their homes and perceived solutions requiring a change in behaviour. Particularly noted in Mogel and Økern was when residents unnecessarily changed their behaviour as they believed they needed to do so to accommodate the new energy performance solutions. In Mogel, residents believed that the solar thermal system, which heated the water in the building, meant that those who used the shower last would have no hot water. The project team remedied this misconception by assuring residents that there is enough hot water heated for all residents in the building. However, this situation could have had negative implications on how residents accepted the solar thermal system. Similarly, there was frustration in Økern nursing home where staff believed they could not open windows due to the ventilation system. However, this was again a misconception, which the building owner corrected. These misconceptions are not the fault of the installed energy systems but misconceptions do exist. The danger of leaving misconceptions unchecked is that they prevail and end users become dissatisfied with the building. The building owner or those who have the knowledge to correct misconceptions must be told about them first, which links back to the need to engage with end users.

There was also challenges in end-users not supporting the project due to not viewing it as a priority or important for the functional needs of the renovation. The challenge of end users opting out of energy related decisions is that the usability of the building may be affected if they are not involved in decision on energy performance solutions. Such barriers require a lot of communication and engagement to ensure end users can make knowledgeable decisions to support and be part of decisions for energy performance solutions. Involving residents is a necessary step to ensure what measures are introduced can be integrated in how users behave in the buildings. However, in one demonstration the building owners did not involve tenants as he was not legally obliged to and he believed not involving tenants eased the decision-making in the renovation process.

2. Comfort and access to residents living in apartment during/after renovation:

Comfort and access are prevailing issues for residents living in apartments during renovation. In Grenoble, some residents chose to stay in apartments in order to stay close to their social circle, but later regretted the decision due to the construction disturbance of the renovation as well as the logistical issues of construction teams not sticking to scheduled times to access apartments. In Lindängen, access to apartments resulted in a lot of logistical planning and notification to residents beforehand during the installation of new windows and sometimes, changes in plans was a nuisance for residents. Mogel renovation required the demolition and reconstruction of a stairway, which resulted in a blocked exit/entry point for 12 hours. Residents were not reallocated during the renovation process. Most residents did not stay in their houses during the 12 hours of demolition and reconstruction. Those who did stay created a difficult and delicate situation for the construction company who was prepared with a crane to take them out from their homes if necessary. The building in Økern was empty during the renovation process.

There are challenges noted in some demonstrators in the initial months after completion as this period is generally a period when defects are found as the building is in full operation. In Økern, there were comfort issues for end users as the testing and commissioning phase of the building overlapped into operation. In the early months of operation, the building owner made available 24 hour emergency response to alleviate end users discomfort to technological defects. In addition, any problems were followed up through meetings with staff and the building owner. In Lindängen, the expectation of a better indoor climate was complicated as indoor temperatures were higher before the renovation and were reduced to meet market standards after the renovation, resulting in a reduction of temperature after the renovation. Additional complaints emerged during adjustments of the heating system, during which temperatures may have been lower at times than what was intended after the renovation. To remedy these complaints, the Building Energy Management Systems (BEMS) has been used to show residents if the temperature in the apartments is meeting the market requirement of 21 degrees and as a result the complaints have diminished. In general, there is a challenge to link operations back to the project aspects of the renovation which leads to a lack of understanding of the decisions. However, both demonstrations in Økern and Lindängen had a continuous link via the building owner. Particular to Økern is the ongoing link between project and operations was managed by having a one year warranty period with the general contractor of the renovation.

3. Not always possible to balance architecture value and cultural heritage with energy performance:

Decision making of the negotiation between energy performance and architectural value and cultural heritage was no easy feat for the demonstration projects. Sometimes it was necessary to impact architectural value of the building in order to meet energy performance requirements. Other times architectural value took priority over energy measures. It was important for the building owners of the nursing home in Økern to consider how renovation plans and energy performance measures would fit with a neighbouring listed building. In this case, architectural value and cultural heritage took priority when considering solutions such as sunscreens. In Grenoble, the decision was to prioritize the aesthetics to maintain architecture value of the building, by conserving the characteristic elements and treating at the same time singular points generated by these elements. In Mogel, the proposal of the new building envelope with the insulation on the external face resulted in the disappearance of the stone wall, which was considered the most interesting feature of the façade. In order to avoid the loss of this feature, insulation to the interior was considered instead of to the exterior. However, the minimization on the interior area of the ground floor apartments made the management of ground floor residents difficult. In Malmö, there is a potential for energy performance measures for renovation to be in conflict with architectural heritage interests of the municipality. Different aspects and qualities of retrofitting measures in a building are considered in approving a building permit and could have a significant impact, e.g. in terms of the will to maintain an architectural concept in relation to the surrounding built environment. In previous new building projects in Malmö, both solar shading and PV cells installations have been impossible to implement due to the municipal interest to avoid salient installations in the facade at this geographical spot. This limitation did not apply to Lindängen demonstration, as the alterations were considered minor such as window replacement. In most cases, the demonstrations indicated that the challenge was to know when to prioritise architectural value and cultural heritage over energy performance and vice versa and this involved a thinking process and examining different ideas.

5.2.2.3 Implications for training needs

In ZenN demonstration projects, the purpose of formal training activities aimed at end users is either to share information about the renovation process, or to educate about control and maintenance of the building in order to optimize the outcomes of the renovation process.

- *Occupants*: Training covers topics such as ventilation quality, balancing energy efficiency, and energy education aiming to raise awareness about choices concerning energy consumption. Different formats of training was used such as;
  - Open House Events
  - User manuals containing specific technical information about the building,
  - Initial training of optimum ways to use the building with recommendation of follow-up training once building has been occupied for 3 months
  - Providing feedback loops to project teams after the building has been in operation.
  - Digital media in the form of a website, emails, Facebook and Twitter, newsletters and face-to-face communication combined to disseminate project progress and results.
  - Face-to-face meetings for residents
- *Janitors and facility managers* receive mostly formal training, focusing on technical aspects of the maintenance and management of the renovated buildings. The timing and content of the training activities varies between the different demonstrators. The types of training provided included:
  - Courses on management of complex energy efficient buildings during all stages of the projects
  - Organizing an informational meeting about the management and operation of the facilities in the initial stage of the project,
  - Formal training to familiarize with the technical installations during commissioning.
- *Consensus building:* In large-scale renovation projects, it is important to build consensus over time and through intense communication. As near-zero energy renovation at neighbourhood scale is not an established concept within the project teams, this topic is even more impactful. On-going communication with building management, contractors and residents involved in the renovation. Such an

approach enables collaboration and consensus building from the initial planning stage of the renovation process. The ZenN demonstrators use several mechanisms to facilitate consensus building, including involvement of knowledgeable expertise, long term planning, and gaining the support of policy makers.

- *Work team collaboration*: Relevant stakeholders collaborating in all stages of the project, with the intensity of collaboration being especially high during the planning and implementation stages. Collaboration facilitated through workshops and meetings, enabling face-to-face communication; as well as on-going communication through various channels.
- *Involving knowledgeable expertise through on-going communication*: Building contractors working together with experts such as energy consultants and research institutes increased confidence in the viability of the near-zero energy renovation process and thereby supported the consensus building process. The involvement is especially relevant in the planning and implementation stages, and involves methods such as meetings and workshops.
- *Long term planning for long term decisions*: In this approach, early involvement of key stakeholders and on-going, intense dialogue in the planning stage provides the background for consensus building. This allows early consideration of technical choices and their consequences for the renovation process and its outcomes, increasing the likelihood of a well-working design and stakeholder confidence in the quality that will be achieved as a result of the renovation.
- *Gaining support from policy makers* is important in ensuring long-term implementation of agreed targets and measures. Early involvement of policy makers through study visits, on-site guided tours and information meetings on nearly zero energy neighbourhoods and on the proposed technical solutions for renovation can result in a more in-depth cooperation between policy makers and demonstrators.

- *Linking social and technical aspects:* ZenN integrates technical solutions and social measures to optimize the effect of the energy efficiency renovation. Such measures include study visits for stakeholders, open house activities and liaison persons.
    - *Liaison person*: The use of people who could directly communicate with residents in socially deprived areas adapting to the needs of the area.
    - *Feedback from end users after adjustment period:* Operation by end users of the completed nearly Zero Energy Neighbourhood renovation is the final test to meeting energy performance targets. If they use the building in optimum ways, it means targets will be met. Gaining feedback on the technical installations and understanding how they use energy will increase likelihood of meeting targets for the demonstration project and disseminating lessons across for future projects.
    - *Learning by doing:* Managing uncertainty of the performance of the energy technology installed in the demonstration projects was done through the use of small scale installation to test a technology before widespread installation into the neighbourhood scale.

5.2.3 Legislation, Governance and Policy

Many current challenges and success factors for achieving largely replicated and successful residential energy retrofitting are within legislation, governance and policy. The legislation, governance and policy issues have an impact on e.g. which retrofitting measures that are legally permitted, the technical performance required when applying the different measures as well as e.g. which measures that allow financial support. In ZenN D4.4, experiences on these challenges and success factors have been gathered from each of the ZenN demonstration sites. Through this, common factors for all countries have been possible to identify. Apart from experiences gathered interviewing the property owners, involved contractors and other stakeholders, general experiences from literature review have also been gathered and presented in the report. The findings should be used to increase awareness on issues to foresee during project development as well as pinpoint policy and legislative suggestions advocated during the data collection.

A general conclusion from the study is that common patterns could be seen for the participating countries. Main general problems include:

- Lacking political ambition nationally
- Lacking financial/economic support
- Lacking of knowledge and information policy measures
- Lacking or uncertain policy instruments for renewable energy

Obtaining high replication of residential area energy retrofitting is a complex transition, since it relies on many different initiatives from politicians, building owners, energy service contractors and energy suppliers.

A main observation is that many different prerequisites must be fulfilled for building owners to make the retrofitting initiatives, not solely if a recoupable or profitable investment can be foreseen. The barriers could be building owners' lack of knowledge, lack of possibility to attain the complete financing amount and hesitation to take risks when the current operation status and economy is seen as good enough. A knowledge gap between energy service contractors and building owners has been displayed in the study. This complicates the possibilities to find a balanced solution of retrofitting measures to an agreeable expense. The financing possibilities for energy retrofitting are sometimes very limited. E.g. this has been expressed for Sweden, where the possibility to finance the demonstration project retrofitting lay only in the building owner's already present loan facility from before the project. The building owner has expressed that they would not have been able to get a new loan facility based on calculated energy savings if any uncertainties were involved. This situation pinpoints the importance of assuring the profitability beforehand, and that it generally should be simplified to receive loan facilities even when risks are involved and profitability could not be completely asserted beforehand.

The investment uncertainties for renewable energy generation have also been a general topic in the study. A key question is whether or not economic support could be asserted, and at what level, during the full life time of the generation facilities. The problems of uncertain prerequisites over time have been illustrated by both the Swedish and Norwegian studies. In Sweden, one of the main uncertainty issues concerns the Electricity Certificate system, since this is a market based system that settle the certificate value and thereby the allowance per generated kWh. A static allowance would decrease the uncertainties in investment calculation from the building owner perspective. In Norway, during the course of the ZenN demonstration, a financial support was implemented resulting in a different view of the preferable investment scale. This variability of financial support over time creates general investment uncertainties.

A general outcome is also the need to assure that the complete chain, from EU energy efficiency targets, national targets and regulations to local or regional decisions and the buildings' real energy performance compared to regulations is managed all-over in a consistent way. For achieving this, improved compliance and control systems could be needed. In France, e.g., a lack of clear sanctions in cases where national legally defined objectives are not fulfilled has been described. An example from this lack of sanctions is e.g. when energy efficiency targets on retrofitting or new construction is not achieved.

A general observation from the study is also that several legislative barriers for energy retrofitting at the same time are legislative benefits in other perspectives. Two examples from the Swedish study concerns the Swedish competition legislation and the Swedish Planning and Building act. The competition legislation denotes that all housing companies (public and private) must be managed according to commercial principles, for avoiding distortion on the market. In cases, this has implied that public housing companies have avoided certain energy efficiency solutions with longer pay-back time through consideration of not contradicting the legislation. The overall focus on short payback time and the requirement of the same commerciality from public and private companies have thereby contributed to decreased energy saving ambitions to a certain extent. A distortion of the market has been thereby countervailed as well as certain levels of energy efficiency. Concerning the Planning and building act, in 2014 the Act was updated stating that municipalities of Sweden should not be able to set stricter energy demand requirements for building permission than those set in the building regulations. This had been a previous practice for some municipalities. The legislative update makes municipal target fulfilment of energy efficiency more difficult, but at the same time it improves the equality on the market for the building sector. These two examples illustrate the complexity in balancing and meeting the different legislative needs and interests.

5.2.3.1 Legislation, governance and policy KSFs description

KSF headline
1. Importance of a high political national **political ambition** and **effective national energy efficiency requirements**
2. Importance of **improving financial/economic support systems and instruments**
3. Importance of increased and equalized **knowledge among the stakeholders**
4. Importance of **national policy measures to overcome barriers for renewable energy**

1. The importance of a high political national political ambition has been demonstrated in several ways for the different countries represented. A conclusion connected to this is made within an assessment of EU's Renewable energy directive, stating that national provisions are most efficient if they are mandatory, well-defined and with requirements of national targets rather than specific actions at regional or local level. These types of provisions are important ways for EU to ensure a high national ambition. For several countries represented in ZenN, including Poland and Norway, it is stated that the national energy requirements should be more ambitious. Another illustration of the need for further political ambition is through the commonly large focus on short pay-back time for retrofitting investments displayed in several countries. Without different political initiatives or economic instruments improving the pay-back time and profitability, many investments that extend the level of energy efficiency would not be implemented.

2. The importance of improving financial/economic support systems and instruments has been expressed in different ways depending on the national or regional circumstances. It is clearly displayed that improved financial support for energy retrofitting often could be necessary even despite having positive prognosis and anticipated profitability of retrofitting investments. E.g., in Sweden this has been demonstrated by the demo site building owner's view that their financing possibilities only have depended on that they already had a loan facility at the bank, and that the bank would not allow a new loan opportunity based on future energy cost savings if there had been any uncertainties in the calculation. Financial and economic measures proposed to solve these problems have been e.g. possibilities for building owners to apply tax-free deposits of money into retrofitting funds and credit-guarantee systems. Further measures implemented or discussed for the different European countries to improve financing and profitability are zero interest loans, income tax credits, municipal financing funds for energy efficiency retrofitting and financial support grants for tenants living in retrofitting buildings.

3. The importance of increased and equalized of knowledge among the stakeholders has been displayed through-out this study. In France and Norway, research and information centers within low-energy construction, retrofitting and urban renewal have been implemented enabling solutions to these problems. Corresponding agencies are also under development e.g. in Sweden. The need to increase the knowledge consist e.g. of inadequate insight for building owners in their retrofitting needs and potential in retrofitting measures. The costs for building owners to gather this knowledge in itself sometimes aggravate the possibilities to find out about the benefits and to form retrofitting projects. The need of equalization of retrofitting knowledge is illustrated by different views displayed from building owners and contractors on the building retrofitting needs and their benefits. Their different knowledge and interests make it difficult to form successful retrofitting concepts agreed upon all.

4. The importance of national policy measures to overcome barriers for renewable energy has been widely discussed and analyzed in all participating countries. The problems for a large-scale implementation of renewable energy are sometimes found within overall national strategies that include a continuation of large-scale fossil energy supply. E.g., for Poland, a conclusion stated in the report is that, according to the Strategy of Energy Security and Environment, it should be expected that the Polish power industry will be based mainly on coal in the long term. In other cases, the barriers for renewable energy are within the uncertainties of how much financial support that could be expected for the renewable solution during the whole of its lifetime. In Norway, during the course of the ZenN demo project, a financial support was implemented which made the views of the preferable investment scale different. In Sweden, the economic support of the electricity certificate system is uncertain over the lifetime since it is a marked based system. These uncertainties in for how long and at what level a certain economic support system will be maintained, and thereby its effect in the long-term, is a general obstacle for renewable energy generation investments.

5.2.3.2 Legislation, governance and policy barriers description

Barrier headline
1. National political ambitions are in part not enough to achieve certain overall goals. Also,

	sanctions when requirements are not fulfilled are lacking.
2.	**Economic policy instruments and supports are lacking** in order to achieve large replication of residential energy retrofitting, even despite often foreseen profitability.
3.	**An overall focus at short payback time investments sometimes partly caused by legislation**. The focus decreases energy saving ambition and at times causes inaccurate investment evaluations in a long-term perspective.
4.	**Local or municipal differences** sometimes disable practice standardization for energy efficiency levels, building permit procedures etc.

1. The national political ambitions partially are described as lacking to achieve certain overall goals, which is a general barrier.

This has e.g. been displayed through an assessment of the EU Energy Efficiency Directive handled in the report, stating that the collective sum of nationally set energy efficiency targets have not been enough to reach the overall EU target for 2020. The sum of the national targets corresponded to 17.6 % primary energy savings, a few percentages short compared to the overall 20 % primary energy savings goal.

Examples of the lacking national ambition have been displayed e.g. in Norway, where one conclusion is that the national energy requirements should be more ambitious. The same barrier has been described for Poland, where also the Strategy of Energy Security and Environment has been described as too oriented towards a continuously significant amount of energy supply from coal.

A further obstacle displayed in the study is a lack of clear sanctions in cases where national legally defined objectives are not fulfilled. This has been primarily delineated for France. Examples described are the lack of sanctions when not achieving the energy efficiency targets on retrofitting or new construction. This barrier displays the importance of achieving a good and consistent concept in the whole chain of overall targets, specific legal requirements and compliance procedures to make sure that the requirements are fulfilled.

1. The lacking of current economic policy instruments and supports is a common barrier displayed throughout the different national studies.

The lacking are not always connected to the difficulties achieving profitable investments for the building owners; often the problems are connected to attain the necessary financing amount (regardless of an anticipated profitability), e.g. if a current loan facility at the bank is not available.

A general problem is that the financing amount is difficult to obtain when it is based on predictions of profitable energy savings and not completely asserted recoupability. The KSFs (see above) pinpoint several possibilities for financial measures that could improve the situation.

A further problem, particularly displayed for Sweden, is that an energy retrofitting project could threaten the tenant base, since it might decrease with a consequent rental increase for the apartments. This could be the case e.g. in deprived areas where the measures increasing living standard of apartments might not increase the will-to-pay and the overall attractiveness of the housing enough. As discussed in the KSFs above, a rental grant to tenants in retrofitted buildings might be a solution. This measure could be seen as a balanced and motivated solution e.g. since rental tenants have a relatively low possibility to impact the retrofitting plans for the buildings. In hand, this could call for a possibility to compensate the tenants. Another motivation is that the measure could improve the viability and scale of energy efficiency projects.

2. The common problem of an overall <u>focus at short payback time investments</u> is an issue to consider ahead. In certain cases this focus is also partly caused by legislative prerequisites.

In e.g. the Swedish study it has been displayed that the Swedish competition legislation since 2011 prescribes that all housing companies should be operated according to commercial principles, for avoiding distortion to the residential market. This has in cases proved to have an impact on the public housing companies' decisions and demands for recoupability of investments, by altering the focus more unilateral to short payback time investments than previously. This problem pinpoints the difficulties of conflicting interests in legislation, both achieving high long-term energy saving ambitions and avoiding distortion of markets.

The general short-term focus is displayed also in Norway, where developers and building owners' main focus tends to be on profitability in terms of the design/construction phase if they are not going to operate the building themselves. The long-term energy efficiency of the buildings is thereby not their priority, and this leaves a large responsibility for a good customer requirement specification and for future interested customers to be able to evaluate the operation costs and value of the building. A more long-term energy efficiency should be reached if developers operate the building themselves in the long-term.

An overall focus at long-term ownership and profitable investments over a long lifetime should decrease these types of barriers. The connection to knowledge and information barriers should be acknowledged, since building owners' evaluation of energy efficiency investments is complex, and focus should be largely on costs over the full lifetime rather than the scale of investment amount.

3. <u>Local or municipal differences sometimes increase the complexity of legislation and regulatory practices</u>.

E.g., geographical differences in terms of both climate and vicinity to certain energy solutions (e.g. an existing district heating network) could alter the level of energy efficiency that should be required. The problem of setting appropriate energy use requirements according to the climatically differences nationally has been described in further detail e.g. for Norway in D4.4.

Another local or municipal difference causing obstacles is that the principles and interests for municipalities as permission authority for certain energy efficiency measures could vary, e.g. in Sweden. For the Swedish case, a building permit from the municipality was necessary for the PV system installation. This is not necessary for all Swedish municipalities, and the process of application in Malmö has been considered an obstacle for the Lindängen demo site. For the wide-spread of solutions such as PV systems, a homogenized process for application should be preferable, and possibilities to a simplified, less administrative, procedure has been advocated at the Swedish site.

A further legislative interest conflict has been described for the Swedish site in terms of the municipal interests and governance. The municipalities are, since a legal update in 2014, not allowed to apply stricter energy efficiency requirements than the building regulations. This in itself is an obstacle for municipalities to achieve energy efficiency targets within the municipal borders, but at the same time it improves the homogenization for building projects in all municipalities. These different legislative interests constitute another example in the complexity of legislation and regulation balances and decisions.

5.2.4 Decision-making management analysis: towards simplification of decision-making process

The approach to decision-making in all demonstration projects was key to renovating functional buildings, which meet ambitious energy performing targets. There were key success factors and barriers to decision making which incorporated the non-technical drivers of architectural value and cultural heritage; stakeholder awareness and behaviour; economic and ownership structures and governance, policy and legislation. The following section examines how key success factors and barriers were managed in each of the demonstrations. A final section is on the holistic design kit which is developed in order to form part of the thinking process so future projects can incorporate non-technical drivers into decision making. The full holistic design kit is included in deliverable D4.5 *Holistic Design* Kit for the nZEB Renovation and a public accessible design kit will be included in deliverable D5.4 *Guidelines for renovation*.

5.2.4.1 Decision-making management KSFs description

KSF headline
1. Knowing when to prioritise architectural value and cultural heritage over energy solutions and vice versa

2.	Developing **energy performance solutions which complement user functionality**
3.	**Strategic thinking and collaborative decision making**
4.	**Support from national funding schemes and governing bodies**

1. Knowing when to prioritise architectural value and cultural heritage over energy solutions and vice versa

Each demonstration considered Architectural value and cultural heritage in decisions where energy solutions could complement listed buildings, in terms of aesthetics and history of the area. In Økern, a point of discussion in the project was whether to use PV solar panels as a statement for energy performance ambitions by installing them on the façade or rather to have them in the background by placing them on the roof. In the end, the decision was to place them on the roof. While there were a number of factors which led to this decision, one of the reasons was to ensure it complemented the neighbouring listed building. In Mogel, the ground floor façade was a stonewall that provided character to the buildings, but the project team, after examining options, decided to remove the stonewall in order to achieve the most energy effective solution. In Grenoble, compatible technical solutions were used to preserve the cultural/architectural heritage of the building. In Lindängen, the PV cells were used as a symbolic and expressive architectural value for energy efficiency.

2. Developing energy performance solutions which complement user functionality

In all demonstrations, there is a need to ensure energy performance measures are sustainable for the long-term functional purpose of the building. This was done in Økern by involving the operations and maintenance department at an early stage, users of the buildings were represented by the client organization and user feedback was obtained in the initial month of operation to help them to adjust to the newly renovated building. In Lindängen, janitors/facility managers informed residents and the tenants' association on the renovation plans, and provided them with information on energy usage. In Mogel, the choice of insulation material on balconies meant that there was no room for racks to dry washing. This led the project team to change from brick to thinner phenolic panels on the balconies, so drying racks could fit. In Grenoble, the use of a liaison person living in the same area as the resident enable positive communication to happen between residents and the project team.

3. Strategic thinking and collaborative decision-making

Strategic thinking and collaboration ensured a collective ownership on decisions of the renovation. In Mogel, targeted communication with key persons who influenced residents and starting with the "friendliest" buildings to renovate helped convincing initially sceptical residents to support the process. In Grenoble, project coordinators ensured the project's global dynamics and relationships between diverse actors worked well, which resulted in a 'collective feeling' in the team and helped integrating the ambitious energy targets. In Økern, the project manager was as a positive link between managing project expectations and end user expectations in energy performance solutions. In Lindängen, while the building owner did not involve residents in decision making for the renovation, he needed their support to access apartments to change the windows and to accept the changes of the renovation. Local informers, who were residents of the apartments and were from a similar background, provided information on the logistics of the renovation. The building owner believed that this was a good approach for gaining resident's acceptance.

4. Support from national funding schemes and governing bodies

All demonstrations received funding in order to reach ambitious energy performance targets. Many of the demonstrations referred to how the return on investment is long so there is a need to be aware of how funding schemes can help reduce payback. Økern obtained funding from ZenN project and ENOVA and aim to use green leasing approach to reduce payback on investment from 13 years to 7 years. The two demonstration buildings of L'Arlequin are part of an ambitious and long-term urban renewal project supported by Grenoble Municipality and the French government to be examples to other building renovation projects in the district. In Mogel, local drivers, such as Eibar city council, provide economic aid to communities when they include energy efficiency measures in their residential building renovations. In Sweden, the national strategy proposition is discussing several instruments to solve knowledge and information barriers, including the lacking insights in property retrofitting needs and level of suitable retrofitting measures.

5.2.4.2 Decision-making management barriers description

Barrier headline
1. Stakeholder's misconceptions on energy performance solutions
2. Access to financing and unexpected costs
3. **Fragmented ownership on investments** in neighbourhood ZEB renovation
4. Closing the knowledge gap to meet policy targets

1. Stakeholder's misconceptions on energy performance solutions

Zero Energy Buildings and its associated concepts are new for the majority of project participants involved in ZenN. Sometimes participants developed their own perception of what the different energy performance installations do which lead to an unnecessary change of behaviour. This highlights a need to explain new concepts of energy performance measures. In Mogel, the residents believed that the solar thermal panels for heating water meant the first who wake up in the morning will consume all the hot water. The architect informed residents about the proper functioning of water usage heated by solar thermal at an event aimed to address different concerns or doubts of the renovation. Developing such events provides an outlet to explain misconceptions. In Lindängen, contractors believed that people tend to notice decreased temperatures more when they know the renovation is energy reducing. There were residents of Lindängen who complained about decreased temperatures. However, the actual temperatures had decreased from prior to the renovation in some apartments due to some initial problems after renovation completion and the reduction of temperatures to market standards. In Økern, there were also misconceptions amongst facilities managers and residents who believed they had to keep windows shut in order to meet energy reduction targets but the building owner corrected this. In Grenoble, having a knowledgeable technical energy expert for renovation eased concerns by the project team. The project team were worried that the adoption of ambitious energy targets would lead to the adoption of ineffectual solutions in the residential demonstration. The technical energy expert addressed the concerns by focusing the project team to examine effective solutions suited to the design details of the renovation and proven methods, which are cost efficient and operational.

2. Access to financing and unexpected costs

All demonstrations received financing from ZenN EU funding, but also sought funding through other means which was sometime challenging. In Sweden, it is important to have a low loan to value ratio (LVR) to receive a bank loan and it can be difficult for ZEB renovation to get a bank loan as the calculated LVR is high. In Mogel, many banks did not provide competitive offers with low interest rates viewing the project as being high-risk which resulted in some residents not receiving loans and having to seek loans from relatives or making individual agreements with banks. Økern and Grenoble provided examples of how unexpected costs arise in renovation. In Økern, there were some unexpected costs in adding a technical room on the roof for the ventilation system but most increased costs were associated with more asbestos found in the old building than expected. In Grenoble, there were unexpected costs associated with a change in regulations, which required amendments in grants.

3. Fragmented ownership on investments in neighbourhood ZEB renovation

There are challenges when the party financing the investment and taking the risk is not the one who obtains the financial benefit from reduced energy use. Økern are examining the use of green leasing which could lead to tenants paying slightly increased rent to the building owner but tenants should benefit from reduced energy bills. In Lindängen, there was one owner, renting apartments to tenants, who saw the investment return as the increase value of the property. However, using increased value of obtaining return on investment is not always possible when buildings are publicly financed. In Mogel, the residential owners are both occupiers and financers of the renovation and the main financing came from public money via the Basque Government. A guarantee was needed from the residents that public money would not be used commercially. This led to an agreement that residents would return the public money to the Basque Government in the event residents sell their properties in the next 20 years. In Grenoble, split incentives addressed the problem of fragmented ownership. Split incentives meant owners would get income through increased rental fees and increased building value while tenants would benefit from lower operational costs, improved quality of life and better living conditions inside the building. In addition, owners worked with residents' associations to agree a 10% rent increase to cover about 7% of the renovation costs, which would be partly compensated by decreased heating costs for the residents. The indications are that fragmented ownership is complex and there are different ways to obtain returns on investment depending on the ownership structure and financial funding source.

4. Closing the knowledge gap to meet policy targets

In general, there is a knowledge gap to achieve policy targets for emissions reduction as the construction industry is still learning to install energy efficient measures and develop measures to influence resident's behavior to be more energy efficient[11]. The demonstrations used expertise from research institutes and consultants to help close the knowledge gap, but this was reliant on access to such knowledge and an initiative on the part of the building owner to meet policy targets.

5.2.4.3 The holistic design kit

The holistic design kit is a thinking tool for the different stages of the project process by all stakeholders. The focus of the design kit is developing and measuring indicators for non-technical drivers, based on learning from the demonstration projects in Økern (Norway), Lindängen (Sweden), Mogel (Spain) and Grenoble (France). Indicators are important to the decision-making process in design, construction and operation to quantification, simplification and communication of decisions. Indicators allow an ongoing reflection of the project progress and can feed into further lessons learnt for future projects. The demonstration projects share similarities through their participation the ZenN project but were also unique in having different goals and power dynamics for decision-making amongst stakeholders. The repetition of lessons learnt in the ZenN project illustrates that the indicators developed for the design kit are not just unique to one project but are applicable to other similar nZEB renovation projects. The recommendation is to implement the design kit on at least three occasions – before, during and after the nZEB renovation project – in

[11] Karlsson, A., Lindkvist, C., Wojtczak, E., Stachurska, K., Holm, D., Sørnes, K. Schneuwly, P., Tellado, N., AND Rodriguez, F. (2013) Deliverable 1.1 Common barriers and challenges in current nZEB practice in Europe. *Nearly Zero enery Neighborhoods (ZenN).* Funded from the Seventh Framework Programme (FP7/2007-2013) under grant agreement n° [314363]

order to update results and inform decisions in line with any changes that may have occurred in the project.

Below is a summary of three main elements of the design kit:

1. *Indicators* illustrate key non-technical aspects to consider during a ZEB renovation process.
2. *Associated indicator questions* developed to guide new nZEB renovations in their performance assessment of non-technical drivers. The associated indicator questions are generic, and need to be further refined to the local context of an nZEB renovation.
3. *Workshop/meeting to discuss responses to indicator questions* to develop a common understanding of the results from indicator questions developed for a ZEB renovation project. The workshop allows representatives of the project stakeholders to agree on which indicators to prioritise at which stage of the project in order to optimize the decision-making processes.

Municipalities who represent the demonstration projects in ZenN and researchers provided feedback on how the design kit could help decision-making. The feedback was overall positive viewing the design kit as a good practice guide. They believe the design kit can help decision-making process by guiding project managers, designers and other stakeholders to include essential dimensions of the project. The list of indicators have the potential to help those responsible for new nZEB renovations to have an overview of challenges and solutions that may arise during the process. In this way, there is a potential to foresee what decisions are needed, as well as identify resource and capacity needs that may arise at later stages, which are not often easy to see at the beginning of the process. They believed applying the design kit early in the renovation process through to implementation and final evaluation of the project. Lessons learnt based on demonstration experiences included in the design kit are useful for project managers and stakeholders to leverage on previous experiences. The framework of the design kit is general and needs to be adapted to the context of a new project. However, it provides a useful guide to develop specific questions to suit the context of a new project's and help move it towards nZEB renovation. Overall, the design kit potentially allows for exploration of different options related to non-technical drivers and a better understanding of the whole ZEB renovation process.