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D1.1 – Identification of barriers and bottlenecks

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Table of Contents

1 Executive summary

Considering today's technological advances, it is not surprising that newly constructed buildings can be 70%[1] more energy efficient than existing buildings. Energy building codes can be pivotal in ensuring that these technologies are in reality deployed at the building level. While building codes can cover both new constructions and renovations, energy-related requirements can be applied and controlled somewhat more easily in new constructions. Undoubtedly, with the transition from prescriptive to performance-based codes as well as introduction of cost-optimality and nearly-zero energy targets, a strong European regulatory framework is in place, which can help the sector deliver its anticipated potential. While energy performance can be addressed more effectively in new constructions, the older building stock has not been designed with energy performance in consideration and a substantial part of it is in desperate need for renovation. These buildings are associated with a huge energy saving potential and although their renovation is linked with many challenges, they offer attractive benefits to their occupants, construction sector, research, economy and society as a whole.

The necessary transformation of the existing stock relies on the availability of technical solutions. Today, we have an impressive number of technologies and measures which can deliver significant energy and CO_2 savings in our buildings. In terms of envelope retrofitting, there is an array of different insulation materials and techniques, targeting different client needs, climates and façade characteristics. These can range from expanded polystyrene foam - the most common insulation material - to more progressive ones such as prefabricated brick cladding systems and phenolic foam panels. Internal insulation techniques are also feasible, although less favourable due to risk of the condensation of water vapour. Undoubtedly, each solution has its own advantages and shortcomings, typically determined by features such as price, wide-scale availability, easiness in installation, thermal properties, innovativeness etc. The current solutions on the market, however, come with a certain set of practical limitations. In badly-hit economies, these limitations are often related to high costs which lead to project cancellations and postponements. Long winters often hinder the smooth execution of retrofitting works and in many cases installations simply cannot be technically conducted in rain, strong wind, sun or high humidity levels. Buildings under heritage protection or buildings with complex facades can only be insulated internally causing space issues or in certain cases indoor air quality problems.

Besides these limitations, there are a number of non-technical barriers inhibiting market maturity. In this report, the barriers hampering energy efficiency measures were investigated from different players' perspectives: the building owner (investor), construction companies and material manufacturers. When looking at the building owner, energy renovation has to be viewed like any other investment option in which a traditional decision-making process is followed. Examining the step-by-step decision-making process of the owner, it is clear that barriers emerge in each stage of the process. In the first stage, the owner must recognise the need for energy renovation. Inevitably, lack of information on how energy is consumed in a building implies that the benefits of energy saving measures cannot be fully appreciated. In comparison with the plethora of non-energy investment options, the owner must feel confident that energy efficiency will have a positive impact in the property value. This, in turn, can ensure that energy efficiency is positioned at a competitive level with respect to other options. Current evidence supporting this, however, is weak. When evaluating the different insulation options, the multitude of choices may be overwhelming for a layman with no technical background. Access to information on more progressive solutions is typically limited and this can be a hindrance for innovativeness to spread in the market. Socio-economic characteristics will have an impact on the evaluation criteria and their respective weight,

[1] Based on IEA report "Energy technology perspectives - Scenarios & strategies to 2050" (International Energy Agency, 2006)

with the price criterion in many cases being of top priority. Issues such as high disruption levels, extensive project duration, long administration procedures and complex project management may also act as discouraging factors for the investor.

For construction companies, the main challenges are related to financial issues, market obstacles, insufficient capacity and complex industry structure. Many renovation projects are performed by SMEs which normally do not have enough resources to invest in R&D or in training courses for installing new technologies. The construction sector focuses primarily on project costs rather than life-cycle costs, undermining the promotion of innovative solutions. Unlike other technology-driven sectors such as IT or pharmaceutical, construction can be described as a traditional and conservative sector which is rather motivated by short-term profit maximisation. Low demand for energy efficiency from customers is also a significant barrier. In this context, it should be acknowledged that a blame game between construction companies and customers typically paralyse any action to be taken in reality. The construction industry does not supply energy efficiency because there is no demand, while buyers do not demand it because there is no supply. Undoubtedly, a major handicap is the high degree of sector fragmentation and the involvement of many different stakeholders in the supply chain for the execution of any project. Skill shortages and capacity building should also be areas of attention. The landscape is on the other hand quite different for producers of construction materials and components which are typically represented by large companies with available resources dedicated in research, innovation and technology. They are typically regarded as the most innovative link of the construction value chain but their main issues are related with the lack of widespread adoption of new materials which is often caused by scepticism and lack of awareness.

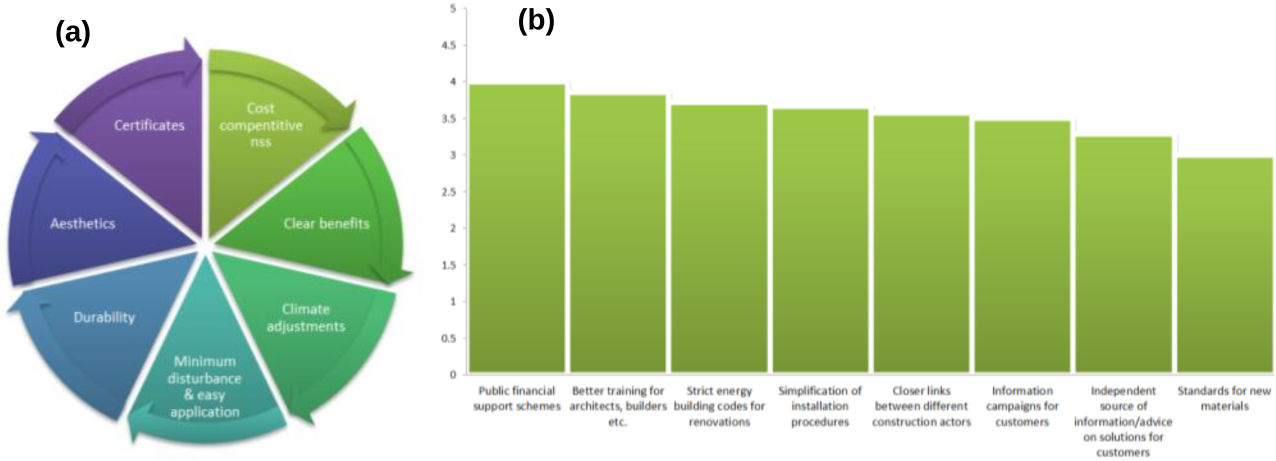


Figure 1 – (a) Success pillars for the research activities of the EASEE project and (b) Factors for a better functioning-market as identified by the EASEE partners [where 0 denotes no relevance and 5 crucial importance]

Considering the challenges and limitations of existing solutions on the market, 7 pillars have been identified in this analysis, upon which any new successful solutions should be designed in the context of the EASEE activities. As illustrated in **Figure 1**, these are: cost competitiveness, clearly stated benefits, climate adjustments, minimum disturbance & easy installation, durability, aesthetics and certificates/EU marking. The cost structure would be a key factor in ensuring that the new solutions are competitive in relation to the existing set of available measures. Their benefits should be clearly identified including the λ coefficient, energy behaviour, safety and system/material warranty time. In order to ensure geographical applicability, different thicknesses should be considered responding to different needs and climates. Considerations should also be made to ensure that the installation is feasible in several conditions (warm/cold temperatures, wind and sun conditions, rain, snow). The underlying research should be carried out in view of minimising disturbance levels on-site while high durability levels should be established. Different colour/material adjustments would be a bonus for aesthetic reasons while appropriate certificates and marking should be made available.

To turn the multiple opportunities that energy efficiency can offer into reality, multiple barriers must also be removed. Firstly, boosting confidence in energy efficiency among all different stakeholders in the construction value chain is a pre-requisite for increasing demand among occupiers, investors and contractors. Better access to independent advice should be made available to consumers who typically lack technical background. The benefits of thermal comfort, healthier indoor environment and lower fuel bills should be highlighted in any marketing strategies as these shape the main motivation reasons and boost confidence among clients. From policymakers to financiers, architects to contractors, real-estate to householders, it is important that better education & training is provided for all actors in the building value chain. Workforce skills need to be enhanced in order to meet increasing demands and the existence of public support schemes should help make the shift from the demonstrative to wide-scale level. The multi-ownership issue can be effectively addressed by appropriate regulations, facilitating the decision making process between the different actors. Moreover, if any holistic renovation approaches are to be offered on the market, it is essential that collaboration and close link between the different construction players is established. In many cases, this would mean that different construction players will need to join forces. Finally, strict regulations can also promote innovative technologies by ending the conservative approaches embraced by both construction companies and clients.

2 Introduction

The present report constitutes Deliverable D1.1 “Identification of barriers and bottlenecks” in the framework of the EASEE project. It refers to activities carried out within Work Package 1 “Definition of systemic approach and new value proposition for envelope retrofitting”, and specifically within Task 1.1 “Identification of public acceptance barriers and bottlenecks”.

The building sector offers considerable opportunities to reduce Europe’s energy consumption and CO_2 emissions. Responsible for 40% of Europe’s total energy use, the greatest potential as well as challenge lie within the existing stock. In most member states across Europe, the biggest share of the stock was built before energy efficiency was introduced in the national building codes, while new constructions represent only around 1% of the total stock every year. Considering the low efficiency levels of the older and biggest part of the stock, actions need to be taken in order to ensure that a substantial share undergoes the necessary renovation work.

The systematic energy retrofitting of the old stock has, in reality, a multi-dimensional importance. Stimulating direct employment in the construction sector and closely-related industries, these renovations and their supporting policies have a great economic bearing, as well as social dimension. The latter is especially true in fuel poverty households, a problem which has become more profound in many European countries in the aftermath of the credit crunch. The impact of these renovations is therefore not just limited to the realisation of the Europe’s 2020 strategy and EU 2050 roadmap targets but has a much wider societal relevance which goes beyond the clear environmental dimension. Energy retrofitting activities in buildings have a great potential in boosting competitiveness and catalysing the creation of jobs not only in the construction sector but also in education, research, innovation etc.

Experience over several years has identified numerous barriers that hinder energy saving investments from becoming a reality, with specific barriers borne by the multi-family sector. A better understanding of these hindrances to the uptake of innovative insulation solutions is deemed necessary in the context of the research activities of the EASEE project. The identification of these barriers is a key success factor for the subsequent design of the EASEE insulation solutions as well as development of an effective business model, marketing strategy and propositions for tangible ways overcoming the traditional bottlenecks. Without embedding these barriers into the thinking process of the research activities, it is not possible to develop an all-rounded set of solutions which can indeed offer a pragmatic approach for retrofitting these buildings as well as a real possibility of large scale deployment. Recognizing its energy saving potential and auxiliary benefits, this report therefore aims to identify, the possible existing barriers borne by key players in the construction value chain for the implementation of new strategies and technologies in energy renovations. The analysis herein, which has an ultimate aim to provide key recommendations, is based on information from interviews carried out with the EASEE partners and their stakeholders, together with our professional experience and the current literature.

The structure of the report is as follows. In chapter 3, the methodology is described. Chapter 4 describes the main characteristics of the multifamily sector, the current retrofititing techniques and main problems and limitations of existing insulation solutions. Chapter 5 identifies the barriers and bottlenecks from the perspective of different actors in the building chain. Recommendations on the key success factors for the upcoming research activities and conclusions are drawn in chapters 6 and 7, respectively.

3 Methodology

The analysis undertaken in the report is based on information drawn from interviews carried out with the EASEE partners and their stakeholders, supplemented by the authors' professional experience and existing literature. Below, the boundaries and different terms used in the report are defined followed by a description of the methodology used in this analysis.

3.1 Boundaries and definitions

For the analysis purposes of this report, we have divided Europe into four regions, as shown in Figure 2. The clustering of the EU27 is drawn by similarities based on:

- climate conditions (temperature, solar radiation, wind speed and direction, rain, humidity),
- socio-economic situations (energy prices, GDP values, stakeholders profiles, living habits and behaviour)
- retrofitting needs (demand for heating/cooling) and most common technical solutions (cladding systems, solutions based on Expanded Polystyrene Foam, rock wool, etc.)

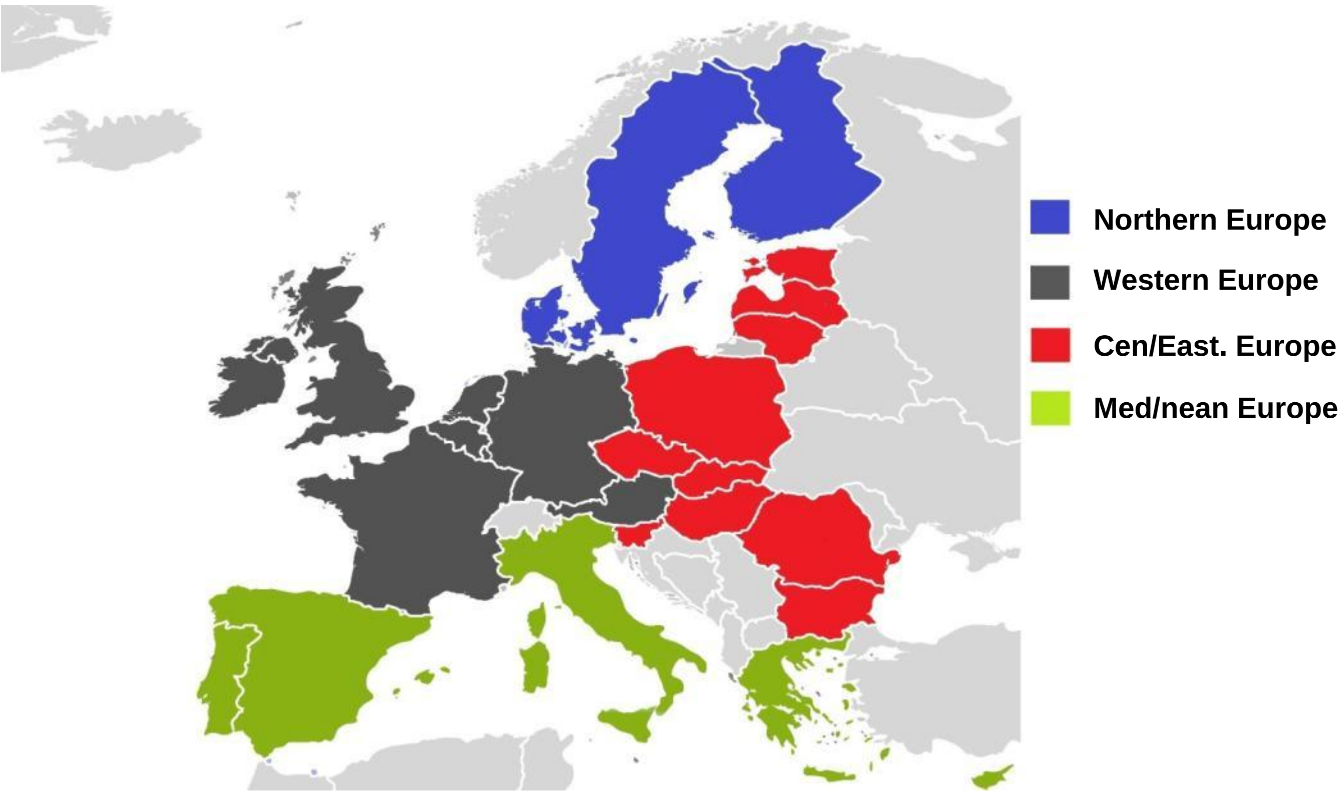


Figure 2 - Regions considered in the EASEE project

In view of these criteria, the following division has been considered:

- **Central-Eastern Europe**: Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, Slovakia
- **Mediterranean Europe:** Cyprus, Greece, Italy, Malta, Portugal, Spain
- **Northern Europe:** Sweden, Finland, Denmark
- **Western Europe**: Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, United Kingdom

3.2 Interviews with stakeholders

In order to complement the existing literature and professional knowledge with some practical expertise, we conducted several interviews with stakeholders through a questionnaire which was circulated to building construction players as well as end users. The questionnaires, which are detailed in the Annex of this report, covered the following topics:

- **energy efficiency measures in residential buildings (**e.g. frequency of installed measures and common packages applied in their countries)
- ***facade* retrofitting measures in residential buildings** (e.g. most common materials, costs)
- **client profile** (types of owners usually undertake retrofits in their homes, income level, drivers and obstacles)
- **client interest and awareness** in energy efficiency & renovations
- **regulation framework** in relation to energy renovations
- **barriers to application of retrofitting measures** (factors prohibiting market uptake, challenges of sector, workforce skills, challenges of prefabricated facade panels)
- **factors for a well-functioning market**

In total, 17 stakeholders were interviewed including project partners (companies and research centres) and their contacts. Out of these, 10 represented the views of the construction sector in their respective countries. The geographical coverage of the responses included Italy, Poland, Belgium, Sweden, Ireland and Germany. These were represented by the following companies:

- Fasada, Poland
- Imprima Costruzioni, Italy
- ECAP, Italy
- Dappolonia, Italy
- STAM, Italy
- Halfen, Italy
- Ridan, Poland,
- SP Research Institute, Sweden
- Ridan, Poland
- BPIE, Belgium
- Fraunhofer Institute, Germany
- Wierzowiecki Group Design Center, Poland
- IES, Ireland

4 Main characteristics and current retrofitting approaches of the sector

4.1 Inventory

Multi-family buildings in Europe account for 35% of the floor space of the residential buildings, representing more than a quarter of total building floor area (BPIE, 2011). The largest share of multi-family buildings as a percentage of all residential buildings is found in Mediterranean Europe (44%), followed by Central-Eastern Europe (42%), while the smallest share is located in Northern Europe (29%), as shown in Figure 3.

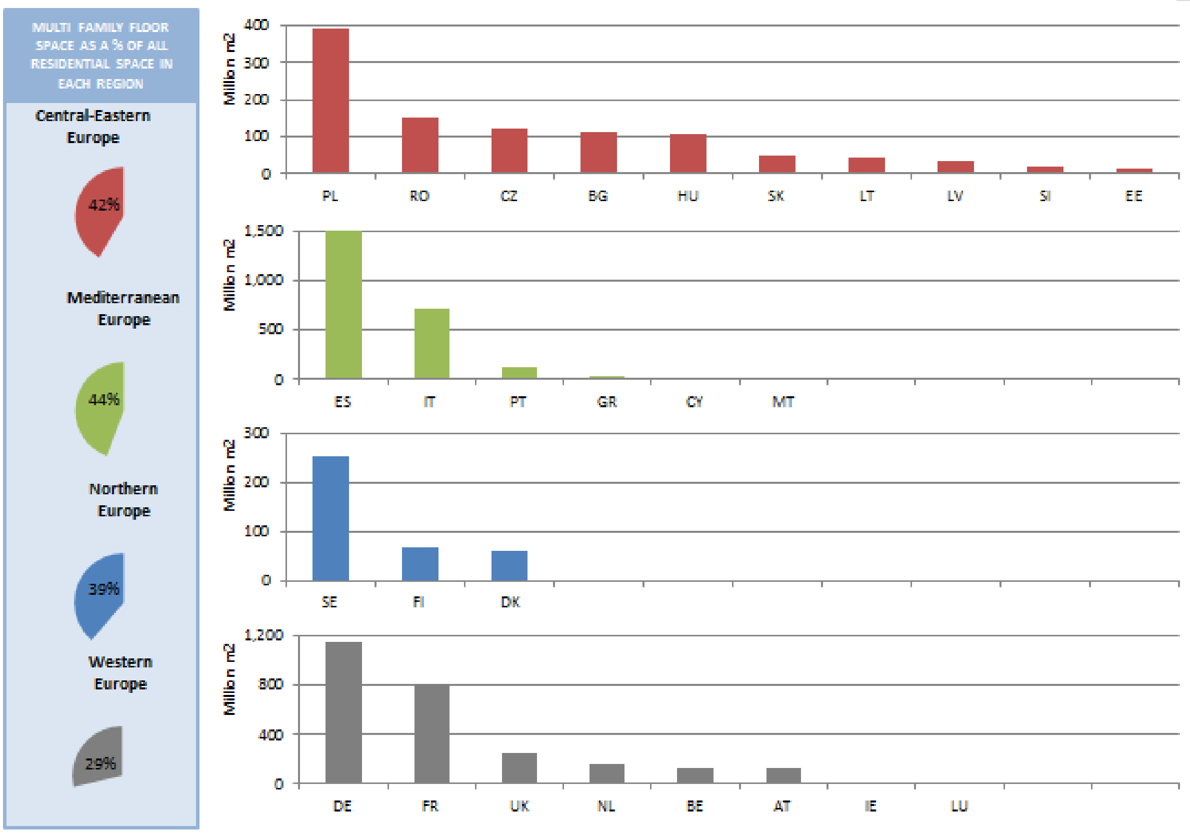


Figure 3 - Multi-family building floor space (in m2) across the different regions in Europe (BPIE, 2011)

From small multi-dwelling houses to tower apartment blocks, multi-family buildings in Europe vary remarkably in terms of their style, performance and occupancy. Within the multi-family residential sector, the most common types are small or large multi-family dwellings while high tower apartment blocks usually represent the minority of the residential sector. For example, high-rise residential blocks only account for 3% in Germany, the country with the largest number of multi-family buildings, while the German small multi-family buildings constitute the majority, as illustrated in Figure 4.

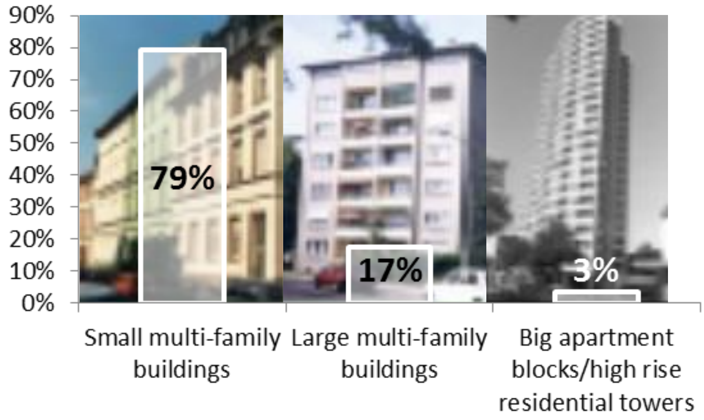


Figure 4 - Multi-family residential floor space in Germany (IWU, 2007)

As construction methods - ultimately affecting the building performance - primarily depend on the period of construction, the energy performance of the residential sector is likely to be influenced by the age of the stock. A substantial share of the stock in Europe is older than 50 years with many buildings in use today that are hundreds of years old. Most European countries experienced a large boom in construction in the period immediately after World War II. This is also evident from Figure 5 which shows the share of dwellings in different countries within each of the four regions constructed: before 1919, between 1920 and 1980, and after 1980. It is clear that the buildings considered in the EASEE project (that is, 1925-1975) fall in the largest segment of the residential sector.

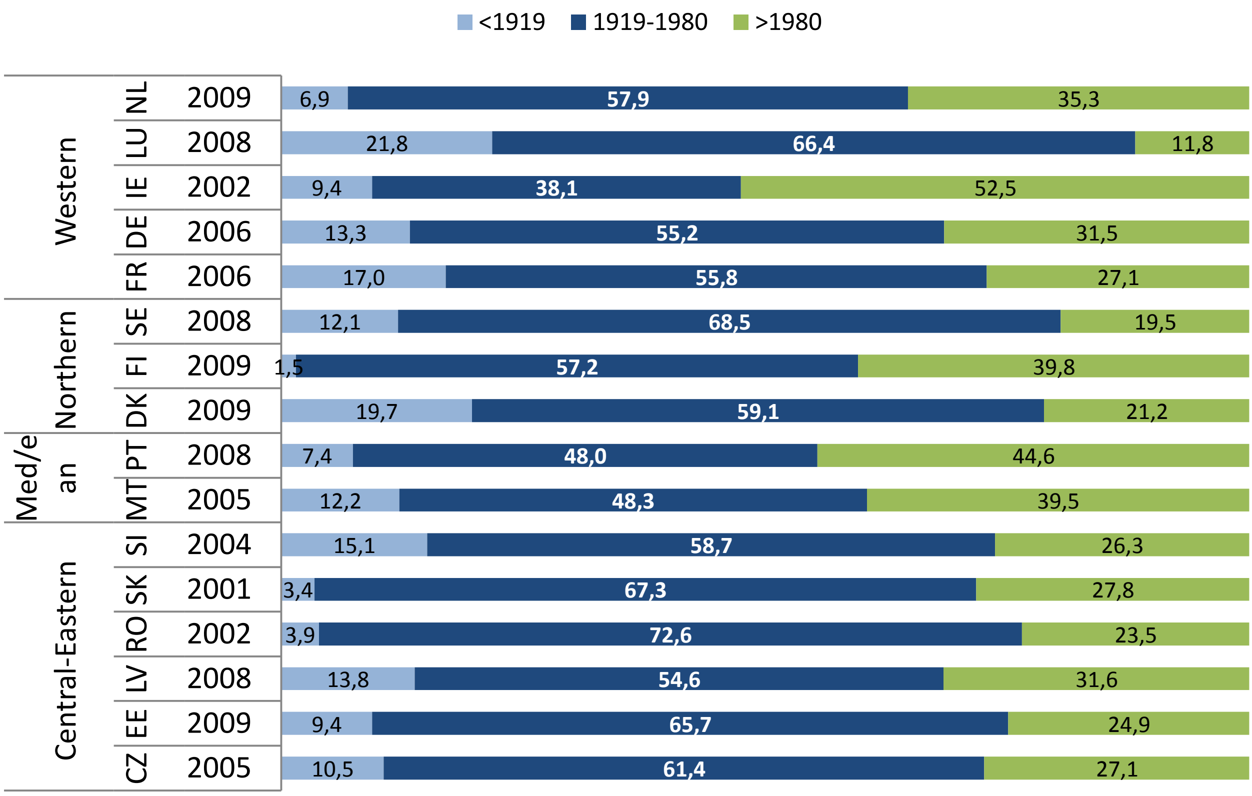


Figure 5 - Age profile of dwellings in Europe. Based on Housing Statistics in the European Union 2010 (Dol & Haffner, 2010) and national statistical data. *The detailed assumptions can be retrieved in respective reports.*

4.2 Owner profile

The diversity in the ownership structure of the building sector brings an additional complexity to the renovation process. The split incentive is probably one of the most long-lasting and widely recognised barriers in the sector. It refers to the problem stemming from the fact that the building user is not always the same entity owning the building. Unless the building owner, with landlord duties in this case, pays the energy bills, s/he does not have a direct financial benefit in investing in energy saving measures for their rental property. Since the tenant does not own the property but pays the energy bills, any investment in lowering energy bills would be impeded except if financial incentives exist for both parties.

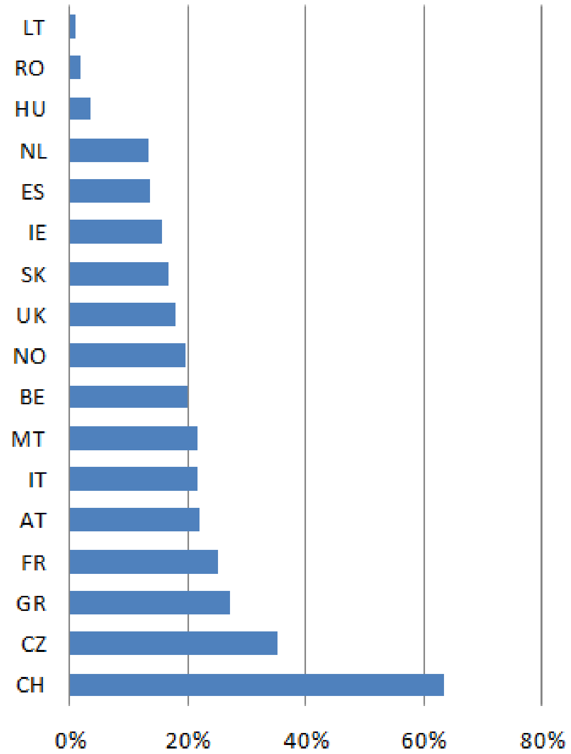


Figure 6 - Percentage of private dwellings which are rented, numbers are based on BPIE survey data

The split incentive issue is in theory more prominent in countries where there is a high share of rental accommodation in the residential sector. However, this does not necessarily mean that countries with the largest share in private ownership are most prone to this issue. As shown by the BPIE study, the biggest share in private ownership for the residential sector are Belgium, Denmark, Hungary, Lithuania, Romania, Slovenia and Spain which all have more than 90% of dwellings either in owner occupancy or private tenancy (BPIE, 2011). However, countries such as Romania and Lithuania are associated with the smallest scale of the spit incentive issue, as shown by Figure 6, which depicts the share of dwellings occupied by private tenants for a number of European countries. Instead, Czech Republic, Greece and France are among the countries with the highest share in privately rented dwellings, and thereby largest extent of this issue. As recommended by the IEA, governments in these cases should help design well-targeted policy packages and consider measures such as contract designs ensuring that end-users face energy prices, regulations determining the necessary level of energy efficiency in appliances and buildings and better access to information about energy efficiency performance (de T'Serclaes & Jolland, 2007). It should be noted that split incentives are not limited between owners and tenants but also occur between constructors and owners. Constructors, who choose the energy-relevant features of a newly-constructed or renovated building, are typically driven by reducing costs rather than the highest energy-efficient equipment or components. This issue is also raised by an EU report which recognizes that building occupants on the other hand prefer energy-efficient equipment as they lead to lower fuel bills (Uihlein & Eder, 2009).

The split incentive is not the only obstacle associated with the ownership structure of the sector. Distributed ownership in multi-family housing brings an additional pier of complexity in the decision process between different actors in a multi-owner, multi residential building. The ownership profile in multi-family buildings is quite diverse and is typically more complex than that of single family houses. This is illustrated by the example of Austria (Figure 7) where the relationship between the size of the apartment buildings (in number of flats) and variety in ownership structure is clear.

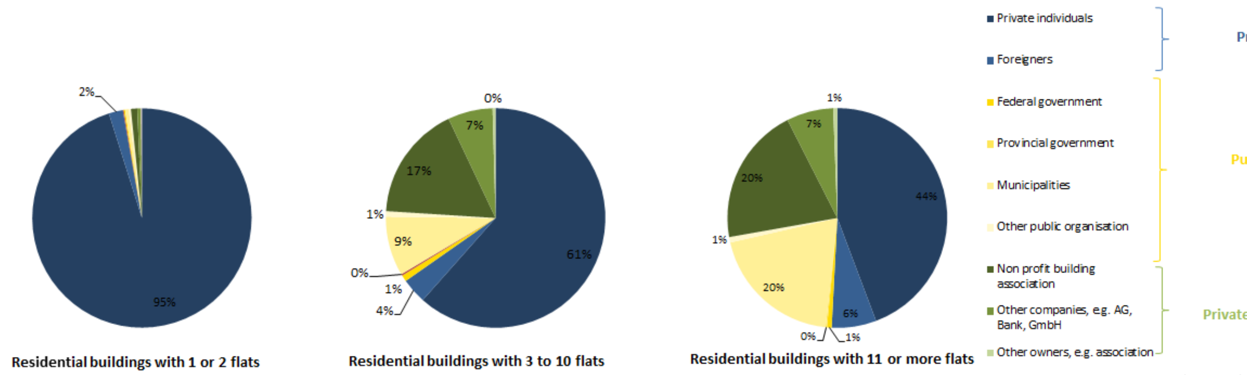


Figure 7 - Ownership profile of residential buildings in Austria in 2001 (Source: Statistics Austria)

Examining the multi-family building owner in more detail in Europe, we have identified the following profiles:

- **Private owner:** a private individual who owns one or more multi-family buildings and rent the corresponding accommodations to other persons;
- **Regional, local, government, municipalities:** public bodies that provide social housing for households in need;
- **Housing association of private owners:** an association of private individuals who share ownership rights in a multi-family building. This can be in the form of a co-operative or condominium as explained below;
- **Non-profit associations:** private organisations that provide low-cost "social housing" for very low income households in need of a home.

The housing association of private owners may operate as: (1) a housing co-operative or (2) a condominium. A **housing co-operative** is a joint corporate ownership of a housing development made by those who reside on the premises. It could be any type of organization which is owned and controlled by its member-users for a common purpose and follows the co-operative principles. A co-operative operates for the benefit of its members on a not-for-profit basis in order to provide the goods and services members need at the lowest practical cost. Members/shareholders own the co-operative and participate equally in the governance of the co-operative. A **condominium** on the other hand is a form of homeownership that combines individual ownership of one's unit with shared ownership of common facilities, such as elevators or surrounding land. The absolute ownership of a unit is based on a legal description of the airspace the unit actually occupies, plus an undivided interest in the ownership of the common elements, which are owned jointly with the other condominium unit owners. Each owner may have a separate mortgage for his or her individual unit and is individually responsible for making the payments and real estate taxes on it.
The way in which decisions between the different owners are taken with regards to retrofitting their multi-owner, multi-dwelling building is a critical part of the renovation process which depends by

the type of owner. For example, the level of consensus needed to be reached between the different private decision-makers and associated procedure is a key factor. BPIE carried out a survey in 2011 across Europe and collated information on the decision-making process in multi-family buildings. Examples of responses are shown in Table 1. In Germany, if only one owner disagrees it is not possible to approve the renovation of a multi-family building. Unanimity for renovation works is also required in Bulgaria and the UK. For all other countries, a majority (50% or more) of votes is needed for any renovation work approvals, where the level of consensus as well as weight of each vote varies from country to country. For example, in Finland, the weight of votes per owner is based on the size of the apartment. In many cases, a 50% majority is required (e.g. Cyprus) while in others a 75% consensus is necessary (e.g. Slovakia and Slovenia). In Czech Republic, the level of consensus is determined by the foundation charter of an organization. It is not clear whether member states have re-considered their legislative vehicles in order to align them with today's policy framework and facilitate the renovation requirements called by the different EU directives and proposals. It is therefore recommended that these legislations are revisited and any legislative barriers imposed by the existing acts are removed in order to simplify the process of retrofitting works in multi-family buildings.

Table 1- Level of consensus required in multi-family buildings in order to undertake renovation works. Based on survey carried out by BPIE

AT	A single majority in co-ownership share, not in number, is sufficient to decide upon these renovation measures. In case of simple joint ownership, there is no entry of residential property foundation in the land register. In order to carry out refurbishment measures, one needs the bare majority (**more than half of the share of the property**).
BE	A **majority** of approval suffices, unless the reglementation of the co-ownership agreement dictate otherwise.
BG	In accordance with the Condominium Ownership Management Act the Assembly of the Owners takes decision for renovation of the building **unanimously**.
CY	There is no relevant provision in law for restoration of a multi-family building In meetings all owners are invited and decisions are taken by **majority** vote, so it must be present persons owning at least 50% of the jointly-owned property
CZ	Housing co-operatives and condominiums have to make decisions via agreement of majority, where percentage of necessary votes has to be defined in the foundation charter of an organisation.
FI	The decisions are based on the **majority** of the votes, where the amount of the votes per owner is based on the size of the apartment
DE	To date, no legal basis exists which forces building owners to undertake renovations. The decision has to be **unanimous** in the multi-family buildings in order to undertake renovation work
GR	Renovations including the installation of renewable systems need to be approved by the **majority** of owners
HU	A consensus by the simple **majority** of the tenants is required for approving the plans for building improvements and the related loan
IT	When the decisions on the renovations are based on the declaration of energy certification or an energy audit made by accredited expert, a majority will be simple (**more than 50% of the common part**).
NL	Decisions with regards to renovation of buildings can be taken when a majority of **51%** and a majority of **67 - 100%** in case of regular maintenance and large scale renovations, respectively.
SK	There is a condition on **3/5** majority of votes when taking decision about major renovation. (Act N° 182/1993 Coll; Act N° 70/2010 Coll.)
SI	Maintenance measures require **50% consensus** or above. For technical improvements (e.g. insulation measures, AC system, PVs, solar collectors) or major renovations, a more than **75% consensus** is requested. Only for demanding works (such as structural or safety-related works), a **100% consensus** and building permit are needed.
ES	Normally the decision of the renovation of a multi-family building is made through the proprietor communities (voting by **majority**).
UK	Maintenance can be undertaken based on a majority decision of the freehold owners. Improvement works (such as additional insulation) however, require a **unanimous decision** of the free hold owners

4.3 Construction methods

Today's energy building regulations are by far more superior and are expected to be tightened even further as we move towards cost-optimal standards and ultimately nearly-zero energy levels in 2020. The older building stock, however, has not been designed with energy performance in consideration and typically, is in desperate need for renovation. This segment of the stock is associated with a very large energy saving potential and although its renovation is linked with many challenges, it offers a well-known array of benefits to the occupants, construction industry, economy and society as a whole.

Below, a few examples of the most common construction types of buildings requiring renovation works are discussed. These have all been constructed between 1945 and 1980.

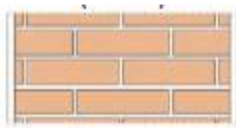
Figure 8 - Example of a residential building constructed from brick without and with plaster

- **Brick buildings (1945 – 1970)**

After the World War II, the most common technology for construction or reconstruction of the buildings was the brick technology, which can be divided into two main types. The first type is associated with two or three storeys buildings (small multi-family buildings) with the external wall made just from brick without any plaster layer, as shown in Figure 8. Depending on the age and location of these buildings, many of these buildings are under protection and heritage conservation. As a result, any external insulation work is typically very expensive and, in many cases, not economically justified. The second type of brick technology is linked with buildings whose brick work is covered with plaster. These are usually large multi-family buildings, with up to 6 floors.

- **Apartment blocks (1920 – 1970)**

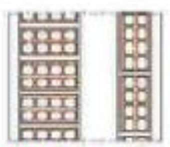
Large apartment blocks represent a very diffused building typology especially in Mediterranean Europe. They are typically 4-6 floors, with up to 30 apartments. Apartment blocks built between 1920 and 1945 (Figure 9) have usually brick walls covered by plaster with a thickness between 30 and 60 cm.



Brick walls, 30-60 cm

Figure 9 – Example of apartment blocks built between 1920 and 1945 (left) and typical wall structure (right**)**

In apartment blocks built after the Second World War instead (Figure 10), the envelope is usually made by using empty bricks structure with cavity wall or by a concrete wall with thickness of around 18 cm. These types of buildings are quite common in residential areas of cities in Italy and Mediterranean Europe in general and they would need facade retrofitting since no insulation is currently in place.



Bricks with cavity wall
(30 cm)

Concrete (18 cm)

Figure 10 – Example of apartment blocks built between 1946 and 1970 (left) and typical wall structures (right)

- **Prefabricated panel buildings (1970-1985)**

The first prefabricated buildings were constructed in the beginning of 1950s with the largest number of this type of buildings being erected in the period between 1970 -1985. The system associated with these buildings was a common construction technique in Czech Republic, Poland and Soviet bloc, with some examples illustrated in Figure 11 and Figure 12. The technology behind these constructions is based on the prefabricated concrete elements with steel joints. The system contains “bearing” walls, floor slabs, staircases, lift shafts, balconies and even some parts of the façade. In Poland, for instance, the year of 1980 saw around 120 of prefabrication plants, which enabled the construction of residential buildings with total area of 12 million m^2 during that year alone. Prefabricated concrete buildings are of high energy demand typically up to 250 kWh/m^2 per year or in more critical cases even up to 350 kWh/m^2. Some of the main reasons why these buildings continue to be of low energy efficiency are related with the low energy prices and lack of the environmental policy.

Figure 11 - Example of a building constructed in prefabricated panel technology – not retrofitted in Poland

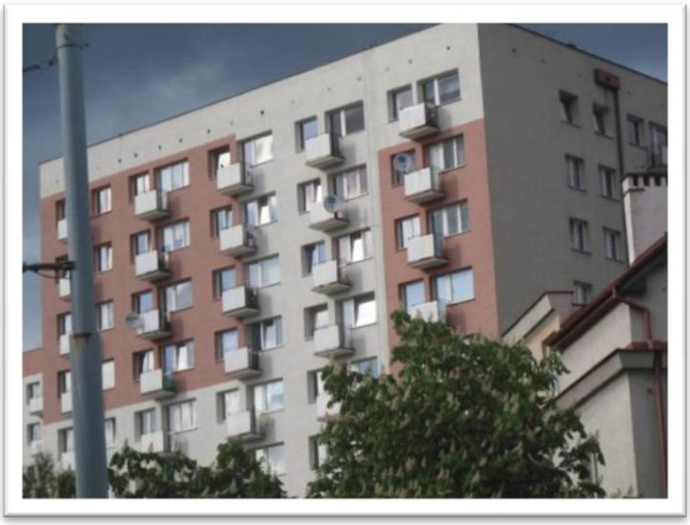


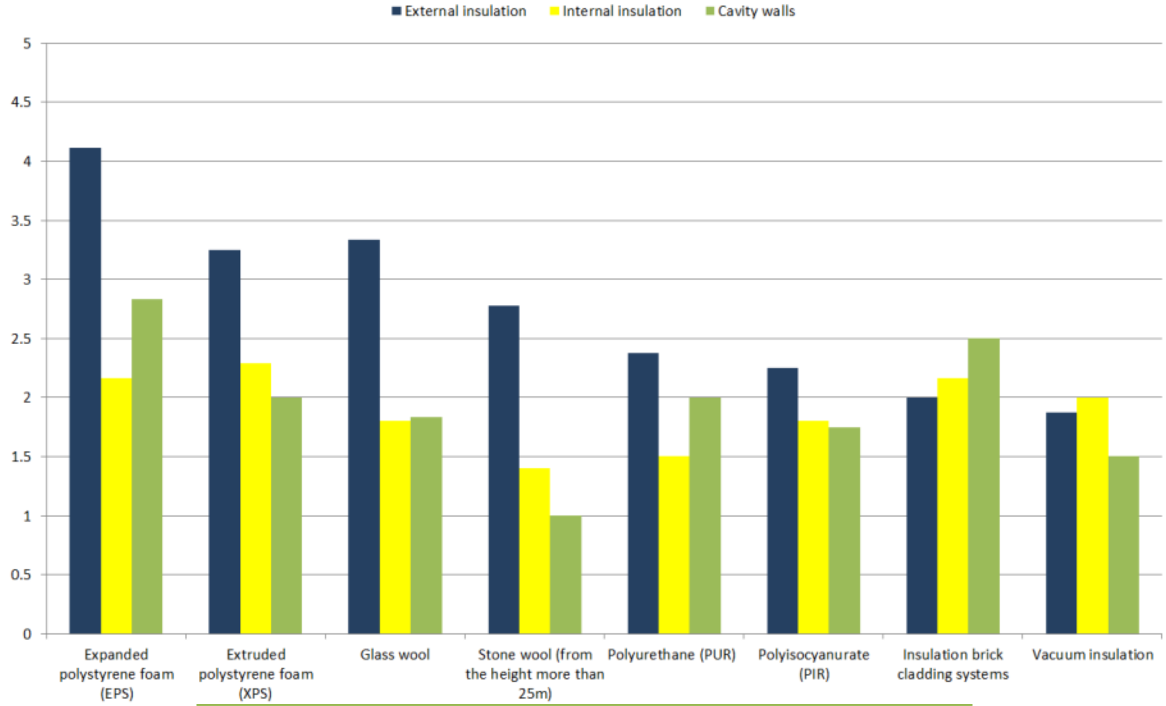
Figure 12 - Example of a building constructed in prefabricated panel technology after retrofitting with expanded polystyrene foam and plaster in Poland

4.4 Most common retrofitting techniques

There are many available solutions improving the internal and external insulation of buildings on the market. The results of our survey have indicated the frequency levels shown in Figure 13 for different materials used in external, internal and cavity wall insulation techniques deployed across Europe. It should be noted that these results reflect the views of the EASEE partners solely.

In general, a large part of energy efficient retrofitting techniques for the outer envelope have a common installation procedure. This consists of the removal of existing plaster, application of several layers as adhesive mortar, insulation foam (either expanded polystyrene bead or extruded polystyrene foam), mechanical fasteners, reinforcing mesh and an exterior coating system including a base coat and a finish coat. Several global companies offer complete systems to implement this retrofitting approach, known as External Insulated Façade System (EIFS).

The exterior surface of an EIFS wall is often either comprised of stucco or ceramic tiles adhered to the base coat. The major drawback of this standard process is that it is extremely labour intensive and time consuming as the façade is built up in series on the job site, requiring scaffoldings around the building for very long times with consequent discomforts for the building occupants as well as for the surroundings. In addition, this is a "wet" process where each layer must dry before the application of the other, thus having many idle times due to weather conditions (up to months in humid climates). A cross-sectional illustration of an EIFS wall is shown in Figure 14.



	Thermal performance coefficient λ [W/mK]
Expanded polystyrene foam (EPS)	0.040
Graphite-enhance expanded plystyrene (GEPS)	0.035
Extruded polystyrene foam (XPS)	0.035
Stone wool	0.042
Phenolic foam panels	0.021
Brick cladding system	0.035

Figure 13 - Most common retrofitting material applied in facades of multi storey residential buildings [where 0 denotes not applied and 5 most common]

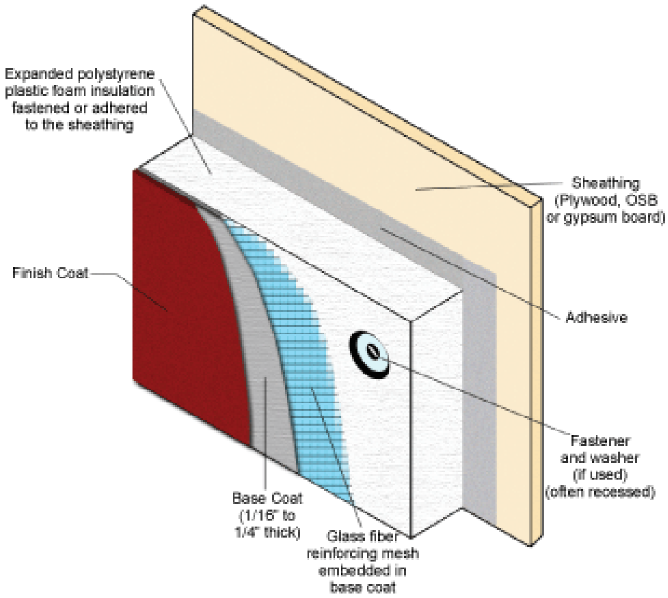


Figure 14 – Typical cross-section of EIFS wall

The most common insulation systems linked with EIFS used in renovation projects, followed by internal insulation technologies are discussed below.

- **Expanded polystyrene foam (EPS)**

Expanded polystyrene foam (EPS) is the most common insulation material used in retrofitting works, an example is shown Figure 15. The popularity of this material is mainly associated with the low price, wide availability and easy installation process. Good thermal properties are caused by fact that EPS contains 98% air per volume. Another attractive benefit of EPS is that it does not change properties during the service time and resists decay. It has a thermal performance coefficient of λ = 0,040 W/m*K and depending on the type of the building and climatic conditions, the thickness of the EPS on retrofitted buildings can vary between 6 – 14 cm. During the installation process, the EPS cannot be subjected to contact with any dissolvent or substances contain dissolvent. EPS panels are not resistant to the UV radiation, meaning that the panels can stay without protection for up to two months. EPS can be delivered to the building site in two variations: (1) with sharp edges and (2) with milled edges. In theory the milled edges enable very accurate and detailed insulation of the walls with almost complete elimination of the thermal bridges. In practice it appears that working with milled edges provokes several problems with direct or indirect causes of defects. External walls have very often many curvatures and the EPS does not have ideally milled edges. Therefore it is difficult to install the EPS panels in a way that the edges create tailored connection. This aspect slows the installation process and increases the waste production. It is worth mentioning that for instance based on the recommendation given by the Ministry of Infrastructure in Poland the buildings only up to the height of 25 m can be retrofitted with EPS system. For higher buildings external thermal insulation system need to be fire resistant. The system based on EPS can be covered with almost all type of plaster.

Figure 15 - Building during retrofitting works with EPS system in Poland

- **Graphite-enhanced expanded polystyrene (GEPS)**

New types of expanded polystyrene so called graphite EPS are also available on the market. This material is grey due to the inclusion of graphite, which substantially increases the insulation performance, Figure 16. Thanks to the presence of graphite, EPS can absorb the heat radiation. Therefore the thermal performance coefficient λ can be around 0,035 W/m*K. Such product is recommended for the external insulation, especially when the thickness of the insulation layer needs to be limited. The thickness of the insulation in fact can be reduced by around 25% in comparison with standard EPS (λ = 0,040 W/m*K). The main disadvantage of the graphite EPS is the price, which is typically 50% higher than standard EPS. During the retrofitting works special attention need to be paid on adhesive properties of the dry set mortar due to the fact that the expanded polystyrene has lower adhesive properties in comparison with standard EPS.

Figure 16 - Graphite expanded polystyrene insulation

- **Extruded polystyrene foam (XPS)**

Extruded polystyrene foam (XPS) is an extruded polystyrene insulation manufactured through a plastic extrusion process. The resulting boards are almost 100% closed cell, strong, highly moisture resistant and easy to cut and shape. The structure of XPS consists of closed cells that tightly adhere to each other. The thermal performance coefficient λ can be around 0,035 W/m*K. Due to the fact that XPS has high moisture and compression resistance, this material is recommended for places where a high mechanic resistance is required i.e. parts of the building that are close to the ground or close to the terraces and balconies, connections of the roof and the wall between buildings, plinths, etc. (see Figure 17). During the performance of the work, special attention should be paid on the surface of the XPS panels. It should not be smooth as smoothness reduces the adhesion of the mortar. Panels of façade XPS with rough surface, which contributes to good adhesive properties are available on the market. The XPS can cost up to even 3 times more than the EPS panels.

Figure 17 - Extruded polystyrene foam - invited by the company DOW and it application on the plinth of the building

- **Stone wool**

Stone wool is produced from the corresponding non-combustible raw material (mainly from basalt rock) and therefore is classified as the non-flammable product. Stone wool has the Euroclass category A1 or A2 (2000/147/EC of 8 February 2000 implementing Council Directive 89/106/EEC) and is an elastic material with higher acoustic properties in comparison with EPS or XPS panels. The thermal performance coefficient λ can be around 0,042 W/m*K and can be compared with EPS thermal properties. According to polish regulation (regulation of Ministry of Infrastructure from 10.04.2002) all the newly constructed buildings for the height more than 25 m need to have non-flammable insulation and mechanical joints. For buildings constructed before 01.04.1995 the regulation allows the use during retrofitting works EPS up to 11 floors, and Fire Stop EPS for any further floors (Figure 18).

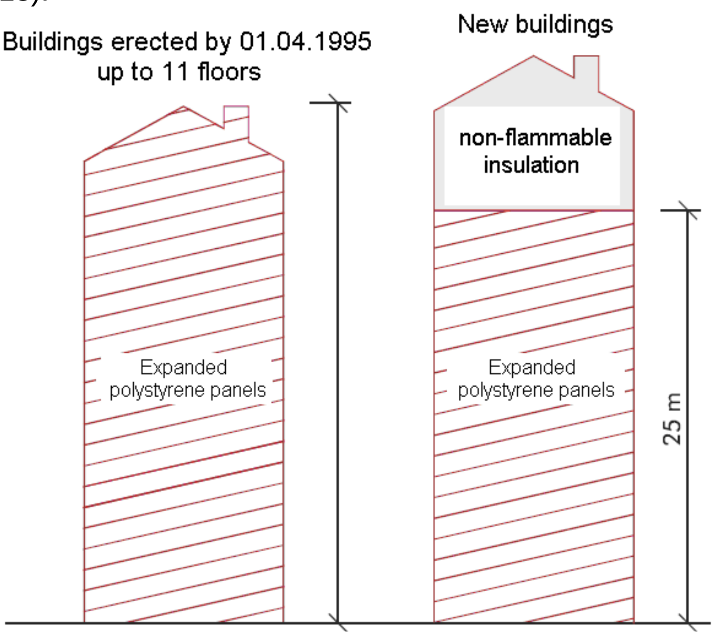


Figure 18 - Illustration of the fire regulation in terms of the material in Poland

Stone wool systems are in use on buildings with large curvatures or in cases where it would be difficult to apply polystyrene insulation, as depicted by Figure 19. An important property of the stone wool is the high vapour permeability that enables the transfer of humidity caused by water vapour and the humidity that was not removed from the external wall. It is therefore recommended to retrofit buildings which have been flooded with the stone wool insulation. For external layering in the stone wool system, polymeric-mineral plasters painted with silicon paints and silicate plasters are used. Stone wool that is applied as insulation of external walls can be divided into two types:

- wool with fibres situated perpendicular to the external wall
- wool with dispersed fibres

Both types have similar thermal properties, but their installation process is different. Wool with perpendicular fibres is aligned with the whole internal surface, while the dispersed wool is placed in a similar manner with EPS panels. Panels with the perpendicular fibre location should be installed with the adhesives (mechanical fasteners are optional and depends on designer) and panels with dispersed fibres need to have both adhesive and mechanical connectors. Mechanical connectors need to have metal parts. Before the installation of the rock wool panels, the external wall should be treated with the primer. During installation process, special attention should be paid on the safety aspects of the workers. Due to the fact that the wool crumbles and dusts during installation process, the workers should wear protection outfits i.e. gloves, respirators and protective goggles.

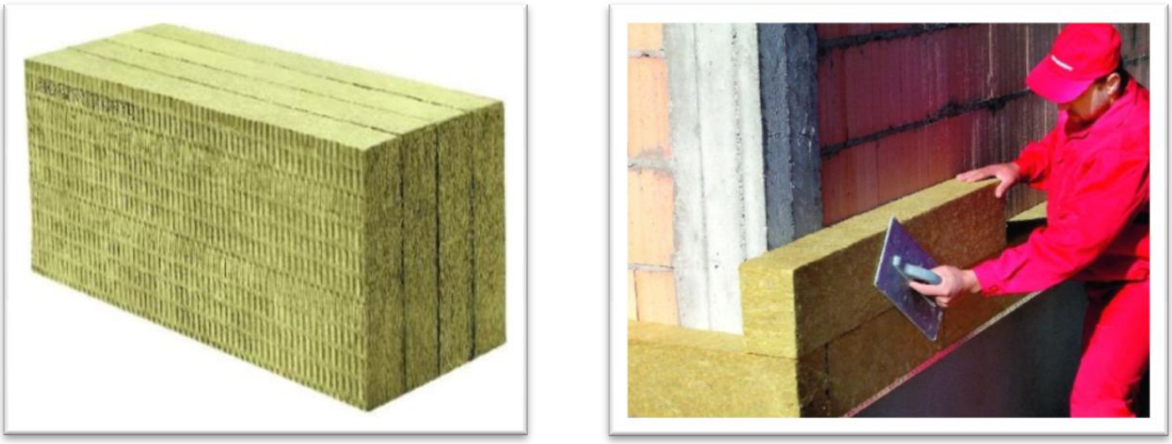


Figure 19 - Stones wool and its installation on the wall (Rockwool)

- **Phenolic foam panels**

Phenolic foam has a closed cell structure which results in low thermal conductivity properties with λ = 0,021 W/m*K. Such low values allow insulating walls with 50% less thickness of material compared with EPS (see Figure 20 and Figure 21) and thereby saving space. Phenolic foam panels have very good moisture properties due to the fact that:

- Phenolic foam has a low water vapour permeability and is therefore highly resistant to the passage of water vapour
- It lowers water absorption which takes place predominantly in the cut/broken surface cells of the foam
- Phenolic foam is non-wicking. This means that if water enters the insulation system due to the vapour barrier becoming punctured, any moisture ingress is limited and confined to the punctured area. This ensures moisture does not build up and compromise the whole system.

Phenolic foam has high compressive strength around 100 kPa (with 10% strains) and is easy to install. It has also good fire properties, being characterised by low flame spread, low smoke emission and low levels of toxic gas emission. Phenolic foam is unaffected by oils, fuels, turpentine, benzene and ethanol. It is also resistant to solvents such as acetone, methyl ethyl ketone and carbon tetra chloride. It is also unaffected by products including saturated saline, olive oil and 10% sulphuric acid. High concentrations of some acids and alkalis will cause swelling and or discoloration. Although the properties of the phenolic foam panel are very good, the main barrier to its successful market penetration is price-related. Such material costs at least a few times more than the traditional EPS.

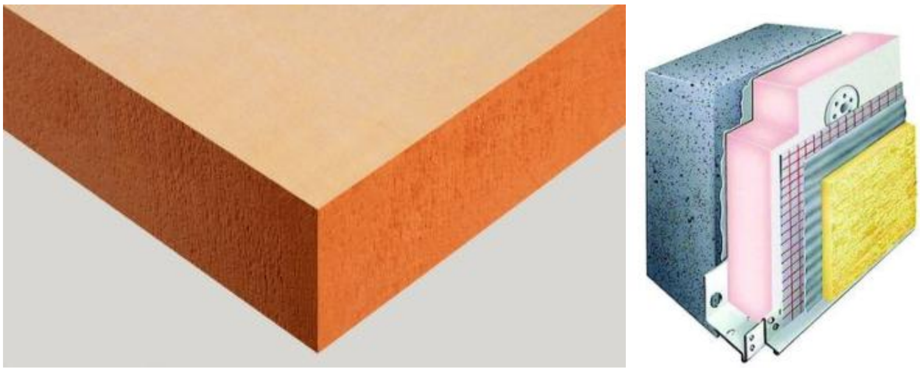


Figure 20 - On the left phenolic foam panel offered by Weber Saint- Gobain, on the right installation cross section

Figure 21 - Kindergarten retrofitted with the use of phenolic foam panels in Dzierżoniów in Poland

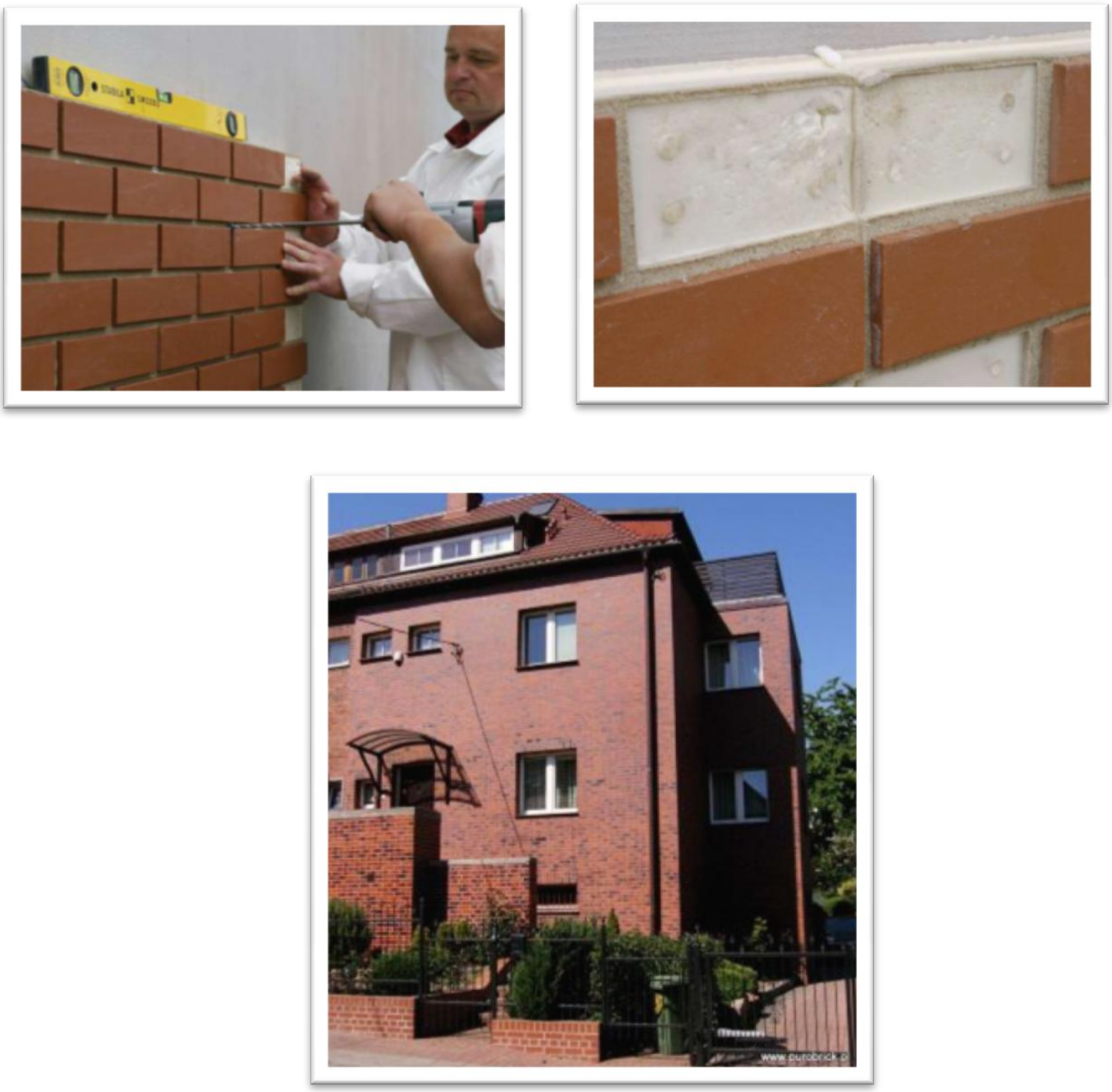


Figure 22 - Building retrofitted with the brick cladding system based on PUR foam (PRE Fasada)

- **Brick cladding systems**

Prefabricated brick cladding systems are also available on the market; an example is illustrated in Figure 22. One brick cladding system is the so-called “Gebrik”, which was invented in Belgium. The system consists of different natural clay brick finishes, cast in polyurethane under factory controlled conditions. Non load-bearing, lightweight stretcher or stack-bond panels are produced to create approximately 1m² ‘sheets’ which can be screwed directly to either masonry, timber or steel frame substrates on site. The standard thickness of the panel is 50 mm and it consists of the polyurethane foam and the brick cladding panel, as shown in **Figure 22**. The thermal performance coefficient λ can be around 0,035 W/m*K. Advantages of the system are: the low thermal conductivity, the small weight of the panels, the high durability, the easy installation process and aesthetic of the clinker façade. The system is widely applied in Belgium and Germany while in Central-East Eastern Europe the critical issue is the price. In comparison with the system based on EPS, brick cladding system based on PUR foam cost in average even two times more than the complete solution based of EPS. However it should be highlighted that prefabricated panels have finished surface, in the case of EPS system there is need for higher numbers of installation materials and plaster finishing. Furthermore, the labour cost are lower for prefabricated façade systems.

- **Internal insulation techniques**

In general it is not recommended to retrofit residential buildings from the inside. The responses from our partners show that less than 20% of all applied cases are associated with internal insulation solutions. There is generally a lack of effective technical solutions for internal insulation. It is in contrast much more efficient to insulate external walls of the buildings. However there are situations where it is impossible or highly difficult due to administrative reasons to perform external retrofitting. This problem can occur for houses that are under heritage conservation and in cases where the interventions on the external wall are not recommended. In many cases, these buildings are of low energy performance levels, inhabitant by families of low income and owned by communities/municipalities. Another example of the utilisation of internal insulation is the situation when the building is located on the border of the plot and the neighbour does not agree on the external insulation. It can happens also that the individual user would like to perform insulation works but the housing co-operative or association of tenants do not agree or do not have money or cannot afford the expense. Then the best option would be to insulate the flat from the inside.
However as it was mentioned before, at the moment there is no thermal and cost efficient solutions for internal retrofitting. The material that can be use is mineral wool but this method requires the construction of the wall with steel profiles, as shown in Figure 23. Since it is necessary to separate insulation material from the internal humidity, therefore profiles are installed with spacing around 2 cm from the wall.

Figure 23 - Internal insulation with the use of mineral wool

There is also possibility to install the EPS or XPS, but the installation is a time and labour consuming. The risk related with the rising damp of the wall below the EPS panel is high. Other techniques are internal paintings, PUR (Polyurethane) and PIR (Polyisocyanurate) foam panels or block from aerated autoclaved concrete, as shown in Figure 24. The main drawbacks of the few available solutions are associated with the risk of condensation of the water vapour, the thickness of the insulation layer, the time consuming labour costs and the total cost.

Figure 24 - Internal insulation with the use of Aerated Autoclaved Concrete blocks – Ytong

4.5 Problems and limitations

The above described technical solutions have problems and limitations which sometimes limit their widespread application in certain geographical areas. In many countries in Central-Eastern and Mediterranean Europe, the price criterion is the decisive driver. The most commonly applied system is the expanded polystyrene foam (EPS) combined with plaster and paints. Although there are more innovative retrofitting techniques on the market, such as phenolic foam panels or brick cladding system based on polyurethane foam, they are only rarely applied.

One of the limitations in parts of Europe with cold climate is simply the length of the winter period that often blocks the execution of retrofitting works. Therefore the retrofitting process has the peak in the late spring, summer and beginning of the autumn. Typically, the retrofitting works cannot be conducted when the temperature is below 5^{o}C or higher than 25^{o}C. In addition such works should not be performed during rain, strong wind and sun. The same problem exists in other European areas, especially in Mediterranean and Western European Countries, where the weather is very humid making the installation of EIFS systems very slow.

It is important to highlight that for many buildings with the external wall made of brick (without plaster), long and difficult administrative processes are often necessary due to the fact that those buildings are under the heritage conservation. Often such buildings are owned by municipalities and local authorities and are inhabited by the families with very low incomes. For them the best option would be the possibility to retrofit them from inside. However such solutions need to be cost and labour efficient. Some significant drawbacks of internal retrofitting are associated with the thickness of the insulation layer, which may reduce the overall apartment surface and risk of the condensation of water vapour, which may worsen indoor quality.

For what concerns prefabricated solutions as brick cladding systems, their main limitation in central-eastern Europe is represented by the high cost, while in Mediterranean Europe their aesthetics do not fit well with the architectural features of the buildings.

5 Barriers and bottlenecks for wide application of innovative retrofitting solutions

It is widely recognised that there is a large cost-effective potential for improving the energy performance of the existing building stock which remains untapped due to a number of barriers hindering the uptake of renovation measures in buildings. This chapter investigates the different types of barriers hampering energy efficiency measures from different players' perspectives, focusing, in particular, on the challenges with regards to the deployment of insulation measures.

Figure 25 - The construction value chain today

The renovation market involves a large number of actors of the construction chain as shown in Figure 25. Pivotal role in the process has the decision maker represented by the **investor/building owner** who may be an individual, a non-profit company or the government as explained in section 4.2. It should be noted that the renovation market strongly differs from other construction areas such as transport infrastructure, industrial and environmental construction, public utility buildings or shopping centres. For example, the investor in many cases is a local player with limited knowledge and no resources in terms of workforce or budget unlike large market clients such as public units, large and medium companies in other construction areas.

The close collaboration between the different players of the construction sector ranging from contractors to material supplier ensures the successful execution of the renovation project. The characteristics of the construction sector can be summarized as: one-of-a-kind production, site production and temporary project organization[2]. Renovation works are in many cases performed by small and medium enterprises (SMEs), which are strongly subject to market fluctuations and on-time payments by the investors.

[2] In general construction works, especially in retrofitting projects, comprise relatively short process. The project organization can change, e.g. on a building site there can be FIDIC procedures, and procedures differ between private owners, and public sector. In other instances, e.g. when the investor does not have technical personnel or time, construction companies can play the role of investor in terms of project management.

The **policy makers** have a distinguished, facilitating role for which they are required to better understand the factors affecting the different decisions of the key players and bottlenecks. Ultimately, the policy maker is called to design and implement policies that will more effectively promote renovation investments and actions. The legislative and administration procedure required for the renovation works, undoubtedly, bears a significant role in the successful implementation of a project, and in many cases can be the primary cause of projects being interrupted, delayed or postponed as a result of the multitude of legislative barriers on the way.

The large untapped energy saving potential is evidence of the various bottlenecks impending consumers, investors, and society in general, from investing in energy saving measures. Indeed, market dynamics are complex with multiple reasons why investors or building owners take certain decisions. In order to understand this complex set of issues, which influence all actors in the buildings chain, the different barriers are mapped from the following players' perspective:

- Owner/investor
- Construction company
- Material and component producer

An overview of the main legislative barriers is also provided. The relevant analysis is based on a literature review, interviews carried out in the context of the EASEE project, as well as professional expertise of the sector.

5.1 Barriers for owners/investors

There is a wealth of literature documenting the problems faced by owners when it comes to energy efficiency investments. Ultimately, the decision-making process would determine whether the owner will invest in energy efficiency in their homes or not. In this context, the human dimension combined with a variety of other factors affecting this decision making process needs to be better understood and addressed if any ambitious retrofit strategies are to be successful. In order to understand the owner's behaviour, we thereafter examine this step-by-step process and identify the barriers throughout each step as moving up the ladder. An illustrative diagram to facilitate this process is shown in Figure 26.

- **Recognition of need for EE measures**

Is the owner aware of energy saving measures and their benefits?
Is the owner motivated by these benefits?

The first question to analyse is whether the owner is aware of the energy saving measures and their benefits. While a deeper understanding of the measures is not a pre-requisite in this step, it could be argued that information campaigns, which have been carried out in many European countries in the context of the EPBD, have had a major contributing role in raising awareness of the existence of the different measures in the last years. However, the lack of awareness is still a key barrier, as the BPIE survey showed that awareness-related issues were in the second most identified barrier category, with 15 of 26 countries giving this a high priority (amongst the top three). Indeed in a survey carried out among Polish citizens, it was found out that only just 4% of Polish citizens were aware that 70% of the energy used by them was consumed for heating purposes (Rockwool, 2007). Inevitably, this lack of information on how energy is utilised a building means that the benefits of energy saving measures cannot be fully appreciated. This issue is acknowledged by many actors, such as the IEA which recognises that potential owners may not be mindful of the implications and costs of low energy efficiency as a consequence of low awareness levels (Laustsen, 2008).

This leads to the next question. Given that the owner is aware of the benefits of energy saving, is s/he motivated by these benefits? In face-to-face interviews carried out with building owners as part of the IDEAL-EPBD project, it was revealed that owner's concerns for their new building were primarily related to potential moisture damages or hidden structural damages, while none of the interviewees mentioned energy auditing as a factor in their home purchasing decision (Tuominen, 2011). While this may be related to awareness issues, owners may not be primarily motivated by energy savings. This is usually linked with the fact that the cost of energy bills is not of major concern, as in most households, energy bills account typically for 3-4% of disposable income. In a question asked to our partners on what drives their customers to improve their building façade, the thermal comfort and appearance of façade emerged as important drivers in addition to fuel bill reduction, as shown in Figure 27. Conversely, when asked to rank the main reasons why householders do not invest in energy efficiency measures in their viewpoint, the lack of motivation in reducing energy bills came in the top 3 reasons. These findings are also in line with the results of a field study carried out in 5 European countries investigating the motivation reasons behind 28 energy refurbished buildings (Beillan, et al., 2011). The study showed that the decision-makers did not consider energy when they started thinking about the renovation projects. Instead, the desire for a comfortable, good quality home was among the main drivers.

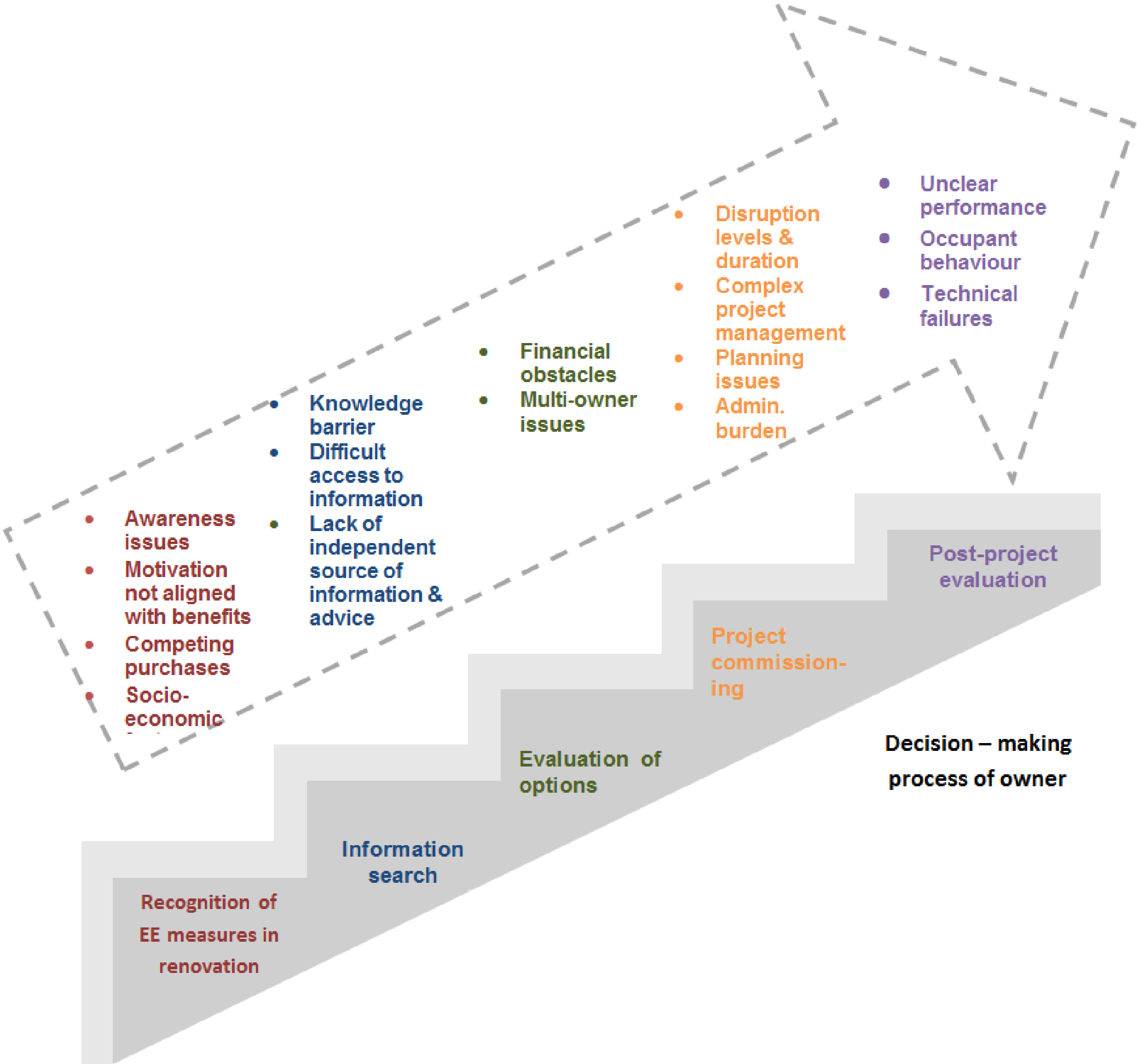


Figure 26 - The ladder of decision making process of the building owner/investors and common barriers in each step

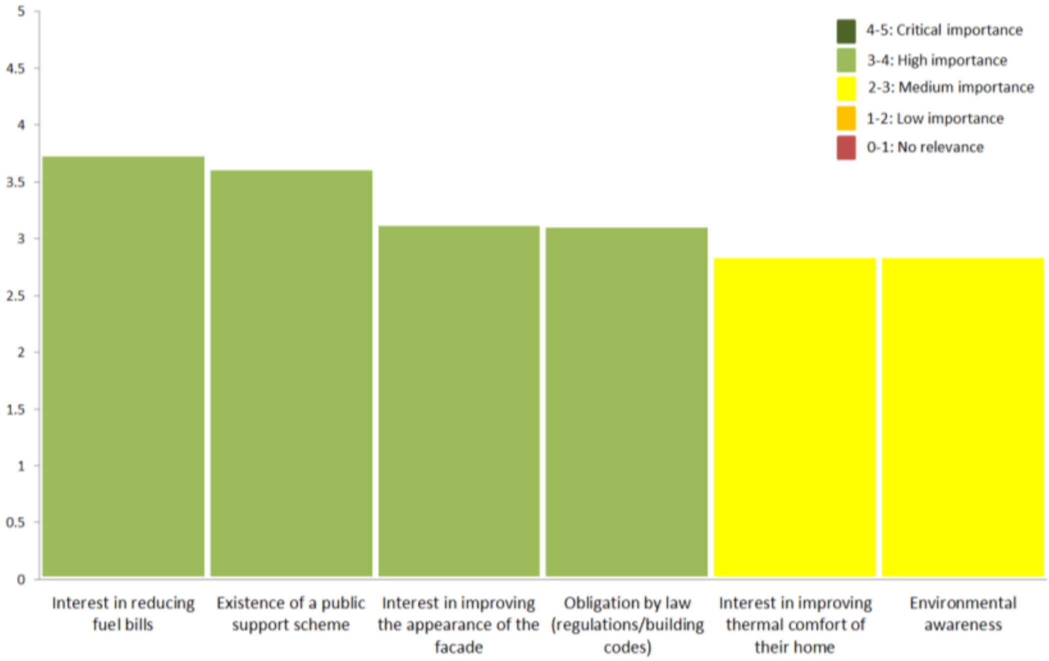


Figure 27 - Factors driving clients to improve their building facade based on the EASEE partner survey

In this context, it is important to identify the conditions under which the owner may consider the option of insulating their building. The owner may recognise the need for adding insulation as a complementary step during necessary façade/wall conservation work (urgent or as part of maintenance routine). In this case, the energy saving measure is indeed "provoked" by other reasons. On the other hand, investments in energy saving measures may also occur as a stand-alone measure. Under these circumstances, the insulation measure would compete with other potential investments (e.g. a kitchen upgrade, PV panels or even the latest electronic gadget). Subsequently, the insulation measure may struggle to compete against other investments as the 'social benefit' would be an additional factor in their motivation process. Logically, for energy renovations to constitute a competitive option among the plethora of investment possibilities, there should be confidence that energy efficiency can have a positive reflection in the property value. While a kitchen renovation will most likely result in some increase in the property price and therefore perceived as a rational decision, it is not yet clear whether energy efficiency has an impact on the house value (Croft & Sunderland, 2011). However, some evidence that energy labelling across the EU brings higher valuations for efficient buildings has been documented in a research report commissioned by RICS. The authors identified a premium associated with properties that demonstrate high levels of energy efficiency, with a 2.8% higher transaction price for properties with an A, B, or C certificate (Brounen & Kok, 2010).

Measures such as envelope insulation are not necessarily visible which may reduce insulation's 'attractiveness' as an investment option. This, indeed, is a significant barrier which may explain why at the moment, stand-alone measures are the least common procedure in which insulation is applied to a building. Instead, maintenance/replacement procedure accounted for more than 50% of the cases in the responses returned when construction companies were asked whether the measures are applied as part of maintenance/replacement procedure of one or more elements, whole house renovation/improvement or as a stand-alone measure.

It is also important to note that their respective weight of the different motivation factors varies depending on the profile of the owner. The thermal comfort may be particularly important for non-profit associations investing in renovation works for elderly caring homes, while costs are of primary importance for low income householders.

- **Information search**

Once the owner recognises the need of investing in improving the insulation levels of their building, the next step in their decision making process involves acquiring all relevant information. In a question posed in our survey on how construction companies describe the knowledge levels of their costumers on average, it was shown that most owners have a limited understanding and require further information. Very rarely, the customer has a good understanding on the most popular solutions, including the benefits and drawbacks of each option. It is therefore expected that the interested party would seek out for more information about the different options.

Undoubtedly, for the market to work well, clear accurate, accessible and readily understood information is essential. Whilst the Energy Performance Certificates can be a pivotal source of independent information on the energy performance of a building and the improvement measures that can be applied, the desired effects are not often obtained. In fact, a recent review of EPC data in the UK demonstrated that householders are often not aware of this instrument, and in many cases they find it confusing or irrelevant to their needs (National Energy Foundation, 2009). The certificates in general suffer from low market credibility in many countries across the EU for a number of reasons.

While there are numerous internet sites detailing information about different measures, an independent source of information and professional advice would be particularly useful for obtaining un-biased information, tailored to the customer needs and different knowledge levels. Some good existing examples include the Upper Austria Energy Agency and UK Energy Saving Trust, which give impartial and accurate advice on how to reduce carbon emissions and use water more sustainably, as well as to help people to save money on energy bills.[3] Several actors, operating across the construction chain value, (see Figure 26) however lack the full skillset necessary to advise clients on energy efficiency renovations. All these factors typically create confusion among clients when faced by a multitude of choices and ultimately have a detrimental role in developing the necessary confidence within the market.

Moreover, while information on traditional solutions is generally more accessible, special effort needs to be paid for more innovative solutions through appropriate channels. Although the private owner will opt for more traditional solutions, the public sector has a pivotal role in creating demand for innovative solutions. The public authorities have the power to act as an innovation broker and promote innovations through the procurement and contract forms, allowing and encouraging companies to offer and research on new solutions. Information on innovative solutions should be in fact more accessible to public authorities compared to private investors.

- **Evaluation of options**

  What are the factors influencing which measure the decision maker will choose?

Following the information search on the existing possibilities, the evaluation of the different options based on a number of criteria is the subsequent step. The criteria used in the evaluation, shown in Figure 28, are differentiated between those which have a positive or negative impact in the choice towards a certain technology.

[3] http://www.energysavingtrust.org.uk/; http://www.esv.or.at/

These criteria and their respective weight can be affected by a number of socio-economic factors, such as household income, size and investor age. For example, the most common criterion, related to the price of the technology/measure, would be a critical stage of the evaluation for low-income households. Conversely, in high-income households or in Western-European countries with higher GDP such as Sweden, Finland, Ireland or Germany, other criteria such as thickness and innovativeness may have a comparable or higher weight compared to price. The price is, nevertheless, a key evaluation criterion as initial up-front investment costs for ambitious renovations can be a real barrier. Arguably, the inability to secure enough finance is generally one of the most cited barriers to investing in energy efficiency measures. In the survey conducted among the project partners, cost-related issues scored the highest points in the list of reasons why owners opt against investing in insulation materials (Figure 28). The barrier related to the lack of sufficient funds also applies at the level of businesses (large or small), social housing providers and the public sector, especially due to the financial crisis. Undoubtedly, it is obvious that the availability of different kinds of subsidies, loans or grants can boost their willingness of private investors and thereby influence their decision making process towards a certain technology. The impact of such public support schemes is clear if one examines the increase in renovation activity during periods when these programmes are running. In order to obtain financial help, private investors are also willing to consider more innovative solutions.

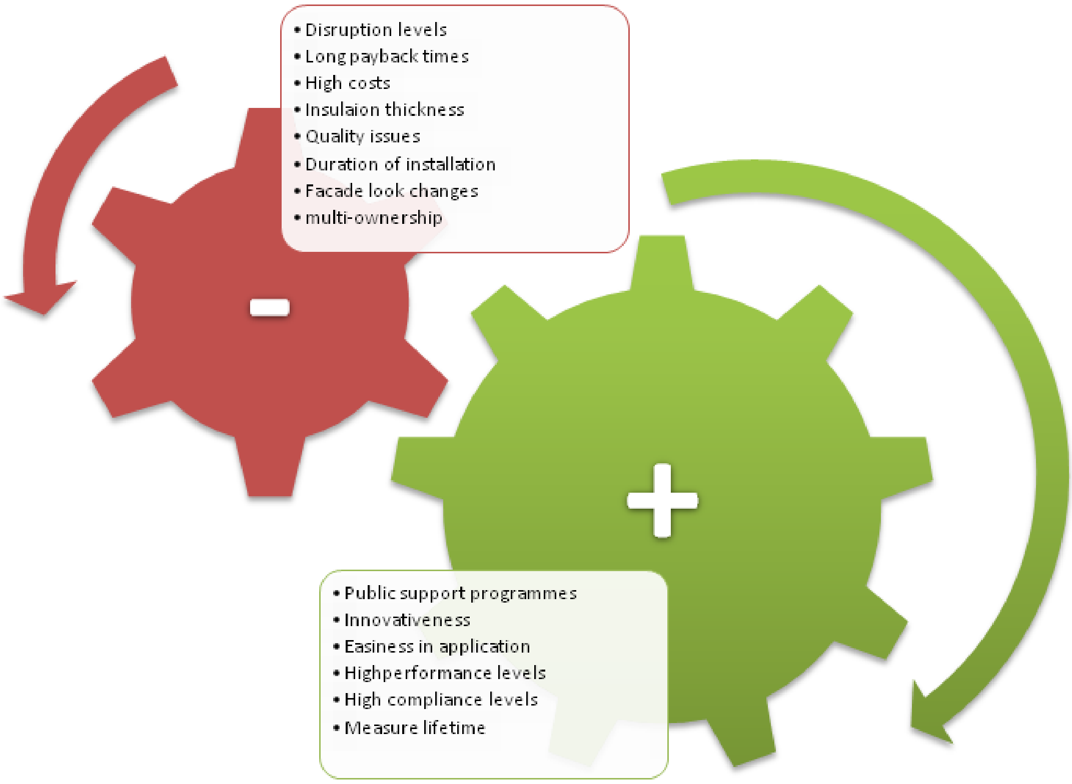


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Figure 28 - Evaluation criteria in the decision making process of the investor

Another common financial-related barrier is the payback time. Even if the measures are economically rational with a positive Net Present Value (NPV) over its lifetime, the length of occupancy for homeowners maybe shorter than the payback period of many energy efficiency measures. If there is a risk that the investor moves before they are able to recoup their investment from the reduced energy bills, the likelihood of the measure being installed is low. This is particularly true in countries with active housing markets such as the UK. The recently proposed

Green Deal in the UK is based on the mechanism 'Pay As You Save' which allows the householder to install a set of measures and repay the capital sum through the fuel bill savings that accrue. The Green Deal overcomes in a way the barrier related to the misalignment of occupancy length and payback time as this repayment charge is tied to the property rather than the occupant so it passes to the next owner or occupant (Sunderland & Croft, 2011).

Even if public support schemes exist and the barrier of securing enough finance is overcome, the investor will strive to find the best solution which provides the perfect match for their needs. The needs differ from case to case and may be related to a maximum limit of the insulation thickness that can be installed, minimum performance levels of the material, lifetime of measure, length and disruption levels of installation, façade appearance changes, etc. There is a magnitude of choices on the market. In a relevant question asked to the end users, the willingness in considering prefabricated solutions has been voiced, showing that their advantageous features of lower disruption levels on site, shorter construction time, lower dependence of quality of works, less waste are important for the consumer.

The factor of innovativeness in the evaluation process is very important in the context of the EASEE activities. The investor usually selects the most beneficial tender based on objective tender evaluation criteria. As discussed, the most important criterion that generally is taken into account is price for many private investors; however the public sector can play a key role in supporting innovativeness. From macro-economic point of view, the public procurement system carries a huge potential which may influence the development of scientific research, modernisation of companies, creation of new jobs and environmental protection. The public administration should actively promote the use of criteria referring to the innovation of the object of a contract in public procurement and aim at eliminating existing barriers. In many countries, some main barriers in the introduction of public procurement system based on innovation are linked to the lack of experience in terms of innovations, low capacity to take risk connected with employing highly innovative solutions procurement and short-term views in public procurement strategy and policy. Moreover the public sector purchases of contracts in the form of a lengthy procedure are perceived by enterprises as bureaucratised and unwilling approaches for supporting new ideas. New approaches in public procurement therefore cannot be based only on the price criterion. In order to present the benefits of promoting innovation by an appropriate tender procedure in the public procurement system, it therefore needs to be stressed that the potential profit is generated in the long run, which is frequently accompanied by additional expenses at the first stage of implementation.

Lastly, as discussed in section 4.2, the diversity in the ownership structure can be a detrimental barrier. Even if a choice has been made by the owner and the necessary funds secured, it can be very difficult to reach a consensus on the energy saving investment in multi-family residential buildings if many different property owners have to either approve a decision or make a financial contribution.

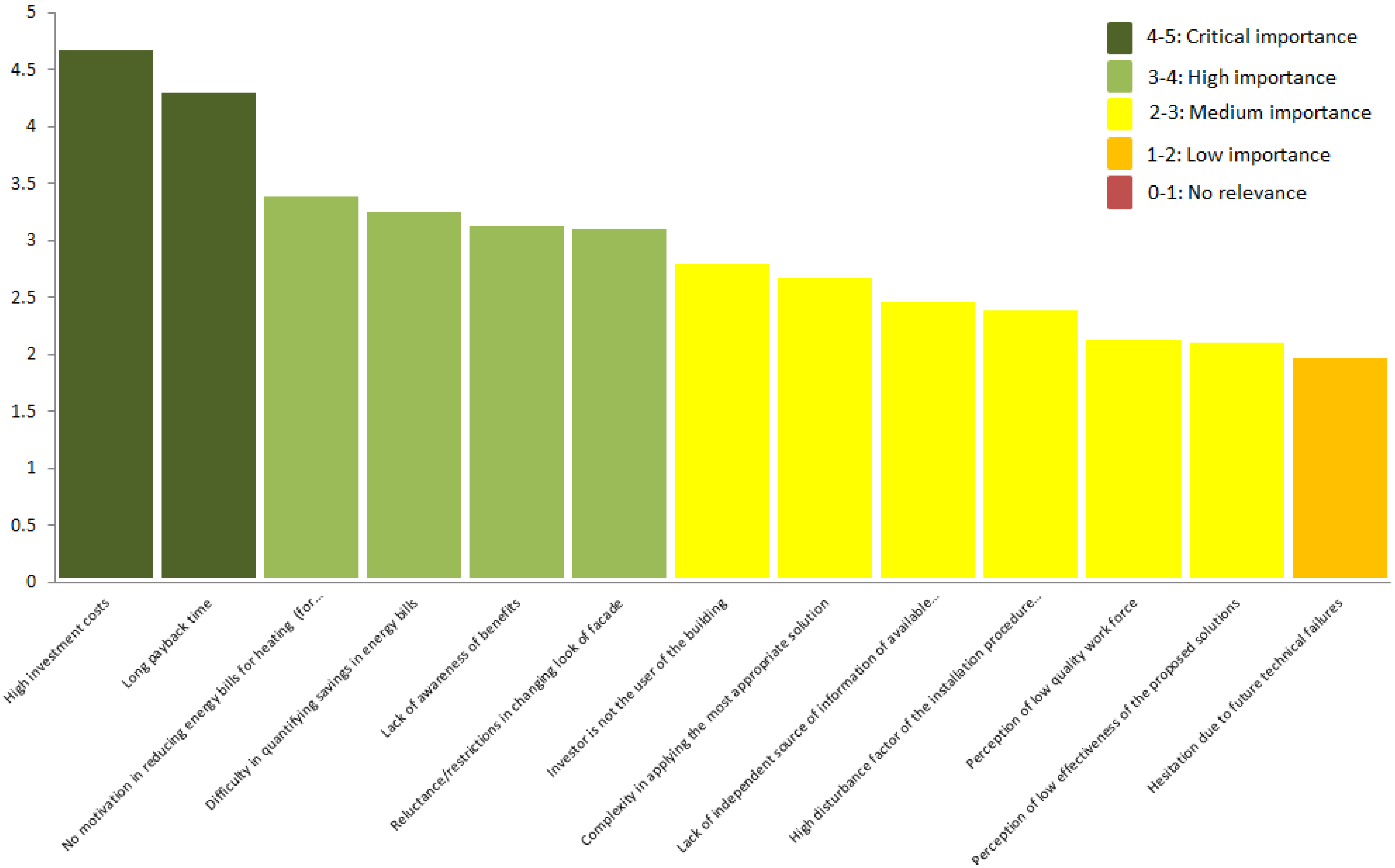

Figure 29 - Reasons why customers do not invest in improving their building insulation

- **Project commissioning and post-evaluation**

Many building owners are reluctant to undergo major renovations because of the considerable length of the works and inevitable disruptions they cause. This is currently regarded as a common barrier among building owners. Given that exposure to the disruption of the works is generally unwelcome, the practical issue of what happens to the building occupant is often raised. In large projects, an additional financial burden may be held by the owner due to the necessary re-location of the occupant for a segment or the whole duration of the project. Furthermore, the management of such projects is not a straightforward matter as it involves the contribution of many players. If the budget of the owner is limited, they may opt to take this role themselves which would require considerable personal time and planning. This, together with frequent administrative burdens introduced by a loan or application of renovation permit and preparation of all paperwork discourage building owners in many cases to commission projects of this scale unless it is deemed absolutely necessary.

When retrofitting works are conducted, it is therefore imperative to do it properly and exploit as much of the energy saving potential as possible. The next renovation may only occur in a few decades. It is also important that information on how the renovation will affect them should be readily available in advance. Actions should be taken to ensure that the length of the project is kept to the minimum with no overruns. In this context, prefabricated solutions offer an advantage as the scaffolding requirements are reduced to a minimum and works to be conducted on the site are simplified.

Following the completion of the project, the owner will make an assessment on the success of the work. In theory, satisfaction levels should be high due to better indoor conditions, higher thermal comfort and lower energy bills. However, there may be a disappointing reality, if the quality works are not up to standards which can lead to technical failures or if there changes in the occupancy behaviour. The concern of long term failure risks has been expressed by many in the industry and this is an issue which may not emerge for a decade or more. Whilst not a barrier in the short term, if such failures began to occur on a large scale in several years, they could result in a massive loss of confidence and a halt in major renovation programmes. Moreover the real performance of building may be different to the theoretical one which can be an additional cause of disappointment. The behavior patterns of the occupant will have a crucial role on the real performance, so proper education in advance is important.

5.2 Barriers for construction companies

A summary of the main challenges faced by construction companies is illustrated in Figure 30. The main obstacles are organised in: financial issues, market obstacles, capacity building and industry structure. These are explained in more detail below.

Figure 30 - Barriers for construction companies

- **Financial issues**

The financial crisis has caused low liquidity levels in the construction industry, especially in small and medium enterprises. Small firms are more susceptible to the crisis as they are highly dependent on market fluctuations and on-time payments by investors. Traditional measures are therefore preferred in these unfavourable economic conditions. As renovation projects are in many cases performed by SMEs, traditional solutions are implemented even in good economic conditions due to higher costs and uncertainties linked with innovative products which consequently bring an additional burden to SMEs. The unwillingness to invest in new solutions is also linked with the fact that small companies do not have the resources to invest in R&D activities. In spite of any potential interest in the implementation of new products, investments in internal resources for training purposes are essential in ensuring the successful installation of these solutions in reality. Indeed, training resources would be a strain for many SMEs which usually have limited budgets. All these requirements lead to additional resources and for a traditional sector which strives to reduce costs, any extra budget allocation would be difficult especially given the frequent occurrence of hidden costs (e.g. overhead costs, disruption, cost overruns). In addition, one of the most important obstacles in the installation of new solutions is the cost factor. Despite the long-term benefits obtained from the use of new products, the initial investment remains a major issue. Indeed, this stems from the fact that the construction sector focuses on the project costs rather than life-cycle costs.

- **Market obstacles**

One of the most cited barriers faced by the construction sector in the context of energy renovations is simply the low demand for energy efficiency from customers. A recent study carried out by RICS documents this issue and also refers to a vicious circle created in the market as a result of all actors blaming each other for the lack of uptake of energy efficiency investments (RICS, 2010).

The construction industry does not supply energy efficiency because there is no demand, while buyers do not demand it because there is no supply. The same blame game arguably applies for the lack of diffusion of innovative solutions in the sector. The construction companies blame potential buyers of lack of interest in new solutions, while customers lay the blame on construction companies for favoring the use of proven and well-established technologies.

The construction sector in general is a settled, cost driven and a conservative sector. Construction companies are driven by short-term profit maximisation, meaning that cheap, low-risk and in many cases less efficient components are usually preferred in construction projects. In contrast, technology driven sectors such as IT and medical sectors, tend to adopt innovations fast in order to remain competitive on the market and respond to the changing needs of the consumers. However, this is not the case in the construction sector which has a tendency to use proven materials and methods. The uptake of innovations does not lead to drastic and vital changes in the final products which would increase the consumer demand considerably. This attitude will continue to undermine energy efficiency and innovation unless sufficient demand is developed. The IEA recommendation to set strong building codes and regulations on the energy performance of buildings can potentially break this circle by pushing construction companies and clients to abandon conservative approaches (International Energy Agency, 2010).

Pricing and valuation of new products is also a complex issue. Many companies do not have knowledge about the application of innovative products in real practice. For the development of new products, it is therefore critical to design solutions which can be easily applied while composed by well-known materials. In this context, the consideration of cost structure of new solutions in relation to more traditional ones is very important. Figure 31 shows the cost structure of two retrofitting solutions based on EPS and prefabricated PUR panels. The main differences can lie in the material costs, where prefabricating panels are more expensive - constituting around 60% of the whole budget. However, the reduced labour cost due to simplified application process ensures the marketability of the prefabricated panels. This aspect is especially important in Western and Northern Europe where labour costs are higher.

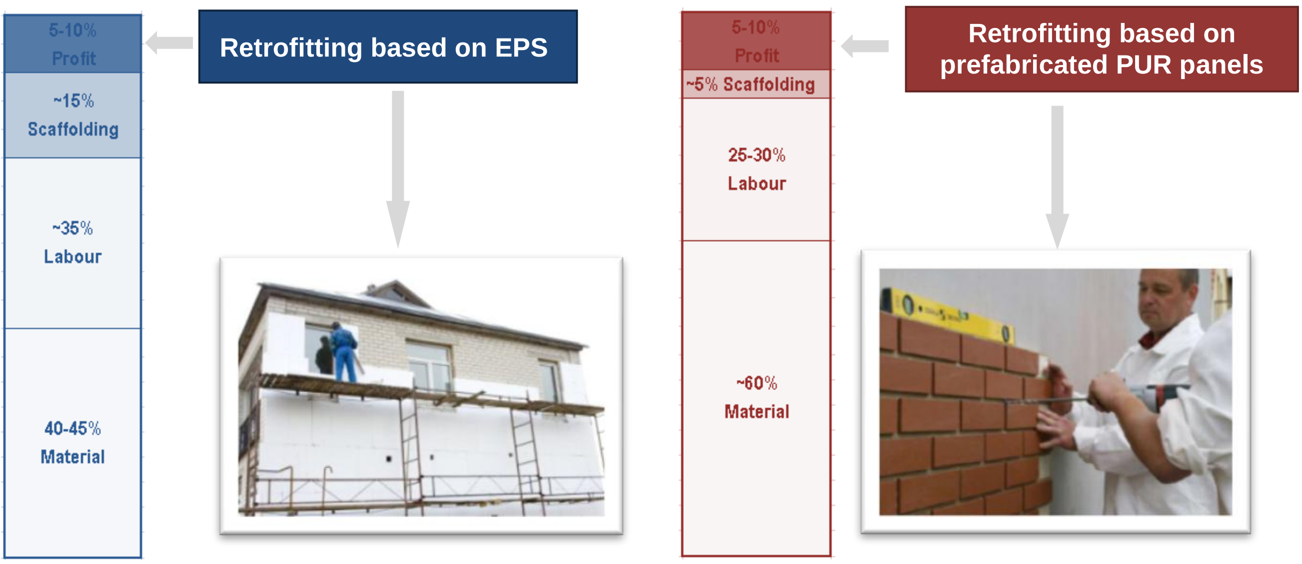

Figure 31 - Cost structure of two retrofitting solutions based on EPS and prefabricated PUR panels. Based on internal data of PRE Fasada

It should be highlighted that the interest of the companies in new products is also related to the maturity of the market. Currently, energy renovations occur only at the demonstration level with no real uptake in the market. When the market situation becomes stable through the longer term scale, SMEs will become more willing to seek new solutions, focusing less on just surviving on the market. Therefore Mediterranean, Northern and Western countries gain some advantage over Central and Eastern Europe. An advantage of SMEs in comparison to big players is that such companies actively look for the market options and have better possibility to adapt to the changes of the economy, market and needs of clients.

Finally, another important aspect that can influence negatively the introduction of innovative solutions is related to standards and certificates. As companies need to give a warranty period for the retrofitted buildings, they are obliged to show necessary certificates for the materials. In order to successfully and widely implement new materials, they need to have appropriate certificates and marking.

- **Industry structure**

Looking at the composition of actors in the construction supply chain in Figure 25, the picture is diverse: the commission of a renovation project would involve producers of construction materials, material suppliers, architects, engineers, building owners, contractors, financiers etc. A smooth collaboration between all these actors is key to the success of the project. However, there is a concern about the difficulty to integrate contractors, suppliers and all other players into an effective project team. This brings an additional complexity which may discourage clients to take part in such activities. Furthermore, if any holistic renovation approaches are to be offered in the market, it is essential that collaboration and close link between the different construction players is established. However, the current characteristics of the industry would only hinder rather than foster such concepts.

Undoubtedly, a major handicap in the building sector is related to how the construction industry is organised. The degree of fragmentation of the sector is a key barrier, with only very few large construction companies and a more than 80% of representation by small players. Moreover, construction services are highly fragmented along national borders, making it difficult for companies to embark on international activities given the vast differences in customs, regulations and culture between countries (Ecorys, 2010). In this context, a reform of the industry would be a necessary part in order to increase its competitiveness and coherence between different actors.

- **Capacity building**

The lack of skilled workforce to meet the requirements of energy-efficient retrofitting is a barrier accepted by several actors. Recognizing the impact that the 2020 EU objectives have on the construction sector, the European Commission through its IEE 2011 call launched a new initiative on the building workforce for training and qualification. Installers and builders are critical for the successful implementation and without appropriate competence levels, the integration of the energy efficiency measures in the building stock would not be possible.

The problem with skill shortages exists in both the contractor market as well as professional services. On one hand construction companies responsible for effective installation of insulation solutions have limited resources for training and on the other hand only a small number of architects and designers are familiar with how to specify a low energy renovation. The limited know-how of these actors may lead to lost opportunities resulting in unsatisfactory energy savings and shallow retrofits. Moreover, the requirements imposed at the building level are becoming more stringent with the introduction of new energy regulations, yet the necessary training to accommodate these needs simply has not happened. This is especially true with performance-based codes which require in many cases advanced professional experience. Moreover, the financial crisis has had a significant impact on the labour market. The labour has shifted for undersupply to oversupply, leading to a rise in sectoral unemployment levels (Ecorys, 2010). In some countries, such as Slovakia and Lithuania, a substantial share of the domestic workforce has left the country to work in other countries causing a shortage of workers in the home market while at the same time increasing risks of social dumping in the destination countries. In some countries (e.g. Austria) re-skilling of workers in the construction sector for work in other sectors, such as public healthcare, is mentioned as one of the challenges relating to increase in unemployment levels.

It is clear that if the energy savings related to the EU targets are to be delivered, the demands on the industry will increase. The industry is currently under-equipped to meet these demands and new skills in all layers of the supply chain are needed. If demand for energy retrofits suddenly increases, there will be issues with regards to material & component shortages as well as inadequate human resources. The supply chains and delivery systems will struggle to respond resulting in suboptimal operation for a certain period of time. Inevitably, in order to meet this demand, a greater capacity, more efficient supply chain and delivery system will need to be built.

5.3 Barriers for materials and components producers

It is generally accepted that most of the innovation in the construction sector stems currently from the material and components producers. Producers of construction materials and components are typically large companies which can afford higher costs for investments. Moreover, investment in new materials is part of the competition among different material manufacturers. Indeed, the sector of material/component producers is strongly related with the chemical sector which is considered as a pioneering industry undertaking some of the most fundamental and applied research. When there is an innovative product which can be of use in the construction industry, a new material/component is generally also developed.

The problems faced by the material manufacturers are linked with the lack of widespread adoption of new materials in the construction sector. This is often caused by the end-user scepticism and lack of awareness of architects and engineers about new solutions. These barriers slow down the adaptation of new products in the sector. Many time end-users have concerns about real energy benefits, long term behaviour, durability and safety issue of new material/components. If the product is also more expensive than other widely established products despite its improved properties, it is very difficult or almost impossible to convince the client. Frequently material/component producers need to carry campaigns promoting the use of these "new" materials with improved properties. The fragmentation of the construction industry and subsequently slow pace of the information flow continue to be a big barrier for market entry of all new products and technologies.

In this context, it is should also be noted that there are several functional and economic requirements for producers of new prefabricated insulation panels. The main ones are:

- Cost-efficiency: The solution should be affordable and competitive with available insulation products.
- Performance: Insulating materials/ panels need to have very low thermal performance coefficient λ to act as good insulators.
- Hydrophobicity: Water vapour or water degrades the insulation performance. For this reason, insulating materials should be hydrophobic and vacuum insulation panels and should not retain water in the structure so that it does not retain moisture. The latter may have a negative impact on its insulating performance.
- Long service life: Insulating panels should retain their properties as long as possible.

- Easy and economically feasible installation; this is an important requirement for insulation materials' and systems' use in buildings.
- Impact resistance: Panels should be resistant to mechanical impacts so they are not damaged during installation and use.

5.4 Legislative barriers

Insulation needs are shaped by a number of factors including climate, building design, location, orientation as well as budget and personal preferences. Regulations can play a critical role for implementing insulation systems and triggering widespread use of insulating materials in buildings. Although sanctions could be imposed through regulations, the implementation speed of these regulations could be very slow in some countries. This would hinder the utilization of insulating materials. For example, the degree and speed at which EU Directives, such as the EPBD, has been implemented by autonomous regions within a Member State had a significant effect. In addition, despite the vast improvements in recent years as a result of the current EU legislation, the field of buildings renovation is not covered to a satisfactory extent. Regulation requirements for insulation measures in renovation projects can be a significant driver.

Building control procedures prior to, during and upon completion of the construction phase typically involve announcement to authority, application for permits, approval of plans, inspections by authority and completion of certificates. The long processes associated with obtaining a building permit can also be a barrier. The enforcement of the relevant regulations can be an issue, as often no strict enforcement procedures are followed. In a question asked regarding the compliance levels of the works undertaken, most of our respondents claimed that it was average or above average. Moreover, the multi-ownership problems are not currently addressed by the legislation. In this respect, it would be important that these legislations are revisited and any legislative barriers imposed by the existing acts are removed in order to simplify the process of commissioning retrofitting works in multi-family buildings.

6 Key success factors for new retrofitting solutions and recommendations for research activities

The report thus far has identified all main obstacles to the large-scale implementation of energy efficient solutions in the market, with a particular focus on the entry of innovative solutions. There are many barriers why energy saving measures are not in practice applied. Financial and behavior issues are only part of the equation, while barriers such as multi-stakeholder issues, split incentives, industry fragmentation and conservatism hinder the uptake of energy efficiency in the market.

Below, we propose a list of recommendations, which should ensure the elimination of the most critical barriers.

- **Confidence:** Boosting confidence in energy efficiency among all different stakeholders in the construction value chain is a pre-requisite for uptake of energy efficiency measures in the market.

- **Independent advice:** Greater access to independent advice on the different solutions on the market and their implementation, in particular information channels for innovative solutions should be made publicly available.

- **Attractiveness:** Solutions should be marketed in a way that the co-benefits of thermal comfort, better indoor environment and lower fuel bills are highlighted. Energy efficiency is not always the primary driver but should have an integral role.

- **Education & training:** As shown, the knowledge barrier emerges in many of the steps of the decision making process of the building owner. From policymakers to financiers, from architects to contractors and householders, education and training of all actors in the building value chain is necessary. Workforce skills need to be enhanced in order to meet the increasing construction demands with regards to energy performance.

- **Public support schemes:** Availability of different kinds of subsidies, loans, grants and innovative measures can boost their willingness of private investors and can act as a driver for innovative solutions to enter the market.

- **Regulations:** The multi-ownership issue can be a detrimental barrier in multi-family buildings. This could be effectively addressed by appropriate regulations, facilitating the decision making process between the different actors. Strict regulations can also promote innovative technologies by ending the conservative approaches adopted by both construction companies and clients.

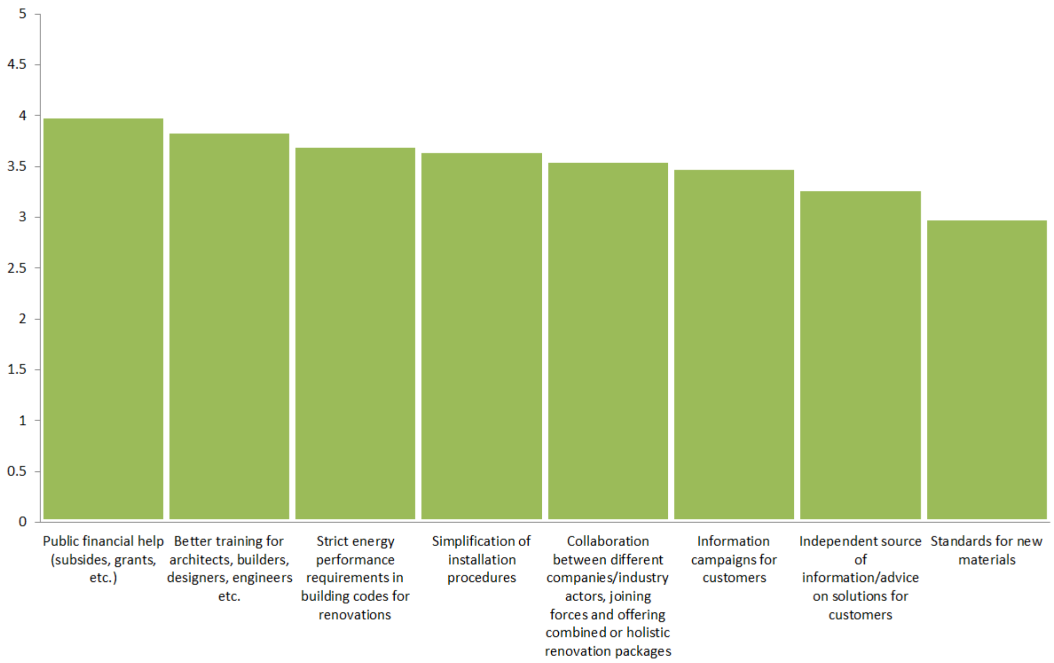

Figure 32 - Factors for a better functioning-market as identified by the EASEE partners

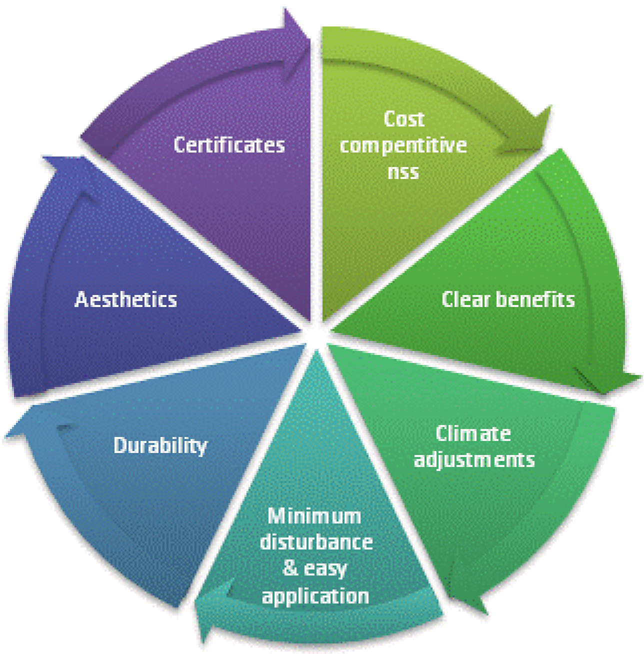

Figure 33 - Features of a successful product

Considering the challenges and limitations of existing solutions widely available on the market (as described in chapters 4 and 5 of this report), we have identified 7 pillars upon which any new solutions should be successfully designed. These are depicted in Figure 33 and described below.

- **Cost competitiveness**: For the proposed solution, it is critical that it is placed strategically among the current available solutions while it remains competitive compared to current measures. The cost structure would be a key factor. The challenge is to maintain the new solution's cost competitiveness at the same level with the most common solutions, such as XPS.

- **Clearly stated benefits:** The energy benefits and properties/features of the new solutions need to be clarified clearly. The new solutions should be characterised in terms of: λ coefficient, energy behaviour, safety and system/material warranty time. In case of internal insulation, additional features should be on the condensation of water vapour, low thickness of the internal insulation and safety of occupants.

- **Climate-adjustments:** Two climatic-related features should be considered here. The **first** is related to variable thickness. In order to ensure widespread application of the new solution geographically, different thicknesses for the external insulation should be designed in order to respond to the different needs of different climates. **Secondly,** the solutions should be designed in view of the weather conditions in which the instalment process takes place. Considerations should be taken so that it is possible for installers to apply this in several conditions (e.g. warm/cold temperatures, wind, high sun exposure, rain and snow).

- **Minimum disturbance & easy installation**: Relatively short installation time (key issue for internal insulation) and low disruption for the occupants are a significant bonus, which will over the time become a necessity if it is to keep a premium position in the market. The installation process (including anchorage system) should be simple with concrete and precise guidelines for installers.

- **Durability:** The new solutions should be designed in such a way that high durability levels should be achieved. The designed approach should enable the possibility of small repairs (e.g. exchange of one or two damaged panel) with minimal additional disturbance works.

- **Aesthetics:** The aesthetic look is important and the possibility to adapt to different colours/material requirements (such as brick) is welcome.

- **Certificates, EU marking**

7 Conclusions

The large untapped energy saving potential is evidence of the various bottlenecks impending consumers, investors, and society in general, from investing in energy saving measures. This report has analysed the technical and non-technical barriers related to the deployment of insulation measures in multi-residential buildings and developed a set of proposals for the future EASEE activities.

In terms of technical issues, high costs and climatic limitations are usually the main barriers. Long winters often hinder the smooth execution of retrofitting works and in many cases installations simply cannot be technically conducted in adverse conditions. Buildings under heritage protection can only be insulated internally causing space issues or in certain cases indoor air quality problems. Non-technical barriers were investigated in terms of different players of the construction value chain. For the building owner, typical hindrances are related to awareness issues, misalignment of desired benefits, competitive purchasing decisions, knowledge obstacles, lack of funds and multi-ownership problems. In terms of the project management, disruption, long procedures, planning issues and administrative burden are usually the main complications. For construction companies, the barriers were organised in 4 categories: financial issues, market obstacles, capacity building and industry structure. Finally, the widespread adoption of innovative materials is the main challenge for material and component manufacturers.

In view of these challenges and barriers, we have identified the key areas upon which any new successful solutions should be based in the context of the EASEE research activities. These are related to cost competitiveness, clearly stated benefits, climate adjustments, minimum disturbance & easy installation, durability, aesthetics and certificates/EU marking. With these factors in mind, it will be possible to develop an all-rounded set of solutions which can indeed offer a pragmatic approach for retrofitting these buildings as well as a real possibility of large scale deployment. Moreover actions should be taken in general to ensure that confidence regarding energy efficiency among different stakeholders is enhanced, independent advice is available and education & training among all construction value chain players is improved. Regulations and public support schemes should also be strengthened.

ANNEX I: Questionnaire

1 EE MEASURES APPLIED IN RESIDENTIAL BUILDINGS

a **How frequently are the measures listed below applied in energy renovations for residential buildings in your country/region?**

	1 - not applied	2 - rarely applied	3 - sometimes	4- quite common	5 - most common
Roof insulation					
Facade insulation					
Cavity wall insulation					
Other external wall insulation					
Internal insulation					
Window replacement (double glazing)					
Window replacement (triple glazing)					
Heating system replacement/upgrade					

Other measures, please describe below and include frequency score

b **Is it common practice to implement more than one of the above measures at once?** (yes/no)

c **If so, what are the most common combined energy efficiency measures applied in a residential building on average?**

d **Is it a common practice to apply all building renovation based on a holistic approach?** (yes/no)

2 FACADE RETROFITTING MEASURES APPLIED IN RESIDENTIAL BUILDINGS

a **What are the most common retrofitting materials applied in facades of multi-storey residential buildings in your country/region?**

In each cell provide a ranking number 1-5 , where: 5= most common, 4= quite common, 3=sometimes, 2= rarely applied, 1= not applied

	External insulation	Internal insulation	Cavity walls
Expanded polystyrene foam (EPS)			
Extruded polystyrene foam (XPS)			
Glass wool			
Stone wool			
Polyurethane (PUR)			
Polyisocyanurate (PIR)			
Insulation brick cladding systems (prefabricated panels with bonded PUR insulation)			
Vacuum insulation			

b **What are the total costs and average installation time of the most common insulation retrofitting techniques based on the**

material mentioned in a)

	Cost EUR/m 2	Average installation HOURS	Details on technique including typical thickness
Expanded polystyrene foam (EPS)			
Extruded polystyrene foam (XPS)			
Mineral wool			
Polyurethane (PUR)			
Polyisocyanurate (PIR)			
Insulation brick cladding systems (prefabricated panels with bonded PUR insulation)			
Vacuum insulation			

c **Please indicate the share in which the main insulation types listed below are applied in your country as a percentage (%) of all insulation measures**

External insulation	
Cavity walls	
Internal insulation	
	100%

d **Please indicate the share (as a %) in which the techniques below are applied in facades of multi-storey residential buildings in your country/region**

Wet processes	
Prefabricated panels	
	100%

e **What are the hourly average labour costs (EUR/hour) for facade retrofitting measures in your country?** (tick correct answer)

less than 5	
5--8	
8--10	
10--15	
15--20	
20--30	
30--40	
above 40	

f **What is the percentage of the cases where insulation measures are applied as part of the processes indicated below?**

	% of cases	Law Obligation? Yes	Law Obligation? No, own incentive
Maintenance/replacement procedure of one or more elements (e.g. facade, roof, external walls etc.)			
Whole house renovation/improvement			

Stand-alone measure			
	100%		

3 CLIENT PROFILE

a Which types of owners usually undertake retrofits in their homes in your country?

	1 - never	2 - rarely	3 - sometimes	4- frequently	5 - very frequently
Low income single family house private owners					
Medium/high income single family house private owners					
Low income multi-family house private owners (renovating their individual apartment only)					
Medium/high income multi-family house private owners (renovating their individual apartment only)					
Single owner of multi-family house					
Association of private owners of a multi-family building					
National/local government as owner of social housing					
Non-profit housing associations for low income/social housing					

b Which of the above profiles is your most common client profile for home retrofits?

c What is the percentage of your *private* customers (0-100%) who live in the properties which they renovate?

d What is the average monthly income range per household in your country

	Min	Max
Low income		
Medium income		
High income		

e From your experience, what are the most prominent reasons why your customers do not invest in improving the insulation of their buildings?

	1 - No relevance	2 - Low importance	3 - Medium importance	4 - High importance	5 - Crucial importance
High investment costs					
Long payback time					
No motivation in reducing energy bills for heating (for owners)					
Difficulty in quantifying savings in energy bills					
High disturbance factor of the installation procedure (dust, noise, scaffolding, discomfort)					
Perception of low effectiveness of the proposed solutions					
Lack of awareness of benefits					
Lack of independent source of information of available solutions					
Reluctance/restrictions in changing look of facade					
Hesitation due to future technical failures					
Perception of low quality work force					
Complexity in applying the most appropriate solution					

Investor is not the user of the building					

Other, please describe below

f **Which of the above factors in your opinion are the three most important ones?**

g **Which is the most important/main driver of your customer for improving the facade of their building?**

	1 - No relevance	2 - Low importance	3 - Medium importance	4 - High importance	5 - Crucial importance
Obligation by law (regulations/building codes)					
Existence of a public support scheme (Subsidy, grant etc)					
Interest in improving thermal comfort of their home					
Interest in reducing fuel bills					
Interest in improving the appearance of the facade					
Environmental awareness					

Describe regulation/building code

Describe support scheme

Are there any schemes specific for social housing (please describe)

4 CLIENT INTEREST AND AWARENESS

a **How would you describe the knowledge levels on existing energy efficiency/retrofitting solutions of your costumers on average?** (tick correct answer)

None - The customer relies completely on our advice	
Low - The customer has limited understanding and requires further information	

Medium - The customer has a good understanding on the most popular solutions	
High - The customer is aware of the different types of solutions including the benefits and drawbacks of each one	

b **What is generally the perceived interest of your customers in improving the energy performance of their homes?** (tick correct answer)

None - Our customers are not motivated/interested by energy performance	
Low - There is some interest, but it is very limited	
Medium - Customers show interest and are willing/open to learn more	
High - Many customers approach us to ask how they can improve their building's energy efficiency	

5 REGULATION FRAMEWORK

a **What are the regulation requirements for insulation measures in renovation projects in your country?**

b **In relation to the regulation requirements stated above, what is generally the compliance level of the works undertaken in your country?** (tick correct answer)

Very low 0-20%	
Low 20-40%	
Average 40-60%	
Above average 60-80%	
Very high 80-100%	

c **Is there a definition of a major renovation in your country? (e.g. cost higher than 25 % of the value of the building etc.)**

d **If yes, is there an obligation to apply EE measure for major renovation projects?**

6 BARRIERS TO APPLICATION OF RETROFITTING MEASURES

a **Please describe the main challenges currently faced by your sector (e.g. low demand, insufficient awareness, low skill levels, etc.)**

b **Please rank the main factors prohibiting market uptake of EE solutions in your country?** (ranking: 1 = most relevant)

	1 - No relevance	2- Low importance	3- Medium importance	4 - High importance	5 - Crucial importance
Lack of trained workforce					

Material/component shortage					
Lack of quick, easy-to-apply installations					
Low quality of work					
Problems with distribution channels for materials and components					
High costs of innovative solutions (e.g. based on PCMs or aerogel materials) compared with traditional ones (e.g. EPD)					
Lack of interest/knowledge					
Lack of public support measures					
Lack of strict regulations					

Other factors

c Which three of the above factors are of the highest priority?

d Are there any specific legislative barriers (e.g. Restriction to operate on building facades, listed building restrictions, complex administrative procedures)?

e Explain the main reasons why the workforce skills are currently low in your country

f What are the main challenges of producing/applying prefabricated facade panels in your country?

7 FACTORS FOR A WELL FUNCTIONING MARKET

a In practice, what are the main reasons why prefabricated solutions are preferred to traditional solutions in your country (even if they are currently applied rarely)?

b In your opinion, how important are the below factors in contributing to a better functioning market in terms of implementation of EE solutions?

	1 - No relevance	2- Low importance	3- Medium importance	4 - High importance	5 - Crucial importance
Simplification of installation procedures					
Independent source of information/advice on solutions for customers					
Public financial help (subsides, grants, etc.)					
Standards for new materials					
Strict energy performance requirements in building codes for renovations					
Better training for architects, builders, designers, engineers etc					
Collaboration between different companies/industry actors, joining forces and offering combined or holistic renovation packages					
Information campaigns for customers					

Other important factors (please describe below)

c **Any success stories in relation to the above factors?**

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