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D4.1 EE renovation market mechanisms, trends and barriers

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Glossary

Acronym	Full name
AEC	Architects engineers and construction
EC	European Commission
EE	Energy efficiency
EED	Energy efficiency directive
EnPCs	Energy Performance Certificates
EPBD	Directive on Energy Performance in Buildings
EPC	Energy Performance Contracts
ESCO	Energy Service Company
EU	European Union
Iot	Internet of Things
MS	Member States
NEEAP	Second National Energy Efficiency Action Plan
nZEB	Nearly Zero-Energy Buildings
ROI	Return on Investment
SME	Small Medium Enterprise
TPF	Third party financing

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1. Executive summary

This report articulates itself within a more general three phase analytical process directed towards the alleviation of market barriers and failures within the EE renovation market. The global structure is composed of an analysis of general market trends and mechanisms in the preliminary phase, then a more contextualized set of more specific barriers that may be overshadowed by the more generalist variables will be compiled and analysed, finally the latter barriers will be mapped out in the EE renovation value chain in order to gain more understanding on the stakeholders most affected and solutions will be offered in order to minimize these negative effects and develop strategies for achieving the EU´s targeted yearly renovation rates.

This specific deliverable delves into the two previously described initial steps in the analytical process, namely market mechanisms and trends and contextualization of identified barriers.

1.1. Market mechanisms and trends of the EE renovation market

The first section will provide an analysis on:

- The macroeconomic environment of the EU countries
- Their climate and social specificities
- The energy policies adopted by Central Governments to incentivize the renovation process of real estate assets, in line with the target set out by the European Commission.

Moreover, the data which has been gathered in this deliverable is regrouped by country and critically analysed in order to:

- Understand more in depth market mechanisms and dynamics of each country (Section 7.1)
- Provide a preliminary general framework of the barriers that hamper the market of energy renovations (Section 5.2)

The report comes to the conclusion that after a long period of economic stagnation, conditions for the construction and renovation industry are currently favourable throughout Europe. Despite rather low energy prices all around, partly as a result of fiscal incentives of many EU countries with reduced VAT rates for energy products making energy efficiency investments less cost-effective, the general economic framework is currently characterized by favourable drivers such as:

- Diffused economic expansion
- Growth of the housing market
- Low interest rates, which imply low yield of free and low-risk investments, such as government securities and, therefore, absence of attractive alternative forms of investment with the same risk profile.

Under the light of these rather positive macroeconomic conditions, it would be reasonable to expect increasing investments devoted to energy-efficient building renovations, at least in those countries showing a better health of the housing sector and characterized by energy polices more oriented towards the greenhouse gas emission reduction, in line with the target set by the European Commission. Instead, growth of the investments in this area until at least 2015 have remained rather week. This situation is most observed in those countries characterized by lesser growth in the Real Estate field, and by a fragile and fiscally constrained economic environment.

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In light of these observations, it seems that evolutions in renovation rates are not attributable to a limited set of macroeconomic drivers or variables but rather a complex combination of factors pertaining to specific factors which could pertain to the inner structure of the EE renovation market in general, regional and country level features, different political and economic realities and building typologies amongst others.

The first section of this general analysis logically drives into the next which attempts to acquire a deeper understanding of what drives and inhibits the growth of EE renovations around the EU through a contextualization of a set of more specific barriers and market phenomena that may be overshadowed by the more generalist variables and indicators that have been compiled and analysed in the early sections.

1.2. Contextualization of market barriers

The next section of the report focuses on the identification of a more precise set of market barriers that are initially identified through existing literature, partner experiences, market knowledge and external consultation and then goes fourth with a definition of the dynamics behind each of these barriers through interview processes, case studies and empirical work which has been performed during the course of this project.

Barriers are ranked by macro-category>typology>barrier as indicated in the following figure.

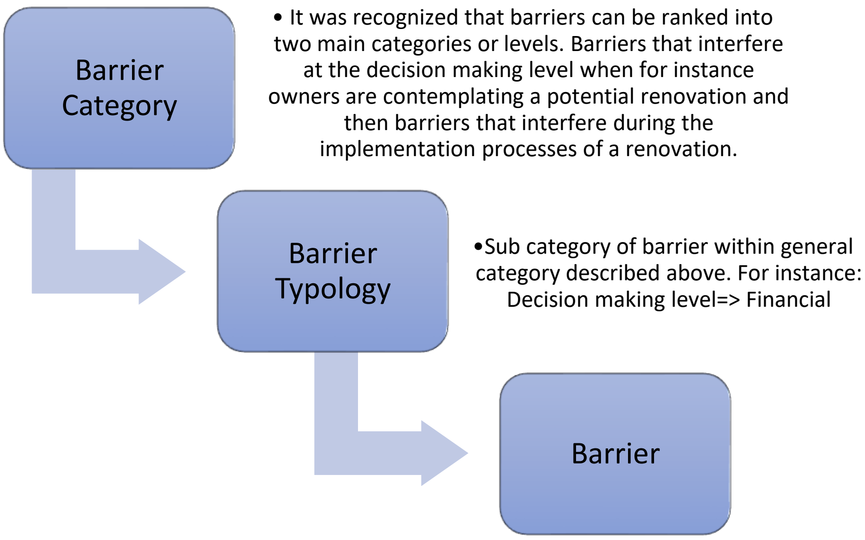

Figure 1 Barrier ranking system

A full ranking of the barriers will be available in the corresponding section on the preliminary identification of barriers. Nevertheless, the following table provides a thinned out version of this classification, showing only the barriers that were contextualized in more depth due to their high significance scores obtained through the STUNNING questionnaire which will be introduced in this report as well as barriers presenting specific interest in relation to the nature of the project call relative to public procurement and PPPs.

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Barrier Category	Barrier typology	Barrier
Barriers that limit uptake of refurbishment solutions at the decision making level for homeowners, buyers or end-users. (likely to be found in most regions in some form or another)	Technical	Performance Gap and uncertainty
		Lack of technological and product developments
	Embedded market inefficiencies	Split Incentives and conflicts of interest
	Informative	Lack of knowledge dissemination and convincing end users of the benefits of deep renovations
		Difficulties in conveying non-energy benefits of retrofits
	Financial	Limited financing options offered by ESCOS and limited TPF involvement
		Limited impact of Energy Performance Certificate improvements on property value
		Limited financing/ insufficient budgets
Barriers that prevent stakeholders taking part in the renovation process (architects, ESCOS, construction companies...) to implement with ease successful business models.	Organization and structure of the EE renovation market	Difficulties in coordinating communication with other involved stakeholders
		Insufficient resources on part of SMEs to tender for public procurement schemes
	Regulatory	Lack of continuity in regulations
		Limited government subsidies and programs
	Knowledge-informative based	Lack of skills/ Lack of training

Table 1 Identified barriers subject to more detailed contextualization during the course of the project

A general overview of survey scores and case studies for each of these barriers will be analyzed along with the inclusion of external data which may be relevant in order to draw conclusions on the importance of these barriers, their workings and who they affect as well as the societal variables that they are mostly affected by.

Two of the most notable effects we have observed is the limited capacities for ESCOs to come up with financing options for potential energy performance contracts as well as the limited participation of third party financing entities in the latter process as well. In terms of direct financing by the ESCO through in-house funds, this is an extremely rare occurrence as the ESCO would be depriving itself from implementing more projects by leveraging through third party financing (TPF).

Furthermore, for TPF, borrowing for ESCOs requires more than just savings requirements but also collateral and credit history presenting disadvantages for SMEs and small structures with scarce resources

These barriers are especially pertinent for smaller or new ESCOs with SME profiles with no previous experience in borrowing, poorly documented credit history and little resources for collateral.

Moreover, another point of interest is that regulatory barriers are still perceived by many industrials as some of the most important obstacles. What was interesting throughout the STUNNNG project is that

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many players complained about regulatory barriers more in terms of the lack of continuity in regulatory measures rather than the actual substance of the regulations. Indeed, industry stakeholders and mainly the ones with limited resources such as SMEs are having trouble constantly adapting their business models and market approaches in an evolving regulatory environment with changing fiscal measures in terms of energy efficiency.

This report will be followed by D4.2 which will cover the third part of the initially described analytical process at the beginning of this section, dedicated towards the identification of solutions for alleviating the contextualized barriers. Naturally, the observations made here in D4.1 will be carried over, namely in terms of the sensitivity of certain barriers towards different societal configurations.

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2. Introduction

This document will provide a review of some of the most significant barriers in the EE-renovation business ecosystem. The objective is to provide a deep understanding of the dynamics driving barriers and the societal variables that affect them in order to then propose efficient solutions to the alleviation of these market failures and obstacles whilst focusing on the integration of SMEs within the EE renovation value chain.

During this investigative process, specific attention will be given to the role of SMEs when possible or relevant and will analyse the relationship that exists between the SMEs stalling within the EE renovation market and the difficulties in replicating certain successful business models.

This document is split into two main sections:

The first one is dedicated to the identification of the main market mechanisms, trends and barriers of the EE renovation market. The second phase is dedicated to a more specific identification and characterization of market barriers according to set criteria such as geography/country, particular refurbishment cases, stakeholders involved and building typology.

The main objective is to bring more insights into the field and acquire a deeper comprehension of the trends, market barriers as well as eventual facilitations and gaps to be filled so as to make adequate propositions for future improvements which will be compiled in D4.2.

Section 1

The first part of this report focuses on a birds-eye view of the EE renovation market and sector as a whole in order to obtain a preliminary understanding of the trends and barriers that characterize the market. This section will base itself off of current literature and reports as well as databases of building materials, construction projects, and the main contracts of refurbishment as well as the GIS based tools in order to bring more insights into the field and to understand the regional dynamics currently taking place in Europe with regard to EE renovations.

The indicators to analyze will be divided by type, into three macro-categories:

- Market trends;
- Awareness and Energy-related actions;
- External factors, peculiarities and constraints.

The data gathered for each category, belonging to the above mentioned macro-categories will be grouped by country and critically analyzed in the light of those gathered for all the other classes and categories, in order to:

- Understand more in depth market mechanisms and dynamics of each country

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- Allow comparisons between different realities and identify the most effective mechanisms for boosting energy renovations
- Provide a preliminary general framework of the barriers that hamper the market of energy renovations

Section 2

The second section of this deliverable consists in a clear contextualization of market barriers in the EE renovation market which lead to market failures. Using the building blocks of this first section and certain macro indicators and KPIs listed, the initially identified barriers will be characterized according to their relevance in terms of certain criteria such as geographic regions presenting specificities to which certain barriers are sensitive, building typologies, stakeholders and more when pertinent. This exercise will be performed on the barriers that are identified as being the most significant within the market or presenting certain peculiarities. Moreover, at the end of each barrier analysis, the sensitivity of identified barriers in terms of certain societal factors and configurations will be evaluated in order to obtain insight on potential solutions and amendments to be performed in order to minimize the latter.

This section is based mainly on the analysis of interviews and surveys (involving – but not limited to – the members of the Advisory Board), real renovation case studies, syndicated data and reports, and empirical findings including inputs from the first section of this report.

This deliverable will contribute directly to D4.2 of the STUNNING project. Through the consolidation of the gathered information, D4.2 will aim at providing new directions and recommendations for alleviating the identified market failures and fostering active SME participation for EE renovation market development. In doing so, the study will do a segmentation and mapping of SMEs by location in the EE renovation value chain to provide a deeper and useful analysis considering strategies and SME categories.

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3. Methodology for the analysis of renovation market mechanisms and trends

This section aims to analyse the renovation market trends, in the light of:

- The macroeconomic environment of the EU countries
- Their climate and social specificities
- The energy policies adopted by Central Governments to incentivize the renovation process of real estate assets, in line with the target set out by the European Commission.

The goal is to provide the foundational data in order to provide a detailed description of trends and mechanisms useful to identify any possible barriers which hamper the growth of energy refurbishment investments in the residential sector.

The following figure (Figure 2) summarizes the strategic approach adopted in the context of task 4.1. The indicators to analyse have been firstly divided by type, into three macro-categories. Namely: Climatic factors and macro-economic trends (Chapter 2), Market trends (Chapter 3) and Awareness and Energy-related actions (Chapter 4)

The data which has been gathered in this deliverable is regrouped by country and critically analyzed in order to:

- Understand more in depth market mechanisms and dynamics of each country (Section 7.1)
- Provide a preliminary general framework of the barriers that hamper the market of energy renovations (Section 5.2)

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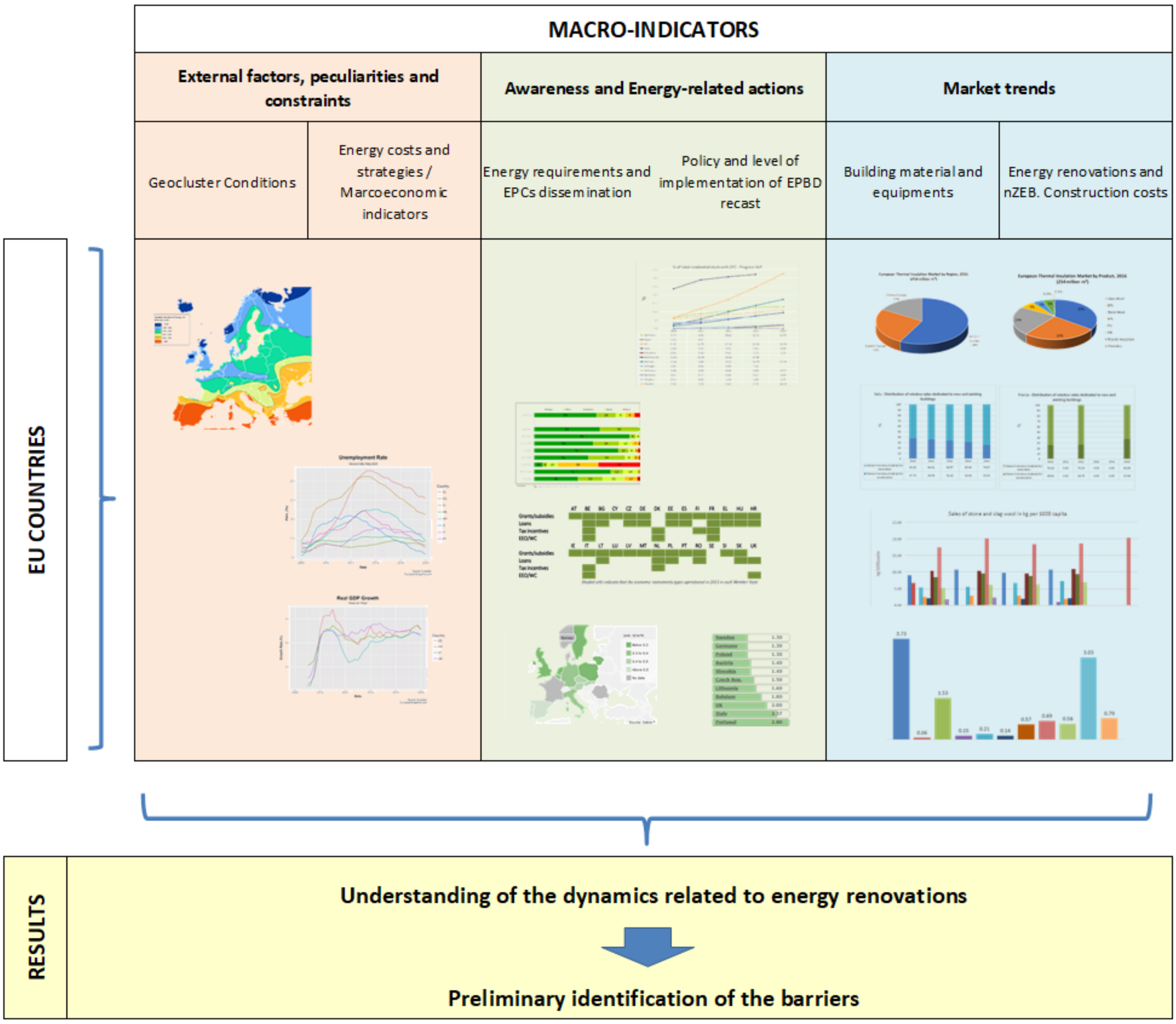

Figure 2: Strategic approach

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4. Economic trends and climatic factors

In order to correctly analyse the market trends related to energy efficient renovations so as to identify possible correlations with the energy policies implemented by the countries of the European Union, it is first necessary to represent the economic and climate context of the individual countries analysed.

It is obvious to expect that climate context, as well as social and macroeconomic dynamics of each countries can have a high impact on specific market trends in the field of energy redevelopment. In particular those dynamics that are related to the real estate sector, which have important macroeconomic and macro-prudential implications for the economy of the EURO Area.

This said, this section aims to represent an overall picture of such context, emphasizing both the climatic aspects and the economic dynamics of the real estate sector, in order to make it possible to attribute the right weight to the fiscal and economic policies implemented by individual countries, in the process of retrofitting the existing building stock, taking into account the particular specificities of each countries.

This section firstly provides a brief overview of the economic framework of the Euro zone, focusing on few meaningful macro-indicators, such as GDP, unemployment rate and energy prices. Then, it will be followed by an analysis of the state of the European real estate market, highlighting similarities and differences between the countries of the EURO area, so as to get more insight on the specifities of the individual national economies. The last paragraph of the section is instead devoted to the European climate framework, which can also be meaningful, together with the description of economic context, to interpret the market trends of materials, equipment and renovation rates linked to energy retrofits.

4.1. Economic context

As anticipated above, this paragraph is devoted to a concise description of the economic context of the EURO Zone. For the sake of brevity, it has been decided to focus on few meaningful macro-economic indicators. Paragraph 4.1.1 presents statistics related to Gross Domestic Product (GPD) and unemployment rate, observed in conjunction with other indicators such as the Economic sentiment indicator (ESI) and the Purchasing Managers' Index (PMI), while paragraph 4.1.24.1.1 addresses the analysis of energy prices which are relevant to households.

4.1.1. Macroeconomic indicators

Market trends and results of the energy saving and efficiency policies implemented by EU countries, following the adoption of the Directive 2010/31/EU, cannot be understood without prior analysis of the macroeconomic context. This section is therefore devoted to briefly providing a picture of the economic activity of the Euro Zone, focusing mainly on real GDP and occupancy rates.

Incoming data confirms that, in 2018, economic growth trend remains overall consistent with ongoing broad-based economic expansion. Real GDP increased by 0.4%, quarter on quarter, in both the first and second quarters of the year, losing momentum after the strong growth observed in 2017 and revising downwards the growth forecast for 2018. Figure 3 (left-hand panel) shows the quarter on quarter Real GDP growth, along with the Economic sentiment indicator (ESI) and the Purchasing Managers'

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Index (PMI), which seems to anticipate further decrease of the expected growth also for the third quarter of 2018.

The improvement of the EURO area started in 2014 and was driven by a decrease in the uncertainties associated with financial tensions, as well as by less restrictive fiscal policies and a favourable monetary policy. Looking at the single economies, the right-hand panel of Figure 3 shows the Year over Year GDP growth, this time broken down by country. Spain´s performance stands out in the period 2015-2017, after five years of recession over the period 2010-2014, during which the economies of the EU countries displayed substantial discrepancies from country to country. For instance, while Germany and the United Kingdom weren’t as significantly affected by the crisis with a year on year growth that remained positive, Italy and Spain were characterized by long recessions. Since 2015 the largest economies appear to be more in tune with each other, all of them showing positive growth rates.

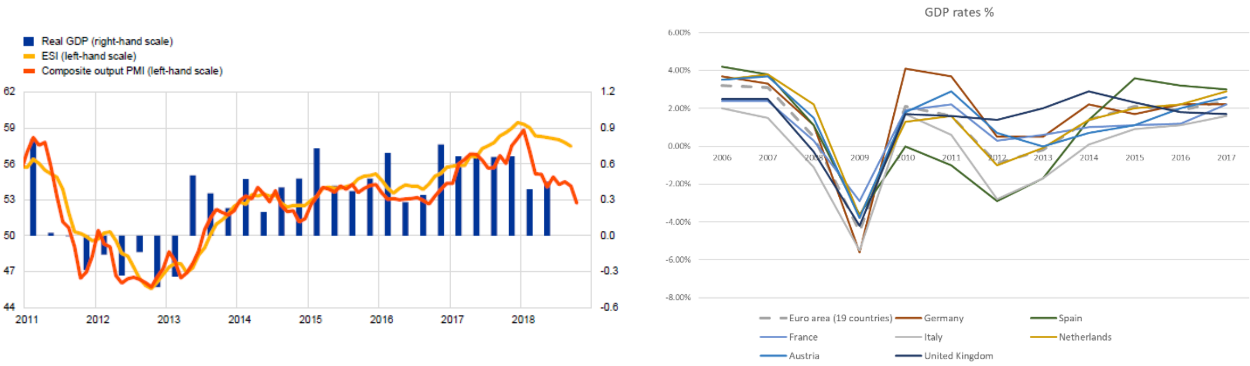

Figure 3: Real GDP of the Euro Zone and broken down by country (Eurostat data source)

During the second quarter of 2018, employment rose further across EURO area countries and sectors, increasing by 0.4% quarter on quarter. Despite the latest increase, unemployment stands some base points above the pre-crisis peak recorded in the first quarter of 2008. The strong growth in employment seen after 2014 wasn’t accompanied by an increase of average hours worked, which primarily reflects the impact of several structural factors (e.g. the large share of part-time workers in total employment).

Figure 23 (left-hand panel) shows the unemployment and employment rates (depicted on quarter-on-quarter basis), along with the Purchasing Managers' Index (PMI) while on the right-side data on unemployment rates are shown broken down by country

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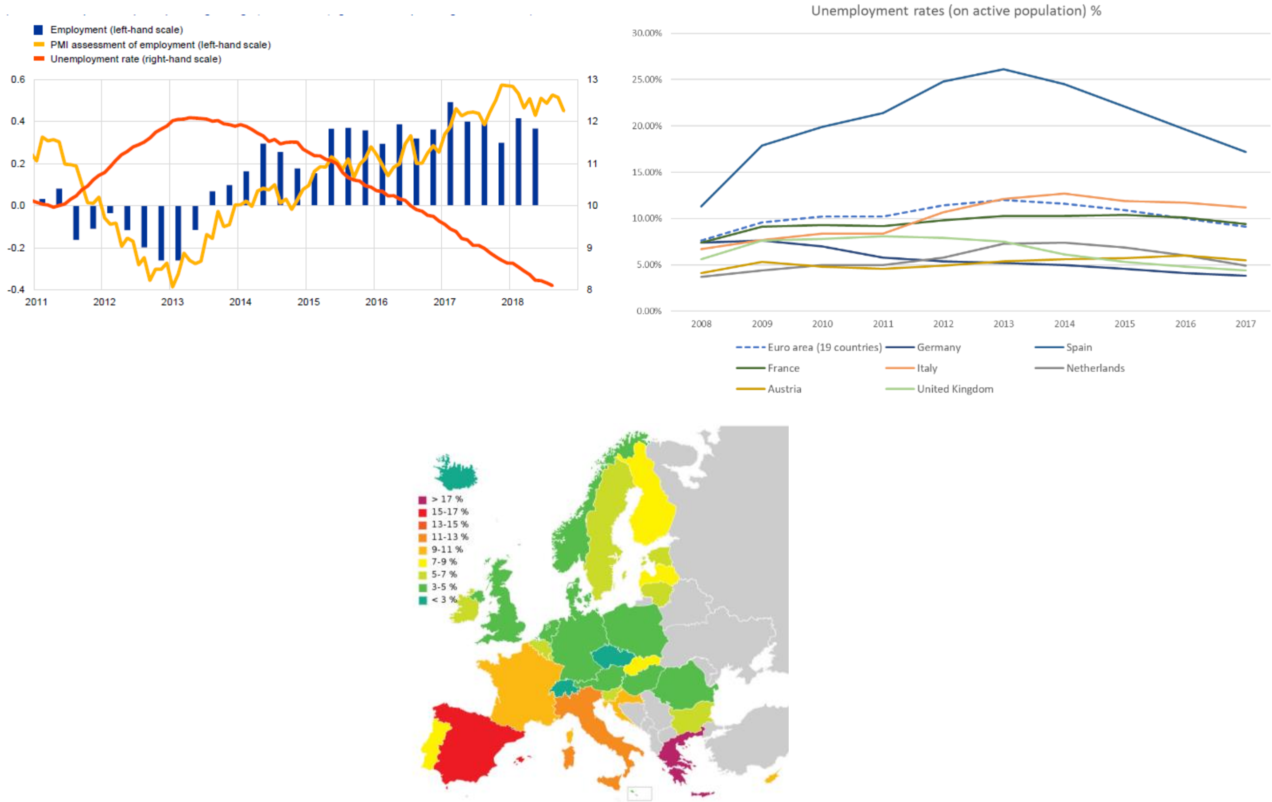

Figure 4: Unemployment Rate of EURO area and broken down by country (Eurostat data source)

As our analysis progresses throughout this report, it will be interesting to assess how significant the relationships between GDP growth rates, economic sentiment, unemployment and energy efficient renovation rates are. It is to be expected that positive economic indicators will be correlated with EE renovations. Nevertheless, it will be interesting to observe whether or not these effects have been mitigated by some of the policies and regulations put in place by respective member states under the Energy Performance of Buildings Directive (EPBD) and the like.

4.1.2. Energy prices

Hereafter, a general view on energy prices with a focus on electricity and natural gas across the EURO Zone is provided. For sake of simplicity, data referring just to medium size household consumers will be reported.

1. Electricity prices

The price of energy in the EU depends on a range of different supply and demand conditions, including the geopolitical situation, the national energy mix, import diversification, network costs, environmental protection costs, severe weather conditions, or levels of excise and taxation. An overview of average electricity prices in euro per kilowatt-hour (EUR per kWh) since 2008 onward (quarter on quarter) is presented in Figure 5**Erreur ! Source du renvoi introuvable.** right-hand panel. On the left side the electricity price registered in third quarter of 2017 are shown, highlighting the shares of taxes, levies and VAT.

For household medium-size consumers (annual consumptions between 2500 kWh and 5000 kWh) electricity prices during the second half of 2017 were highest among the EU Member States in Germany (EUR 0.305 per kWh), Denmark (EUR 0.301 per kWh) and Belgium (EUR 0.288 per kWh); The lowest electricity prices were in Bulgaria (EUR 0.098 per kWh), Lithuania (EUR 0.111 per kWh) and Hungary (EUR 0.113 per kWh). The EU-28 average price was EUR 0.205 per kWh

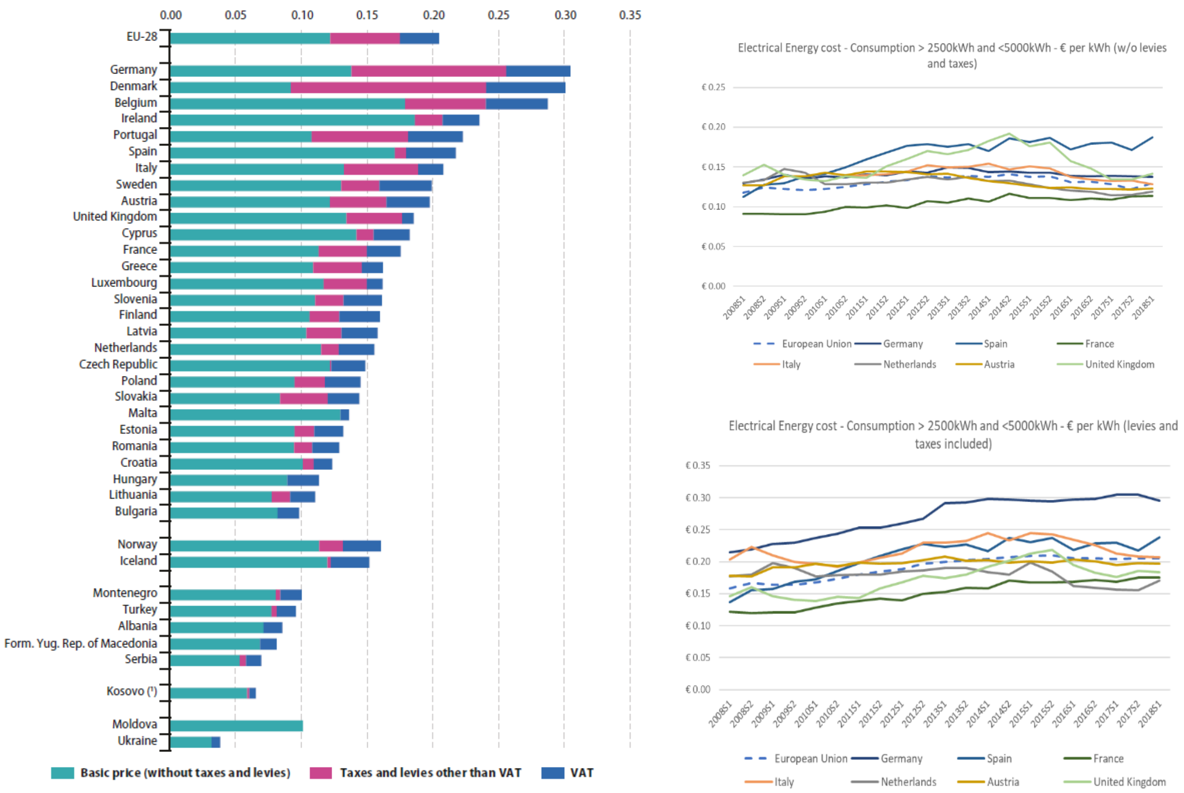

Figure 5 Electricity prices - broken down by country: Household consumption. Annual consumption comprised between 2500 kWh and 5000 kWh (Eurostat data source)

The share related to taxes and levies paid per kWh by household medium-size consumers shown in 5.

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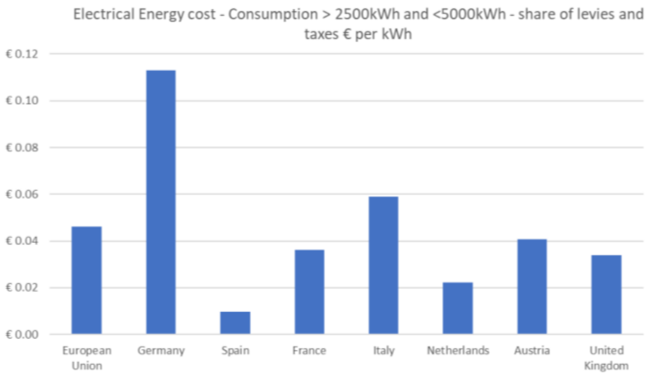

Figure 6: Electricity levies and taxes (s1 2018) - broken down by country: Annual consumption comprised between 2500 kWh and 5000 kWh. (Eurostat data source)

2. Natural Gas prices

An overview of how average prices in euro per kilowatt-hour (EUR per kWh) for natural gas have changed since 2008 onward (quarter on quarter) is presented in the right-hand panel of 6. Chart on the left side, instead, shows the prices in euro per kilowatt-hour (EUR per kWh), highlighting the composition between basic price, taxes, other levies and VAT. For household medium-sized consumers (consumptions between 20 GJ and 200 GJ) natural gas prices during the second half of 2017 were highest among the EU Member States in Sweden, Denmark and Italy. The lowest natural gas prices were in Romania, Hungary and Croatia.

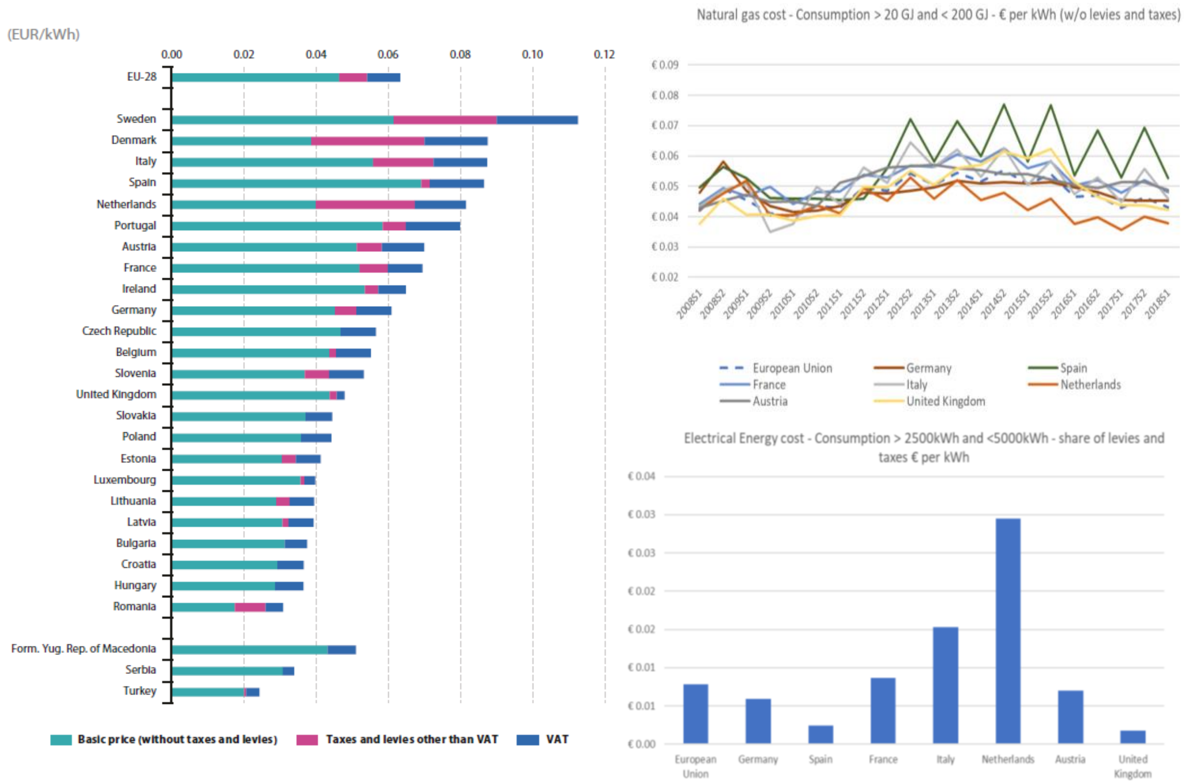

Figure 7: Natural gas prices - broken down by country: Household consumption. Annual consumption comprised between 20 GJ and 200 GJ. (Eurostat data source)

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As our analysis progresses, taking into account energy prices will enable us to observe the incentivizing effects that higher energy prices truly have on energy efficient renovation within the European Union. Theoretically, the higher energy prices should lead to higher savings and shorter ROI timeframes which should result in higher renovation rates locally. Nevertheless, these effects could be offset by climatic conditions, regulations and the like.

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4.2. Analysis of the housing market in the euro zone

The Real Estate market has been described from a dual perspective:

First, it has been represented by focusing mainly on the trends of both (1) building-related investments and (2) housing prices. This in order to understand what the expectations of growth are in the coming years, and whether, in past years, Real Estate (and retrofitting) investments may have been stimulated or depressed by the upward or downward trend in housing prices.

Secondly, the focus shifts to the analysis of housing supply and demand, analysing how it is expected to evolve in the coming years.

4.2.1. Residential investments and house prices.

The upturn of the real estate market is in its fourth year in the EURO area. In terms of annual growth, prices began to recover from 2013, while in terms of investment, they started to return at their normal level from 2014.

Figure 8 shows growth rates (left-hand chart) and levels (right-hand) for EURO area of Gross Domestic Product, house prices and residential investment. The three parameters in the right-hand chart have been indexed on the basis of their level immediately before the beginning of the crisis (1st quarter 2008), while the average values in the left-hand chart (dashed lines) have been computed since 1999.

It is apparent that in terms of annual growth, both housing prices and investments in the first quarter of 2018 have reached higher values compared to long-term averages and that the annual growth of investments now seems to have stabilized.

Looking instead at the annual amount of investments, right-hand chart shows how these have only partially recovered and, at the beginning of 2018, they were still 15% lower than their pre-crisis levels.

At the same time, nominal housing prices, that contracted by only 6% immediately after 2008, at the beginning of 2018 is already 5% higher than the maximum values recorded before 2008, although in real terms they are still 5% lower.

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Figure 8: Residential investment, house prices and real GDP in the Euro Area (Eurostat data source)

Looking at the single countries of the EURO area, basically, all of them have shown the same trend in terms of investments and house prices, albeit with substantial degrees of intensity.

Figure 9 shows for each MS:

- With reference the “X” axis: the average annual growth in house prices recorded between 2014 and 2018 (blue dots) and between 2007 and 2013 (yellow dots)
- With reference the “Y” axis: the average annual growth in investments recorded between 2014 and 2018 (blue dots) and between 2007 and 2013 (yellow dots)

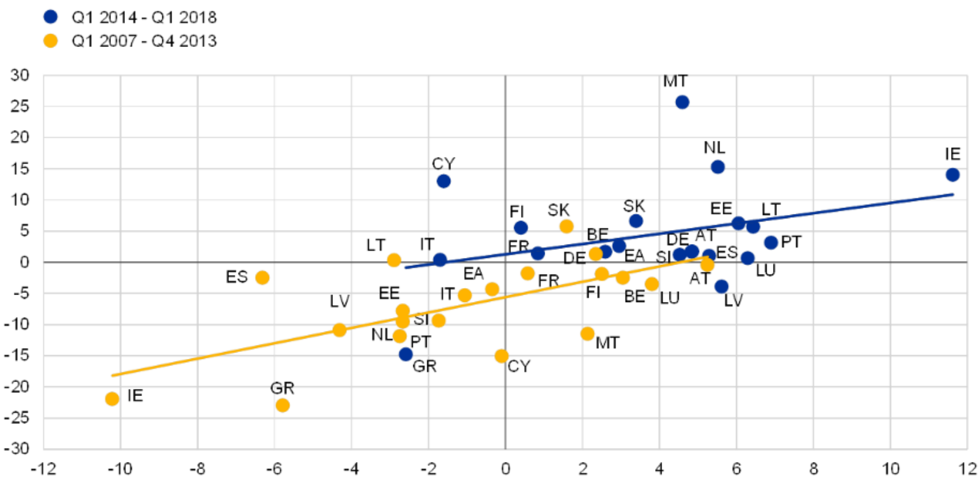

Figure 9: Residential investment and house prices during the most recent upturn and downturn

From a chronological point of view, considering the whole EURO area, the current upturn in the Real Estate sector has lasted for 4 years, therefore reaching the average duration of the upturns occurred in Europe since the post-war period onward.

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Looking more in detail at the five largest economies of the EURO area in terms of GDP, from the point of view of real estate investments, the upturn has now reached its full maturity in Netherlands and Germany, while it is still at a preliminary stage in Italy France and, to a lesser extend in Spain (Figure 10– data and calculation from ECB).

	Euro area	Germany	Spain	France	Italy	Netherlands
Residential investment						
Latest trough	Q3 2014	Q4 2009	Q1 2014	Q2 2016	Q4 2014	Q3 2013
Average duration of upturns (quarters)	15	19	38	37	22	17
Duration of recent upturn (quarters)	14	36	16	7	13	19
Average annual growth during recent upturn (%)	3.5	3.3	4.1	3.2	2.0	13.8
Average growth during upturn(s) with the same duration as the current one (%)	1.9	4.9	6.4	2.2	2.9	5.1

Figure 10: Upturns' durations in European housing markets (Source: Eurostat. Calculation: ECB)

Useful insights to evaluate the state of the Real Estate cycle can be also provided by comparing house prices and residential investments with estimates based on factors able to affect them (ancillary fundamentals).

Niccolò Battistini, Julien Le Roux, Moreno Roma and John Vourdas (ECB - Economic Bulletin, Issue 7/ 2018), for the case of residential investments, adopted a synthetic indicator constructed from different (standardised) ratios for output and employment in the construction sector. The results are shown in the right-hand chart in figure 10, where estimates for housing prices are based on indicators such as: the price-to-income, price-to-rent ratios and estimates based on a demand-driven model.

The chart shows how house prices in the Euro area appear to be slightly overestimated, especially in the cases of France and Germany while with regard to investments the cycle appears to be close to its norm, somewhat above for Germany and somewhat below in the case of Italy.

(left-hand panel: standardised index (left-hand scale); percentage points (right-hand scale); right-hand panel: x-axis: percentage points for house price valuation in Q1 2018; y-axis: standardised index for residential investment activity in Q1 2018)

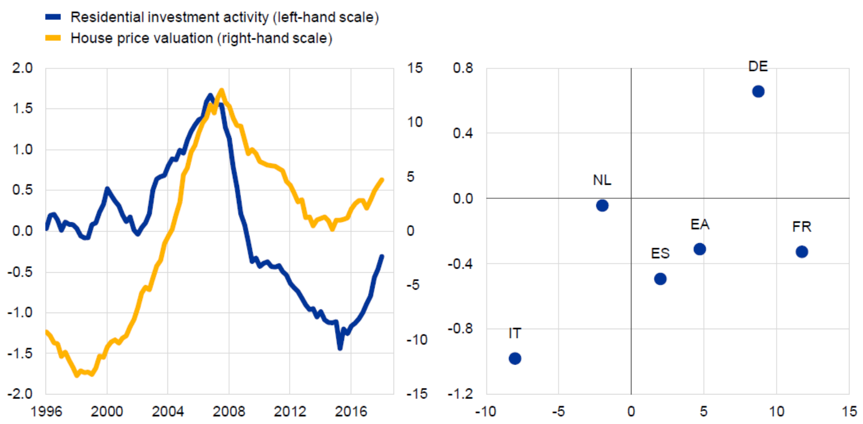

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Figure 11: Over/under evaluation of residential property prices – 5 biggest European Economies (Source: Eurostat. Calculation: ECB)

With regard to the last issue, the ECB (ESRB risk dashboard - 13 September 2018), among all the indicators considered to assess the credit risk in the EURO area, provides the following chart (Figure 12) showing the discrepancies between the range of estimates based on the indicators above mentioned, and the estimates carried out by means of demand model.

In the light of the previous results, the current upturn appears to have reached its full maturity and, although it does not appear justifiable to expect a further increase in investment, on the other hand, it does not entail the imminent risk of contractions in the economic cycle.

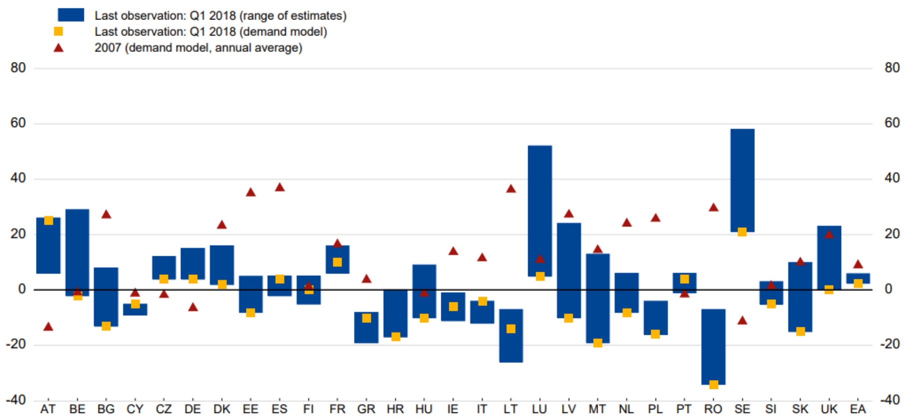

Figure 12: Over/undervaluation of residential property prices –European Economies (Source: Eurostat. Calculation: ECB)

The dynamics at play here could have substantial impacts on energy efficient renovations in the European Union. Having experienced substantial increases in real estate investment during the last years, it seems as though the market upturn could be reaching a phase of maturity and limit energy efficiency renovations in the coming years.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768287.

4.2.2. Housing demand

In line with the aim of obtaining relevant indications of the current state of the Real Estate market, this section focuses on the analysis of housing demand and supply.

According to survey indicators (Eurostat), over the last years the number of owners or potential investors planning to carry out home improvements has grown steadily since the immediate post-crisis period, reaching its maximum levels at the beginning of 2018. This trend has also applied to the intentions to purchase or build a home, although this indicator has shown a less important improvement, and remains to date below the pre-crisis level.

An important factor that could have supported housing demand is the increased attractiveness of housing as an investment asset, especially in comparison with other investment categories. Figure 12 shows a comparison between average return of investments in residential property with alternative investments by relative percentage point differences. Specifically, the bottom part of the figure depicts the differences, evaluated Year over Year, between return on investment in Real Estate with government bonds yields (blue line), deposits rate (yellow), return on equities and (red) the cost of borrowing (green).

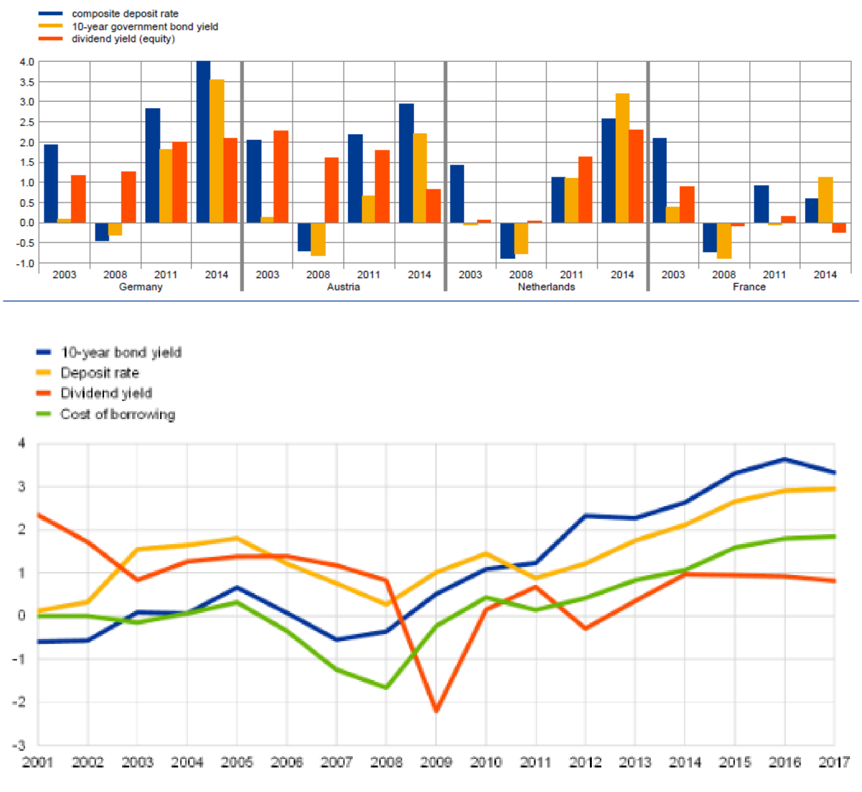

Figure 13 Average return of investments in residential property vs alternative investments. (ECB Economic Bulletin, Issue 6 / 2015 and ECB - Economic Bulletin, Issue 7/ 2018)

However, leaving aside investors looking for return, the main factors that should have incentivized the rise in demand are the average expansion in real disposable income across the EURO area and the financing conditions, whereas the rates of home loans have fallen by more than one percentage point since 2013 (EURO area bank lending survey carried out by ECB - Economic Bulletin, Issue 7/ 2018).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768287.

A last indicator closely related to residential investment is population growth rate between 20 and 49 years old, as observed at country level by Eric Monnet and Clara Wolf (figure 13). With regard to this latter aspect, Niccolò Battistini, Julien Le Roux, Moreno Roma and John Vourdas suggest that the steady decline of this age bracket since 2008 could have partially contributed in counteracting housing demand. On the other hand, they also observed that the trend should have already bottomed out, letting them suppose a trend inversion that could favour an increase in house demand and, therefore, in residential investments and house prices.

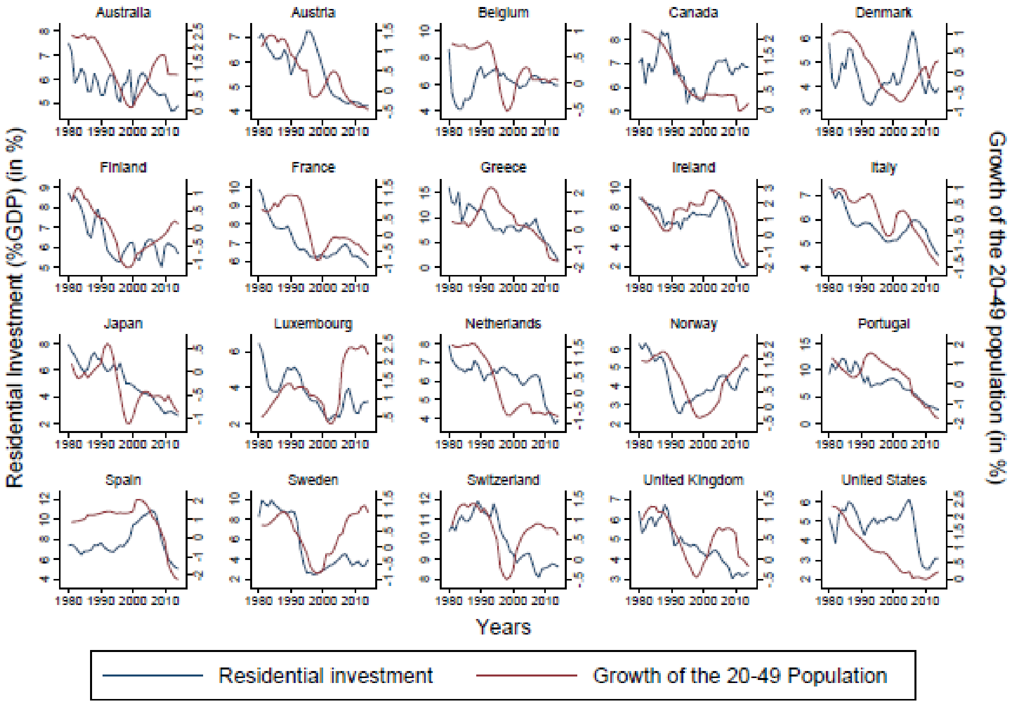

Figure 14 Residential investment and growth of the 20-49 population

4.3. Climatic factors

Climate and the environment where a building is located affect the conditions to which the building is exposed and therefore determines its thermal behaviour and final energy consumption. Consequently, this influences the final selection of technologies, materials, concepts or refurbishment techniques to be used in order to optimize energy efficiency.

In analysing the data on the market trends related to energy-efficient retrofitting of residential buildings, it is essential that this exercise is carried out after having understood to which extent they are influenced by the climatic context.

This section is therefore devoted to analyse the climate conditions and the related parameters that most affect the energy consumptions and the technological choices in residential buildings. Some of the influential climate parameters in question are:

- external air temperature;
- wind velocity and direction;
- solar radiation;
- Infrared radiation.

The aim is to obtain an overall picture that allows the analysis of market trends in the light of specific climatic conditions. To provide such an overall picture, the following climatic classifications for the EURO area will be used:

- The Köppen-Geiger scale, which helps to select the climate similar to the location being investigated;
- The degree-day (DD) for heating (HDD) and cooling (CDD), showing an expert user if the location requires mostly heating or cooling or both;
- European Heating Index (EHI) & European Cooling Index (ECI);
- The European solar irradiation map.

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4.3.1. Köppen-Geiger classification

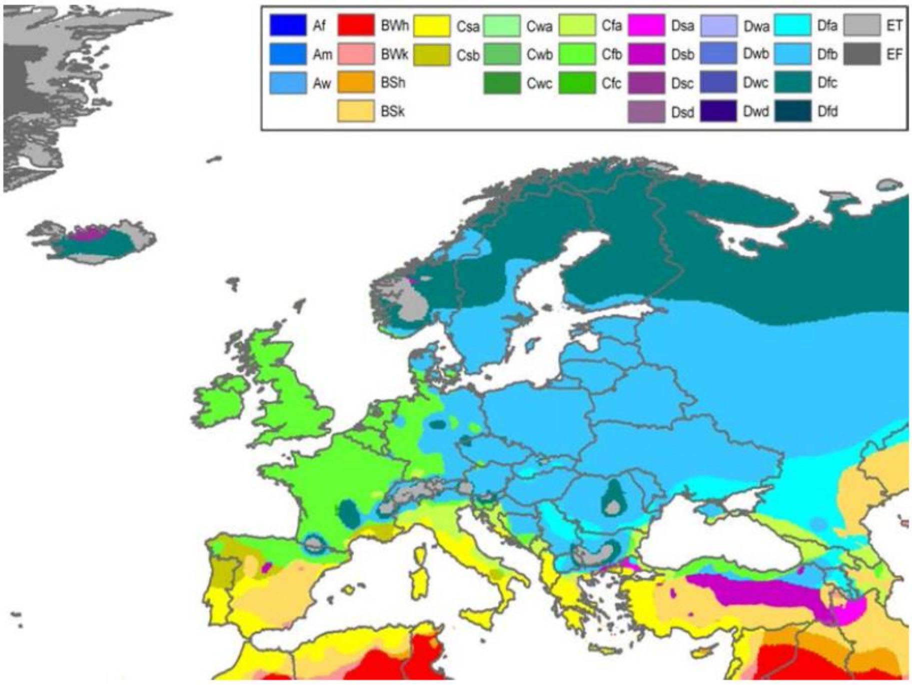

Figure 15. Köppen-Geiger climate classification of Europe

The Köppen-Geiger system is the most widely used general climate classification. This system was originally developed by Wladimir Köppen around 1900. Early versions were based on previous maps of vegetation growth, but it has subsequently been revised as more comprehensive monitored data became available. As Peel et al (Peel, Finlayson et al. 2007) note, the classification still bears criticism, but it remains the benchmark against which others are assessed.

Csa:	Temperate with dry, hot summer. (Mediterranean climate)
Cfb:	Temperate without dry season and warm summer
Dfb:	Temperate continental climate/humid continental climate without dry season and with warm summer;
Dfc:	Cold, without dry season and with cold summer.

Figure 2.1 According to Köppen – Geiger climate classification, there are four prevailing climatic zones in Europe

Figure 16 four prevailing climatic zones in Europe

Countries may have more than one climatic zone and it is sometimes difficult to establish the prevailing climate classification of Köppen.

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4.3.2. Heating and cooling degree days

Degree days are a specialist type of weather data, calculated as the sum of all daily temperature differences between a minimum (and maximum) indoor temperature of comfort and the daily average outdoor temperature for a location, if the outdoor temperature is lower (or higher) than a specified limit temperature (threshold value).

Heating degree-day (HDD) expresses the severity of the cold over a specific time period taking into consideration outdoor temperature and room temperature and represents how much, in degrees Celsius (°C), and for how long, in days, the outside air temperature is below a certain threshold value. This technique provides an immediate indication of the heating needs for a predefined building at a specific location. In the same way, the value of cooling degree-day (CDD), reflects the amount of energy used for building cooling, by giving information regarding how much, in terms of °C, and for how long, in terms of days, the air temperature is above a certain threshold.

For the degree-day for heating and cooling, different definitions and set of conditions are proposed in literature. Figure 16 shows the results calculated using the ASHRAE method, for the Cooling degree days, and the EUROSTAT method, for the Heating degree days.

Heating degree days (HDD) – EUROSTAT –method:

$HDD = (18°C - T_m)$ If T_m is lower than or equal to 15°C (heating threshold)

$HDD = 0$ if T_m is higher than 15°

Where T_m is the mean $((T_{min} - T_{max})/2)$ outdoor temperature over a period of 1 day. Calculations are executed on a daily bases, added up to a year.

Cooling degree days (HDD) – ASHRAE –method:

$CDD = (T_m - 18{,}3°C)$ If T_m is higher than or equal to 18,3°C (cooling threshold)

$CDD = 0$ if T_m is lower than 18,3°

Where T_m is the mean $((T_{min} - T_{max})/2)$ outdoor temperature over a period of 1 day. Calculations are executed on a daily basis, added up to a year.

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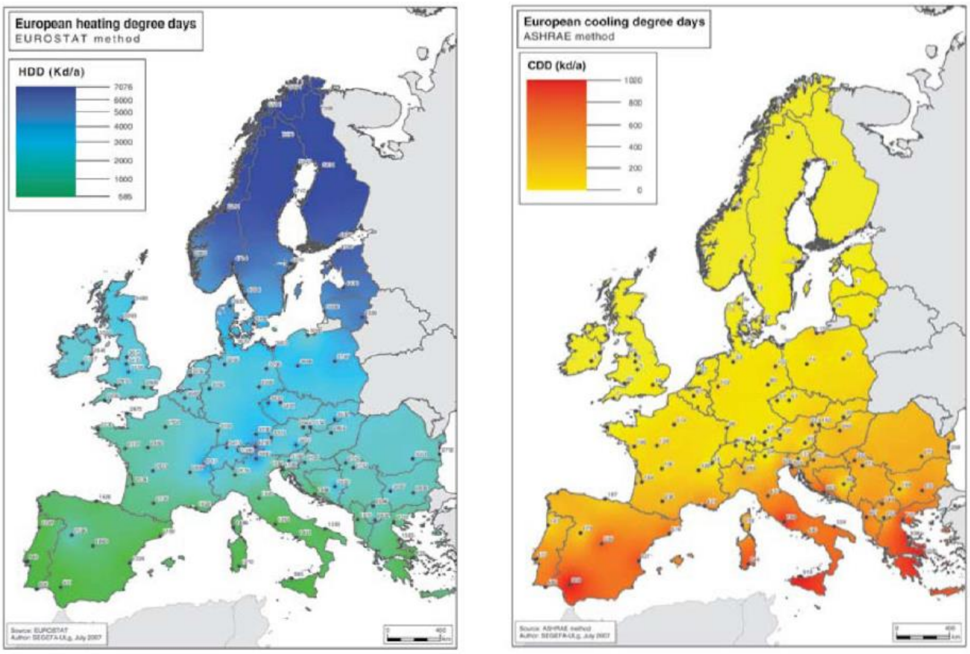

Figure 17 Mapping European heating and cooling degree days

4.3.3. European Heating Index (EHI) & European Cooling Index (ECI)

The Degree-Days method is simple but cannot be used to explain how the space heating demands vary from south to north in Europe, since the actual demands also depend on how well the buildings are insulated.

In order to have a better idea of how the demand for heat and cooling varies across Europe, it would be much better if a heating index could include an average rational use of heat resistance in buildings.

The introduction of the European Heating Index (EHI) and the European Cooling Index (ECI), defined in the frame of a European research project ECOHEATCOOL (2006), aims to overcome the limits of the Degree Days methods. They provide an estimate of the expected space heating and cooling demand at a uniform construction cost and a uniform indoor temperature, for different degree-day numbers, and based on principles such as:

- The long-term optimal insulation thickness is proportional to the square root of the degree-day number, by assuming a certain heat cost and certain insulation cost;
- The recovery of heat from ventilation systems follows the same relationship.

Both the indices are normalized, where 100 is equal to an average European condition. With reference to EHI (Figure 17. Left-hand panel), using a reference degree-day number of 2600, corresponding to an annual average outdoor temperature just above 10°C fulfils this normalization. Strasbourg in France is the typical space heating city in Europe, with a heating index of 100. With reference to ECI (Figure 17. right-hand panel), average European condition occurs in, for example, Strasbourg and Frankfurt, where the average outdoor temperature is just above 10ºC. The solar and internal gains are also adjusted by the square root of the heating degree-day number, since these gains are more valuable in temperature addition, when a building is well insulated.

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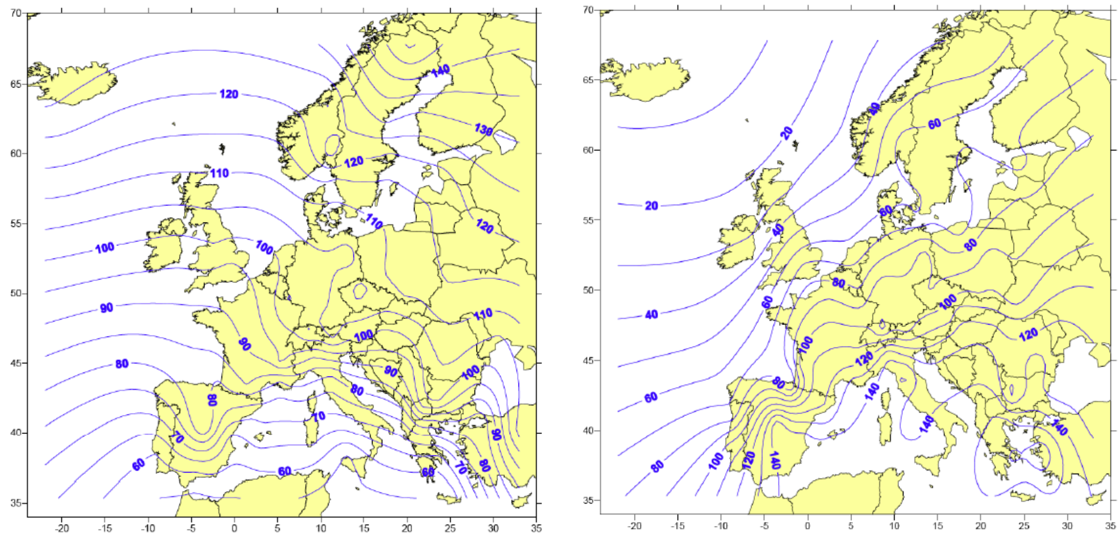

Figure 18 Mapping EHI and ECI

In the construction of the ECI it is assumed that the cooling systems are designed to maintain an indoor temperature of 22°C only when the outdoor temperature is below 29°C. When the outdoor temperature exceeds this limit, the indoor temperature will start to slide at a constant difference of 7°C below the outdoor temperature.

The EHI and ECI have been constructed according to Figure 18.

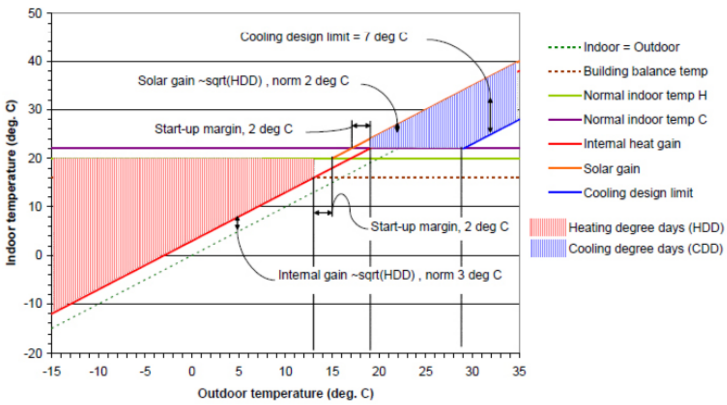

Figure 19 EHI and ECI methodology

4.3.4. Photovoltaic solar electricity potential in EU countries

This last section is devoted to provide insights of the exploitation potential of Photovoltaic systems and, to a lesser extent, of solar collector systems, across European countries. To this end the geographical analysis of the availability of the primary solar energy resource can improve our understanding of the potential of such technologies to cover household energy demands, both in terms of heat and electricity,

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and thus contribute to correctly assess market trends and policies related to energy production from RES.

The map below (figure 19) represents the yearly sum of global irradiation on horizontal and optimally inclined surface. Over most of the region, the data represents the average of the period 1998-2011, however, north of 58° N, the data represents the 10-year average of the period 1981-1990. All data values are given as kWh/m2. The same colour legend represents also potential solar electricity [kWh/kWp] generated by a 1 kWp system per year with photovoltaic modules mounted at an optimum inclination and assuming system performance ratio 0.75.

The yearly sum of the electricity generated for each kWp of PV with horizontal modules in EU countries ranges from about 470 up to 1390 kWh

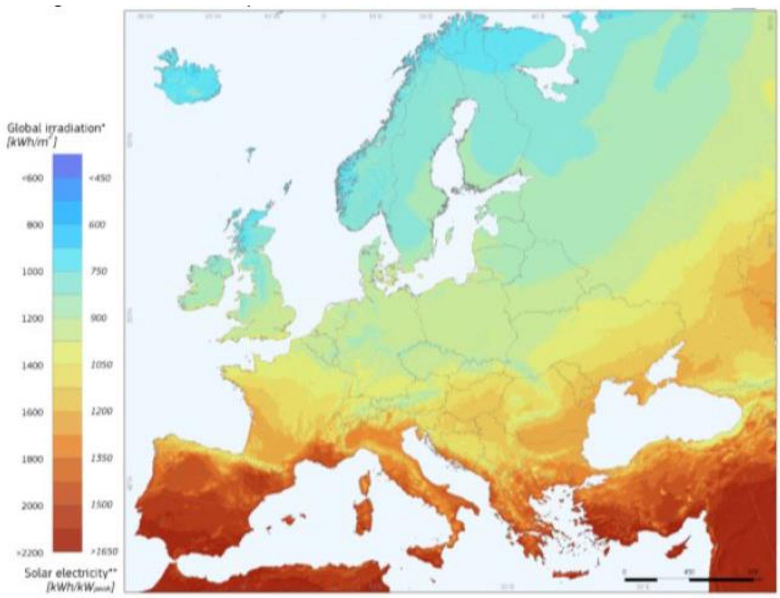

Figure 20: European solar irradiation map - Šúri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007.

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5. Market trends

Through the Energy Performance of Buildings Directive (EPBD, 2010/31/EC) the European Union, within the general purpose of reducing the GHG emissions and energy consumption of its building stock, has committed the Member States to adapt their national legislations so that all the new buildings built after 2020 are nZEB – after 2018 in case of public buildings. Namely, from that date onward, all the new buildings have to be very high energy performant so as to require nearly zero or very low amount of energy, possibly produced by onsite or nearby renewable energy sources. Considering that more than 80% of residential buildings of the Euro Zone (BPIE 2011) dates back to the pre-1990´s and are, to a large extend, highly inefficient from an energetic point of view, the most important challenge lies in managing the deep renovation of the existing buildings. This section will provide an overview of the market dynamics related to nearly Zero Energy Buildings (nZEB) and renovations in the European Union. This should provide a deeper understanding, through the analysis and the comparison of the energy policies implemented by the Member States (section 6), of the main barriers hampering the development of the market for the renovation of existing buildings.

5.1. General renovations

This section aims to provide indications related to general renovation rates for the different MSs so as to highlight differences between countries and to understand where the greatest discrepancies with the strategic targets set by European Commission are.

In 2013 BPIE (A guide to developing strategies for building energy renovations) indicated two essential requirements to achieve 90% of CO2 savings in the period 2020-2050. Namely:

1- *“Renovation rates needed to ramp up from the prevailing rate of around 1% of total floor area renovated annually in 2011, to between 2.5% and 3% from 2020 onwards*”- In addition, the progression to be sustained to achieve such goal was reported.

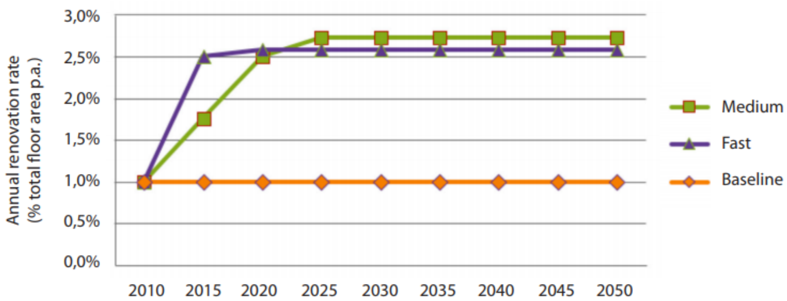

Figure 21 Annual renovation rates

2- *“The depth of typical building renovation needed to shift from the majority currently being at a “shallow” level to either “deep” or increasingly “nZEB” for the period 2020-2050*”. Also in this case, the BPIE provided an indication on how the distribution among renovation levels should have evolved over time, from the starting point observed in 2011 (i.e. 85% minor, 10% moderate, 5% deep renovation).

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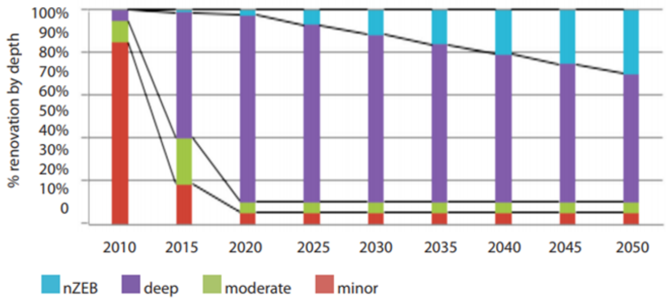


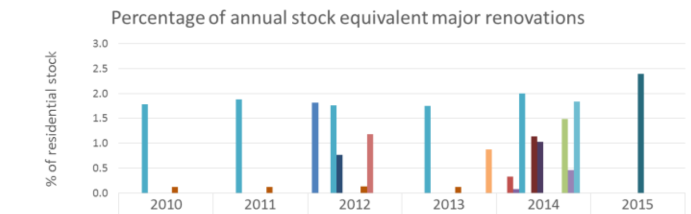
Figure 22 Renovation depths

BPIE defines the four degrees of depth of renovation as follows:

- Minor renovations: the implementation of 1 or 2 measures (e.g. a new boiler) resulting in a reduction in energy consumption of between 0% and 30%;
- Moderate renovations: involving 3-5 improvements (e.g. insulation of relevant parts of the dwelling plus a new boiler) resulting in energy reductions in the range of 30%-60%;
- Extensive renovations: in this approach the renovation is viewed as a package of measures working together leading to an energy reduction of 60% - 90%;
- Almost Zero-Energy Building renovations: the replacement or upgrade of all elements which have a bearing on energy use, as well as the installation of renewable energy technologies in order to reduce energy consumption and carbon emission levels to close to zero.

It is important to underline that this classification doesn't match the definitions provided by the EPBD Recast which, in article 2, defines “major renovation” as those interventions where *(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; Or (b) more than 25 % of the surface of the building envelope undergoes renovation.*

Analogously, each country when implementing the EPBD provisions in its own legislation, provides its own specific definition of different levels of renovation to be subject to different requirements. On the other hand, in order to allow experts and analysts to make comparisons between data of different MSs, it is essential to divide them into homogeneous categories. For this reason, ZEBRA2020 project, in order to eliminate existing differences in national definitions and ease comparisons, developed an indicator of “major renovation equivalent”. The definition of Major renovation slightly differs from that provided by the EPBD recast. In the context of ZEBRA2020 “equivalent major renovations” include all the interventions that can reduce the building's final energy demand for heating by 50 to 80% (range depending on the country defined by national experts according to the current efficiency of the building stock). The results of the most recent statistics obtained by member states adopting the ZEBRA2020 definition are showed in Figure 23.



	2010	2011	2012	2013	2014	2015
Austria	0	0	1.82	0.00	0.00	0.00
Belgium	0	0	0.00	0.00	0.33	0.00
Spain	0	0	0.00	0.00	0.08	0.00
France	1.78	1.88	1.76	1.75	2.01	0.00
Italy	0	0	0.77	0.00	0.00	0.00
Lithuania	0	0	0.00	0.00	1.13	0.00
Netherlands	0	0	0.00	0.00	1.03	0.00
Norway	0	0	0.00	0.00	0.00	2.40
Poland	0.13	0.13	0.13	0.12	0.00	0.00
Czech Rep.	0	0	1.18	0.00	0.00	0.00
Germany	0	0	0.00	0.00	1.49	0.00
Romania	0	0	0.00	0.00	0.47	0.00
Slovakia	0	0	0.00	0.00	1.84	0.00
Sweden	0	0	0.00	0.88	0.00	0.00

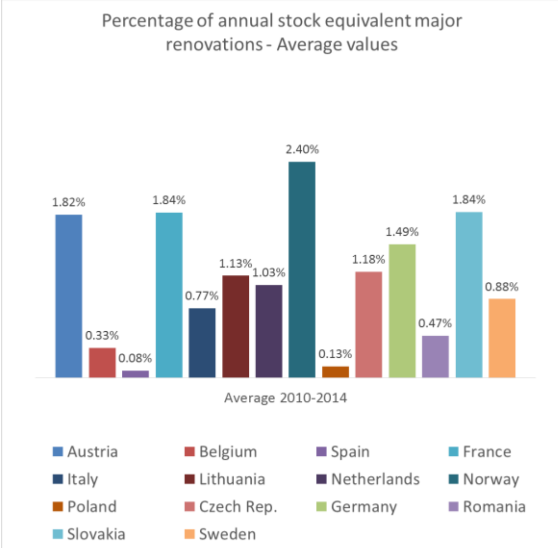


Figure 23: ZEBRA2020 – Percentage of annual residential stock renovated, Deep renovation

Beyond the macroscopic differences between countries, the data on rates are discouraging and seriously call into question the interim objective of reducing energy demand in the building sector by 20% by 2020. In fact, compared to the 3% of surface area that would need to be upgraded each year to energy-efficient levels, the European average is only 1%.

There are exceptions, however. While almost all the countries of Mediterranean Europe, characterized by a greater spread of energy poverty (measured by the European Domestic Energy Poverty Index), show requalification levels that are always well below the European average, in some cases the north-western countries exhibit rates that are close to and 2% (Austria, France, German, Slovakia) and in the case of Norway are even higher.

In order to investigate the differences highlighted here in more depth, the next sections will focus on the analysis of product sales data, broken down by category, relating to energy refurbishment measures. This will allow a broader view, together with the analysis of energy policies implemented by each Member State addressed in the following chapter, of the dynamics that determine the requalification rates being shown, allowing the identification of hindrances and barriers.

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5.2. Building insulating materials and equipment

Important insights may be gained from the analysis of the sales of building materials and equipment somehow related to energy renovations. Hereafter, trends of the sales of materials and equipment belonging to the following macro categories are analyzed:

- Thermal insulation
- Glazing
- Heating solution
- Renewable Energy

5.2.1. Thermal insulation

The total market for thermal insulation products in Europe stood at 254 million m3 in 2016 (8.0 million t), with a CAGR (Compounded Average Growth Rate) growth forecast of 2.5 % to 2021. This equates to an approximate market value of just under EUR 16 billion in 2016. The 2017 market is estimated at 259 million m3, a 2 % rise over 2016.

Western Europe accounted for 58 % of the European thermal insulation consumption, and the market is forecast to show modest growth at a CAGR of 2.0 % to 2021. Eastern Europe continues to drive growth with a CAGR of 4.2 % forecast to 2021 due to heightened activity in residential construction. In Central Europe, the Hungarian and Romanian markets are also experiencing strong growth as a consequence of the increased expenditure to improve housing stock and infrastructure.

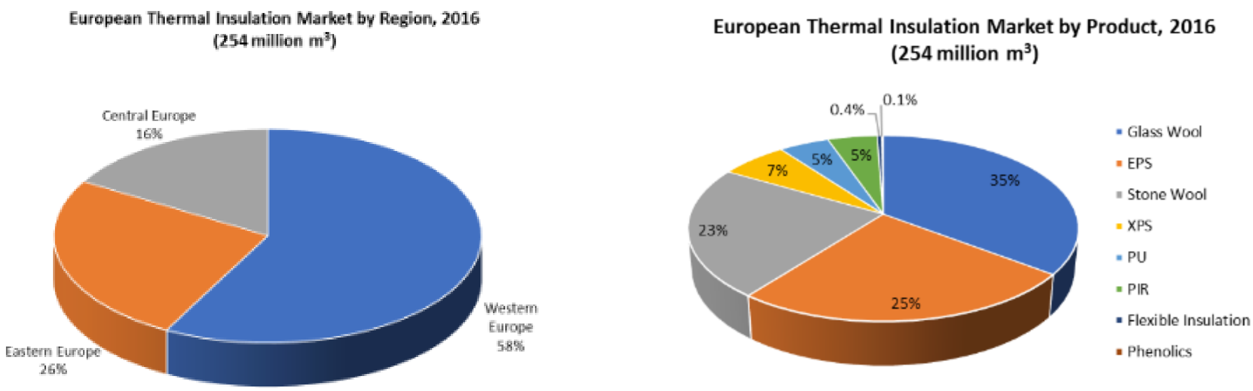

Figure 24: IAL Consultants – European Thermal Market by Region and European Thermal Market by Product

Although the construction industry has remained relatively subdued since the financial crisis in 2008, concerns over improved energy efficiency in buildings and rising energy prices have boosted demand for thermal insulation materials. Regulatory authorities are highlighting the importance of minimising heat loss through the building envelope and are adopting legislation encouraging zero energy buildings. Retrofit construction is now also regulated and minimum energy performance standards have been set, which are a key driver for thermal insulation materials. Commercial and domestic buildings continue to

represent the bulk of the demand at 86 % for thermal insulation materials in Europe, with the overall use in industrial applications remaining considerably smaller at 14 % of the market.

Hereafter, results of the ZEBRA2020 project have been graphically represented.

Glass and stone wool

Data show a slight decrease in sales volume in western European countries between 2010 and 2013. As foreseeable, countries characterized by higher per capita sales volumes are those with most cold climates. With the only partial exception of the polystyrene, cheaper than glass and stone wool and less suitable in contexts with stricter fire-fighting regulations, Mediterranean countries show low rates of sales.

Figure 25: ZEBRA2020 – Sales of glass wool and stone / slag wool by Country

Lightweight expanded clay aggregate (LECA) or Expanded clay and polystyrene

This peculiarity does not characterize lightweight expanded clay aggregate (LECA), whose sale rates seem to be linked to the climatic context to a lesser extent. This could be explained by its intrinsic characteristics. LECA is a cheap lightweight versatile material, but without strong heat-insulating properties (as low as 0.097 W/mK, while typical EPS values range from 0.032 to 0.038 W/mK). In the construction industry, it is used mostly in the production of lightweight concrete, blocks and precast or incast structural elements that, in warm contexts, can be an ideal compromise solution, as it can provide the minimum needed thermal insulation in winter, also increasing the thermal inertia of the building in summer. In addition, due to its lightness it is a suitable solution in seismic contexts such as in Portugal and Italy.

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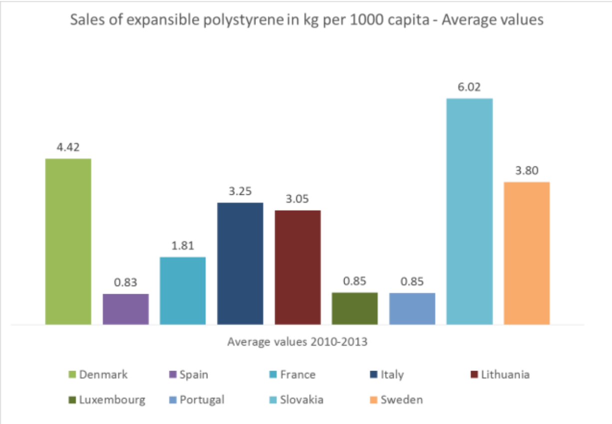

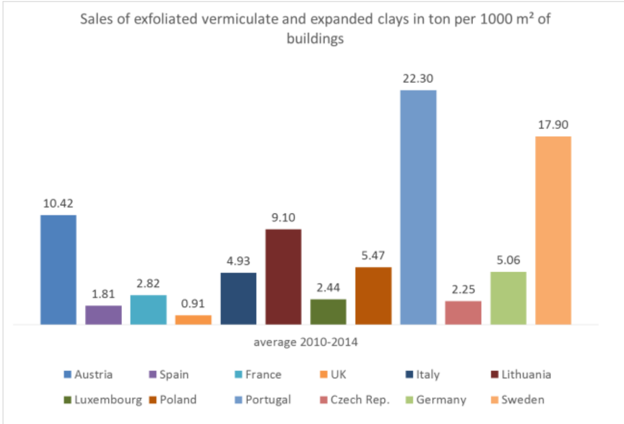

Figure 26: ZEBRA2020 – Sales of polystyrene and exfoliated vermiculate / expanded clays by Country

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5.2.2. Windows

Another useful element for the understanding of the market of energy renovations is related to the sales of windows. The Zebra consortium gathered data mainly from:

- UFME (Union des Fabricants de Menuiseries) for France,
- UNCSAAL (Unione nazionale costruttori serramenti alluminio acciaio leghe) for Italy, today called UNICMI (Unione Nazionale delle Industrie delle Costruzioni Metalliche dell'Involucro e dei serramenti), and
- RVO (Rijksdienst voor Ondernemend)

In order to provide a picture that, as far as possible, could be considered truly representative for the whole European context (or at least of the western countries).

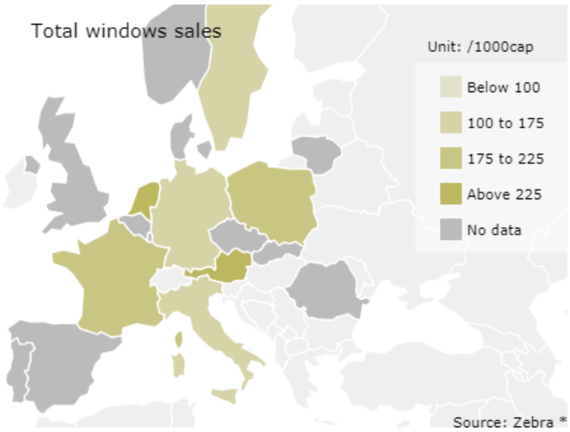

Figure 27: ZEBRA2020 – Sales of non-metallic heat/sound-insulating materials by Country

Apart from the three countries above-mentioned, data gathered concern the overall volume of sales in Austria, Poland, Germany and Sweden, and are reported as number of windows sold per 1000 inhabitants. As for the insulating materials it emerges a certain correlation between sales data and the climatic context.

Due to their high prices (at least 250-300 €/sqm) their replacement is rarely cost-effective in mild climate areas, especially without important incentives. On the other hand, they can imply important energy savings in cold climate contexts.

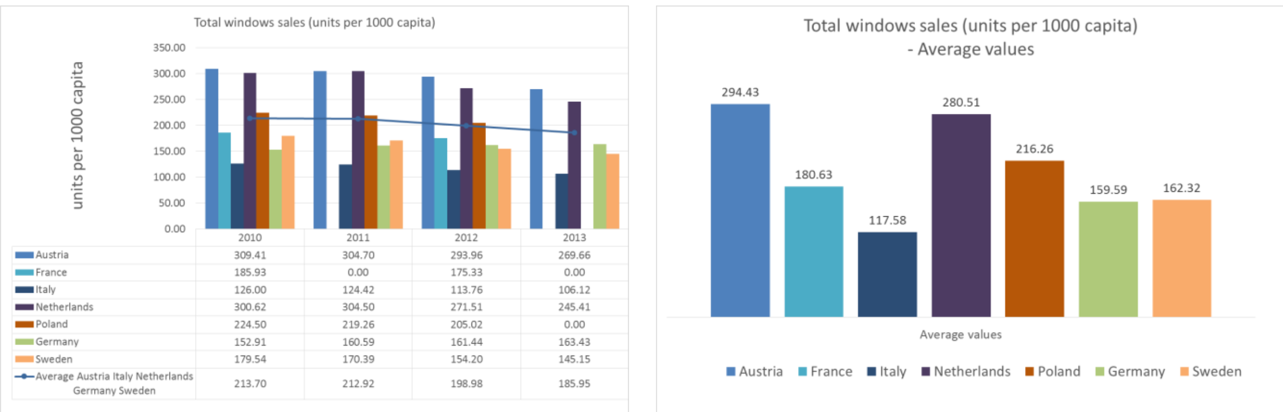

Figure 28: ZEBRA2020 – Sales of window units per 1000 capita by Country

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The negative trend shown in Figure 28 until 2013, following the general economic downturn during the period 2008-2015, was confirmed by the «Pôle Fênetre» of FFB, also for the two-year period 2014-2015, registering a decrease by 8,3% in the number of windows installed in 2015, in line with Figure 8, which showed that Residential Investments have started to slowly rise again only after 2014.

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5.2.3. Heating solution and Renewable Energy systems

Also, in this case, choices between different systems seem to be taken mainly on the basis of the different climate areas. Condensing boilers are mainly the most common choice in cold countries, although with some peculiarities. For instance, data of sales in UK and Netherlands, where with few exceptions condensing boilers are the most widely spread heating system solution (TABULA-EPISCOPE), stand out a lot compared to data in other countries. In Italy gas boiler is the most common heating system used but, in case of refurbishment or new buildings, the choice is increasingly directed towards aerothermal heat pumps, especially in combination with the installation of Photovoltaic systems, which are indicated as the ideal advanced refurbishment solution for most building typologies, both in case of centralized and individual systems, (TABULA-EPISCOPE) and have the advantage of being used both for heating and cooling conditions.

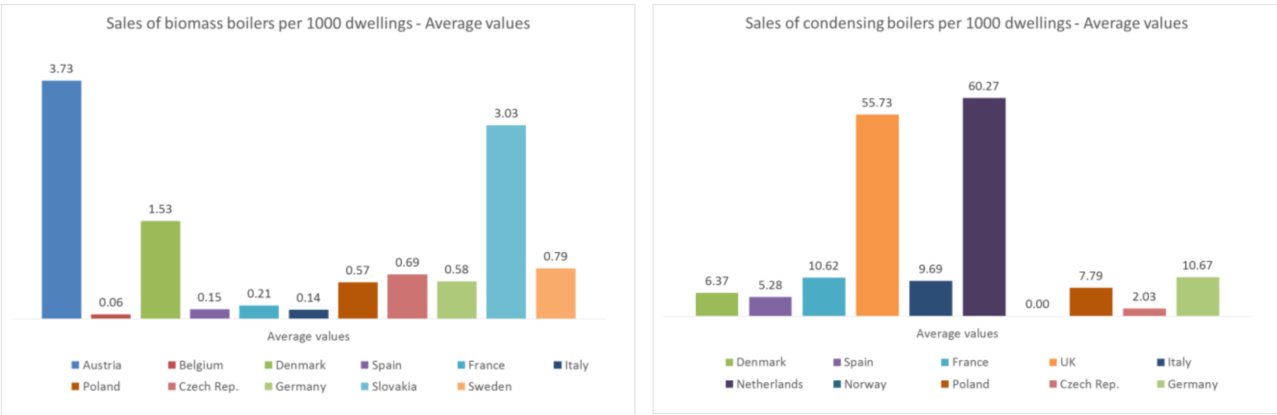

Figure 29: Sales of biomass boilers and condensing boilers per 1000 capita by Country (ZEBRA2020)

Heat pumps are the ideal solution in case of alternation of cooling and heating periods (section 4.3), especially in the case of contexts characterized by climate with mild winters and summers, as their performance (COP) increases with an increase of the external temperature. Similarly, it happens for the Energy Efficiency Ratio (EER), which increases with a decrease of the external temperature.

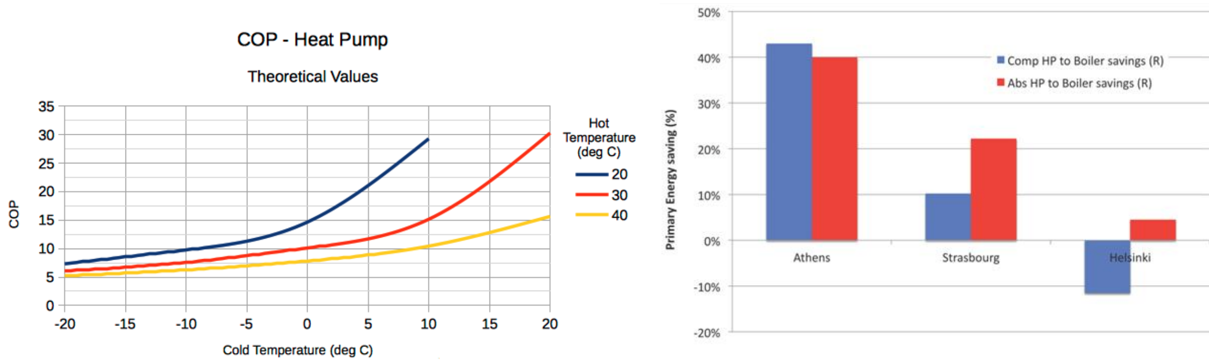

Figure 30: COP variations in response to a variation in outside temperature (on the left) and achievable Primary Energy savings through Heat Pumps in different climate zones (on the right)

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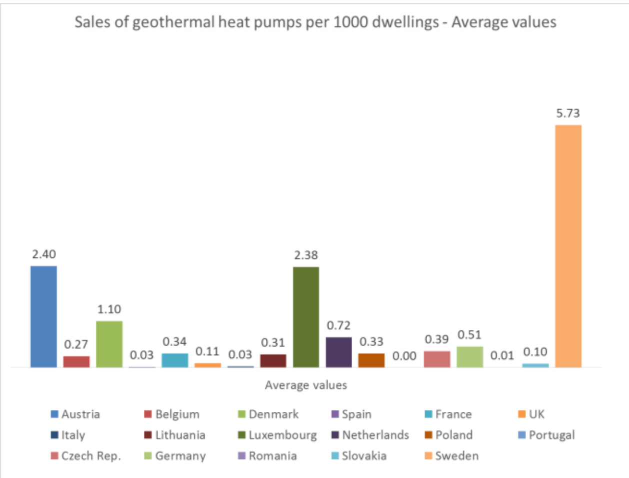
Accordingly, Figure 30 shows that aerothermal heat pumps are mainly spread in Mediterranean countries (Italy, Portugal, France and to a lower extent Spain). Relatively high quantities for Sweden, Austria and Netherlands represent an interesting anomaly that can be partly explained by looking at (1) the energy prices, expecially for Sweden where natural gas prices are by far the highest in Europe (section 4.1.2), and (2) the state of the housing market in the period 2008-2013, expecially for Austria which appears to be one of the countries which suffered less from the 2008 crisis, as it was for Slovakia and Germany (section 4.2) that in fact stand out also for general renovations and sales of related materials.

Data related to geothermal heat pumps seem to confirm these last considerations. Sales data for Sweden appear to be driven by high prices of natural gas, leading households to opt for electrically powered solutions (although the standard solution in case of refurbishment is district heating -TABULA project). Due to their high costs, geothermal heat pumps are not a cost-effective solution, especially in densely populated areas (being the need to dig deeply), compared to aerothermal heat pumps in Mediterranean countries. However, despite their high costs, in dynamic housing markets, geothermal heat pumps become an interesting alternative investment in those countries characterized by cold winters, where the aerothermal heat pumps become less effective because of the reduction of their COP.



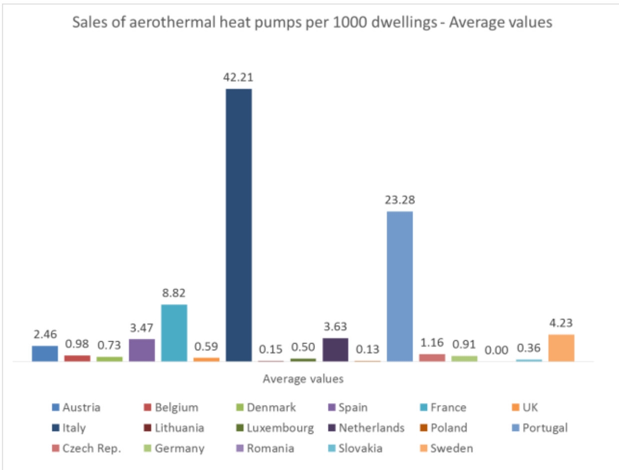


Figure 31: Sales of geothermal and aerothermal heat pumps per 1000 capita by Country (ZEBRA2020)

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Figure 32 shows sales data related to Photovoltaic and Solar thermal systems. With regard to Photovoltaic systems they are mainly spread accordingly to exploitation potential, with the exception of Belgium and Austria (in this last case an explanation is provided by the national policies - Paragraph 6.2.1 - Green electricity subsidies from the Federal Government).

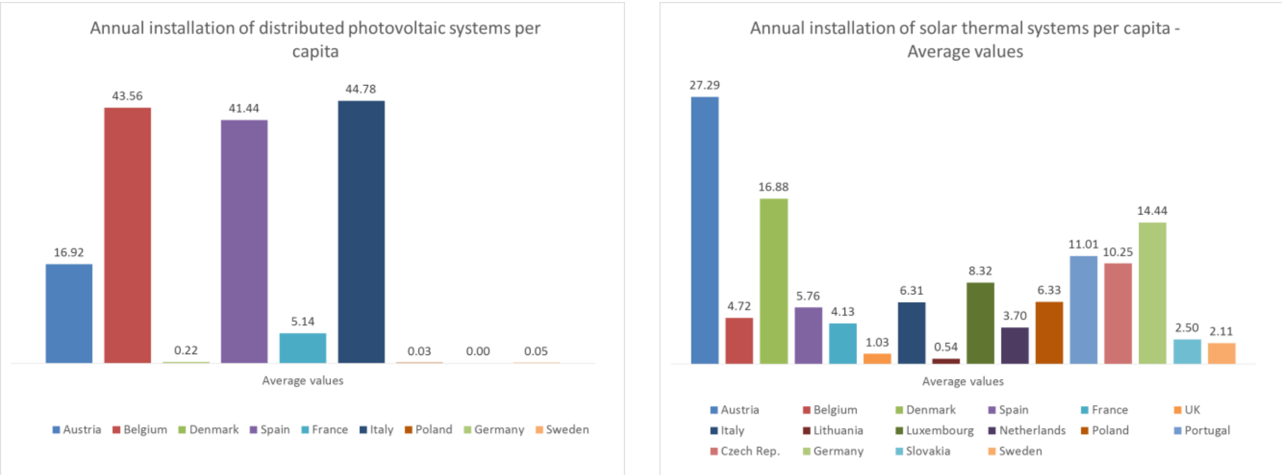

Figure 32: Sales of photovoltaic and solar thermal systems per 1000 capita by Country (ZEBRA2020)

With regards to solar thermal systems, the opposite is observed, as sales data show that they are most disseminated in cold context, apparently in contradiction with the irradiation map reported in Figure 20 but in accordance with the following considerations:

- The sizing of solar collectors is done on the basis of the summer requirements, because otherwise, the heat surplus not used in the summer would damage the collectors
- Due to less irradiation, in cold countries there is the need of more collector's surface to cover the same heat requirement
- Solar collectors are often installed in combination with district heating grids, that are more common in cold countries (TABULA project)

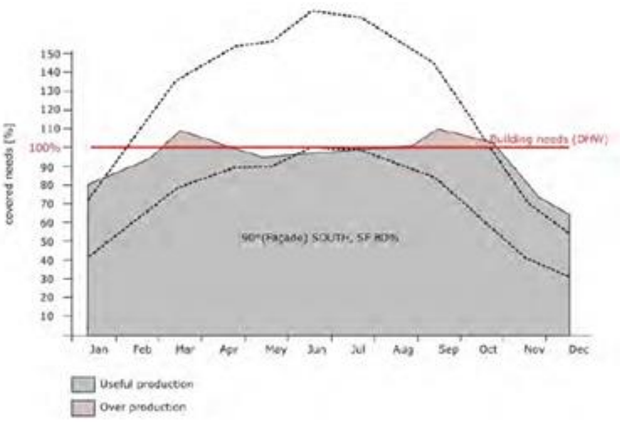

Fig. 3.A.10: Annual production profile of a solar thermal system mounted on a southern façade and covering 80% of domestic hot water needs (mid-latitudes, north hemisphere)

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Figure 33 Production of solar thermal systems (south facing and covering 80% of hot water needs)

A turning point could be represented by the dissemination of the solar cooling technologies (absorption heat pump), by which heat produced by a solar collector in summer could be exploited in order to provide cooling, avoiding heat surplus and allowing designers to size solar collectors on the basis of winter requirements. To date, solar cooling is still expensive but through the introduction of appropriate incentives, it could become an interesting cost-effective alternative to photovoltaic systems, which can usually cover only a portion of the power needs of mechanical heat pumps.

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6. Awareness and Energy related action

This section focuses on the drivers that can stimulate the growth of the renovation process. They are usually linked to Energy policies adopted by MSs, and may be summarized in the following macrocategories:

- Awareness of the benefits obtainable by deep renovations
- Financial benefits
- Law constraints

The first section explores the topic of the Energy Certificates, analyzes (1) the diffusion, (2) the impact they have on property prices and (3) the way they are perceived. This will enable a better understanding of the level of awareness and knowledge of the benefits achievable through deep renovation of buildings.

The second section provides a brief overview of the laws MSs have adopted in order to implement EPBD (Energy Performance of Buildings Directive) and EED (Energy Efficiency Directive), focusing on both the requirements that apply in the context of renovation of existing buildings, and the financial incentives.

6.1. Energy Performance Certificates and impact on property prices

A meaningful indicator, able to provide insights on the widespread level of awareness about both energy consumptions of buildings and the benefits that can be obtained through their energy renovations, is given by the level of dissemination of the Energy Performance Certificates (EnPCs).

The requirement of issuing EnPCs has been introduced by the 2002/91/we directive of the European Parliament and Council concerning the energy performance of buildings. Its primary aim was energy saving, due to the amount of energy being wasted resulting from using inappropriate technologies, improper materials or building design errors. EnPCs usually assign energy classes to particular buildings, which inform a potential purchaser or tenant about the energy quality and consumption.

For instance, in Austria, France, Norway, Romania, Italy and Spain, the EnPCs shows the energy performance of real estate in the scale from A to G, similarly to the system used for electric devices and household equipment in Europe. The energy performance scale ranges from 0 to 1000 in Poland and Germany.
Certificates are required for concluding contracts for the sale and lease of real estate.

Figure 34 shows the level of dissemination of the Energy Performance Certificates among the European countries between 2010 and 2014.

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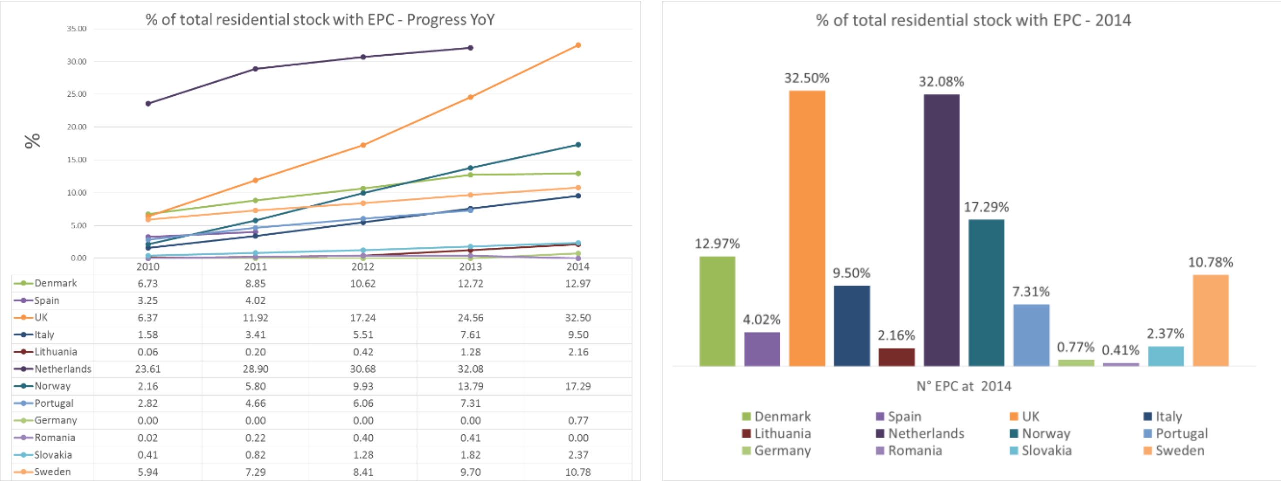

	2010	2011	2012	2013	2014
Denmark	6.73	8.85	10.62	12.72	12.97
Spain	3.25	4.02			
UK	6.37	11.92	17.24	24.56	32.50
Italy	1.58	3.41	5.51	7.61	9.50
Lithuania	0.06	0.20	0.42	1.28	2.16
Netherlands	23.61	28.90	30.68	32.08	
Norway	2.16	5.80	9.93	13.79	17.29
Portugal	2.82	4.66	6.06	7.31	
Germany	0.00	0.00	0.00	0.00	0.77
Romania	0.02	0.22	0.40	0.41	0.00
Slovakia	0.41	0.82	1.28	1.82	2.37
Sweden	5.94	7.29	8.41	9.70	10.78

Figure 34: ZEBRA2020 – Percentage of total residential stock with EnPCs

The differences are mainly due to the following factors:

- The number of transactions in the residential sector
- The trends in the new construction market
- Differences between Member States laws and regulations. For instance, some countries do not impose EnPCs for concluding contracts for the lease

The Zebra consortium produced other important outcomes with respect to EnPCs, aimed at achieving a deep understanding on whether and to what extend EnPCs can affect the Real Estate market and, therefore, boost energy renovations of residential buildings.

More specifically, the Zebra consortium carried out surveys among real estate agents in order to assess, for each country, how energy certificates are perceived among the experts, thus providing an overall indication of their reliability and usefulness.

With regard to the first of the two indicators, the results showed that the perceived level of reliability of the Energy Certificates is relatively low (Figure 33). Looking at the overall number of surveys undertaken in all countries, there are 35% negative responses. Similarly, 35% respondents have evaluated EnPCs on an average level while, only 27% respondents have evaluated EnPCs positively.

Compared to other countries that take part in the survey, the German respondents evaluate the EnPCs data reliability most negatively (54% negative responses) along with Norwegians and Poles (47% negative responses) and the French (42% negative responses).

In terms of the evaluation of data reliability, Austria generated the best results with over a half of respondents (54%) that evaluated the EnPCs data reliability positively.

The evaluation of the certificate reliability went relatively well in Spain (44% positive responses) and in Italy (31% responses).

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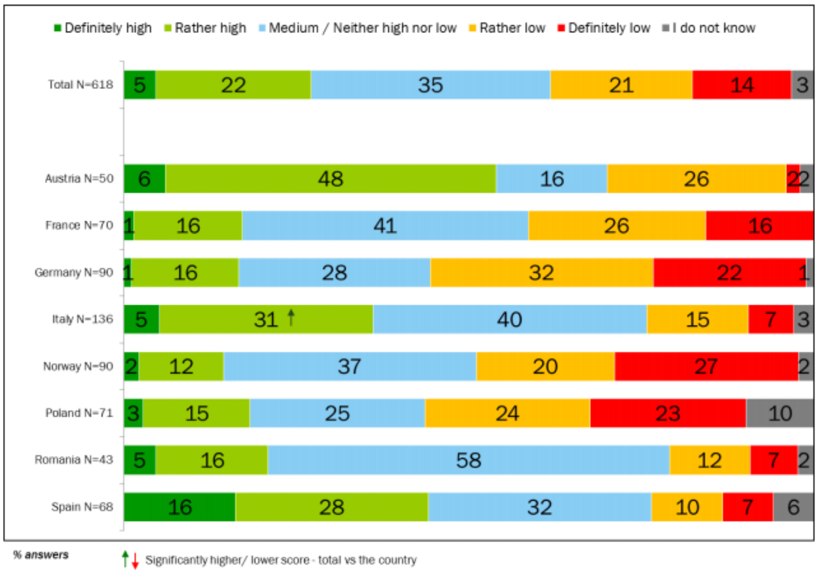

Figure 35: Reliability with which EnPCs are perceived – Quantitative report on real estate agents survey ZEBRA2020

Also with reference to the usefulness of certificates, meant as their efficiency to provide key information for the purchase or the rental (for example, with regard to energy consumption, or to the quality of the building), the results are rather disappointing. in fact, only slightly more than 25% of the surveyed participants answered that consider of some use the Energy Certificates in carrying out their activities.

Looking at the single countries, Norwegians evaluate the certificate usefulness particularly bad, almost 80% negative responses. Also the Germans (56% negative responses), the Spanish (55% negative responses) and the Poles (53% negative responses) do not speak in favour of the certificate usefulness. Whereas, the Romanians 61% and the French 40% best evaluate the certificate usefulness.

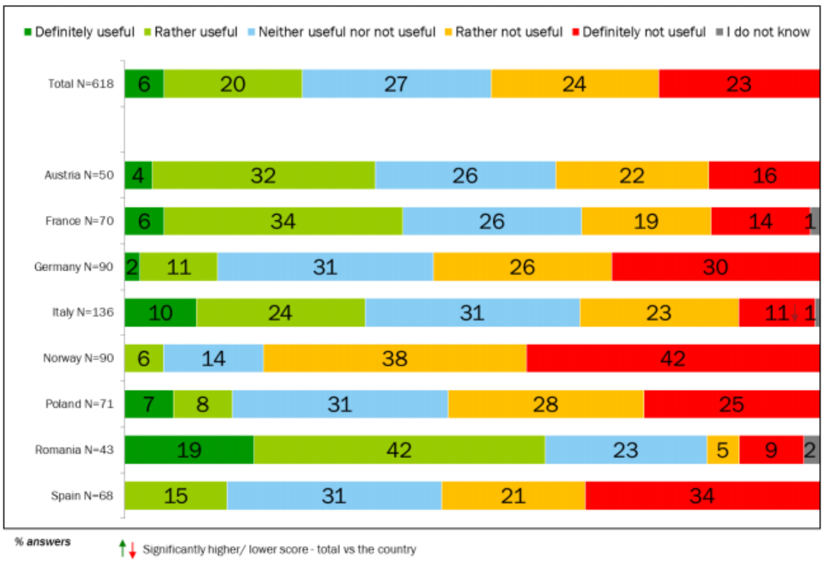

Figure 36: Usefulness perceived of the EnPCs – Quantitative report on real estate agents survey ZEBRA2020

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Given the widespread opinion about the usefulness and reliability of energy certificates, it is not surprising that, for the most cases, respondents do not find a correlation between the energy performance certificate and the improvement of the energy performance of buildings, nor a correlation between a high-energy rating and an increase in the price of the property.

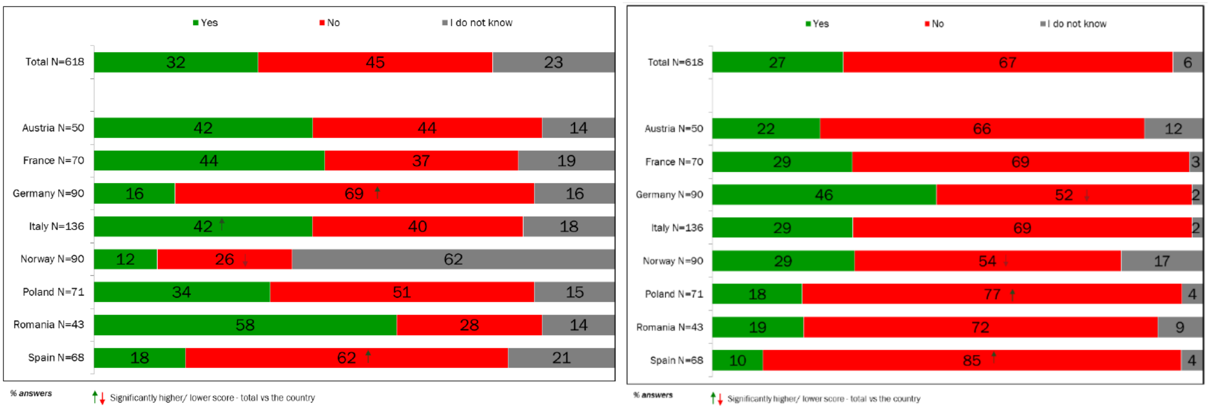

Figure 37 – Link between EnPCs and the improvement of the energy efficiency of buildings (left side) and link between price and energy performance rating (right side) – ZEBRA2020

Only 27% of the respondents see the connection between a high-energy performance of buildings and an increase in the price of the building. Looking at the individual countries only the Germans seem to detect a strong connection between price increases and high-energy classes, while Spain is the country where energy efficiency has the least impact on prices.

Similarly, even when looking at market exposure times, there are no significant differences between buildings belonging to high energy classes and those of other classes, proving that the level of attention to energy consumption is still relatively low throughout Europe.

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6.2. Energy Policies in Europe

In this section on the different national energy policies aligned with EPBD provisions in Europe at member state level, this report has focused on Austria, Germany, France, Italy and Spain as they are the regions most relevant to the members of our consortium as well as the renovation cases that have been observed so far and which will be used as inputs to contextualize the barriers to renovation.

Observing the different energy policies in Europe is a good way of assessing how potential barriers to renovation such as unsupportive regulation, financial support and lack of awareness are being tackled by national governments.

6.2.1. Austria

Implementation of the EPBD

In Austria, the implementation of the EPBD (Directive 2010/31/EU) has been completed by each of the nine provinces. The Austrian Institute of Construction Engineering (OIB) was assigned to manage the harmonising process of the implementation of the EPBD in the provinces in 2006. The outcome is the recent OIB Directive 6, published in March 2015, whose contents are implemented in each respective province's building regulations.

It sets the framework for the buildings' energy performance and defines NZEB 2020. The NZEB standard sets requirements for the efficiency of both new buildings and major renovations as regards to the building envelope, heating and cooling systems and energy supply.

Regulation and plans to improve the existing building stock

The requirements for turning existing buildings into NZEB by 2020 were firstly published in 2014, and then updated again in 2017. The second Austrian National Energy Efficiency Action Plan (NEEAP), developed by the Federal Ministry of Science, Research and Economy together with the Austrian provinces, was published in April 2017 according to Article 4 of Directive 2012/27/EU (Energy Efficiency Directive - EED). This plan updates the NEEAP 2014 and describes the way towards increasing energy efficiency and standardising the energy efficiency regulations in Austria until 2020, and envisages the increase in demand for energy-efficient services, reduction of energy consumption and simultaneously fighting energy poverty while avoiding nuclear energy. Additionally, the government shall set a good example by speeding up the implementation of energy efficiency in public buildings. Through these measures, the government aims to reduce energy consumption by 20% compared to 2007 (equivalent to 1,100 Peta J; the present target based on the Energy Efficiency Act is 1,050 Peta J).

The measures for the building sector focus on the following categories:

- Subsidies for residential buildings (e.g., a renovation subsidy like the “Sanierungscheck”);
- Subsidies for district heating (e.g., for the installation of a heat transfer station);
- Operational and environmental subsidy schemes for companies in Austria (e.g., subsidies for PV installations);
- Energy efficiency measures in building regulations (e.g., further development of the OIB Directive 6).

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Financial instruments and incentives for existing buildings

In Austria, in the residential sector, incentives are mainly granted by subsidy programmes provided by the Austrian provinces. The conditions under which these subsidies are granted focus on the improvement of building quality in terms of higher comfort and better energy performance. Subsidies are mostly distributed in the form of non-refundable payments (grant and one-time non-repayable investment expense).

In addition, Austrian Federal Government provide subsidies (national scheme) on building renovations since 2009 for privately owned single-family households in the form of grants and financial support for the thermal insulation of roofs, external walls, floors, replacement of windows and exterior doors and for changing the heating system into a renewable heating system.

The following table, extract from NEEAP 2017, provides an overview of policy measures set in the context of Directive 2012/27/EU. The incentives devoted to buildings refurbishments are highlighted in blue and briefly described hereafter.

Measures	Target groups/sectors	Annual savings achieved in TJ		Cumulative in TJ
		2014	2015	2014-2020
Energy efficiency obligation scheme for energy suppliers	All sectors	2 487.0	7 057.1	59 751.7
Residential building, energy and environmental subsidies from the provinces	Residential buildings, private households	1 906.4	1 765.3	23 936.46
Domestic environmental support (UFI)	Industry and services, processes and non-residential buildings	1 431.1	2 521.0	25 143.6
Green electricity subsidies from the Federal Government	Distributed energy generation	31.7	136.4	1 040.8
Energy taxes	All sectors Total energy consumption	3 254.3	3 796.7	45 560.0
HGV toll	Commercial transport	70.0	81.7	980.0
The Austrian Federal Government's Renovation Drive	Buildings	293.8	319.2	3 972.2
klimaaktiv mobile	Transport	16.5	8.1	164.3
Climate and energy fund	Services, industry, transport, Public bodies / municipalities / regions	251.8	730.5	6 145.8
Total		**9 743**	**16 416**	**166 695**

Table 2 NEEAP extract with Policy Measures for EE

1. Residential building subsidies, energy subsidies and environmental subsidies from the provinces

In the provinces, the enhancement of the thermal quality of residential buildings and the expansion of efficient heating systems are supported by the funds earmarked for residential building subsidies. The level of subsidy is dependent on the thermal quality achieved or the efficiency of the heating system. In addition to requirements relating to usable energy and final energy, new construction subsidies are subject to increased requirements as regards primary energy demand and CO2 emissions.

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The nature of the support differs from province to province and is provided in the form of loans, grants and/or subsidies.

Budget: In 2015: €2530 million, including around €710 million for renovation (IIBW, 2013).

2. Green electricity subsidies from the Federal Government

The Green Electricity Act provides for, among other things, feed-in tariffs for photovoltaic systems. For systems mounted exclusively on the side or on top of a building, a feed-in tariff of 8.24 cent/kWh is granted on application if the contract was signed by the end of 2016.

Photovoltaic systems with an installed capacity of more than 200 kWp and systems installed in open spaces are not eligible for subsidies. For systems mounted on the side or on top of buildings, in addition to the feed-in tariff an investment costs subsidy of 40% of the investment costs is granted, up to a maximum of €375/kWp. Furthermore, subject to certain conditions, cogeneration plants are incentivised by means of investment costs subsidies pursuant to Section 25 of the Green Electricity Act

Budget: In 2016: €122.9 million for photovoltaics.

3. The Austrian Federal Government's Renovation Drive

The Austrian Federal Government's Renovation Drive has become established as an important and successful incentivising instrument for companies and private individuals for the purposes of reducing energy consumption. The subsidies are provided in the form of one-off, non-repayable grants.

In 2016, around 10 400 renovation projects were supported, and sustainable investments of €370 million were thus initiated. Up to €8 000 was able to be claimed for the renovation of buildings and dwellings. The average subsidy amount per renovation project was €3 450.

Thermal renovation, renovation cheque for private individuals 2016

Subsidies are paid in respect of thermal renovations in private housing for buildings which are more than 20 years old (date of the building consent). The insulation of external walls and top-floor ceilings and the renewal of windows are eligible for subsidies. The renovation cheque is aimed at (joint) owners, leaseholders or tenants of detached or semi-detached houses or at owners/tenants of apartments in multi-storey residential buildings. The subsidy amounts to up to 30% of the costs eligible for subsidy, or at most €8000 for the thermal renovation in the sphere of detached houses and up to €3000 per apartment in multi-storey residential buildings.

If insulation products made of renewable raw materials are used, a supplement of €1000 can be claimed. One innovation in the 2016 renovation cheque in comparison with the federal support initiatives for thermal renovation over the last few years is that the model renovation in the sphere of detached houses has been added as a new type of renovation, i.e. more support is provided for renovation projects which are particularly ambitious from a thermal/energy perspective.

Budget: In 2016, funding of €43.5 million was earmarked for the Federal Government's Renovation Drive. €33.5 million of this is available for private dwellings and €10 million for enterprises.

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6.2.2. France

Implementation of the EPBD

In France, the current thermal regulation in response to the EPBD is the **RT 2012 (Réglementation Thermique 2012)**. It has been mandatory only for some public buildings since the end of 2011, and for all new buildings since 2013 while it does not apply to renovation of existing buildings.

The next thermal regulation is planned for 2020 and it will contain even more ambitious objectives, since it will also include environmental requirements, most likely based on a life-cycle analysis. In order to anticipate this new regulation, a testing scheme called "E+C- (standing for Energy plus Carbon minus) was launched for volunteering contractors in late 2016.

Regulation and plans to improve the existing building stock

As mentioned above RT 2012, which transposes the requirements of EPBD, is applicable only in case of new buildings. Renovations of existing buildings go under two different thermal regulations. The first one, called "RT par élément" (Regulation by Building Component or item-by-item Thermal Regulations), was published in late 2007 and the second one, called "RT globale" (Global Thermal Regulation), in April 2008.

Both regulations were reviewed in 2016 and the new requirements are set to come into force in 2018. Although the updated regulations are quite ambitious, they are still below NZEB requirements, so that renovated buildings do not systematically reach the NZEB level. Figure 38, below, extracted from the CA-EPBD report of 2016, shows how to determine the type of renovation (major or minor) and therefore the necessary regulation to apply.

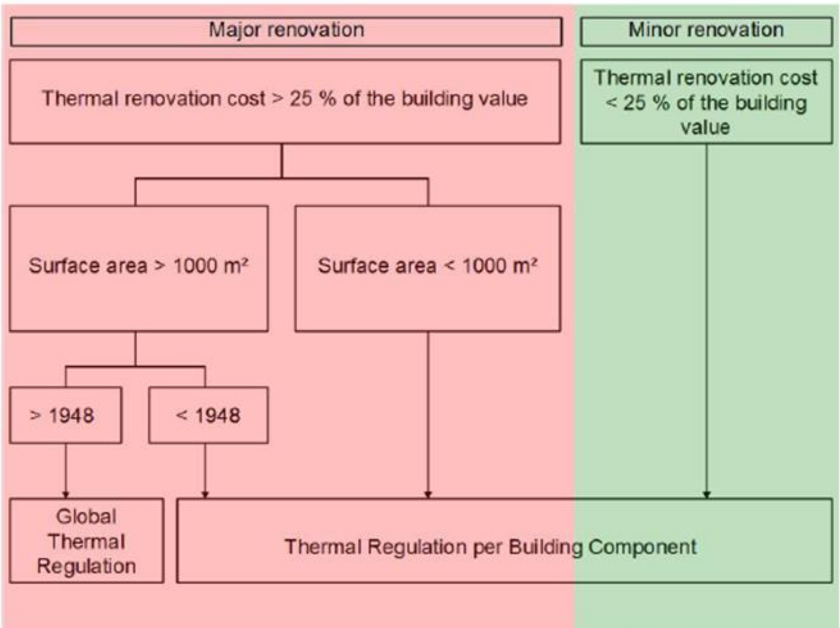

Figure 38 Thermal regulations for existing buildings

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The Global Thermal Regulation, that applies on specific Major Renovations (surface area greater than 1000 sqm and year of construction of the building under renovation succeeding 1948, see Figure 38) is based on the overall consumption with minimum requirements for each component of the building (envelope and technical systems). The methodology of calculation adopted is currently under review in order to make it consistent with the methodology used for new buildings (dynamic hourly calculation, run every hour of a full year).

For housing, the Global Thermal Regulations impose a maximum consumption value: the energy consumption of the renovated building for heating, cooling and domestic hot water must be below the limit value, which depends on the type of heating and climate. This maximum consumption is between 80 and 195 kWhep/m2/year. For buildings smaller than 1 000 m2 or for buildings larger than 1000 m2 undergoing minor renovation work or constructed before 1948, the item-by-item Thermal Regulations set a minimum performance for those items replaced or installed: this covers in particular insulation, heating, hot water, cooling and ventilation equipment.

In order for renovated building to reach the standards set for NZEB level, French Government has developed several quality seals in order to encourage owners to go beyond the regulation requirements.

For existing residential buildings there are two quality seals: “High Performance Energy 2009” (HPE 2009), demanding a level of 150 kWh/m^2/year, and “Low Energy Consumption Renovation 2009” (BBCR 2009), demanding a level of 80 kWh/m^2.

Furthermore, the National Plan for Housing Thermal Renovation launched in 2013 is based on 3 pillars:

• assisting private individuals with free of charge independent advice;

• improving financing by optimised grants based on households incomes;

• raising the skills in the construction sector to handle the cost and quality of renovations.

Finally, in order to provide motive for investments, a fund will be established, which will serve as guarantee of loans with higher risk and will reimburse banks in case of non-payment. This should also keep the interest rates of loan at the lowest level.

Financial instruments and incentives for existing buildings

French Government has adopted a wide selection of financial instruments and tax measures in order to promote the renovation of existing buildings. In detail:

1. <u>Energy transition tax credit (crédit d’impôt transition énergétique – CITE)</u>

The energy transition credit tax (CITE) is a tax credit givent for the purchase and installation of the most energy efficient materials or equipment in terms of energy savings or for the production of renewable energy.

The tax scheme was enhanced in 2014 and since then the tax benefit covers up to 30% of the expences is repaid in one installment, regardless any income conditions. The only requirement is for installers to be have RGE qualifications.

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Budget: The cost of the scheme in 2016 (for expenditure made in 2015) is estimated at EUR 1.6 billion, which has enabled EUR 5.8 billion of work.

2. <u>VAT at reduced rate for renovation work</u>

The reduced rate of VAT of 5.5 % was introduced in 2014. It can be applied only for work to improve the energy quality of housing constructed more than two years earlier, as well as associated work that cannot be avoided. The only requirement is for materials used to respect technical characteristics adopted by a ministerial order.

Budget: The cost of the measure is estimated at EUR 1.1 billion in 2015 and in 2016.

3. <u>Interest-free eco-loan (eco-PTZ)</u>

Eco Loans were introduced in 2009 and consist in loans with a 0% interest rate, provided by banks that can then benefit from the tax credit on the interest not received. It is aimed at owner occupiers or landlords carring out major renovation works and is subject to the satisfaction of specific requirments:

- the renovation must be substantial (roof or wall insulation, replacement of at least half of the windows, installation of a high-performing HVAC system, RES heating or domestic hot water system)
- The renovation has to result in a minimum level of 'overall energy performance' of the housing, calculated by a thermal consultancy office;

The maximum amount is 30,000 € over a 10-year period, although banks can extend them up to 15 years.

Eco-loan have been amended and improved over the years. For instance,

- since 2011 the eco-PTZ have been opened up to associations of joint owners
- since 2015 technical criteria of the eco-PTZ have been aligned with those of the CITE and, above all, since then, it has been become possible to apply for an eco-PTZ in order to purchase a property and carry out the renovation work.
- since 2016 it has been possible to combine the eco-PTZ with the CITE without any income conditions.

Budget: The tax expenditure on the eco-PTZ amounted to EUR 110 million for 2015, while for 2016 were expected to amount to EUR 75 million. When talking about tax expenditure in this case it is from the point of view of the government through the tax credit on interest granted to the financing parties. Moreover, it is important to note that these tax expenditures are spread over 5 years. Figure below (NEEAP) provide the trend of the tax expenditure since 2009 onwards.

Generation	Number of loans	Total budget (in million EUR)	Budget breakdown (in million EUR)						
			2009	2010	2011	2012	2013	2014	2015
2009	70 933	140		28	28	28	28	28	
2010	78 484	200			40	40	40	40	40
2011	40 755	120				24	24	24	24
2012	33 861	85					17	17	17
2013	32 464	75						15	15
2014	31 196	70							14
2015	23 567	40							
	311 260	730	0	28	68	92	109	124	110

Table 6. Generational cost of the eco-PTZ (source: MEEM)

Figure 39 Tax expenditure of eco-PTZ 2009-2015

4. <u>Anah's financial support (Grants)</u>

The National Agency for Housing Improvement (Anah) helps owner-occupiers with low income to carry out housing improvement work, and also associations of joint owners to carry out work on communal parts and equipment. Anah can finance major work on housing constructed more than 15 years earlier, if they reduce their energy consumption by at least 25%. The level of financial support varies depending on the income of the beneficiaries (35% - 60% of the investment can be funded), with a maximum amount of 20,000 € (50,000 € for deep renovations).

Budget: up to a limit of EUR 590 million per year.

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6.2.3. Germany

Implementation of the EPBD

Germany has adopted a body of legislation on the thermal insulation of buildings and system requirements for central heating since 1976 with the Energy Savings Act (EnEG).

Since 2002 the reference law is the Energy Saving Ordinance (EnEV), which replaced the Thermal insulation Ordinance (1995) and the Heating Systems Ordinance (1998) and sets energy performance requirements for new buildings and for existing buildings in case of major renovation.

Over the years the EnEV has been updated in order to either implement European Directives concerned with Energy efficiency of buildings, or to strength minimum requirements (i.e. in 2009 the minimum energy requirements were tightened up by an average of 30%).

The implementation of the requirements set by Directive 2010/31/EU was completed in 2013, with the last amendment of the EnEV, which entered into force on 1 May 2014. The strengthened minimum requirements for new building have been applied since 1 January 2016, while existing buildings are excluded from these changes of requirements

Regulation and plans to improve the existing building stock

The Federal Government of Germany foresees an energy-neutral building stock by 2050. Consequently, by that date, the non-renewable primary energy demand of the building stock needs to be reduced by 80%. The three instruments considered to be used in that strategy are regulatory law, financial incentives, as well as information and advice.

As anticipated, Energy Saving Ordinance (EnEV) is the reference law which sets energy performance requirements also for the refurbishment of existing buildings, even though the last amendment, entered into force on 1 May 2014, didn't introduce any tightening of the requirements to external components of existing buildings in the event of their replacement.

However, in the specific case of relevant refurbishment, the Energy Saving Ordinance allows choosing between the following two procedures:

• To meet specific energy performance requirements for building elements and installations;

• To attain 140% of the performance requirements for a new building (calculated using the reference building status 2014).

With reference to the financial incentives, the main programmes can be summarized as follows:

- KfW programme
- incentives programme for energy efficiency (APEE)
- incentives programme for heating with RES (MAP)

Financial instruments and incentives for existing buildings

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The Federal Government has implemented many measures aimed at directly or indirectly incentivizing the process of the deep refurbishment of the existing buildings. Many of which are included in the 'National Action Plan on Energy Efficiency' (NAPE), which represents a comprehensive energy efficiency strategy summarising the relevant goals as well as the new immediate measures, funding sources and the remits of individual stakeholders.

Among the others, the federal CO2 Building Renovation Programme set up by KfW is the largest funding instrument in Germany. Through this programme, Energy efficiency measures in buildings are supported with low-interest loans and in part repayment or alternatively investment grants.

The "Energy-Efficient Refurbishment" programme offers low interest loans for financing measures aimed at saving energy in existing residential buildings and applies to refurbishment of houses that, after refurbishment, do not exceed a specific energy requirement for a comparable new house, as set out by the Energy Saving Ordinance (EnEV). Six levels of support for a "KfW Efficiency House" have been defined:

- KfW Efficiency House 55
- KfW Efficiency House 70
- KfW Efficiency House 85
- KfW Efficiency House 100
- KfW Efficiency House 115
- KfW Efficiency House Monument

Where the number indicate in per cent how much of the maximum primary energy requirement, specified by the EnEV, the house consumes after the refurbishment.

Private investors can apply either for a grant or an exemption from a share of debt (bonus repayment). Both grant and debt relief vary in proportion to the level of refurbishment. Specifically, grants range from 15% (for a KfW Efficiency House Monument, up to a maximum amount of EUR 15,000) to 30.0 % (for a KfW Efficiency House 55, up to a maximum amount of EUR 30,000)) of the incurred costs. Alternatively, incentives, in terms of partial debt relief, range from 12.5% to 27.5% of debt for the most ambitious level, Efficiency House 55. The maximum loan amount is 100,000 € per housing unit

There is also the option to apply for a grant (7,500 € for a heating or ventilation package; otherwise a maximum of 5,000 € per housing unit).

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6.2.4. Italy

Implementation of the EPBD

Italy took the first step toward the implementation of the EPBD recast (Directive 2010/31/EU) into national law in 2013, with the presentation of the Italian cost-optimal methodology to the European Commission and the issuing of legislative Decree No 63 of 4 June 2013, which amended Legislative Decree No 192/2005, transposing Directive 2002/91/EC (the Energy Performance of Buildings Directive, EPBD).

The transposition was finally completed in 2015, when Interministerial Decree of 26 June 2015, composed of three separate Decrees, was published.

A review of the cost optimal methodology is planned in time for the five-year review of the minimum energy performance requirements, as provided for in Article 4 of the Directive.

Regulation and plans to improve the existing building stock

The three Decrees making up the Interministerial Decree are split as follows:

The first Decree

1- defined the criteria for nearly zero-energy buildings and set new minimum standards, in force since 1 October 2015;
2- introduced a new method for calculating a building's energy performance;
3- amended the services to be taken into account when evaluating the building's performance;
4- determine how to classify the buildings from an energetic point of view;
5- Introduce different levels of renovation of existing buildings, depending on the extent of the work.

The second Decree provided procedures and framework for compiling the project technical reports, relating to (1) new buildings, major renovations and nearly zero-energy buildings, (2) works on upgrading the energy efficiency of existing buildings and secondary major renovations, by improving the building envelope and heating systems and (3) upgrading the energy efficiency of technical installations.

The third Decree described the guidelines, transitional measures, the modalities for consultation and cooperation between the State and the Regions with regard to the issuing of energy performance certificates (EnPCs);

As mentioned the first decree defines different levels of renovation, according to the extend of the work. In detail they are defined as follows:

- Major renovations – first level: refurbishment of at least 50% of the envelope and renovation of the heating and/or cooling plant of the entire building
- Major renovations – second level: refurbishment of at least 25% of the external surfaces of the building with or without renovation of the heating and/or cooling plant.
- Minor renovations: refurbishment of less than 25% of the external surfaces of the building and/or modification of the heating and/or cooling plants.

In case of major renovations of first level, the standards for new buildings (nZEB), set through the cost-optimal methodology, apply to the whole building, limited to the considered energy service. Otherwise, in case on major renovations of second level, the mean transmission heat transfer coefficient of refurbished building elements has to be lower that the limit values set in the decree. Finally, for the last

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level or renovation, is sufficient for the performance of single components to comply with mandatory limit values.

Considering the current the low rate of new constructions, efforts are being concentrated on renovating towards nZEB levels, which is confirmed by the requirement for major (1st level) renovated buildings to comply with the same nZEB requirements as new buildings.

Among the measures addressing the transition of the existing stock to nZEB can be mentioned:

- Progressive strengthening of the building regulations: minimum standards in 2016 are 15% more rigorous compared to the previous ones.
- Awareness raising and capacity building pursued by several public and private initiatives.
- Incentives to nZEB standards for major (1st level) renovation are provided in terms of reduced construction tax burdens, both at national and regional levels.

Financial instruments and incentives for existing buildings

Various incentive-based instruments exist at national level to promote energy efficiency in buildings. Among them the most effective in fostering the transition of the national building stock towards nearly zero-energy buildings are:

1- Thermal energy account

Incentives for small-scale thermal energy production from renewable sources and for energy efficiency improvements. In accordance with the provisions laid down in Legislative Decree No 102/2014, the Decree of the Ministry of Economic Development of 14 February 2016 updating the Thermal Energy Account (‘Thermal Energy Account 2.0’) provides, for all projects eligible for the Thermal Energy Account, through direct access (public authorities and private individuals), for the release of the amount payable in a single instalment, provided the value does not exceed EUR 5,000.

Budget: Since the mechanism was launched on 1 December 2016, more than 24 400 applications have been approved and have benefited from the incentive. This equates to a total of around 89 million in committed incentives, 71 million of which concern projects carried out by private individuals, and the remaining 18 million relating to projects executed by public authorities.

2- Tax relief for the energy-efficient renovation of building stock

Tax reliefs on projects designed to upgrade the energy efficiency of buildings was introduced by the Italian 2007 financial law and are a key driver of energy efficiency improvements in the housing sector. Overall, the projects carried out (around 1.85 million at 31 December 2013) have contributed to a final energy saving currently in excess of 1.16 Mtoe/year. This has had a positive environmental effect, resulting in CO2 emissions avoided of more than 3 million tonnes per year.

They consist of reductions of personal income tax (IRPEF) and corporate income tax (IRES) granted to cover, over a ten-year time horizon, up to 65% of the expenses incurred for the overall energy performance upgrade of the building, including major and minor renovations.

If the works are carried out under finance leases, the user is entitled to claim tax relief, which is then calculated on the basis of the cost incurred by the leasing company. The following in particular are eligible for the subsidy:

- individuals, including skilled tradespeople and professionals;

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- taxpayers who earn business income (individuals, partnerships, corporations);
- professional associations;
- non-profit public and private organisations.

The following individuals may also take advantage of the subsidy:

- holders of a right in rem over immovable property;
- tenants' associations, for works on common areas of a multi-apartment building;
- tenants.

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6.2.5. Spain

Implementation of the EPBD

Royal Decree 314/2006 of 17 March 2006 adopting the CTE (Código Técnico de la Edificación [Spanish Building Code]) is the regulatory framework that establishes the basic safety and habitability requirements that buildings have to fulfil. Among the core documents of which is composed, those on energy saving (Documento Básico de Ahorro de Energía, DB-HE), have been amended by Order FOM/1635/2013 (10 September 2013), which came into force in March 2014 and raised the level of the minimum energy-efficiency requirements for new buildings and for extension and renovation of existing buildings.

The update of the above-mentioned core document, constitutes the first step towards the goals set by Directive 2010/31/31 for Members States. Further steps toward the implementation of the EPBD recast into national law in 2013, have been taken by the issuing of the Decree 235/2013 and the Royal Decree 238/2013.

Specifically:

- Royal Decree 238/2013 amended the Regulation on Building Heating Systems (RITE) of 20 July 2007), devoted to regulate the minimum output requirements applicable to heating, cooling, ventilation and domestic hot water systems, setting out stricter requirements concerning the energy performance of heating and cooling equipment.
- Royal Decree 235/2013 approved the basic procedure to certify the energy efficiency of new and existing buildings

While the official definition of nZEB is still to be approved, the Royal Decree 56/2016, transposing EU Directive 2012/27/EU, presented the nZEB concept as it is stated in the EU Directive 2010/31/UE, although not providing details neither on its implementation nor on specific requirement targets.

Regulation and plans to improve the existing building stock

Despite Spain having experienced an excellent growth in terms of renovations of existing buildings in recent years (+12.8% of building permit for refurbishment and/or restoration between 2014 and 2016), renovation rates of the residential stock are still low in comparison with other countries in the EU.

The strategy adopted to improve the existing building stock at higher rate is based on a critical analysis of the results of action plan developed and described in the framework of the ERESEE 2014 (Long Term Strategy for energy renovation in the building sector in Spain pursuant to article 4 of Directive 2012/27/UE). Consequently, the update focused on the qualitative improvement of those public policies and instruments already adopted in order to achieve the final objectives of energy savings and reduced emissions, which are based on the following points:

- measures of finance and operations;
- information and communication measures;
- measures to develop business strategies, specifically focusing on communities of building owners;
- specific measures to deal with energy poverty.

Financial instruments and incentives for existing buildings

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The main measures taken to promote renovation of existing building are broken-down as follows:

1. State plan to promote rental housing, building renovation and urban regeneration and renewal 2013-2016 (extended to 2017) (Ref ERESEE 2017)
   Among the several housing aid programmes introduced by Royal Decree 233/2013, programme n°4 is specifically designed to promote building renovations.

   Programme n° 4 to promote building renovation.

   This programme aims at financing maintenance and renovation works of common private houses, of collective residential buildings that meet certain requirements, including dating from before 1981.

   Three types of actions are eligible for subsidies, one of these being related to “improving quality and sustainability”, This includes works on the building envelope allowing to achieve a reduction in the global annual energy demand for heating and cooling of the building, in terms of energy certification, of at least 30 % with regard to the situation prior to the works. In this case subsidies can amount up to €2 000 while, if the reduction is over 50 %, can go up to €5 000.

2. Pareer and Pareer Crece programmes
   PAREER programme, initially launched in September 2013, was allocated a budget of EUR 125 million and aimed at promoting the implementation of energy-efficiency improvements and the use of renewable energies in existing residential buildings (houses and hotels).

   Law 36/2014 of 26 December 2014 was applied in order to expand PAREER's scope and to include the largest possible number of existing buildings, in accordance with the objectives of Directive 2012/27/EU. This extended the programme´s budget including an allocation of EUR 75 million. On top of this, the programme was carried on the 3rd of May 2016 with EUR 200 million of budget and then a second round was launched until 31st of December 2018 (Pareer II) with EUR 203.6 million (78 million on top of the initial 125.6 million). The measures that can be financed fall into one or more of the following categories:

   1. Improvement of the energy efficiency of the thermal envelope;

   2. Improvement of the energy efficiency of heating and lighting systems;

   3. Replacement of conventional energy with biomass in heating systems;

   4. Replacement of conventional energy with geothermal energy in heating systems.

   Moreover, the beneficiaries of any aid coming through the program must enter the following category:

   a) The owners of existing buildings intended for any use;

   b) The communities of owners or groupings of communities of owners of residential buildings for residential use, constituted as Horizontal Property;

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c) Owners who, in a grouped manner, own buildings and have not established the title of horizontal property;

d) Operators, tenants or concessionaires of buildings;

e) Energy service companies.

The measures receiving support must improve the overall energy rating of the building by at least one letter, as measured on the carbon dioxide emissions scale (kg CO2/m2 per year), when compared with the building's initial energy rating. That improvement in the building's energy rating may be achieved by adopting a single measure or a combination of several measures.

The aid consists of a monetary grant without consideration, based on the eligible cost of the measure. This aid could be increased by additional aid, dependent on fulfilment of the three criteria below, up to the maximum permitted amount.

a) Social criteria: actions carried out in residential buildings that have been definitively qualified under some public protection regime, by the competent body of the corresponding Autonomous Community, or the actions are carried out in residential buildings located in the areas of Urban Regeneration and Renewal, in accordance with the State Plan for the Promotion of Housing Rental, Building Rehabilitation, and Urban Regeneration and Renewal 2013-2016;

b) Energy efficiency: actions that raise the energy rating of the building to obtain an energy class "A" or "B", on the CO2 scale, or, increase in (2) two letters the initial energy rating;

c) Integrated action: actions that simultaneously perform the combination of two or more types of action.

The following table details the payment structure of the Pareer II program which ended recently at the end of 2018:

Types of renovations/measures	Maximum grant given without defined set of conditions		Maximum grant for reimbursable loan
	Base grant	Additional grant	
Type 1: Improvement of the energy efficiency of the thermal envelope.	30%	Depends on social criteria, EE improvement goal or combined measures.	60%
Type 2: Improvement of the energy efficiency of heating and lighting systems.	20%		70%
Type 3: Replacement of conventional energy with biomass in heating systems.	30%		60%

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Type 4: Replacement of conventional energy with geothermal energy in heating systems.	30%		60%

Table 3 Pareer grant program structure

The percentages above are expressed as part of the eligible costs.

Furthermore, the following table depicts the repartition of the funds for the 2013 exercise emphasizing support given to the first type of measures relating to envelope renovations.

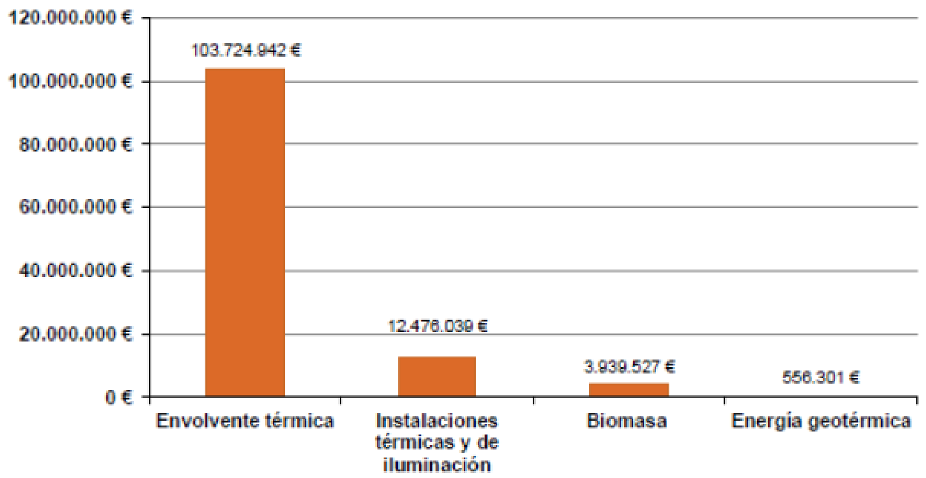

Figure 40 Repartition of Pareer Crece grants during 2013 for each typology

3. ICO FINANCING FACILITY

   Financings provided by Spanish Official Credit Institute's [Institutos de Crédito Oficial – ICO] devote to cover any items that are renovation works in dwellings and/or buildings and/or the refurbishment of their shared elements, including labour and professional fees.

   The conditions of the loans are as follows: the maximum amount per customer is up to EUR 12.5 million, in one or several transactions. The interest rate may be fixed or variable, plus the margin established by the credit institution according to the maturity period, which can be up to 20 years with up to two years' grace period.

   In 2016, 995 actions have been financed for an amount of € 30,427,282

4. Jessica-FIDAE Fund

   The JESSICA Holding Fund and the FIDAE (Fondo de Inversión en Diversificación y Ahorro de Energía [Energy Saving and Diversification Investment Fund]), aimed at financing sustainable urban development projects that improve energy efficiency, use renewable energies and are implemented by energy service companies or other private enterprises, provided that the project:

   - is located in the following autonomous communities: Andalucia, the Canary Islands, Castile and Leon, Castile-La Mancha, Valencia, Extremadura, Galicia, Murcia or autonomous cities of Ceuta and Melilla

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- guarantees an acceptable return on investment
- included in integrated sustainable urban development plans

The financing can cover up to 70% of the eligible expenditure while the interest rate is calculated as the Euribor plus a margin that can range from Euribor +0.75 % to Euribor +4 %.

Budget: EUR 123 Millions

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7. Preliminary results

7.1. Understanding of the dynamics related to energy renovations

After a long period of economic stagnation, conditions for the construction and renovation industry are currently favourable throughout Europe. In fact, although on the one hand energy prices are still low (paragraph 4.1.2), partly as a result of the fiscal policies of many EU countries which incentivize the energy consumptions setting reduced VAT rates for energy products making energy efficiency investments less cost-effective and consequently less attractive, on the other hand the economic framework is currently characterized by favourable drivers such as:

- Economic expansion rather diffused (paragraph 4.1.1)
- Growth of the housing market, featured by a growth in demand (paragraph 4.2.2)
- Low cost of money, which implies:
    - Low interest rates
    - Low yield of free and low-risk investments, such as government securities (paragraph 4.2.1) and, therefore, absence of attractive alternative form of investment with the same risk profile.

Under the light of this rather positive macroeconomic momentum, it would be reasonable to expect increasing investments devoted to energy-efficient building renovations, at least in those countries showing a better health of the housing sector and characterized by energy polices more oriented towards the greenhouse gas emission reduction, in line with the target set by the European Commission.

Instead, growth of the investments in this area until at least 2015 have remained weak (paragraph 5.1). Looking for instance at Germany, seen as a model by other EU countries especially for its KfW's support scheme, not only was the volume of subsidies awarded by KfW Group on the decline, but more in general, the total volume of energy efficiency investments was stagnant as represented in the following figure.

Million Euros at current prices

	2009	2010	2011	2012	2013	2014
New construction of energy efficienct buildings	3,094	3,654	3,613	5,640	6,265	5,623
Energy efficiency refurbishment	5,769	5,092	2,896	4,247	4,103	3,697
Program: “KfW Effizienzhaus”	3,772	3,292	1,639	1,976	1,862	1,795
Small scale refurbishment	1,898	1,653	1,198	2,186	2,022	1,725
KfW grants	99	147	59	85	159	148
supplementary loans	–	–	–	–	60	29
total	14,632	13,838	9,405	14,134	14,471	13,017

Figure 41: Volume of committed loans and grants by KfW among 2009 and 2014 (DIW Economic Bulletin 19.2015)

Even worse was, obviously, the situation in those countries characterized by lesser growth in the Real Estate field (paragraph 4.2), and by a fragile and fiscally constrained economic environment. In this sense, looking at Italy, again in 2015, data related to energy efficiency measures in place (Tax relief and thermal account) shows that the surface annually renovated was just equal to 0,5% of that potentially affected by such measures and within which only 1% would qualify as nZEB level requirements (PANZEB 2015).

While figures for Italy appear to be partly justified by the particular economic situation, with regard to Germany this seemed to be to a large extent due to the wait-and-see attitude of real estate owners who

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occupy their own house and who, in the best case scenario, were tending to carry out small-scale interventions instead of energy renovation initiatives implying the comprehensive modernization of the houses.

The new stimuli agreed in the third NEEAP (paragraph 6.2.3) have allowed a trend reversal in Germany and, since 2017, investment in existing buildings has started to grow again significantly (+7% in 2017 - DIW Weekly Report 1+2 – 2019 Construction industry momentum continues – state stimulus impacts prices). There remains, however, some concern such subsidies may result in one-off effect. Potentially, the additional financial incentives and in general the introduction of liquidity at low rates would appeal to owners who would have had to retrofit their homes anyways, regardless of the subsidies, subtracting that slice of demand in future periods involving therefore the risk of a new housing bubble.

In light of these observations, it seems that evolutions in renovation rates are not attributable to a limited set of drivers or variables but rather a complex combination of factors pertaining to specific regions and countries with different geographical, political and economic realities and typologies. Indeed, when observing for instance exceptionally low renovation rates of Spain (compared to other MS averages) in comparison to their relatively high natural gas prices compared to the rest of EU countries and their high reliance on this source within their energy mix, it becomes clear that high energy prices are not always a critical variable or automatically correlated to higher EE renovations. This is also supported by the fact that France possesses lower natural gas and electricity prices than many EU countries and yet has a significantly higher renovation rate, albeit still low. Moreover, macroeconomic indicators and positive trends are insufficient in bringing light to these dynamics on their own as well. As discussed above in this very section, Germany has seen stagnating or decreasing energy efficiency refurbishments (in sheer volume) contrasting with a rather favourable macroeconomic landscape. In terms of climate, it seems to be a potential driver as colder nations with higher HDD and lower CDD results do tend to exhibit higher renovation rates underlining more incentives for thermal renovations as underlined by the dynamics in supply and equipment sales (windows, thermal insulation products…). Nevertheless, this effect is not universal as exemplified by the exceptionally low renovation rates of certain member states such as Poland. Incentives through EnPCs provide no direct explanation either as Norway, which boasts the highest renovation rates in Europe between 2010-2014, is one of the nations with the lowest appreciation score for the usefulness of EnPCs. Finally, considering the analysis we have performed on respective energy policies (within the 5 nations most represented within this consortium) it is impossible to only attribute higher renovation rates to government aids and subsidies as the total volume spent on these programs is not always equivalent to proportionally higher renovation rates in respective nations.

Therefore, it is clear that in order to acquire a deeper understanding of what drives and inhibits the growth of EE renovations around the EU, it is important to contextualize a set of more specific barriers that may be overshadowed by the more generalist variables and indicators that have been compiled and analysed in this deliverable so far. Furthermore, in order to gain further insight, the relevance of these barriers must be characterized in terms of criteria such as geography and climate, building typologies, stakeholders involved and specific renovation cases where they may appear (to name a few).

The next section of the report will thus be focused on the identification of the said barriers through existing literature, partner experiences, market knowledge and external consultation and then go fourth with a definition of the dynamics behind each of these barriers through interview processes, case studies and empirical work which has been performed during the course of this project.

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7.2. Preliminary identification of the barriers

As mentioned in the above section, it is crucial to move from a macro-level of analysis into the trends of the EE renovation market to a more specific micro level of analysis of the potential barriers that have potentially impeded the rise in renovation rates across the EU. Once these potential barriers are identified it is possible to evaluate their relevance and importance in understanding renovation dynamics throughout the European continent (in the case of this project focus was brought on Germany, France Spain and Italy mainly).

In order to perform this identification task, a literature review, partner experiences, market knowledge and external consultation were employed.

From the point of view of the literature review, a series of different sources were used and consolidated such as multiple publications and reports of the BPIE, The Centre for Energy Policy and Economics, research papers such as that of Beillan et al. (2011) or Palm and Reindl (2018), JRC publications, European Parliament and the Directorate General for Internal Policies.

All barriers that are identified in this section will generally enter within the realm of one of the more general variables examined in the previous section on market trends for the European EE renovation market. For instance, potential financial short comings such as lack of access to capital relate directly and will be influenced by the more general macroeconomic indicators discussed earlier such as YoY GDP growth.

In this case the consortium, as a result of gathered inputs and upon feedback of the advisory board, has proceeded to a more precise segmentation of barriers in order to pinpoint survey questions in a more precise and efficient manner so as to obtain the best feedback possible.

Identified barriers have been ranked according to barrier category, barrier typology and then the actual barrier with a description provided.

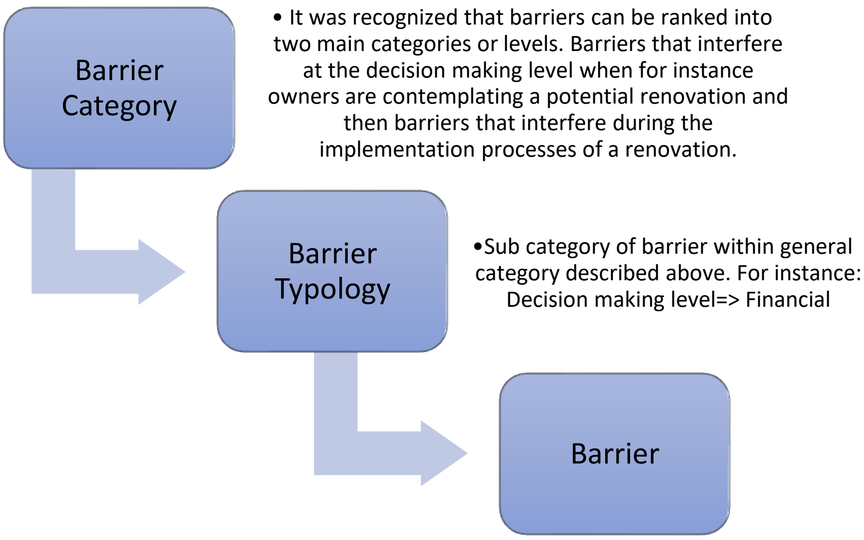

Figure 42 Barrier nomenclature

Taking the above classification system into consideration, the resulting preliminary identification through the above described processes has yield the following table (see next page).

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Taking into consideration the above classification, the next part of the deliverable will focus on bringing insight in terms of the relevance of each of the barriers through interview processes, case studies and empirical work which has been performed during the course of this project. This will enable an understanding of the situations and areas in which particular barriers are likely to limit renovation uptake and therefore propose more specific solutions tailored to these particular situations.

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Barrier Category	Barrier Typology	Barrier	Description
Barriers that limit uptake of refurbishment solutions at the decision-making level for homeowners, buyers or end-users. (likely to be found in most regions in some form or another)	Technical	Performance Gap and uncertainty	Difference between simulated or predicted savings with savings during actual building operation Hinders the appeal and formulation of financial approaches and incentives such as EPCs. Need for materiels and technologies that can be implemented faster (ie prefab solutions...) in order to limit the obstructiveness of renovations.
		Lack of technological and product developments	Need for digital technologies as well as materials and equipment aiming benefits such as shortened renovation times
	Embedded market inefficiencies	Split Incentives and conflicts of interest	Oversizing of equipment, Tenant vs owners
	Informative	Lack of knowledge dissemination and convincing end users of the benefits of deep renovations	Lack of information and awareness in relation to: • non-energy and non-financial benefits that result from refurbishments (comfort, spillovers on productivity, health...) • Financing options • Expert and unbiased advice to help small owners to balance between financial and technical risks/benefits • Uncertainties about contractor reliability
		Difficulties in conveying non-energy benefits of retrofits	Non-energy and non-financial benefits that result from refurbishments (comfort, spillovers on productivity, health...)
	Financial	Investment approach and perspective	Opportunity costs too high Limited impact of Energy Performance Certificate improvements on property value Lack of integration of life cycle costs in financial decisions
		Limited financing	Lack of incentives and access to capital: • Limited involvement of third parties and banks to provide loans in energy performance contracts. • Limited ability for ESCOs to offer financing for energy performance contracts. High risk perception and high interest rates/discount rates/ Paybacks periods and ROIs vary and can be long.
		Externalities	Price of energy and its volatilities

Barriers that prevent stakeholders taking part in the renovation process (architects, ESCOS, construction companies...) to implement with ease successful business models.	Organization and structure of the EE renovation market	Fragmentation of the construction and renovation market	Short term coalitions and ad-hoc subcontracting leads to: • Lack of communication and poor coordination • Adversarial relationships • Inhibited learning opportunities • Short term vision with lack of life cycle cost integration in project process • Country specific cultural, industry and standardized processes Contract structures (PPPs…)
		Time and pressure on profit margins	Contractors are selected through competitive tendering with price being one of the main drivers Leads to reuse of bids and cookie cutter project approaches
		Public procurement barriers (especially towards SMEs)	• Insufficient resources on part of SMEs to tender for public procurement schemes • Sub-division of contracts into lots leads to unstable partnerships and difficulties for efficient teamwork
	Regulatory	Lack of supportive regulation	Lack of subsidies Minimum energy performance standards Renovation obligations
		Normative barriers	Local norms impeding the implementation of the optimal solutions or penetration of innovative technologies Difficulties of complying building codes
	Knowledge-informative based	Lack of skills/ Lack of training	Insufficient knowledge on EE refurbishment technologies, design approaches, contracting and when and how to implement existing solutions. Lack of specialized SMEs or other relevant companies

Table 4 Preliminary identification of potential micro-level EE renovation market barriers

8. Methodology for the contextualization of identified micro-level barriers to energy efficient renovations within the EU

The next sections of the report will be dedicated towards the compilation of the information gathered during interviews, case studies and other empirical work which has been conducted in order to understand the dynamics at play behind each of the potential barriers which have been identified in the previous section.

The survey in question was designed in order to have a high degree of segmentation that can be applied to the responses (stakeholder type, geography, climate, project size and more).

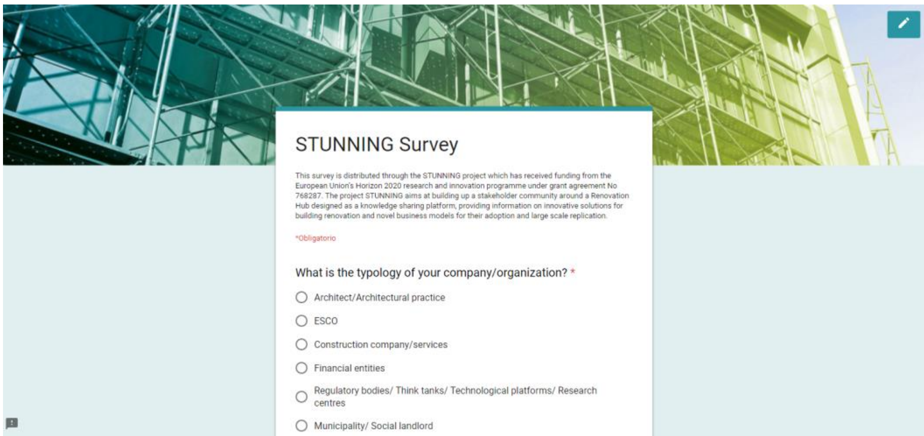

Figure 43: Online survey on barriers

The survey was not exclusively in a closed response format meaning that the respondents also had the possibility of expressing certain opinions and issues which they identified as not being directly addressed within the survey. In most questions, participants had the choice of rating barriers on a numerical scale of 1- insignificant all the way up to 5 – significant. Questions were allocated in barrier typology sections which enables an averaging of scores capable of indicating the most highly rated or significantly scored barrier typologies and then also observe significance scores at the individual barrier level.

Considering the possibility for segmentation and high granularity through the survey, the STUNNING consortium has decided to focus on the main trends and contextual dynamics for each barrier while highlighting certain aspects and developments that are more noteworthy.

The barriers tested in the questionnaire are aligned with the nomenclature of barriers provided earlier. Nevertheless, the STUNNING consortium focused on contextualizing the barriers having received the highest significance scores when more than 3 barriers were tested for a specific typology. Generally, the threshold score in these cases was of 3.5.

In terms of actual breakdown of responses, there were a total of 32 respondents segmented in the following way:

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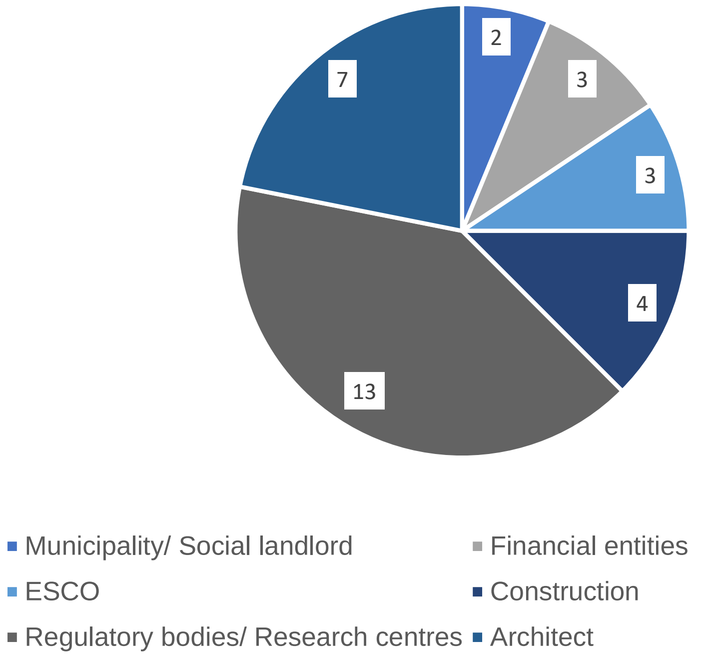

Figure 44 Segmentation of survey responses

Furthermore, general averaged significance scores per barrier typologies were as follows.

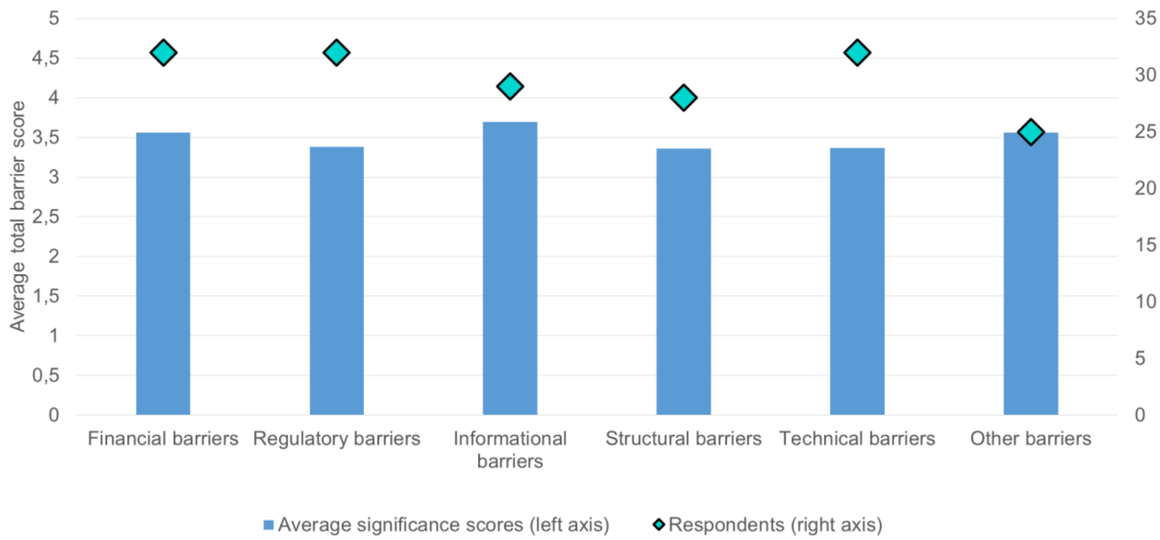

Figure 45 Average significance scores per barrier typology

In terms of case studies and DBs, a small database of cases where barriers have been identified and where the associated setting and data necessary for contextualization is available was used. Cases were mainly coming from Construction 21 and SCIS (smart cities information system) along with partners´ own experiences. These cases are also used for understanding the sensitivity of certain barriers towards certain societal configurations as required by the task. The following figure provides a

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breakdown of the number of times certain barrier typologies where observed in the analysed case studies.

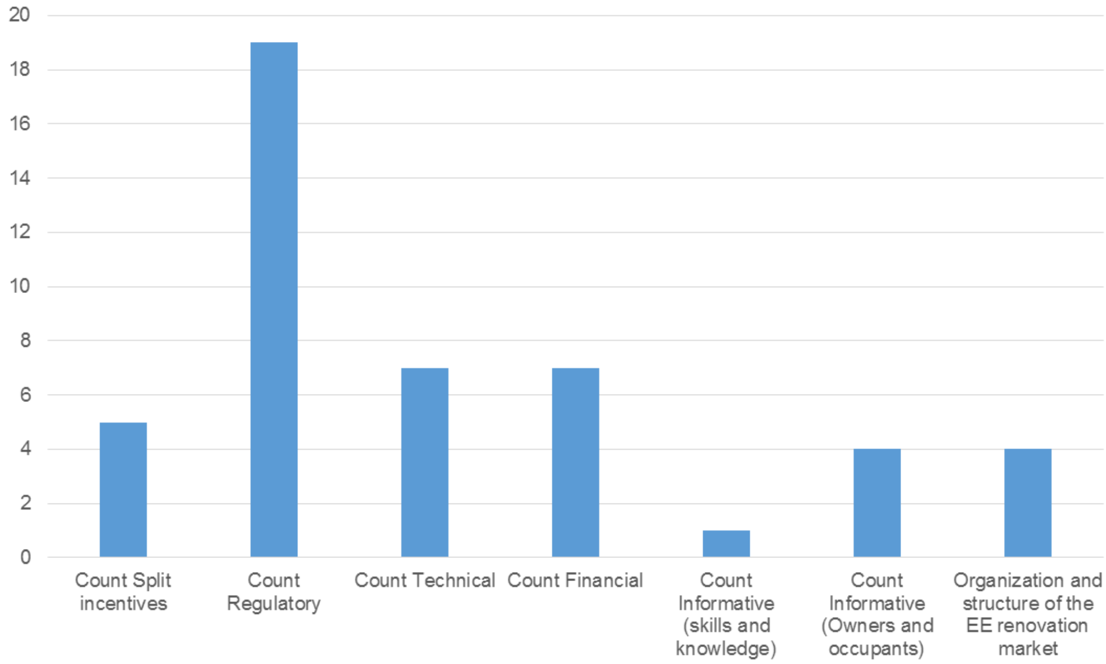

Figure 46 Breakdown of observed typologies in gathered case studies

All of this information was also cross referenced with syndicated reports in order to gather insights on the most influential barriers of the EE renovation market, what drives these barriers and to which societal variables are they most responsive to.

It is important to understand that many of the survey scores are used as preliminary indications of the market situation for a barrier. These effects where then cross checked through the remaining empirical work.

Barriers will mainly be contextualized according to the following set of criteria:

- Stakeholders: How significant is a given barrier to a specific stakeholder category;
- Size of entity: How significant is a barrier to smaller or larger organizations (can obtain insight on which barriers affect SMEs the most);
- Building typology: Are certain barriers more relevant towards specific types of buildings;
- Project size: Are certain barriers more pertinent to smaller or larger renovation projects;
- Region/country: Are certain barriers found more often in certain. The regional focus will be especially brought upon regions pertinent to the STUNNING consortium and which were well represented within the questionnaires and interviews (i.e. Germany, France, Spain as unfortunately no responses from Italy were obtained).

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For each barrier typology, the report will offer a mapping of the average barrier typology scores obtained for different member states having participated in the survey. Moreover, a mapping will also be offered which accounts for the amount of times a certain barrier typology was observed in different member states in the renovation cases we used to better understand the dynamics between the EU renovation market and its impediments. This exercise is more indicative than prescriptive at this stage as samples in the survey are too small to truly represent the entirety of European trends and the same can be claimed for the amount of cases.

9. Barriers that limit uptake of refurbishment solutions at the decision making level

9.1. Technical barrier typology

The first barrier typology that will be analyzed and contextualized within this section of the deliverable is related to technical barriers. The EE renovation market is characterized by the application of technical equipment and supplies with high requirements that are subject to changes in standards. Currently, the EE renovation market is defined by a plethora of solutions such as pre-fab systems which have increased modularity with the integration of active RES (renewable energy sources) systems such as solar panels and photovoltaic (PV) systems, IoT applications with advanced building energy management systems (BEMS), advanced heat pumps and ventilation systems as well as innovative materials. Moreover, with advanced digital design processes in the form of Building Information Modelling (BIM) and building energy performance simulation models (BEPSM), more and more advanced solutions have been gaining traction. Nevertheless, with such technical advancements there are a number of barriers that can emerge. The following maps represent on the one hand the average significance scores segmented per country for this barrier typology as a whole obtained in the survey while the other represents how many times this type of barrier was accounted for in the case studies used as an indicative measure.

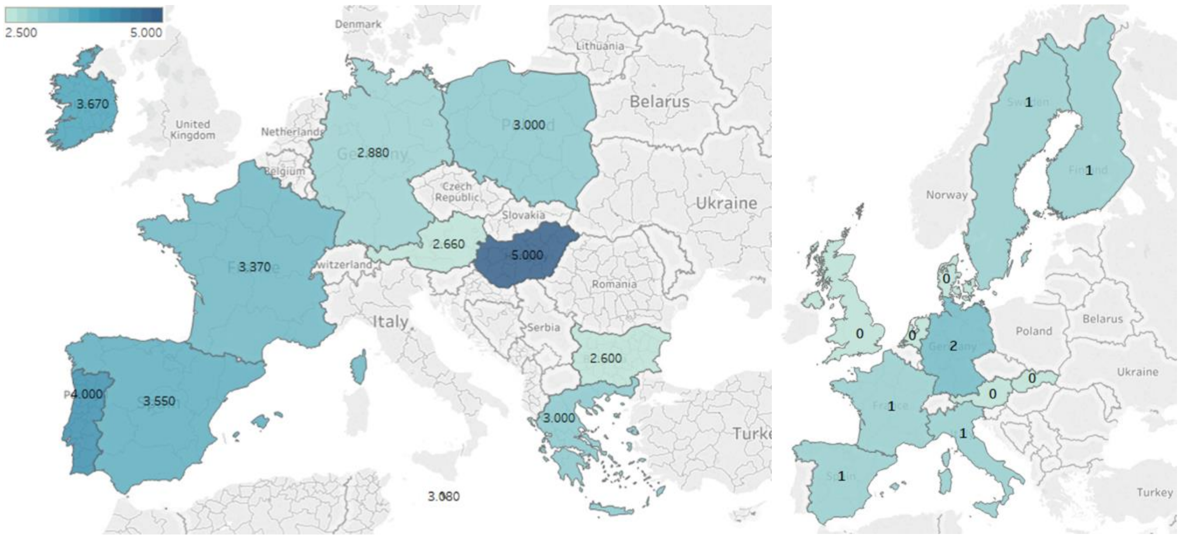

Figure 47 Left: Average technical typology score per country/ Right: Number of times technical typology was observed in case studies

Two of the most recurring barriers with regard to this typology are identified as performance gaps that emerge between simulated savings and actual operation of the building along with more general technical shortcomings and the need for more developments. It is these two barriers that will be observed and contextualized within this report according to the described methodology compiling survey responses case studies and syndicated research.

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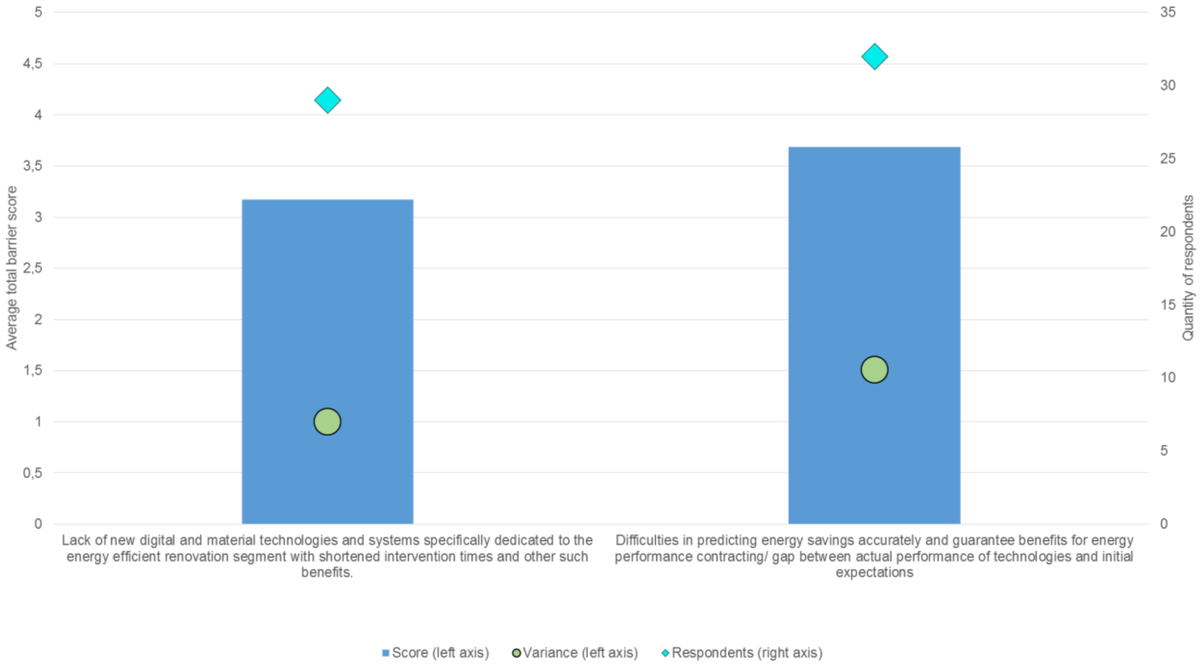

Figure 48 Technical barrier typology score and respondents

9.1.1. Performance gaps and uncertainty

The causal factors that hinder fast growth and do not allow for the vast exploitation of the unleashed energy efficiency potential, especially in the building sector, lie in the fundamental technical weaknesses of current ESCO practices and models which can be plagued with uncertainty in actual operational post retrofit savings and deceiving payback periods (which become even bigger in case of non-subsidized projects). This comes in part from the inability of current methods, techniques and tools used by ESCOs to provide accurate estimates and guaranteed savings to their clients, while eliminating risks and removing additional services that are integrated in such project to mitigate uncertainties about the effectiveness and efficiency of EE measures and associated contracts. This is often referred to as the performance gap and can sometimes amount to more than 40% difference in relation to the BEPSM model having extremely negative impacts on payback periods and ROI calculations that were used during project assessment.

For the question relevant to scoring the barrier significance for performance gaps and uncertainty within the survey, a total of 32 respondents provided feedback with a variance of 1.5. The following Figure 49 provide an overview of these scores per country and per stakeholder type. More countries have participated in the questionnaire than the ones appearing in Figure 48; as shown in Figure 49 which provides a fully segmented and averaged breakdown of responses. Nevertheless, most respondents came from France, Germany and Spain. This is rather in line with the composition of the STUNNING consortium and these will be the represented countries for the country breakdown sections for the rest of the report. The consolidated significance score for the barrier as a whole, regardless of stakeholders, country or other types of segmentation is 3.6875 out of five.

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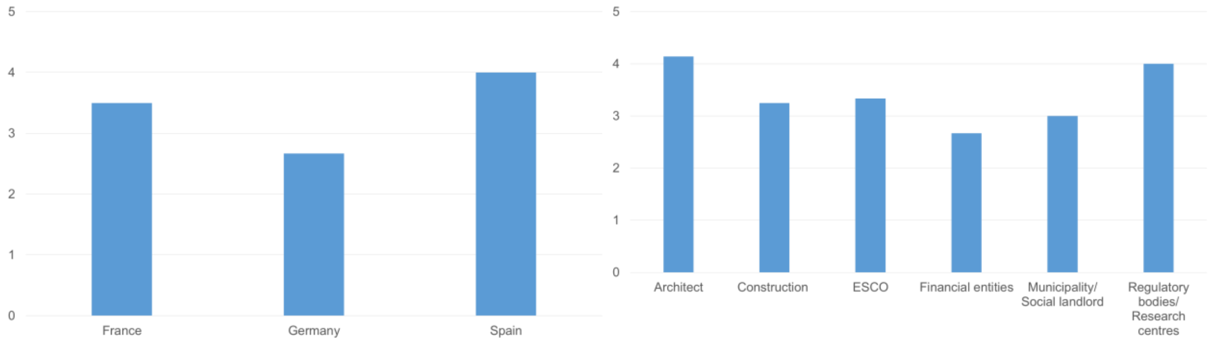

Figure 49 Country and stakeholder breakdown of barrier scores for "performance gaps and uncertainty"

A certain number of elements can be observed from the results in Figure 49 above and Figure 50 in the following page.

In terms of the stakeholders that responded, the two categories with the most important quantity of respondents are architects and research and regulatory bodies, both of which have exhibited the highest scores at 4 or above. Considering that architects intervene at earlier design stages for energy efficient renovations they may be more affected by design uncertainties which affect predictions in performance, energy efficiency and cost savings. This should logically be the case for other stakeholders who intervene in the earlier stages of the renovation process. From the perspective of financial entities, their responses were characterised by very high variability. However, if focus is brought upon the largest institutions who provide a higher volume of loans and work on projects of all sizes and building typologies, the score is considerably higher implying that the barrier can be decisive as it would bring a plethora of issues such as longer ROIs, difficulties in baseline calculations for EPCs, etc.

From the point of view of the size of the stakeholders that responded to the questionnaire, as expected, smaller entities seem to be the stakeholders that are most affected by this barrier. Considering that the energy performance gap is generally reduced through a combination of advanced modelling solutions and other materials and technological systems, larger companies are generally the ones that will have the financial power and ability to implement these solutions as well as recruit the experts that have received adequate training.

As far as building typologies go, the score seems to be highest for stakeholders working on public buildings and tertiary buildings. This is not particularly a surprise as current case studies and cases suggest that building energy performance gaps are likely to be greater in non-domestic buildings. Indeed, considering these building typologies are characterized by higher amounts of occupants and end users coming and going with different behaviours and motivations, it is harder to factor these variables when predicting energy savings. Generally, occupants and building owners or operators have conflicting desires with facility managers seeking energy efficiency especially when managing a portfolio of non-residential assets vs. occupants trying to maximise comfort with little to no regard for energy efficiency.

As would be expected, respondents working on single family buildings have given the lowest aggregated average score for the barrier although the difference is not as important as perhaps expected. Single family homes are generally less affected by the energy performance gap due to the fact that one

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accounts for less occupants making behavioural variables less important and also systems and solutions implemented are often on a much smaller scale and less complex. Moreover, as occupants are paying for energy bills in residential settings, their motivations are aligned with greater levels of energy efficiency. This of course does not mean that the issue is inexistent for these residential building types.

From a regional or country perspective, the performance gap barrier was rated significantly higher by Spain if only focusing on the countries within the STUNNING consortium. It is often coined that the building energy performance gap s reduced through the implementation of better performing refurbishment packages during the renovation process but also the integration of more advanced ICT tools during the simulation and design stage of an energy efficient renovation. Therefore, when observing such differences between countries, an important question to ask is whether or not there are any significant differences in the penetration of ICT tools within the local architecture, engineering and construction industries (AEC). Indeed, construction in general is known for having been extremely sluggish at leveraging the productivity, precision and quality benefits that can come from the integration of ICT tools. This effect is even more pronounced for smaller sized companies that tend to be the later adopters. In fact, this may bring light to regional differences in itself as countries with higher amounts of small players within the sector may be more likely to have lower adoption rates in state of the art ICT tools such as the most advanced Building Energy Performance Simulation (BEPS) software.

When approaching ICT penetration rates from the point of view of BIM, using market penetration as an indicative variable or proxy for the more general ICT technology adoption rates of individual markets, it seems as though there may be a direct correlation although more profound testing would of course be required. Although many projects exist for the reductions in performance gaps between models and actual buildings through the coupling of BIM with thermal and energy modelling, it is not implied here that BIM leads to more precise energy simulations but rather reflects adoption levels of the latest state of the art building, construction and renovation processes. According to McGraw Hill Construction´s Report on the Business Value of BIM, the NBS report, the Arch Vision Survey and Architosh reports penetration rates of BIM especially amongst architectural professionals in Spain are lesser than the rates reported for France, Germany or the UK with 18% of architectural practices using BIM in Spain against 54% in Germany, 75% in the U.K. and 50% in France. Moreover, the level of BIM engagement and maturity in Germany, France and the U.K. also present higher levels.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

When focusing on the defining variables to which this barrier might be sensitive to, it seems as though the following major factors can be highlighted: nature of the building stock, implementation of new technologies for simulation and modelling and finally the dominance of SMEs in the AEC sector which are generally defined by very low advanced ICT adoption rates.

In terms of the nature of the building stock, regions with larger quantities of ageing non-residential buildings may be more affected by this issue for the reasons spelled before. Indeed, as mentioned above, occupant behaviour is often seen as one of the driving forces behind this issue, a variable much harder to control in tertiary and public buildings with differing motivations of these occupants since they are not covering energy expenses. Moreover, tertiary and public buildings more often than not present architectural singularities which are harder to account for and require solutions that are not backed up by the same depth of data, monitoring and testing.

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Whether or not the regional AEC sector is using the most modern Energy Modelling approaches will have great effect on this barrier. Many models contain generic assumptions about building use and internal heat gains, and often simplistic methods of calculating system performance. This leads to simplified models that predict heating demands lower by sometimes five times the amount of the real building demand. The used energy modelling must be building-specific and account for the many singularities such as use, appliances, fabric and building services performance. Currently, many Horizon 2020 projects are tackling this challenge such as MOEEBIUS or TOPAs with ongoing or continuous building performance monitoring and corrective models.

Finally, SME market composition might be another driving factor behind this barrier. This is however a variable which correlates directly to the one above related to the availability of advanced modelling capacity. Indeed, it is a known fact that SMEs have more difficulties in implementing such new methodologies mainly due to lack of trained personnel or possibilities of training, lack of resources and time.

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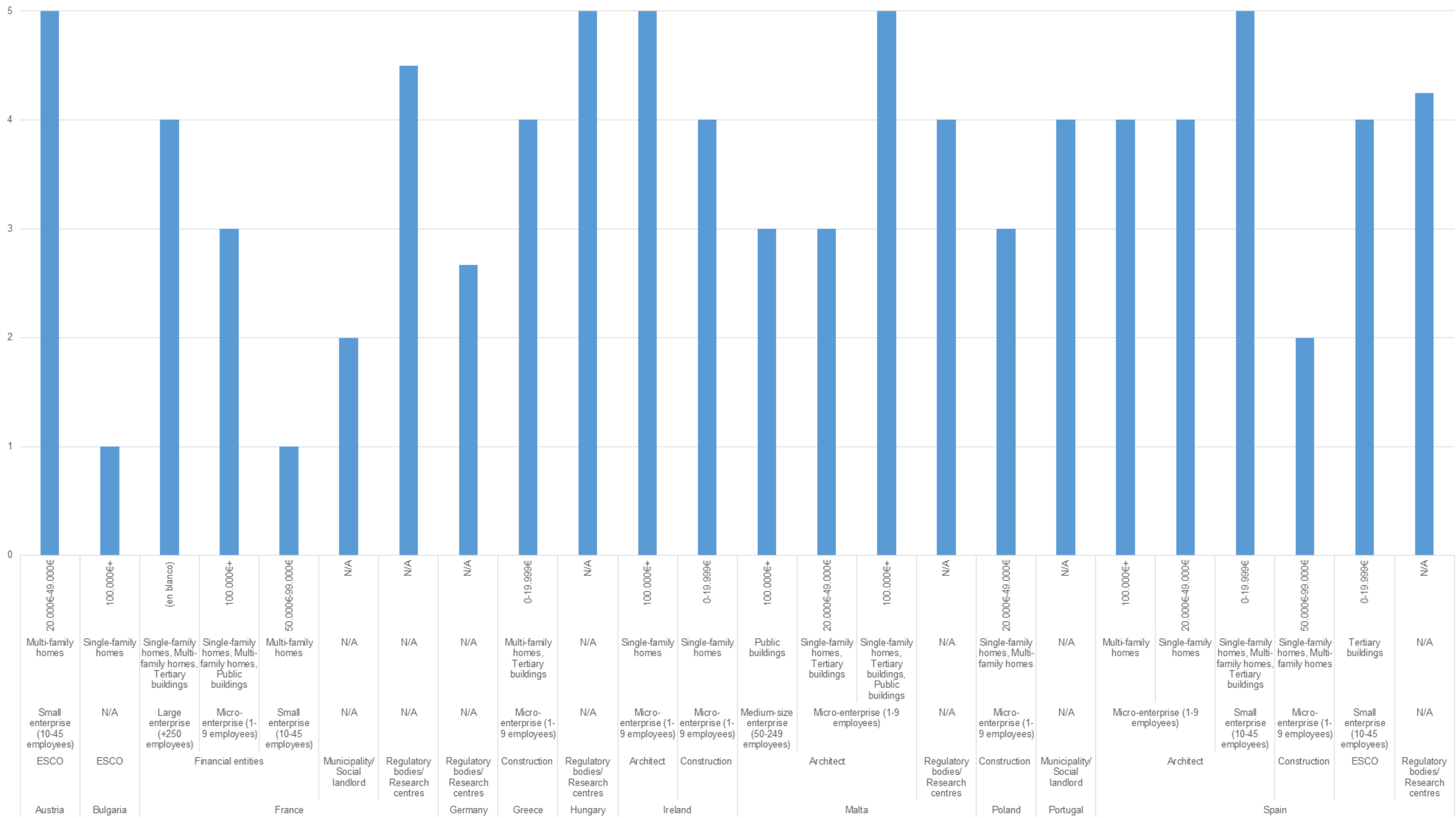

Figure 50 Breakdown of barrier scores for "performance gaps and uncertainty"

9.1.2. Technological and product developments in digital technologies as well as materials and equipment aiming benefits such as shortened renovation times

This refers to technologies capable of addressing the singular issues of the EE renovation market in Europe. One of the potentially identified problems in this regard is limiting the obstructiveness of renovations (prefab speed of implementation). It is possible that current retrofitting approaches and technologies do not take into account enough the obstructiveness of the renovation process. Indeed, EE renovations often imply displacements and burdens on families. Therefore, the lack of extremely modular solutions that are rapidly implemented with fast modelling and little on-site work could be hindering the market. The market may still be in need of certain modular plug and play systems capable of limiting intervention time and displacement as well as costs for deep renovations which could potentially reduce payback periods. This can be particularly relevant for advancing renovation rates of lower income areas. In a section on other evaluated barriers, the lack of housing alternatives is scored by questionnaire respondents and will provide feedback on this effect as well.

There are 29 respondents that have provided feedback on this barrier with a relatively lower variance of 1 and a total score of 3.1724. It is therefore identified as being less significant or common of a technical barrier as the one described above. Figure 51 provides a country level and stakeholder level segmentation of the scores while a more detailed picture and segmentation of respondent feedback is given in Figure 52.

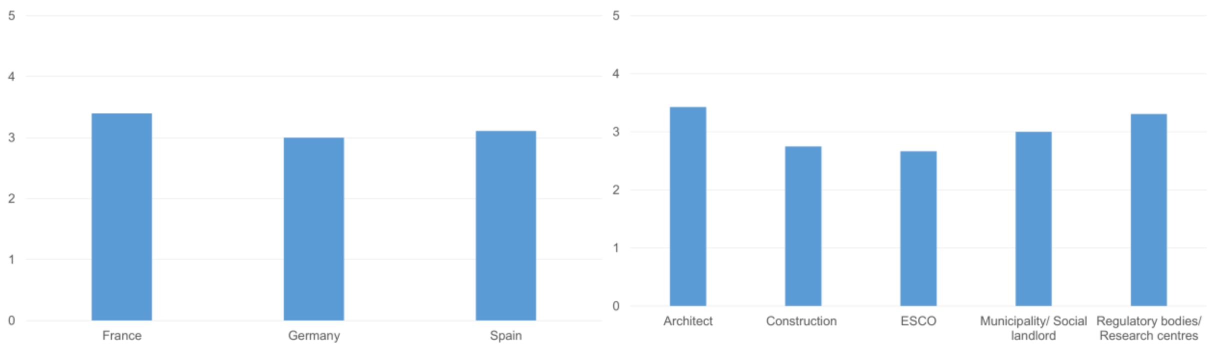

Figure 51 Country and stakeholder breakdown of barrier scores for "need for more technological products and developments"

Similar to the preceding barrier, architects and regulatory and research bodies have rated this barrier the highest relative to other stakeholder groups. This could come across as somewhat of a surprise as ESCOs and construction service companies and contractors could be just as affected by this barrier. When looking deeper at the breakdown in Figure 52, it also becomes apparent that most respondents who work on public buildings and tertiary buildings are architects. It is possible that fast and modular technical solutions are still unadapted to the singularity of certain buildings with historical buildings being the obvious case. Certain buildings within certain contexts may require certain custom made or problem-specific technical solutions which might not always be available and could hinder the growth of the EE renovation market due to heightened renovation costs and lengthy renovation processes. As tertiary and public buildings often contain singularities or can be characterized by preservation rules and codes, it is hard to apply standardized approaches, technologies or materials that will function and comply with the stricter codes for such assets whilst delivering benefits in efficiency, speed and costs from higher

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productivity. When looking at a segmentation of these scores exclusively through the lenses of building typology, it seems that the previously described effect confirms itself with a marginally higher score given by stakeholders working on public and tertiary building assets. Nevertheless, this effect is also prevalent with residential buildings as demonstrated by the scoring of the barrier related to lack of housing alternatives for occupants during renovations works within the STUNNING questionnaire ("Lack of housing alternatives for occupants during renovation work.") which reached a consolidated average of 3.56 with a 1.25 variance through the feedback of 25 respondents. This barrier clearly implies a need for fast renovation solutions in order to limit displacement time.

Furthermore, when observing case studies, it is possible to see certain examples that tend to confirm the prevalence of this barrier when faced with stringent building codes. In the Smarter Together project, the refurbishments planned for the Lyon Confluence area bumped into issues with the local regulation delaying the renovation process. Indeed, the refurbishment of the buildings takes place in an area with strong constraints due to heritage protection. This impacts the type of works that are authorized with respect to the appearance of the buildings (external insulation, change of windows, etc.) and can also increase the cost of the eco refurbishment as pre-fabricated or modular solutions are not allowed.

As a result of these effects, some projects are currently dedicated towards the development of technologies that address technical challenges. One such project is Geo4Civhic where the consortium is developing fast shallow geothermal technologies with smaller rigs capable of being applied precisely for historical and civil building typologies where preservation is a concern.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

From the collected case data and questionnaire, it seems as though this barrier may be most pertinent in settings with stringent building codes and preservation orders, unique building typologies which require specific refurbishment packages as well as specialized companies, and finally low income areas in need of faster and cheaper solutions for deep renovations.

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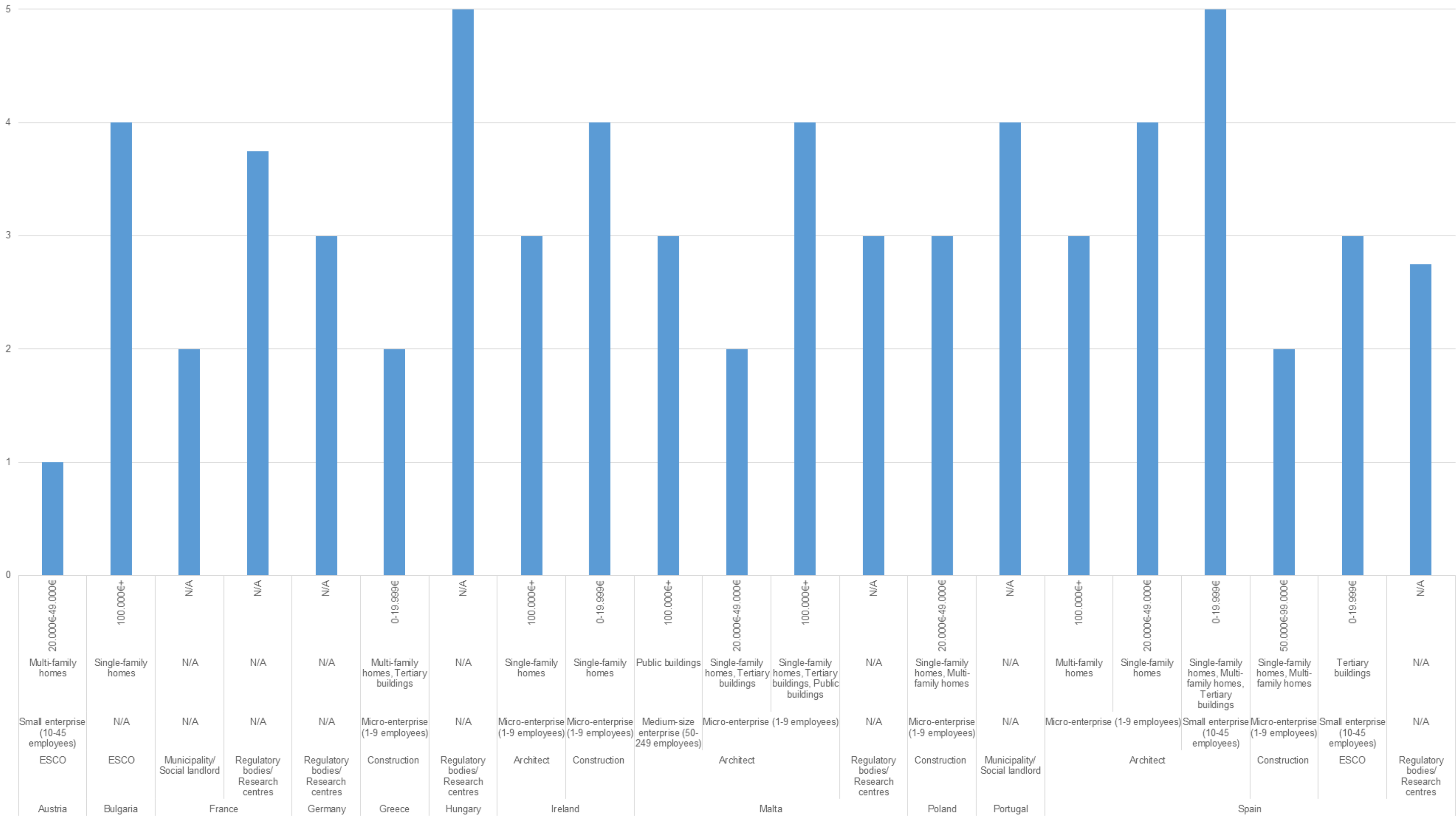

Figure 52 Breakdown of barrier scores for “need for more technological products and developments”

9.2. Embedded market inefficiencies typology – Split incentives and conflicts of interest

No feedback was obtained through the survey on this specific issue. Nevertheless, there is a breadth of literature, reports and case studies that bring light to the significance of this barrier and how decisive it is often times. The following map indicates how many times this type of barrier appeared in our cases across different MSs.

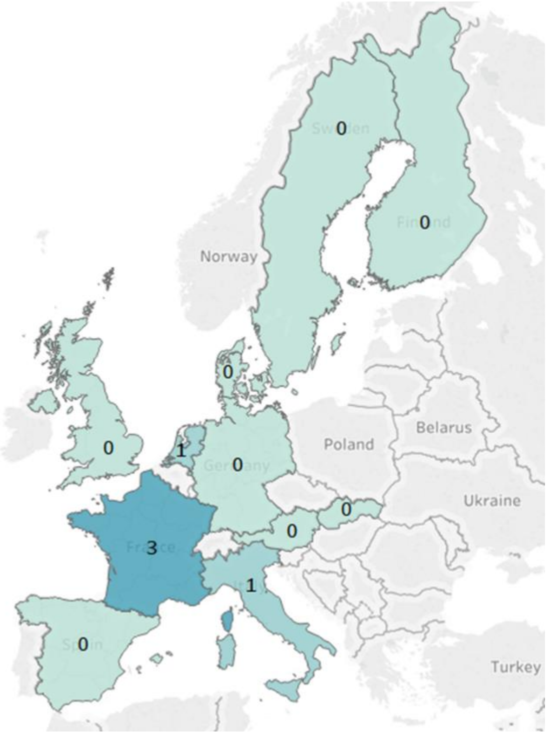

Figure 53 Number of times split incentive issues were observed in case studies

Within the context of the performed survey, many of the underlying influential elements behind this barrier are represented in the financial barriers section. Indeed, many of the conflicts between tenants and owners emerge from shortcomings in terms of return on investments and who truly benefits from the invested money represented by the duality between energy savings and renovation impacts on property value.

Despite not having directly obtained feedback on this barrier via the STUNNING questionnaire, many of the case studies used during this project to obtain a deeper understanding of market failures behind the EE refurbishment sector have indicated that conflicts of interest between owners and tenants or groups of tenants have been decisive at impeding the implementation of processes.

The original split incentives dilemma originates from the poor repartition of rewards and benefits from EE renovations between building owners and tenants. If the building owner is to implement a refurbishment, the tenants will be the ones benefitting from the reduced energy bills while the building owner or investor is the one who backed the initial investment. Nevertheless, conflicts of interest

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between owners and tenants also take different forms as demonstrated by the following feedback obtained through specific case studies:

- The structure of ownership (mostly family-owned apartments) and property laws in Spain can also be barriers for the normal development of projects. Apartment owners have a decision-making power and an agreement from the community is needed before reaching any decision to undertake integral building refurbishment projects, and/or to connect to the district heating;
- Often, owners do not anticipate the amount of disturbance that is created by the phasing of ongoing renovations around the building's exterior, and receive complaints from tenants due to unexpected remedial work after the refurbishment;
- Projects can encounter problems with multiple families living in the same building when a minority of these tenants are interested in the sought technical solutions and implements. Indeed, many tenant protection laws across the EU demand that a large majority (often up to 70 %) of the tenants agree to a physical improvement of the houses in case the landlord wants to increase the rent in order to reclaim the costs of the improvement. This can result in tenants disagreeing with the necessary refurbishments and blocking projects.

From a general point of view, spit incentives and owner tenant conflicts will of course be more relevant in regions with lower home ownership rates, which is the rate of home occupied dwellings. This rate is quite high for the European Union as a whole reaching 69.3% in 2018 although coming down from 73.1% in 2010. The countries with the lowest home ownership rates in Europe are Germany with 51.4%, Austria with 55% and France with 64.4%. Moreover, high house prices and urbanisation are driving the demand for renting particularly in multifamily units. It is likely that split incentive barriers and complications between owners and tenants emerge in member states that present a combination of low ownership rates, strict tenancy protection laws and a high percentage of multifamily homes in their building stock.

Societal/cultural/economic variables affecting the barrier/ Sensitivity assessment

The split incentives barrier is most prevalent in countries where EPCs have not yet been normalized or where there is no incentives or legal requirements for private landlords to provide minimum backstop standards for building performance. Moreover, when EPCs have virtually no impact on property value, the incentives for a renovation are only on the side of the tenant and not the owner when assessing a renovation from the point of view of payback and ROI. Indeed, landlords should take part of the investment cost in view of the property's value increase as a result of the energy efficiency upgrade. This is currently not the case when observing the previous figure in this report in relation to property price premiums and energy performance certificate improvements.

Successful approaches to overcoming misaligned incentives between tenants and owners should consider splitting costs and benefits in a balanced way. This could for instance take the form of repayment fees on top of reduced utility bills for tenants. Such solutions will be explored in D4.2.

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9.3. Informative barrier typology

Two types of informative barriers entering this macro barrier category were specifically analysed: one referring to general benefits of deep renovations and one referring to the less traditionally identified benefits of renovations such as comfort. Imperfect information and information asymmetries between parties have always been recognized by most available reports and literature as a defining barrier. It stipulates that relevant stakeholders and in this case end users such as building occupants and owners are not well informed on the plethora of benefits that can come about from energy efficient renovations. In terms of the segmentation of average informative typology scores and number of cases observed per member state, the following maps provide a quick overview.

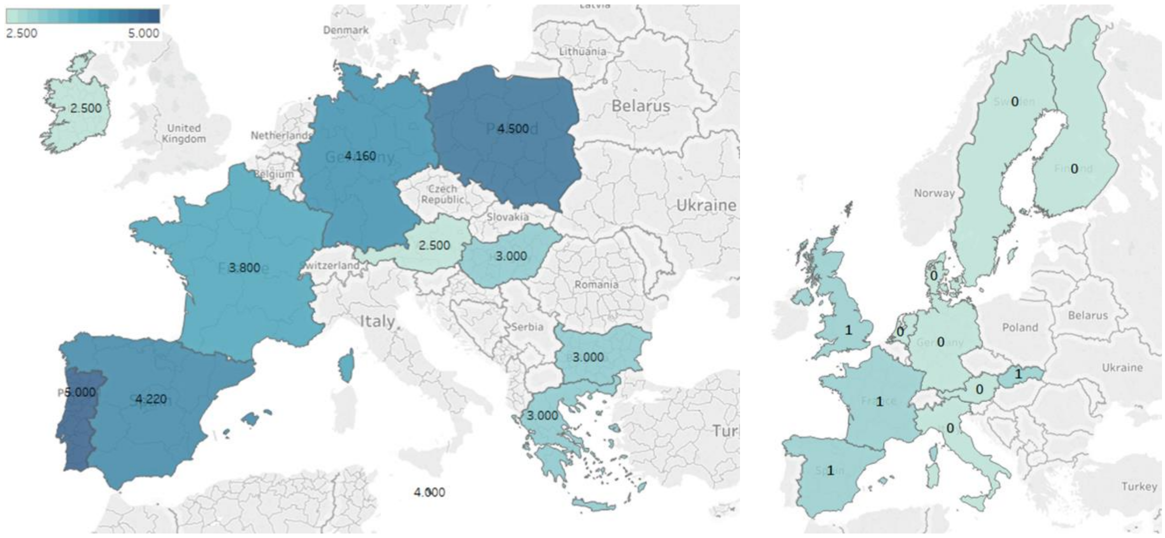

Figure 54 Left: Average informative (owners and occupants) typology score per country/ Right: Number of times informative (Owners and occupants) typology was observed in case studies

Implied by this barrier type is a general lack of information and knowledge about energy-efficient and sustainable materials and products. What is interesting in this case is that it will be possible to compare the country scores with the well documented information programs in each country in order to perhaps observe whether they have some effect. The following figure represents the general scores obtained by both of these barriers.

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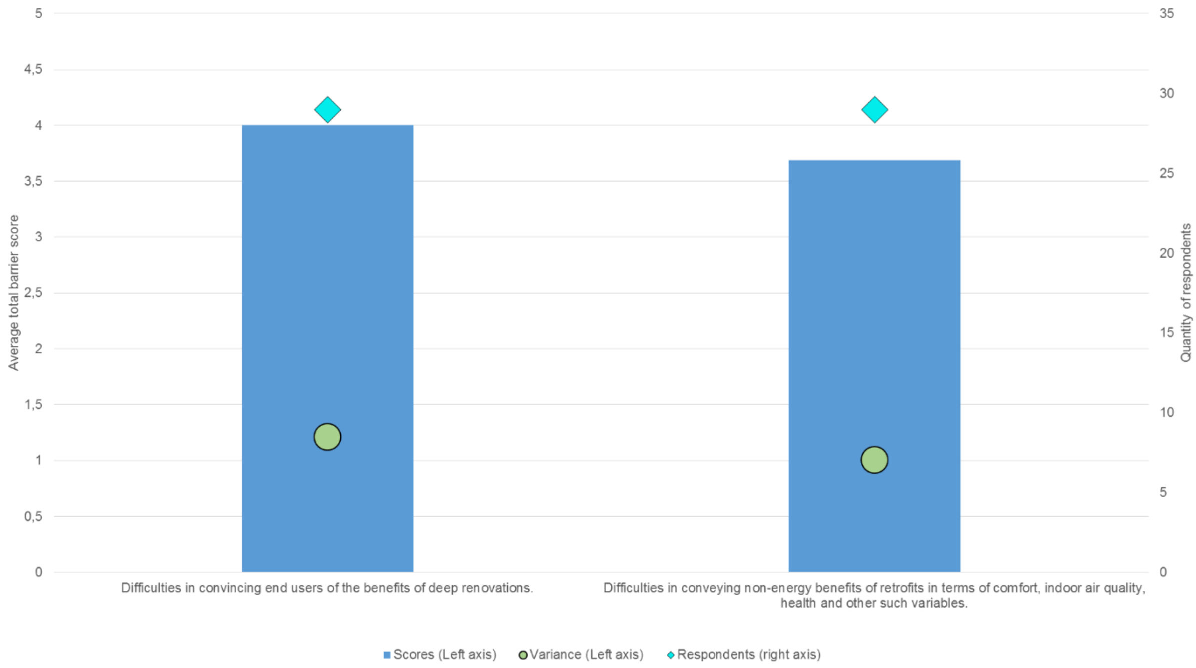

Figure 55 Informative barrier typology score and respondents

9.3.1. Difficulties in convincing end users of the benefits of deep renovations

The first barrier to be evaluated relates to the difficulties in providing relevant information to end users such as building occupants, investors and owners on the numerous benefits of deep renovations. These benefits are diverse in nature involving the basic energy savings that can be expected, financing options that exist as well as positive impacts on health comfort and wellbeing.

Within the Stunning survey, this barrier received feedback from 29 respondent with a score of 4 and a variance of 1.2 making it a highly significant barrier. Figure 56 provides a more generalist view on the breakdown of responses with country and stakeholder segmentation of results. Figure 57 provides the more compartmentalized breakdown.

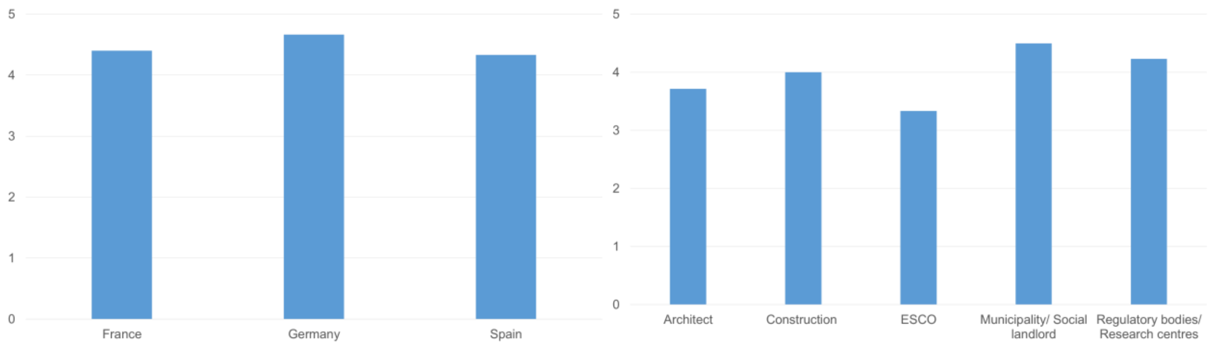

Figure 56 Country and stakeholder breakdown of barrier scores for "difficulties in informing end users on benefits of deep renovation"

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The results obtained through the survey are aligned with the biases and priorities that could be expected by all stakeholders. Namely, municipalities and social landlords have scored the importance of this barrier as extremely high. This is no surprise as they are the direct stakeholder required to address such issues in the national renovation strategies imposed by the EU Energy Efficiency Directive (EED Article 4).

From a general point of view, this barrier transcends boarders and is rated as high in all of the countries in Figure 56.

Germany is the country with the highest rating for this barrier at more than 4.5. When observing their strategy for deep renovation within the framework of the EED Article 4, this is reflected in how raising awareness is set as an integral part. The report states that information and advice must be provided in order to drastically raise the level of acceptance of energy saving measures and also to enable planners, investors and companies implementing the measures to initiate renovation work and structural changes at the required level of quality. On the demand side, consumer awareness must be further increased.

It is crucial for building owners and investors to obtain appropriate information, support and incentives to choose the deep renovation option that most corresponds to their needs. Most of the time an optimum balance needs to be struck between available capital, financial and energy savings benefits, risks and technical feasibility. In such situations, decisions are often made in constrained environments that result in limited, or bounded, decisions instead of being made based on perfect information and complete rationality. These elements of imperfect information and dark areas in the decision making process of investors and building owners has been qualified as bounded rationality (Sorrell 2003; Palm and Reindl 2016). Germany has addressed this issue with local or regional energy agencies under the Federal Association of German Energy and Climate Protection Agencies. Moreover, in 2017 they introduced a new software based tool for the energy-efficient retrofitting of buildings providing a renovation road map tailored to individual buildings. This software-based tool is used by technical stakeholders implementing a renovation to give owners a clear overview of the modernisation work that their building needs. The tool points to untapped possibilities for energy conservation and the use of renewables, and also gives an estimate of the relevant investment costs and of the savings that could be achieved in terms of heating costs and carbon emissions.

In France, their national strategy in line with EED objectives takes care of its informational and awareness barriers through the French Environment & Energy Management Agency known as ADEME which is set up by the Ministry for the Ecological and Inclusive Transition and can serve as an investment, educational and advisory arm.

Feedback obtained through interviews of Spanish professionals and more notably from architects and property administrators during the course of the project tend to indicate a general lack of scientific and verifiable information on costs, savings and amortization which could presented to the homeowners who will bear the brunt of the costs for an energy efficient refurbishment. Most of the information available and the awareness programs are centred on the promotion of general incentive programs without offering tools or avenues to learn about potential solutions at their hand.

- **Sensitivity assessment: societal, economic and country specific variables affecting the barrier**

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The main variable that can affect this barrier will be the presence of municipal and government support organisms for the diffusion of information and awareness in relation to energy efficient refurbishments. Moreover, it is necessary to assess the effectiveness of these programs and what tools they are using to tackle these issues.

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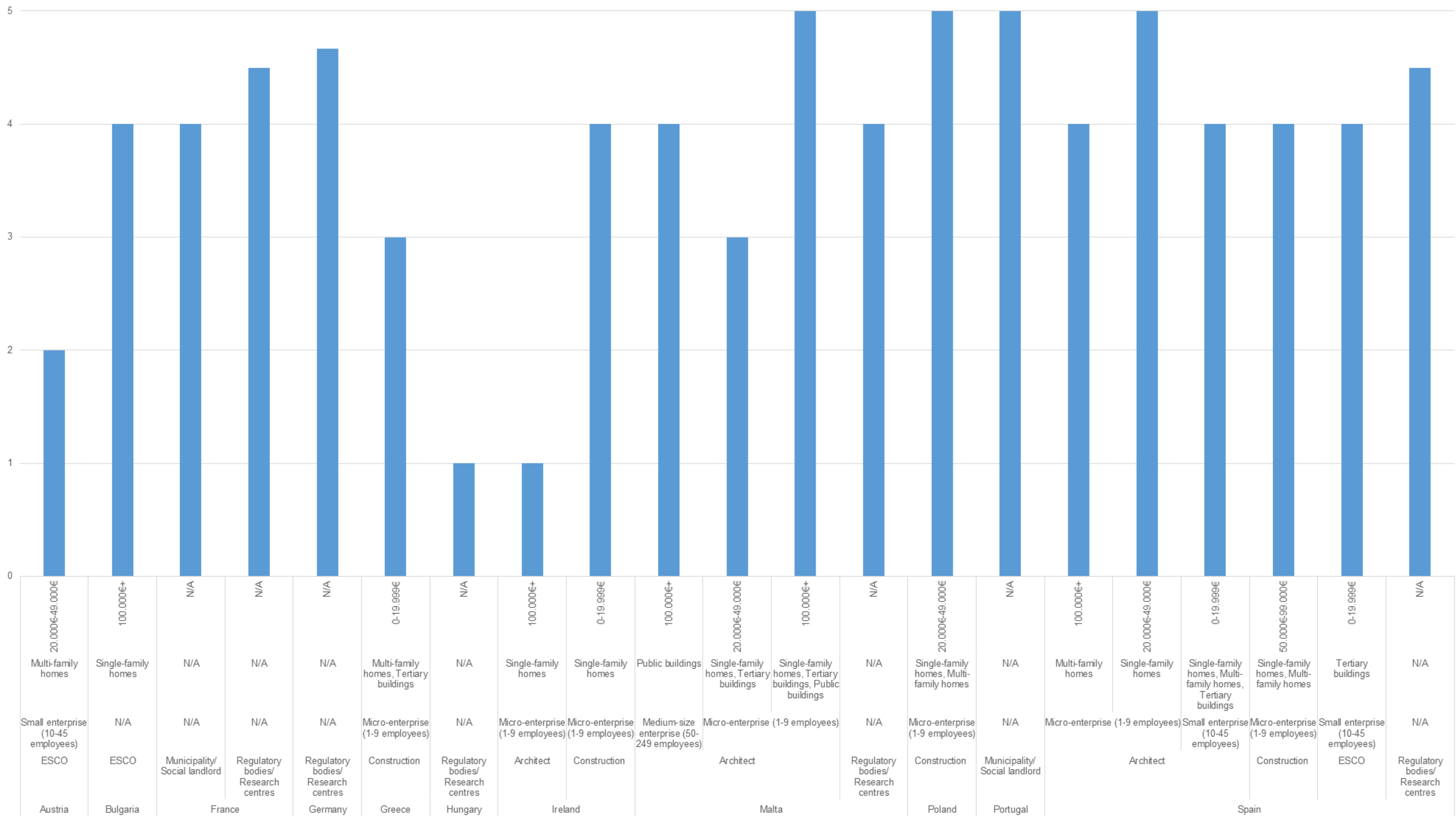

Figure 57 Breakdown of barrier scores for "difficulties in informing end users on benefits of deep renovation

9.3.2. Difficulties in conveying non-energy benefits of retrofits in terms of comfort, indoor air quality, health and other such variables.

This barrier tends to enter as a sub section of the previously evaluated barrier. There were 29 respondents who provided feedback with a limited variance of 1 in relation to most barrier scores of the questionnaire as a whole. The consolidated score was of 3.689 making it less significant than the previous informative barrier according to the feedback obtained during the questionnaire.

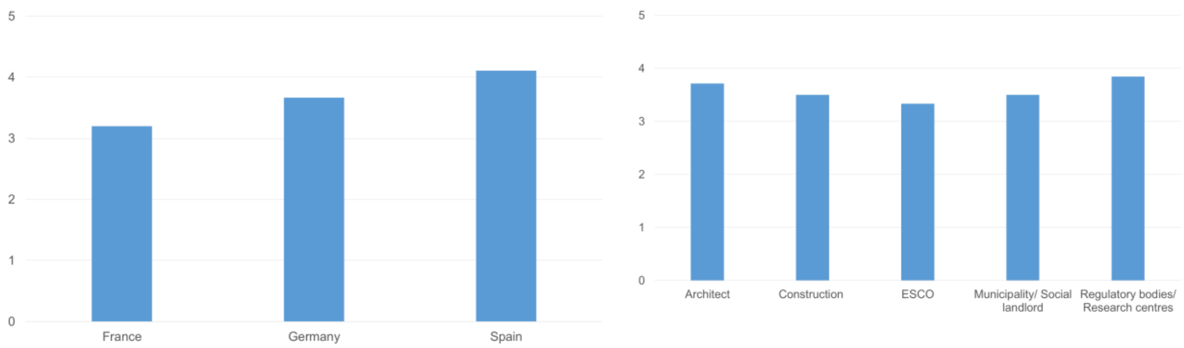

Figure 58 Country and stakeholder breakdown of barrier scores for "information on non-energy benefits of EE renovations"

During the multiple meetings and conversations with the advisory board, it was decided that observations should be made in terms of the pertinence of non-financial and non-energy related benefits of refurbishments. The thought process behind this is that within the identified information and awareness barriers relative to end users, focus is perhaps being brought on the wrong elements of renovations. Indeed, most educational, informational and awareness programmes focus exclusively on savings, energy performance certificate upgrades, monetary savings, average ROIs (or other such financial KPIs). Applied behavioural research on energy efficiency has so far tended to represent individual homeowners making reasoned decisions, subject to mainly available capital and financial profit maximizing motives. It is possible that this depiction of reasoned, goal-oriented and isolable decisions has limited itself to an improperly narrow set of variables. For instance, potential adopters of renewable heating systems in Germany reported convenience and comfort rather than cost as more influential sources of relative advantage. Therefore, it is possible that homeowners, especially in the residential sector derive utility from other factors and are not always acting like rational utility maximizers solely looking at the profitability of their investment. Such factors can be the increase in comfort, air quality, health benefits, luminescence, acoustics, esthetics and other such variables.

Similar to the previous barrier and in line with the relatively low variance in barrier scores it seems as though it transcends boarders and stakeholder groups although receiving a slightly higher score in the Spanish market.

An interesting observation in the results relative to this barrier is in terms of building typologies. Stakeholders working on public and tertiary buildings have scored this barrier much higher (4-5 average range) than stakeholders working on single family and multifamily homes (3-4 average range).

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This difference could perhaps be explained in the fact that public buildings and tertiary buildings are managed like assets within a portfolio and thus the investors' perception bias towards making sound financial decisions and energy savings during renovations supersedes interest in increasing comfort for the occupants. It could be important to communicate on these aspects for such players as renovations can have impacts on employee/visitor/customer well-being, comfort, health and ultimately productivity.

Furthermore, one could think this barrier is prevalent for areas or countries with significantly higher purchasing power and adjusted GDP per capita meaning that building owners are not as pressed financially and are thus able to take into consideration other variables in the decision making process. By comparing the results to the macroeconomic indicators listed at the beginning of this report, no such effects are noted. Of course, larger sample sizes could reveal higher degrees of correlation between this barrier score and such economic indicators.

Certain European projects have tackled this barrier and the issue of comfort within energy efficient renovations. Indeed, certain projects like UtilitEE are putting comfort and health variables of individual building occupants in the centre stage and trying to maximize them whilst achieving energy efficiency on the side.

- **Sensitivity assessment: societal, economic and country specific variables affecting the barrier**

Similar to the preceding barrier, the main variable that can affect this barrier will be the presence of municipal and government support organisms for the diffusion of information and awareness in relation to such benefits. Moreover, it is necessary to assess the effectiveness of these programs and what tools they are using to tackle these issues.

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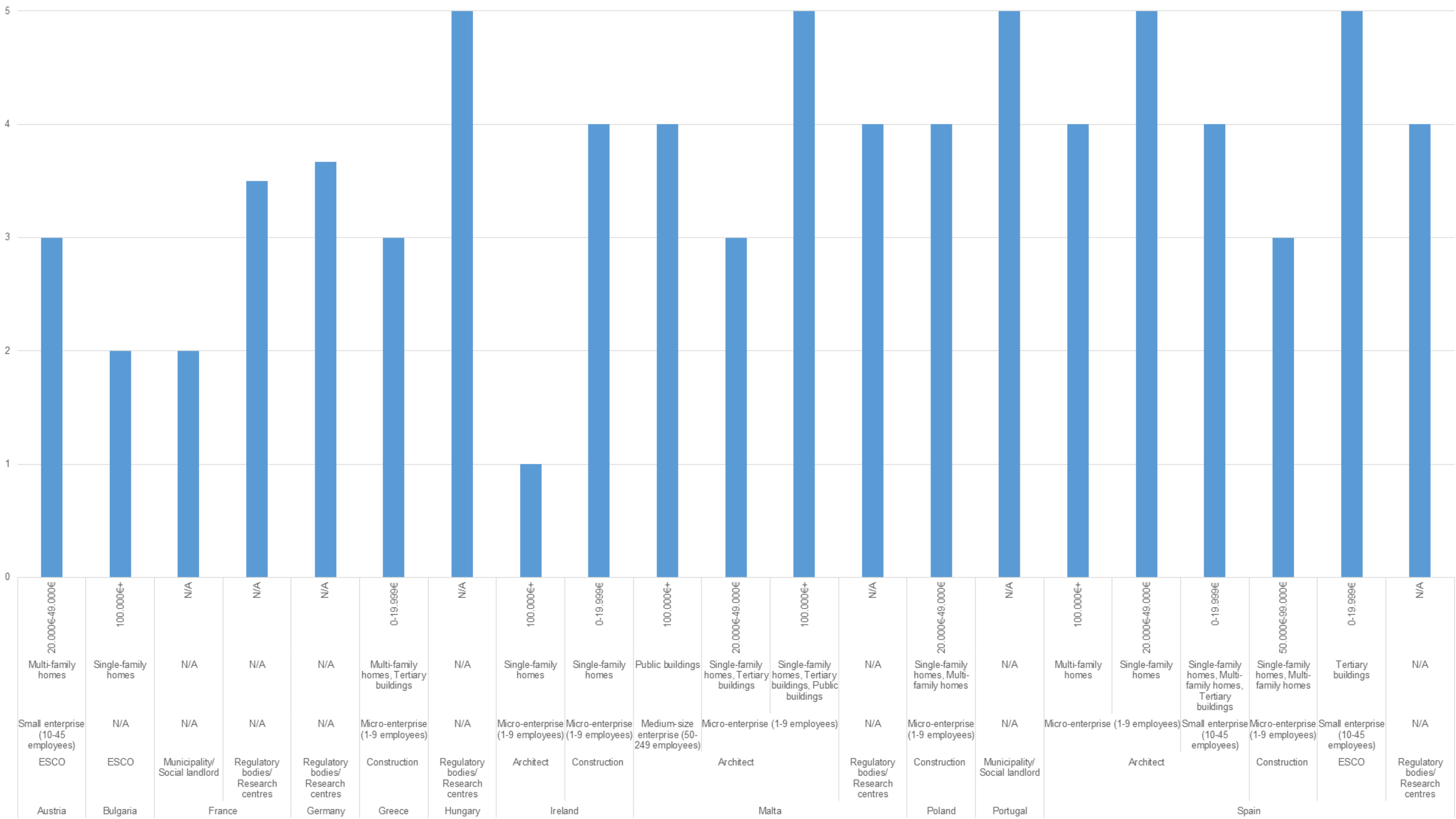

Figure 59 Breakdown of barrier scores for "information on non-energy benefits of EE renovations"

9.4. Financial barrier typology

A plethora of financial barriers are recognized and well documented within the EE renovation market. Financing Energy Efficiency in buildings is a major challenge as despite proven positive cost benefit analyses of certain implements and refurbishment packages, reluctance on part of homeowners to invest is still observed as they prefer to allocate their capital towards other areas. Such barriers can include the initial cost barrier (insufficient budget), limited financing options, long payback time, and risk exposure with hidden costs and uncertain cash flows as well as exogenous factors that can have an impact on payback periods and actual savings such as energy prices. Traditional financing investment criteria does not always apply to investments in energy efficient renovations as lack of knowledge among financial providers on energy efficiency topics impedes customers from accessing capital. Financial typology barrier score averages and the number of observed cases on hand were divided according to the following maps.

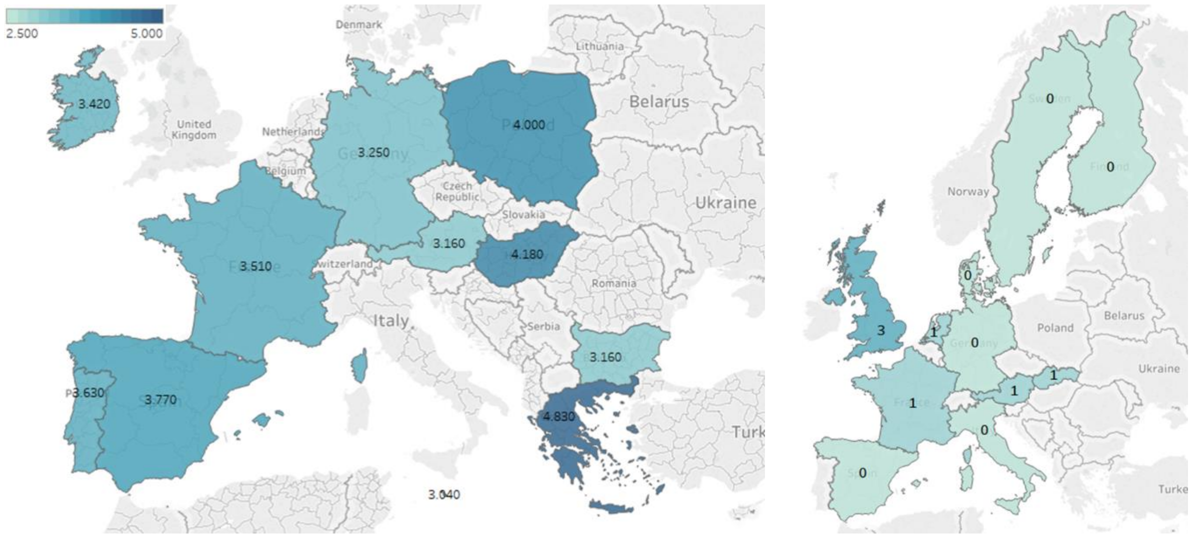

Figure 60 Left: Average financial typology score per country/ Right: Number of times financial typology was observed in case studies

It is noteworthy to mention that many of the case studies used are publicly financed or EU financed projects which greatly minimize the obstacles and issues relevant to these types of barriers during the renovation process.

Within the survey the following financial barriers were assessed (figure below). In terms of our barrier nomenclature, these barriers enter as sub barriers or descriptions of the more generalized barriers referred to as investment approach and perspective barriers, limited financing option barriers and externalities barriers.

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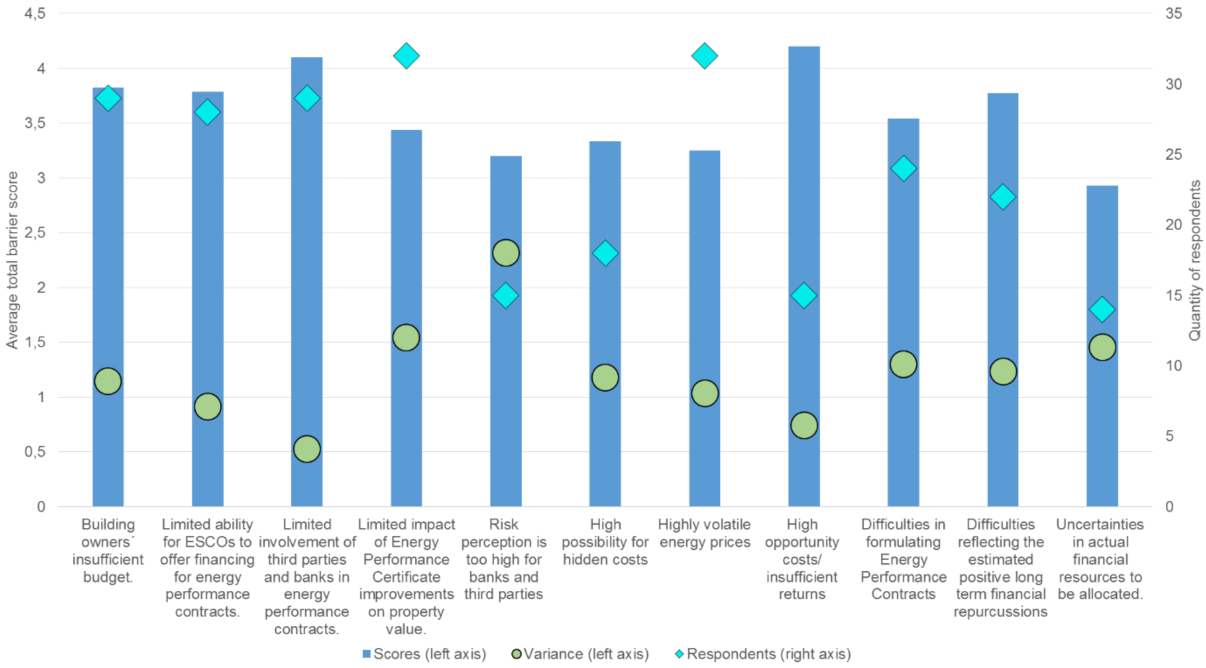

Figure 61 Financial barrier typology scores and respondents

With the intention of providing more focused assessments, this report will focus on only 4 of the assessed barriers. The barriers in question are the ones that received the highest number of respondents observable in the above figure and listed below:

- Building owners´ insufficient budget (limited financing barrier);
- Limited ability for ESCOs to offer financing for energy performance contracts (limited financing barrier);
- Limited involvement of third parties and banks in energy performance contracts (limited financing barrier);
- Limited impact of energy performance certificate improvements on property value (investment approach and perspective barrier).

Considering the clear overlap in considerations and issues between the second and third listed barriers on EPCs, both of these will be treated at the same time.

9.4.1. Building owners´ insufficient budget

This barrier refers to the most commonly cited barrier to energy efficient investments and refurbishments, initial capital costs for implementing EE renovations that exceed the financial capabilities and limits of investors and building owners. Whether this is a question of an actual insufficiency in funds or a question of investment perspective and priorities with a perception of high opportunity costs associated to such investments and inabilities to factor life cycle costs on the long term will be explored in this section. A total of 29 respondents have provided feedback for this barrier yielding a total score 3.82 and a variance of 1.14 as well as the following segmented results (further segmentation is offered at the end of this section):

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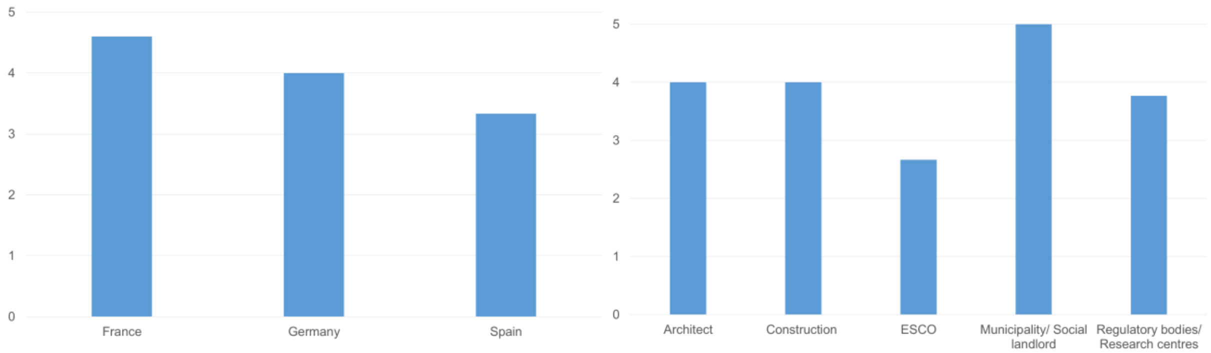

Figure 62 Country and stakeholder breakdown of barrier scores for "Building owners´ insufficient budget"

Limited budgetary capacity of involved parties interested in renovations constitutes a very commonly recognized barrier to improving energy efficiency in dwellings. As demonstrated by the case studies we have regrouped which rarely go below the cost of 600€/m2 and article 2 of the EPBD Recast which states that "major renovations" are defined as renovations where the total cost of the renovation relating to the envelope or its systems is more than 25% of the value of the building, or where more than 25% of the surface of the building envelope undergoes renovation, it is obvious that refurbishments are extremely costly interventions, even in fairly new buildings (Baek and Park 2012).

Instinctively, one may be led to thinking that within the questionnaire performed during the STUNNING project, stakeholders from member states with lower GDP/capita and other such macro indicators may rate this barrier the highest among respondents. In fact, when observing average renovation rates per country from 2010-2014 in Figure 23 and GDP from Figure 3, there seems to generally be a clear positive relationship between GDP evolutions and renovations of national building stock. However, observing the results of the questionnaire, this relationship between higher disposable income and a reduction in significance of budgetary barriers is not established. As observed in the beginning sections analysing general renovation trends and macroeconomic conditions, out of the three countries represented in the above segmentation, Spain comes out with a significantly lower score compared to Germany and France. When looking at the GDP per capita of the three countries, Spain is below with a GDP per capita of around €25,800 against €35,100 for France and €40,900 in Germany. When looking at the PPP indicators from the World Bank, all three countries remain similarly ranked with Spain at $37,997, France at $42,850 and Germany at $50,638. Moreover, Spain still has a very important unemployment rate at around 17% in 2017 against less than 5% for Germany and less than 10% for France. Part of the explanation could potentially come from the current conjunctures that each country is traversing in terms of economic cycles. Spain has suffered a much longer economic contraction than Germany and France post 2008. Indeed, when looking at GDP growth rates, from 2008-2014 Spain experienced negative growth. In opposition to this France and Germany experienced only one year of contraction after the 2008 meltdown. Nevertheless, since 2015-2018, Spain has been experiencing superior GDP growth compared to the two other mentioned member states with 3.6% in 2015 compared to France´s 1.1% and Germany´s 1.7% during the same period. The following tables provide an overview of these national macroeconomic KPI evolutions.

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Evolution: Annual GDP Spain

Date	**Annual GDP**	**GDP Growth (%)**
2018	1,206,878M.€	2.5%
2017	1,166,319M.€	3.0%
2016	1,118,743M.€	3.2%
2015	1,081,165M.€	3.6%
2014	1,037,820M.€	1.4%

Evolution: GDP per capita Spain

Date	**GDP per capita**	**GDP P.C. Annual Growth**
2018	25,80 €	2.8%
2017	25,10 €	4.2%
2016	24,10 €	3.4%
2015	23,30 €	2.3%
2014	22,78 €	1.2%

Evolution: Annual GDP France

Date	**Annual GDP**	**GDP Growth (%)**
2018	2,348,991M.€	1.5%
2017	2,291,697M.€	2.2%
2016	2,228,568M.€	1.2%
2015	2,198,432M.€	1.1%
2014	2,149,765M.€	1.0%

Evolution: GDP per capita France

Date	**GDP per capita**	**GDP P.C. Annual Growth**
2018	35,10 €	2.3%
2017	34,30 €	2.7%
2016	33,40 €	1.2%
2015	33,00 €	1.9%
2014	32,40 €	0.9%

Evolution: Annual GDP Germany

Date	**Annual GDP**	**GDP Growth (%)**
2018	3,386,000M.€	1.4%
2017	3,277,340M.€	2.2%
2016	3,159,750M.€	2.2%
2015	3,048,860M.€	1.7%
2014	2,938,590M.€	2.2%

Evolution: GDP per capita Germany

Date	**GDP per capita**	**GDP P.C. Annual Growth**
2018	40,90 €	3.3%
2017	39,60 €	3.1%
2016	38,40 €	3.0%
2015	37,30 €	2.8%
2014	36,30 €	3.7%

Table 5 isolated GDP indicators France, Spain, Germany

What seems to be happening is that Spain is going through a period of optimism characterized by higher growth rates after a long spell of economic contraction leading to more investments in real estate as the country starts to see more liquidity once more. The residential investment trends given in Figure 10 seem to confirm this with shorter upturns and higher growth rates for Spain. As the willingness to invest in homes increases so will general renovation rates and EE refurbishments. Whether the scores in the questionnaire reflect this effect or not, the data is here to corroborate this effect.

When looking at stakeholder ratings, all of the respondent categories have scored this barrier as significant for the most part scoring above 4. The exception comes from ESCOs with a lower score resulting from an outlier. As this stakeholder operates mainly on single family home projects with budgets higher than €100,000 it could be interesting to prolong the information gathering process in order to understand whether or not financing issues are more present in smaller residential renovation projects.

Municipalities and social landlords have rated this barrier as the most significant they encounter. Social housing operators are faced with extreme financing constraints and have very little flexibility in terms of raising rents to amortize EE investments for instance. This segment is extremely important with a rough estimate of up to 670 billion Euros to be invested in the EU Social Housing sector between 2011 and 2050 as part of a consolidated strategy to reach a 75% reduction in GHG emissions by 2050 compared to 1990 (FRESH project and Factor 4).

In addition to the latter effect, the results tend to indicate much higher barrier scores for stakeholders working on public and tertiary buildings. This may be a result of the significant investments required by the refurbishment of these generally larger buildings within these typologies and limited investment capital.

Furthermore, what is important to understand in this section is that energy-efficiency goals are often secondary to economic considerations and thus the perspectives of the building owners relative to this will determine how much they are willing to dedicate to a refurbishment. When renovating rental properties, life-cycle costs are rarely taken into consideration and energy-efficiency options are overlooked, even though the return rates would substantially exceed the capital costs. Moreover, even with positive returns, homeowners may have the impression that these investments contain hidden costs, are risky and that higher returns are to be obtained elsewhere. In relation to the latter, opportunity costs and insufficient returns was tested in the questionnaire obtaining the highest score of any barrier with a 4.2 although with only 15 respondents having given feedback. The important take away from this is that insufficient budgets may not result solely from lower disposable income but from individual utility curve specificities and low willingness to spend money in these issues. As an example, if a building owner or investor has the liquidity to carry out a major renovation on his asset costing him 25% of the building´s value at least, in line with Article 2 of the EPBD recast, it is also likely that he prefers investing in a new property.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

As would be expected the main variables that this barrier is sensitive to are macroeconomic variables capable of describing the general disposable income of the population in question. Nevertheless, it is also important to understand that biases on part of homeowners towards EE investments and refurbishments will also affect the amount of money they are willing to spend and thus their budgets. This last effect pertain to behavioural and individual utility traits that are difficult to observe across borders. From the point of view of building typologies, the problem may be more pertinent to the generally larger scale nature of public and tertiary renovation projects.

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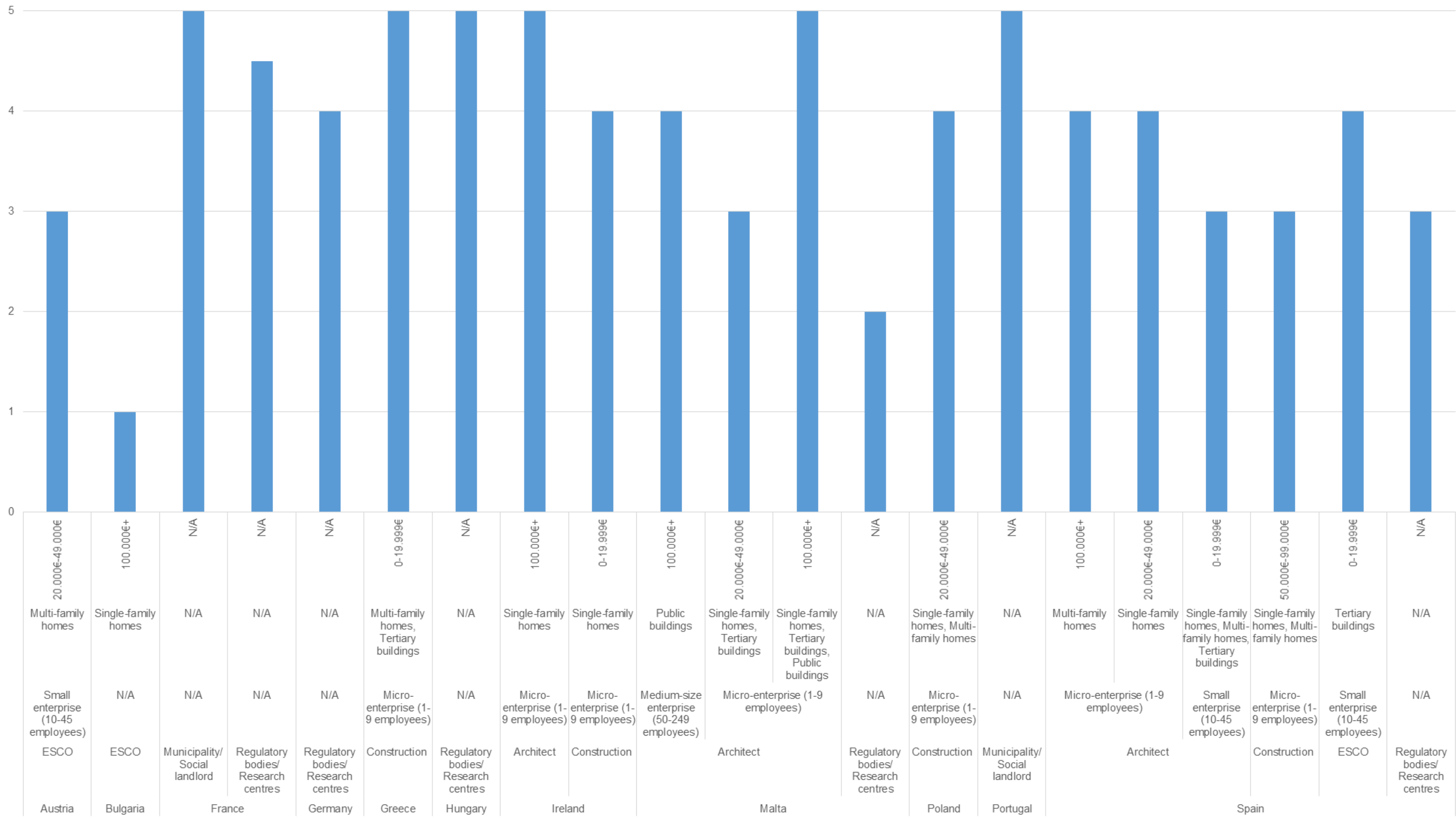

Figure 63 Breakdown of barrier scores for "Building owners´ insufficient budget"

9.4.2. Limited ability for ESCOs to offer financing options on energy performance contracts and limited involvement of third parties and banks

This barrier refers to energy performance contracts and whether or not an energy service company has the ability to offer different forms of contracting by leveraging itself through third parties or through direct financing. The consolidated score for the ESCOs limitations barrier was of 3.78 with a variance of 0.92 coming from the feedback of 28 respondents in total and the consolidated score for third party involvement was of 4.1 with a variance of 0.524 and 29 respondents. The following figures provide country and stakeholder breakdowns.

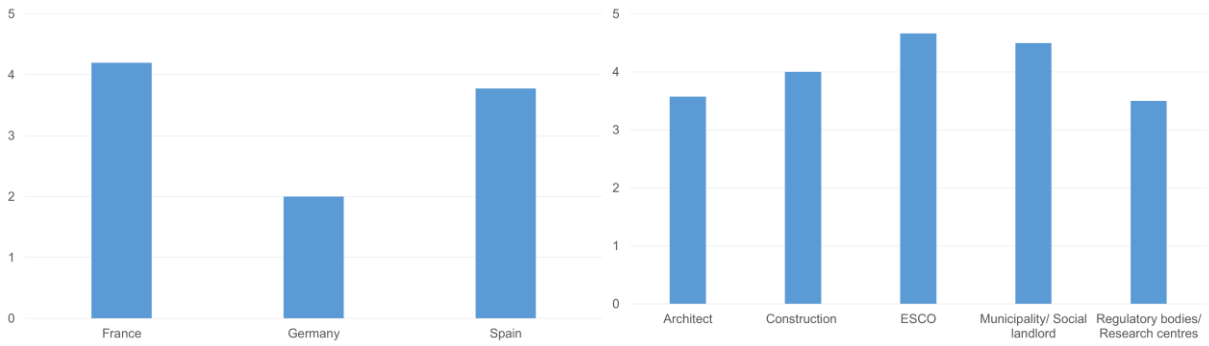

Figure 64 Country and stakeholder breakdown barrier of scores for "limited ability for ESCOs to offer financing on Energy Performance Contracts"

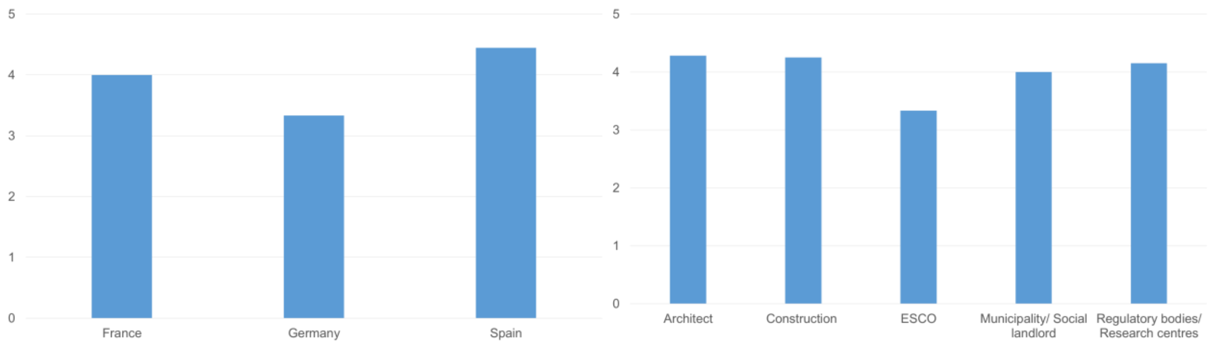

Figure 65 Country and stakeholder breakdown of barrier scores for "Limited involvement of third parties and banks in EPCS"

Under an energy performance contract, an ESCO provides a comprehensive building retrofit and assumes performance risk for the project in the form of a long-term financial guarantee to ensure that the projected energy, water, and operational cost savings materialize and are preserved over time. The refurbishment is then paid for by the obtained savings which requires regular measurement and verification (M&V) of building performance. When energy savings are not realized, the ESCO must pay the difference to the building owner or reduce its service or shared savings fee accordingly.

In terms of financing, the ESCO's assumption of risk and the associated guarantee provision open up numerous options for financing the upfront investment required to undertake the retrofit. These can come in the form of:

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- Owner financing – the building owner pays;
- ESCO financing – the energy service company pays;
- Third party financing – a bank provides a loan;
- A third party entity or fund pays for the investment;
- Governments or utilities provide full or partial funding through grants, loans and/or fiscal incentives.

With the exception of owner financing, all of the other options mean that the building owner is not required to make any significant upfront investments bringing solutions to the previously investigated barrier on limited budgets of building owners and investors. Instead, the cost of the ESCO's services is essentially paid for over the lifetime of the project through a reduction in the building's energy, water and other operating costs.

There exist two main types of contractual setups for EPCs. The shared savings contracts or the guaranteed savings contract:

- The guaranteed savings scheme entails the client paying the ESCO for the energy efficiency interventions upfront but requires a financial guarantee from the service provider against the achievement of the projected savings. Should the savings not be achieved, the client uses the guarantee to reimburse the difference between actual savings and projected savings;
- In a shared savings scheme, the ESCO most often raises the investment capital required and the cost savings are split between the client and the service provider. There is no predefined percentage split for any shared savings scheme and the percentage split is determined by the client and ESCO involved.

In terms of financing, guaranteed savings contracts generally imply a client paying the ESCO upfront for the EE investment and therefore TPF loans to the customer are more common under this model with the ESCO only bearing performance risk. In shared savings contracts, the EE investment is commonly financed by the ESCO through own funds or TPF meaning that they bear performance and credit risk. In the case of both barriers being assessed in this section, we are of course referring mainly to the shared savings models where ESCOs are financing investments as seen on the left of the below figure. The shared savings approach is a good model in developing markets because customers assume no financial risk.

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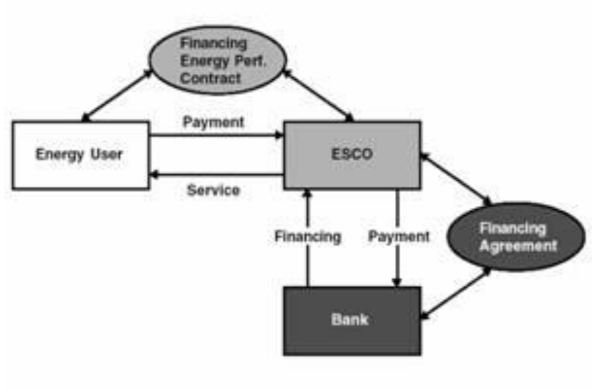
Third Party Financing (TPF) with ESCO borrowing (Shared Savings)



Third Party Financing (TPF) with energy user/customer borrowing (Guaranteed Savings)

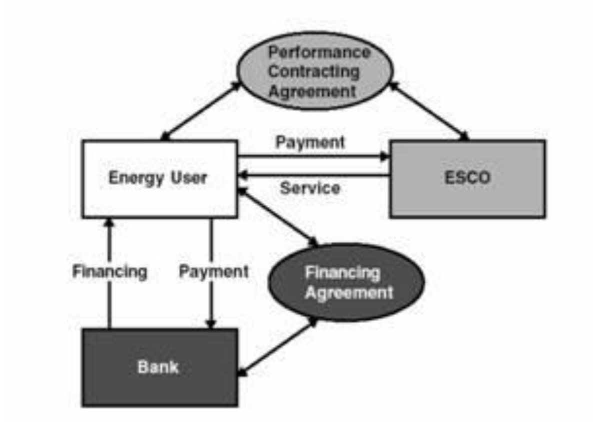


Figure 66 TPF financing approaches for EPCs

In terms of direct financing by the ESCO through in-house funds, this is an extremely rare occurrence as the ESCO would be depriving itself from implementing more projects by leveraging through third party financing (TPF). The only ESCOs with the true capacity to provide such financing would be very large ESCOs coming from MNCs such as Dalkia. This could in part explain the extremely high score for this barrier on part of ESCOs having responded since they are all SMEs and hence do not have the same resources for such operations.

For TPF, when the ESCO is the borrower, the customer is safeguarded from financial risks related to the project technical performance because the savings guarantee provided by the ESCO is either coming from the project value itself or is appearing on the balance sheet of the ESCO; hence the debt resides on someone else's balance list as the ESCO collateralizes the loan with anticipated savings payments from the customer. In this scenario performance risk and business risk is assumed by the ESCO.

As borrowing for ESCOs requires more than just savings requirements but also collateral and credit history it is clear that SMEs and small structures with scarce resources will most likely perceive barriers in going down this avenue and this seems to reflect itself in the survey scores obtained for this barrier by ESCOs (all SMEs). This is extremely important as the ESCO market is in majority composed of SMEs that may be deprived from these financing opportunities. Furthermore, even if they are able to obtain loans, there is an important barrier as they can become too highly leveraged and unable to contract further debt for subsequent projects. This clearly hinders the market as a whole since ESCOs financing EPCs through TPFs could impose itself as a solution to the insufficient budgets of stakeholders (characterized in the prior section) such as social housing operators that have limited possibilities or inclinations for obtaining TPF financing themselves and offer lower scale projects that are of little interest to larger ESCOs with funding capacity. In fact, ESCO/TPF financing approaches are mentioned in the FRESH project (Financing energy REfurbishment for Social Housing) as a viable solution to these issues. Moreover, this seems corroborated by the feedback obtained in the STUNNING survey as Municipalities and Social landlords have given this particular barrier (ESCO financing capacity in EPCs) a very high score of 4.5.

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In terms of banks and third party involvement in energy performance contracting, as stated earlier in this report, EE residential investments require particular financial expertise and technical knowhow to evaluate the investments, risks, savings feasibility etc. This can be resource and time consuming for many third parties or banks especially for smaller scale projects.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

It is clear that these barriers are especially pertinent for smaller or new ESCOs with SME profiles with no previous experience in borrowing, poorly documented credit history and little resources for collateral. Generally speaking, this barrier will also be easier to alleviate in countries having already a number of ongoing EPCs offering standards, processes and contracts on which SMEs and TPF entities can base themselves in order to develop expertise and grow the EE renovations market. A number of efforts have been led in order to create a uniform European wide model contract for EPCs in the form of the Eurocontract Project Development Models.

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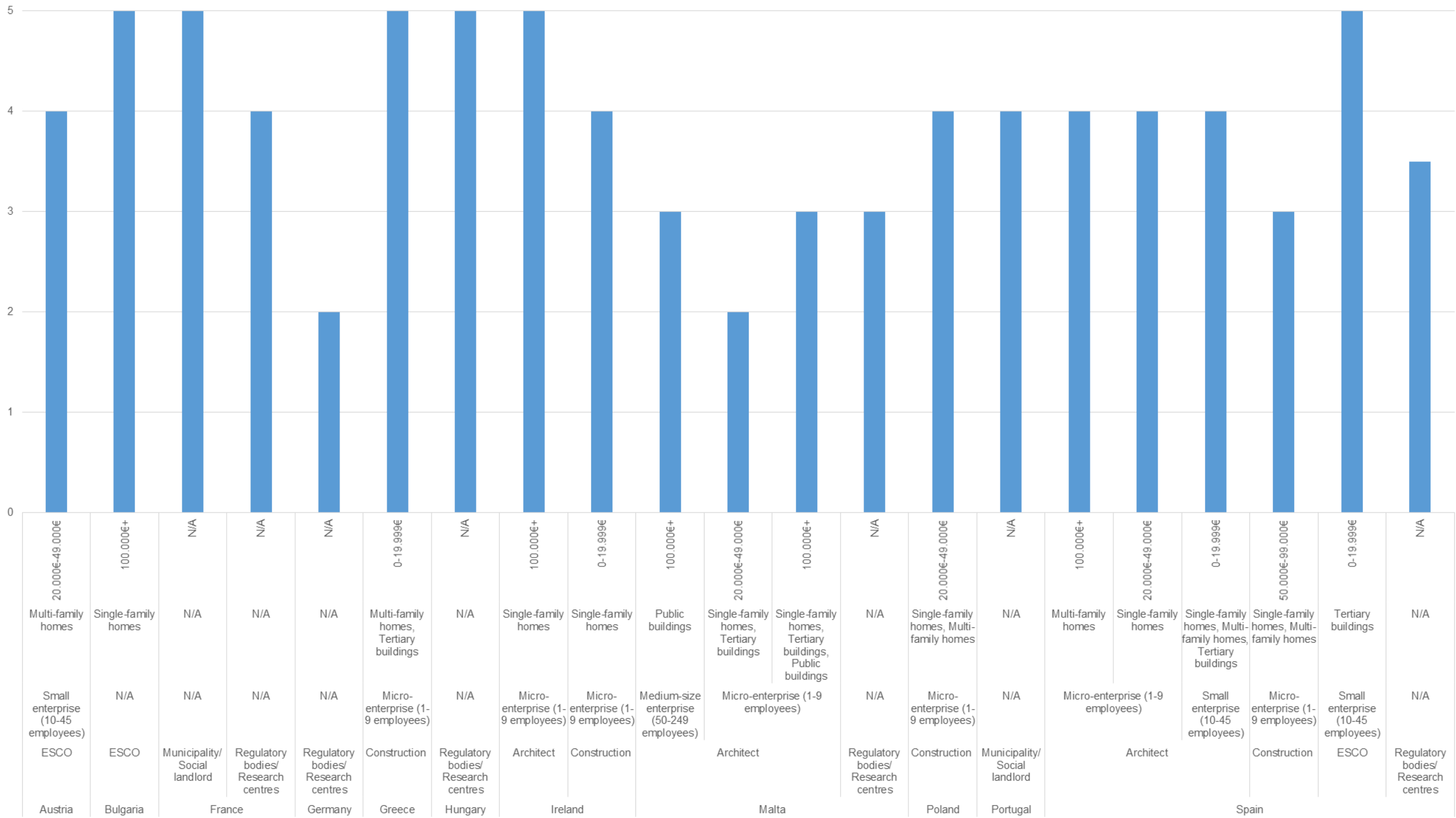

Figure 67 Breakdown of barrier scores for "limited ability for ESCOs to offer financing on Energy Performance Contracts"

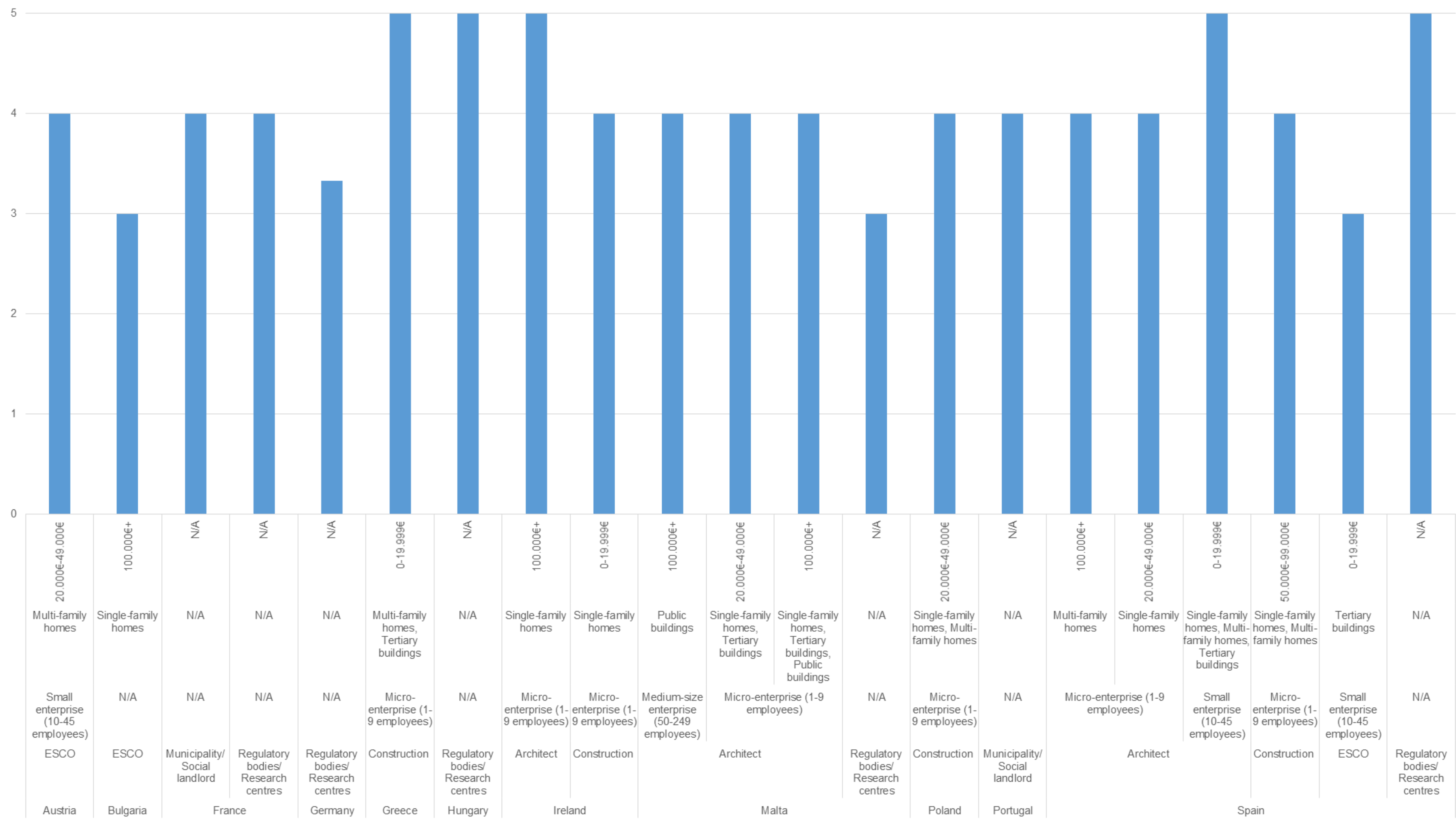

Figure 68 Breakdown of barrier scores for "Limited involvement of third parties and banks in EPCS"

9.4.3. Limited impact of Energy Performance Certificate improvements on property value

This barrier is concerned with the effects on property value of the improvement of energy performance certificates that could be brought about by EE refurbishments and renovations. It received a total average score of 3.4375 with a variance of 1.54 and 32 respondents.

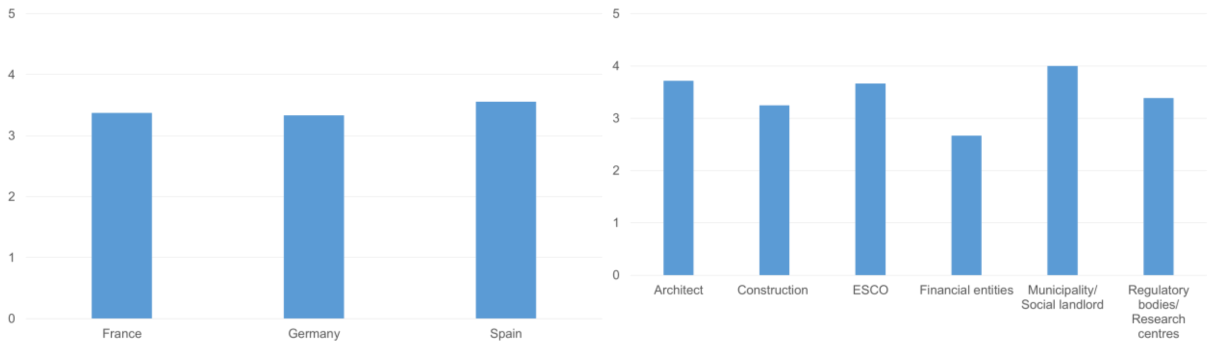

Figure 69 Country and stakeholder breakdown of barrier scores for "Limited impact of energy performance certificate improvements on property value

It commonly stated that linking certificate improvements to property value could be an effective mechanism at promoting EE refurbishments across Europe. Real estate investors could be interested in harnessing the power of EE renovations to revalue an asset and this could perhaps be a way of coping with certain issues such as split incentives for instance with the building owner benefitting from increased property value rather than having the tenants benefit exclusively from reduced energy bills.

Currently, when observing the findings of the EeMAP project and ZEBRA2020 it is extremely difficult to observe what could be qualified as a "Green Premium" in the real estate market which could lead to direct correlation between good energy certificates and property value. To this day, the traditional structural characteristics and factors of real estate are still the ones that predominate the value equation. These include location, size and surrounding area as the most significant while the factors indirectly correlated with certificates and potential renovations, such as lighting and energy consumption, are relegated to being less influential variables. This could potentially act as a barrier since real estate agents are less likely to encourage renovations and the market penetration of EE refurbishment approaches just as much as owners will not renovate on their own account.

This observed effect is very much correlated with their belief in a rent/price surplus originating from high energy performance ratings as shown in the following

Figure 37. In all cases a majority of respondents have denied a connection between rent/price surpluses and high energy performance ratings which generally speaking means attractiveness for building owners to perform retrofits. What is interesting is that there seems to be a relationship between the regions that most reject the belief in the existence of rent/price surplus from high energy ratings and their evaluation of this barrier (although score differences are marginal). Indeed, Germany with the most "Yes" responses in

Figure 37 rate this barrier lowest among France and Spain while Spain rated it the highest out of the three countries with the lowest amount of "Yes" responses.

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Despite this fact, the scoring for this barrier is characterized by a rather high variance in scores especially amongst financial entities (although they are all from France) that are most likely exposed to these effects daily.

At this stage, it seems that the link between energy certificates and property value is a question of perception and individual experience. Nevertheless, if a link does exist or is starting to develop, it is most likely observed in terms of the poorest energy certificates and low property value rather than high energy ratings and premiums on property value. Indeed, the improvements on energy certificates seem to have diminishing positive effects on value as one moves up to the best ratings.

Part of the EPBD and EED national plan requirements is the implementation of obligatory energy performance certificates for every building which should inevitably create incentives for renovations and strengthen the feedback effects between energy performance and value. Nevertheless, currently the enforcement of energy performance certificates is not uniform throughout member states as is the perception associated to them as demonstrated by the work on these certificates presented in the ZEBRA2020 project and also discussed in the beginning of this report.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

The factor that will most affect this barrier is the implementation of true enforcement mechanisms for energy performance certificates of buildings. Currently, such mechanisms are heterogeneous throughout member states explaining certain differences in the perception of their importance, reliability and usefulness as demonstrated in ZEBRA2020 and Figure 35, Figure 36 and Figure 37 of this report.

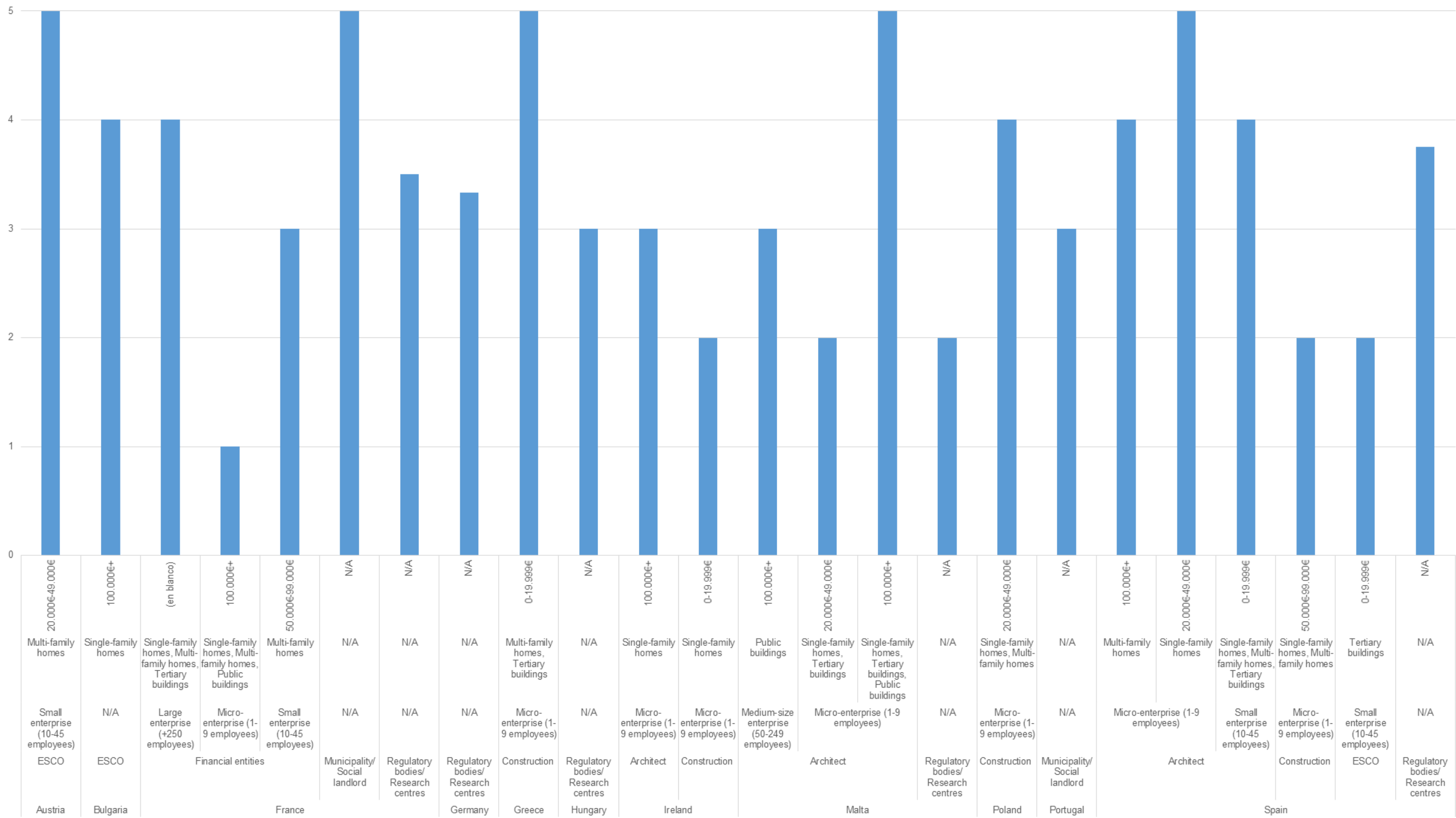

Figure 70 Breakdown of barrier scores for "Limited impact of Energy Performance Certificate improvements on property value"

10. Barriers that interfere during the implementation phases and processes of energy efficient renovations

10.1. Organizational and structural shortcomings of the energy efficiency renovation market barrier typology

These barriers refer to the multiple inefficiencies in terms of the coordination and standard operating procedures that exist within the energy efficiency renovations market. The following maps provide a summary in terms of mapping out the typology average scores per country and the number of observed case studies.

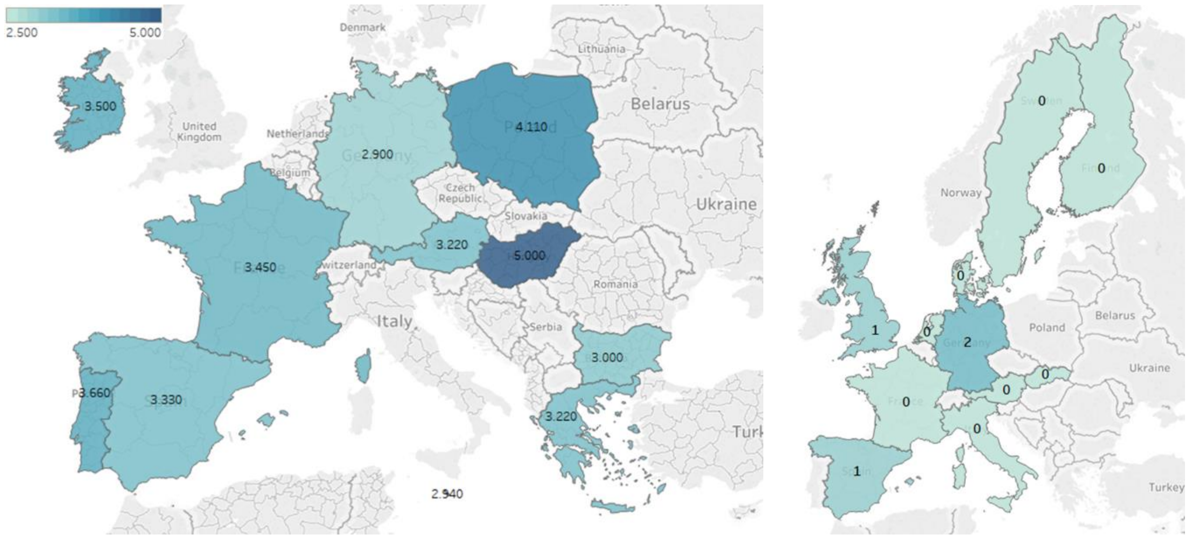

Figure 71 Left: Average structural typology score per country/ Right: Number of times structural typology was observed in case studies

The following set of barriers have been the focus of the STUNNING survey for this barrier typology. Within these barriers, issues on public procurement have been investigated. The three last barriers to the right of the below figure are specifically targeted toward public procurement schemes and were answered only by stakeholders having participated in such processes. It was chosen to focus attention on the barriers of this typology having received the highest significance scores (3.5+):

- Difficulties in coordinating work with other stakeholders involved in the project
- Public procurement scheme barriers:
  - Insufficient resources on part of SMEs o tender for these contracts
  - Sub-division of contracts into lots leading to unstable partnerships and difficulties for efficient teamwork

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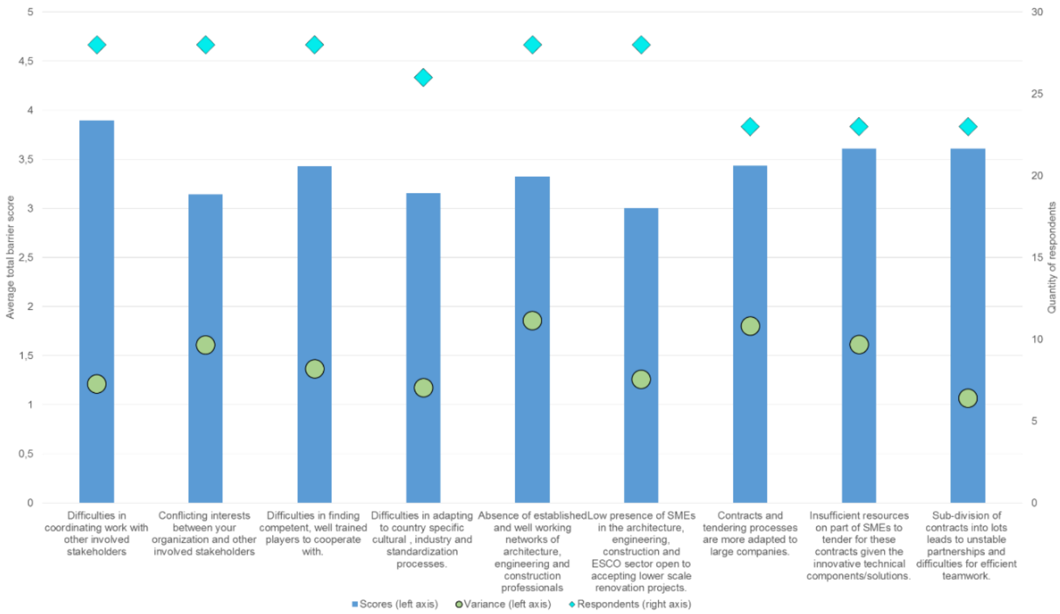

Figure 72 Organizational and structural short comings barrier typology scores and respondents

10.1.1. Difficulties in coordinating work with other involved stakeholders

Generally, the construction industry is characterized by a lack of lack of communication and mutual understanding among the involved professional disciplines in a project. Energy efficient refurbishments and renovations involve a plethora of different stakeholders intervening. This combined with the current standards in the industry being subcontracting with new teams of designers, builders, and suppliers for every new project means coordination and learning are inhibited and there are no possibilities to develop integrated teams of professionals who are used to working with each other and can have mutual trust in each other's expertise and quality of work. This barrier obtained a score of 3.9 with a variance of 1.2 and 28 respondents providing feedback. The following figure provides a country level and stakeholder breakdown of received significance score in the STUNNING survey.

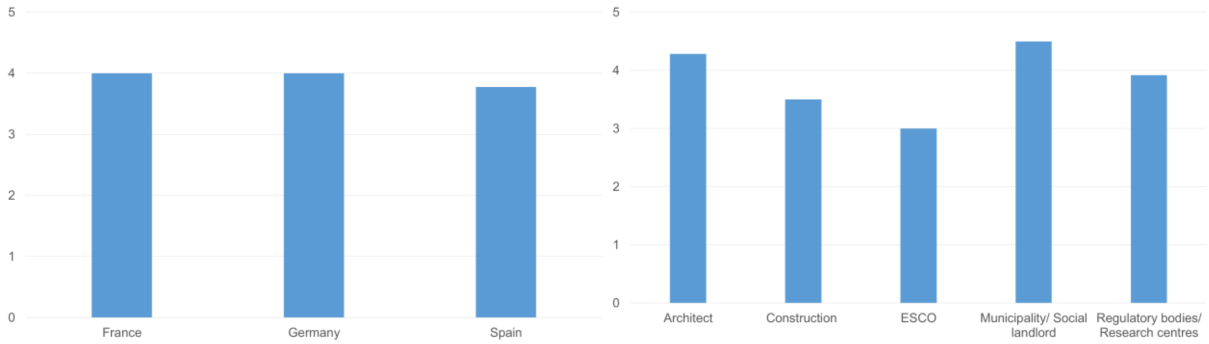

Figure 73 Country and stakeholder breakdown of barrier scores for "difficulties in coordinating work with other involved stakeholders"

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As projects are defined by multiple stakeholders, companies and practices cooperating with each other, many inefficiencies are noted during the renovation process. Indeed, construction and energy services markets throughout Europe are characterized by their competitive and fragmented nature. As energy efficient renovations often require the use of new technologies and advanced materials, every building must be studied in detail in order to assess the right set of solutions to be applied given it´s unique characteristics. It is harder to achieve this when stakeholders intervene individually with little information sharing and following their own interests and priorities. Indeed, according to Sorrell 2003 (Making the link: Climate policy and the reform of the UK construction industry), the lack of project integration and cooperation between actors inhibits creative approaches in EE renovations and generally leads to each stakeholder re-using bids from previous work in an attempt to minimize work and costs. This can lead to another layer of issues down the road such as inadequate sizing of equipment and performance gaps due to inadequate simulations and modeling at the beginning of the project.

When observing the scores given for this barrier in the three most relevant regions (Germany, France, Spain) one can observe a rather homogenous appreciation of the importance of this barrier with scores all being set at four or very close to that. Moreover, architects are the actors actually intervening in the implementation of the renovation that have rated the significance of this barrier the highest at 4.3. This may be due to the fact that fragmentation within the construction industry has commonly arisen in the separation of the design and construction phases. It is possible that architects and other design professionals have difficulties in taking into consideration how construction professionals will implement the designed project results.

Moreover, from the point of view of building typologies most relevant to this barrier, the survey tends to indicate that lower budget projects are most affected with stakeholders working on projects ranging from 0-49.000€ (composed of the two lower brackets for average project budgets) attributing on average a score of 4; significantly higher than what is attributed by stakeholders working on higher budget renovations with a score of below 3.5. This is not necessarily a surprise as the lower budgets may lead designers and construction companies into adopting the least costly options with re-use of bids and limited involvement during the whole renovation process due to the lower potential margins. This may also be due to the fact that companies operating on such projects will most often be SMEs that are not as accustomed to integrated design processes and software for information sharing.

One of the secondary effects of this barrier is also the limitation of learning opportunities for all involved stakeholders in the renovation process. Indeed, as creative and novel solutions and approaches are less likely within such a fragmented market, the sector experiences the inhibition of knowledge development potential and stagnates as a whole.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

It seems as though this issue or barrier will be equally prevalent in all member states of the European Union as the industry in general throughout Europe is characterized by high levels of fragmentation and sub-contracting practices with little exchange in information and high pressure on margins of each stakeholder pursuing individual interest and leading them to the re-use of bids for their bottom line rather than pursuing what is best and most optimal for the building in question. Nevertheless, this barrier can be mitigated through the implementation of integrated design protocols and processes where information is centralized and shared. Moreover, these advanced software tools have the capability of assessing the effect of different combinations of sub components on the whole building performance.

Therefore, member states where software tools of a lesser piece meal nature than the ones specifically targeted towards the optimization of one system or protocol are more widely used will most likely experience this barrier to a lesser extent. One of the metrics that can be used for evaluating this is the diffusion of BIM in respective countries. Indeed, BIM adoption for building design, construction and maintenance directly addresses issues of fragmentation and coordination between all involved stakeholders.

As seen and explained above, it seems most likely that lower scale projects with lower budgets are most affected by barriers relevant to fragmentation and coordination issues between involved actors. Indeed, the lower budgets and smaller company profiles with less sophisticated design processes characterized by less integration will most likely result in less cooperation and more conflictual relationships during the renovation process as a whole.

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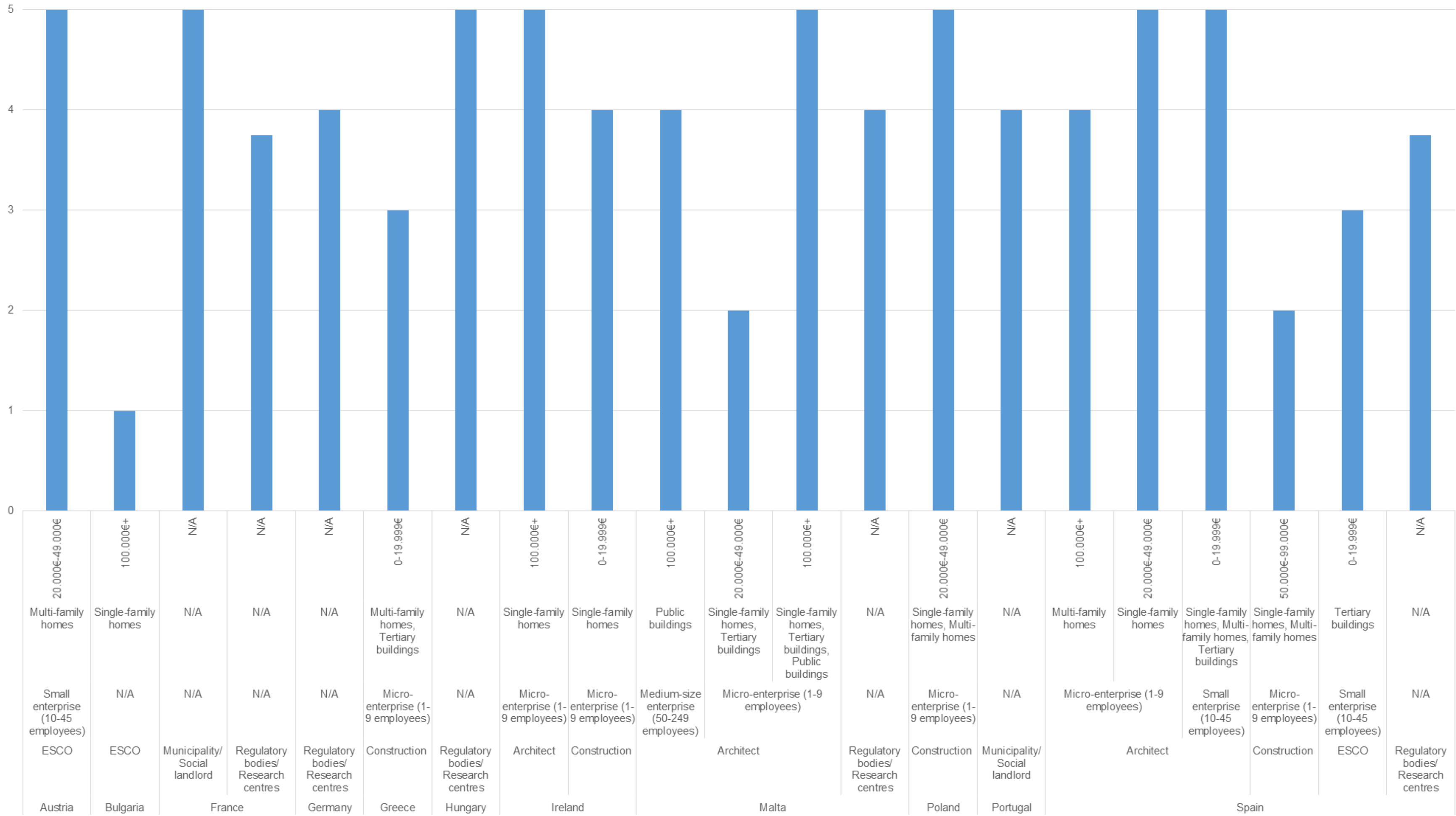

Figure 74 Breakdown of barrier scores for "difficulties in coordinating work with other involved stakeholders"

10.1.2. Insufficient resources on part of SMEs to tender for public procurement schemes - Sub-division of contracts into lots leads to unstable partnerships and difficulties for efficient teamwork

The two following barriers have been regrouped as they are both relevant to public procurement schemes and the integration of SMEs within these processes. The first barrier relevant to the difficulties encountered by SMEs in competing on public tenders due to their limited resources has received a score of 3.61 with a relatively high variance of 1.6 from 23 respondents. The second, related to fragmentation of renovation processes due to lots allocation has been scored at 3.61 as well with a lower variance of 1.06 from 23 respondents.

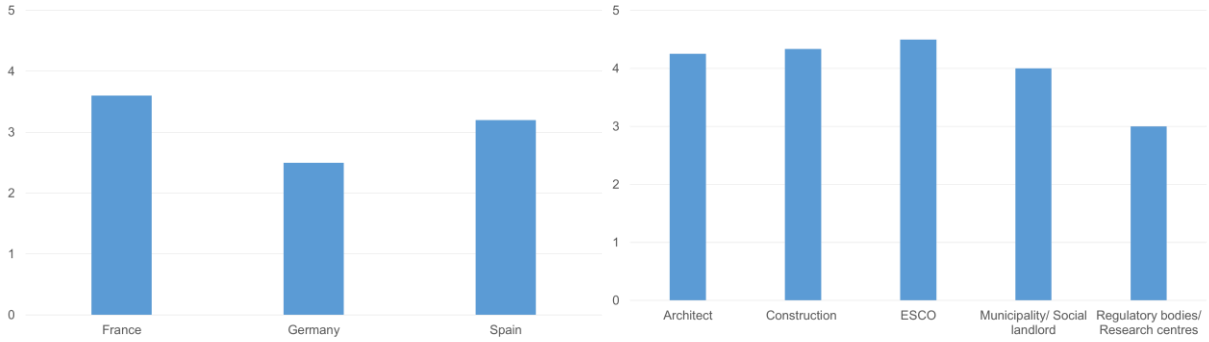

Figure 75 Country and stakeholder breakdown of "Insufficient resources on part of SMEs to tender for these contracts given the innovative technical components and solutions"

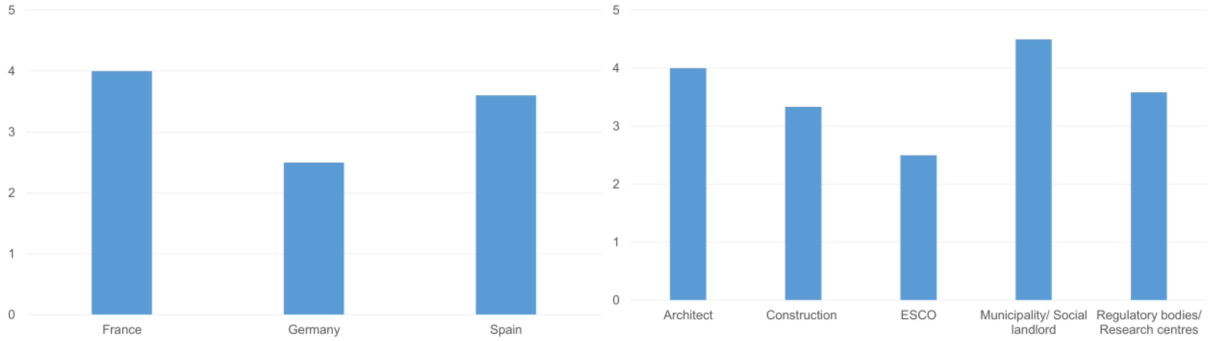

Figure 76 Country and stakeholder breakdown of barrier scores "Sub-division of contracts into lots leads to unstable partnerships and difficulties for efficient renovations"

Public Procurement in the EU is generally structured in a way that when central governments require supplies or services above a threshold of €130,000, or works to be carried out above a cap of €5m, the tender must be published in the Official Journal of the EU (OJEU) and follow all applicable requirements of the directives. The European Directive 2014/24/EU provides 4 procedures: open, restricted, negotiated and competitive dialogue procedures for procurement of goods, works, or services.

Barriers to SME participation in public procurement schemes have been well researched and documented.

The first difficulty identified is the large size of contracts which require a large amount of resources as implied by the first barrier being evaluated in this instance. Indeed, SMEs which only have the resources to only provide one part of the tender also face excessively high fixed costs which are easier to face for

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larger companies. One of the commonly cited solutions is the sub-division of contracts into lots. Procurers could take advantage of the possibility for SMEs to form groups and rely on their combined economic and technical ability. This could also foster cooperation between larger players and SMEs helping the latter develop. Procurers are claimed to often ask for disproportionate qualification levels and financial and certification requirements. To help SMEs to participate to public procurement they should keep selection criteria proportionate and take advantage of the possibility for SMEs or a group of SMEs to prove their combined economic and financial standing and technical ability. In addition to this, they should require only proportionate financial guarantees. The second barrier evaluated in this instance attempts to evaluate this possibility.

The lack of resources on part of SMEs is also not solely a question of technical ability. Indeed, it is hard for these actors to access the relevant information because they do not have enough resources to allocate to information collection or administrative capacity to prepare a quality tender response. By coming together they may be able to manage this better.

To increase this access, e-procurement websites could be improved to offer more information, contracting authorities should work on information centers, and on feedback to tenderers which can help SMEs. SMEs find it difficult to understand the information provided. This could be improved by developing more training and guidance for contracting authorities, and training and guidance for SMEs on drawing up tenders. Some of these barriers are being overcome through the use of clusters of stakeholders with an interest in the area of energy efficiency and innovative products and services by facilitating collaborations between the supply and demand sides of EE refurbishment public contracts. Furthermore, such clusters can also favor the cooperation of SMEs with larger players on public tenders.

In the case of the STUNNING survey, we are faced with an overwhelming majority of SME stakeholders giving very high scores to our first barrier related to the lack of resources for SMEs participating in these tenders. Indeed, Architects, ESCOS and construction service companies all gave an average score between 4.2 and 4.5. These are all stakeholders intervening in the actual renovation process. This tends to legitimize the validity of the arguments being advanced in the previous paragraphs on limited SME resources. Moreover, significantly lower scores for these same stakeholders in the scoring of the second barrier related to inefficiencies when dividing contracts into lots tends to support the idea that SMEs could create cohesive groups that answer public tenders and alleviate issues related to lack of resources for participation in public procurement programs.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

Compiling the previous information, it is possible to observe that the most influential variable in coping with limited resources of SMEs for public tendering is the implementation of public procurement systems that favour the division of works and services in lots, notably for EPC style contracts in the framework of EE renovations.

In Germany, the Regulation on Contract Awards for Public Supplies and Services (Vergabeverordnung) is applicable for awarding of contracts for energy services (particularly for EPC) although energy services are not listed separately in the Annex I part A of VOL/A.

In the VOL part A (General rules for procurement) it is stated that: “the award must be granted to the most economically advantageous tender with due consideration of all circumstances. The lowest tender

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price alone is not the sole decisive criterion". Special account shall be taken to consider the interests of small and medium-sized enterprises when awarding public contracts. Contracts shall be subdivided into partial lots and by type or trade (technical lots). Several partial or technical lots may be awarded together if required on economic or technical grounds. In addition, depending on the type, scope and purpose of the service to be rendered, the enterprise can provide evidence of its professional and technical capabilities. This bias towards SMEs and sub division into lots may explain why German stakeholders have given lesser scores to both of these barriers affecting SMEs in public procurement schemes and tenders.

Dividing contracts into lots, especially for EPCs, is not a standard across member states. France is an example of this and coincidentally, stakeholders have scored barriers to SME participation in public procurement schemes significantly higher. Indeed, the Grenelle 2 law of 2010 has given the possibility for central and local administrations to now have access to "EPC type" global contractual agreements (Marche Public de Performance Energétique – MPPE) bypassing the obligation of allotment.

Another variable that can make a difference in this instance is the existence of clusters and associations of relevant EE stakeholders and actors that provide cooperation opportunities on public EPCs and public tenders of all sorts as well as information and guidelines on how to proceed and respond to these tenders. In Germany for instance, in order to standardize and simplify public procurement of energy services, several public institutions and professional associations have developed guidelines, manuals and standard procedures for public procurement of energy services. Some of the most used documents are:

- "Guidelines for the procurement of energy supply contracting" issued by Association of Heat Suppliers (Verband für Wärmelieferung);
- "Guidelines for procurement of energy supply contracting" issued by German Energy Agency (DENA);
- "Guidelines for energy performance contracting in public buildings" issued by Hessian Ministry for Environment, Energy, Agriculture and Consumer Protection.

In this respect, the existence of these types of clusters in member states can provide part of the solution for more SME inclusion in public EE refurbishments.

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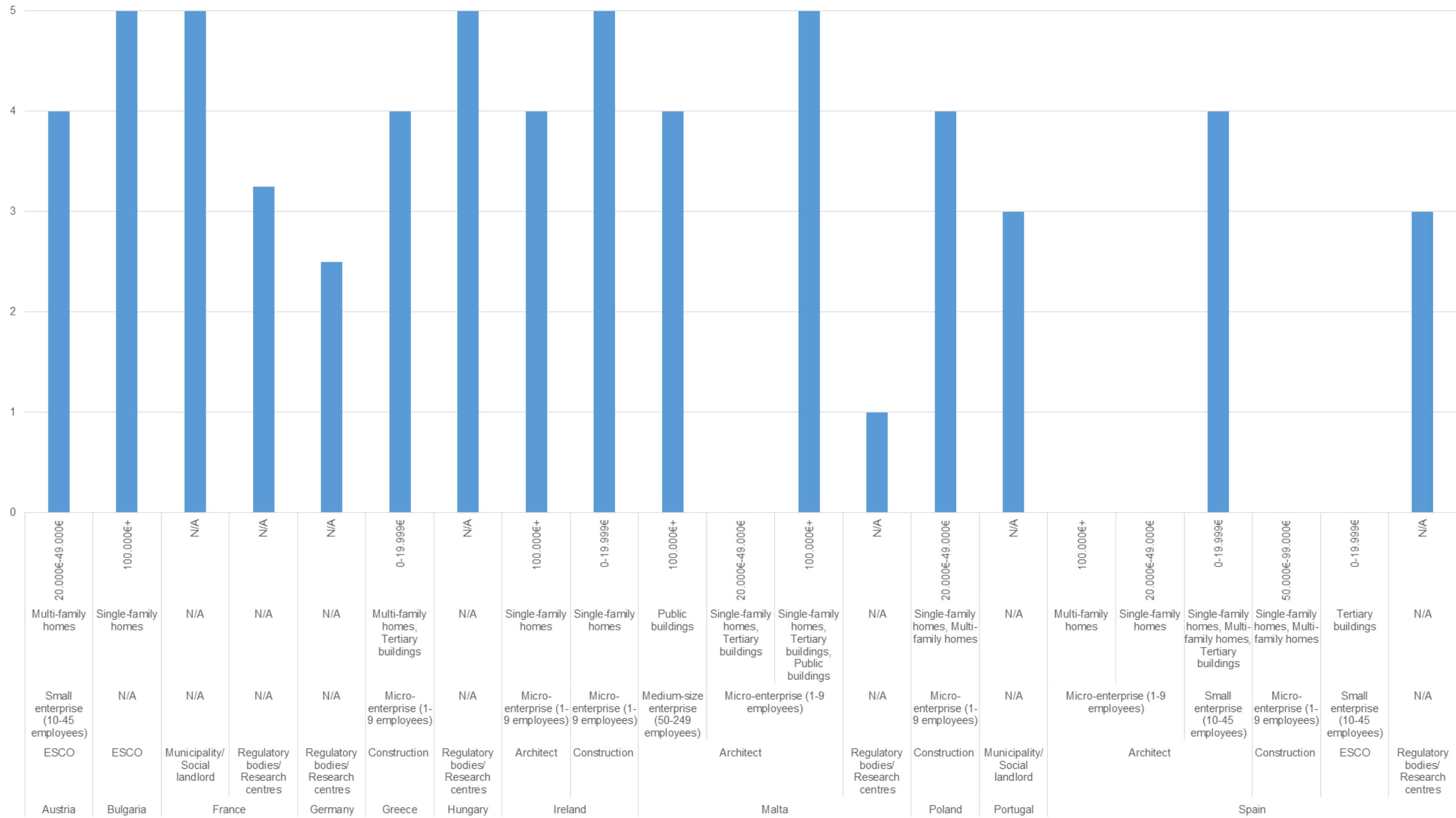

Figure 77 Breakdown for barrier scores for "Insufficient resources on part of SMEs to tender for these contracts given the innovative technical components/solutions"

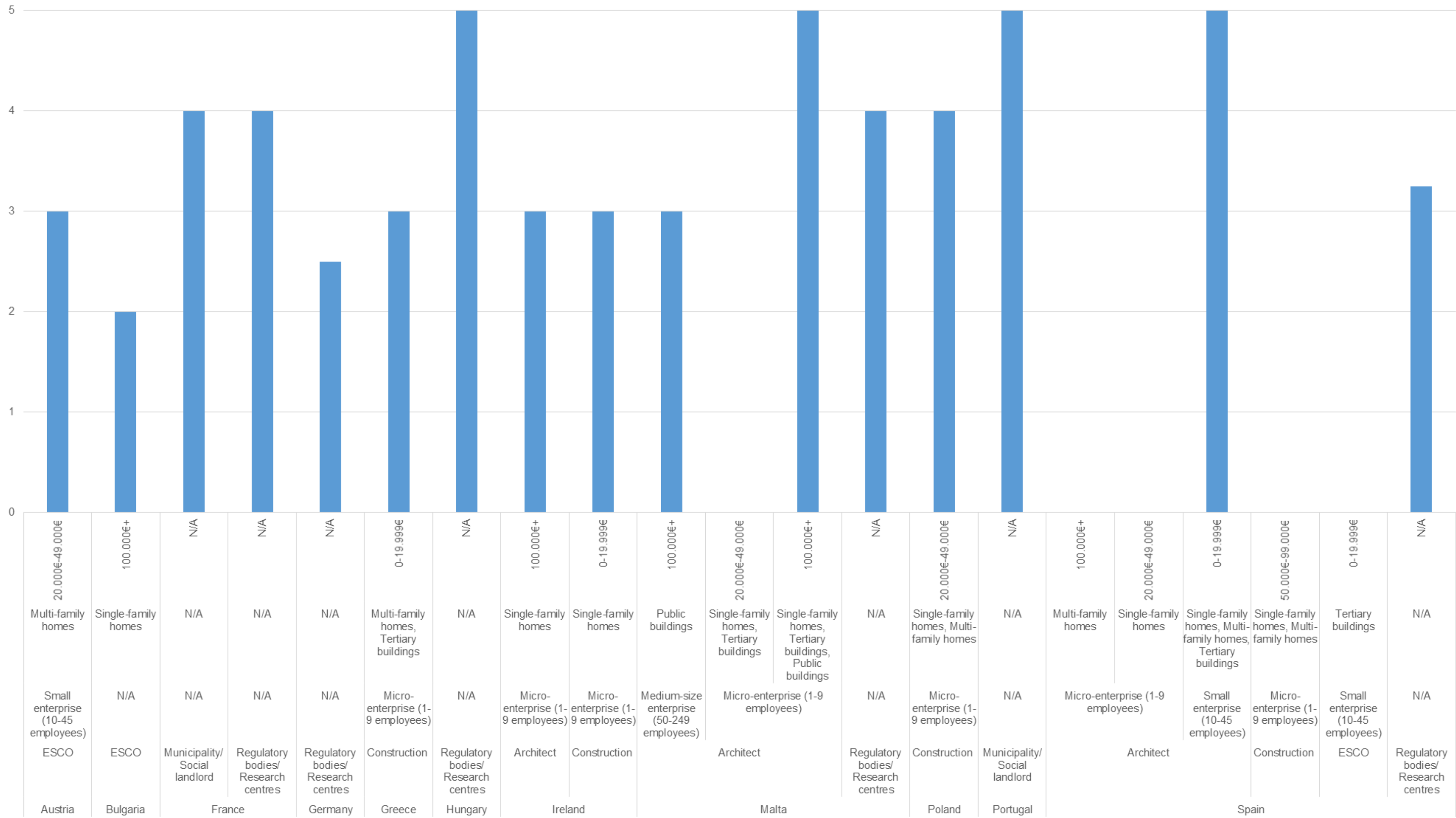

Figure 78 Break down of barrier scores for “Sub-division of contracts into lots leads to unstable partnerships and difficulties for efficient teamwork”

10.2. Regulatory barrier typology

Regulatory barriers relate to the shortcomings in European directives and guidelines as well as national legislation in support of the EE renovation sector. The following maps are an overview of this typology´s questionnaire score breakdown and the amount of observed case studies per country.

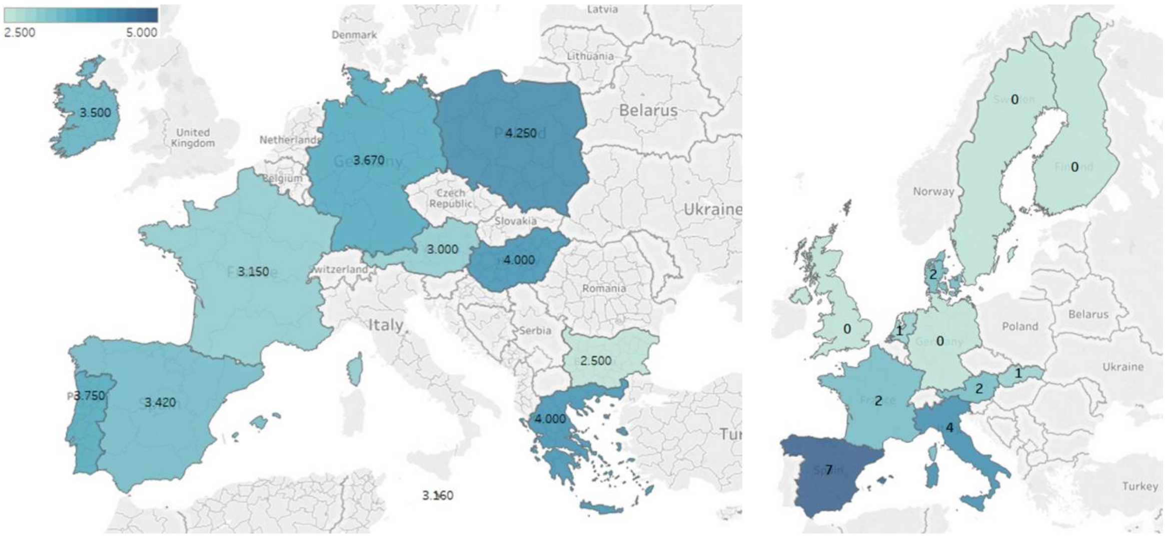

Figure 79 Left: Average regulatory typology score per country/ Right: Number of times regulatory typology was observed in case studies

The sole barrier evaluated in more depth in this instance is that of limited government subsidies and programs for renovations. It is the only one having received a score above 3.5 and is commonly cited as the main barrier in this typology.

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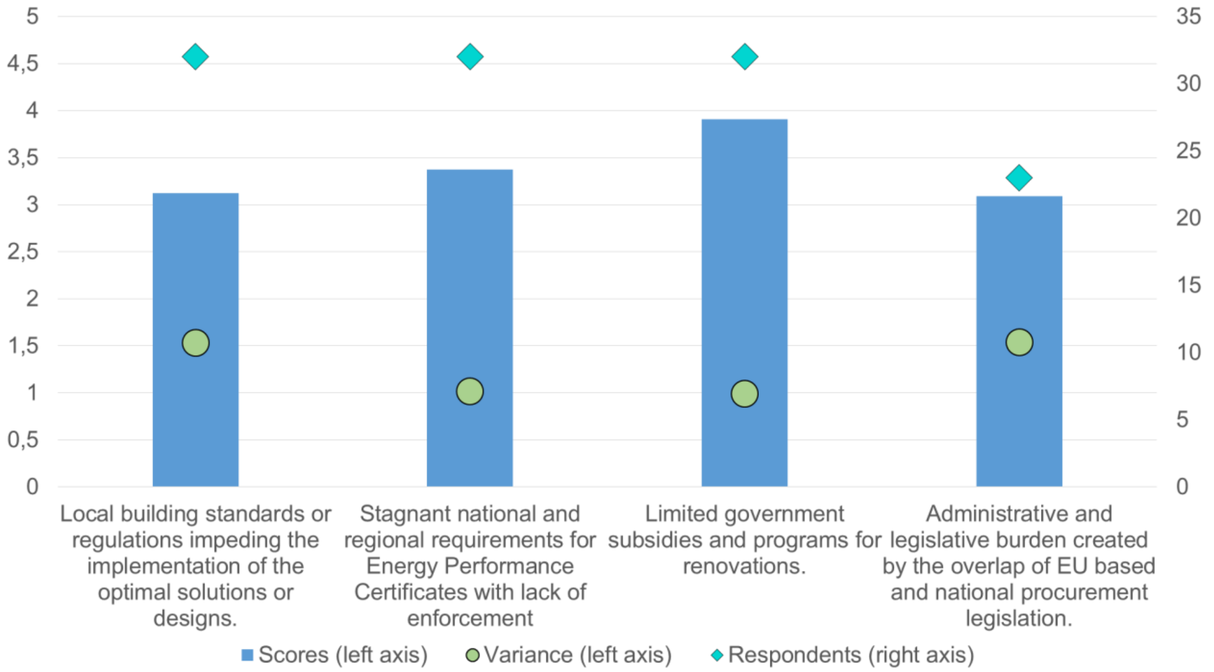

Figure 80 Regulatory barrier typology barrier scores and respondents

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10.2.1. Limited government subsidies and programs

Within the framework of the STUNNING survey, this barrier has received a consolidated score of 3.9 and a variance of 0.99 through the feedback of 32 respondents.

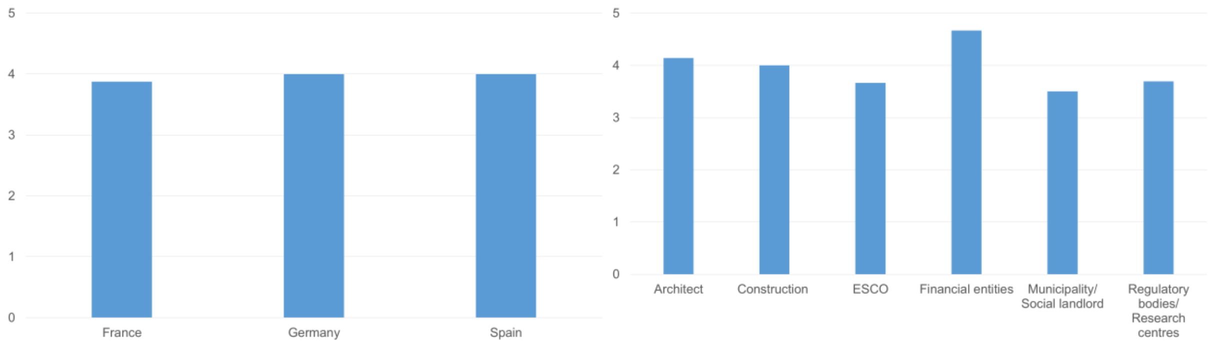

Figure 81 Country and stakeholder breakdown of barrier scores for "Limited subsidies and programs"

An interesting effect of this barrier and obtained stakeholder feedback would have been to compare the specificities of local subsidy programs detailed in the earlier part of this report with scoring differentials between countries and stakeholder types. Nevertheless, as demonstrated in Figure 81 above, scores are rather similar across the three main regions that we have used as a benchmark and are most significantly represented in the questionnaire. This is also reflected in the rather homogenous composition of subsidies and support programs throughout different member states, which ultimately are very much in line with EPBD provisions. Generally, available support and aids come in the form of European structural and investment funds, EU financial instruments, tax credits, reduced VAT on eco products, supplies and services, zero interest eco loans and national funds providing grants to a plethora of stakeholders including public buildings themselves.

One element that may be interesting is how high all private financial entities have scored this barrier very high yielding a consolidated average of 4.7. This could perhaps highlight the need for more actions and aid programs coordinated between private financial entities, banks and local governments such as 0% eco-loans in France whereby the government takes charge of the borrowers´ interest and administrative costs to the lender. The loan interest is financed by the State which gives the lender a tax credit to make up for the interest payments foregone.

On another note, during the course of the STUNNING project, an important number of stakeholders and case studies have highlighted the lack of continuity in government support programs and regulations in general. This has forced stakeholders and economic actors from the EE renovation sector to continually adapt their business models as well as technical know-how. A resource intensive process which makes it hard for SMEs with fewer resources to continually adapt themselves to the regulatory landscape compared to larger companies in the sector.

Such regulatory changes that affected specific renovation case studies and interviewed stakeholders during a project are listed as follows:

- The Italian Regulatory Authority for Electricity Gas and Water (AEEG) established the payment

of surcharge costs for the self-generation systems (Decision AEEG 12 December 2013, 578/2013/REEL). This obligation created a barrier to the development of Organic Rankine Cycle applications to the recovery of waste heat from industrial processes. Indeed, this rule reduces the value of the electricity produced by a heat recovery system from an industrial process with Organic Rankine Cycle technology, prolonging investment payback times up to 100 % (Technical University of Milan, Energy & Strategy Group, Energy Efficiency Report 2013);

- The Spanish electricity market has been running into deficit in recent years. They have therefore implemented a 'tariff deficit', largely as a result of the cost of running the country's electrical system exceeding the revenues generated by the sales of power. In 2016, the Spanish government proposed a new deficit reduction measure called the 'sun tax' that increases the price of self-generated solar power, largely based around photovoltaic technology. According to Spain's Photovoltaic Union (UNEF), the new law requires self-consumption photovoltaic system owners to pay the same grid fees that all electricity consumers in Spain pay, plus the so-called 'sun tax'. This made planned PV installations significantly less attractive;

- In Spain, the Royal Decree-Act 1/2012 entered into effect, suspending procedures for the pre-allocation of payments and suppressing economic incentives for new power generation installations based on cogeneration, renewable energy sources and waste. However, section 3.3 of the aforementioned Royal Decree-Act states that a new specific regime will be developed for power generation installations that use biomass, waste and cogeneration technologies;

- An Irish Government requirement that its funding applies only for bundles of five or more house renovations has undermined the traditional market for one-off bespoke house energy retrofit. One-off renovation is the traditional way the Irish construction industry has delivered renovation. All the recently NZEB up-skilled professionals in the country are now excluded from the funding scheme and a small handful of under-skilled (no recognized NZEB qualifications) market operators have access to unlimited funding, are promoting unsafe retrofit practices and now have a monopoly on the retrofit market. This has resulted in architects capable of delivering energy retrofits at the highest level of competency in the EU, some holding specialized MSc´s in Energy Retrofit Technology qualifications, being excluded from the market;

- In Denmark, a national regulatory change announced in 2016 forced the cancellation of the programme where electricity from photovoltaics sold to the grid received a guaranteed price per kWh rather than the fluctuating spot market price;

- In Denmark in 2016, it was announced that the financial incentive for open-door wind turbines will end in 2018. Only the wind turbines connected to the national grid by 21 February 2018 are entitled to receive the incentive. This made the business case for many early-stage projects worse and endangers their entire feasibility. The change is especially burdensome due to the short time frame in which it is impossible to speed up wind projects to gain access to the incentive. Future public subsidies should not be taken for granted, and the planning stage of project replication should include a Plan B for a changing regulatory environment.

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

It is clear that the most defining variable for this barrier will be a full set of aid programs in line with EPBD requirements and well explained and defined in the national strategy for EPBD compliance.

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Nevertheless, it is also quite evident that other factors come into play. Some of these are identified here as potentially being the lack of enhanced cooperation programs between private financial spheres and government institutions as well as and mainly a lack of continuity in the regulatory frameworks that define the EE renovation sector in the EU as demonstrated above.

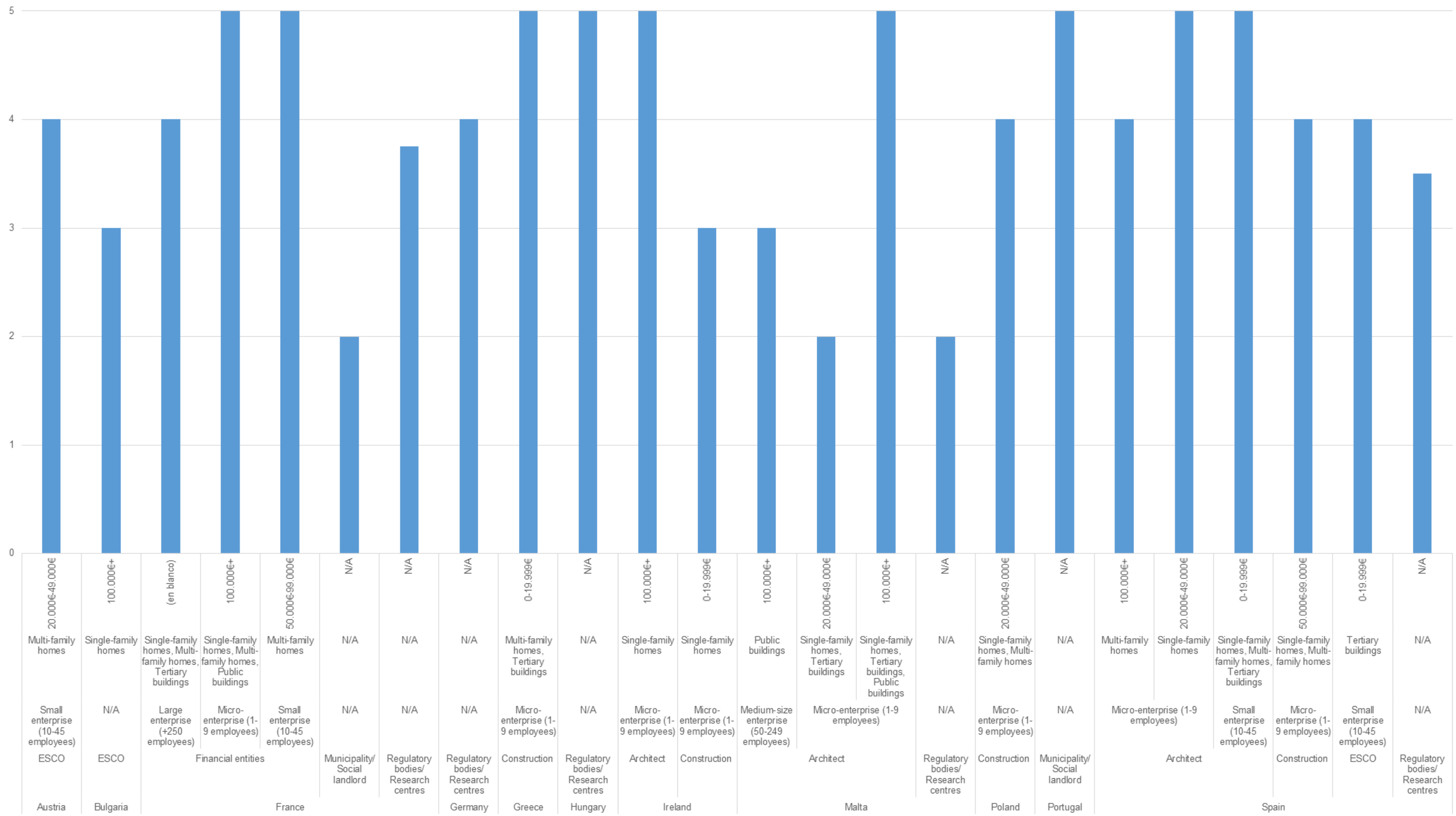

Figure 82 Breakdown of barrier scores for “Limited government subsidies and programs”

10.3. Informative and knowledge based barrier typology

10.3.1. Limited information campaigns and training programs on energy efficiency

This barrier is relevant towards the availability of information campaigns and training programs for EE refurbishment and AEC professionals. As seen in initial technical barrier typologies as well as the potential solutions to the coordination problems between different stakeholders with the implementation of software driven integrated design processes, the integration and diffusion of adapted technical implements within the EE renovation market is vital. This barrier has received a rather high consolidated score of 3.93 with a low variance of 0.42 from 29 respondents indicating all around consensus that this barrier is very significant at all levels of the market.

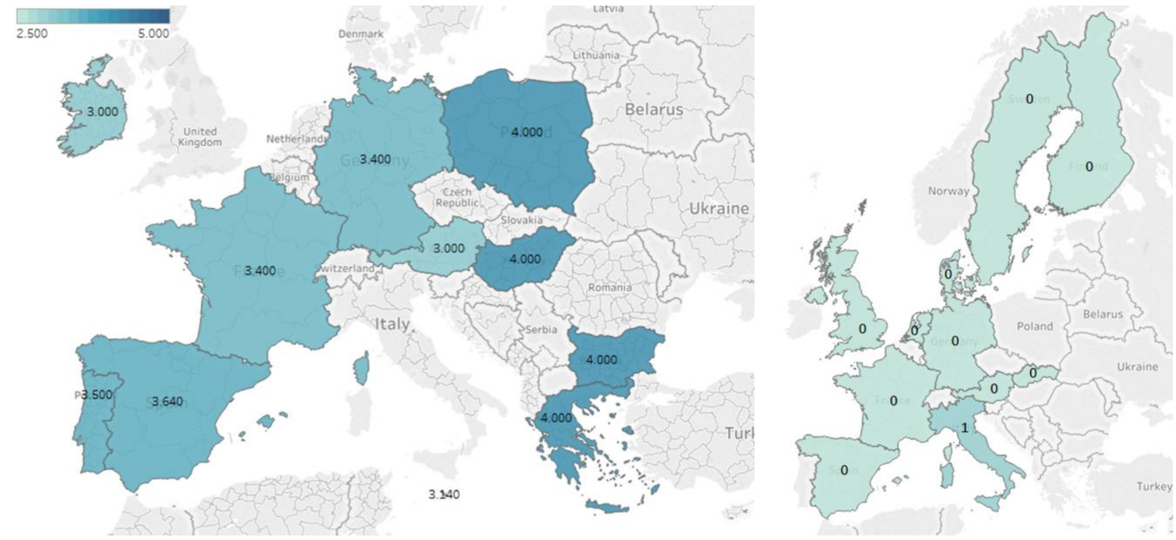

Figure 83 Left: Average informative (knowledge and skills) score per country/ Right: Number of times informative (knowledge and skills) was observed in case studies

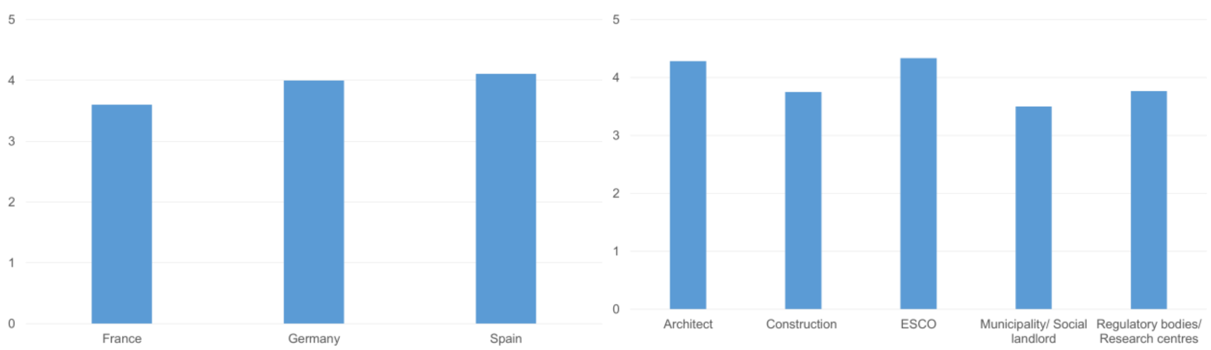

Figure 84 Country and stakeholder breakdown of barrier scores for "limited information campaigns and training programs"

What is interesting with these results is the significantly higher barrier scores coming from stakeholders in the architects and ESCOs category with a 4.3 score from ESCOs and 4.28 rom architects both with

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a variance around 0.4 which represents substantially less variance than other barriers assessed in this questionnaire. This comes as no surprise as green building practices and energy efficiency renovations have supposed drastically new approaches especially in terms of integrated design and planning approaches which directly affect these types of stakeholders. For instance, many architects have started to train themselves in energy simulation approaches or integrate such components within their models. Providers of modelling and design software have also started developing solutions and suites that integrate such features which imply a need for constant training for these stakeholders. One such example could be Insight by autodesk which empowers architects and engineers to design more energy-efficient buildings with advanced simulation engines and building performance analysis data integrated in their BIM suite Revit. Furthermore, for ESCOs, as the market is still characterized by constantly evolving technologies and entry of new products and features, companies must stay up to date with most current portfolio of solutions available in the market and update the skills of their workforce to be able to implement such solutions. Energy auditing approaches along with other relevant disciplines are now characterized by stringent certifications and standards. Some of the skills and competencies that ESCOs must stay up to date with include advanced measurement and verification standards, energy analytics, ISO 50001 standard implementation, energy auditing and building certification among a plethora of other disciplines and topics.

Moreover, the need for training and skills development is not only manifested in new technological offerings but also in terms of administrative and contractual capacities. Indeed, considering the sometimes complex nature of contractual agreements around EPCs in the ESCO market, some companies must update their skills on standardized contractual standard operating procedures to stay afloat. The Transparense project is a testament to this as it was launched to help increase the transparency and trustworthiness of Energy Performance Contracting (EPC) markets throughout Europe attempting to transfer know-how across Europe, support EPC markets in Europe and thereby achieve substantial energy efficiency improvements. During the project, the Code of Conduct for EPC was developed in co-operation with the European associations of EPC providers - the European Association of Energy Service Companies (eu.ESCO) and the European Federation of Intelligent Energy Efficiency Services (EFIEES).

Sensitivity assessment: societal, economic and country specific variables affecting the barrier

The most important variables that will affect this barrier are most likely the presence of effective clusters, associations and projects capable of bringing together relevant stakeholders from the AEC and EE renovations sector in order to organize workshops and courses as well as publish national or transnational European guidelines and modules in order for all stakeholders to update the skills and competencies of their staff at a minimal cost especially for SMEs who do not necessarily have the time and resources to always perform the research and stay up to date on such matters.

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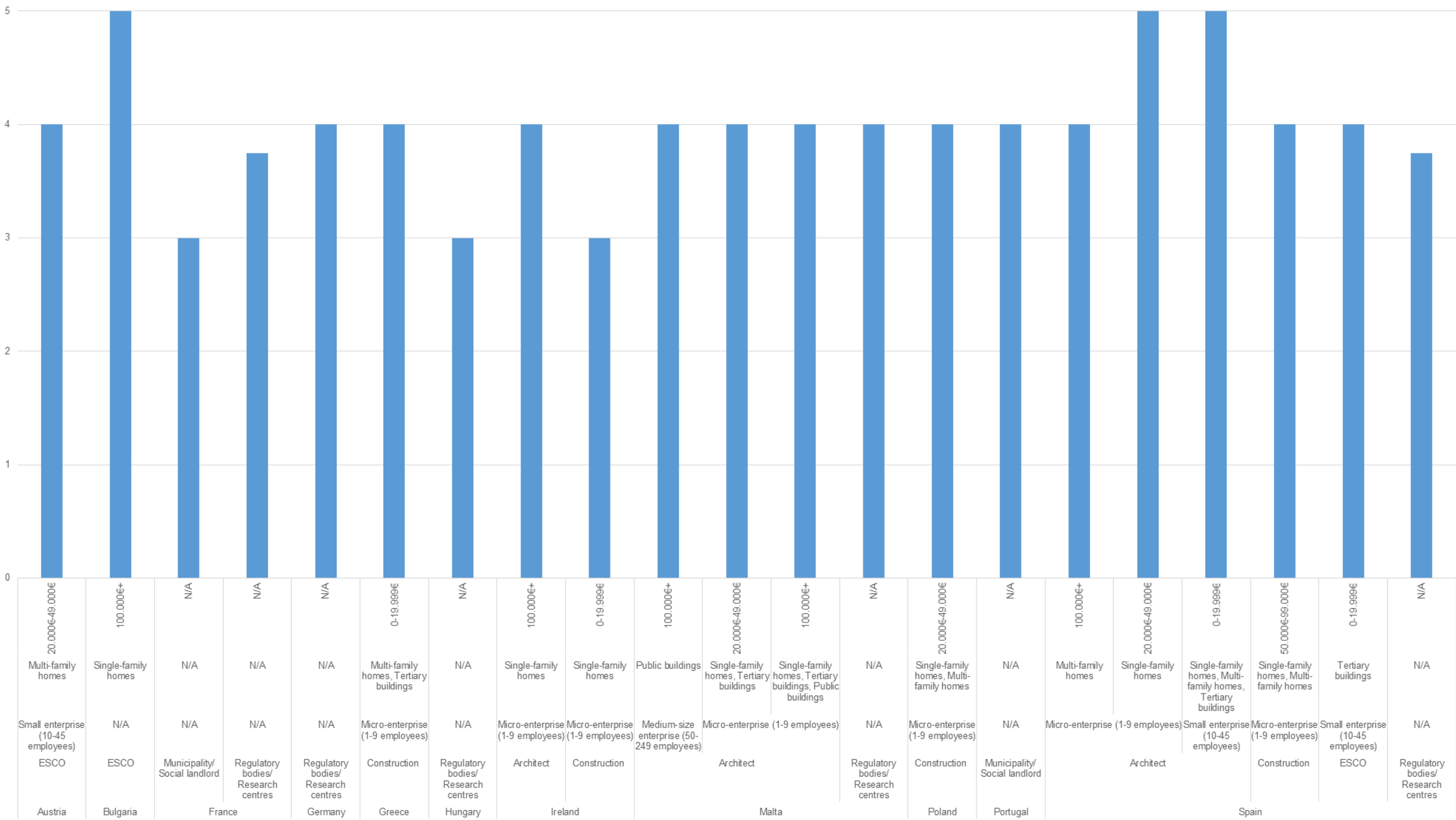

Figure 85 Breakdown of barrier scores for "Limited information campaigns and training programs"

11. Conclusion

This report has focused on two layers in the investigative process attempting to recognize barriers to the EE renovation market and sector as a whole. The first layer is an analysis of the macro environment influencing EE renovation activity across the EU whilst the second is a more micro level of analysis whereby more precise singular barriers are observed, characterized and better understood. What comes out of this study is that for the most part barriers seem to be rather uniform in their relevance and significance across regions. The national strategies established in line with EPBD and EED guidelines will obviously have a homogenizing effect in terms of MS policies and thus how market barriers evolve within different countries. Nevertheless, there are still some country level differences that lead to observed differences. These entail but are not limited to GDP growth and upturn cycles, public procurement rules and laws which especially affects SME participation, continuity in relevant and related regulatory frameworks and the existence of supporting organisms for SMEs which can provide guidelines and training for technical as well as contractual know how around the EE sector as a whole.

From the point of view of SMEs, a focal point of this work package and project, the barriers that affect them the most are issues related to EPC contracting approaches and limited TPF solutions for EE renovations, public procurement processes that tend to favour larger players, lack of support structures and frameworks for helping them keep afloat of the ever changing EE renovation technological and regulatory landscape with limited resources.

Analysing barriers as done in this report helps identify and give an overview of the possible obstacles to energy-efficiency renovations. But, universal prescriptions or affirmations are difficult to make when looking at such vast and diverse markets and different barriers appear in different phases and some disappear or transform in the process. For this reason, it would be extremely beneficial to prolong the data gathering process on barriers with new refurbishment cases being inputted into STUNNING in order to obtain larger samples and overtime draw out more specific country level insights on barrier evolution.

The information gathered in this report will be used as a foundation for D4.2 which aims to offer solutions that can address the barriers. Particular emphasis will be given to solutions that integrate SMEs and how these actors bring about successful changes, fostering active SME participation for EE renovation market development.

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