European Commission

Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU

Final report

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Table of Contents

1. Introduction

Within the 2030 climate and energy framework, the European Union (EU) has committed to several key targets for the period 2021-2030. The overall target for 2030 is to cut the energy system greenhouse gas (GHG) emissions by at least 40% as compared to the 1990 levels. Furthermore, the Renewable Energy Directive requires a binding minimum share of 32% of renewable energy for final energy use as EU-average. The Energy Efficiency Directive sets an indicative target of at least 32.5% improvement in energy efficiency by 2030 at EU level versus the projections. This is expected to lead the way towards a low-carbon economy and to meet the commitments under the Paris agreement.

A key measure to accomplish this goal is the improvement of the energy performance of buildings. The building sector is the largest single energy consumer in Europe. It is estimated that by 2050 at least 75% of today's buildings will still exist. Therefore, energy *renovation* is key to shift to a low carbon building stock. The bulk of the current building stock was built without significant energy performance requirements and for that reason offers a high potential for energy saving measures. However, neither the rate nor the depth of current energy renovation - 0.4-1.2% depending on the country according to the European Commission's estimations - live up to that savings potential.

It has to be kept in mind that also new constructions serve as technology locomotive for energy renovation; buildings erected between today and 2050 will still have a significant share of 20-25% in the building stock and therefore need high attention as well.

The Energy Performance of Buildings Directive (EPBD) is the main policy instrument to tackle this challenge within both existing and new buildings. According to the EPBD, all new buildings are required to be nearly zero-energy buildings (NZEB) from 2021 onwards (public buildings from 2019 onwards). Following the introduction of minimum energy performance requirements, new buildings today consume only half as much as buildings constructed in the 1980s. Instruments like Energy Performance Certificates (EPCs) are to deliver a demand-driven market signal for energy efficient buildings in the stock and to provide recommendations for energy renovation measures. This Directive is complemented by building related elements in Ecodesign Directive and Energy Labelling Regulation, and in the Energy Efficiency Directive.

Improving the energy performance of the building stock has multiple benefits for various stakeholders such as reduced energy bills, improved indoor air quality and a higher comfort level for households. It also contributes to increased productivity and competitiveness in firms, and to job creation and higher energy security for the public.

The EPBD was revised as part of the "Clean Energy for all Europeans" package with two complementary objectives: (i) to accelerate the renovation of existing buildings by 2050; and (ii) to support the modernisation of all buildings with smart technologies and make a clearer link to clean mobility.

Recent initiatives like the "Smart Finance for Smart Buildings" initiative complement the clean energy legislative framework with actions to help redirect private capital towards energy efficiency, and in particular towards buildings and their renovation.

A new buildings database, the EU Building Stock Observatory (BSO), was recently established to track the energy performance of buildings and other characteristics across Europe. The BSO serves as a centralised, official repository of information on Europe's buildings stock and informs policy making.

The objective of this study is to deliver a comprehensive analysis of the renovation activities and NZEB uptake in the EU from 2012 to 2016. Data was obtained through extensive desk research and three large-scale surveys with consumers, architects, and main contractors and installers in the EU28. The findings will be used to inform the design, monitoring and evaluation of energy efficiency policies. For this purpose, a set of quantitative and qualitative indicators was developed (section 3) in line with the indicators of the BSO. A EU28 building stock inventory (Annex section 4) and the collection of new construction data in the EU (Annex section 5) further informed the analysis. Renovation rates, achieved energy savings and investment costs are broken down by type of renovation, building type and renovation depth (section 4.1) as far as the data allows. The uptake of NZEB has been analysed for both renovation and new construction in both residential and non-residential buildings (section 4.2). The study also explores triggers, drivers, barriers and incentives for energy renovation, as well as prevalent financing sources (section 4.3). The methodology is outlined in detail in the Annex to this report, section 3.

2. Methodology

In order to obtain primary data on energy and non-energy renovation activities and NZEB uptake in the EU28 Members States, three surveys were conducted, taking into account the perspectives of multiple stakeholders. The table below presents the sample size, complementary objectives and fieldwork dates of the three surveys. The questionnaires were built on quantitative and qualitative indicators that were developed at the very beginning of the project (section 3). For a detailed description of the survey methodology, see Annex section 3.

- The large-scale **online consumer survey** targeted consumers with (energy) renovation experience to collect data related to residential buildings. The sample is composed of three main groups: Owners[1], tenants[2] and landlords[3].
- The **online architect survey** focused on the demand side, both for residential and non-residential buildings (e.g. offices, schools, hospitals, etc.). Despite extensive efforts to secure participation of independent architects and architect firms, the survey still resulted in a small sample size of architects (1,581) which does not allow for generalisations of the findings at regional or country level but provides insight at the overall EU level.
- The **main contractors[4] and installers[5] telephone survey** was tailored towards the supply side. The aim was to understand the demand and supply chain as well as the quality of the works related to energy efficiency and NZEB. This survey focused on residential and non-residential renovation projects and NZEB.

1 Respondents who own the residence they live in, with no other residential property that is rented out to individuals.

2 Respondents who rent the residence they live in, with no other residential property that is rented out to individuals.

3 Respondents who rent out residential dwellings.

4 Companies that offer (either themselves or through subcontractors) or coordinate all required installer services for new construction or renovation projects.

5 Companies that offer installer services for new construction and renovations products, usually focusing on one (or sometimes several) specific trades, such as installing windows or installing heating systems.

Table 1 : Overview of surveys

	Consumer survey	Architects survey	Survey of construction companies (main contractors) and suppliers (installers) of construction materials
Method	Computer-Assisted Web Interview (CAWI)	Computer-Assisted Web Interview (CAWI)	Computer-Assisted Telephone Interviewing (CATI)
Achieved sample size	N = 30,118 of which 18,302 energy renovators, EU28	N = 1,581, EU28	N = 2,009, EU28
Sampling	Representative sample of the national population 18+	Convenience sample	Sample based on Dun & Bradstreet company database
Target respondents	Consumers with (energy) renovation experience	The European Architects Council's (ACE) member organisations	Construction companies involved in renovation activities + suppliers of construction materials
Objective	Collect data on renovation of residential buildings (time span: 2012 – 2016)	Collect data for residential and non-residential buildings, covering renovation and NZEB (time span: 2012 – 2016)	Collect data for residential and non-residential buildings, covering renovation and NZEB (time span: 2012 – 2016)
Timing fieldwork	16 August – 28 September 2018	27 August 2018 – 15 March 2019	13 August – 6 November 2018

For the purposes of this study, the following works are considered as **non-energy renovations**:

- Facade renovation without applying insulation
- Roof renovation without applying insulation
- Building extensions without applying insulation
- Electric installations
- Interior wall painting, plastering or wallpapering
- Interior flooring
- Renovation/installation of the bathroom or toilet
- Renovation/installation of the kitchen
- Grinding & painting doors or window frames
- Renovation/installation of stairs
- Dry-wall or ceiling constructions
- Renovation/installation or replacement of elevator

Accordingly, the following works are considered as **energy renovations**:

- Replacement of windows
- Replacement of the/a building entrance door
- Installation of thermal insulation on the facade (incl. cavity wall insulation)
- Installation of thermal insulation of the roof
- Installation of thermal insulation on the ground plate (floors)

- Installation of thermal insulation inside basements
- Installation of thermal insulation on the attic's floor
- Replacement or first-time installation of a space heat generator
- Replacement or first-time installation of a water heater (incl. solar thermal collector on the roof)
- Replacement or first-time installation of a radiator
- Replacement or first-time installation of a floor heating system
- Replacement or first-time installation of a mechanical ventilation system
- Replacement or first-time installation of a space cooling system (air-conditioner)
- Installation of a photovoltaic system (solar modules for electricity generation on the roof)
- (Automatic) shading system for windows to avoid overheating in summer
- New lighting installations (lamps)[6]

Different complex approaches were designed to quantify different renovation rates, energy savings and investment costs for residential and non-residential buildings. The possibility to split results by sub-groups such as single and multi-family homes or office buildings and other types of buildings was pursued. For this purpose, the surveys' results were combined with overall market data providing information on installed technologies in existing buildings. For some of the considered renovation measures, data has been purchased, e.g. for windows and insulation from Interconnection Consulting and for space, and water heating technologies as well as ventilation systems from BRG Building Solutions. The aim was to extrapolate specific results from the survey samples to the general market with the overall objective to calculate renovation rates, total investments and energy savings.

The approaches also include a number of assumptions. This is particularly the case for non-residential buildings for which considerably less data is available and was intended to be obtained from the surveys (e.g. observed average specifications were applied to those countries where the sample sizes were by far too small to calculate meaningful outputs).

For calculating the achieved energy savings from the renovations, for each renovation case in the sample, the Navigant Building Energy Performance (BEP) Model based on ISO 52016 was used. More information about the approaches and used sources can be found in the Annex, section 3 (e.g. a list of considered investment costs per renovation measure in Annex section 3.3).

Although results have been calculated for different residential and non-residential building types (see Annex section 1.2), due to different complications during the analysis, the gathered data was not representative to provide meaningful projections. Therefore, it was decided to present results collectively for residential buildings and also for non-residential buildings (see Annex, section 3.6).

For the task of assessing the NZEB uptake in EU Member States (MS), the results of the architect survey described above were used and combined with information from "The architectural professions in Europe sector studies" by the Architect's Council of Europe (ACE). Therefore, it is based on the conducted surveys and *represents the perceived uptake from an architect perspective*. This may differ from an uptake based on *today's* definitions of NZEB by Member States, as far as already available. Due to significant lack of Member States' definitions for the investigated period *2012-2016*,

6 Lighting was not considered for determining renovation rates of residential buildings as it is not a default part of the primary energy uses of residential buildings according to EPBD Annex I.

the perceived uptake was chosen instead. Since "the architectural professions in Europe sector studies" are just published biannually, the perceived uptake was calculated for the years 2012, 2014 and 2016 and interpolated for the years in between. Details of the approach can be found in the Annex, section 3.4.

Based on an extensive literature research, most common triggers, drivers, barriers and incentives for energy renovation were selected to be assessed in this study. Their actual prevalence was investigated using the three surveys mentioned above. Consumers, architects, installers and main contractors all provided insights into their own triggers, drivers, barriers and incentives. Furthermore, architects and main contractors also reported on their clients' perspective. Information from the surveys, purchased data (as already mentioned above) and extensive desk research were used to evaluate investment needs.

3. Covered indicators

In order to measure all required aspects of building renovation activities, the uptake of NZEB, as well as drivers and barriers, a set of quantitative and qualitative indicators was developed.

Quantitative indicators provide all relevant information to quantify the renovation activities and measure the uptake of NZEB in the EU28. The main dimensions are: **renovation rate, investments costs, primary energy savings achieved and number of NZEB constructed**.

These main dimensions were combined with other variables to create the final grid (set of quantitative indicators) that guides the collection of all required information (see Annex section 2). These additional variables are:

- countries (the EU28 Member States),
- years (2012-2016),
- renovation type (energy and non-energy renovations),
- energy renovation depths (below threshold, light, medium and deep[7]),
- sector (residential and non-residential),
- building types (according to Annex I EPBD),
- reference unit (building floor area and number of buildings), and
- relative/absolute reference (relative compared to stock or compared to status before renovation; absolute for all renovations or specific per m² of renovated building floor area).

While this study focusses on the calculation of the renovation rates, depths, savings and investments in the EU and in each of the Member States, it also looks at determinants for energy renovation decisions. These determinants are understood as "**qualitative indicators**" and complement the set of quantitative indicators.

All energy renovation measures are the consequence of investors' decisions. Each decision is the result of one or several **determinants such as motivations/drivers, triggering events, barriers or incentives**. Obtaining a clearer picture of the relevance of these determinants for decisions on energy renovations allows areas in which policy measures are or can be most effective to be identified, as well as any differences between regions, building and investor types. Policy instruments need to be continuously developed, evaluated and adapted to effectively lower barriers and strengthen drivers, with the goal to increase the renovation rate and depth in Member States and leverage investments in the building stock.

In addition to what is usually understood as "drivers and barriers", the qualitative assessment also looks at:

- the role of stakeholders during the renovation process,
- quality assurance during the renovation process,
- funding of the renovation works,
- the prominence of energy renovation, and
- reasons for recommendations (of certain products/measures).

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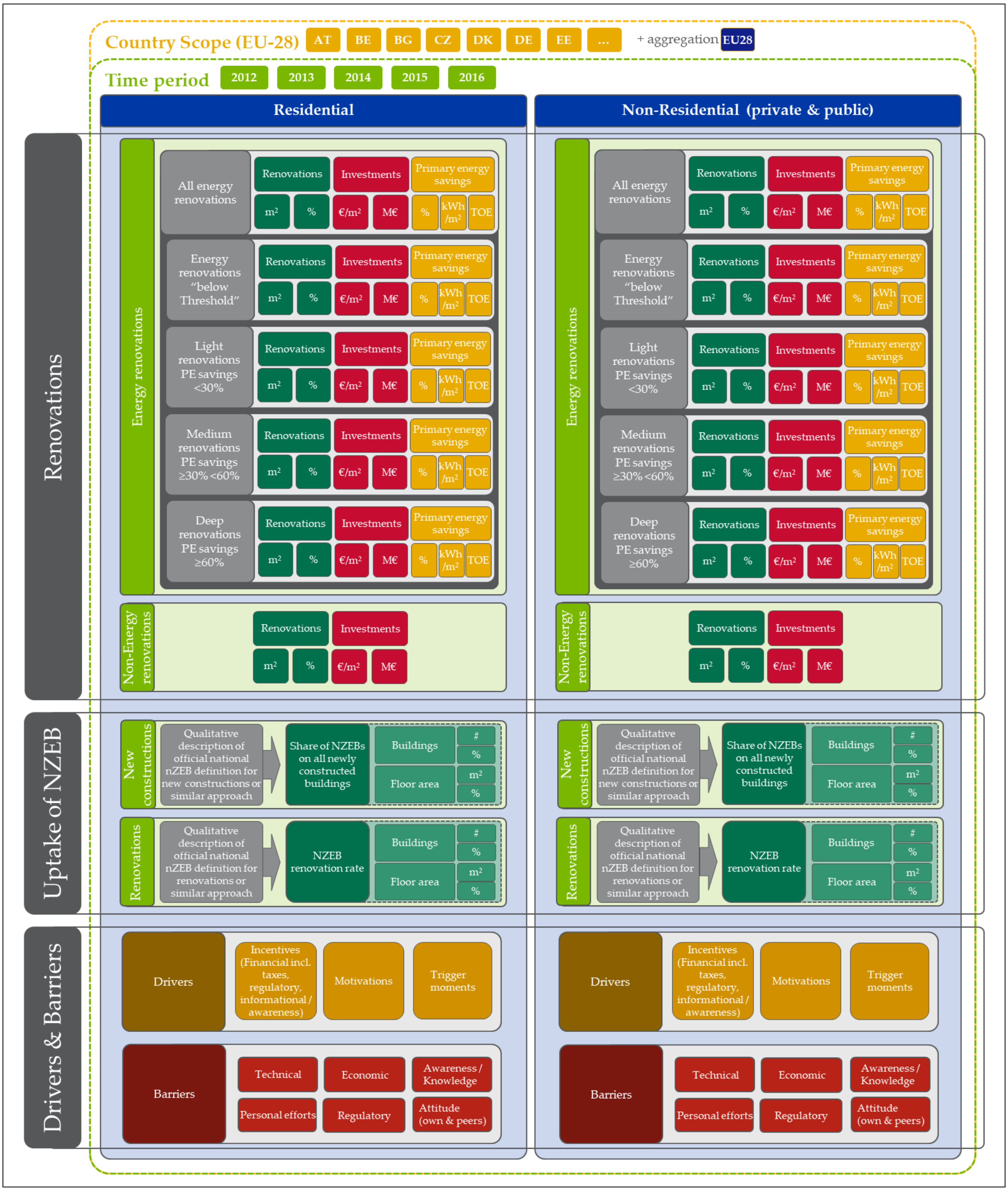
7 Renovations in category "below threshold" comprise all renovations with primary energy (PE) savings <3%, "light" renovations those with PE savings from 3% ≤ 30%, "medium" renovations those with PE savings from 30% ≤ 60% and "deep" renovations those with PE savings > 60%. – For details see Annex, section 1.1.

The result of this task is an extensive set of quantitative and qualitative indicators which are presented in Figure 1. A detailed list of all covered indicators is provided in the Annex (section 2).

Figure 1: Illustration of main indicators covered in the study



4. Findings

In this section, the findings for the following key areas are presented:

- renovation (section 4.1)
- uptake of nearly zero-energy buildings (NZEB) (section 4.2)
- determinants for performing energy renovations (section 4.3).

In general, all these items are addressed for both the EU28 and each Member States.

Section 4.1 on energy renovations presents the different renovation rates (below threshold, light, medium and deep) for the period 2012-2016 for both residential and non-residential buildings and for both energy and non-energy renovations. Furthermore, related primary energy savings and investment costs are included. The study also addresses some wider benefits related to energy renovations such as greenhouse gas emissions (GHG) reductions and work force employed in renovation of buildings.

The uptake of NZEB is covered in section 4.2. The analysis is based on the conducted surveys and represents the uptake *as perceived by architects* in the Member States for the period 2012-2016, because only a few Member States had an NZEB definition in place during this period. It presents the shares of NZEB for both residential and non-residential buildings in new constructions and renovation.

The surveys undertaken in this study provided deep insight into various determinants for performing energy renovations, like triggers, drivers, barriers and available funding. Results on all determinants that were covered in the surveys are presented in section 4.3.

As mentioned in section 2, results are presented collectively for residential buildings and also for non-residential buildings.

4.1. Renovation rates, achieved energy savings and investment costs

4.1.1. Achieved renovation rates

The report presents average annual values for the period 2012-2016.[8] The full set of definitions underlying these results is provided in the Annex to this report, section 1.1.

Energy renovation rates have been calculated both based on floor area and number of buildings. Here, results based on floor area are presented, while data based on number of buildings can be found in the Annex.[9]

Please note that all findings are based on surveys and market data as shortly explained in section 2 and in more detail in Annex section 3.

8 More details can be found in Data Annex_Renovation Results EU28

9 More details can be found in Data Annex_Renovation Results EU28

Energy renovation in residential buildings

Renovation rates steeply decrease when moving from "below threshold", to "light", to "medium" and "deep" renovations. [10] **The annual amount of deep renovations in the EU28 is only around 0.2%**, with relatively small variation when looking at individual Member States. This clearly shows that in practice such "one-off' deep renovations occur only very sporadically within all renovation activities. From the surveys it became very clear that the vast majority of renovations are implemented as individual or step-by-step measures.

The **average total annual energy renovation rate** of residential buildings, namely the sum of all different levels of energy renovation depths from "below threshold" to "deep renovations", for the period 2012-2016 ***based on floor area*** is estimated to be at around **12% for EU28 as a whole**.

For residential buildings, the annual **weighted energy renovation rate was estimated close to 1%** within the European Union.[11] This is in line with other estimations of the European Commission (0.4-1.2% depending on the Member State) and highlights the insufficient progress in the building sector in terms of moving towards decarbonisation of the building stock.

Results show significant differences between countries. Notably, Eastern European countries show high values, which is mainly driven by comparatively high numbers of "below threshold of 3% savings" and "light" renovations. Nevertheless, this striking trend in Eastern European countries has also been reported in ACE's 2016 sector study[12].

Table 2: Energy renovation in residential buildings (average 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
EU28	**12.3%**	**7.1%**	**3.9%**	**1.1%**	**0.2%**
Austria	11.6%	6.3%	3.3%	1.7%	0.2%
Belgium	15.6%	7.8%	6.5%	1.0%	0.2%
Bulgaria	20.1%	10.1%	8.6%	1.3%	0.1%
Croatia	21.7%	13.4%	6.7%	1.5%	0.1%
Cyprus	15.5%	9.9%	3.2%	2.0%	0.4%
Czech Republic	13.7%	6.7%	5.2%	1.6%	0.1%

10 Renovations in category "below threshold" comprise all renovations with PE savings <3%, light renovations those with PE savings from 3% ≤ 30%, medium renovations those with PE savings from 30% ≤ 60% and deep renovations those with PE savings > 60%. More details can be found in the Annex, section 1.1.

11 As renovation depths have been classified based on achieved primary energy savings, it was possible to summarise these numbers into a weighted energy renovation rate meaning the annual reduction of primary energy consumption, within the total stock of buildings (residential or non-residential respectively), for heating, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy, achieved through the sum of energy renovations of all depths.

12 The architectural professions in Europe 2016. A Sector Study by the Architect's Council of Europe (ACE), table 4-15

Denmark	7.5%	3.6%	3.2%	0.6%	0.0%
Estonia	11.2%	6.8%	3.6%	0.7%	0.1%
Finland	9.9%	6.4%	3.2%	0.3%	0.0%
France	13.3%	7.4%	4.7%	1.0%	0.2%
Germany	9.8%	5.4%	3.5%	0.9%	0.1%
Greece	8.9%	5.3%	2.3%	1.1%	0.2%
Hungary	8.9%	5.0%	2.9%	0.9%	0.1%
Ireland	8.0%	3.9%	3.4%	0.6%	0.1%
Italy	13.7%	8.0%	4.0%	1.5%	0.3%
Latvia	9.8%	5.4%	3.4%	0.9%	0.0%
Lithuania	8.9%	5.1%	2.9%	0.7%	0.2%
Luxembourg	7.1%	4.3%	2.3%	0.4%	0.1%
Malta	13.0%	10.0%	2.4%	0.6%	0.1%
Netherlands	12.7%	7.5%	4.3%	0.8%	0.1%
Poland	17.4%	8.9%	7.0%	1.5%	0.0%
Portugal	16.3%	8.8%	6.0%	1.3%	0.1%
Romania	24.1%	13.4%	9.3%	1.3%	0.1%
Slovakia	9.7%	5.1%	3.5%	1.0%	0.1%
Slovenia	9.8%	5.4%	3.1%	1.3%	0.1%
Spain	17.0%	13.0%	2.1%	1.7%	0.3%
Sweden	13.0%	8.0%	4.3%	0.7%	0.1%
United Kingdom	7.9%	4.0%	2.7%	1.1%	0.1%

As for renovation rates based on number of buildings[13] as well as for absolute numbers (floor area, numbers of buildings) see Data Annex_Renovation Results EU28.

Energy renovation in non-residential buildings

Renovation rates significantly decrease when moving from "below threshold", to "light", to "medium" and "deep" renovations. **The annual amount of deep renovations in the EU28 is estimated to be only around 0.3%**, with seemingly a bit more variation when looking at individual Member States compared to residential buildings.

Hence, like with residential buildings, in most countries 'one-off' deep renovations only occur sporadically; yet there are few exceptions, for example Italy or Portugal which appear to have higher rates of deep renovation.

The **average total annual energy renovation rate** of non-residential buildings - including all levels of renovation depths - for the period 2012-2016 ***based on floor area*** is estimated to be at **around 10% for the EU28**. Similar to residential buildings, there are significant differences between countries.

13 Note that rates for the EU as a whole differ from those based on m², as they are calculated based on different weighting factors per country, i.e. the renovated floor area or renovated numbers of buildings per Member State respectively. As reference buildings are not the same size in every country, the weighted EU28 average differs between floor area and numbers of buildings approach.

As for residential buildings the study also confirms that, on average, for non-residential buildings the **weighted energy renovation rate is estimated to be close to 1% within the European Union.**

Table 3: Energy renovation in non-residential buildings (average 2012 – 2016)

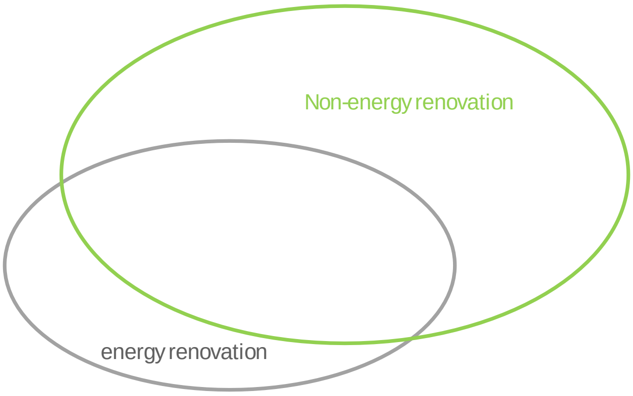
	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
EU28	**9.5%**	**4.1%**	**3.0%**	**2.1%**	**0.3%**
Austria	6.8%	3.8%	2.2%	0.6%	0.2%
Belgium	21.4%	9.1%	5.3%	6.0%	1.0%
Bulgaria	17.9%	7.2%	4.8%	5.3%	0.6%
Croatia	18.8%	12.8%	4.7%	1.1%	0.2%
Cyprus	26.6%	12.1%	5.8%	7.7%	1.0%
Czech Republic	15.9%	8.6%	5.5%	1.4%	0.4%
Denmark	9.1%	4.6%	3.1%	1.2%	0.2%
Estonia	6.0%	2.8%	2.2%	0.8%	0.2%
Finland	7.7%	3.5%	2.7%	1.4%	0.2%
France	6.0%	2.5%	1.9%	1.4%	0.2%
Germany	6.9%	3.3%	2.1%	1.3%	0.2%
Greece	10.6%	4.0%	3.2%	2.9%	0.4%
Hungary	7.0%	2.9%	2.0%	1.8%	0.2%
Ireland	3.9%	2.1%	1.3%	0.4%	0.1%
Italy	17.4%	6.8%	5.1%	4.9%	0.6%
Latvia	9.0%	4.7%	2.8%	1.3%	0.3%
Lithuania	6.2%	3.1%	2.3%	0.6%	0.2%
Luxembourg	13.0%	8.2%	3.7%	0.8%	0.2%
Malta	18.4%	9.0%	7.1%	1.9%	0.4%
Netherlands	8.9%	3.6%	2.8%	2.2%	0.3%
Poland	11.6%	5.1%	3.8%	2.3%	0.3%
Portugal	18.8%	7.5%	5.3%	5.1%	0.8%
Romania	19.3%	11.1%	5.9%	1.9%	0.4%
Slovakia	14.6%	6.2%	4.5%	3.4%	0.5%
Slovenia	8.8%	4.2%	2.9%	1.5%	0.3%
Spain	11.2%	4.3%	3.5%	2.9%	0.5%
Sweden	14.8%	7.0%	5.4%	2.0%	0.3%
United Kingdom	9.6%	3.2%	3.7%	2.4%	0.4%

As for renovation rates based on number of buildings[14] as well as for absolute numbers (floor area, numbers of buildings) see Data Annex_Renovation Results EU28.

14 Note that rates for the EU as a whole differ from those based on m², as they are calculated based on different weighting factors per country, i.e. the renovated floor area or renovated numbers of buildings per Member State

For the total building stock, consisting of residential and non-residential buildings, this study confirms that the weighted energy renovation rate is close to 1% within the European Union, as estimated by other European Commission sources.

Non-energy renovation



The results of the study also allow for an estimate of non-energy renovation rates.

Non-energy renovation takes place both as a stand-alone measure (e.g. interior painting or flooring)[15] or in combination with energy renovation measures. Both these shares are included in the numbers presented for the total non-energy renovation rates as illustrated with the green elliptical-shaped set in Figure 2.

Figure 2: Illustration of building sets for non-energy-renovation and energy renovation

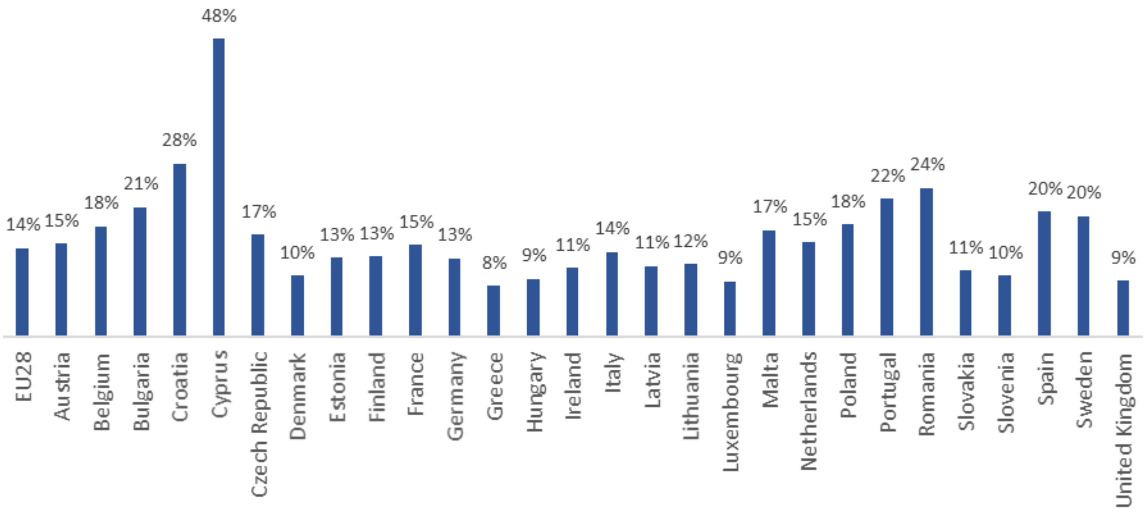
Non-energy renovation in residential buildings

More than 90% of residential energy renovations take place in combination with non-energy renovation measures. This means that less than 10% of energy renovators reported only "energy" renovation measures. On the other hand, four times as many respondents indicated to have implemented "non-energy" renovation measures only, i.e. without any energy renovation measure. Altogether, this leads to the survey results suggesting **significantly higher non-energy renovation rates than energy renovation rates** for the EU28 as a whole and for most of its Member States. While approx. 12% of the total residential floor area is estimated to be affected by whatever level of depth of energy renovation, **for non-energy renovation measures this number appears to be around 14% for the EU28**.

respectively. As reference buildings are not the same size in every country, the weighted EU28 average differs between floor area and numbers of buildings approach.

15 For a complete list of measures included in the consumer-survey compare section 2.

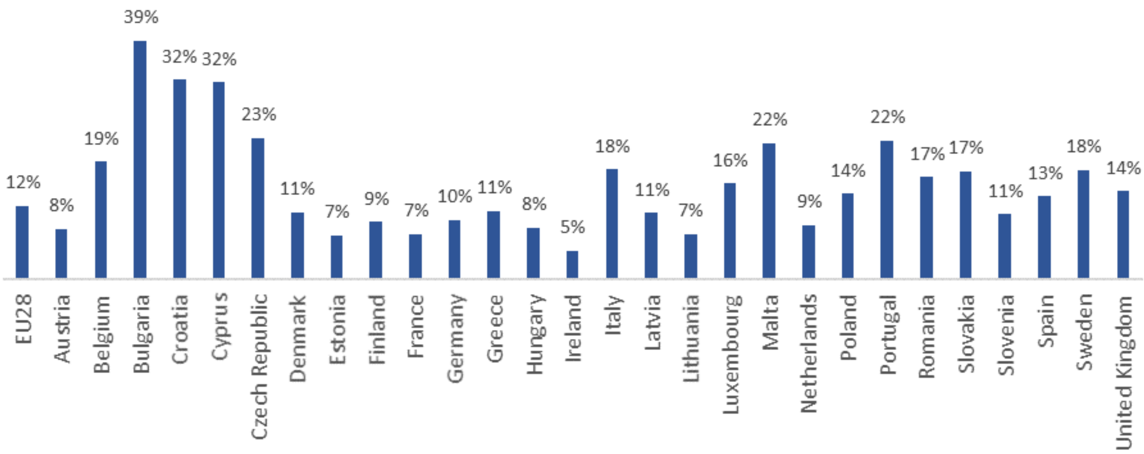
Figure 3: Non-energy renovation in residential buildings



Non-energy renovation in non-residential buildings

The study results also allow for an estimate of non-energy renovation rates. Results for non-residential buildings have been estimated by calculating the total investment costs spent for energy renovations and subtracting this amount from provided turnover numbers from Euroconstruct & EECFA where data was provided. Based on this analysis, an average ratio between investment costs spent for non-energy and energy renovations was calculated. Combining this with average specific investment costs for non-energy renovations allows the calculation of non-energy renovations and rates[16]. The renovation rate is estimated to be slightly lower than for residential buildings, **about 12% for the EU28**.

Figure 4: Non-energy renovation in non-residential buildings



16 More details about the approach can be found in the Annex, section 3.1.

As for non-energy renovation rates based on number of buildings[17] as well as for absolute numbers (floor area, number of buildings) see Data Annex_Renovation Results EU28.

An overview of the quantitative results related to renovations and the uptake of NZEB is presented in Figure 17.

4.1.2. Achieved energy savings

Achieved primary energy savings in residential buildings

In line with the EPBD, energy savings have been calculated in terms of primary energy. Different aspects have been looked at: the relative saving that is achieved on average if a building is affected by any depth of energy renovation; the corresponding average absolute savings; as well as the absolute annual total primary energy savings achieved within the residential building stock of a country or the European Union as a whole, respectively.

The relative annual primary energy savings per residential renovation (comparing the performance of the building before and after renovation), taking the average of all energy renovations across the EU28 that took place between 2012 and 2016, is estimated to be at around 9% (8.8%). Concretely this means the *average* relative annual reduction of primary energy consumption after an *average* renovation[18] compared to the status before that renovation.[19] It is presented for all energy renovations and split up by renovation depths. After the renovation this saving continues.

The relatively low average saving achieved again highlights the above mentioned finding that a **typical** energy renovation is characterised by only one or few measures that yield comparatively little savings. Evidently, there is variation across countries, yet the general finding holds for all countries. The numbers confirm that "one-off" deep renovations only occur occasionally.

Table 4 not just shows the annual savings achieved within all energy renovations ("total"), but also within the categories "below threshold", "light", "medium" and "deep". As a European Union average, they amount to approx. 0.2%, 13%, 41% and 66%.

17 Note that rates for the EU as a whole differ from those based on m², as they are calculated based on different weighting factors per country, i.e. the renovated floor area or renovated numbers of buildings per Member State respectively. As reference buildings are not the same size in every country, the weighted EU28 average differs between floor area and numbers of buildings approach.

18 Average of all renovations (below threshold, light, medium, deep) that have taken place between 2012-2016.

19 Example: A building undergoes a light renovation in 2013. After that renovation the annual primary energy consumption is 15% lower than before the renovation. This reduced consumption is assumed to continue through 2016 (and beyond).

20 These values represent the achieved average savings in all energy renovations. It considers the quantitative share of renovations per depth and the achieved savings by each renovation depth.

Table 4: Relative primary energy savings in residential buildings (average savings per year for the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
EU28	**8.8%**	**0.2%**	**12.7%**	**41.1%**	**66.0%**
Austria	11.1%	0.3%	12.7%	42.1%	66.8%
Belgium	9.0%	0.4%	12.4%	40.8%	66.4%
Bulgaria	9.1%	0.0%	14.6%	40.4%	71.7%
Croatia	7.9%	0.1%	15.0%	41.4%	68.1%
Cyprus	10.5%	0.2%	14.5%	44.5%	64.0%
Czech Republic	10.8%	0.2%	14.1%	40.4%	65.4%
Denmark	9.1%	0.3%	12.1%	41.4%	66.9%
Estonia	7.3%	0.3%	13.7%	37.5%	69.9%
Finland	4.8%	0.2%	11.1%	37.5%	0.0%
France	8.1%	0.3%	11.2%	41.0%	66.3%
Germany	8.9%	0.2%	12.6%	41.7%	66.1%
Greece	10.7%	0.1%	13.2%	44.5%	66.1%
Hungary	9.0%	0.3%	12.5%	39.6%	62.0%
Ireland	9.2%	0.3%	12.0%	43.8%	63.9%
Italy	9.8%	0.3%	13.5%	40.8%	67.0%
Latvia	8.7%	0.2%	12.8%	40.7%	72.7%
Lithuania	8.7%	0.3%	12.4%	41.2%	64.7%
Luxembourg	7.6%	0.2%	12.5%	43.5%	73.4%
Malta	4.9%	0.1%	12.5%	45.6%	63.7%
Netherlands	7.3%	0.2%	12.2%	39.1%	67.1%
Poland	8.6%	0.3%	12.8%	37.2%	62.3%
Portugal	8.7%	0.3%	12.7%	41.7%	63.7%
Romania	7.8%	0.2%	13.3%	41.5%	64.1%
Slovakia	10.3%	0.2%	14.3%	41.9%	65.1%
Slovenia	10.3%	0.2%	14.8%	39.1%	62.4%
Spain	7.0%	0.1%	14.4%	41.0%	66.1%
Sweden	6.3%	0.3%	11.4%	41.0%	67.3%
United Kingdom	11.4%	0.2%	13.2%	42.3%	64.2%

In terms of absolute savings, **the average energy renovation within the European Union is estimated to reduce a residential building's specific primary energy consumption by 14 kWh/(m^2.y).**[21]

21 Note that in order to calculate the primary energy consumption the same primary energy factors have been used for all Member States, applying the default values from ISO 52000-1:2017 Energy performance of buildings -- Overarching EPB assessment -- Part 1: General framework and procedures.

As can be expected from the differences in relative savings between the different categories, very significant differences can be observed for the average *absolute* specific savings when doing “below threshold”, “light”, “medium” and “deep” renovations according to the definitions used in this project. For the EU28 they amount to approx. < 1 kWh/(m^2.y), 19 kWh/(m^2.y)), 64 kWh/(m^2.y) and 122 kWh/(m^2.y) respectively.

For the average primary energy consumption “before renovation” of those buildings that have been renovated “below threshold”, “light”, “medium” and “deep” it means that energy performance before renovation was 154 kWh/(m^2.y), 152 kWh/(m^2.y), 156 kWh/(m^2.y) and 185 kWh/(m^2.y) respectively .[22]

On average deep renovation actually tackles the worst performing buildings, which on the one hand is economically plausible, but on the other hand will lead to a situation where it is getting more and more difficult to keep up with the current rate of primary energy savings due to a decreasing number of worst performing buildings that can be renovated very cost-effectively.

Table 5: Specific primary energy savings in residential buildings (average savings per year for the period 2012-2016)

	Energy related: “Total”	Energy related: “below Threshold”	Energy related: “Light”	Energy related: “Medium”	Energy related: “Deep”
	kWh/(m^2.y)	kWh/(m^2.y)	kWh/(m^2.y)	kWh/(m^2.y)	kWh/(m^2.y)
EU28	**14**	**1**	**19**	**64**	**122**
Austria	25	1	25	96	177
Belgium	14	1	19	66	117
Bulgaria	11	0	17	51	105
Croatia	17	0	30	92	174
Cyprus	16	0	18	71	108
Czech Republic	23	0	29	88	206
Denmark	19	1	23	92	164
Estonia	24	1	44	122	241
Finland	16	1	35	127	-
France	15	0	18	76	159
Germany	18	0	25	87	158
Greece	15	0	16	62	98
Hungary	21	1	27	92	198
Ireland	21	1	24	110	183
Italy	10	0	12	43	90
Latvia	35	1	48	168	395
Lithuania	41	2	56	194	346

22 Example: the average absolute annual saving in EU28 achieved in a "medium" renovation is 64 kWh/(m^2.y) according to Table 5. According to Table 4 the corresponding relative saving is 41.1%. This means the average primary energy consumption before renovation of all buildings that underwent “medium” renovation must have been approx. 156 kWh/(m^2.y).

Luxembourg	11	0	14	70	158
Malta	8	0	15	84	113
Netherlands	10	0	14	63	141
Poland	18	1	25	81	130
Portugal	3	0	4	17	43
Romania	15	0	25	87	159
Slovakia	17	0	22	71	140
Slovenia	25	0	34	100	171
Spain	6	0	9	36	97
Sweden	12	1	21	81	141
United Kingdom	15	0	17	54	93

Total primary energy savings from all residential energy renovations have been estimated. **Within EU28 they amount to an average of approx. 3 Mtoe per year in the period 2012-2016.**[23] This roughly equals **1% primary energy reduction per year** considering all EPBD related energy uses.[24] Light and medium renovations contributed the bulk of savings during that period.

Table 6: Total primary energy savings in residential buildings (average savings per year for the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
	TOE/year	TOE/year	TOE/year	TOE/year	TOE/year
EU28	**3,016,336**	**42,669**	**1,351,815**	**1,290,839**	**331,013**
Austria	89,594	1,078	25,974	51,796	10,745
Belgium	112,873	2,378	63,047	34,544	12,904
Bulgaria	38,007	752	25,220	10,803	1,232
Croatia	39,258	531	22,002	15,051	1,673
Cyprus	9,183	88	2,135	5,437	1,523
Czech Republic	91,173	883	43,228	41,524	5,538
Denmark	39,951	574	21,350	15,895	2,132
Estonia	9,331	218	5,618	2,967	528
Finland	30,694	782	22,356	7,556	-
France	447,412	7,492	194,183	175,591	70,146
Germany	577,030	7,909	276,009	239,745	53,367
Greece	41,462	229	11,865	22,300	7,068
Hungary	46,605	881	19,675	21,312	4,737

23 1 Mtoe = 11.63 TWh

24 According to an analysis conducted for the impact assessment of the EPBD, the total primary energy consumption for space heating, hot water generation, space cooling, ventilation and auxiliary energy in residential buildings was approx. 304 Mtoe in 2013.

Ireland	19,752	314	9,801	7,704	1,934
Italy	279,789	3,698	95,362	127,486	53,244
Latvia	15,838	196	7,700	7,332	610
Lithuania	26,215	636	11,794	10,040	3,745
Luxembourg	1,907	22	800	666	419
Malta	2,122	16	766	1,043	298
Netherlands	89,818	1,090	43,226	35,129	10,373
Poland	274,601	4,932	156,985	109,456	3,228
Portugal	19,208	296	9,053	8,018	1,842
Romania	107,739	1,334	67,399	33,176	5,830
Slovakia	24,196	294	11,553	9,978	2,371
Slovenia	13,810	137	5,851	7,248	573
Spain	164,003	750	29,208	92,369	41,675
Sweden	63,696	1,745	36,906	21,945	3,099
United Kingdom	341,067	3,412	132,748	174,729	30,177

Achieved primary energy savings in non-residential buildings

The relative annual primary energy savings per non-residential renovation (comparing the performance of the building before and after renovation), taking the average of all energy renovations across the EU28 that took place between 2012 and 2016, is estimated to be at around 17%[25].[26]

It is presented for all energy renovations and split up by renovation depths. After the renovation this saving continues. The relatively low average saving achieved again highlights the above mentioned finding that a **typical** energy renovation is characterised by only one or few measures that yield comparatively little savings. Evidently, there is variation across countries, yet the general finding holds for all countries. The numbers confirm that "one-off" deep renovations only occur occasionally.

Table 4 not just shows the annual savings achieved within all energy renovations ("total"), but also within the categories "below threshold", "light", "medium" and "deep". As a European Union average, they amount to approx. 0.4%, 16%, 44% and 66%.

25 Average of all renovations (below threshold, light, medium, deep) that have taken place between 2012-2016.

26 Example: A building undergoes a light renovation in 2013. After renovation that renovation the annual primary energy consumption is 15% lower than before renovation. This reduced consumption is assumed to continue through 2016 (and beyond).

27 These values represent the achieved average savings in all energy renovations. It considers the quantitative share of renovations per depth and the achieved savings by each renovation depth.

Table 7: Relative primary energy savings in non-residential buildings (average savings per year for the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
EU28	**17.1%**	**0.4%**	**16.0%**	**44.4%**	**65.8%**
Austria	11.6%	0.5%	16.0%	46.5%	66.3%
Belgium	21.3%	0.7%	18.0%	47.7%	69.5%
Bulgaria	20.4%	0.0%	18.3%	44.6%	71.2%
Croatia	8.6%	0.3%	20.0%	46.7%	65.0%
Cyprus	20.8%	0.3%	18.1%	49.1%	63.5%
Czech Republic	12.4%	0.4%	18.8%	48.6%	64.9%
Denmark	13.0%	0.6%	15.2%	45.7%	66.4%
Estonia	14.1%	0.5%	17.2%	41.4%	69.4%
Finland	13.8%	0.4%	13.9%	41.4%	59.8%
France	16.8%	0.5%	15.2%	41.1%	64.7%
Germany	16.0%	0.4%	17.4%	44.9%	71.2%
Greece	20.9%	0.2%	17.8%	46.7%	65.1%
Hungary	18.3%	0.6%	15.6%	43.7%	61.6%
Ireland	12.1%	0.6%	15.1%	48.4%	63.5%
Italy	18.9%	0.5%	14.0%	44.1%	63.1%
Latvia	13.8%	0.5%	16.0%	44.9%	72.1%
Lithuania	12.1%	0.7%	15.5%	45.5%	64.3%
Luxembourg	8.8%	0.3%	15.7%	48.0%	69.2%
Malta	12.7%	0.1%	15.6%	50.3%	63.2%
Netherlands	19.8%	0.4%	14.3%	51.8%	67.1%
Poland	15.5%	0.6%	16.0%	41.1%	61.9%
Portugal	20.0%	0.6%	15.9%	46.1%	63.3%
Romania	10.4%	0.4%	15.4%	42.3%	62.1%
Slovakia	18.5%	0.4%	17.9%	46.3%	64.6%
Slovenia	15.3%	0.4%	18.6%	43.1%	61.9%
Spain	18.9%	0.1%	15.2%	43.4%	65.6%
Sweden	13.1%	0.5%	14.4%	45.3%	66.8%
United Kingdom	19.3%	0.5%	15.8%	43.4%	62.2%

In terms of absolute savings, **the average energy renovation within the European Union is estimated to reduce a non-residential building's specific primary energy consumption by 47 kWh/(m².y).**[28] This is more than the average absolute savings achieved in residential buildings as the average primary energy

28 Note that the same primary energy factors have been used for all Member States, applying the default values from ISO 52000-1:2017 Energy performance of buildings -- Overarching EPB assessment -- Part 1: General framework and procedures.

consumption before renovation exceeds that of residential buildings and the relative saving achieved per renovation is estimated to be slightly higher.

As can be expected from the differences in relative savings between the different categories, very significant differences can be observed for the average *absolute* specific savings when doing "below threshold", "light", "medium" and "deep" renovations according to the definitions used in this project. For the EU28 they amount to approx. < 1 kWh/(m².y), 50 kWh/(m².y)), 116 kWh/(m².y) and 167 kWh/(m².y) respectively.

For the average primary energy consumption "before renovation" of those buildings that have been renovated "below threshold", "light", "medium" and "deep" it means that energy performance before renovation was 195 kWh/(m².y), 311 kWh/(m².y), 262 kWh/(m².y) and 254 kWh/(m².y) respectively.[29]

Although differences in consumption before renovation are smaller than for residential buildings, the still low average savings per renovation pose a significant risk for creating lost-opportunities (meaning lost savings potentials by lack of a set of well-coordinated measures) in energy renovations of non-residential buildings, too.

Table 8: Specific primary energy savings in non-residential buildings (average savings per year for the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
	kWh/(m².y)	kWh/(m².y)	kWh/(m².y)	kWh/(m².y)	kWh/(m².y)
EU28	**47**	**1**	**50**	**116**	**167**
Austria	50	1	73	190	270
Belgium	75	1	66	167	259
Bulgaria	49	1	51	99	159
Croatia	50	1	123	254	386
Cyprus	58	1	51	140	165
Czech Republic	58	1	104	166	314
Denmark	53	1	68	180	250
Estonia	91	2	128	241	367
Finland	90	1	103	250	364
France	54	1	51	136	166
Germany	43	1	46	122	177
Greece	80	0	71	175	259
Hungary	81	2	78	182	301
Ireland	54	1	69	217	278
Italy	47	1	37	110	149

29 Example: the average absolute annual saving in EU28 achieved in a "medium" renovation is 116 kWh/(m².y) according to Table 8. According to Table 7 the corresponding relative saving is 44.4%. This means the average primary energy consumption before renovation of all buildings that underwent "medium" renovation must have been approx. 262 kWh/(m².y).

Latvia	109	2	140	330	603
Lithuania	113	4	164	381	528
Luxembourg	24	0	41	137	200
Malta	38	0	44	166	173
Netherlands	51	0	36	138	154
Poland	62	1	73	160	198
Portugal	16	0	12	34	65
Romania	22	1	33	94	90
Slovakia	60	1	66	139	213
Slovenia	74	1	100	196	261
Spain	30	0	29	55	149
Sweden	49	1	62	159	215
United Kingdom	33	1	34	69	65

Total primary energy savings from all non-residential energy renovations have been estimated as well. **Within the EU28, they amount to an average of approx. 2.6 Mtoe per year in the period 2012-2016.** This roughly equals 1% primary energy reduction per year considering all EPBD related energy uses.[30] Light and medium renovations contributed the bulk of savings during that period. The following table also illustrates the huge differences in total consumption between Member States.

Table 9: Total primary energy savings in non-residential buildings (average savings per year for the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
	TOE/year	TOE/year	TOE/year	TOE/year	TOE/year
EU28	**2,597,667**	**20,473**	**874,933**	**1,393,257**	**309,005**
Austria	43,360	583	20,960	15,529	6,289
Belgium	145,035	1,081	31,937	89,772	22,245
Bulgaria	47,866	392	13,426	28,669	5,380
Croatia	28,082	313	17,154	8,497	2,118
Cyprus	3,820	16	738	2,645	421
Czech Republic	80,634	765	50,035	19,940	9,894
Denmark	59,110	694	25,906	25,791	6,719
Estonia	6,954	73	3,568	2,583	730
Finland	47,555	329	18,776	23,297	5,153
France	269,758	2,054	80,573	160,172	26,959
Germany	486,427	5,539	161,397	256,538	62,953

30 According to an analysis conducted for the impact assessment of the EPBD, the total primary energy consumption for space heating, hot water generation, space cooling, ventilation, auxiliary energy and lighting in non-residential buildings was app. 215 Mtoe in 2013.

Greece	99,937	143	27,040	60,510	12,244
Hungary	78,253	625	22,083	45,611	9,934
Ireland	12,782	192	5,407	5,051	2,131
Italy	248,579	1,047	56,787	162,355	28,390
Latvia	12,875	106	5,047	5,704	2,017
Lithuania	16,787	293	9,029	5,302	2,163
Luxembourg	1,277	16	628	453	180
Malta	2,611	5	1,161	1,180	265
Netherlands	122,121	451	27,367	80,509	13,795
Poland	230,219	2,275	89,491	118,565	19,887
Portugal	23,753	126	5,286	14,045	4,296
Romania	23,706	482	11,063	9,963	2,199
Slovakia	31,782	202	10,773	17,234	3,574
Slovenia	13,916	91	6,160	6,261	1,404
Spain	161,456	178	49,681	78,660	32,937
Sweden	91,083	1,040	41,632	40,097	8,314
United Kingdom	207,928	1,362	81,828	108,325	16,413

An overview of the quantitative results related to renovations and the uptake of NZEB is presented in Figure 17.

4.1.3. Investment costs

Based on in-depth research on specific investment cost, the financial investments related to the above explained activities have been estimated for the EU28 as a whole and each Member State (a list of considered investment costs per measure and country including sources is provided in the Annex in section 3.3). Results are presented for both total investments and specific investments of energy renovations.

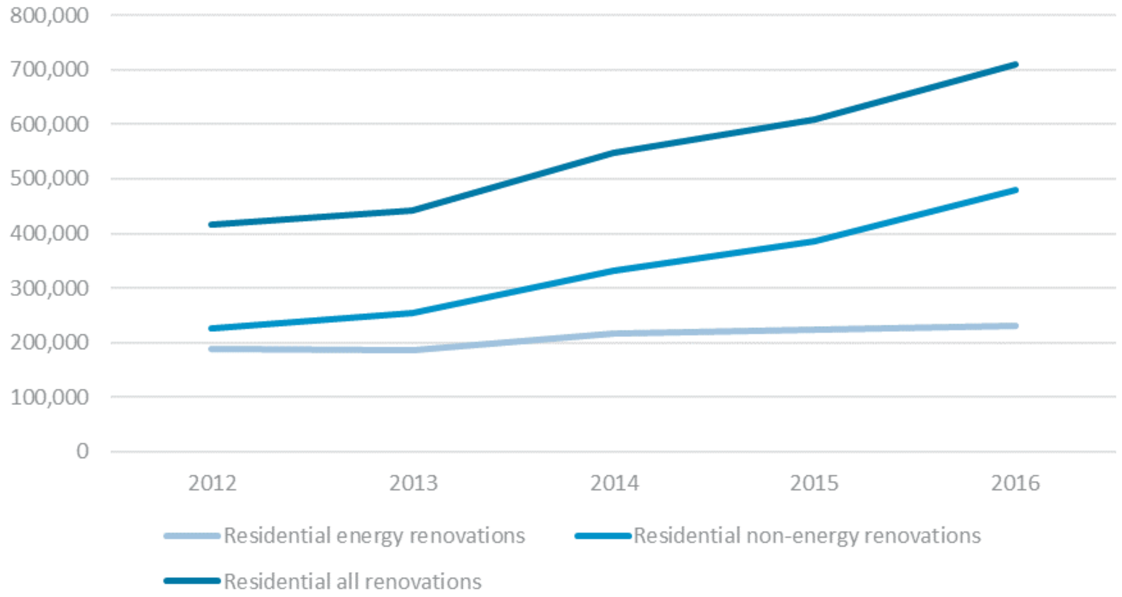
Investment costs in residential buildings

The findings show that energy renovation of residential buildings is not yet at the level needed (neither in terms of speed, nor in terms of structure and investment costs) to achieve a climate neutral building stock by 2050. Yet, for the period 2012-2016, it is estimated that **more than 200 billion Euros for energy renovations and 300 billion Euros for non-energy renovations which adds up to an estimated half a trillion Euro of annual investments in residential building renovation was invested in the European Union**. This highlights the significant impact building renovation already has within the European economy. It would see further significant growth if renovation activities moved towards a level that ensures a decarbonised building stock by 2050.

It has been mentioned above that energy renovations very often go hand in hand with non-energy renovations or vice versa. But there are also significant non-renovation activities without any accompanying energy renovation. In general, investments in non-energy renovations exceed investments in energy renovations because on average non-energy renovations both have higher rates and higher specific investment cost than energy renovations.

The following figure shows the development of spent investments for residential building renovations in the EU between 2012 and 2016.

Figure 5: Residential renovation investments in million Euro per year



The growing discrepancy between the two curves is a result of reportedly more intensively growing non-energy renovation rates compared to energy renovation rates in combination with a constant ratio of specific non-energy costs (Euro per m² floor area) to specific energy renovation costs. As the specific energy renovation costs are a direct result of the realised shares of different renovation depths per year, also variances in specific non-energy renovation costs result and influence the curves.

The following tables first show total investments (in million Euro) and then specific (per m² floor area) investments.

Table 10: Total investments in residential buildings (average investment costs per year in the period 2012-2016)

	All reno-vations	Energy related: "Total"	Energy related: "below Thres-hold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"	Non-energy related "Total"
	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)
EU28	**541,113**	**209,326**	**78,155**	**76,642**	**44,148**	**10,381**	**331,788**
Austria	14,608	4,845	1,326	1,733	1,555	230	9,763
Belgium	17,814	8,395	2,594	3,688	1,495	618	9,419
Bulgaria	3,341	1,414	430	562	406	16	1,926
Croatia	3,278	1,240	557	393	278	12	2,037

Cyprus	2,247	414	229	51	124	10	1,833
Czech Republic	6,606	2,567	701	1,059	716	91	4,039
Denmark	11,929	4,187	1,333	1,977	780	97	7,742
Estonia	550	173	43	69	52	8	377
Finland	11,550	3,459	1,595	1,483	381	-	8,092
France	75,066	34,262	11,095	14,185	6,145	2,836	40,804
Germany	100,632	41,083	11,736	16,592	10,490	2,265	59,548
Greece	4,800	2,248	1,058	428	581	182	2,551
Hungary	4,076	1,732	748	592	320	73	2,343
Ireland	3,235	1,228	332	591	183	122	2,006
Italy	47,583	20,141	8,473	6,429	4,037	1,202	27,443
Latvia	570	219	85	82	47	5	351
Lithuania	1,341	437	187	122	102	26	905
Luxembourg	612	192	42	85	48	17	420
Malta	548	195	117	40	31	7	354
Netherlands	31,814	11,660	5,979	4,293	1,181	207	20,154
Poland	22,089	9,894	3,584	4,354	1,884	72	12,195
Portugal	8,343	2,491	1,069	969	401	53	5,852
Romania	7,486	2,808	1,171	1,035	528	74	4,678
Slovakia	2,414	934	311	375	219	28	1,480
Slovenia	1,080	550	257	140	140	13	530
Spain	42,284	13,811	10,388	1,992	1,330	101	28,473
Sweden	36,261	10,599	4,618	4,418	1,421	142	25,661
United Kingdom	78,957	28,147	8,099	8,905	9,271	1,871	50,811

Table 11: Specific investments in residential buildings (average investment costs per year in the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"	Non-energy related "Total"
	EURO/m²	EURO/m²	EURO/m²	EURO/m²	EURO/m²	EURO/m²
EU28	**83**	**56**	**104**	**154**	**219**	**-**
Austria	115	58	156	230	257	177
Belgium	91	63	103	174	296	89
Bulgaria	36	23	43	86	79	47
Croatia	46	35	54	93	110	58
Cyprus	61	54	31	130	130	87
Czech Republic	56	35	62	115	120	72
Denmark	168	117	198	313	271	235
Estonia	38	22	52	117	50	72

Finland	151	111	208	389	-	268
France	97	64	121	193	310	103
Germany	112	58	146	285	306	124
Greece	68	56	50	144	157	83
Hungary	66	54	71	113	125	85
Ireland	110	64	130	266	308	128
Italy	62	44	66	121	204	84
Latvia	41	30	44	86	270	56
Lithuania	59	47	60	138	59	92
Luxembourg	94	57	125	241	392	162
Malta	59	47	73	190	158	81
Netherlands	113	98	124	181	242	162
Poland	55	42	66	78	111	64
Portugal	37	31	40	54	107	62
Romania	34	27	37	84	82	57
Slovakia	57	40	64	118	81	81
Slovenia	86	57	120	129	122	82
Spain	46	46	52	38	51	80
Sweden	171	122	227	388	366	275
United Kingdom	103	66	129	157	293	162

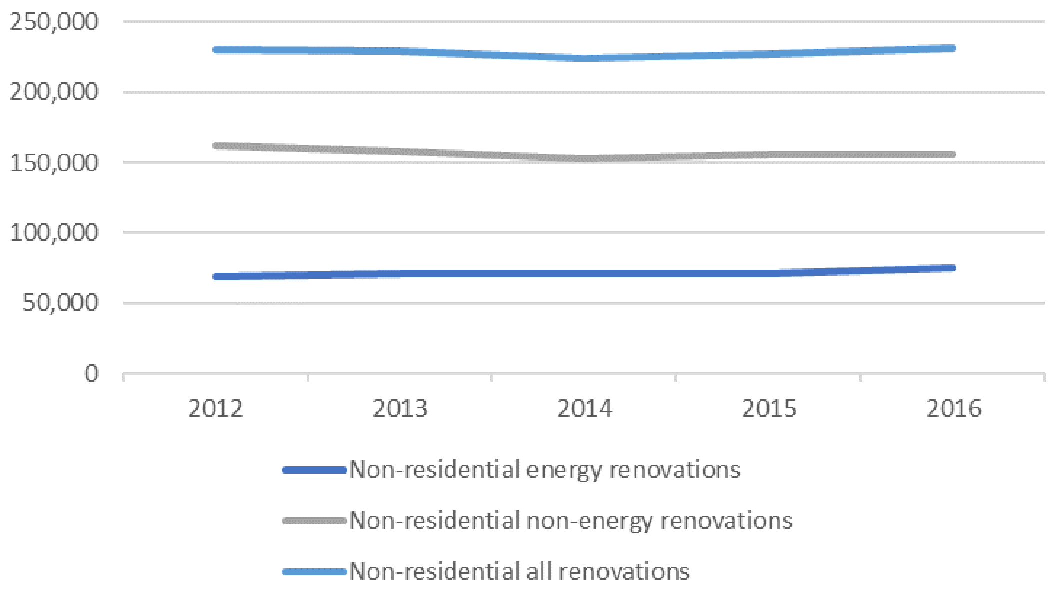
Investment costs in non-residential buildings

For the period 2012-2016, it is estimated that on average **more than 73 billion Euros per year for energy renovations and 145 billion Euros per year for non-energy renovations which adds up to more than 200 billion Euros per year wer invested in non-residential building renovation in the European Union**.

Numbers underline the fact that also in non-residential buildings there are significant non-renovation activities. Investments in non-energy renovations are clearly exceeding investments in energy renovations because on average non-energy renovations are estimated to have almost twice as high specific investment cost than energy renovations.

The following figure shows the development of spent investments for non-residential building renovations in the EU between 2012 and 2016.

Figure 6: Non-residential renovation investments in million Euro per year



The following tables first show total investments (in million Euro) and then specific (per m² floor area) investments.

Table 12: Total investments in non-residential buildings (average investment costs per year in the period 2012-2016)

	All reno-vations	Energy related: "Total"	Energy related: "below Thres-hold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"	Non-energy related "Total"
	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)	EURO (MM)
EU28	**228,212**	**71,312**	**14,679**	**21,960**	**29,084**	**5,589,**	**156,900**
Austria	3,385	1,226	279	573	293	80	2,160
Belgium	6,007	2,513	522	293	1,341	356	3,494
Bulgaria	2,365	803	113	177	471	43	1,562
Croatia	1,468	499	132	239	107	21	969
Cyprus	284	96	24	9	57	7	188
Czech Republic	2,976	1,038	269	392	287	90	1,937
Denmark	6,115	2,077	657	765	535	120	4,038
Estonia	138	47	8	18	19	1	91
Finland	4,777	995	269	342	324	59	3,783
France	34,838	8,237	1,341	2,653	3,640	603	26,601
Germany	50,308	15,954	3,195	4,111	7,202	1,447	34,353
Greece	4,289	1,455	306	440	610	100	2,833
Hungary	2,481	962	214	254	439	54	1,519
Ireland	998	338	83	128	96	31	659
Italy	31,071	7,049	1,254	1,806	3,405	584	24,022

Latvia	196	66	18	20	23	5	129
Lithuania	329	111	36	43	30	3	217
Luxembourg	177	60	19	24	12	4	117
Malta	198	67	16	25	21	5	131
Netherlands	11,310	4,906	958	1,434	2,125	389	6,404
Poland	7,851	2,744	682	1,021	894	147	5,108
Portugal	3,079	1,046	232	274	424	115	2,033
Romania	2,849	967	174	512	199	81	1,882
Slovakia	1,440	489	90	135	227	37	951
Slovenia	637	217	51	94	64	9	420
Spain	13,949	6,114	1,247	1,725	2,649	493	7,836
Sweden	11,566	3,919	1,077	1,559	1,085	199	7,647
United Kingdom	23,132	7,316	1,413	2,895	2,504	504	15,816

Table 13: Specific investments in non-residential buildings (average investment costs per year in the period 2012-2016)

	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"	Non-energy related "Total"
	EURO/m²	EURO/m²	EURO/m²	EURO/m²	EURO/m²	EURO/m²
EU28	**111**	**53**	**107**	**209**	**260**	**182**
Austria	121	50	171	308	294	198
Belgium	113	55	53	215	358	250
Bulgaria	70	24	58	141	110	64
Croatia	76	30	147	275	329	88
Cyprus	129	71	53	266	227	213
Czech Republic	65	31	70	206	247	88
Denmark	161	101	173	322	385	265
Estonia	53	19	57	156	57	87
Finland	161	96	161	299	358	265
France	141	55	143	267	319	229
Germany	120	50	100	295	350	170
Greece	101	56	100	152	182	189
Hungary	86	46	77	150	142	141
Ireland	123	56	142	355	351	202
Italy	116	52	101	200	265	224
Latvia	49	25	48	114	137	80
Lithuania	65	41	67	186	68	106
Luxembourg	97	49	137	322	384	159
Malta	85	41	81	258	308	140
Netherlands	176	85	164	313	375	349

Poland	64	36	72	104	126	105
Portugal	59	33	54	88	151	97
Romania	76	24	132	162	286	174
Slovakia	79	34	70	158	189	130
Slovenia	100	49	132	173	140	165
Spain	97	52	86	161	192	160
Sweden	183	106	199	370	442	301
United Kingdom	99	57	103	137	171	132

For the total building stock, for the period 2012-2016, annual investments in energy renovation are estimated to be about 280 billion Euros and about 480 billion Euros in non-energy renovation, adding up to about 760 billion Euros.

An overview of the quantitative results related to renovations and the uptake of NZEB is presented in Figure 17.

4.1.4. Wider-benefits

Today, the major, ultimate goal of reducing primary energy consumption across the European Union is to mitigate climate change. Greenhouse gas emissions (GHG) need to decrease dramatically during the next three decades. Applying equal GHG emission factors[31], the study determined the average relative specific GHG emission reduction for each m^2 floor area that underwent energy renovation, and then using the total renovated floor area for each year between 2012 and 2016 the total annual GHG reduction for all renovated area per Member State and the EU28.

Residential buildings

The relative annual GHG reduction per residential renovation (comparing the performance of the building before and after renovation), taking the average of all energy renovations across the EU28 that took place between 2012 and 2016, is estimated to be roughly 9%[32]. After the renovation this saving continues.

In absolute terms, year by year **energy renovations in residential buildings on average reduced emissions by roughly 11 MtCO2eq per year during the period 2012-2016**.

31 See Annex, section 3.2.

32 Average of all renovations (below threshold, light, medium, deep) that have taken place between 2012-2016.

Figure 7: Emission mitigation in ktCO2e/a, residential buildings (average 2012-2016)

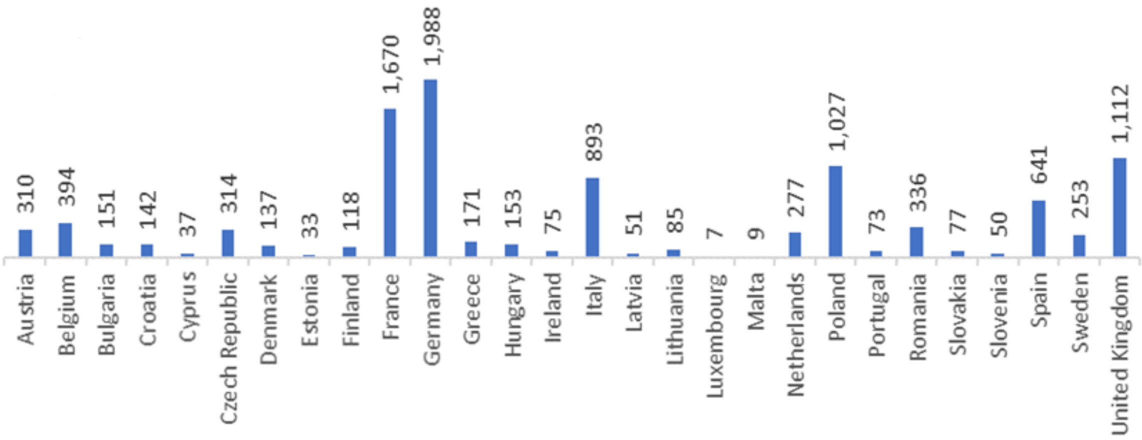
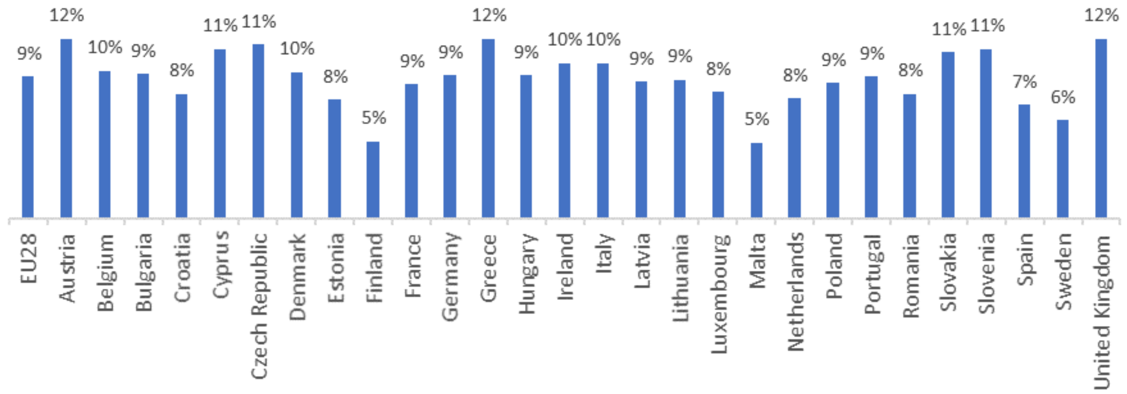


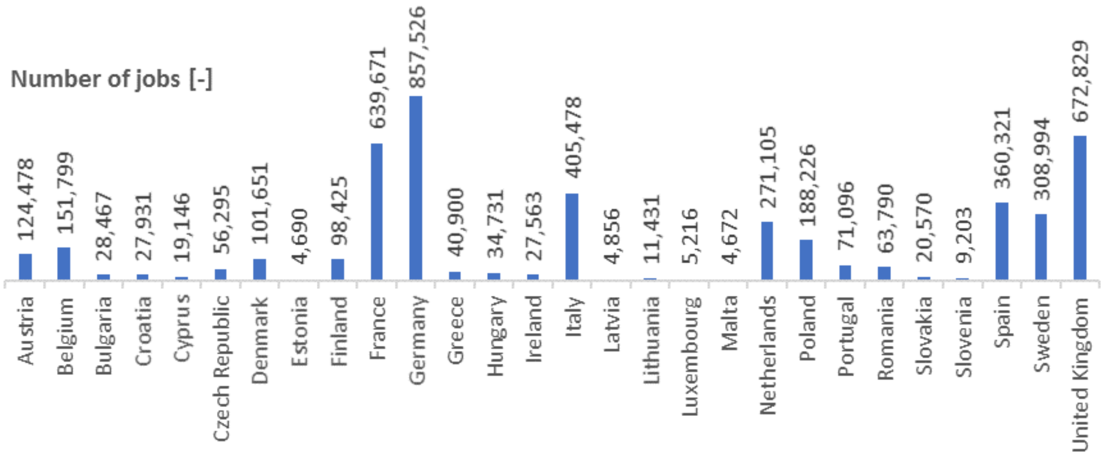
Figure 8: Emission mitigation in %, residential buildings (average 2012-2016)



With regards to the workforce employed in renovation of buildings **the total number of fulltime employees (FTE) in the construction sector involved in renovation of residential buildings is estimated to be about 4.6 million per year on average[33] for the period 2012-2016**. This also illustrates the additional workforce needed if the intensity of energy renovations (speed and depths) should increase significantly in the next few years. Additional spill-over effects would be generated amongst manufacturers, i.e. more capacity and personnel would also be needed there.

33 A factor of 8.52 FTE per million EURO spent has been applied based on Janssen & Staniaszek (2012) and Amélie Cuq et al (2011)

Figure 9: Jobs maintained by building renovations in FTEs, residential buildings (average 2012-2016)

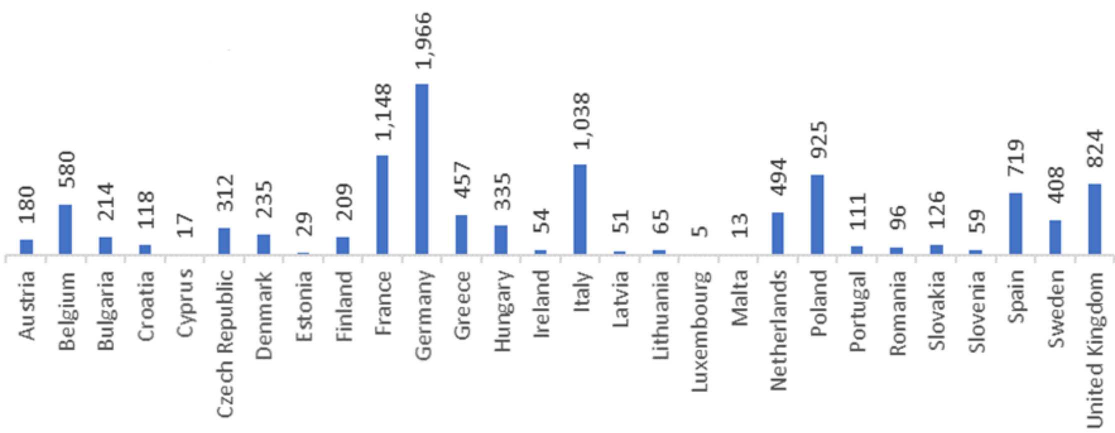


Non-residential buildings

The relative annual GHG reduction per non-residential renovation (comparing the performance of the building before and after renovation), taking the average of all energy renovations across the EU28 that took place between 2012 and 2016, is estimated to be roughly 18%[34]. After the renovation this saving continues.

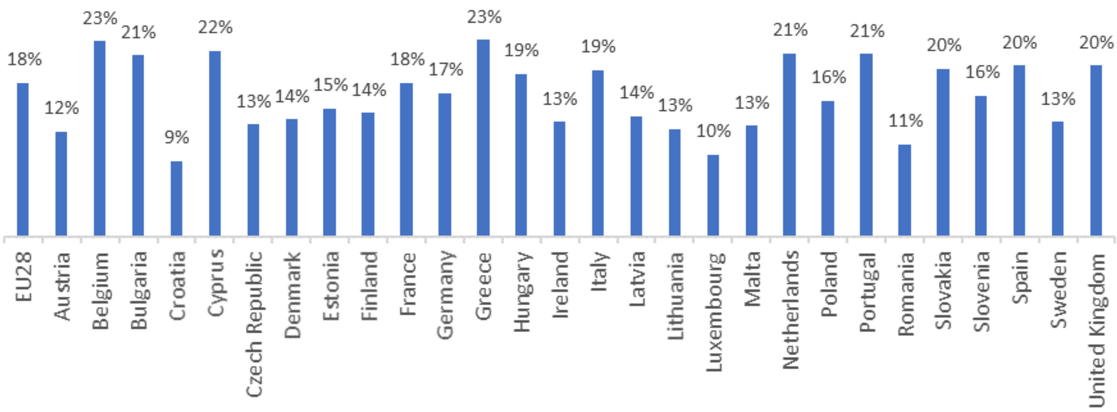
In absolute terms, year by year **energy renovations in non-residential buildings on average reduced emissions by roughly 11 MtCO2eq per year during the period 2012-2016**.

Figure 10: Emission mitigation in ktCO2e/a, non-residential buildings (average 2012-2016)



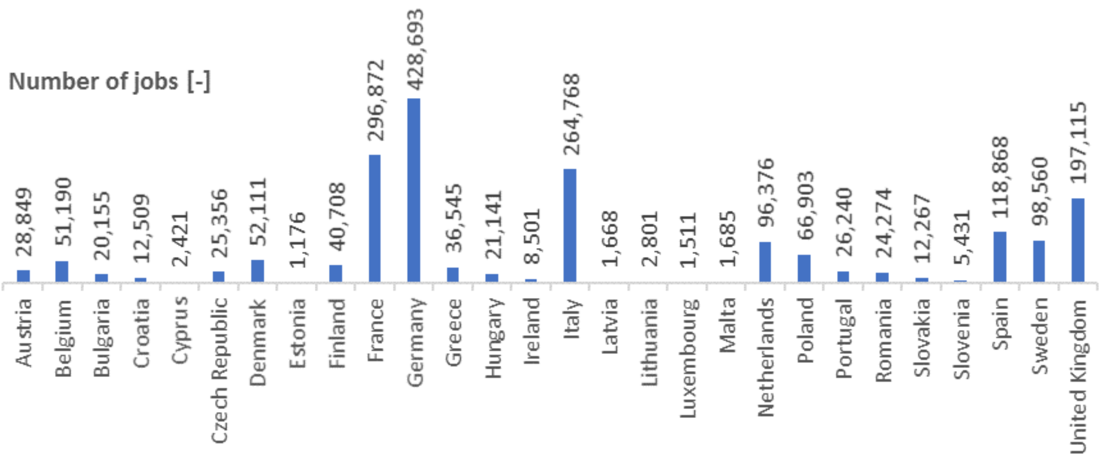
34 Average of all renovations (below threshold, light, medium, deep) that have taken place between 2012-2016.

Figure 11: Emission mitigation in %, non-residential buildings (average 2012-2016)



The total number of fulltime employees (FTE) in the construction sector involved in energy and non-energy renovation of non-residential buildings is estimated to be about 1.9 million[35] per year on average for the period 2012-2016. This adds to the bottleneck already produced by residential buildings that may occur if the intensity of energy renovations (speed and depths) should increase significantly in the next few years also in the non-residential sector. Similarly to residential buildings, additional spill-over effects would be generated amongst manufacturers, i.e. more capacity and personnel would also be needed there.

Figure 12: Jobs maintained by building renovations in FTEs, non-residential buildings (average 2012-2016)



The data Annex of this report provides a detailed overview of the results of the analysis in Excel format. The following topics are covered in the data set for the time period 2012 to 2016 on Member State and on EU28 level:

- Renovated residential and non-residential building floor area and number of buildings (absolute and relative) for all considered types and depths of renovations.

35 A factor of 8.52 FTE per million EURO spent has been applied based on Janssen & Staniaszek (2012) and Amélie Cuq et al (2011)

- Spent investments for building renovations in residential and non-residential buildings for all considered types and depths of renovations (total and specific per renovated m²).
- Primary energy savings from renovation activities in residential and non-residential buildings for all considered depths of renovations (total in toe, specific in kWh per renovated m² and relative in percentage of saved energy comparing the performance of the building before and after renovation).
- Co benefits: Jobs maintained by building renovations (in full time employees) and emission mitigation (total in kt_{CO2e} and relative in percentage of mitigated emissions comparing the performance of the building before and after renovation).

4.2. Uptake of nearly zero-energy buildings (NZEB)

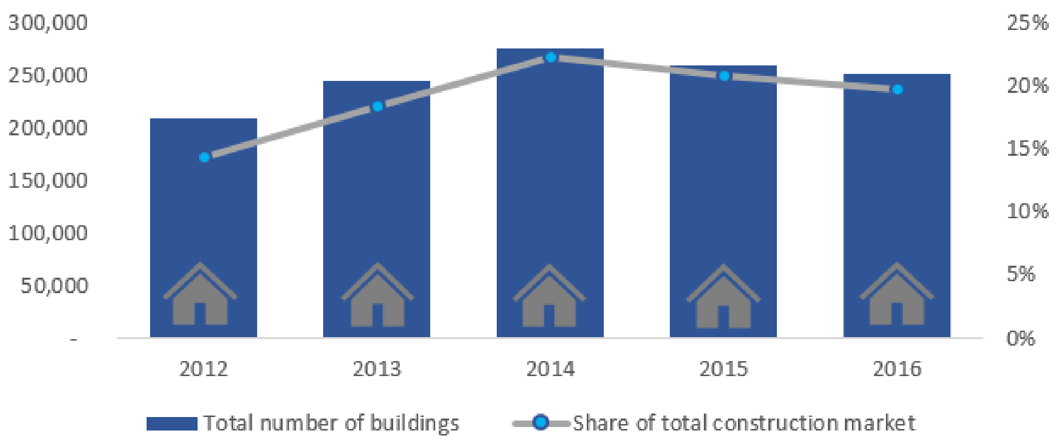
According to the EPBD all new buildings have to be NZEB from 2021 onwards (for public buildings this obligation applies as of 2019). This study covers the period 2012-2016, which is well before the actual obligation for new buildings to be NZEB. For that reason, the uptake of NZEB has been measured in this study from a **market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero**". Therefore, the here presented numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today.

For achieving this aim, information has been collected from the architect survey of this study and from "The architectural professions in Europe sector studies" by the Architect's Council of Europe (ACE). Details of the approach can be found in the Annex to this report, section 3.4.

The following graph illustrates the qualitative uptake towards NZEB in terms of total number of buildings, and the share of these buildings within the construction market, i.e. of total constructed new and renovated buildings in the EU.

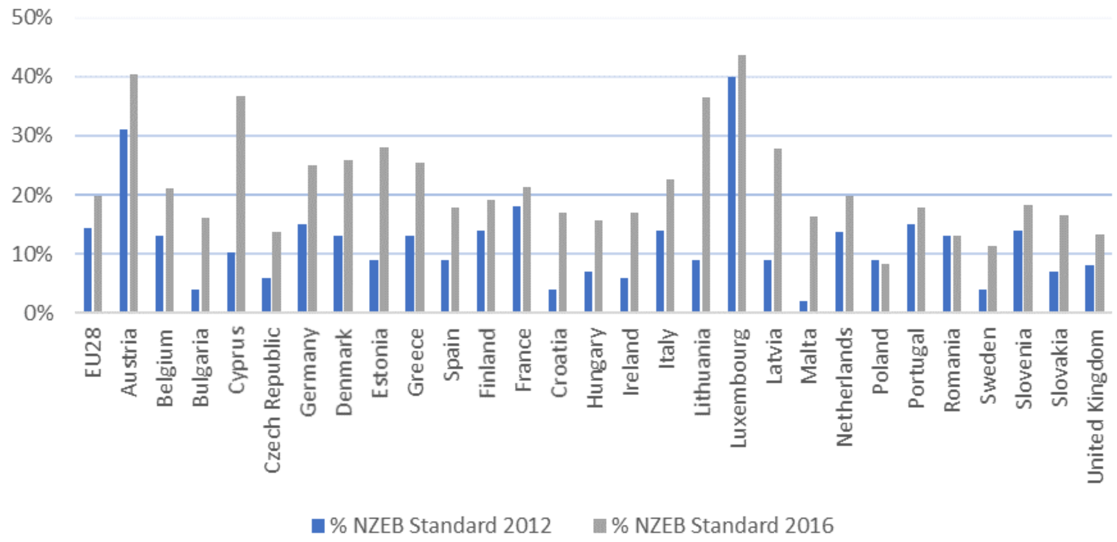
The results show that the number and share of buildings constructed in nearly-zero energy standard increased with a peak in 2014 and slightly decreased between 2014 and 2016. However, the overall trend of constructing towards to NZEB standards is positive for the period 2012 to 2016.

Figure 13: Overview of total number of buildings newly constructed or renovated to nearly-zero energy buildings standard and its share in the construction market on EU28 level



The following graph illustrates the share of buildings constructed with high performing standards among all new building constructions and renovations on Member State level for the years 2012 and 2016. The shares include both constructed new buildings and renovated buildings in each year. On EU28 level, buildings with standards close to NZEB are built 38% more often in 2016 than in 2012.

Figure 14: Overview of the perceived share of NZEB and its share of the total constructed new and renovated buildings on Member State and EU28 level.



The next two graphs give an overview of the share of buildings with high performing (NZEB) standards compared to all new buildings (Figure 15) and compared to all renovated buildings (Figure 16) in 2012 and 2016. The results show that nearly-zero energy standards are preferably applied to newly constructed buildings, i.e. on EU28 level 27% times more new buildings are constructed in nearly-zero energy buildings standard than renovated buildings.

Figure 15: Overview of share of NZEB and its share of total constructed new buildings on Member State and EU28 level

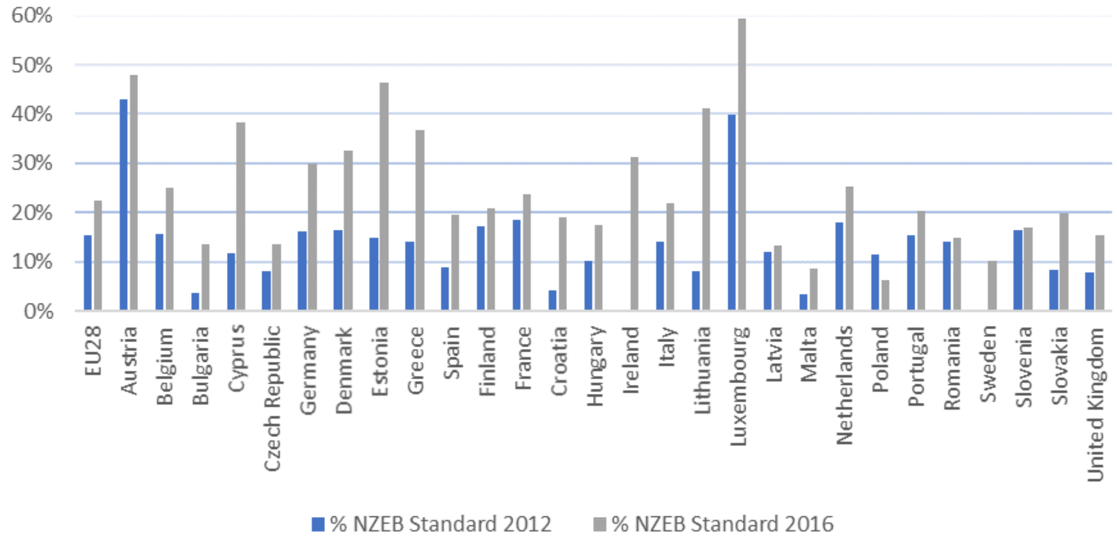
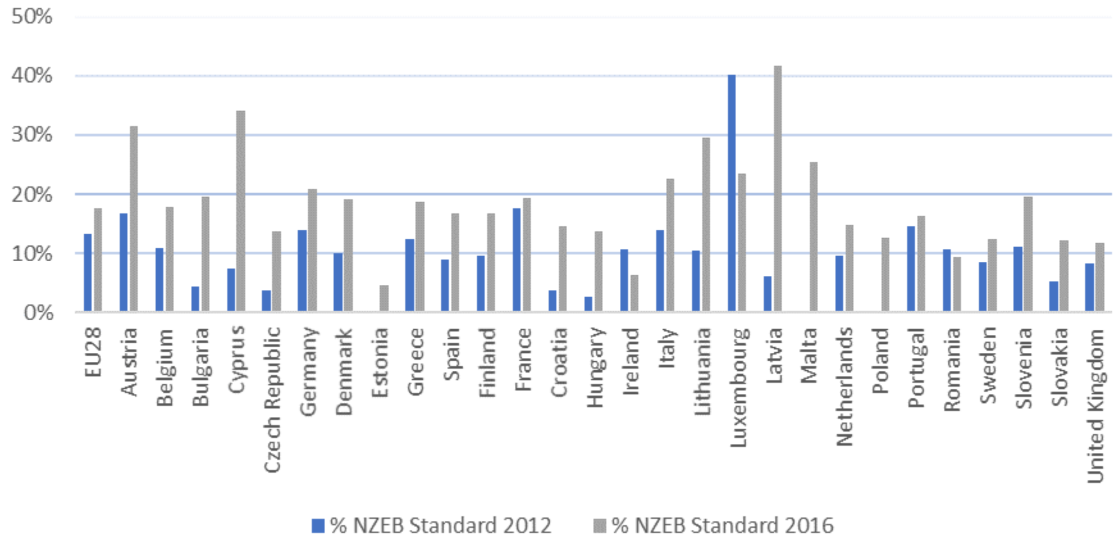


Figure 16: Overview of share of NZEB and its share of total renovated buildings on Member State level



It should be noted again that the shares are presented from a market perspective, meaning that stakeholders have been asked about their view on realised the NZEB requirements. However, this does not need to be in line with already mandatory requirements in some countries that all new buildings already need to be NZEB (e.g. France or Luxembourg).

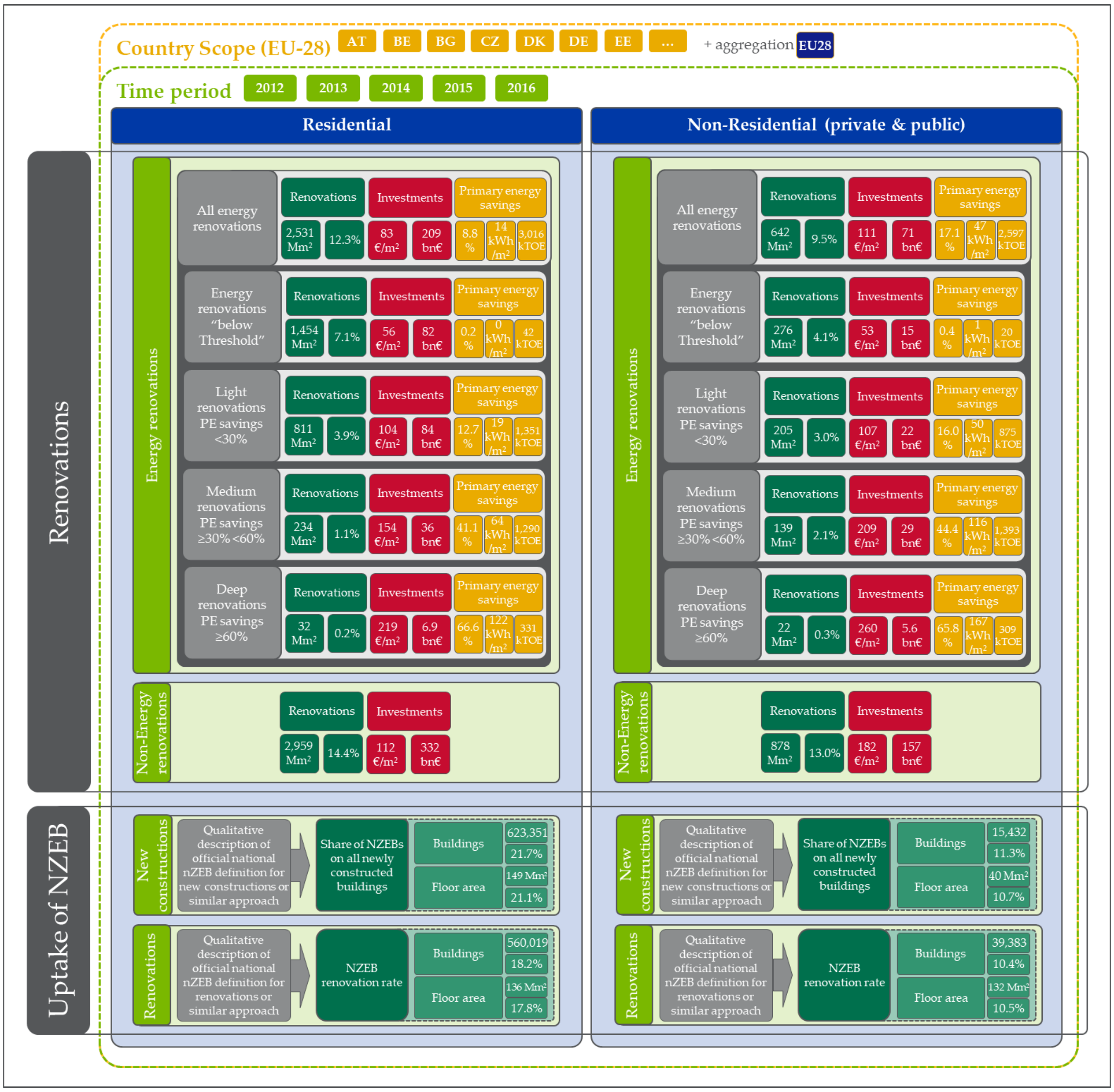
The exact methodology for calculating these numbers including the used sources can be found in Annex section 3.4.

The data Annex of this report provides a detailed overview of the results of the analysis in Excel format. The following topics are covered in the data set or the time period 2012 to 2016 on Member State and on EU28 level:

- Total number of NZEB and for new residential and non-residential, as well as renovated residential and non-residential buildings.
- The share of NZEB in relation to the overall construction activities within each of the categories new residential and non-residential, as well as renovated residential and non-residential buildings.
- Total square meter of NZEB for new residential and non-residential, as well as renovated residential and non-residential buildings.
- The share of square meter in NZEB in relation to the overall construction activities within each of the categories new residential and non-residential, as well as renovated residential and non-residential buildings.

An overview of the quantitative results related to renovations and the uptake of NZEB is presented in Figure 17.

Figure 17: Overview of the quantitative results related to renovations and the uptake of NZEB



4.3. Determinants for performing energy renovations[36]

As outlined in section 2, in addition to the calculation of energy renovation and NZEB uptake, this study collected qualitative data to identify triggers, drivers, barriers and incentives to perform energy renovations. In order to take the perspectives of multiple stakeholders into account, surveys were conducted with consumers[37], architects, main contractors and installers (for an extensive overview of the survey methodology see Annex section 3.5)[38]. Building professionals were further asked about factors that have influenced their clients' decision to invest in energy renovations[39]. The fact that different aspects are relevant for different stakeholders, is reflected in the target group specific indicators in each questionnaire. As described above, the findings are meant to feed into future development of policy instruments to increase the rate of energy renovation in the EU. A section on policy implications is included at the end of this section.

The different determinants are further divided into groups. These groups may relate to personal/emotional or external/practical determinants. For instance, for some respondents a personal benefit or environmental concerns may be more decisive, while for others structural aspects and opportunities (e.g. financing options, administrative requirements, repair, etc.) have more influence. The following groups are represented in the analysis:

- Repair, replacement and maintenance (e.g. necessary inspection, replacement of a defective component)
- Technical (e.g. technical constraints, complicated installation)
- Information and recommendation (e.g. information from media or on the energy bill, recommendation from installer)
- Ratings and certificates (e.g. rating on the energy label of a component or the EPC)
- Guarantee and security (e.g. energy cost saving guarantee)
- Administrative and regulatory (e.g. administrative requirements, regulations)
- Financial (e.g. budget, financing conditions, payback time)
- Skills (e.g. confidence to do works independently, complexity of calculating costs and benefits)
- Transaction (e.g. change or purchase of residence)
- Environment (e.g. protection of the local environment and from the effects of global warming)
- Profit and personal (benefits) (e.g. improved health, improved home/property, increased profit, no personal benefit, negative consequences of renovation)
- Client (benefits) (e.g. installation of high quality components, healthier living or working, difficulty to explain benefit to client)

36 This section only reports on the aspects that were most often indicated by respondents, i.e. they either "fully agreed" or "rather agreed", or indicated an aspect as "very important" or "rather important".

37 Renovation works could have been commissioned by the property owner, tenant him/herself or the landlord.

38 Only data of consumers and building professionals who have performed energy renovations is discussed in this section.

39 Includes both residential and non-residential clients.

Firstly, triggers for consumers and clients of architects and main contractors are presented. Drivers for these groups as well as architects, main contractors and installers are described in the next section. Barriers and incentives per group follow in the subsequent sections. Funding sources of consumers and commercial/public clients of architects are outlined in the next section, followed by ascribed responsibility for quality assurance of renovation projects. Policy implications of the findings are specified at the end. A summary box of the triggers, drivers, barriers and incentives analysis is provided below and at the end of each section.

Table 14: Summary box – triggers, drivers, barriers and incentives

Consumers and commercial/public clients

- Financial aspects (available budget, costs) are consistently of relevance.
- For consumers, reducing energy costs and improving their health and comfortability through energy renovations are important factors.
- Repairs and maintenance provide opportunities to invest in energy renovation.
- Structural barriers are strongly perceived, particularly by younger consumers and those with a lower income.
- Information from media, the social circle and financial institutions is more encouraging for younger consumers to perform energy renovations.

Building experts: Architects, main contractors and installers

- Environmental aspects are of high relevance to recommend energy renovations.
- Benefits for the client may have more weight than personal profit/benefits.
- Structural barriers are strong, particularly administrative and regulatory.
- Architects note a barrier due to unavailability of qualified installers.
- Main contractors and installers view clients as highest barrier.
- Increased opportunities for cooperation, exchange and receiving recommendations/training among building experts are requested.

4.3.1. Triggers

Triggers for (energy) renovation can be various events or circumstances that encourage the decision to invest in energy renovations, for instance the urgent repair of a defective component (boiler in winter), the change of a tenant or a recent purchase of a building. This section explores the triggers for those who have performed energy renovations, either as consumers or building professionals.

The EPBD define triggers as "*opportune moments in the life cycle of a building, for example from a cost-effectiveness or disruption perspective, for carrying out energy efficiency renovations*".

In the European Commission's Recommendations on building renovation from 2019[40], differentiation is made between three categories of triggers:

a) a transaction (e.g. the sale, rental or lease of a building, its refinancing, or a change in its use);

b) renovation (e.g. an already planned wider non-energy-related renovation; and

c) a disaster/incident (e.g. fire earthquake, flood).

The scientific background used for the design of the surveys significantly overlaps with this recent Commission recommendation. The category 'transaction' is fully covered in this report, while the other two categories overlap with other aspects that can be put under the headings "opportune moments in the life-cycle of the decision maker" and "triggers related to relevant EU legislation", like Energy Labelling, Energy Efficiency and Energy Performance of Buildings Directives, as this appeared to be most appropriate for the purpose of this study.

This section explores the role of triggers.

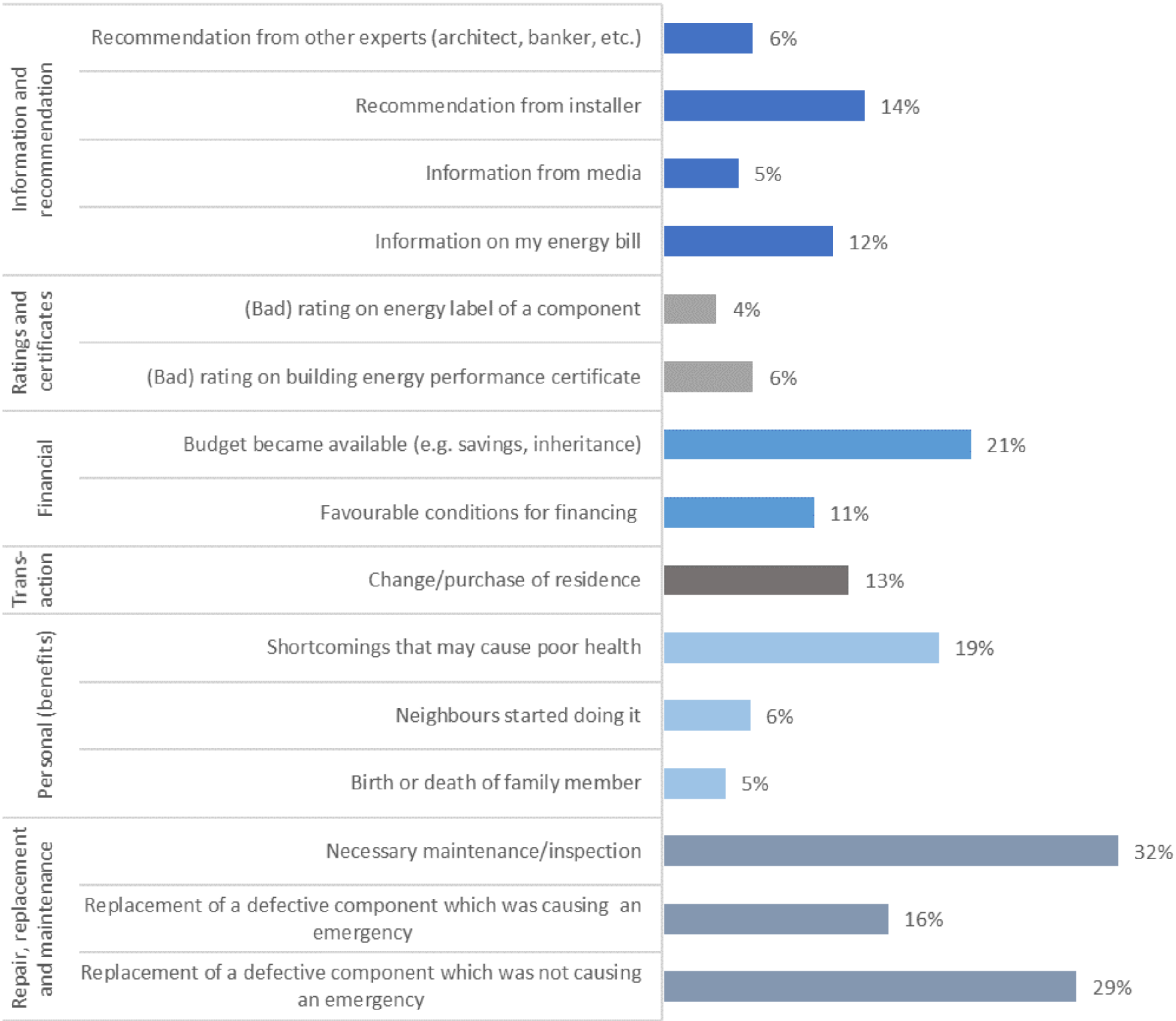
Consumers[41]

Among consumers (who have conducted energy renovations), situations related to (necessary) repairs, replacements and maintenance are considered as strong triggers. Budget and health-related aspects also play a central role when investing in energy renovations. In contrast to the information on the energy bill, which is required by the Energy Efficiency Directive, energy labels on components (Energy Labelling Directive) or the Energy Performance Certificate (EPC) are reported less commonly as *triggers* (Figure 18).

40 Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019H0786

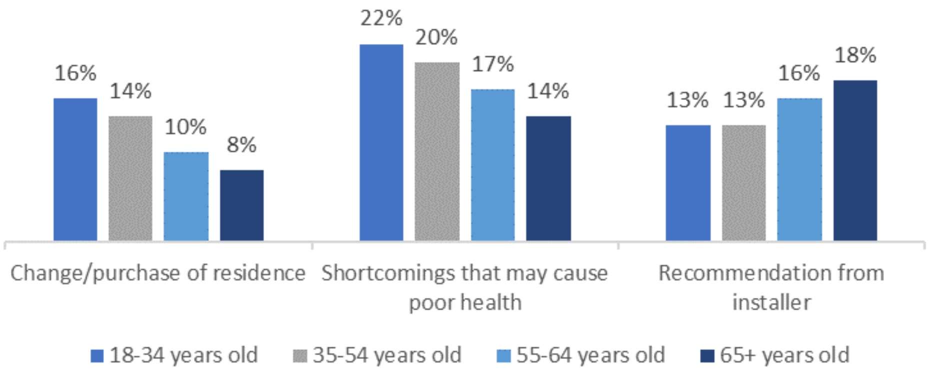
41 Question to consumers: "Which circumstances triggered your energy renovation/installation actions?"

Figure 18: Triggers for consumers



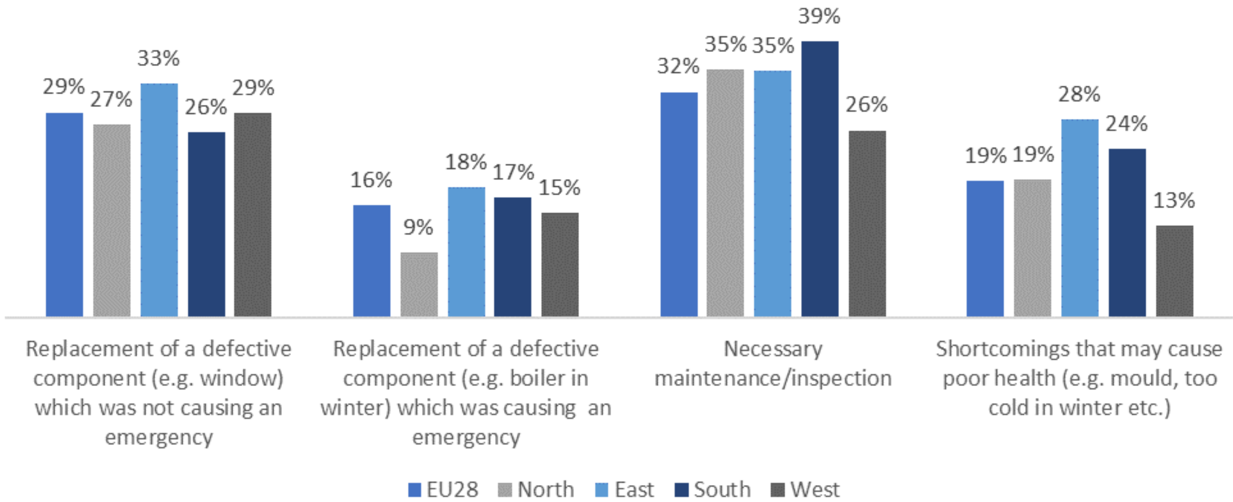
Younger consumers are more triggered by a transaction which might indicate that this population group more often acquires property or changes their residence, and/or that energy-related concerns when moving to a new home are more prevalent among this group. Health-related concerns are also a stronger trigger for younger tenants and owners compared to older cohorts. On the other hand, recommendations from installers have more weight in older owners' and landlords' decision to invest in energy renovations (Figure 19).

Figure 19: Triggers - age differences



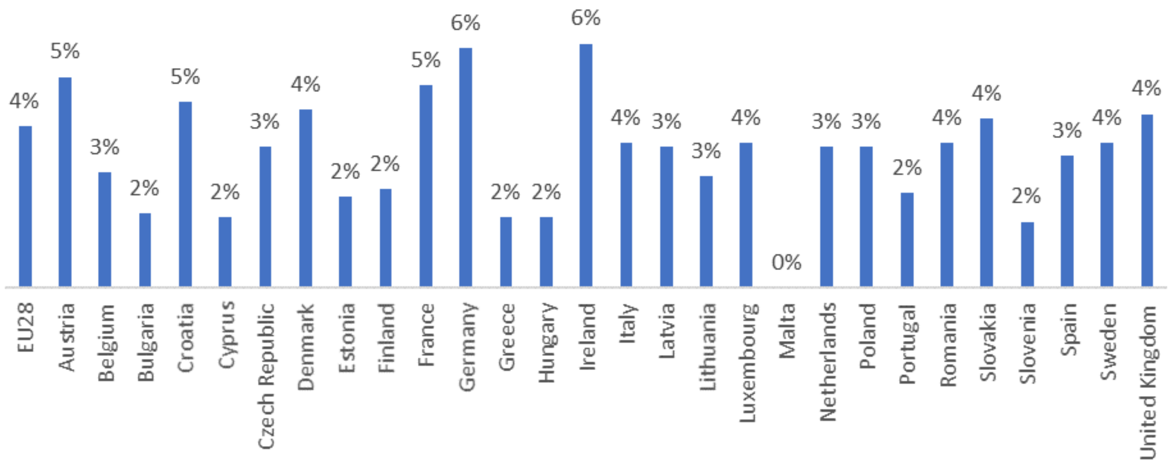
Overall, the different triggers are more prevalent in Eastern and Southern Europe. Results suggest that emergency works occur less often in Northern regions, which may be an indication of slightly better maintained technical building systems. Concerns that shortcomings may cause poor health might indicate a prevalence of these shortcomings in the country. This is in line with findings on housing problems from the EU SILC survey. (Figure 20).

Figure 20: Triggers - regional differences



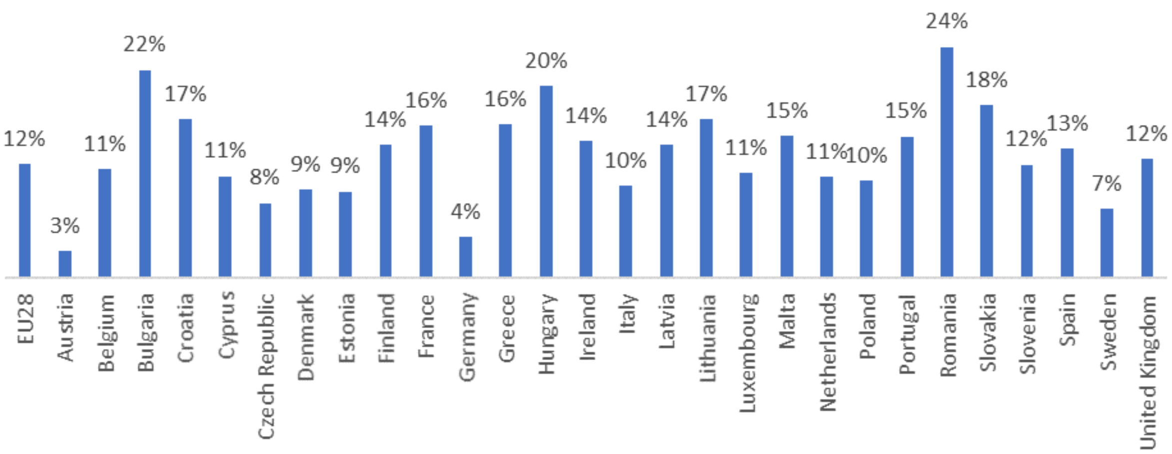
In comparison to other European regions, consumers in Western Europe more often stated that they performed energy renovations to improve the rating on the energy label of a component (Figure 21).

Figure 21 : Triggers – (bad) rating on the energy label of a component by country



Consumers in Eastern Europe are more often triggered by information on cost and amount of energy consumption on their energy bill than consumers in other regions. This information is the least relevant in Austria and Germany (Figure 22).

Figure 22: Triggers – information on the energy bill by country

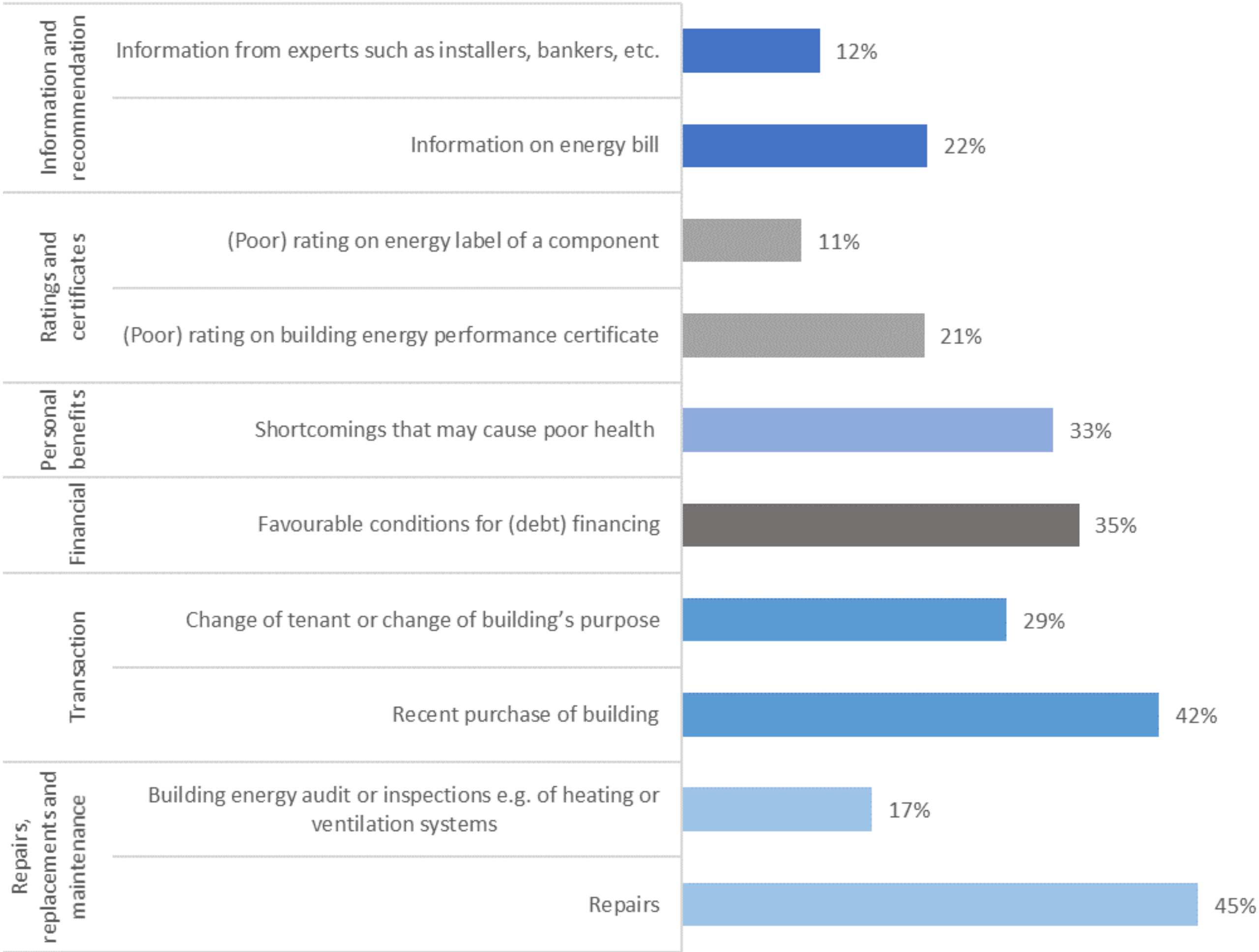


Clients of architects[42]

In line with consumers, **architects report that repairs and health-related aspects are the strongest triggers for their clients to perform energy renovations**. Architects attribute more weight to transactions and favourable financing conditions to their clients than consumers do for themselves. This is probably due to the fact that architects – here mainly consulting on non-residential buildings - have a significant share of commercial clients who are more business and financially driven than consumers. In this segment, obviously, the EPC rating plays a much stronger role than for consumers.

42 Question to architects and main contractors: "What circumstances trigger your typical [non-residential/residential single-family house/residential multi-family house] clients to perform energy renovation?"

Figure 23 : Triggers for clients of architects



Clients of main contractors and installers[43]

Similar to architects, **main contractors view health-related aspects, transaction and repairs as strong triggers for their clients**. However, they give more relevance to information and ratings/certificates than architects and consumers (Figure 24). In this context, it should be noted that only main contractors were interviewed who are also active in non-residential renovation.

43 Question to architects and main contractors: "What circumstances trigger your typical [non-residential/residential single-family house/residential multi-family house] clients to perform energy renovation?"

Figure 24: Triggers for clients of main contractors

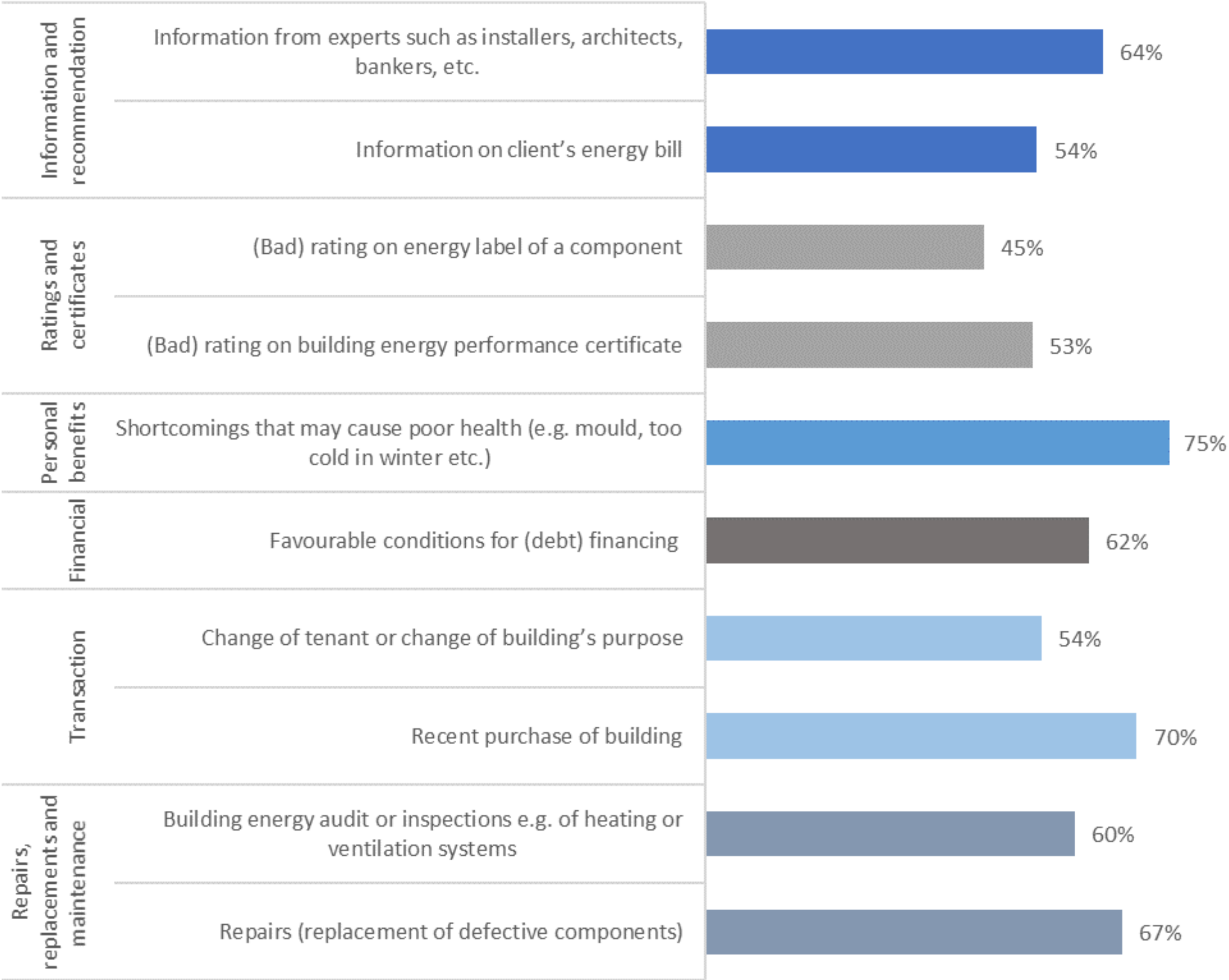


Table 15: Summary box - triggers

- For consumers and clients of building experts, it is not possible to identify a specific group of triggers as most impactful. Both practical and personal determinants function equally as triggers.
- **Necessary maintenance**, non-emergency **replacement of a defective component**, available **budget** and shortcomings that may cause poor **health** are important triggers for *consumers*.
- *Clients* of building experts – residential and non-residential – likewise emphasise **health-related concerns** and **repairs**, but also the **purchase of a building** and **favourable financing conditions**.

4.3.2. Drivers

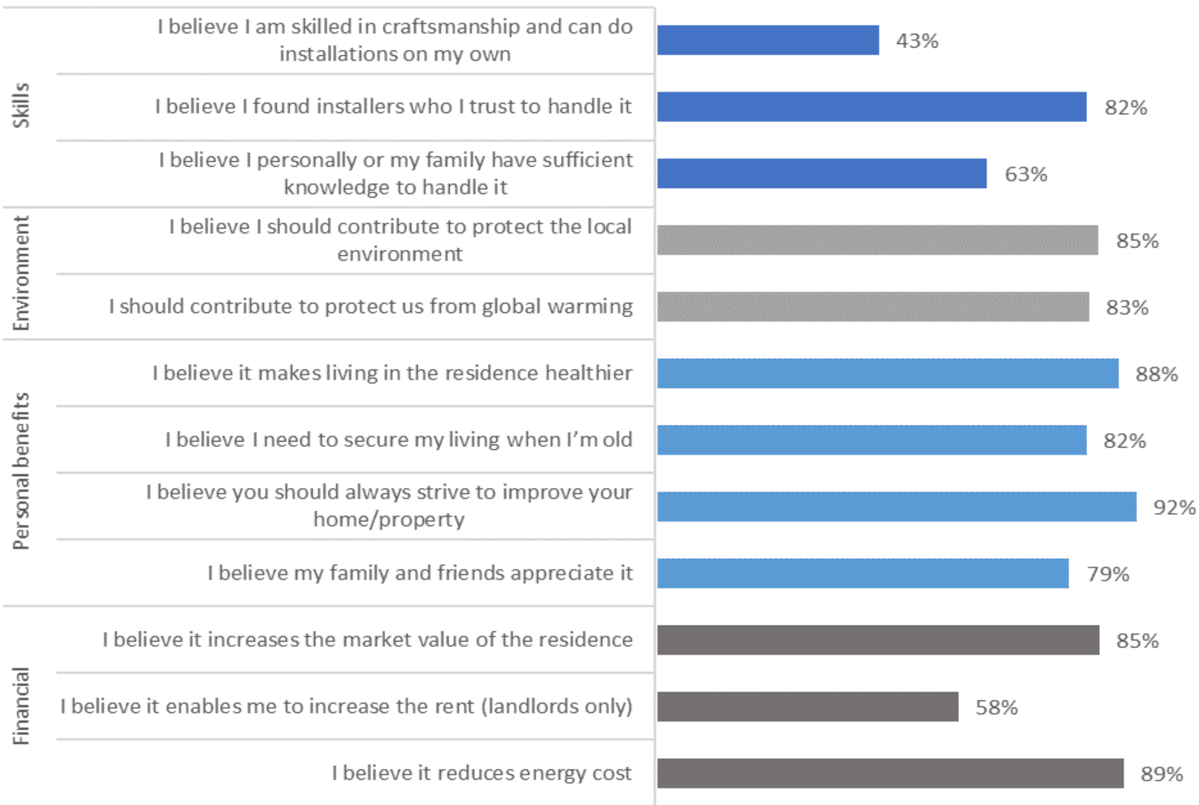
Drivers or motivations in the context of energy renovations are assumed to be of economic, personal (attitudes) or environmental manner. In contrast to triggers, they do not depend on a specific event or circumstance but on the person and her/his environment. Motivations are for example increased profit, improved health, or the protection from consequences of global warming. This section explores the drivers for those who have performed energy renovations, either as consumers or building professionals.

The EPBD requires Member States' long-term renovation strategies (LTRSs) to include an evaluation of wider benefits of improved energy performance, for instance in relation to health, safety or air quality. In this study, these benefits are assessed as drivers and (partly) incentives.

Consumers[44]

Consumers report various drivers for performing energy renovations that differ in their nature. **Personal benefits, health, environmental and financial aspects (lower costs) are all strong motivations** (Figure 25). **The driver to improve the residence is the strongest**. This is important for communication, as obviously respondents who already did an energy renovation feel they can improve their residence and its value by performing an energy renovation.

Figure 25 : Drivers for consumers



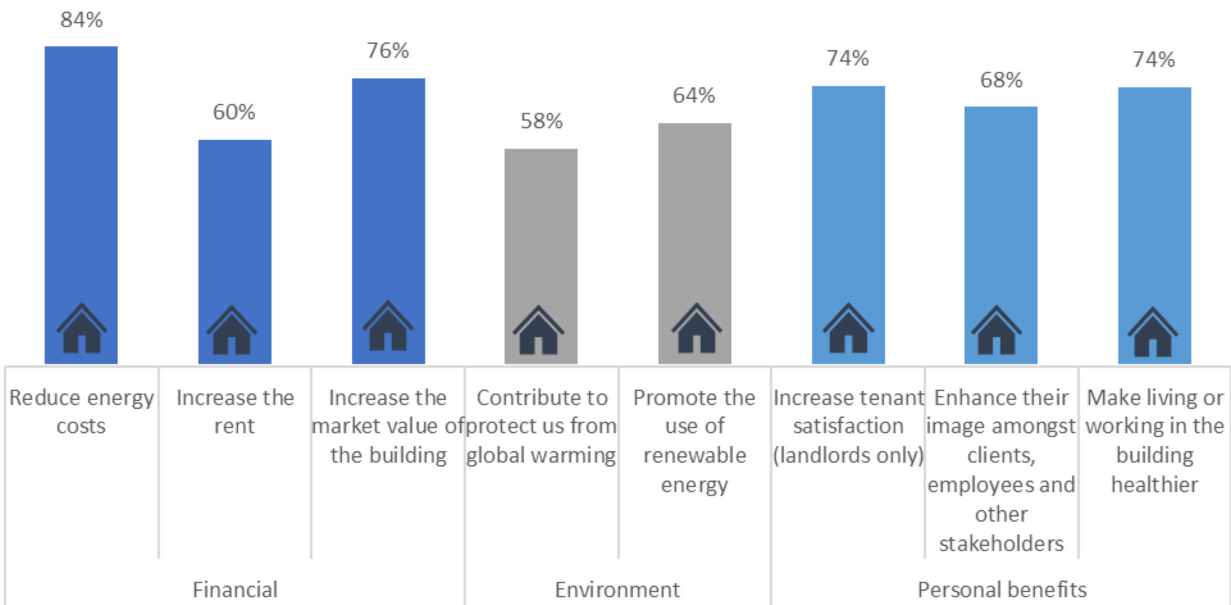
44 Question to consumers: "To what extent do you agree with the following statements? I did these energy renovations/installations, because I believe …"

Younger consumers are more motivated to perform energy renovations because of their confidence in their own necessary skills (51% vs 32% of older consumers). For older consumers, the circumstance to have installers they trust is more relevant in the decision for energy works compared to younger cohorts (90% vs 77%). Similarly, consumers with a higher income level are rather motivated by this aspect than those with a lower income level (85% vs 77%).

Clients of architects[45]

Architects report financial aspects and personal benefits as strong drivers for their clients, most noteworthy the reduction of energy costs. They view environmental factors as less motivating than consumers themselves (Figure 26).

Figure 26 : Drivers for clients of architects



Clients of main contractors[46]

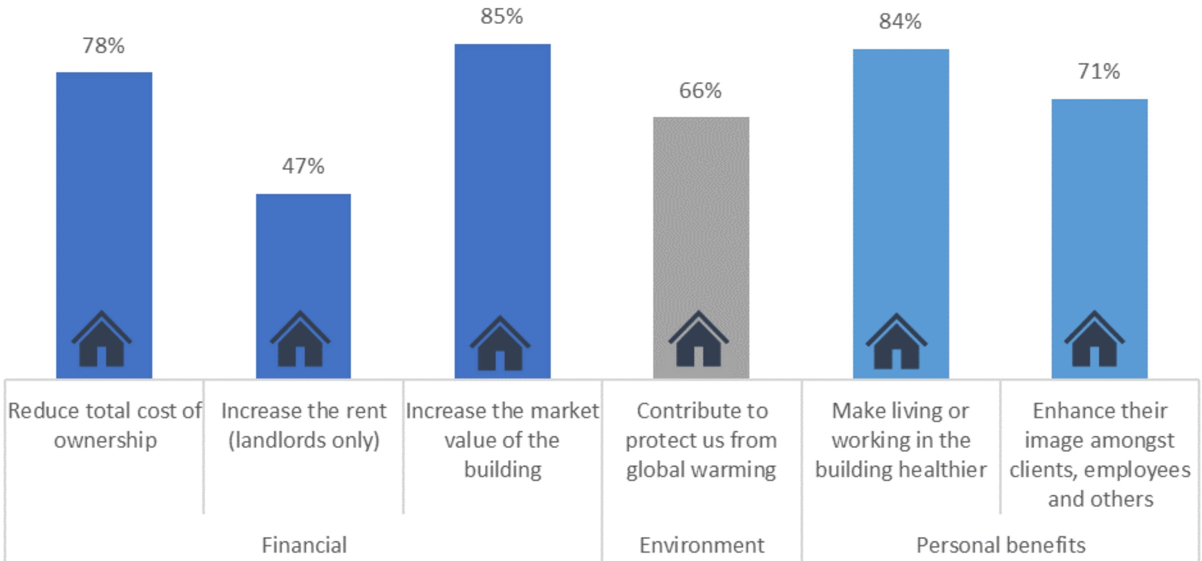
In line with architects, **main contractors indicate financial aspects and personal benefits as strongest drivers for their clients to perform energy renovations**. Again, environmental concerns are seen as less prevalent among clients, though still very relevant (

Figure 27).

45 Question to architects and main contractors: "To what extent do you agree that the following factors motivate your [non-residential/residential single-family house/residential multi-family house] clients to perform energy renovations?"

46 Question to architects and main contractors: "To what extent do you agree that the following factors motivate your [non-residential/residential single-family house/residential multi-family house] clients to perform energy renovations?"

Figure 27: Drivers for clients of main contractors



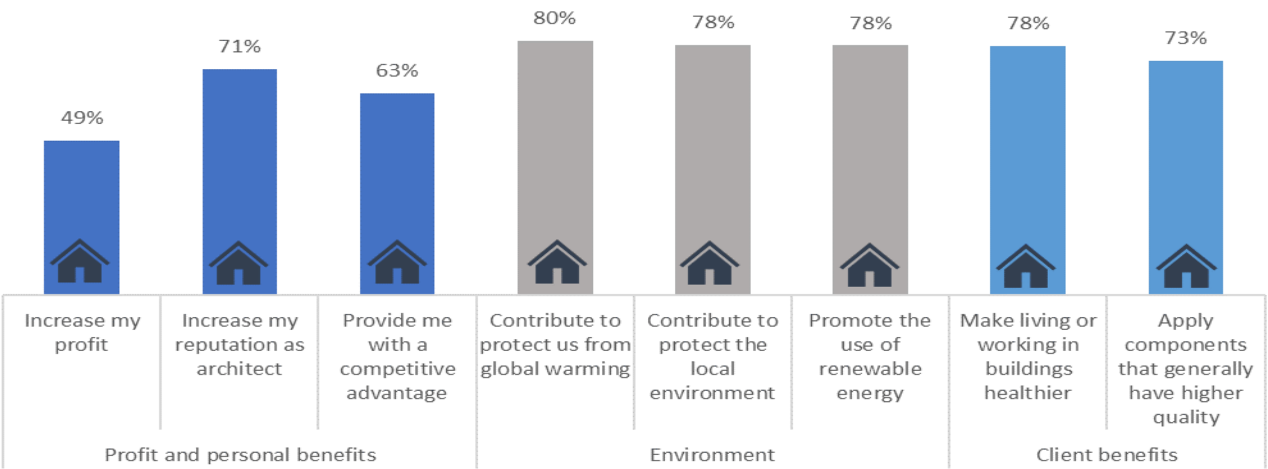
Architects[47]

The study also asked building experts about *their* drivers, barriers and incentives to be involved in energy renovation. Architects are most **motivated to recommend energy renovation because it benefits the environment[48] and the client**. Personal profit and benefits – though still strong drivers – are less motivating (Figure 28). **Architects are particularly driven to promote the use of renewable energy when working on non-residential construction projects** (86% compared to 78% for residential projects).

Figure 28: Drivers for architects

47 Question to architects, main contractors and installers: "To what extent do you agree with the following statements about energy renovations: I believe that energy renovations …"

48 More architects stated to "fully agree" compared to "rather agree" that they are motivated to contribute to the protection from global warming and to protect the local environment.

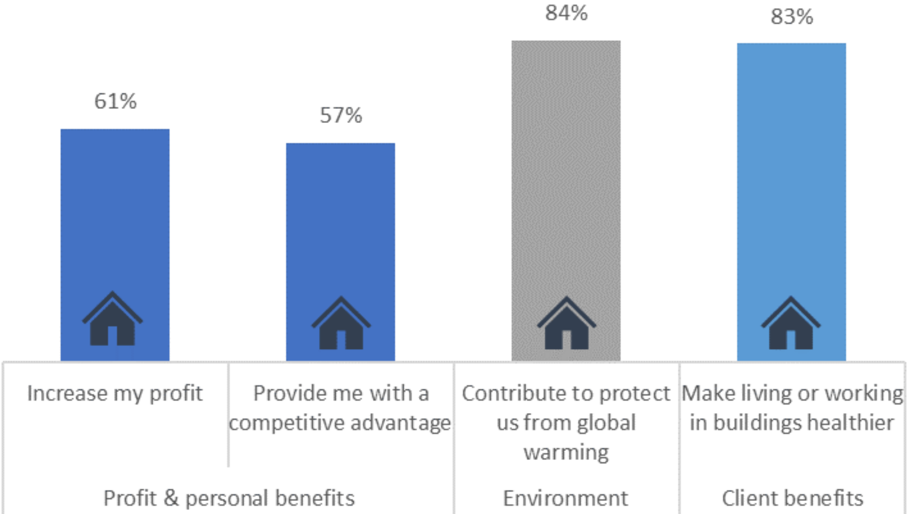


Main contractors and installers[49]

Similar to architects, **main contractors and installers attribute most relevance to environmental[50] and client-related drivers for themselves to recommend energy renovation**. Nevertheless, the vast majority also mentions **profit and personal benefits as motivational factors** to recommend energy renovation (Figure 29).

The relevance of the different drivers differs by construction sector. Environmental aspects are most relevant for heating (87%). A competitive advantage and healthier living and working is expected in particular from works on air-condition/photovoltaic (66% and 88%. respectively).

Figure 29 : Drivers for main contractors and installers



49 Question to architects, main contractors and installers: "To what extent do you agree with the following statements about energy renovations: I believe that energy renovations …"

50 More main contractors and installers stated to "fully agree" compared to "rather agree" that they are motivated to contribute to the protection from global warming.

Main contractors and installers across the EU28 view the relevance of drivers differently. Following the same pattern as consumers, construction professionals in Eastern and Southern Europe report the drivers most frequently which suggests that – in comparison to Western and Northern Europe - addressing the drivers in these regions with appropriate policy instruments may have a stronger impact on the frequency energy renovation is recommended. Differences are most noteworthy related to personal benefits, the environment and health, as illustrated in

Figure 30.

Figure 30 : Drivers – regional differences

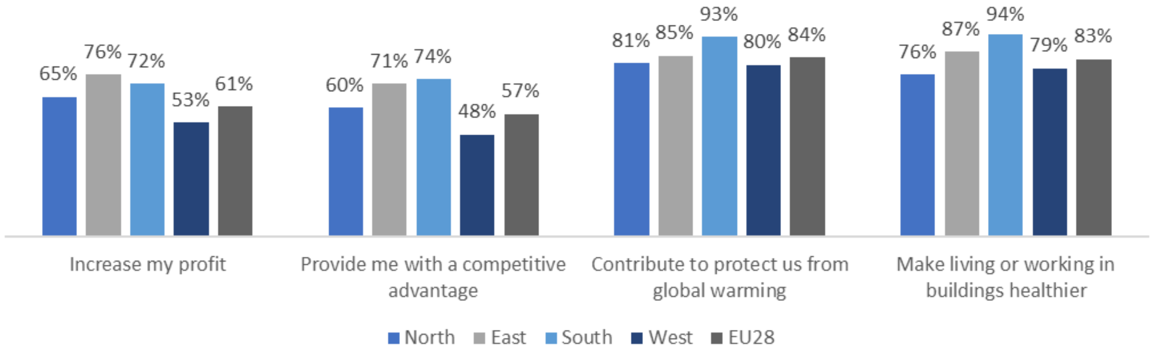


Table 16: Summary box - drivers

- Environmental aspects and benefits for the resident in terms of health, comfortability and finances are strong drivers.
- **Environmental aspects**, **personal benefits** (improved homes and health) and **financial factors** (increased marked value and reduced energy cost) are similarly important drivers for *consumers*. Building experts also report a high relevance of these determinants for their *clients* but attribute less weight to environmental aspects.
- **Environmental aspects** (countering consequences of global warming) and **benefits for clients** (healthier living/working) are most driving for *building experts* (compared to profit and personal advantages).

4.3.3. Barriers

Barriers address the various aspects that may prevent the implementation of energy renovation. Like drivers, they are specific to the person and her/his environment, for instance attitudes, technical or regulatory barriers. It is important to note, given the nature of the study, only respondents who have performed energy renovations were asked about barriers they have encountered and overcome.

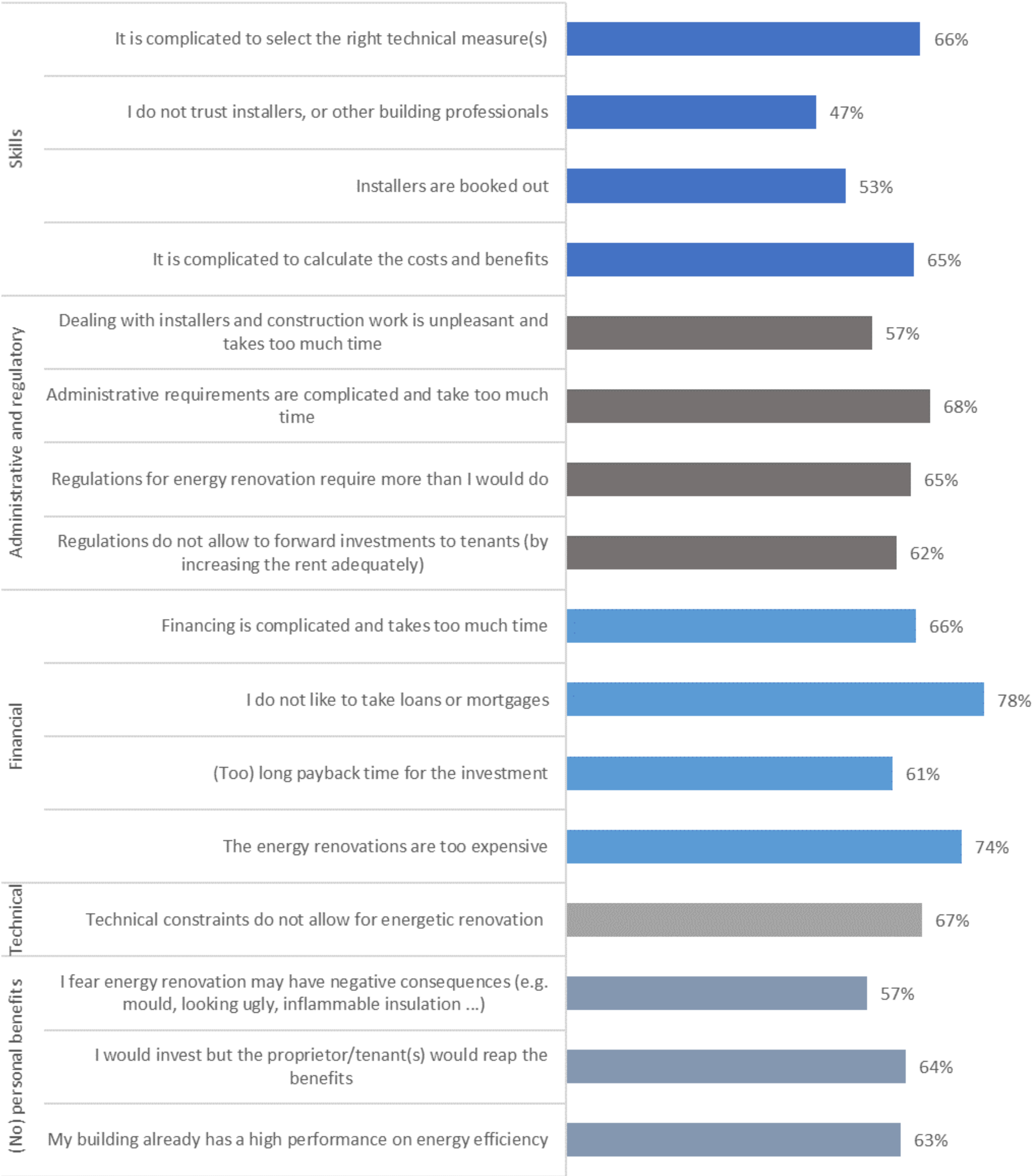
Competence and skills are key to implement requirements defined by the EPBD and other policy instruments. Therefore, this section also explores the relevance of, for example, availability of qualified and certified installers as a barrier.

Consumers[51]

Consumers are motivated or triggered to perform energy renovations by various factors, therefore it is not surprising that they also strongly experience barriers to invest in energy renovation. These have different origins, though the vast majority of **consumers have encountered financial barriers**. Interestingly, a high proportion of consumers would not invest because they do not see the (personal) benefits of it (Figure 31). **Tenants are more concerned that benefits will be reaped by landlords than the other way around** (68% of tenants; 54% of landlords).

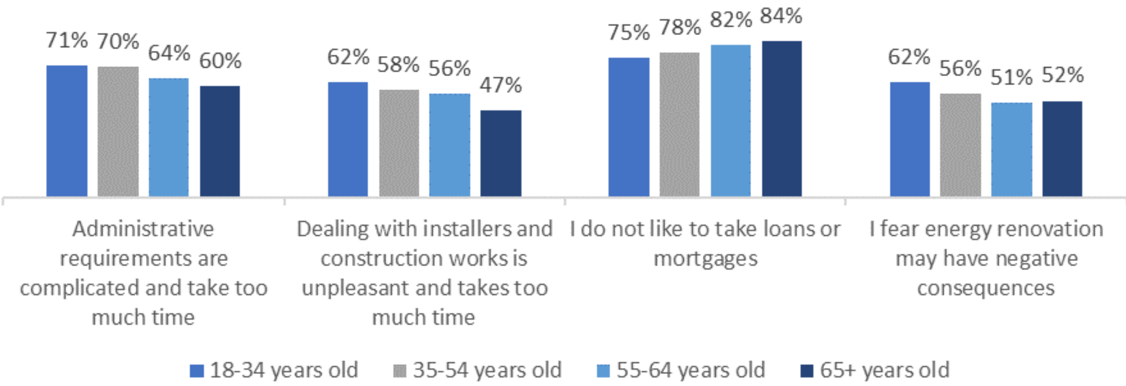
Figure 31: Barriers for consumers

51 Question to consumers: "How important were the following aspects as a barrier for your energy renovation/installation?"



The younger population group most often reports administrative and regulatory barriers. Older consumers, on the other hand, are more restrained by the necessity to take out a loan or mortgage, as illustrated in Figure 32.

Figure 32 : Barriers – age differences



Consumers with a lower income more frequently experience administrative and regulatory barriers to invest in energy renovations. They are also more sceptical towards energy-related works and the trustworthiness of building professionals (Figure 33).

Figure 33 : Barriers – differences by income level

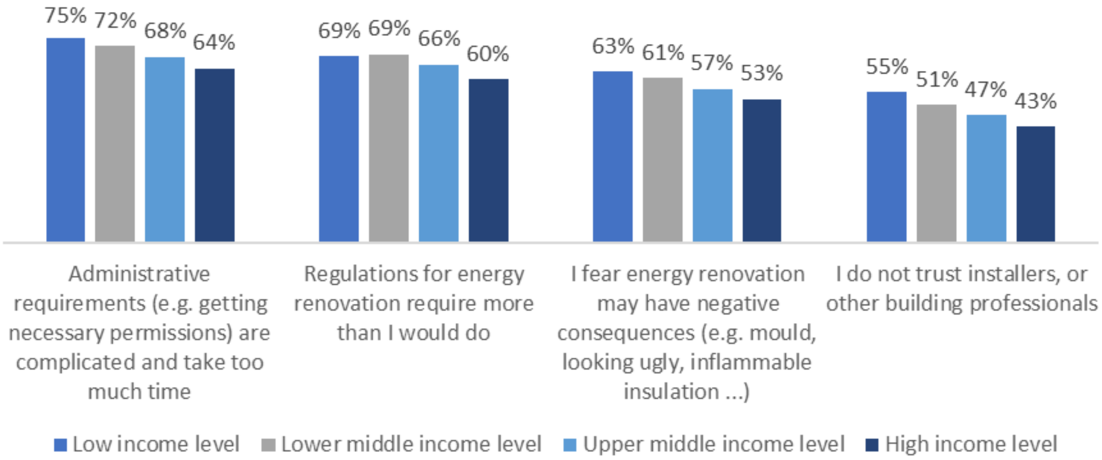
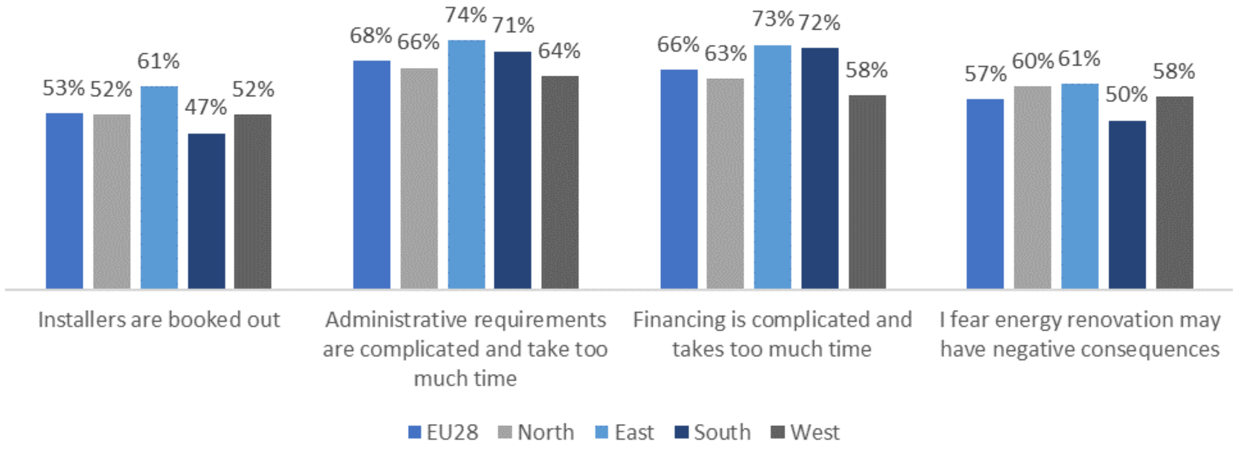


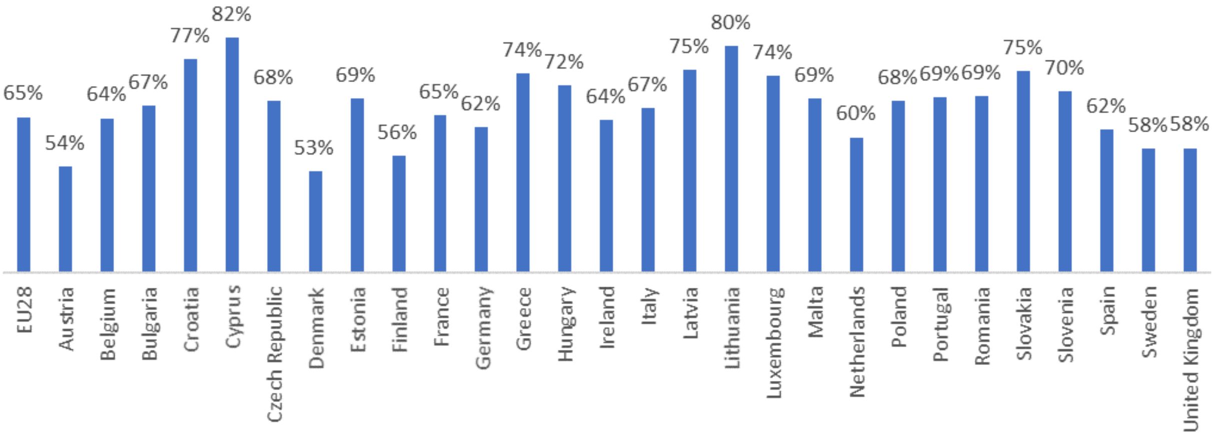
Figure 34 shows the strongest differences between European regions in terms of barriers. Barriers are most often perceived in Eastern Europe (as are triggers and drivers).

Figure 34 : Barriers – regional differences



Countries in Eastern and Southern Europe report most frequently that regulations that require more than they would do, have posed a barrier to perform energy renovations. Most noticeable are the high proportions in Cyprus and Lithuania (Figure 35).

Figure 35 : Regulations require more than consumer would do by country

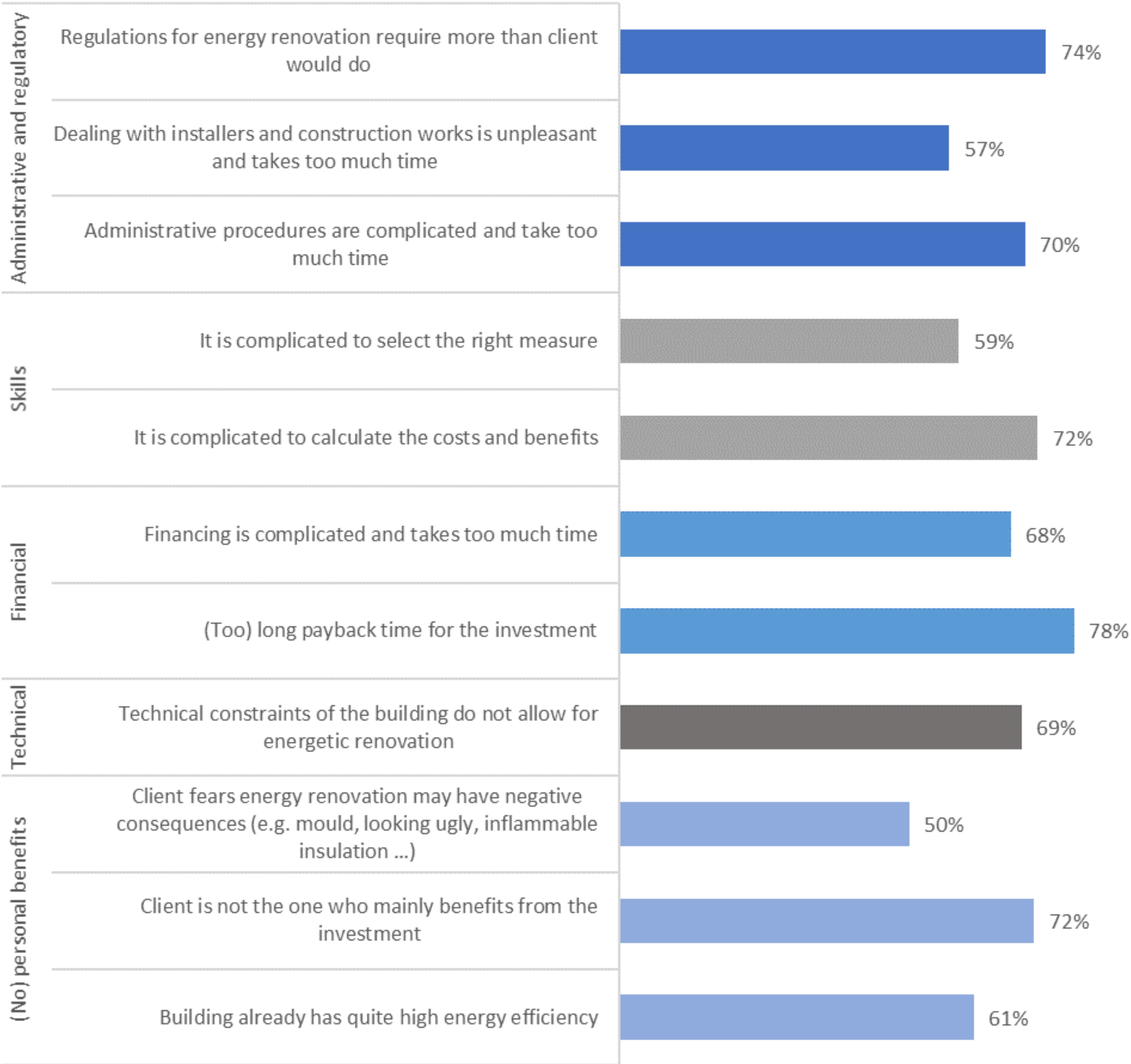


Clients of architects[52]

Architects attribute very similar weight to different kinds of barriers their clients may have as consumers do for themselves. (Figure 36). A higher weight especially of "**too long payback time**" probably reflects the share of commercial clients in architects' portfolio.

Figure 36 : Barriers for clients of architects

52 Question to architects: "How important do you think the following aspects were as a barrier for your non-residential/residential single-family house/residential multi-family house clients to perform energy renovation?"

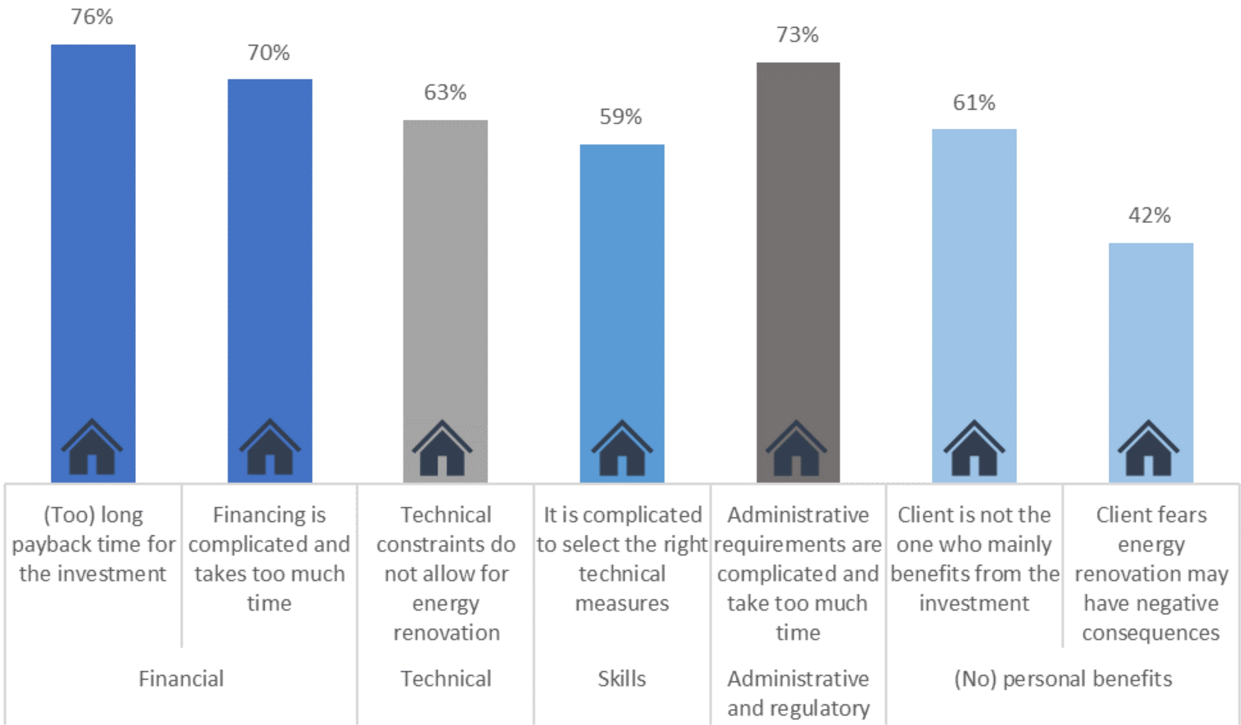


Clients of main contractors[53]

In comparison to architects, main contractors report very similar proportions of prevalence of barriers, except for personal benefits for which they see significantly lower barriers (approx. minus 10%) on the side of their clients (Figure 37).

Figure 37 : Barriers for clients of main installers

53 Question to architects: "How important do you think the following aspects were as a barrier for your non-residential/residential single-family house/residential multi-family house clients to perform energy renovation?"

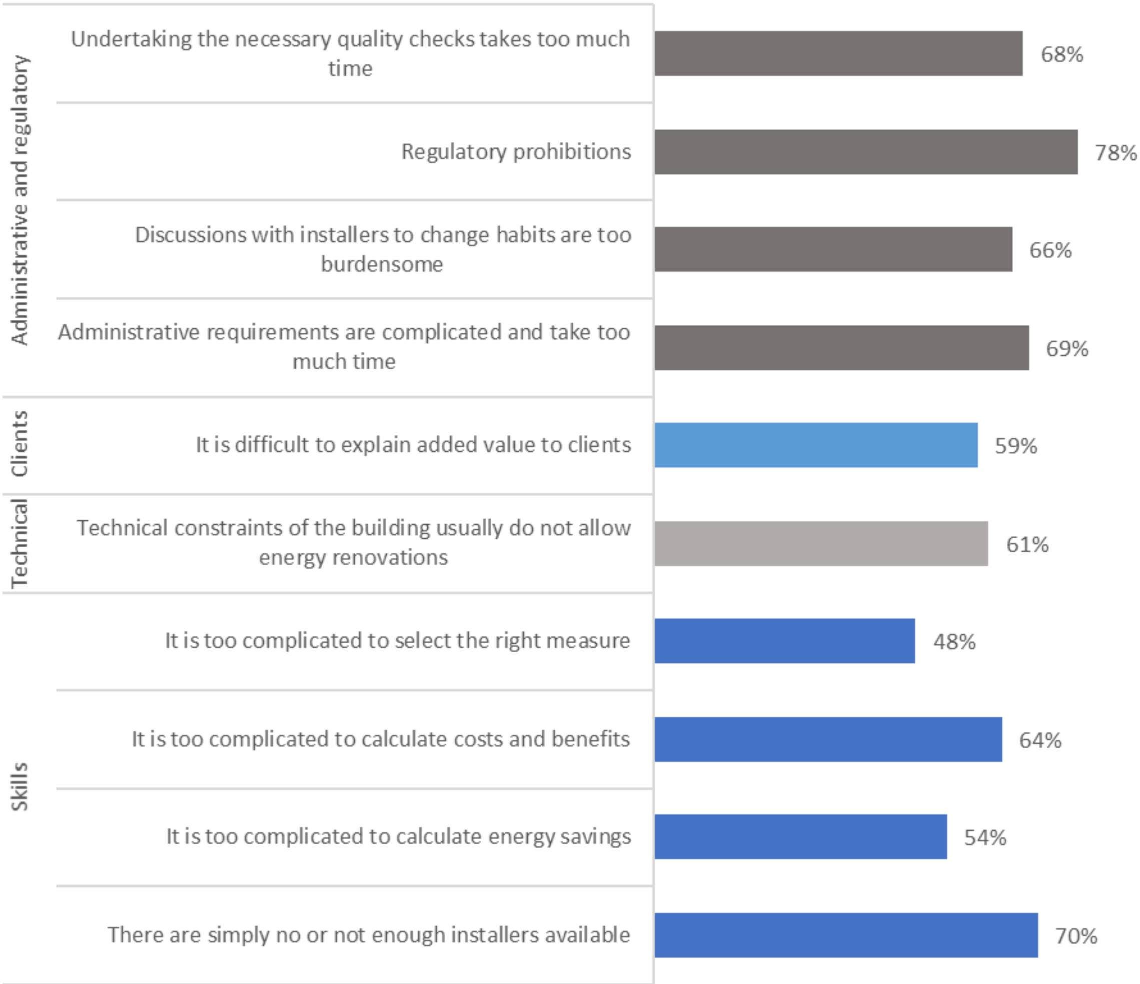


Architects[54]

Beyond the experiences of their customers, architects themselves report high barriers. They have frequently encountered **administrative and regulatory barriers** to recommend energy renovation to clients. For the vast majority, it has also been **difficult to explain the benefits to clients**. The unavailability of installers poses another barrier (Figure 38).

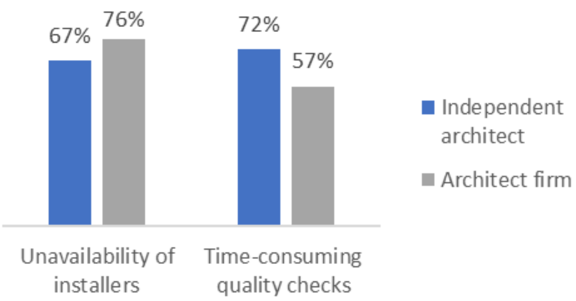
Figure 38 : Barriers for architects

54 Question to architects, main contractors and installers: "How important are the following aspects as a barrier for you to recommend energy renovations?"



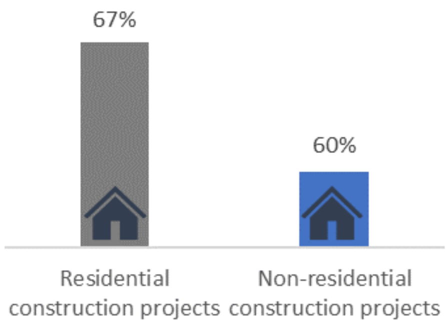
Architect firms more often **struggle to find installers.** Necessary quality checks restrain in particular independent architects to recommend energy renovation.

Figure 39 : Barriers – differences by architect type



Architects state that it is more **complicated to calculate costs and benefits of energy renovation** for residential than non-residential construction projects.

Figure 40 : Complexity of calculating costs and benefits by type of construction project



Main contractors and installers[55]

Main contractors and installers report several barriers. **Client-related aspects pose the highest barriers to recommend energy renovation** (Figure 41). Barriers are more often experienced by installers compared to main contractors, though the differences are small. Interestingly, negative consequences are of least concern for airconditioning/phovoltaic works (47%).

Figure 41 : Barriers for main contractors and installers

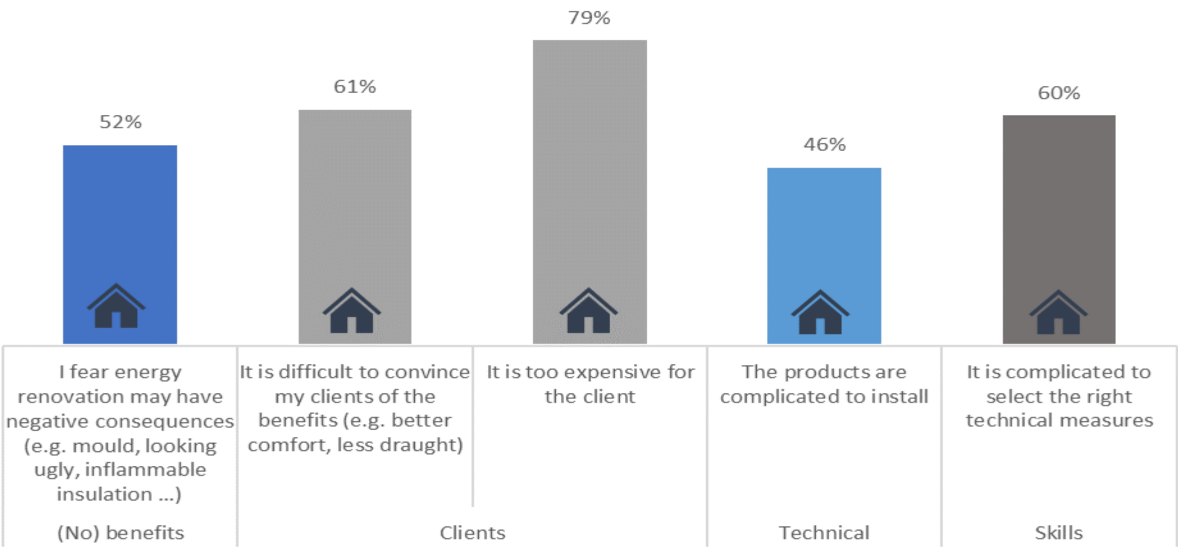


Table 17: Summary box - barriers

- Structural barriers are most prevalent among all groups. Unawareness of benefits provides another high barrier.
- **Financial** (taking out a loan or mortgage, general costs of renovations), **technical** (constraints, skills) and **administrative/regulatory** (requirements) **barriers** are prevalent among *consumers* and *clients* of building experts. However, the high percentage of those not seeing a personal benefit of energy renovations is also noteworthy.
- *Architects* see **regulatory prohibitions/requirements** and **unavailability of installers** as main barriers.
- *Main contractors and installers* see **client-related aspects** (high cost and convincing clients of benefits) as strongest obstacle.

55 Question to architects, main contractors and installers: "How important are the following aspects as a barrier for you to recommend energy renovations?"

4.3.4. Incentives

Incentives have two objectives: Foster favourable motivations or weaken unfavourable motivations to overcome barriers. For example, incentives can be of financial, regulatory or informational nature. Incentives covered in this study logically correspond to the before mentioned barriers. This section explores the incentives for those who have performed energy renovations, either as consumers or building professionals.

In their recommendations on building renovation from 2019[56], the European Commission specifies incentives to use smart technologies and skills, such as education in the construction and energy efficiency sectors – which is covered in this analysis.

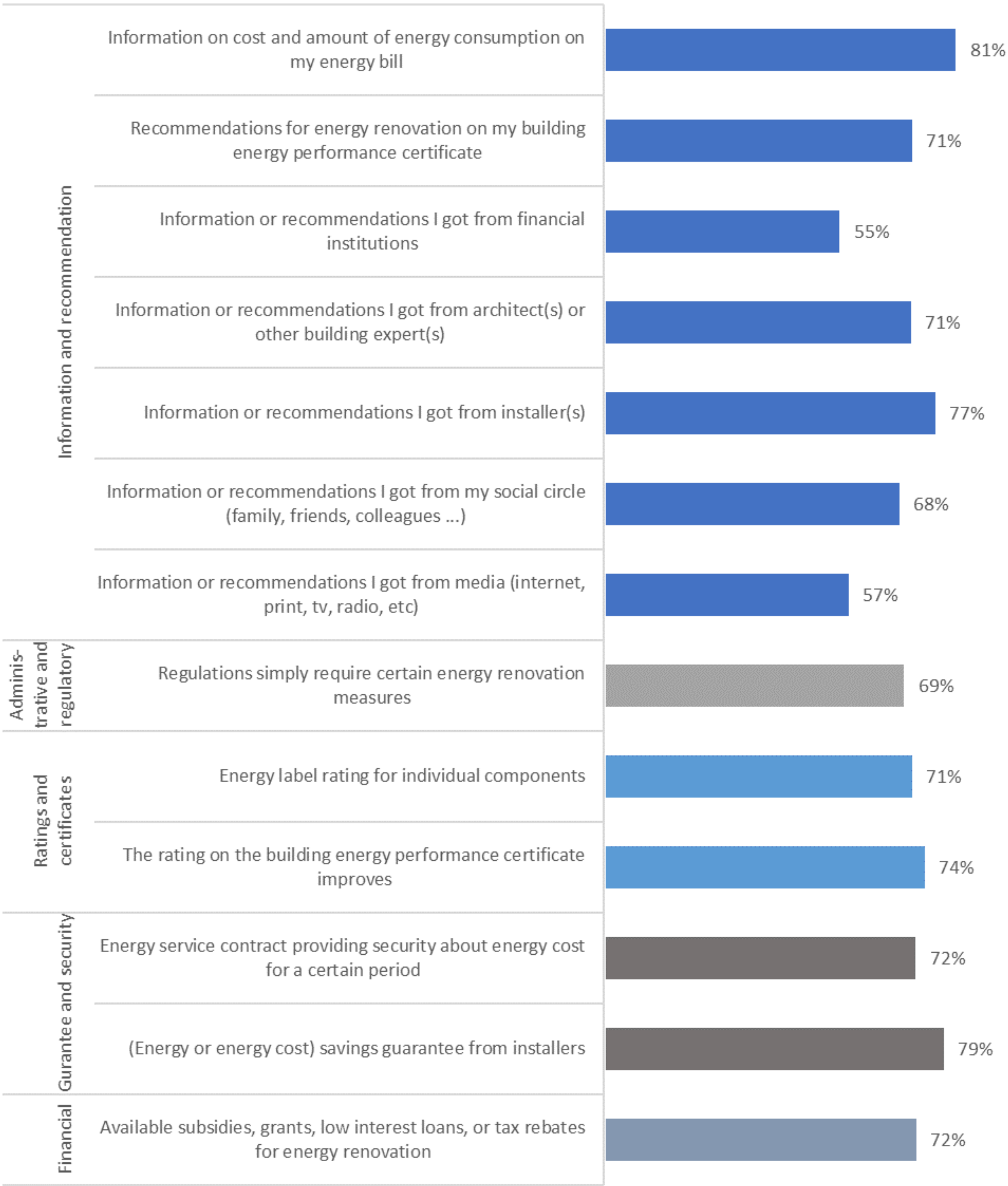
Consumers[57]

Incentives have a high importance for consumers. **Information on cost and amount of energy consumption on the energy bill** is the strongest incentive to invest in energy renovation. Similarly **encouraging are recommendations from installers** (interestingly, the survey findings suggest that this is a relatively weak *trigger, which also suggests that installers are involved when a renovation decision has already been made)*. **Guarantees, ratings and certificates likewise function as central incentives** (Figure 42). The importance of some factors as incentives but less as triggers suggests the unavailability or unawareness of these factors to function as trigger.

Figure 42 : Incentives for consumers

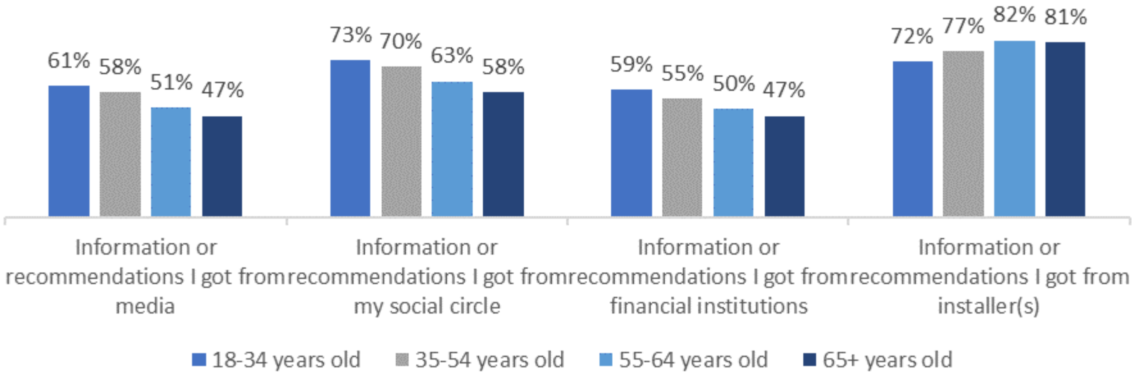
56 Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019H0786

57 Question to consumers: "How important were the following aspects to help you overcome barriers for your energy renovations/installations?"



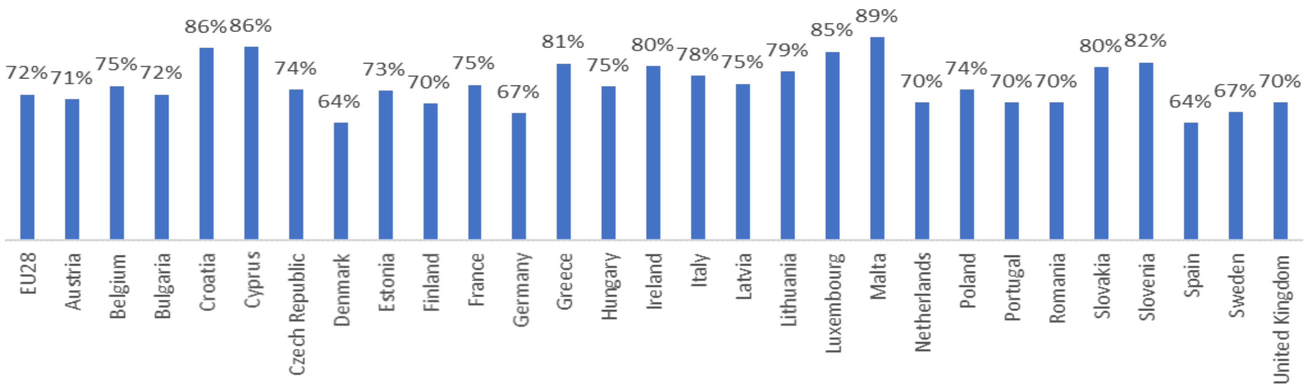
Information from media, the social circle and financial institutions is more encouraging for younger consumers to perform energy renovations. The same applies to consumers with a lower income, though the differences in the income category are smaller. Older cohorts see recommendations from installers as stronger incentive. For older tenants, administrative and regulatory aspects are more incentivising than for younger tenants (Figure 43).

Figure 43 : Incentives – age differences



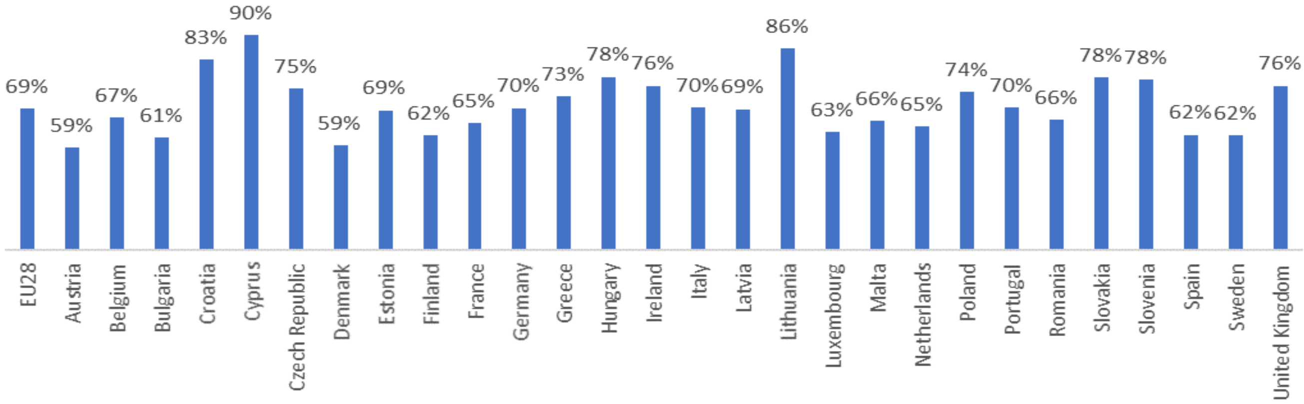
Favourable financing options are relevant incentives in all EU28 countries, with Croatia, Cyprus and Malta standing out in particular (Figure 44).

Figure 44 : Available subsidies, grants, low interest loans, or tax rebates for energy renovation by country



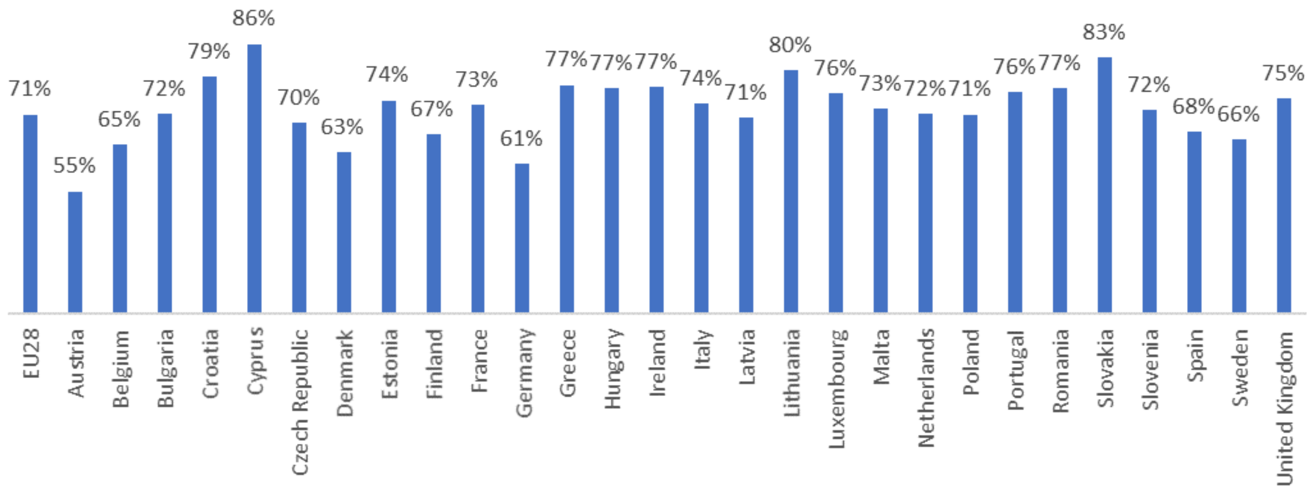
Regulations are most incentivising in Eastern Europe. Consumers in Croatia, Cyprus and Lithuania are most encouraged by regulations to invest energy renovation (Figure 45).

Figure 45 : Regulations simply require certain energy renovation measures by country



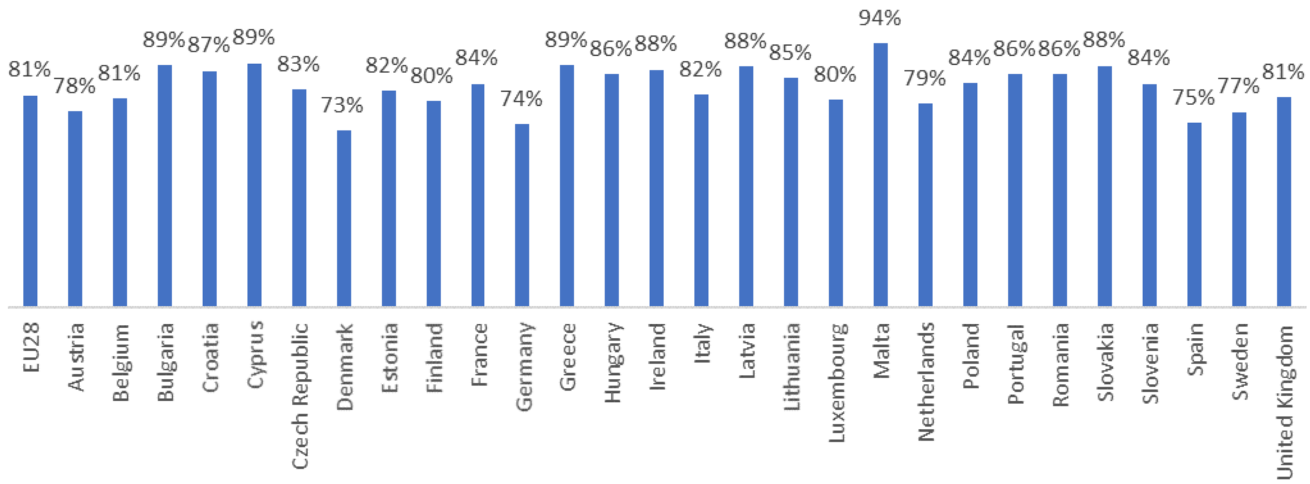
In Eastern and Southern Europe, **recommendations on the EPC are particularly incentivising**, with Cyprus, Lithuania and Slovakia at the top. In Austria, Denmark and Germany, information on the EPC are less encouraging, but the majority still views it as incentive (Figure 46).

Figure 46 : Recommendations for energy renovation on the EPC of my building by country



Information on the energy bill is a main incentive in all EU28 countries, and specifically in Eastern Europe. Almost all consumers in Malta view it as encouraging (Figure 47).

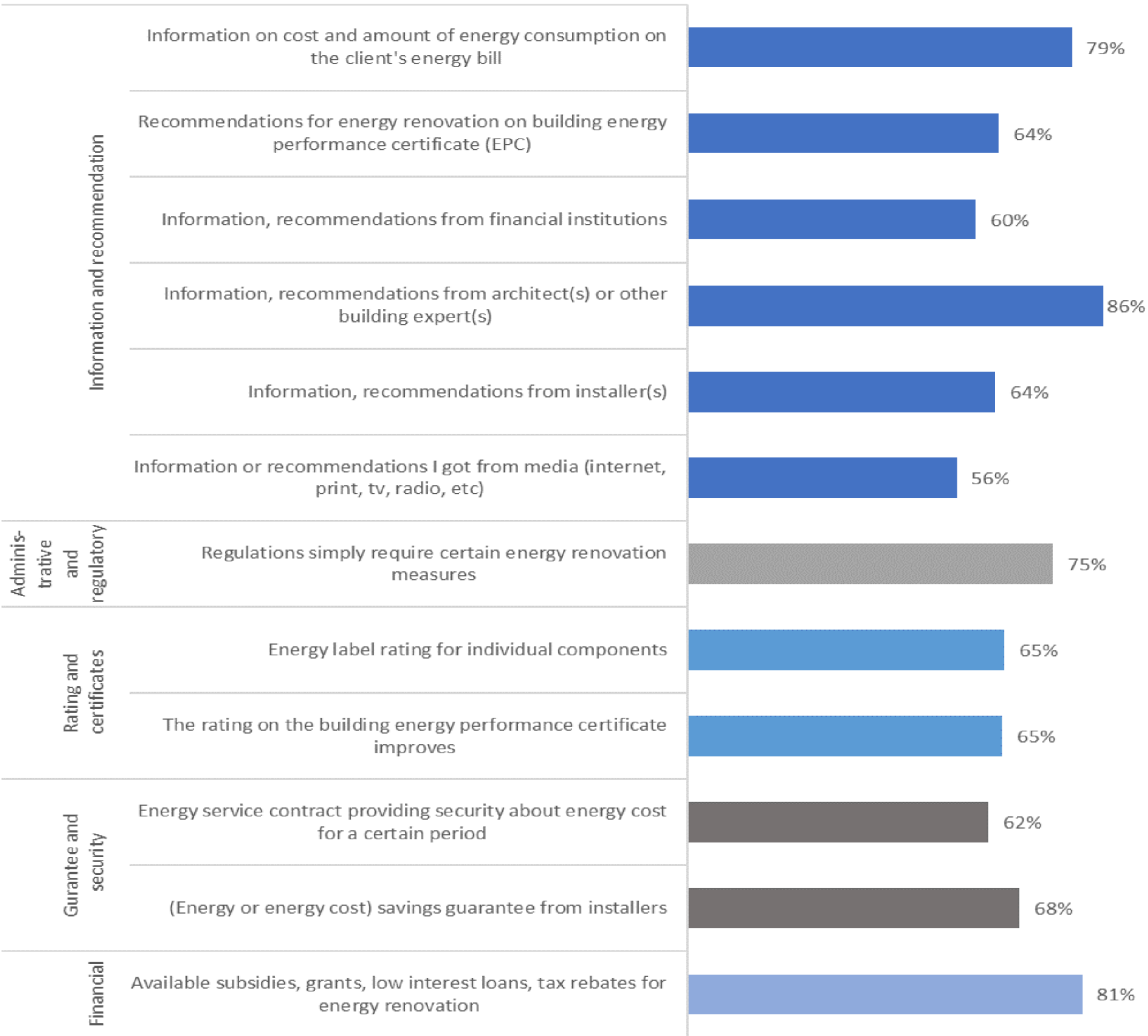
Figure 47 : Information on the energy bill by country



Clients of architects[58]

Architects highlight favourable financial and administrative options as incentives for clients to invest in energy renovation. In line with consumers, they also emphasise information on the energy bill. Interestingly, they see recommendations of themselves or other building experts as more encouraging than consumers reported (86% vs 71%), which may stem from consumers having little contact with architects (Figure 48). Compared to incentives reported by consumers, this means that architects may specifically underestimate the influence of installers' savings guarantees and recommendations; for all other criteria, architects' view on customers' incentives is very similar to those consumers report.

Figure 48 : Incentives for clients of architects

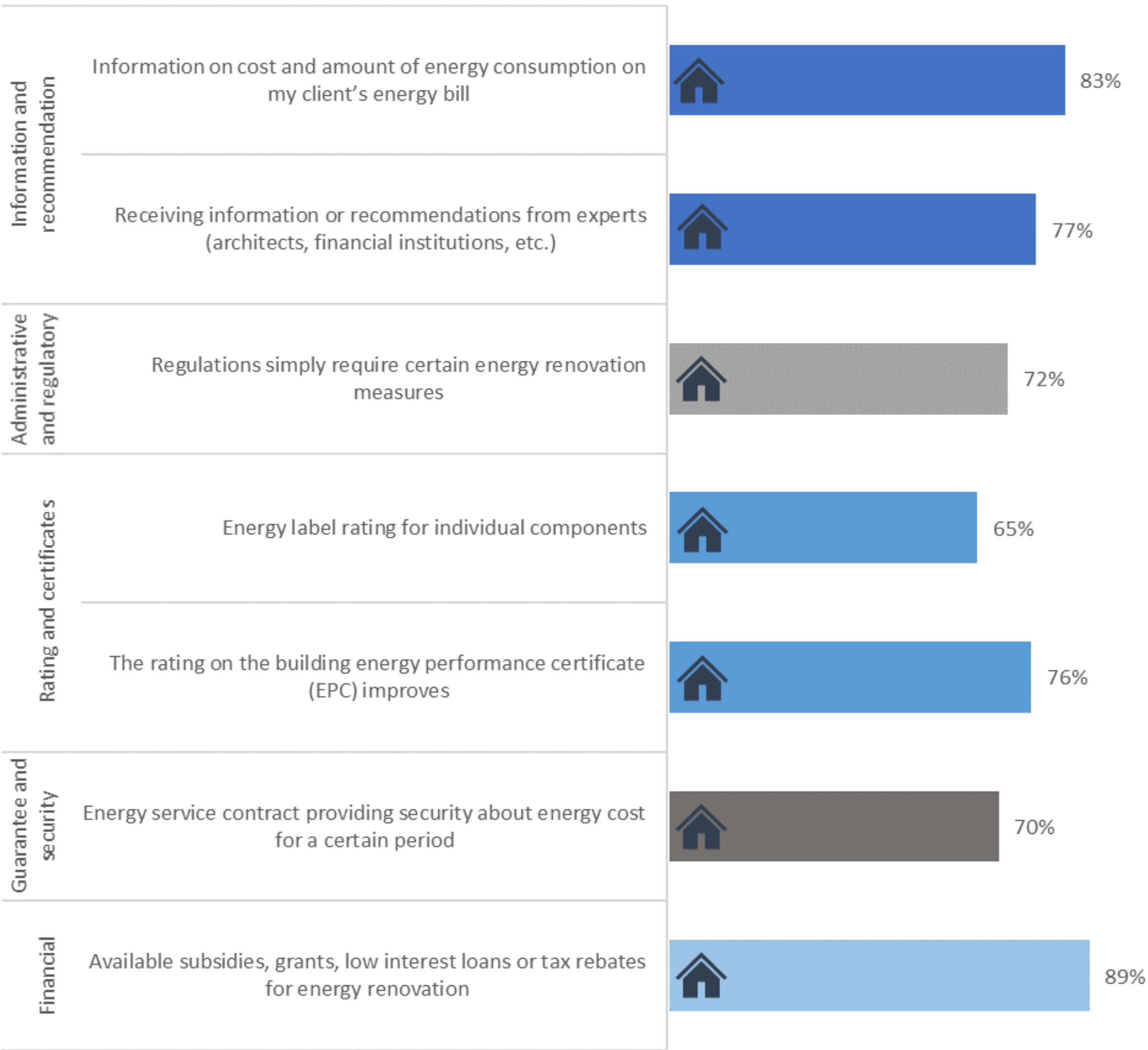


58 Question to architects and main contractors: "How important were the following aspects to help your [non-residential/residential single-family house/residential multi-family house] clients overcome the barriers to perform energy renovation?"

Clients of main contractors[59]

Likewise, contractors' view on their clients' incentives reflects well what consumers report. However, they attribute considerably more weight (even higher than architects do) to **financial incentives** than consumers do for themselves. From a regulation point of view, it is encouraging that similar to consumers and architects, main contractors report **information on the energy bill as a central incentive** (Figure 49).

Figure 49 : Incentives for clients of main contractors

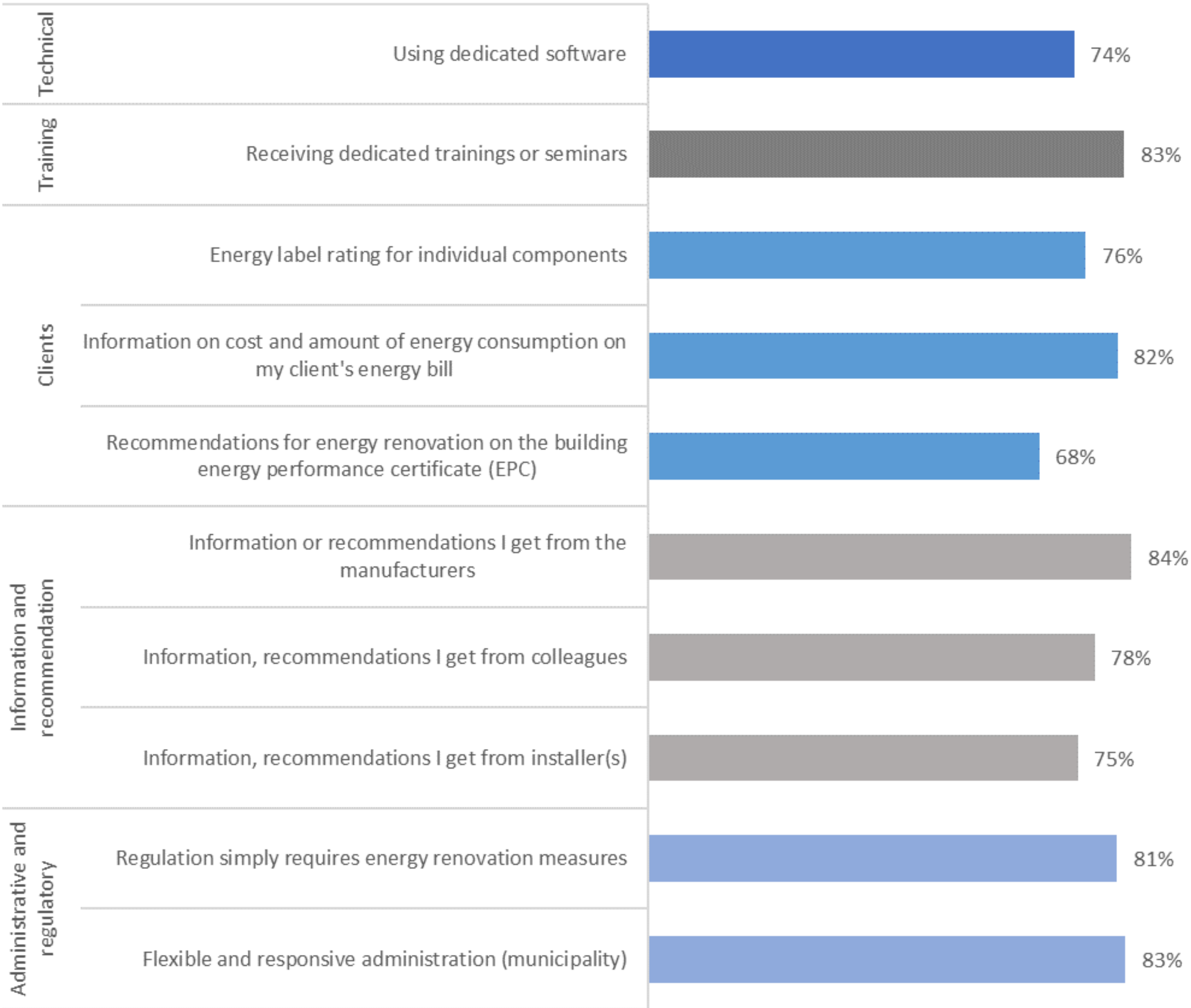


59 Question to architects and main contractors: "How important were the following aspects to help your [non-residential/residential single-family house/residential multi-family house] clients overcome the barriers to perform energy renovation?"

Architects[60]

Different aspects are helpful for architects to overcome barriers and recommend energy renovation to clients. Most noteworthy, **supportive administrative and regulatory conditions, as well as training or seminars**. **Information or recommendation from manufacturers is also of importance** (Figure 50). According to architects, flexible and responsive administration at municipality level is particularly encouraging for non-residential construction projects (87% vs 81% for residential projects).[61] From the point of view of regulation, it is a pity that recommendations on the EPC rank last.

Figure 50 : Incentives for architects



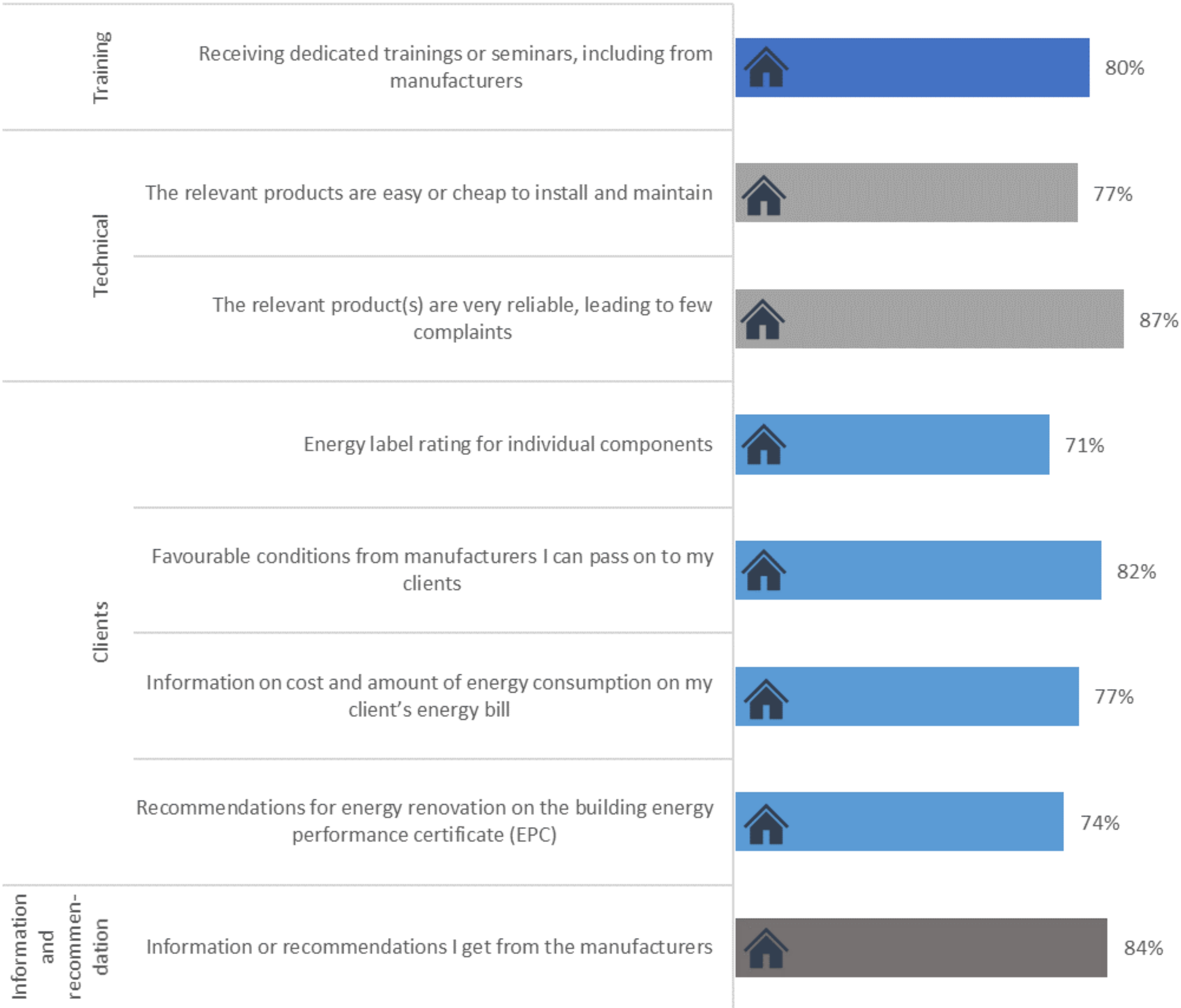
60 Question to architects, main contractors and installers: "How important are the following aspects to help you to overcome barriers to recommend energy renovations?"

61 More architects stated that flexible and responsive administration is "very important" compared to "rather important"

Main contractors and installers[62]

In line with architects, main contractors and installers also underline **recommendations from manufacturers and training as strong incentives**. It becomes clear that this group very much appreciates hassle free-components (installation and after care) and relations with manufacturers (Figure 51).[63]

Figure 51 : Incentives for main contractors and installers



Across the EU28, the different incentives are viewed as helpful to overcome barriers to recommend energy renovation. Eastern and Southern Europe have, again, particularly high proportions of building experts reporting the incentives (Figure 52).

62 Question to architects, main contractors and installers: "How important are the following aspects to help you to overcome barriers to recommend energy renovations?"

63 More main contractors and installers stated that reliable products and trainings and seminars are "very important" compared to "rather important".

Figure 52 : Incentives – differences by region

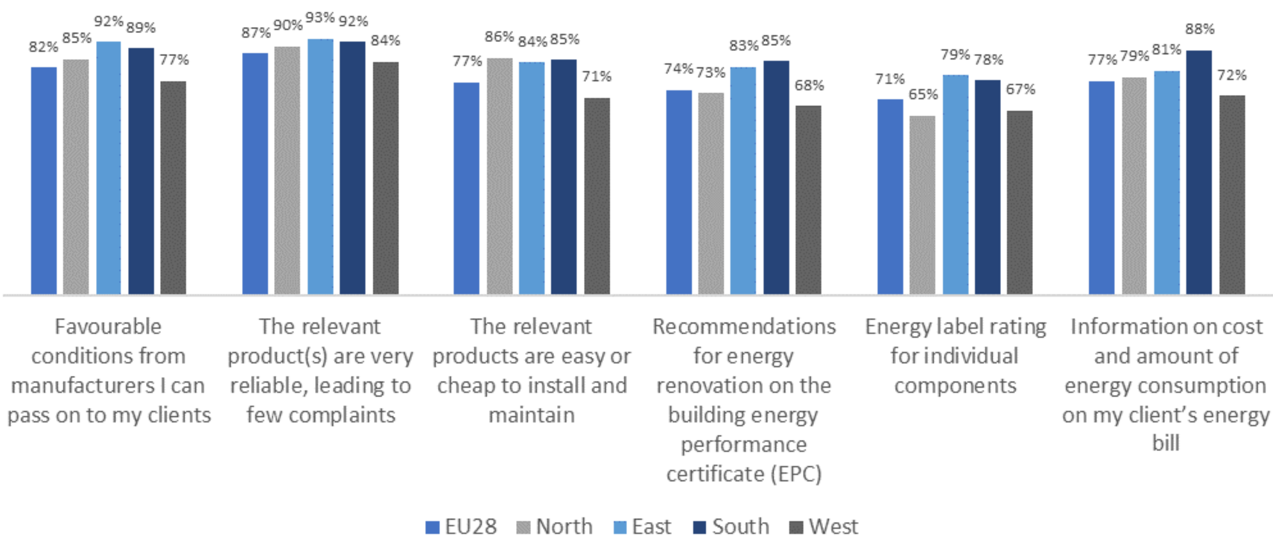


Table 18: Summary box - incentives

- Quality, favourable conditions, low administrative barriers and guarantees are important incentives, highlighting the central role of building experts and suppliers in overcoming barriers.
- Aspects related to **guaranteeing lower costs and less energy consumption** - in particular by **energy suppliers and building experts** – are strong incentives for *consumers*. **Favourable financing** options are also important. Building experts also highlight **requirements set out by regulations** as incentives for their *clients*.
- *Building experts* view **administrative/regulatory aspects, information, recommendations, favourable** conditions from other building experts and manufacturers, as well as **training** as strong incentives. **High quality of products** is also very relevant.

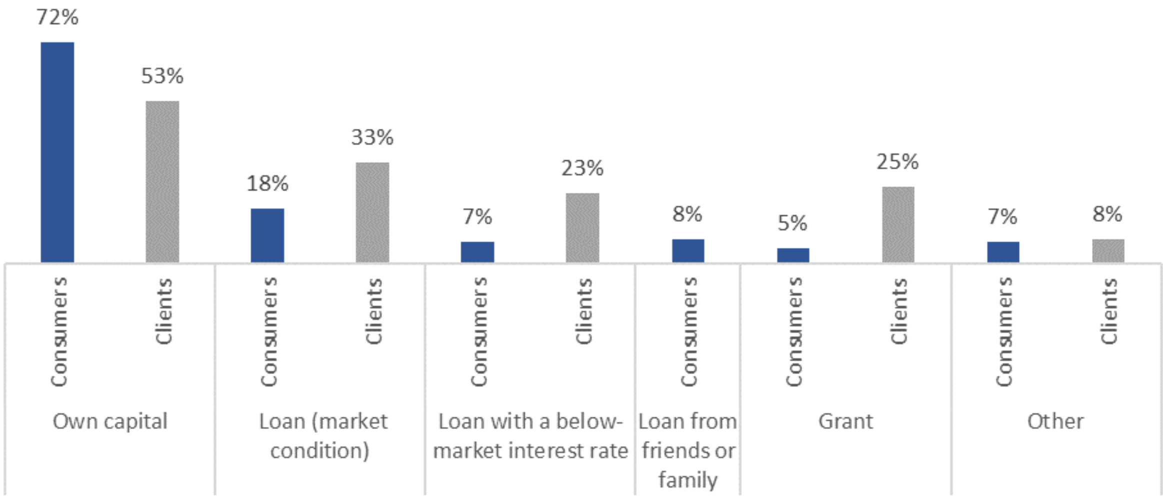
4.3.5. Funding sources

The vast majority of consumers[64] have used their own capital to finance renovation works, suggesting that consumers undertake energy renovations when they have sufficient capital. Some respondents took out a loan at market condition, and only a handful used a loan with a below-market interest rate or from friends/family (Figure 53). **The most popular financing option is a combination of own capital and a loan at market condition**. The second most prevalent combination is own capital with a loan from friends or family. Overall, 29% of consumers indicated having used two funding sources.

64 Question: "How was this financed? In case of multiple renovations, please consider the most expensive renovation. You can tick maximum 3 options (focus on the most important options)."

In comparison to consumers (i.e. residential buildings), non-residential renovation work is less frequently financed by own capital, as indicated by architects for their clients. Loans and grants are more often used than among consumers. One-third of non-residential renovation work is (partly) financed by a loan at market condition, and one-fourth by a loan with a below-market interest rate or a grant (Figure 53).

Figure 53: Funding sources of consumers and commercial/public clients of architects



Owners finance energy renovation with their own capital more often than tenants or landlords. Landlords, on the other hand, more frequently use a loan with a below interest rate or a loan from family or friends than owners do. A higher proportion of older consumers finance their energy renovations with their own capital compared to younger cohorts. The younger population group uses loans more often than older consumers. There is also a difference in terms of income level. Consumers with a higher income make stronger use of their own capital. Those with lower income more frequently use a loan or grant than high-income earners. This result is in line with results presented in Figure 32 and Figure 44.

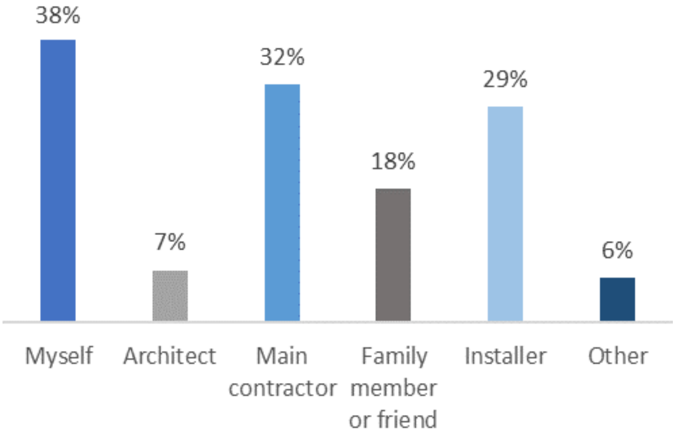
In general, there is a **significantly negative attitude towards loans**, the older the cohort the stronger. This clearly explains the high shares of own capital used for financing energy renovation measures and its increase with increasing age of respondents. On the other hand "grants, loans etc." are mentioned to be a very strong incentive to overcome financial barriers. As grants and loans have been put into the same question, it can be assumed that people prefer grants over loans.

4.3.6. Quality assurance

The consumer survey provides interesting insights into who is seen to be responsible or is assigned for the quality of energy renovation works.[65] Consumers themselves or main contractors and installers are most often perceived as responsible. However, the responsibility assignment depends of course on who carried out the work because this person is seen as responsible for assuring quality.

65 Question: "Who was responsible for the quality of these energy renovation/installation works? In case of multiple renovations, please consider the most expensive renovation. You can tick multiple answers."

Figure 54: Responsible for quality assurance



Yet, there are differences between tenants, owners and landlords. For tenants there is a rather equal distribution between themselves, main contractors and installers. Owners have a clear emphasis on being responsible themselves (more than 40%), while landlords have the highest share for architects (around 12%) and main contractors (around 37%).

For younger consumers, and particularly those between 34 to 54 years old, each actor involved in the energy renovation works (themselves, architects, contractors, etc.) has a stronger responsibility to ensure the quality of the works. Older consumers attribute less responsibility to each person or professional group.

There are variations across countries in terms of perceived responsibility for the quality of renovations works. Differences can also be observed for different groups; results for owners are presented below (Figure 52).

Figure 55: Proportion of owners reporting to be personally responsible for the quality of renovation works by country

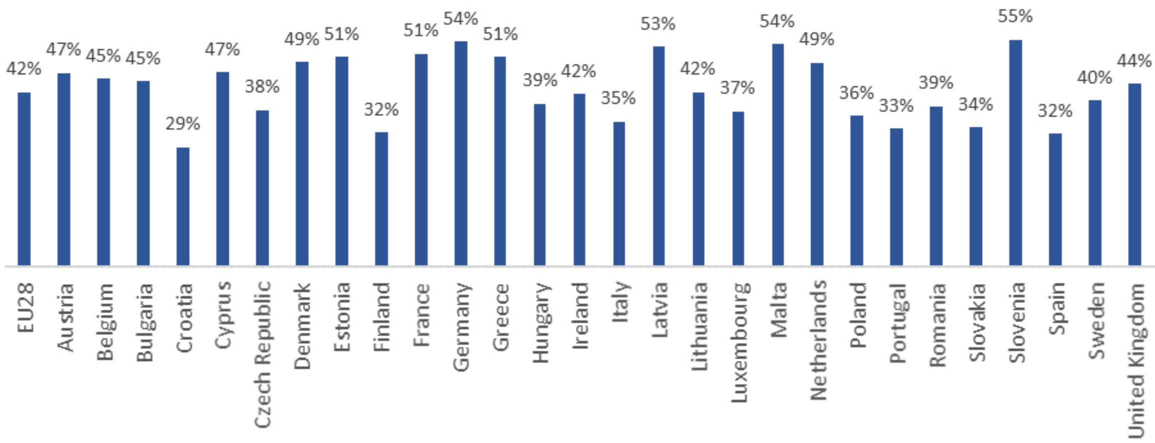


Figure 56: Proportion of owners reporting architects to be responsible for the quality of renovation works by country

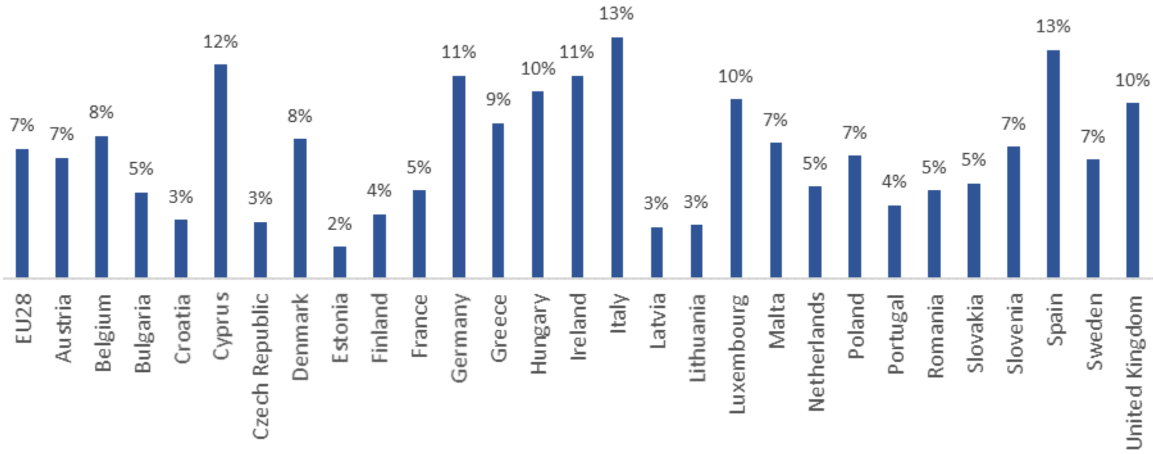


Figure 57: Proportion of owners reporting main contractors to be responsible for the quality of renovation works by country

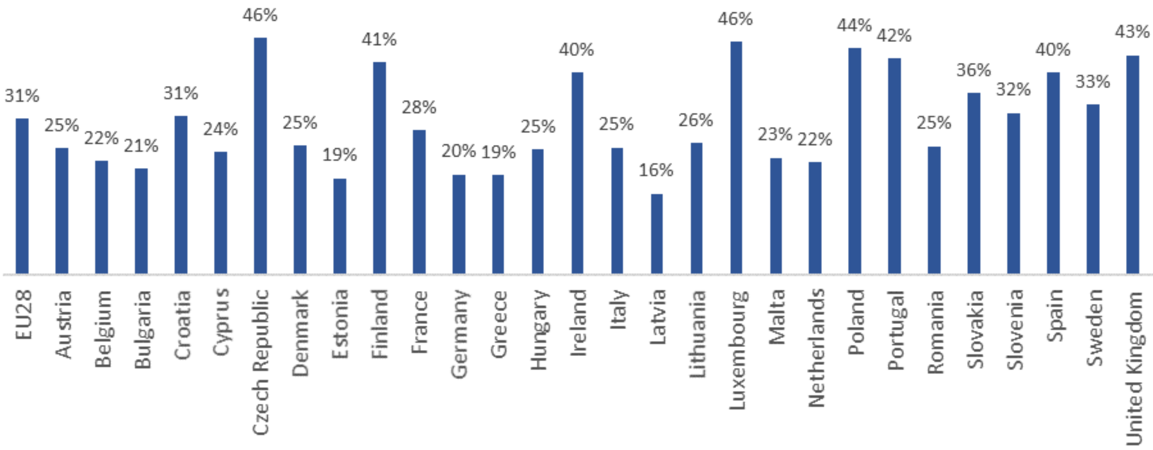
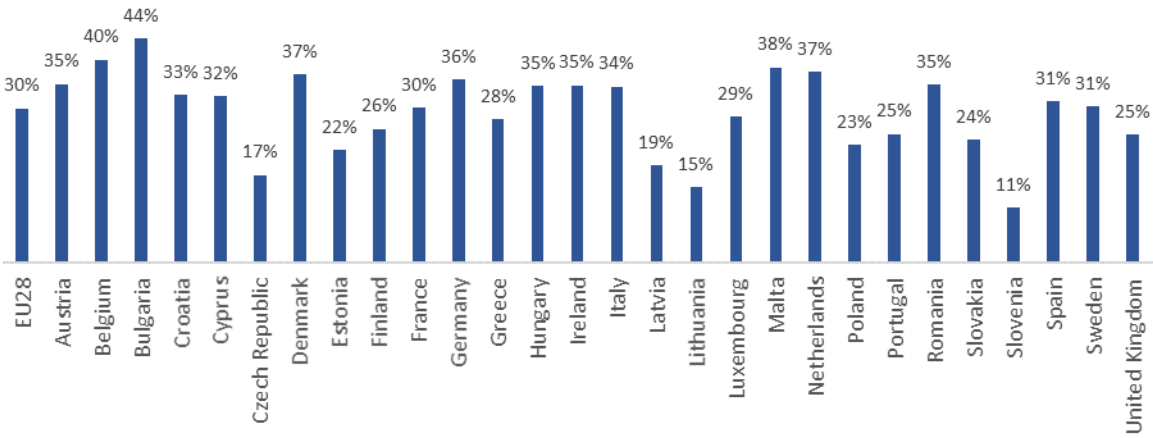


Figure 58: Proportion of owners reporting installers to be responsible for the quality of renovation works by country



Some other results related to quality:

- From the literature it is known that "construction team" approaches have a positive impact on quality. Yet, there is strong mistrust among consumers but also commercial investors towards installers (cf. Figure 31 and Figure 38, Figure 41), which certainly explains the high share of laymen taking responsibility for quality controls.
- Another reason for concern with regards to quality is that a clear majority of independent architects feel that quality checks take too much time (Figure 39).
- Finally, the perception of about half installers across Europe that energy efficiency measures are too complicated to install, certainly also hampers quality.

4.3.7. Observed impact of selected policy instruments

As mentioned above, all energy renovation measures are the consequence of investors' decisions. Each decision is the result of one or several **determinants such as motivations/drivers, triggering events, barriers or incentives**. These determinants can be influenced by policy instruments in form of regulations, (financial) incentives and information (including education).

The above analysis of triggers, drivers, barriers and incentives included several elements from EU Directives, aiming to stimulate investments in energy renovation, namely

⇨ Energy Performance Certificates (EPC)

⇨ Energy audits/inspections

⇨ information on energy bills

⇨ Energy labels

In the following, insights on these instruments are summarised.

Energy performance certificates

The results of the surveys revealed different magnitudes of impact of EPCs depending on the stage in the decision process, type of decision maker and country.

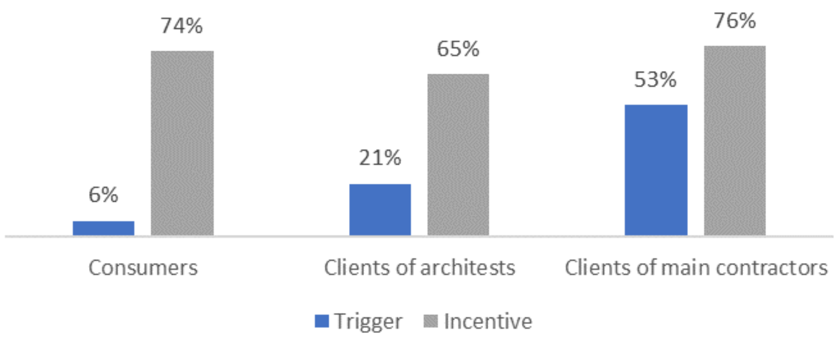
The first stage in the decision process is to be *triggered* to do an energy renovation *at all*. For consumers who are owners or tenants of their dwelling, EPCs only have a modest trigger function compared to e.g. maintenance and repair, available budget, shortcomings that cause poor health, recommendations of installers or information from the energy bill (see Figure 18). Yet the triggering impact increases for groups having a commercial interest. For landlords of residential dwellings, a slight increase can be observed across the EU, although there are significant differences between countries. About 20% or more landlords in Croatia, Denmark, Ireland and Slovakia report EPCs as having been a trigger for energy renovation, while e.g. in Belgium not even 3% mention this aspect.

The triggering impact of EPCs for stakeholders with commercial interest gets significantly more pronounced when looking at what architects (Figure 23) but especially main contractors (Figure 24) report on their clients. These clients include a significant share of commercial clients owning and/or operating non-residential or residential buildings. EPCs impact further increases within the subsequent decision stage, i.e. when the decision to renovate at all has been taken (see Figure 42). This is when *recommendations* on the EPC get relevant to overcome the wide-spread uncertainty about which measures to take (Figure 46) and where the rating itself motivates to *improve* (Figure 42).

Results hint at architects underestimating the importance of EPCs for their clients. Architects assume less importance of the recommendations on the EPC for their clients as an incentive (Figure 50) than consumers do for themselves (Figure 42) and main contractors assume for their clients (Figure 49).

This asks for more promotion of EPCs amongst architects as an incentive to do more and deeper measures, especially since the view of main contractors and installers is more positive towards these items (Figure 49, Figure 51).

Figure 59: EPC rating as trigger and incentive



Energy audits/inspections

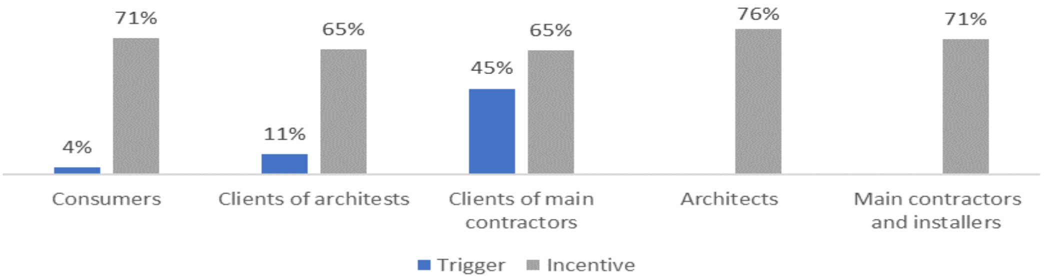
Necessary maintenance and inspection is the strongest trigger of consumers to undertake energy renovations (Figure 18). Therefore, information on potential energy renovation measures should be closely linked to these inspections. In this context, it might be surprising that architects see energy audits or inspections of heating or airconditioning systems as only a moderate trigger for their clients e.g. compared to repairs, which score highest (Figure 23). The picture changes when asking main contractors and installers about their clients – here energy audits score much higher (Figure 24).

A reason might be that compared to main contractors and installers, architects deal less with technical building systems, which are typically the subject of audits and inspections. This again highlights the need for promoting different instruments differently amongst diverse potential multiplicators for energy efficiency measures on the supply side. However, compared to EPCs, inspections appear to have more influence on triggering energy renovation than on subsequent phases.

Energy labels

Main contractors report energy labels on components playing a perceptible role in triggering energy renovations (Figure 18, Figure 21, Figure 23, Figure 24) for their clients, while this impact is much less pronounced as self-reported by consumers and reported by architects for their clients (Figure 60). They gain importance when it comes to finding the right product, both from the point of view of consumers themselves and from suppliers' reports on their clients (Figure 42, Figure 48, Figure 49). The highest impact, however, energy labels seem to have to support recommendations of architects and main contractors/installers (Figure 50, Figure 51), although they do not rank amongst the top incentives that help these groups to provide recommendations.

Figure 60: Energy label rating for individual components as trigger and incentive



Information on energy bills

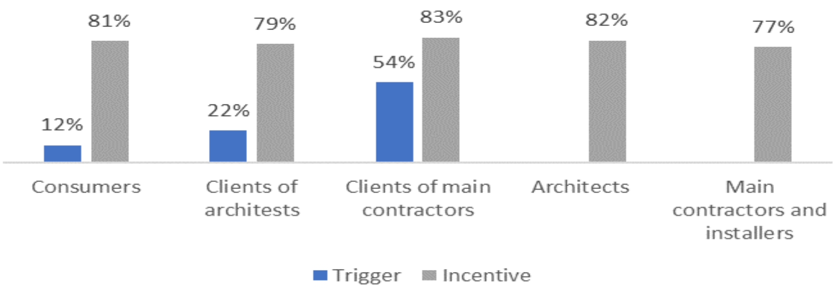
Amongst consumers, information provided on energy bills has a strong impact on *triggering* energy renovation, stronger than EPCs (Figure 18) or energy labels. This is different for clients of architects (Figure 23) and main contractors/installers (Figure 24) for whom the impact is equally strong, although on quite different levels.

A much higher impact can be observed when it comes to *overcoming barriers* for energy renovation, i.e. for the information on energy bills serving as an incentive, which can be observed across all EU countries (see e.g. Figure 42, Figure 47, Figure 48, Figure 49). In this context, **information on the energy bills is amongst the top incentives**. The information also helps architects and main contractors/installers in their argumentation in favour of energy renovation (Figure 50, Figure 51). This also fits with the very high relevance all groups assign to financial energy savings as a driver for energy renovation.

It leads to the conclusion that many energy renovators only start looking closer at their energy bills and the impact an energy renovation could have, when already having taken an unspecified decision to renovate.

Last but not least, the existence of "regulations that simply require energy renovation measures" receives quite different weights amongst consumers as an incentive (Figure 45), while it is seen as very helpful support to recommend energy renovations by architects (Figure 48, Figure 51).

Figure 61: Information on the (client's) energy bill as trigger and incentive



5. Conclusion

Conclusions of the analyses and results of this study are presented per area:

- renovation
- uptake of nearly zero-energy buildings (NZEB)
- determinants for performing energy renovations.

Renovation

This study contributes to the discussion about renovation rates and depths in the EU28 building stock. The information provided in this study through the development of three different surveys intends to support policy makers and relevant stakeholders to understand the impact of policy measures and about the distance that needs to be bridged to get on track towards a decarbonised building stock by 2050.

The determination of renovation rates and depths requires a clear common understanding of what renovation "rate" and "depth" mean. For this reason, the study proposes and applies clear definitions for different renovation depths (also in line with the definitions applied in the EU Building Stock Observatory), relating them to annually achieved primary energy savings:

- Below threshold ($x < 3\%$ savings)[66]
- Light renovations ($3\% \leq x \leq 30\%$ savings)
- Medium renovations ($30\% < x \leq 60\%$ savings)
- Deep renovations ($x > 60\%$ savings)

It is strongly recommended that these or similar - but uniform - definitions should be applied throughout Europe for the sake of speaking a common language.

Approximately 12% of residential floor area or 9.5% of non-residential floor area is estimated to be affected each year by an energy renovation according to one of above mentioned four categories. Out of this approximately 7% are below threshold renovations in residential buildings and 4% in non-residential buildings. Light and medium renovations together affect approximately 5% of both the residential and non-residential floor area[67], while the annual rate of "one-off" *deep* renovations is only around 0.2% - 0.3% in the EU28. Thus, in practice, deep renovations only occur sporadically while step-by-step renovations dominate by far. This is also reflected in significantly and increasingly higher rates of medium, light and "below threshold" renovations. In reality, therefore, a climate neutral level of the building stock cannot be achieved only by deep renovations, but by a series of light and medium renovations.

66 It was decided to include this minimum threshold in order to avoid misleadingly large numbers of light renovations and separate out and highlight those renovations, where significant lost-opportunities have been created as for improving the energy performance.

67 For residential buildings 3.9% accounts for light renovations and 1.1% for medium; For non-residential buildings the rates are 3.0% and 2.1% relatively.

According to these results an average renovation[68] saves about 9% (14 kWh/(m².y)) annual primary energy consumption in residential buildings and about 17% (47 kWh/(m².y)) in non-residential buildings. The corresponding relative annual GHG reduction is 9% in residential buildings and 18% in non-residential buildings, i.e. close to the numbers for primary energy.

The relatively low average saving achieved again highlights the above mentioned finding that a typical energy renovation is characterised by only one or few measures that yield comparatively little savings.

Split up by renovation depths, an average light or medium renovations save 13% or 41% of annual primary energy consumption in residential buildings and 16% or 44% in non-residential buildings (comparing the performance of the building before and after renovation). An average deep renovation achieves approximately 66% primary energy savings in both residential and non-residential buildings.[69]

The question arises how the determined rates for different renovation depths translate into the speed at which the building stock approaches a decarbonised level. An appropriate measure to answer this question is the annual reduction of the total building stock's primary energy consumption through energy renovation. This rate, the weighted energy renovation rate, was determined to be around 1% for both residential and non-residential buildings, which is in line with other estimations of the European Commission (0.4-1.2% depending on the Member State.[70]

If this rate of 1% persists, the building sector will clearly and significantly fail to deliver its share in the overall need for primary energy reduction and consequently a reduction in greenhouse gas emissions. A very significant uptake of the renovation rate is urgently needed to meet long-term primary energy and greenhouse gas emissions targets, as e.g. set out in the European Commission's communication "A Clean planet for all".[71]

A tripling to 3% primary energy savings per year would need to be achieved by a combined uptake of renovation rate (floor area) and average renovation depth, i.e. average achieved primary energy savings per renovation.[72] Currently light and medium renovations account for 80%-90% of total annual primary energy savings in the building stock. These categories can be expected to continue dominating the renovation market in terms of achieved savings. Therefore, the focus of incentives, removing barriers and funding should be on

- increasing the rate of currently together 5% (in terms of floor area) of these two renovation depths e.g. towards 7-8%,

68 Average for the assessed period 2012-2016 , including all four renovation depths mentioned above.

69 „Below threshold" renovations yield negligible savings of on average less than 1%.

70 Within EU28 total annual primary energy savings amount to an average of approximately 3 Mtoe per year in the period 2012-2016 in residential buildings and approximately 2.6 Mtoe per year in non-residential buildings. Corresponding average reduced greenhouse gas emissions are approximately 11 MtCO2eq per year for both residential and non-residential buildings.

71 COM(2018) 773 final.

72 Note that primary energy can be saved by on-site or „off-site" renovations or improvements, where off-site improvements could be a decreasing primary energy factor of e.g. power, gas or district heat supply. This aspect will gain importance in the future due to rising electricfication of and currently still low renewable energy share within heat supply.

- managing a shift from light towards medium renovations, as their current rate is significantly lower than that of light renovations, e.g. resulting in average primary energy savings of light and medium renovations of 30%-40%, compared to less than 20% today,

- organising renovations towards a carbon neutral level as a *chain* of light and medium renovations (step-by-step renovations) where lost opportunities and lock-in effects are effectively avoided.

The latter item needs special care. The economic law of diminishing marginal utility leads to picking the "low-hanging fruits" first. For this reason, light and medium renovations having most favourable cost-benefit ratios will typically come first. Subsequent light or medium renovations within the same renovation package will typically appear less favourable when being treated as stand-alone measures. Therefore, policy and market conditions need to ensure that investing in packages of energy efficiency renovations is attractive, too. This can be achieved by switching to a mind-set where deep renovation is not only considered as a one-off renovation, but also as a *package* consisting of a coordinated chain of medium and light energy renovations eventually leading to the same savings as a deep renovation being in line with a carbon neutral building stock. Whenever possible, cost-benefit analyses should be done for the whole *package* rather than for individual measures. Otherwise, measures at the end of the chain will be disincentivised and the already too slow renovation can be expected to even further slow down.

In the face of this reality, incentives for building renovation must put a strong focus on packages of step-by-step renovations and how to make them cost-effective without creating lock-in effects or lost-opportunities. This dynamic around individual building renovation should also be reflected in the Energy Performance Certificates (EPCs). Already today EPCs have a significant market impact specifically once the renovation decision has been made. To build on this strength EPCs could play a relevant role in incentivising a shift from light towards medium renovations that do not create lock-in effects. Thus, recommendations for "lock-in-proof" renovations are needed, which in several "medium" steps ideally will achieve a level, which is compatible with a carbon neutral building stock.

The risk of lock-in increases with high rates of "below threshold" and "light" renovations. Notably, some Eastern European countries show high renovation values, mainly driven by comparatively high numbers of "below threshold" and "light" renovations. Higher renovation rates in Eastern European countries have been confirmed by ACE's 2016 sector study[73]. These countries therefore have a great potential and could benefit from good practices and examples to significantly improve the energy performance of their buildings.

Complementary optional schemes such as renovation roadmaps or "building renovation passports" for individual buildings gain a very high relevance for coordinating this series of measures in a way that is cost-effective and avoids lock-in effects. Without such coordination, there is a significant risk to lose cost-effective savings potentials and waste financial resources on a large scale.

This study also revealed a high coincidence of energy renovation and non-energy renovation. Furthermore, a high proportion of respondents reported repairs, regular maintenance and inspections to be typical trigger points for energy renovation. These

73 The architectural professions in Europe 2016. A Sector Study by the Architect's Council of Europe (ACE), table 4-15

insights underline the necessity to interpret deep renovations as a journey with several milestones - rather than a "one-off" action - that needs to be coupled to regular maintenance, non-energy renovations and natural obsolescence of components. Integrating all those natural trigger points for energy renovation into individual building renovation roadmaps templates and getting this step-by-step reality more on the political agenda to adapt regulations, information and financial incentives accordingly is an urgent challenge that needs to be addressed.

Reality also includes do-it-yourself activities (DIY). The findings of the surveys suggest that these activities have a significant share in building renovation – and thus need coordination as well for the same reasons mentioned above: lock-in effects need to be avoided, with potential lack of quality of works – and thus missed potential savings - having increased importance in DIY. One-stop-shops also for DIY activities could be considered as support.

Deep renovations and cost-effective renovation towards NZEB levels which are achieved step-by-step are not covered by the abovementioned definitions of renovation depths. Step-by-step renovations, being a series of a set of e.g. light or medium renovations, may stretch over a couple of years or even decades. It is recommended to further develop the definitions and monitoring of renovation activities into this direction as it is expected to be the dominating reality of renovations towards decarbonisation of the buildings stock. National long-term renovation strategies in line with the Energy Performance of Buildings Directive appear to be the right place to address this challenge.

In spite of lagging behind the needed speed of renovation, this study estimated that current activities amount to annual investments of already more than 200 billion Euros for energy renovations and another 300 billion Euros for non-energy renovations in the residential sector in the EU28. Another 200 billion is invested in non-residential buildings. This highlights the significant impact building renovation already has within the European economy, and it highlights the interconnection of energy renovation with the even bigger market of non-energy renovation. It would see further significant growth if renovation activities moved towards a level that ensures a decarbonised building stock by 2050. If for example the current weighted energy renovation rate would triple from 1% to 3%, a corresponding tripling of needed investments in energy renovation to about 800 billion Euros could be expected. Evidently, this needs new and different funding schemes and financing instruments. This will also involve more private funding. For attracting private funding further de-risking of investments in energy renovation is needed.

Obviously, there is a strong link between investments in (energy) renovation and the workforce being active to execute the works. The average total number of fulltime employees in the construction sector involved in renovation (energy and non-energy) of residential buildings is estimated to be about 4.6 million per year for the period 2012-2016 and another 1.9 million for non-residential buildings. This also illustrates the additional workforce needed if the intensity of energy renovations (speed and depths) should increase significantly in the next few years. Depending on productivity increases resulting from higher production an additional workforce of 2 – 4 million fulltime employees in the construction sector could be expected due to a tripling of energy renovation efforts. Additional spill-over effects would be generated amongst manufacturers, i.e. more capacity and personnel would also be needed there.

The new energy policy framework that has been created with the "Clean Energy for all Europeans" package provides several opportunities to properly address the aforementioned issues. Instruments like the long-term renovation strategies or the

"Smart Finance for Smart Buildings"[74] initiative can provide the proper context for the transformation ahead.

Uptake of nearly zero-energy buildings (NZEB)

In the context of achieving a decarbonised building stock by 2050 new buildings also deserve utmost focus, as 20%-25% of 2050's building stock is still to be built. Mainly because a significant share of already existing buildings will be hard to transform to NZEB or close to NZEB standards. According to the European Commission's recommendation on nearly zero-energy buildings[75] the "NZEB level … cannot be … less stringent … than the 2021 cost-optimal level … The NZEB level of energy performance for new buildings will be determined by the best technology that is available and well introduced on the market at that time, financial aspects and legal and political considerations at national level." Based on this understanding and findings from the study[76] "Towards nearly zero-energy buildings" the recommendation includes benchmarks for NZEB energy performance for different EU climatic zones. Yet, some of today's published national performance targets for NZEB clearly exceed the performance benchmarks provided in the recommendation.

Although NZEB means a big leap towards a decarbonised building stock, it does not automatically tick the "decarbonised" box.[77] In this context there still is significant development potential for NZEB.

With the current low progress of increasing the performance of the existing building stock, NZEB in new construction inevitably must deliver their contribution to decarbonisation by 2050. NZEB, which for new public buildings are already mandatory since 1st January 2019 and will be mandatory for all other new buildings from 1st January 2021 on, need to be the answer to the challenge of making new buildings compatible with carbon-neutrality. However, although this study found a slight upward

74 The "Smart Finance for Smart Buildings" initiative, which, launched by the European Commission in close cooperation with the European Investment Bank (EIB) and the Member States, could support the development of flexible financing platforms at national level and make more attractive financing options available on the market. This initiative encourages the more effective use of public funds, help aggregation and assistance of projects and tries to de-risk investments in energy efficiency and make them more trusted and attractive for project promoters, financiers and investors.

75 European Commission (EC) (Hg.) (2016): Commission Recommendation (EU) 2016/1318 of 29 July 2016. on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings.

76 Schimschar, Sven; Hermelink, Andreas; Boermans, Thomas; Pagliano, Lorenzo; Zangheri, Paolo; Voss, Karsten; Musall, Eike (2013): Towards nearly zero-energy buildings. Definition of common principles under the EPBD. Research report by order of the European Commission. ECOFYS; Politecnico di Milano; University of Wuppertal. Cologne, Milan, Wuppertal Schimschar, Sven; Hermelink, Andreas; Boermans, Thomas; Pagliano, Lorenzo; Zangheri, Paolo; Voss, Karsten; Musall, Eike.

77 A 90% reduction of emissions until 2050 compared to 1990 would require average emissions in the building stock of approx. 3 kg CO2eq/(m2.y), which can be considered a benchmark that definitely should not be exceeded by a NZEB(cf. Boermans, Thomas; Hermelink, Andreas; Schimschar, Sven; Grözinger, Jan; Offermann, Markus; Engelund, Kirsten et al. (2011): Principles for nearly zero-energy buildings. Paving the way for effective implementation of policy requirements). Such interpretation of NZEB could be taken up by Energy Performance Certificates' top performance class like "A+" or "A++".

trend of NZEB for the period 2012-2016,[78] by 2016 the perceived share of high performing buildings (similar or close to NZEB definitions) in new construction was just above 20% across the EU28. It is important to point out that these results are based on architect surveys and therefore represent the subjective perceptions of these important market players.[79] However, this does not need to be in line with already mandatory requirements in some countries that all new buildings already need to be NZEB (e.g. France or Luxembourg), but it reflects the qualitative perception in the market.

New constructed buildings with high standards also deserve attention for another reason: Typically, they serve as locomotives of innovations in the construction sector, which afterwards are adopted in renovation. From this perspective it makes sense that the EPBD requires NZEB for new buildings first and asks Member States to gradually increase the share of NZEB in renovation. Like with new buildings this study found an upward trend for NZEB in renovation as well, although on a lower level.

Specifically for NZEB, it is very hard to compare ambition levels across Member States due to very different approaches across Member States for defining them and to calculate their energy performance.[80] To allow Member States an easier exchange of experience and to avoid losing focus on the efficiency first principle, a similar approach for NZEB that would produce an indicative performance level being comparable across Member States would be of help. As this study covered the period 2012-2016 it is hard to predict whether Member States will have fully implemented NZEB by 2020 meeting an ambition level as e.g. set out by the Commission's NZEB recommendation.[81] For 2016 architects in EU28 perceived a share of newly constructed "high performance buildings" being just above 20%. When extrapolating the 2012-2016 trend of slow market uptake of buildings which architects perceive to be NZEB to the end of 2020, a 100% implementation of such ambition level does not seem to be very likely. Yet in the light of the EPBD requirements for all new buildings to be NZEB by 2021, Member States should ensure maximum ambition, clear legal framework and suitable market conditions to avoid lost opportunities.

Several projects with well-designed NZEB have demonstrated that ambition levels like the benchmarks set out in the Commission's recommendation are achievable at reasonable cost, typically being only slightly above the cost-optimal *point* if well-designed. The Commission's cost-optimality guidelines[82] encourage Member States to use the left border of the cost-optimal *range* as guidance for the definition of their

78 For all buildings, new and renovation, for EU28 level the share of buildings with standards close to NZEB rose from 14.4% in 2012 to 19.8% in 2016. This is a relative increase of 38%.

79 The period covered by the study (2012-2016) did not allow to comprehensively examine the NZEB uptake according to the NZEB definitions which are supposed to be mandatory only after 2020 (or 2018 for public buildings).

80 In this study, primary energy savings achieved through energy renovation have been calculated using the same set of primary energy factors and the same calculation algorithm for all countries while considering differences in climate and building types.

81 European Commission (EC) (Ed.) (2016): Commission Recommendation (EU) 2016/1318 of 29 July 2016. on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings.

82 EC Guidelines Regulation No 244 (2012): Guidelines accompanying Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.

cost-optimal level. This is one possibility to increase the ambition level and to merge NZEB and cost-optimality. As NZEB gain market shares across Europe, the gap between NZEB and cost-optimal levels is expected to steadily decrease and eventually disappear, which means that NZEB will become cost-optimal.

Full implementation of NZEB by 2020 does not just require the availability of suitable technology, it also requires full readiness of all market players meaning a steep uptake of NZEB capacities till then. In this context, it is alarming that a recent study of the Architect's Council of Europe found a significant decline in the proportion of architects who are designing to nearly zero-energy standards more than 50% of the time – from 14% in 2016 to 11% in 2018.[83] This hints at significant challenges for both capacity building and market readiness towards NZEB.

Determinants of energy renovation

Apart from pure numbers on status and progress of energy renovation and uptake of NZEB, this study also looked at triggers, drivers, barriers and incentives on the demand side (consumers split into tenants, owner-occupiers and landlords) and supply side (architects, main contractors and installers).

The most common triggers for all types of consumers turned out to be necessary maintenance, replacement of a defective component (in a non-emergency situation), the available budget to carry out the renovation or the will to counteract shortcomings that lead to health issues.

This means that information on potential energy renovation measures should be closely linked to maintenance and inspections as it serves as an effective trigger. Maintenance and inspections are the business of main contractors and installers. Hence, specifically these groups must be used as ambassadors for promoting energy renovation of technical building systems. Interestingly, inspections - compared to EPCs - appear to have more influence on triggering energy renovation than on subsequent phases.

Going back to the long list of most common triggers for policy making, it is important to note that not only "hard" factors like technical necessities (breakdown of components, maintenance) trigger energy renovations but also "soft" emotional factors, and especially health. Recent studies have shown a clear relationship between the quality of dwelling, energy poverty and health.[84] For a high-energy performance scenario the Commission mentions annual health benefits of €64-140 billion through improved life quality, less public health spending and fewer missed days of work.[85]

The most relevant aspects of energy renovation for consumers are not the energy savings, but the cost savings, making their home more comfortable and healthier. This is another aspect that needs to be considered in Member States' long-term renovation

83 Architects' Council of Europe (2019): The Architectural Profession in Europe 2018. A Sector Study.

84 VELUX; Ecofys Germany GmbH; Fraunhofer Institut für Bauphysik (Fraunhofer IBP); Copenhagen Economics (2017): Healthy Homes Barometer 2017. Buildings and Their Impact on the Health of Europeans and Ecofys - A Navigant company; Fraunhofer IBP; Velux (2018): Healthy Homes Barometer 2018. (Un)healthy homes, offices, and suburbanisation in Europe. Edited by Velux.

85 Kephalopoulos, Stylianos; Geiss, Otmar; Barrero-Moreno, Josefa; D'Agostino, Delia; Paci, Daniele (2017): Promoting healthy and energy efficient buildings in the European Union: National implementation of related requirements of the Energy Performance Buildings Directive (2010/31/EU). JRC Science for Policy Report.

strategies and the set of measures that aim to activate the market towards achieving a decarbonised building stock.

Results show that different instruments like EPCs (recommendations and rating), information on the energy bill and energy labels for energy using components have different levels of importance throughout the "renovation journey". While most of these instruments have limited function as triggers, their influence is much higher once the renovation decision has been taken. Then they help to justify the decision, to select or recommend the right solutions from the maze of options, or to increase the ambition level. For example, the surveys revealed that component labels are especially useful for installers both as a quality indicator and as a means to convince their clients to choose an efficient product.

Focusing on the example of EPCs, there are significant differences between countries. In some countries EPCs are a significant *trigger* for energy renovation, while in others this impact is lower. EPCs' relevance significantly increases the moment the decision to renovate has been taken. This is when recommendations on the EPC get relevant to overcome the uncertainty about which measures to take and where the rating itself motivates to improve

However, the study reveals that in many cases the importance of EPCs is underestimated. More promotion of EPCs is needed, especially amongst architects, main contractors and installers.

The in-depth analysis of the demand side that has been conducted, shows noteworthy differences between countries but also between age groups within countries. Aspects like information sources used, share of own capital in the investment, willingness to take out loans or the importance of health improvements significantly differ between age groups and need to be carefully considered when setting up national policy instruments for financial support, regulations and information. It is another aspect to be included in the currently ongoing drafting of national long-tern renovation strategies. Above mentioned health as a driver to do better or deeper renovations appears to be a consumers' driver, which at the same time tends to be underestimated by architects and installers and probably could be utilised more in their communication towards the demand side.

Talking about architects and installers leads to another topic that the study concludes is under-represented in the current discussion; the role of so-called *intermediaries* in renovation activities, meaning architects, but also - and specifically - main contractors and installers. Above all these are the people consumers mostly listen to when deciding about the extent and depth of energy efficiency measures.

Analyses show that intermediaries themselves are driven both by their own motivation, e.g. to benefit the environment but also and mainly by a most-hassle-free delivery, installation and after-care. These aspects are related to the quality and service offered by manufacturers of components and technical building systems, which creates strong links between installers or main contractors and those manufacturers who manage to provide them with such "convenient all-in-one packages".

From the literature it is known that "construction team" approaches have a positive impact on quality. Yet consumers but also commercial investors feel uncertain about what to expect from installers, which certainly partly explains the high share of laymen taking responsibility for quality controls. Finally, the attitude of about half installers across Europe already dealing with energy renovations that energy efficiency measures are too complicated to install certainly also hampers quality. More collaborations of this kind towards "one-stop-shops" also taking architects on board will create benefits both on the demand side and supply side.

These insights highlight a clear need for a differentiated, target group-oriented communication and trainings both on the demand side (tenants, owners, and landlords) and on the supply side (installers, main contractors, architects) due to the quite different views and habits in different countries.

Fostering collaboration between installers, main contractors and manufacturers might not only help to mitigate both the relatively wide-spread uncertainty about what to expect from installers or main-contractors. It also might support installers to master the complexity of energy efficiency components and change their view of efficiency components being too complex or too hard to install.

Even many architects find it hard to select the most suitable components or products, which is time-consuming. This over-consumption of time related to energy efficiency measures in the eyes of many architects continues on the construction site, where they feel quality controls of energy efficiency measures take too much time.

This study confirmed that intermediaries appear to have a much-underestimated impact on the uptake of energy renovation with regard to both speed and depth. As long as these intermediaries do not fully support energy efficiency measures, they will not act as the main lever for boosting renovation activities in the market which they could be. Hence, policy measures and long-term renovation strategies need to find solutions on how to better activate installers, main contractors and architects for the benefit of reaching a climate neutral building stock.

Talking about quality assurance, there are very different views on responsibility. Tenants equally distribute it between themselves, main contractors and installers. Owners have a clear emphasis on being responsible themselves (more than 40%), while landlords assign highest shares to architects (around 12%) and main contractors (around 37%).

Last but not least, consumers, architects and contractors/installers across the board view financial and administrative barriers as being the main roadblocks for consumers carrying out energy renovation works or for those on the supply side to recommend such renovations. In this context, it is striking, that a vast majority of consumers use their own capital to finance renovation works, suggesting that consumers don't undertake energy renovations unless they have sufficient own capital. The most popular combination is with a loan at market conditions rather than with a preferential loan. Still only 29% of consumers indicated having used two or more funding sources. It indicates the strong negative attitude towards loans, the older the consumer the stronger. *On the other hand "grants, loans etc." are mentioned to be a very strong incentive to overcome financial barriers.* Merging these two findings, it can be assumed that consumers clearly prefer grants over loans. These findings confirms the need to simplify administrative process, to de-risk energy efficiency investments for buildings and significantly leverage the private investments for buildings; renovation – in line with the pillars of the "Smart Finance for Smart Buildings" initiative. For commercial clients financing and savings appear to be even bigger drivers than for consumers.

Results show that energy renovation and uptake of NZEB is not a 'simple' story but the result of their complex determinants like drivers, barriers and incentives.

For effective policy making, results show that it is worthwhile segmenting into landlords, tenants and owners as well as age groups, income levels, professional or private investors, regions or countries – and to not forget intermediaries. This will help policy-makers to design tailor-made effective packages of policy instruments to get building renovation on a track towards a carbon-neutral economy.