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

Final report

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Executive Summary – Key messages

Objective

The objective of this study is to deliver a comprehensive analysis of the **renovation activities and nearly zero-energy buildings (NZEB) uptake in the EU from 2012 to 2016**, applying indicators in line with the **Building Stock Observatory (BSO)**. The following main results are available for the EU and for each of the 28 Member States:

- Precise **definitions** in the context of energy renovation of buildings
- EU28 building stock **inventory** and new construction data
- **Renovation rates and investment costs**; split into energy renovation, non-energy renovation, residential and non-residential buildings, and renovation depths
- Related **primary energy savings**; split into residential and non-residential buildings, and different renovation depths
- **Avoided greenhouse gas emissions** through energy renovation; split into residential and non-residential buildings
- **Impact on employment** rate of overall building renovation
- Rates for the **uptake of NZEB**; split into new construction and renovation
- Information on **triggers, drivers, barriers and incentives**.

Methodology

Secondary data was obtained through extensive **desk research** and purchase of **market data** on some renovation measures. In order to obtain primary data on energy renovation activities and NZEB uptake in the EU28 Members States, three surveys were conducted, taking into account the perspectives of multiple stakeholders.

- The large-scale **online consumer survey** (30,118 respondents in the EU28, 18,302 energy renovators) targeted consumers that have performed (energy) renovations. The sample is composed of three main groups; owners, tenants and landlords. It provides information on residential buildings and respondents' drivers and barriers to perform energy renovation.

- The **online architect survey** (1,581 respondents in the EU28) focused on both residential and non-residential buildings. The data is also used to explore architects' and their clients' drivers and barriers to conduct energy renovation.

- The **main contractor and installer telephone survey** (2,009 respondents in the EU28) was tailored towards the supply side. This survey focused on residential and non-residential renovation projects and NZEB. It provides insight into the drivers and barriers for energy renovation of main contractors, installers and their clients.

Energy savings, renovation rates, and investment costs were derived based on a **detailed simulation** using inputs from secondary and primary data collection.

Results and conclusions

Renovation

The determination of renovation rates and depths requires a clear common understanding of what renovation "rate" and "depth" mean. To reduce uncertainty about definitions, this study proposes and applies **clear definitions for different renovation depths**, relating them to non-renewable primary energy savings achieved in a specific calendar year:

- **Below threshold** (x < 3% savings)

- **Light** renovations (3% ≤ x ≤ 30% savings)

- **Medium** renovations (30% < x ≤ 60% savings)

- **Deep** renovations (x > 60% savings)

"One-off" deep renovation gets significant attention in discussions about a decarbonised building stock. Yet, with an estimated rate of only around 0.2% - 0.3% in terms of affected floor area, deep renovations **only occur sporadically in the EU28**.

In practice, **step-by-step renovations with little primary energy savings per step dominate the market**. "Below threshold", "light" and "medium" renovations are more prevalent than "deep" renovation (the lower the depth the higher the rate). This typically means that only a few measures are implemented.

The speed at which the building stock improves its energy performance can be expressed as **annual reduction of the total building stock's primary energy consumption**. This weighted energy renovation rate is calculated to be **about 1%**.[1]

[1] This is in line with other estimations of the European Commission (0.4-1.2% depending on the Member State).

If this rate persists, the building sector will clearly and significantly fail to deliver its share of the overall need for primary energy reduction and consequently a reduction in **greenhouse gas emissions**. Significant acceleration is needed.

Energy renovations and non-energy renovation highly coincide. At the same time repairs, regular maintenance and inspections are major triggers for energy renovation. Furthermore, do-it-yourself activities have a significant share in building renovation. This underlines the necessity to interpret **deep renovations** as **a journey with several milestones** that needs to be planned ahead and coordinated.

Another concern is the economic law of diminishing marginal utility. Naturally "low-hanging fruit renovations" (typically light renovations) with most favourable cost-benefit ratios will be realised first. Hence, **future renovations will have a tendency to feature less attractive cost-benefit ratios**. **This might potentially further slow-down the renovation process**. Within an unchanged market and policy environment, it will get increasingly hard to even keep the current too slow speed.

In the EU28, **residential sector current investments in energy renovations**[2] are **about 200 billion Euros per year** and **another 300 billion Euros for non-energy renovations** in the residential sector. Another **200 billion appears to be invested in non-residential buildings**. Further significant growth would occur if renovation activities moved towards a level that ensures a decarbonised building stock by 2050. Then energy renovation investments would probably exceed those in non-energy renovation.

There is a strong link between investments in (energy) renovation and the work force being active to execute these works. The **average total number of fulltime employees in the construction sector involved in renovation of residential buildings** is estimated to be **about 4.6 million** per year for the period 2012-2016 and **1.9 million for renovation of non-residential buildings**. This illustrates the significant **additional work force 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. This poses the question whether the European labour market is ready for this challenge.

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 initiative can provide the proper context for the transformation ahead.

Uptake of nearly zero-energy buildings

Nearly zero-energy targets – depending on their ambition level - **could represent the way towards a decarbonised building stock,** both in renovation and new construction. However, this study revealed significant differences in approaches to achieve NZEB levels in new constructions compared to renovations. Furthermore, some of today's published national performance targets for NZEB clearly exceed the performance benchmarks provided in the European Commission's recommendation on nearly zero-energy buildings[3].

[2] Calculated as full cost, not as incremental cost on top of renovations that would take place anyway.

[3] European Commission (EC) (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.

Based on market perceptions (and not on actual NZEB definitions), this study found **a slight upward trend of NZEB for the period 2012-2016 in new construction across the EU28**.[4]

It is important to point out that these results are based on perceptions of important market players and multiplicators such as architects. Therefore, 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 reality on the market.

Determinants of energy renovation

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, **budget becoming available** to carry out the renovation or the will to counteract shortcomings that lead to **health issues**. Recent studies showed a clear **relationship between the quality of dwelling, energy poverty and health**. Therefore, the most relevant aspects of energy renovation for consumers are not the energy savings, but the cost savings and making their home more comfortable and healthier.

Results show that different **instruments such as 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 different options, or to increase the ambition level.

This asks for **more promotion of EPCs especially amongst intermediaries**.

Intermediaries - architects, main contractors and installers – appear to be a group whose **influence** on energy renovation decision making is **largely underestimated**. These intermediaries are not only the ones being assigned the most prominent role in quality assurance of energy renovation measures by investors. They are also the persons consumers listen to when deciding about the extent or depth of energy efficiency measures.

Consumers but also commercial investors report **uncertainty about what to expect from installers,** which probably partly explains the **high share of laymen (tenants, home owners) taking responsibility for quality** controls. Half of all installers across Europe already dealing with energy renovations report energy efficiency measures being too complicated to install. This certainly also hampers quality and signals a high need for capacity building.

Even many **architects find it hard to select the most suitable measures**. This is time consuming, which continues on the construction site, where many architects feel quality controls of energy efficiency measures take too long. **Education is needed here, too**.

Only if intermediaries fully support energy efficiency measures, they will effectively catalyse renovation activities – speed and depth - in the market.

[4] 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).

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. For commercial clients financing and savings are even stronger drivers. 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.

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

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FINAL REPORT

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 today's buildings will make up at least 75% of the 2050 building stock. 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.

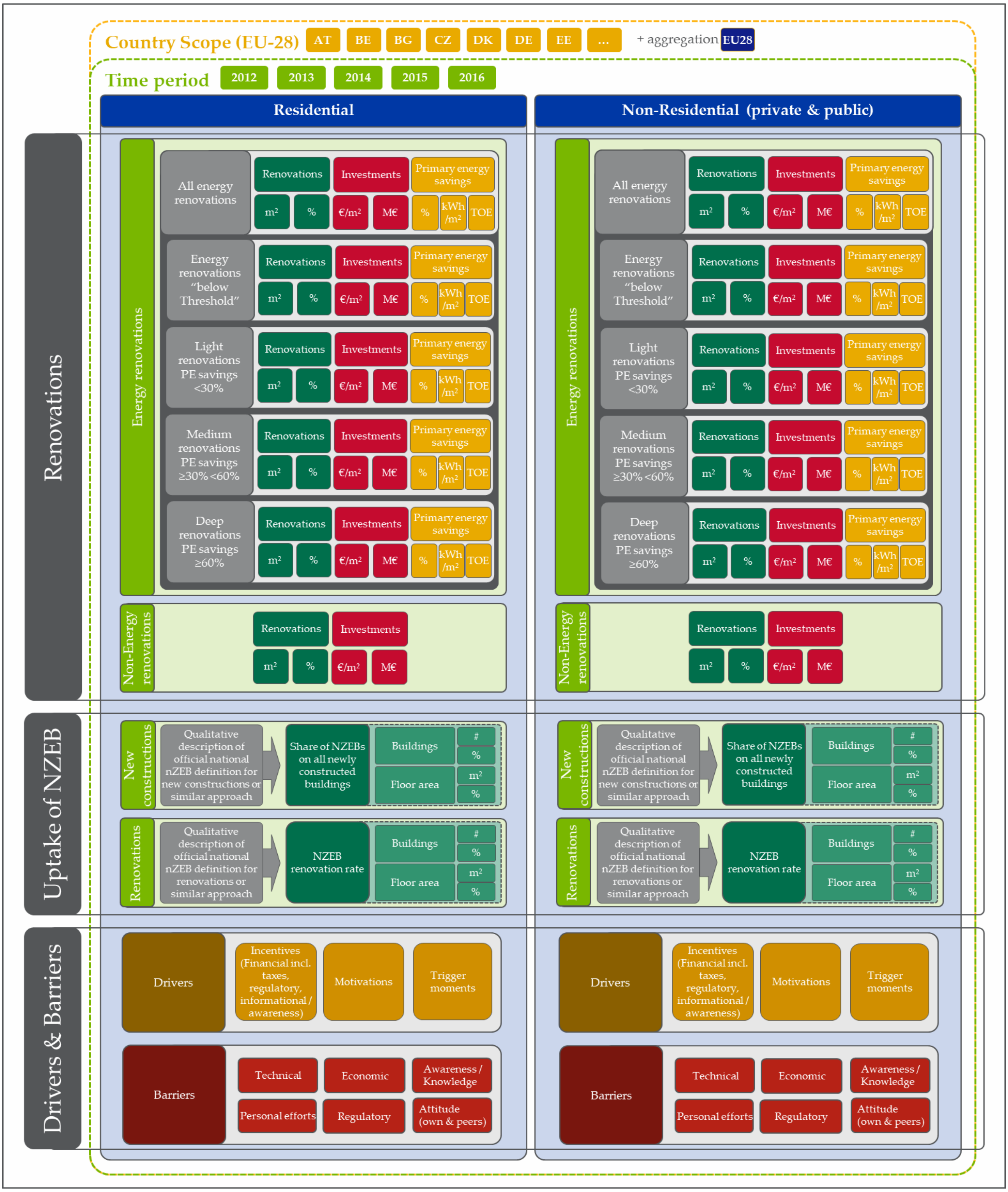
In addition to what is usually understood as "drivers and barriers", the qualitative assessment also looks at:

- 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).

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)

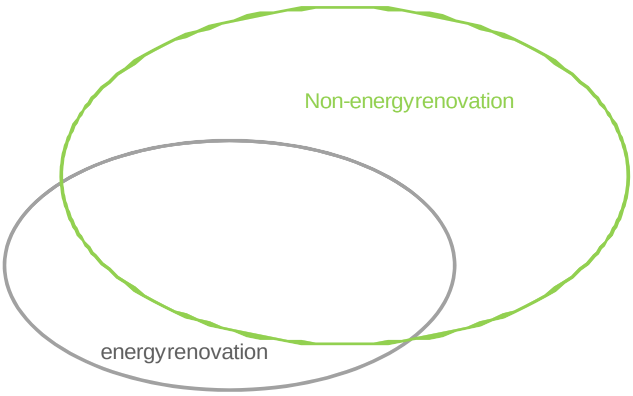
	Energy related: "Total"	Energy related: "below Threshold"	Energy related: "Light"	Energy related: "Medium"	Energy related: "Deep"
EU28	**9.5%**	**4.1%**	**3.0%**	**2.1%**	**0.3%**
Austria	6.8%	3.8%	2.2%	0.6%	0.2%
Belgium	21.4%	9.1%	5.3%	6.0%	1.0%
Bulgaria	17.9%	7.2%	4.8%	5.3%	0.6%
Croatia	18.8%	12.8%	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

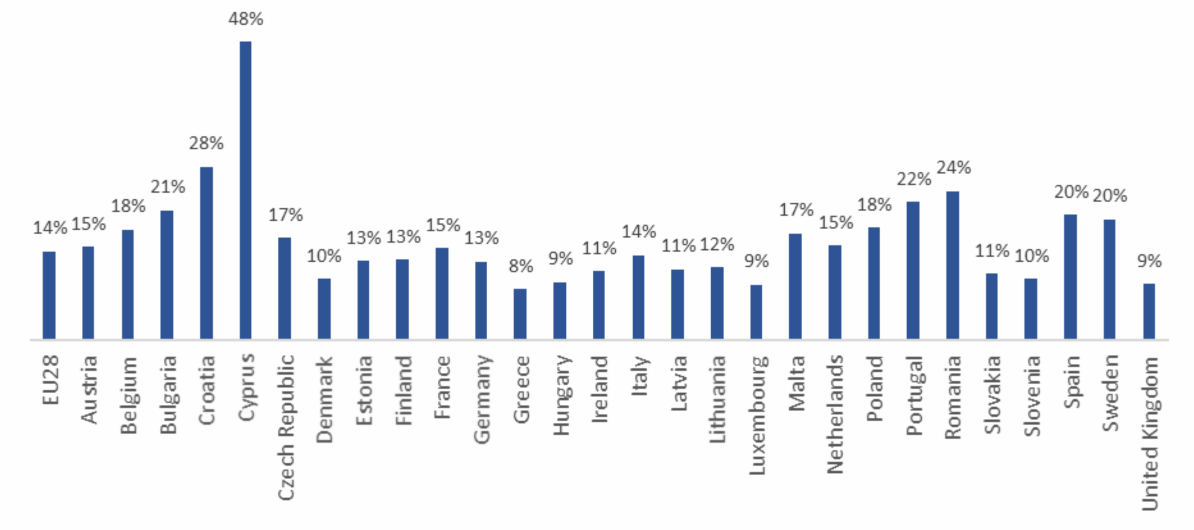
Non-energy renovation in residential buildings

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.

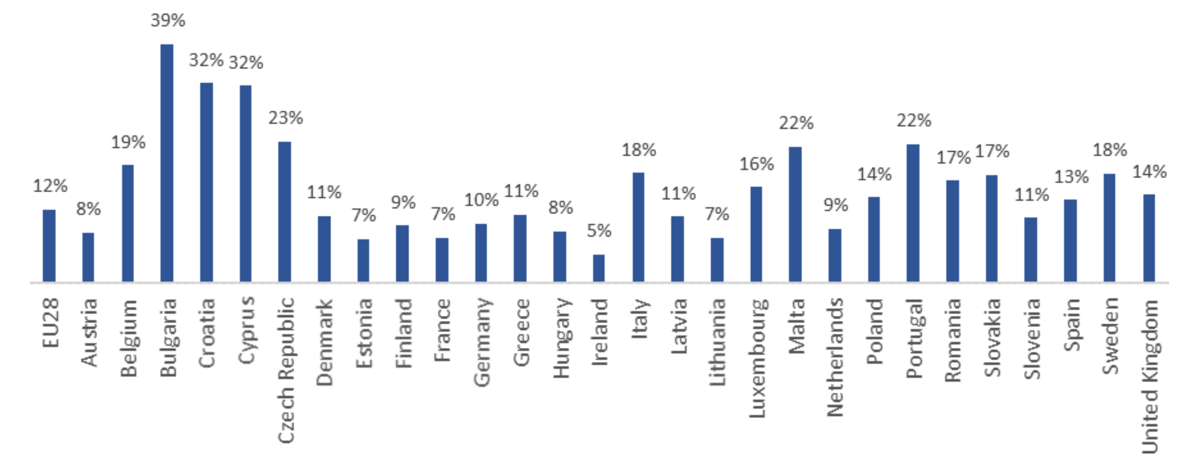
Figure 3: Non-energy renovation in residential buildings



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%.

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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/(m².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%[27].

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.

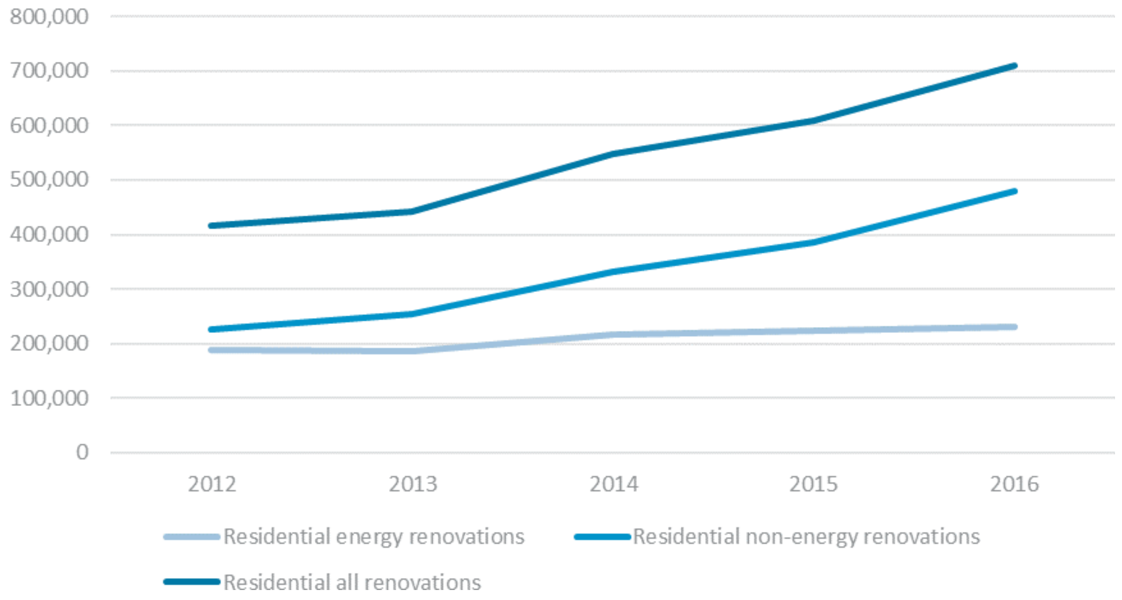
Investment costs in residential buildings

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 m^2 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

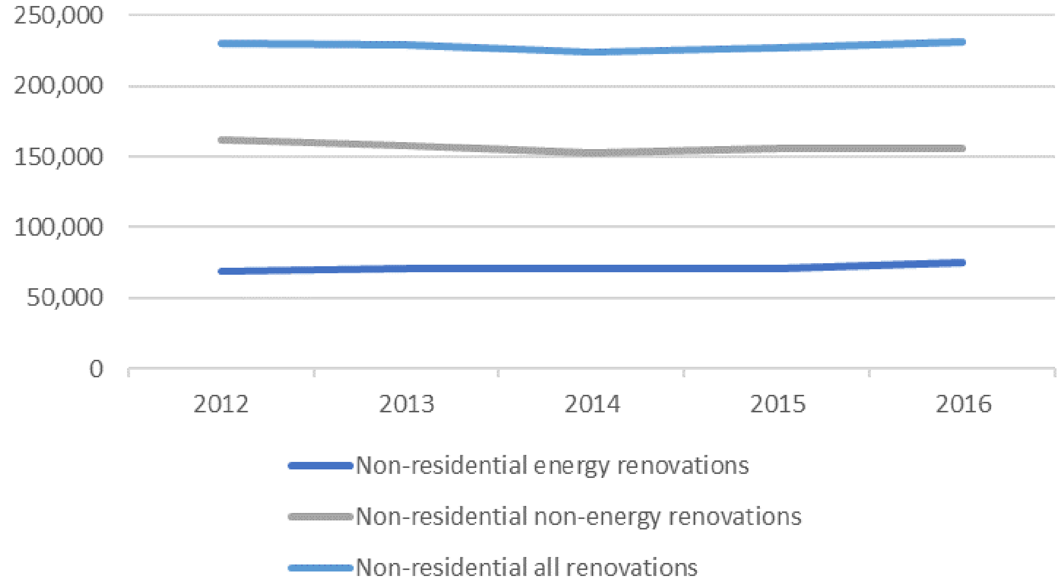
Investment costs in non-residential buildings

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)

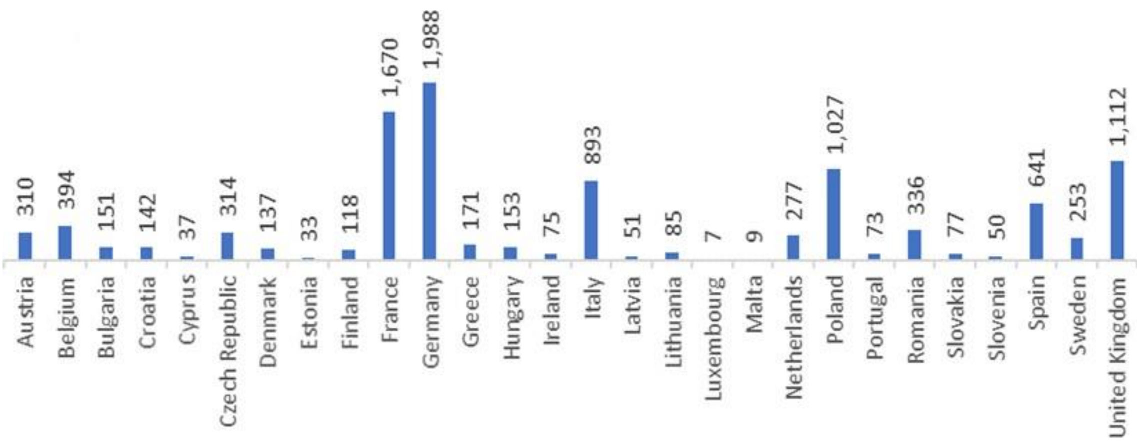
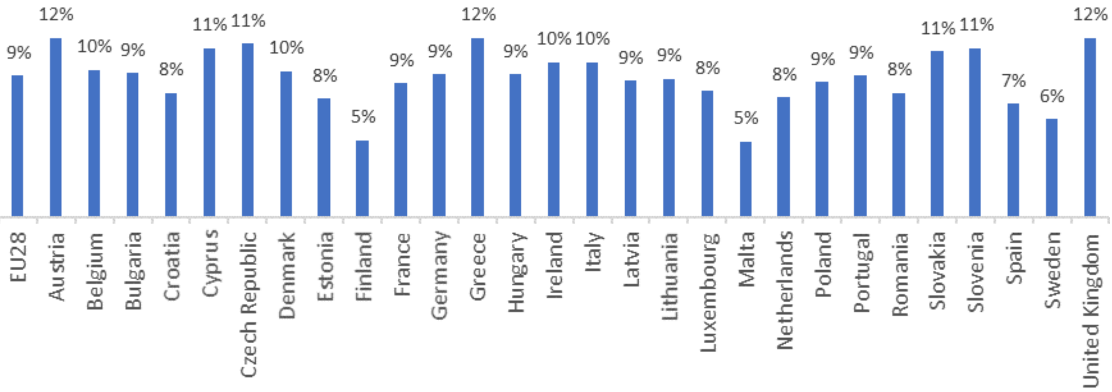


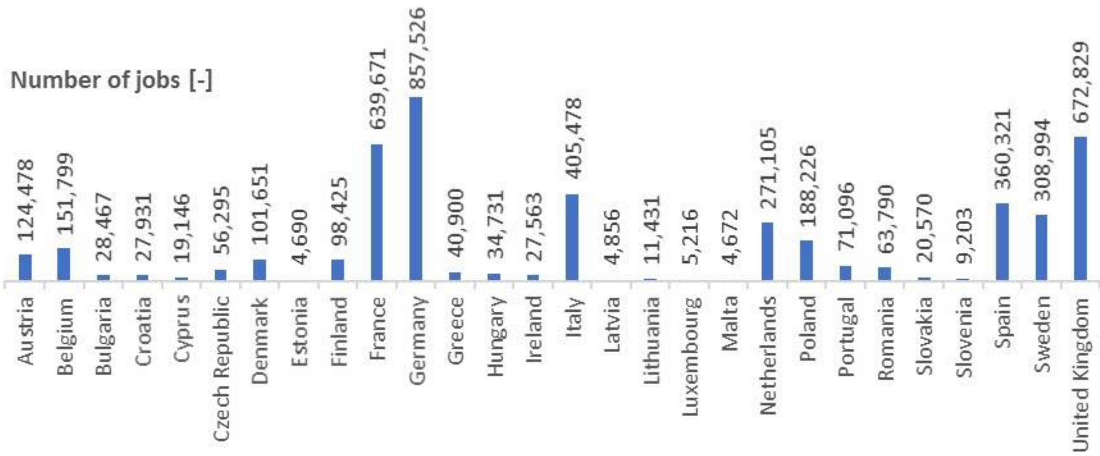
Figure 8: Emission mitigation in %, residential buildings (average 2012-2016)



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)

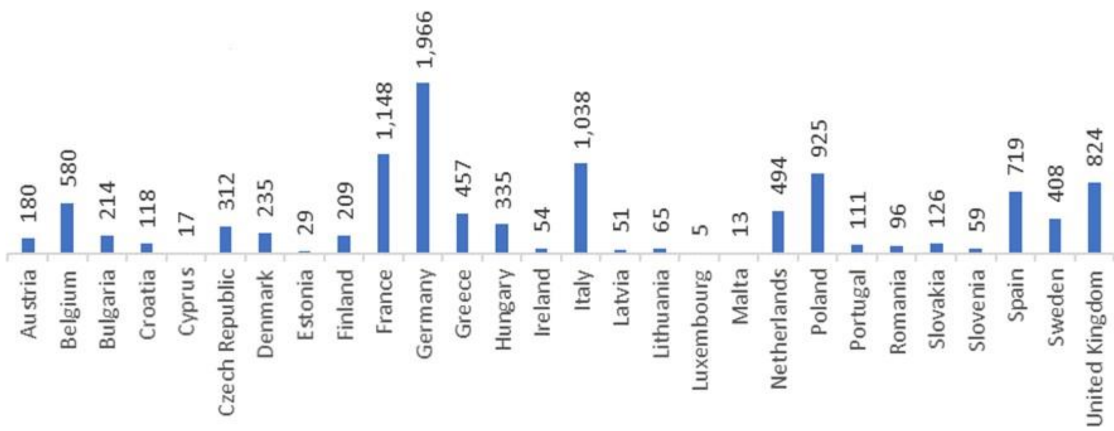


Non-residential buildings

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.

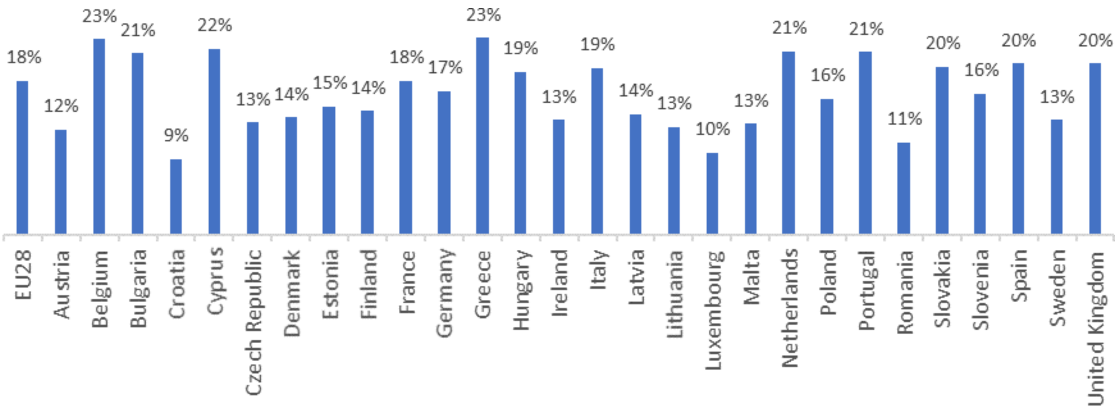
In absolute terms, year by year **energy renovations in non-residential buildings on average reduced emissions by roughly 11 MtCO2eq per year during the period 2012-2016**.

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



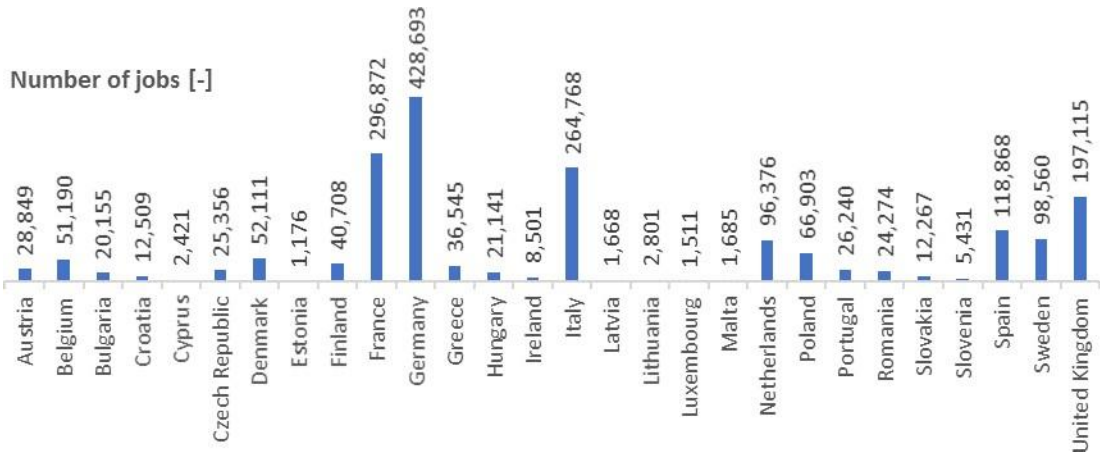
34 Average of all renovations (below threshold, light, medium, deep) that have taken place between 2012-2016.

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)

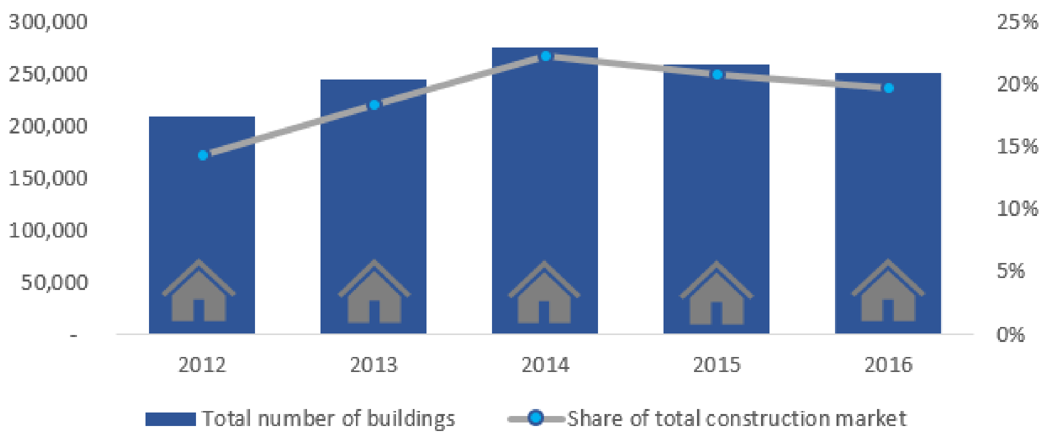
According to the EPBD all new buildings have to be NZEB from 2021 onwards (for public buildings this obligation applies as of 2019). This study covers the period 2012-2016, which is well before the actual obligation for new buildings to be NZEB. For that reason, the uptake of NZEB has been measured in 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.

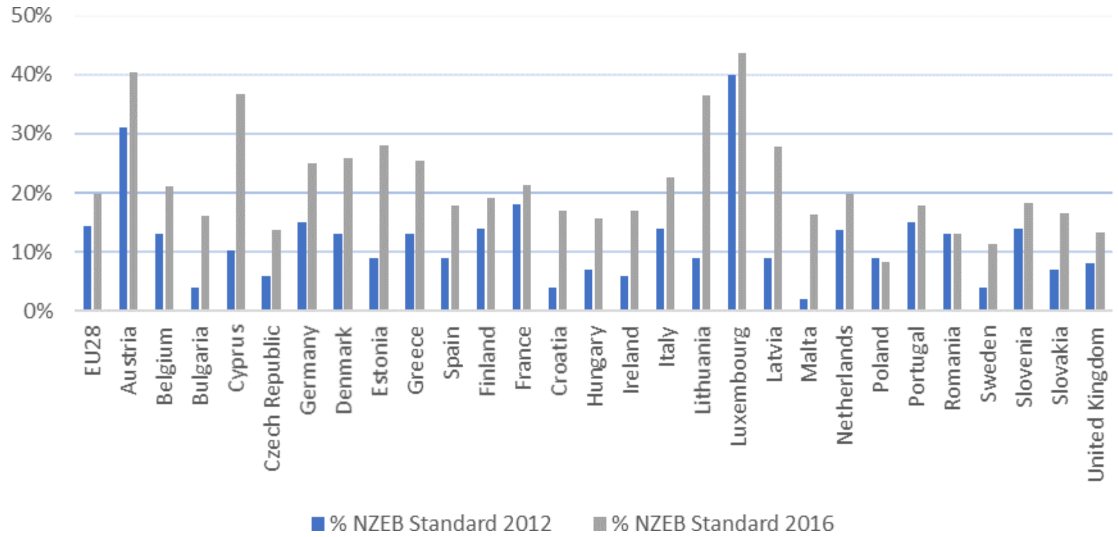
The results show that the number and share of buildings constructed in nearly-zero energy standard increased with a peak in 2014 and slightly decreased between 2014 and 2016. However, the overall trend of constructing towards to NZEB standards is positive for the period 2012 to 2016.

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

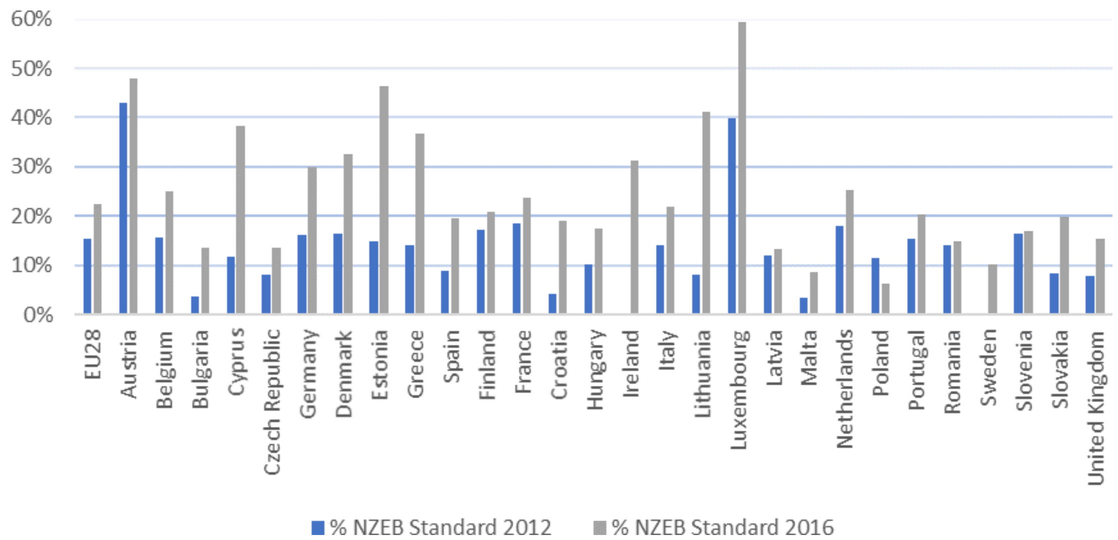
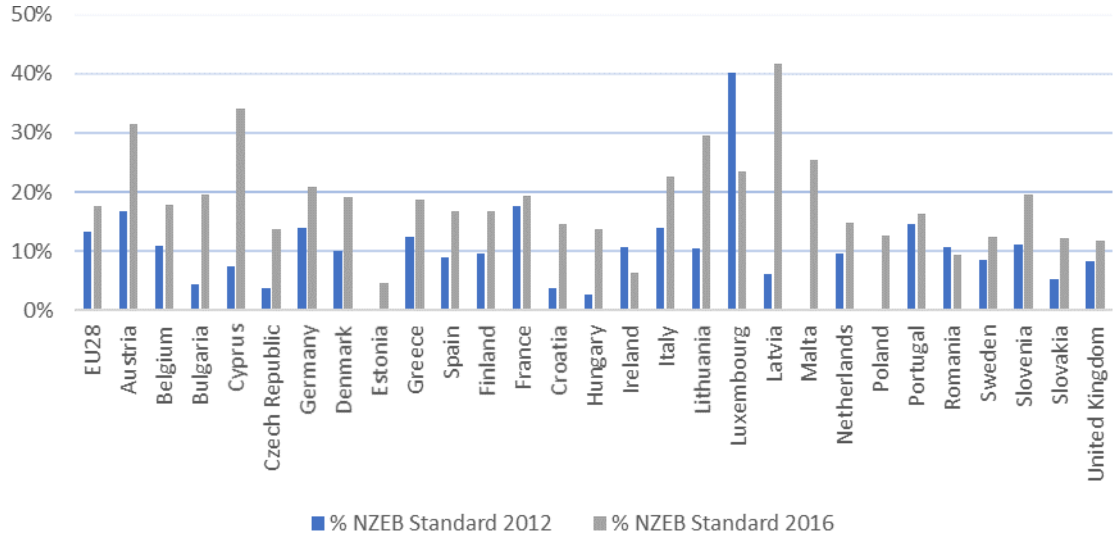


Figure 16: Overview of share of NZEB and its share of total renovated buildings on Member State level



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).

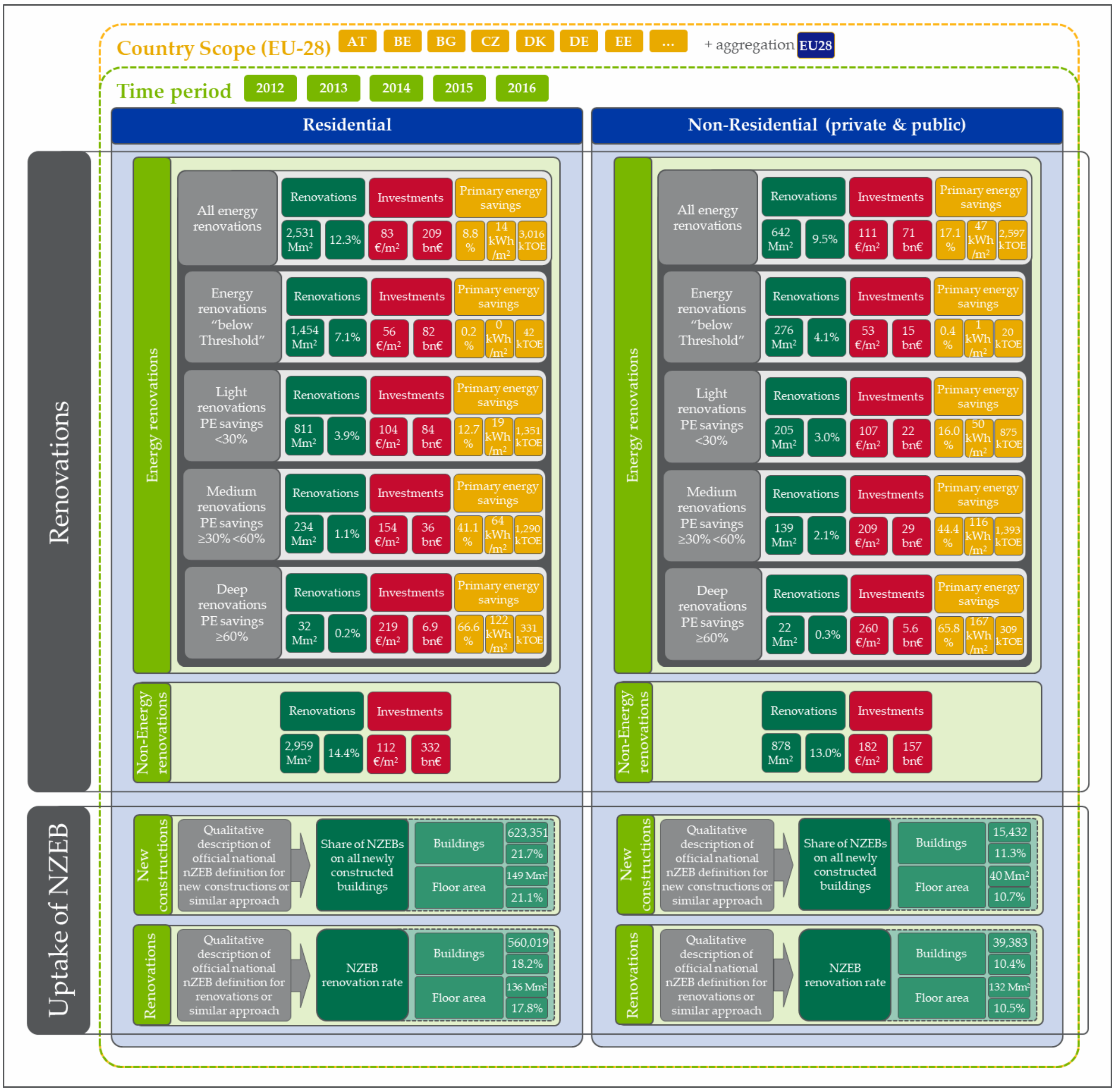
The exact methodology for calculating these numbers including the used sources can be found in Annex section 3.4.

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.

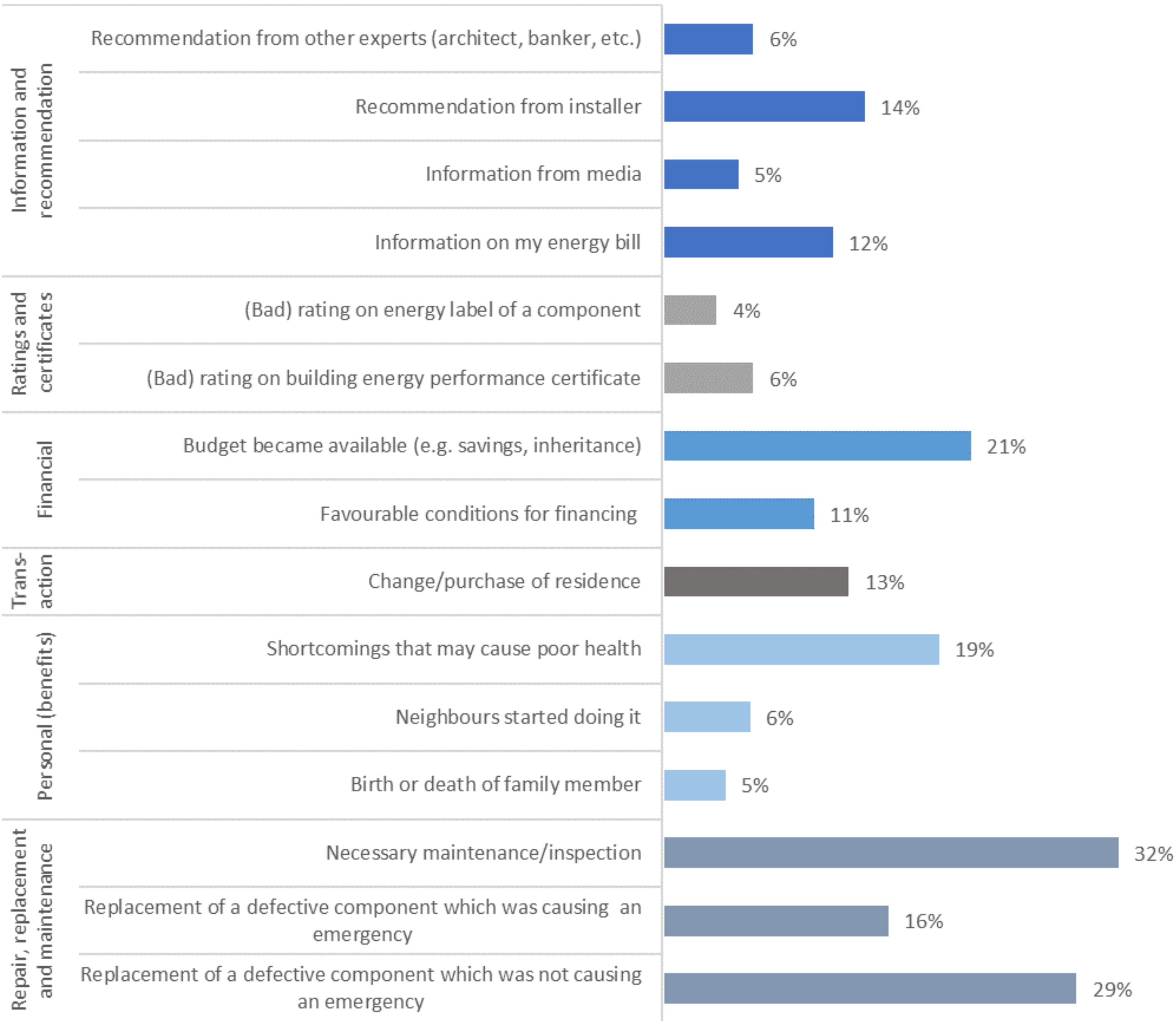
Consumers[41]

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

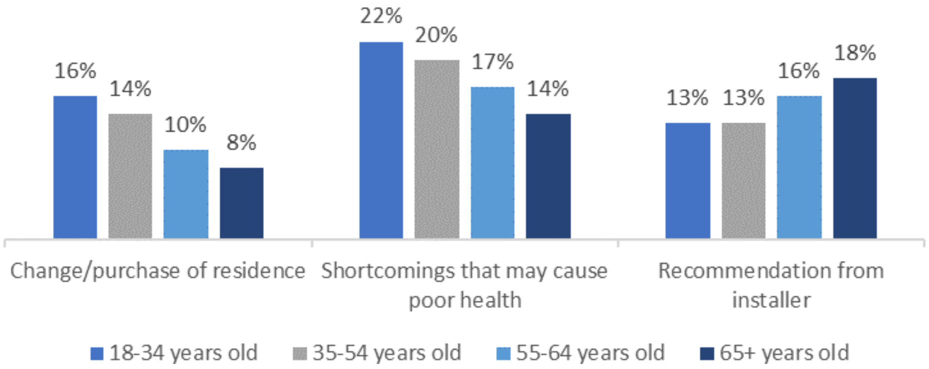
41 Question to consumers: "Which circumstances triggered your energy renovation/installation actions?"

Figure 18: Triggers for consumers



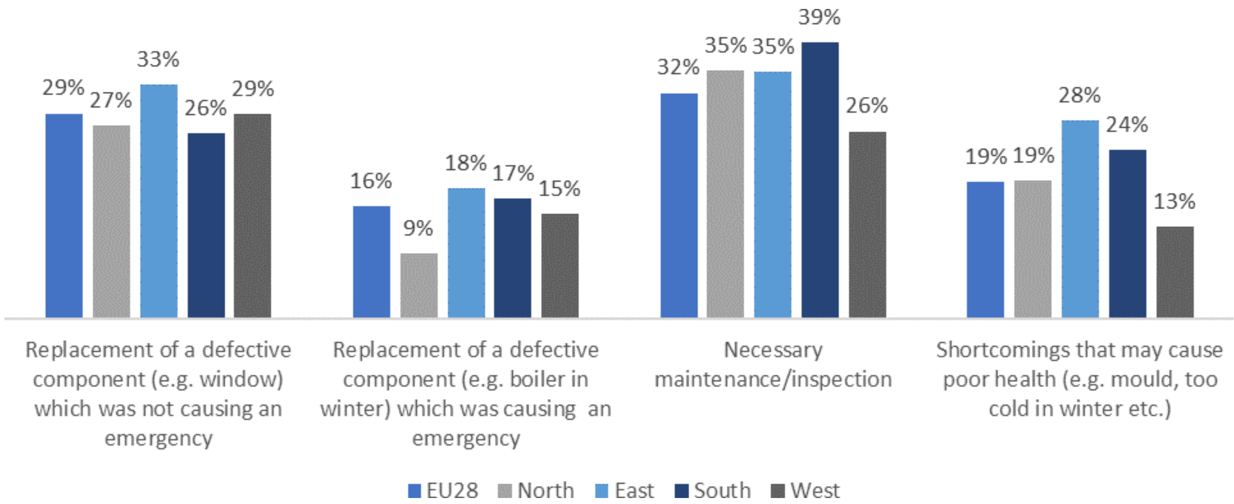
Younger consumers are more triggered by a transaction which might indicate that this population group more often acquires property or changes their residence, and/or that energy-related concerns when moving to a new home are more prevalent among this group. Health-related concerns are also a stronger 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



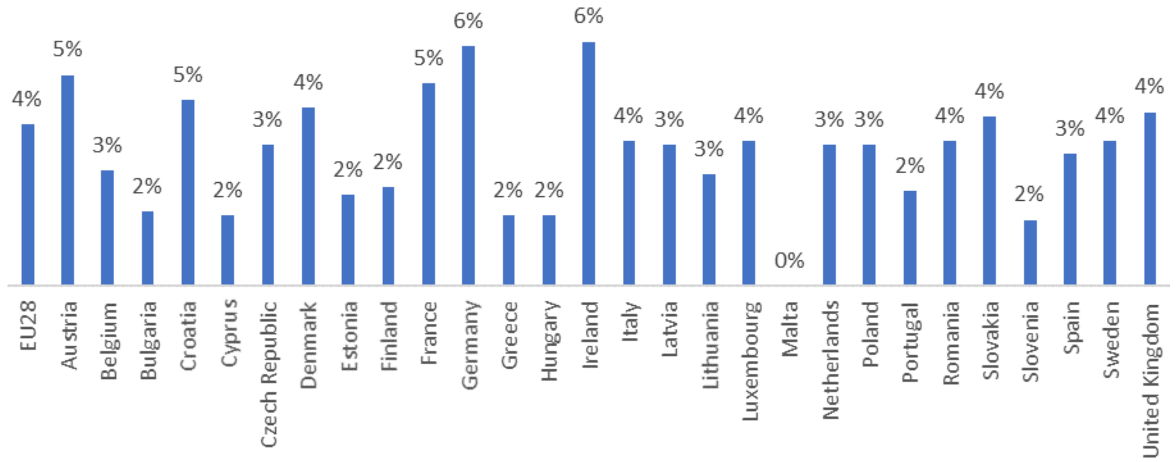
Overall, the different triggers are more prevalent in Eastern and Southern Europe. Results suggest that emergency works occur less often in Northern regions, which may be an indication of slightly better maintained technical building systems. Concerns that shortcomings may cause poor health might indicate 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



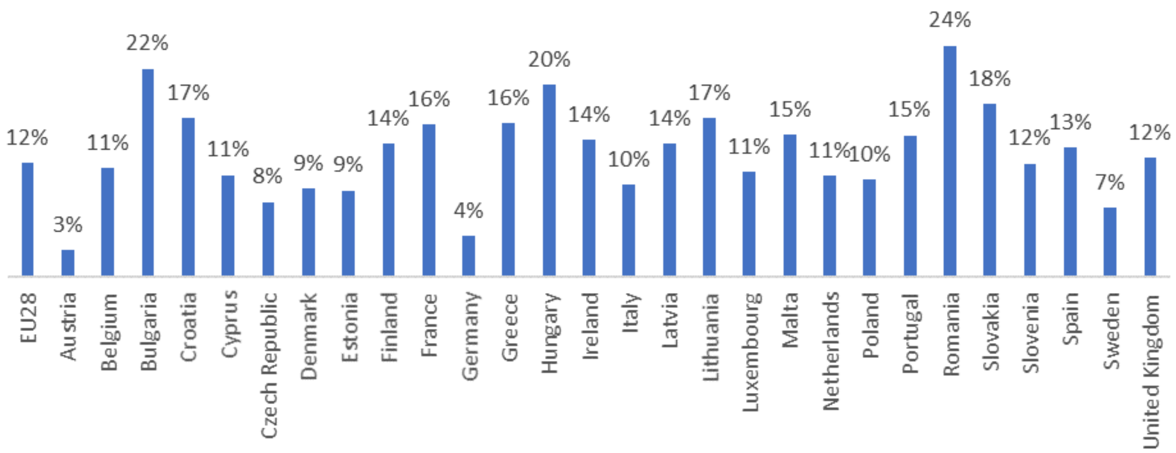
In comparison to other European regions, consumers in Western Europe more often stated that they performed energy renovations to improve the rating on the energy label of a component (Figure 21).

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

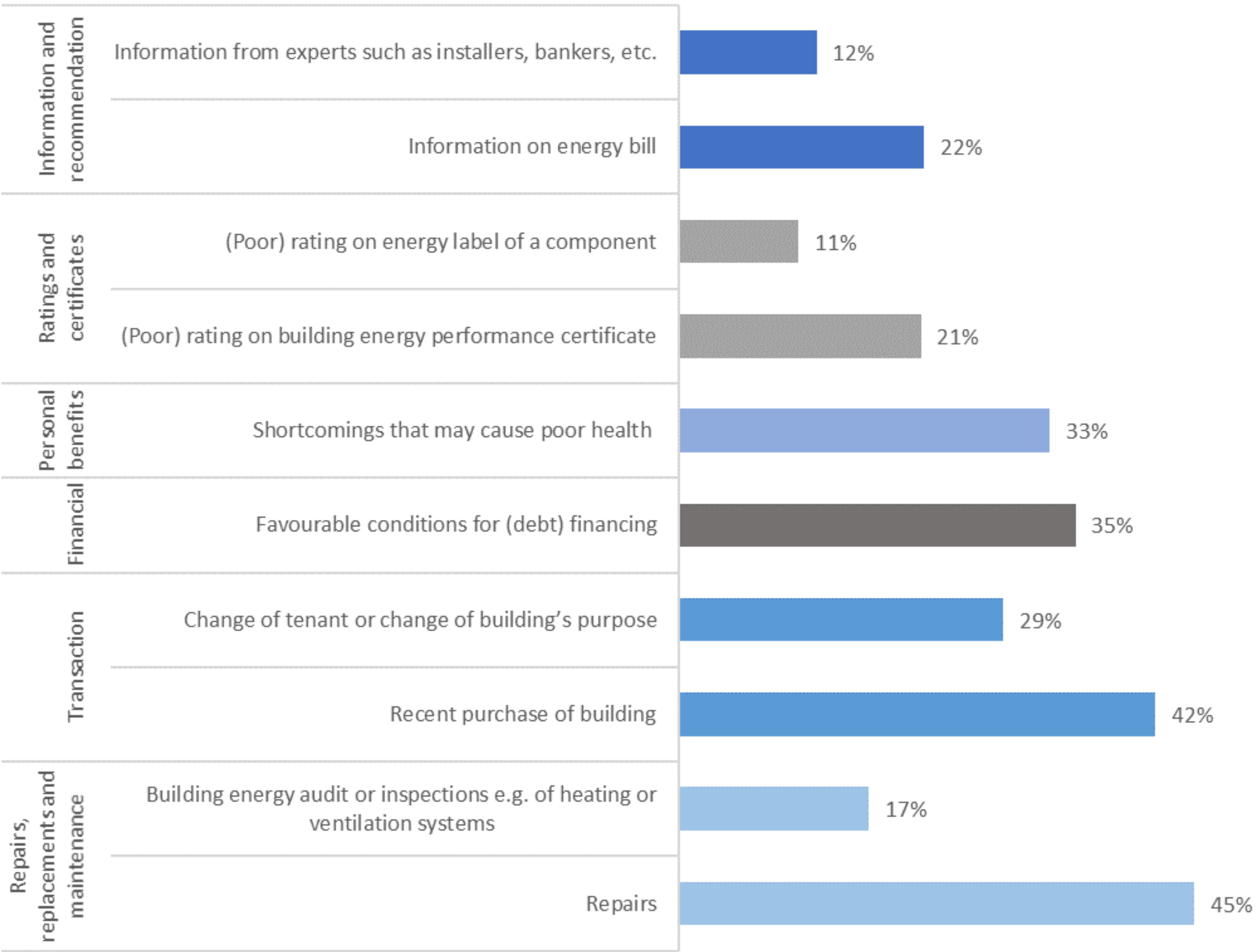


Clients of architects [42]

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

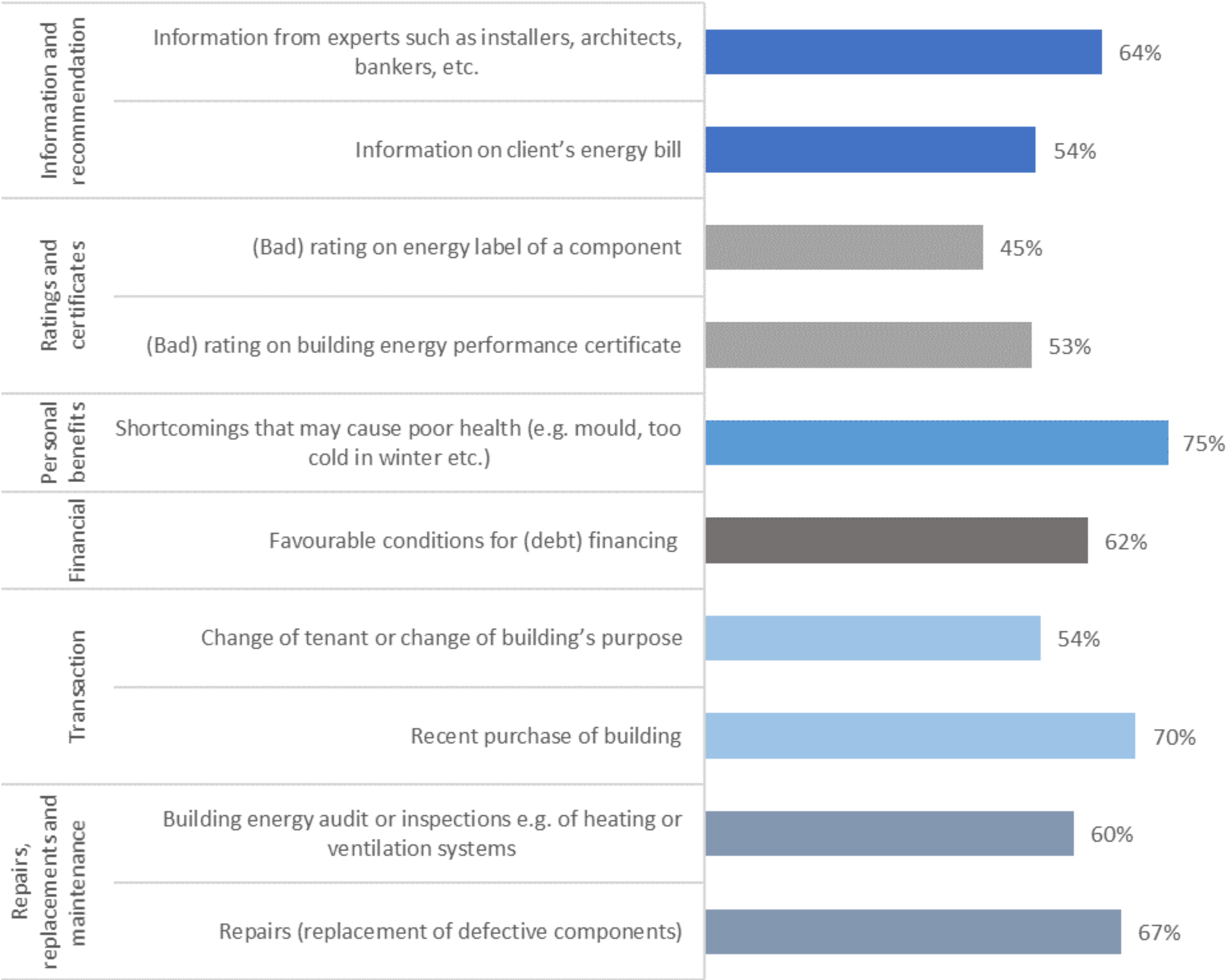


Table 15: Summary box - triggers

- 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

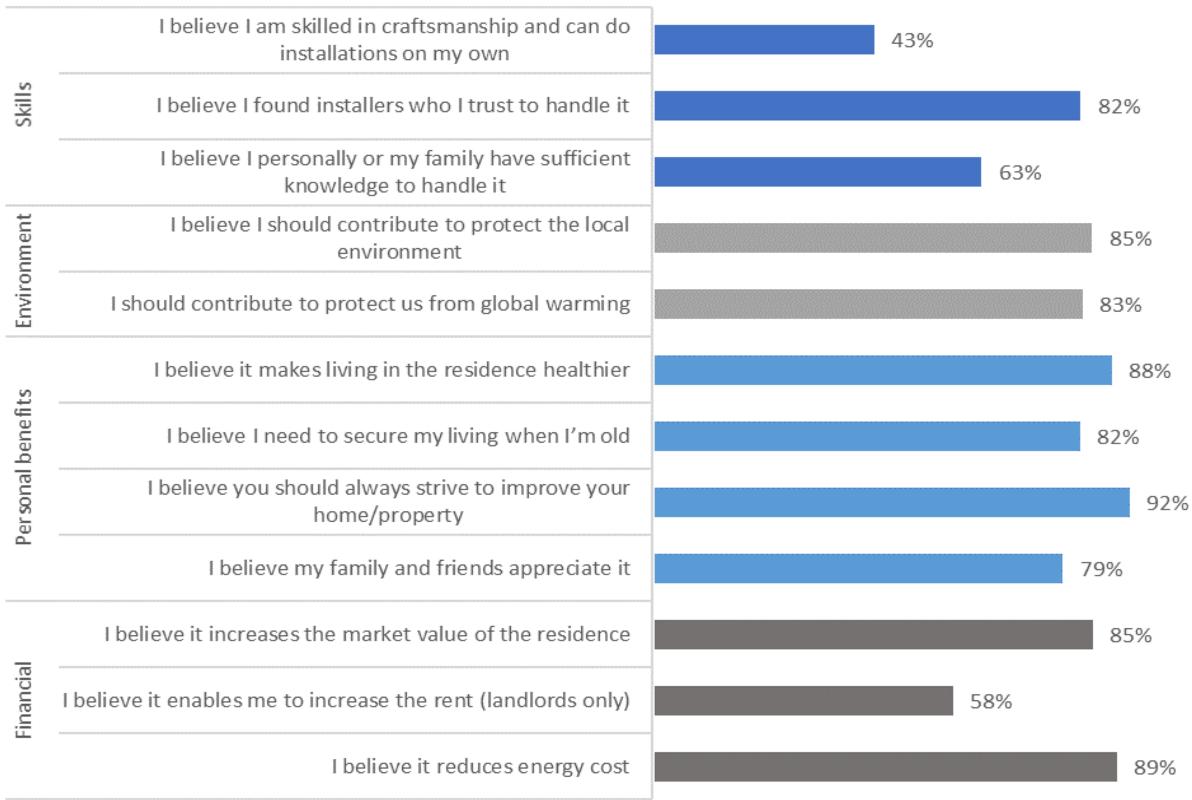
Drivers or motivations in the context of energy renovations are assumed to be of economic, personal (attitudes) or environmental manner. In contrast to triggers, they do not depend on a specific event or circumstance but on the person and her/his environment. Motivations are for example increased profit, 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



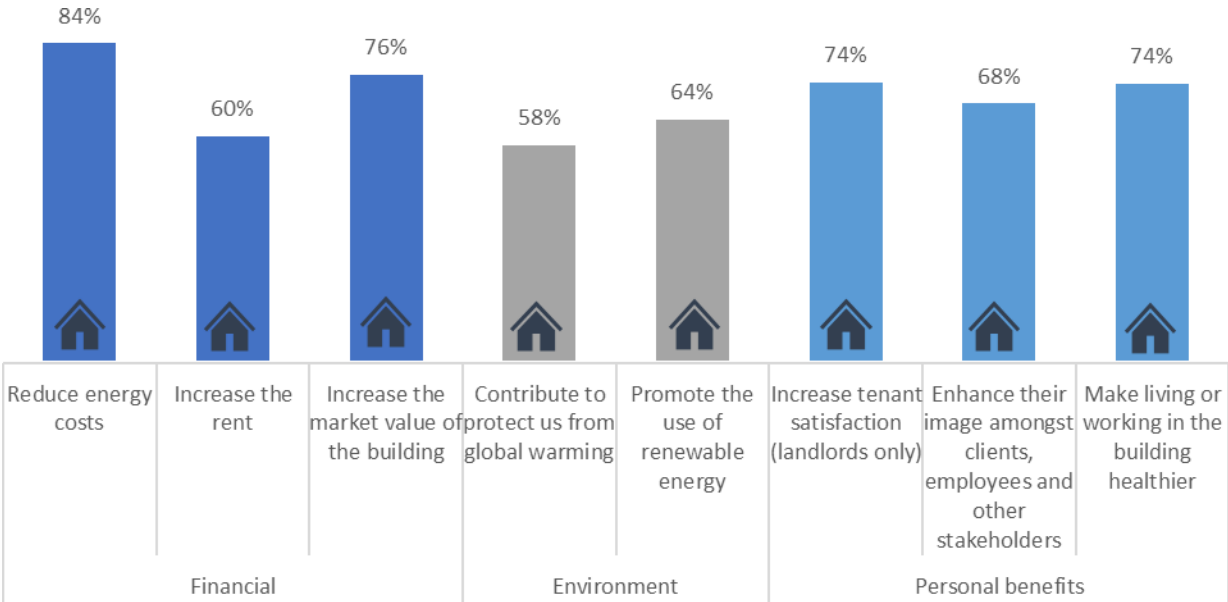
44 Question to consumers: "To what extent do you agree with the following statements? I did these energy renovations/installations, because I believe …"

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



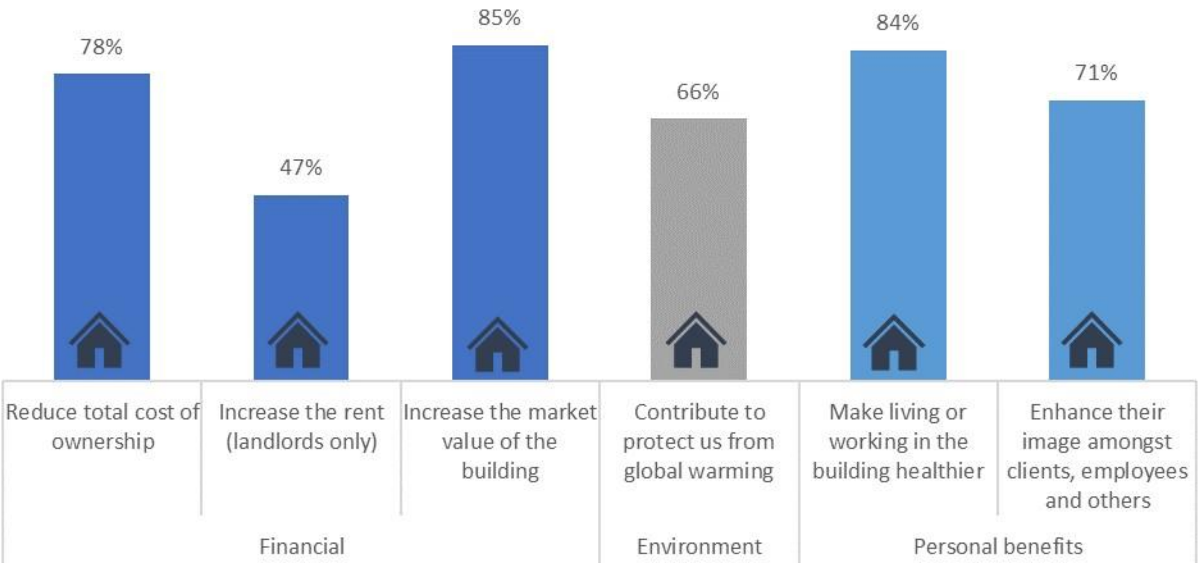
Clients of main contractors [46]

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?"

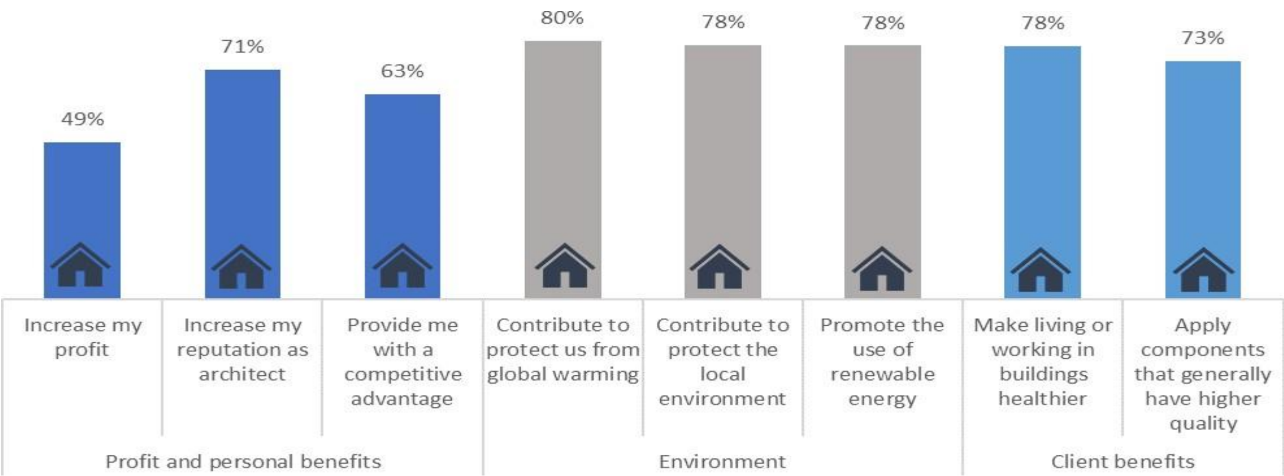
Figure 27: Drivers for clients of main contractors



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 …"

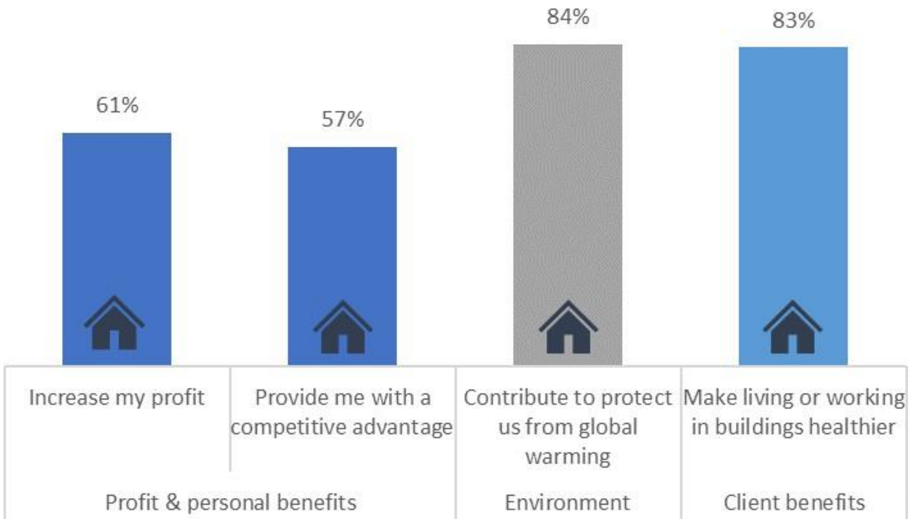
48 More architects stated to "fully agree" compared to "rather agree" that they are motivated to contribute to the protection from global warming and to protect the local environment.

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).

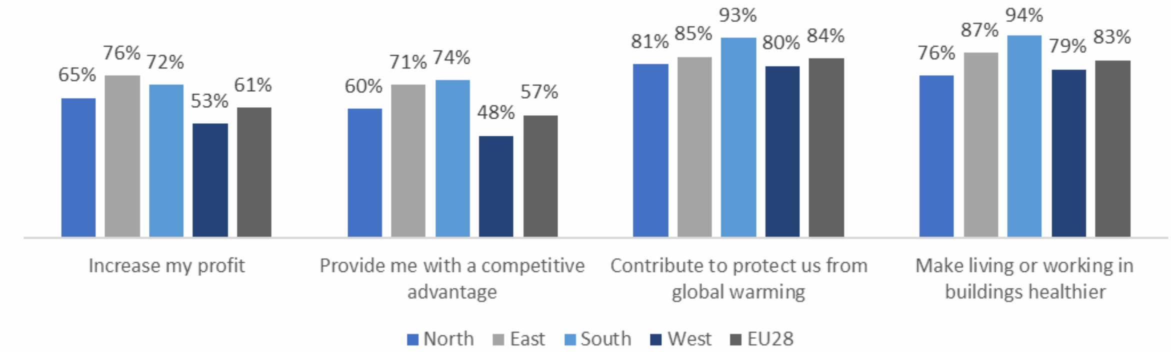
The relevance of the different drivers differs by construction sector. Environmental aspects are most relevant for heating (87%). A competitive advantage and healthier living and working is expected in particular from works on air-condition/photovoltaic (66% and 88%. respectively).

Figure 29 : Drivers for main contractors and installers



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



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.

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.

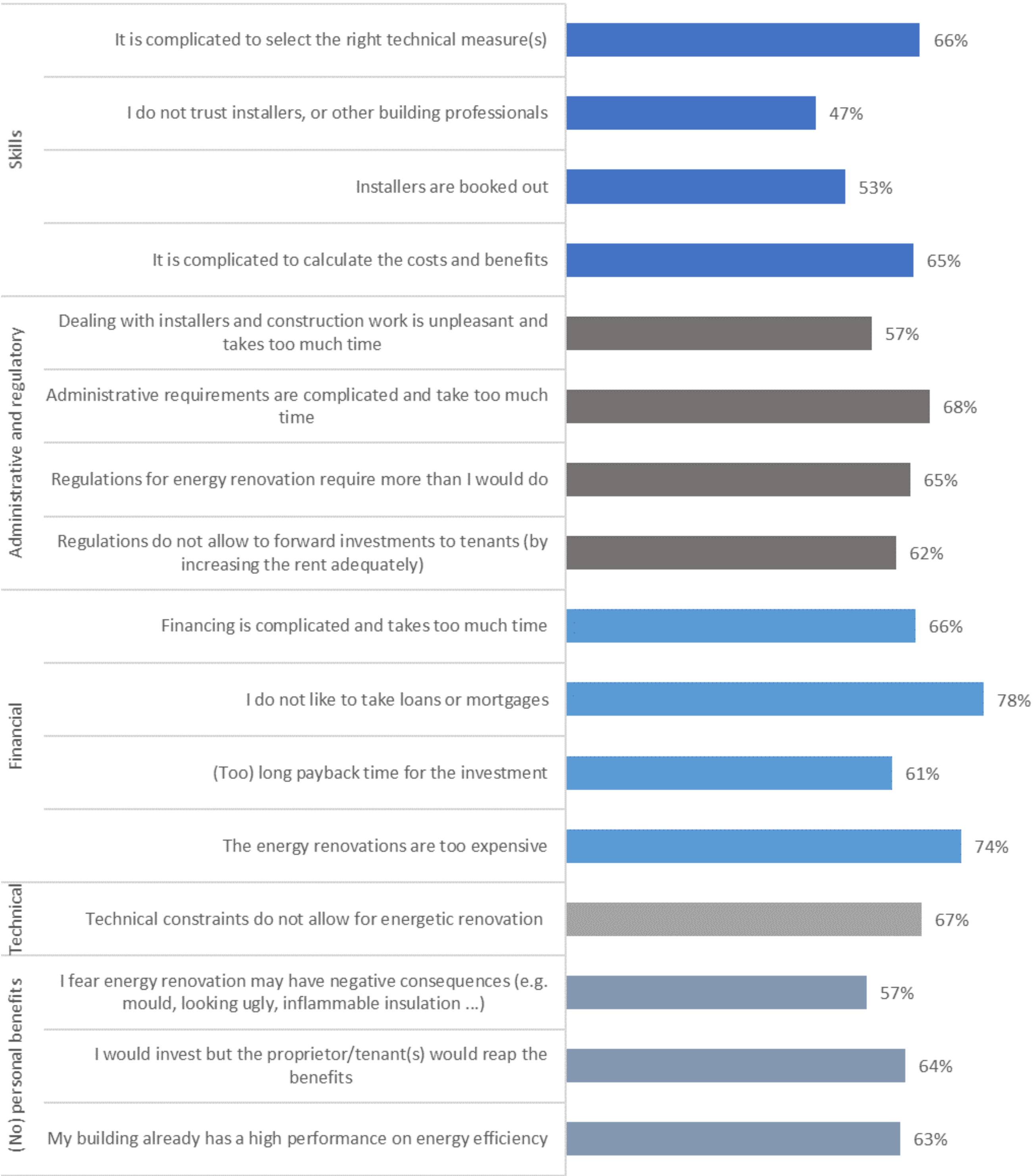
Competence and skills are key to implement requirements defined by the EPBD and other policy instruments. Therefore, this section also explores the relevance of, for example, availability of qualified and certified installers as a barrier.

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).

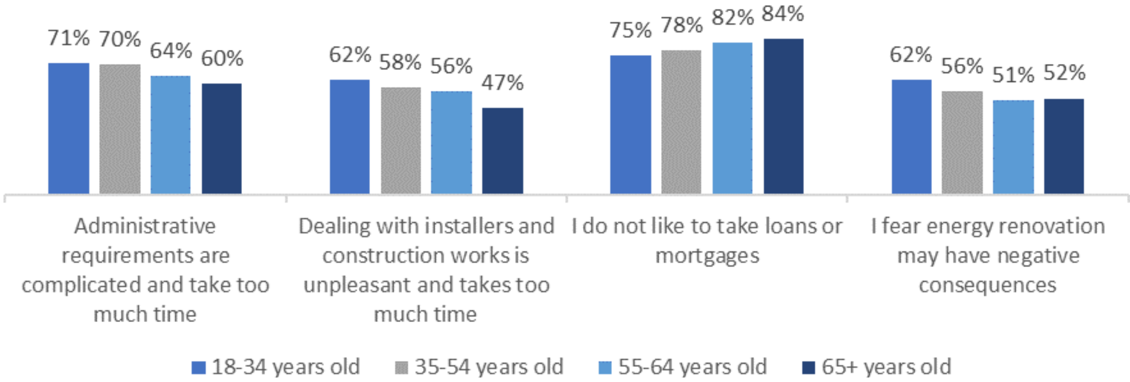
51 Question to consumers: "How important were the following aspects as a barrier for your energy renovation/installation?"

Figure 31: Barriers for consumers



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

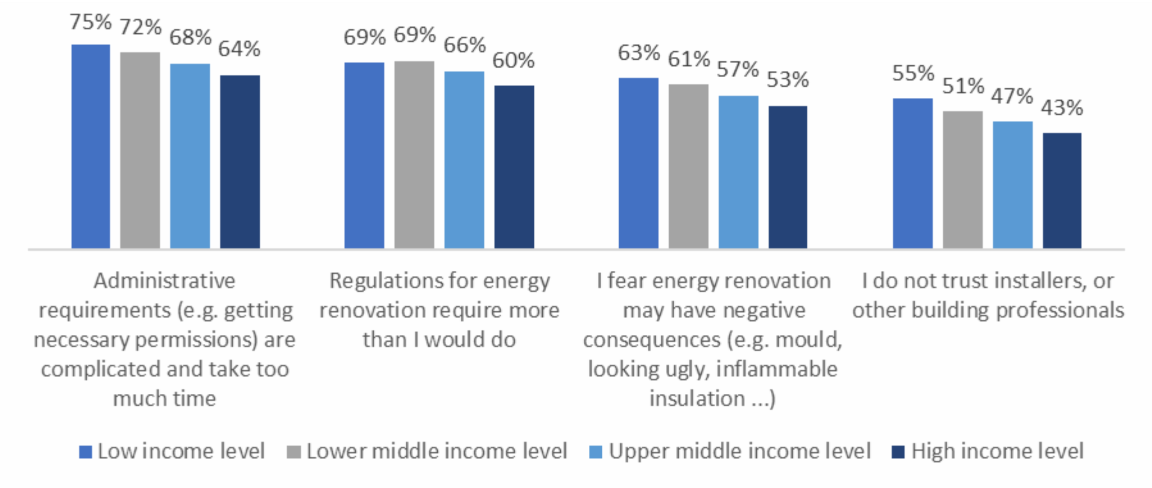
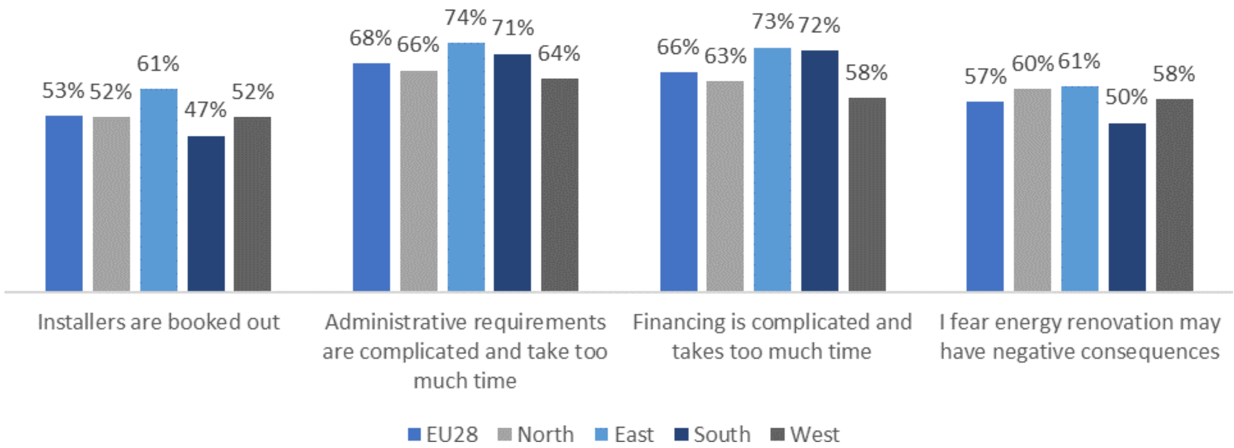


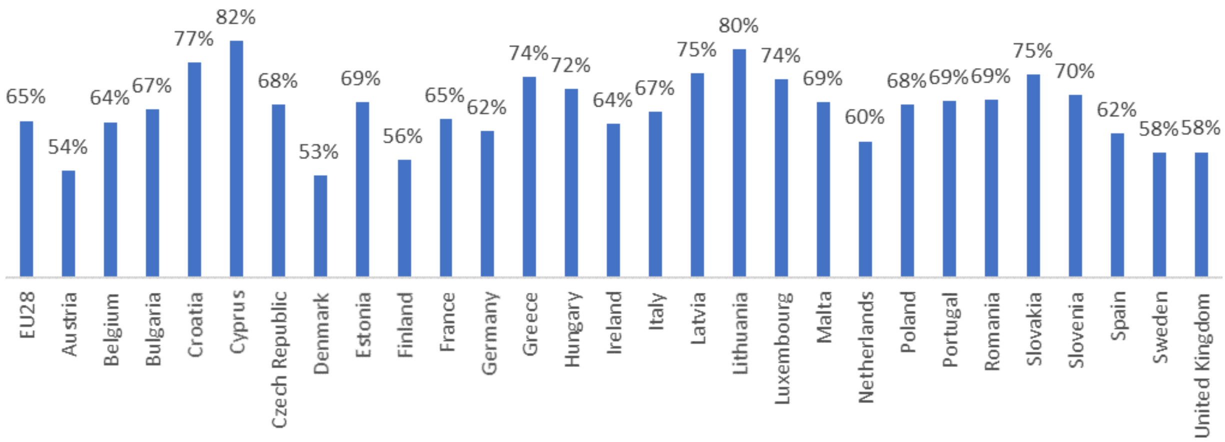
Figure 34 shows the strongest differences between European regions in terms of barriers. Barriers are most often perceived in Eastern Europe (as are triggers and drivers).

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

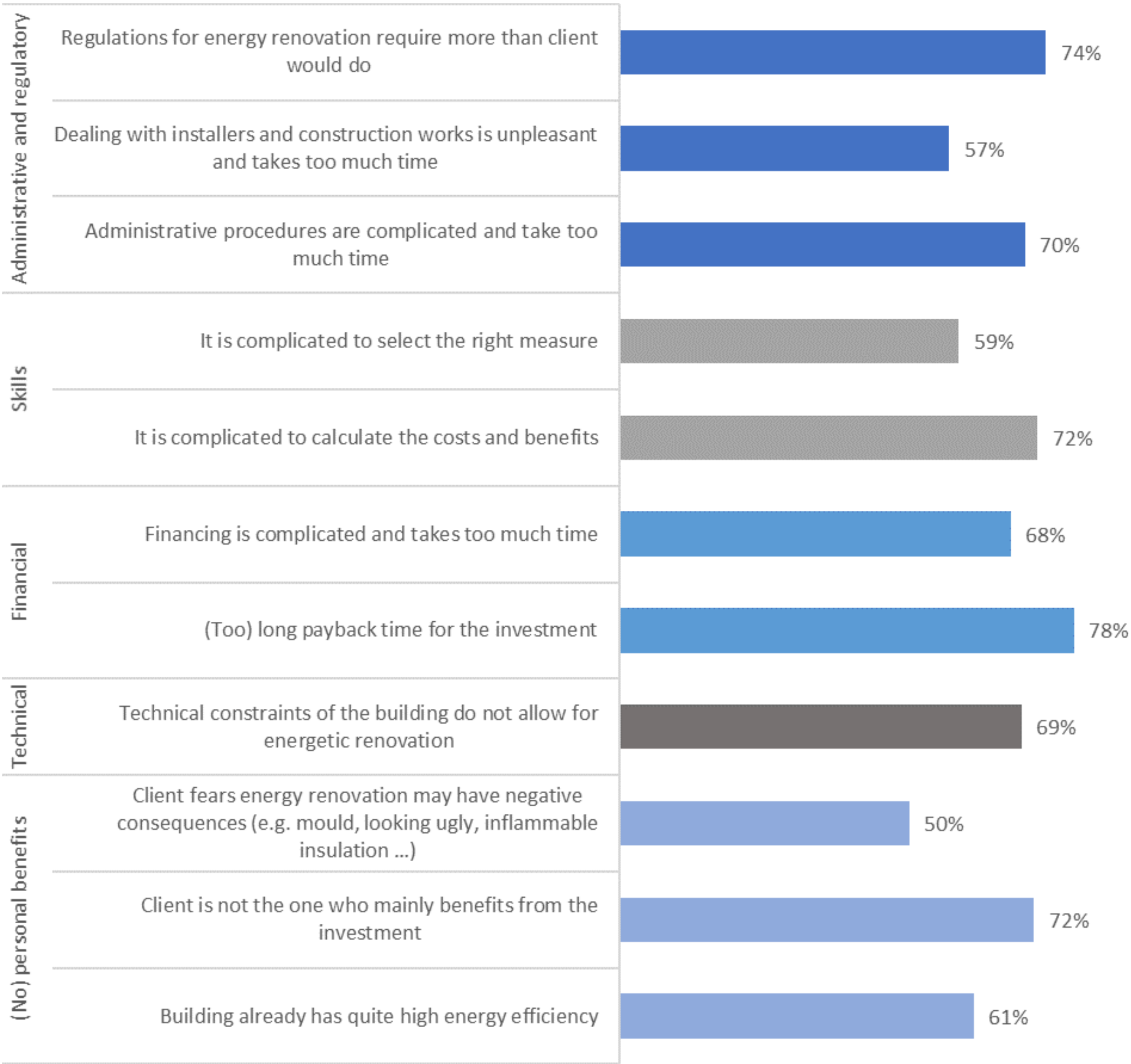


Clients of architects [52]

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.

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?"

Figure 36 : Barriers for clients of architects

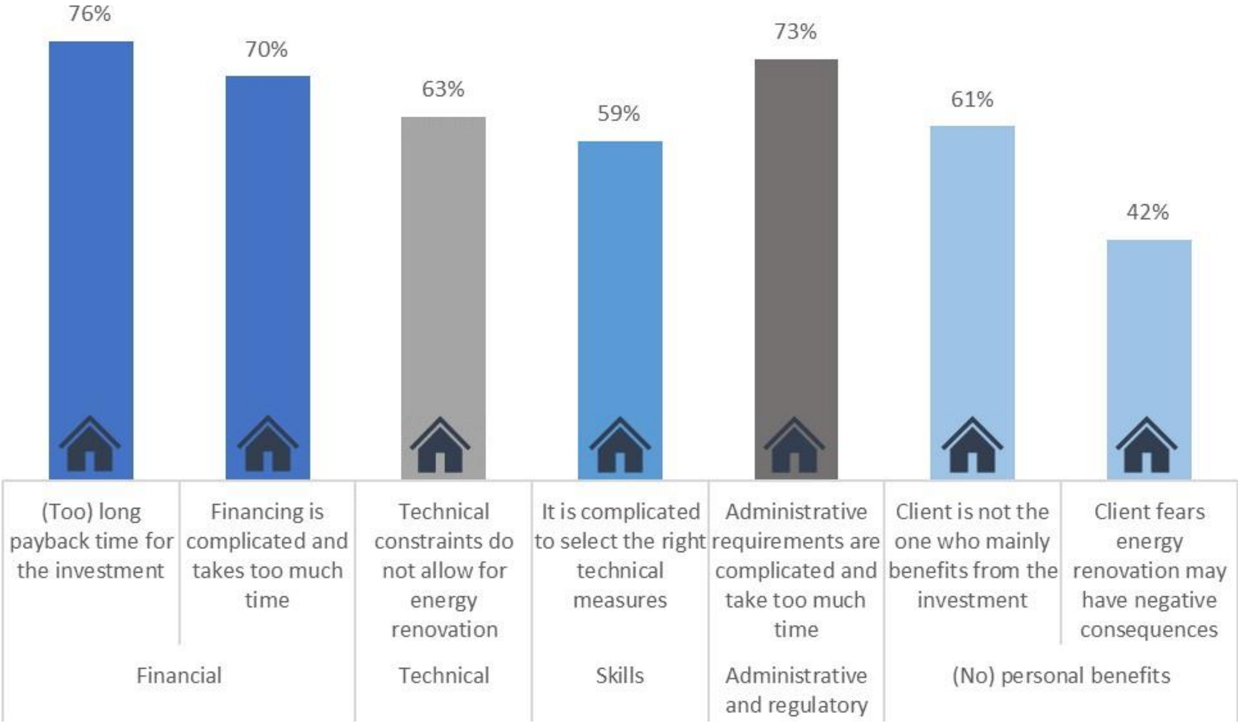


Clients of main contractors [53]

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).

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?"

Figure 37 : Barriers for clients of main installers

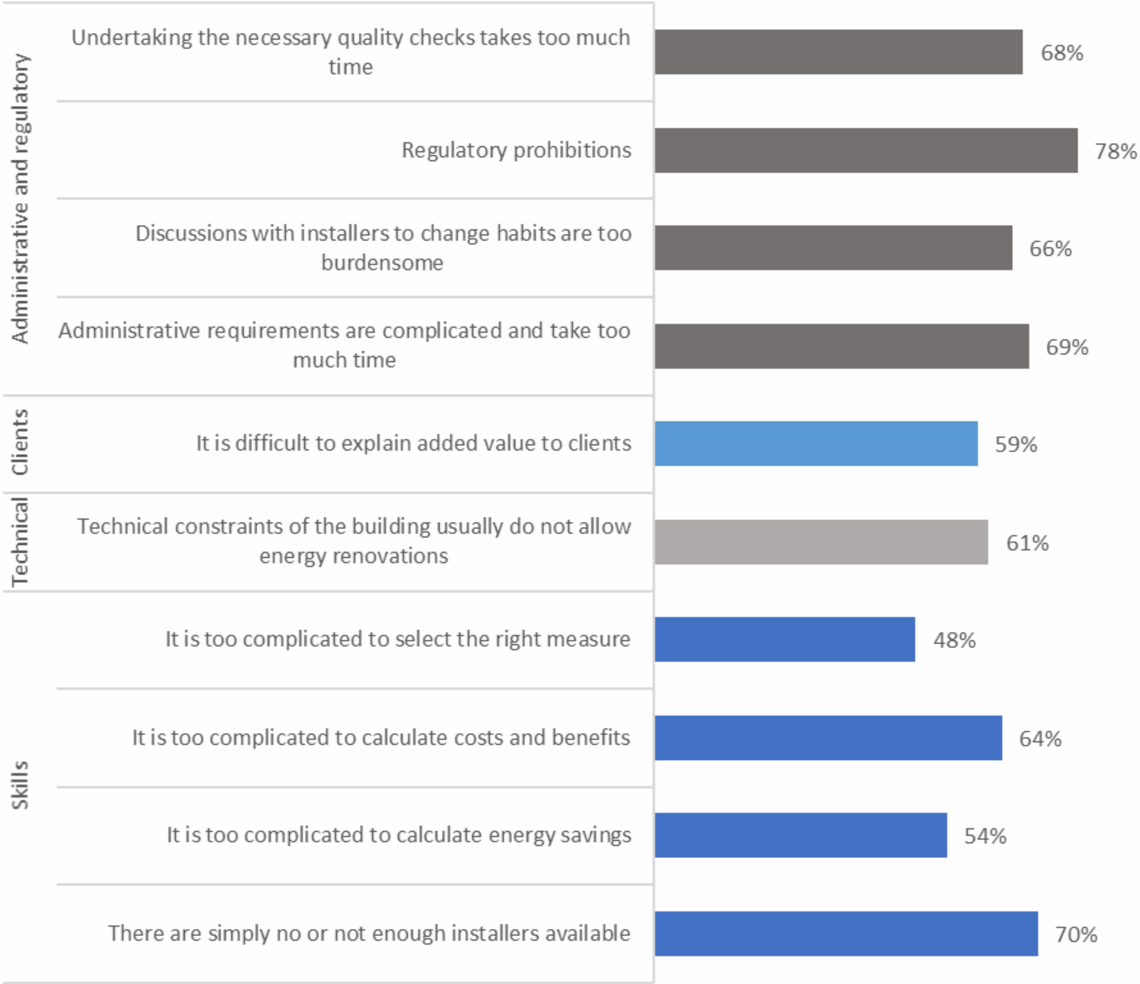


Architects[54]

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).

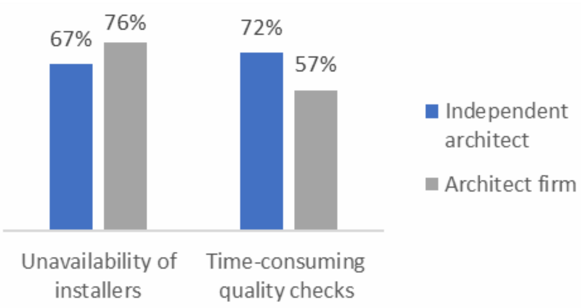
54 Question to architects, main contractors and installers: "How important are the following aspects as a barrier for you to recommend energy renovations?"

Figure 38 : Barriers for architects



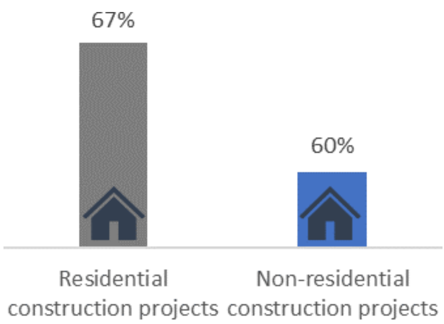
Architect firms more often **struggle to find installers.** Necessary quality checks restrain in particular independent architects to recommend energy renovation.

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

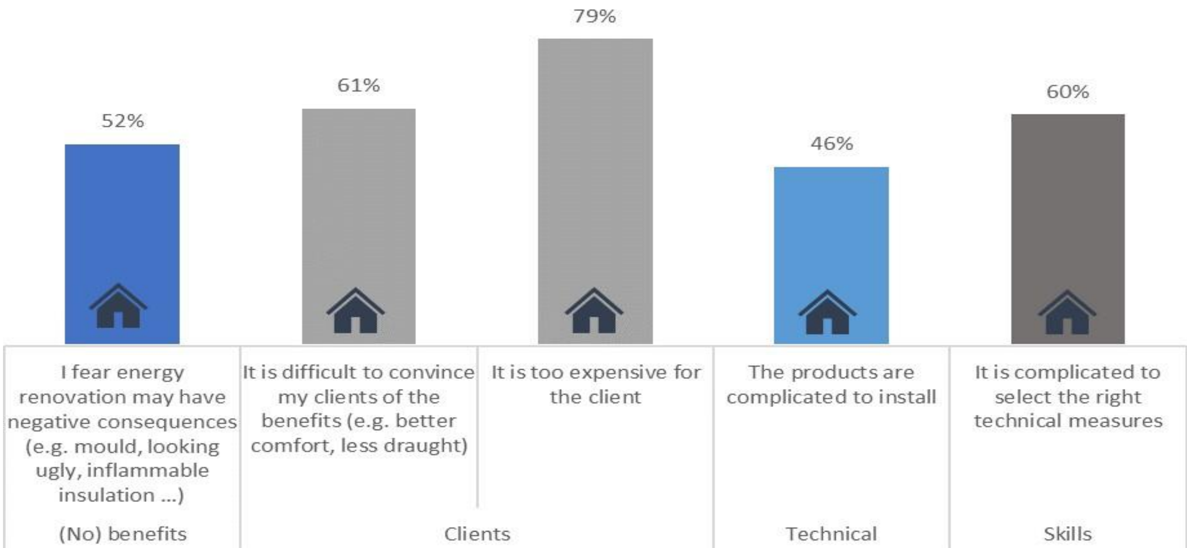


Table 17: Summary box - barriers

- 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.

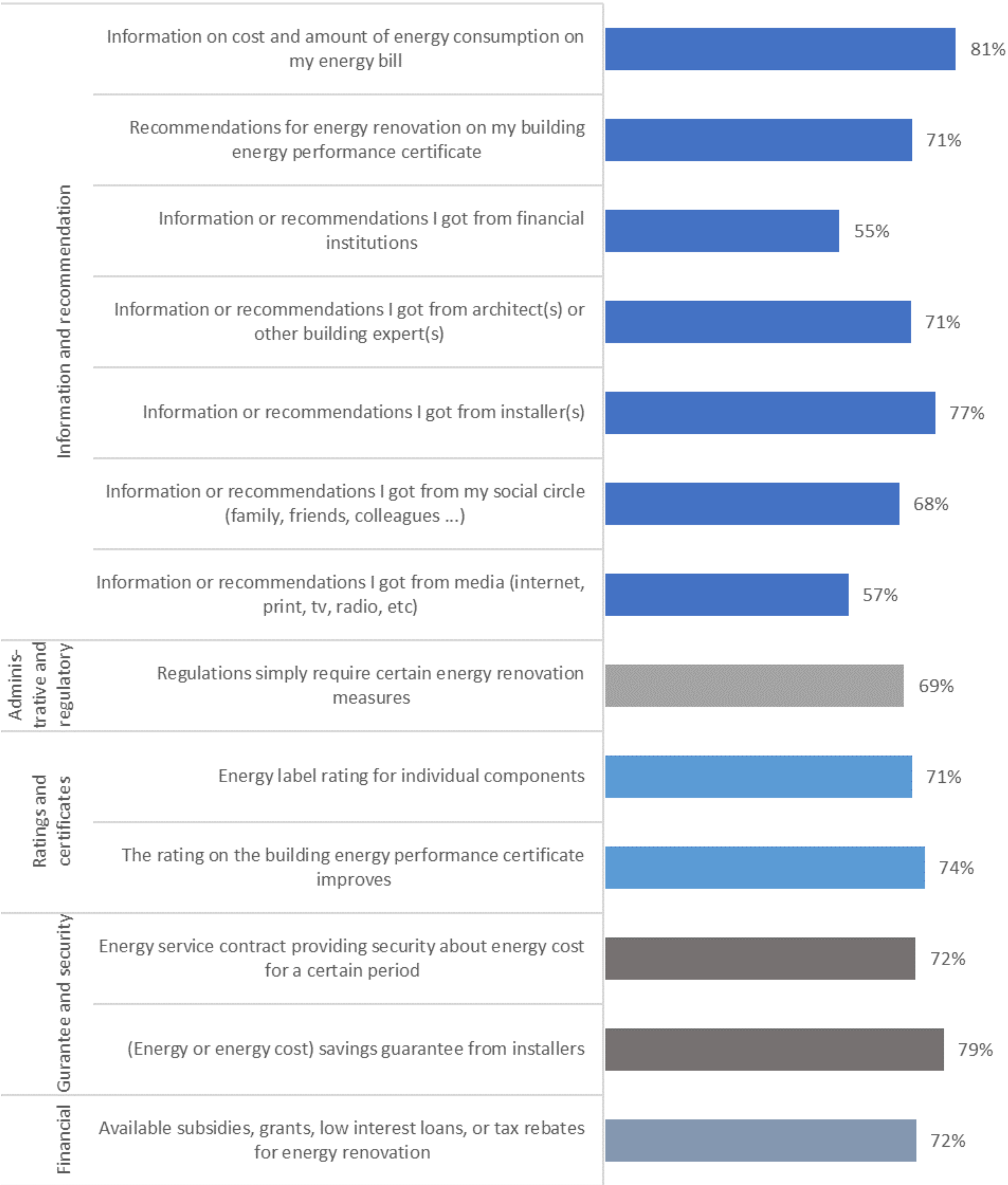
Consumers[57]

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.

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

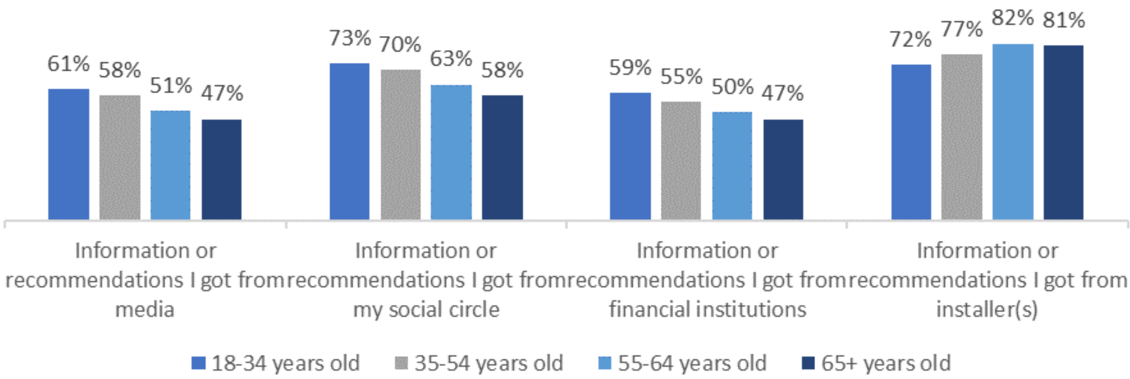
57 Question to consumers: "How important were the following aspects to help you overcome barriers for your energy renovations/installations?"

Figure 42 : Incentives for consumers



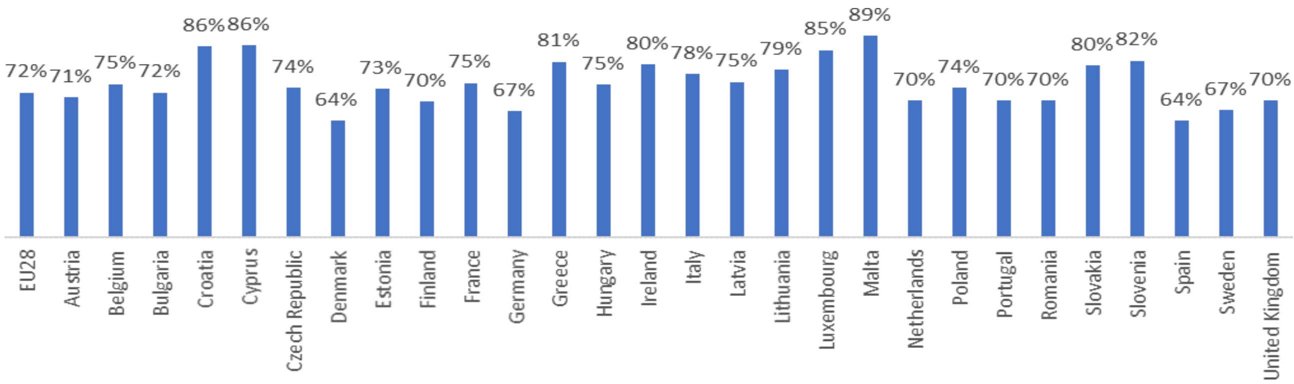
Information from media, the social circle and financial institutions is more encouraging for younger consumers to perform energy renovations. The same applies to consumers with a lower income, though the differences in the income category are smaller. Older cohorts see recommendations from installers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

Figure 43 : Incentives – age differences



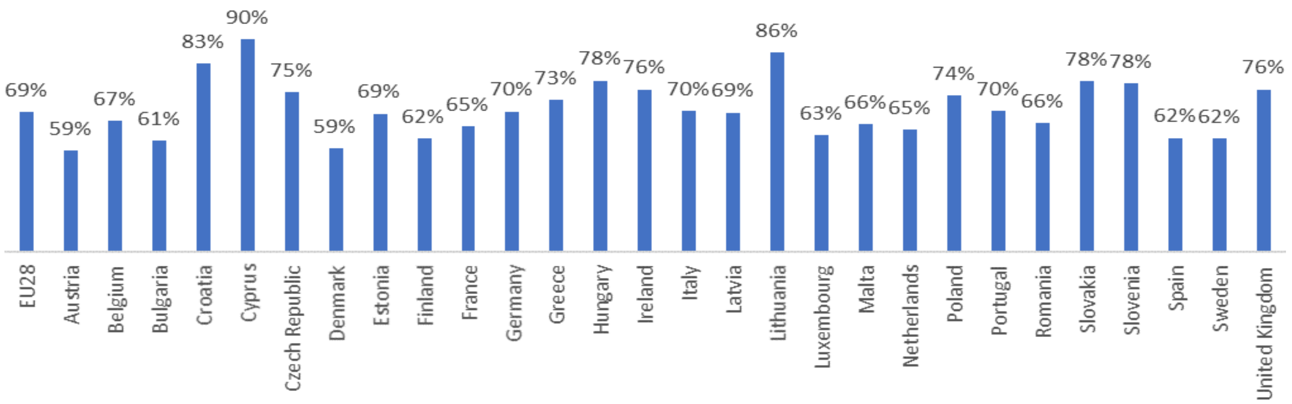
Favourable financing options are relevant incentives in all EU28 countries, with Croatia, Cyprus and Malta standing out in particular (Figure 44).

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



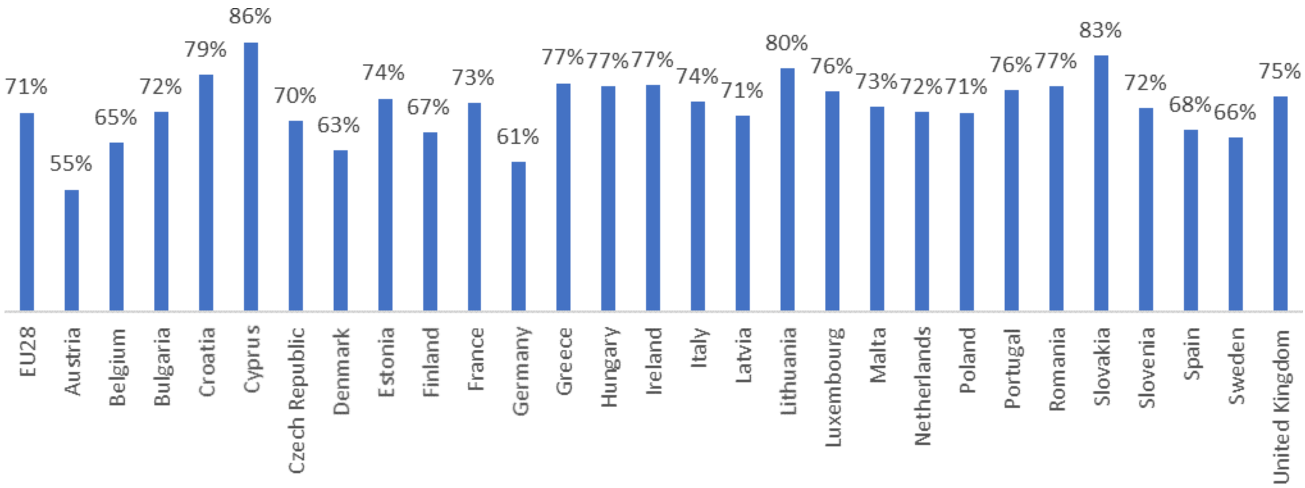
Regulations are most incentivising in Eastern Europe. Consumers in Croatia, Cyprus and Lithuania are most encouraged by regulations to invest energy renovation (Figure 45).

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



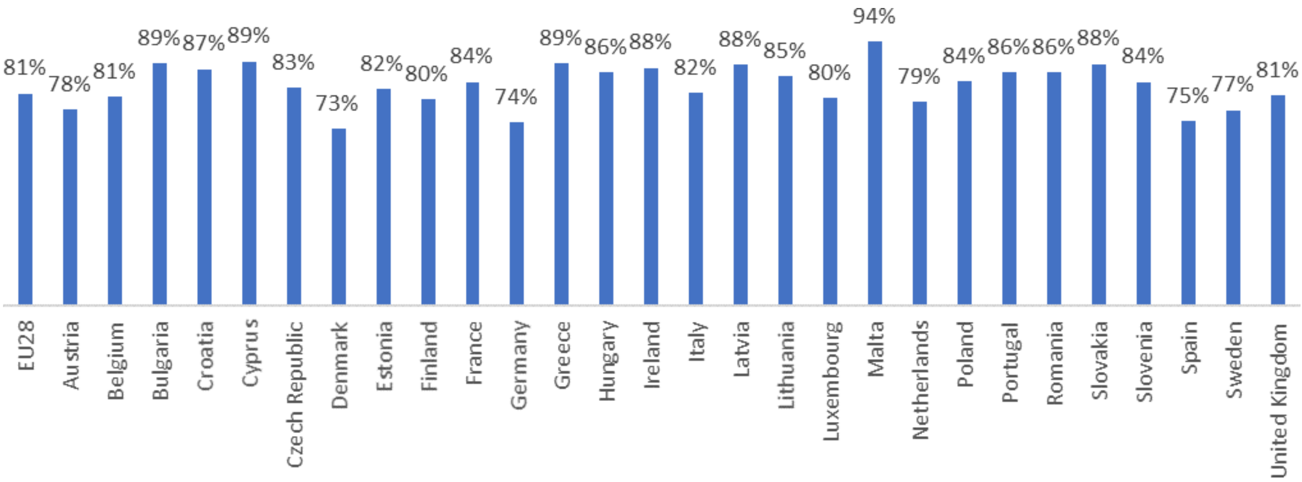
In Eastern and Southern Europe, **recommendations on the EPC are particularly incentivising**, with Cyprus, Lithuania and Slovakia at the top. In Austria, Denmark and Germany, information on the EPC are less encouraging, but the majority still views it as incentive (Figure 46).

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).

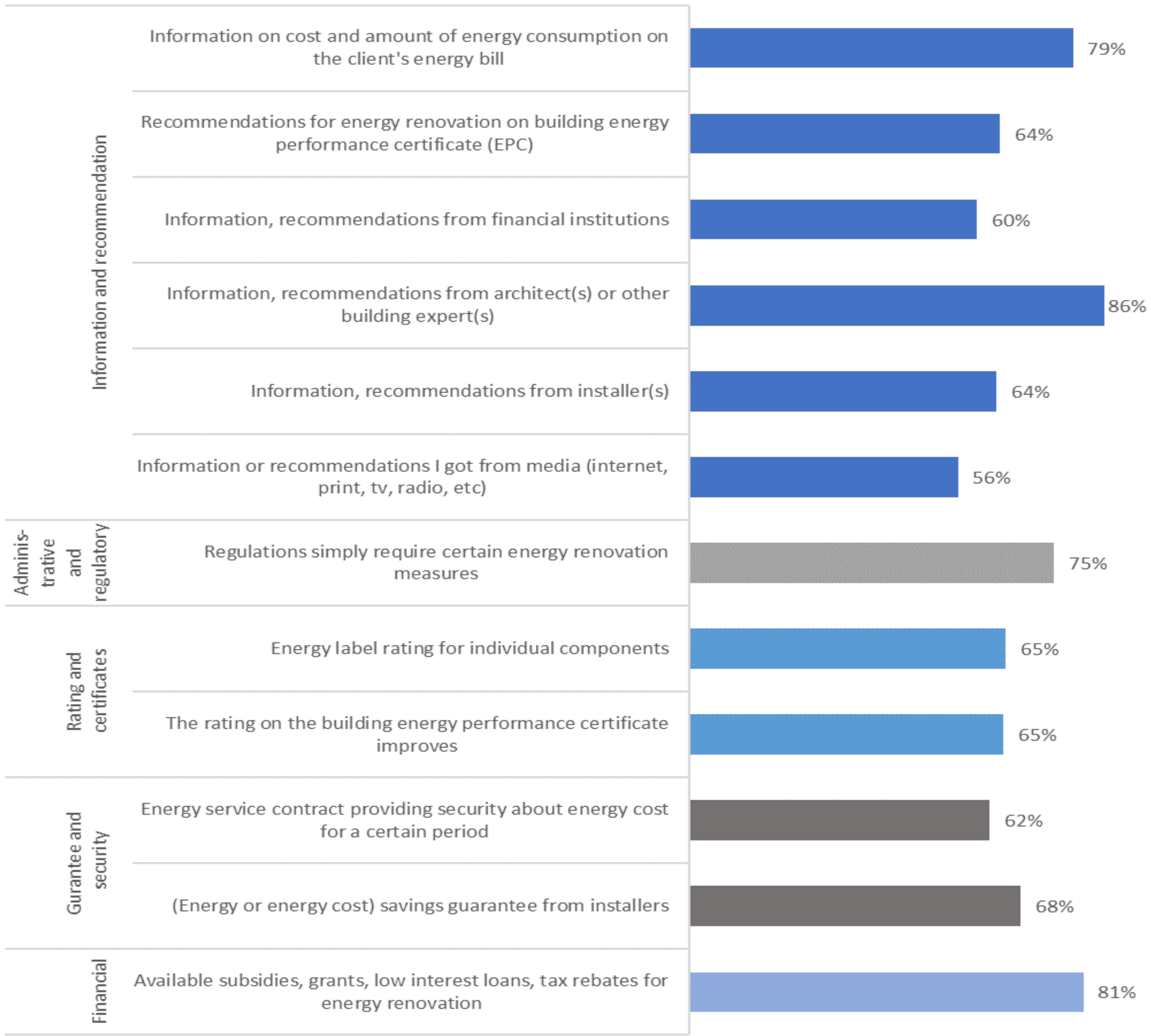
Figure 47 : Information on the energy bill by country



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

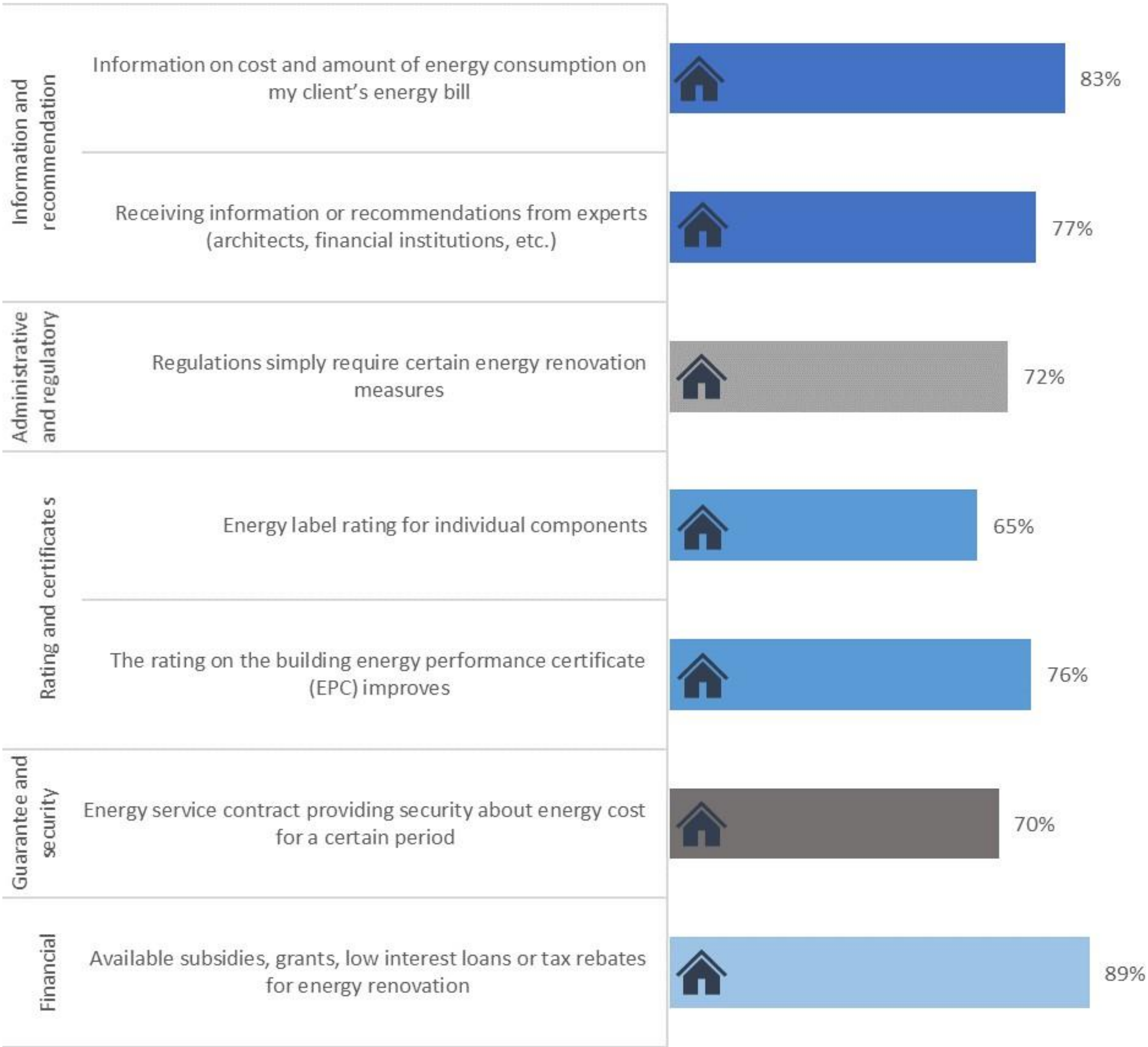


58 Question to architects and main contractors: "How important were the following aspects to help your [non-residential/residential single-family house/residential multi-family house] clients overcome the barriers to perform energy renovation?"

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

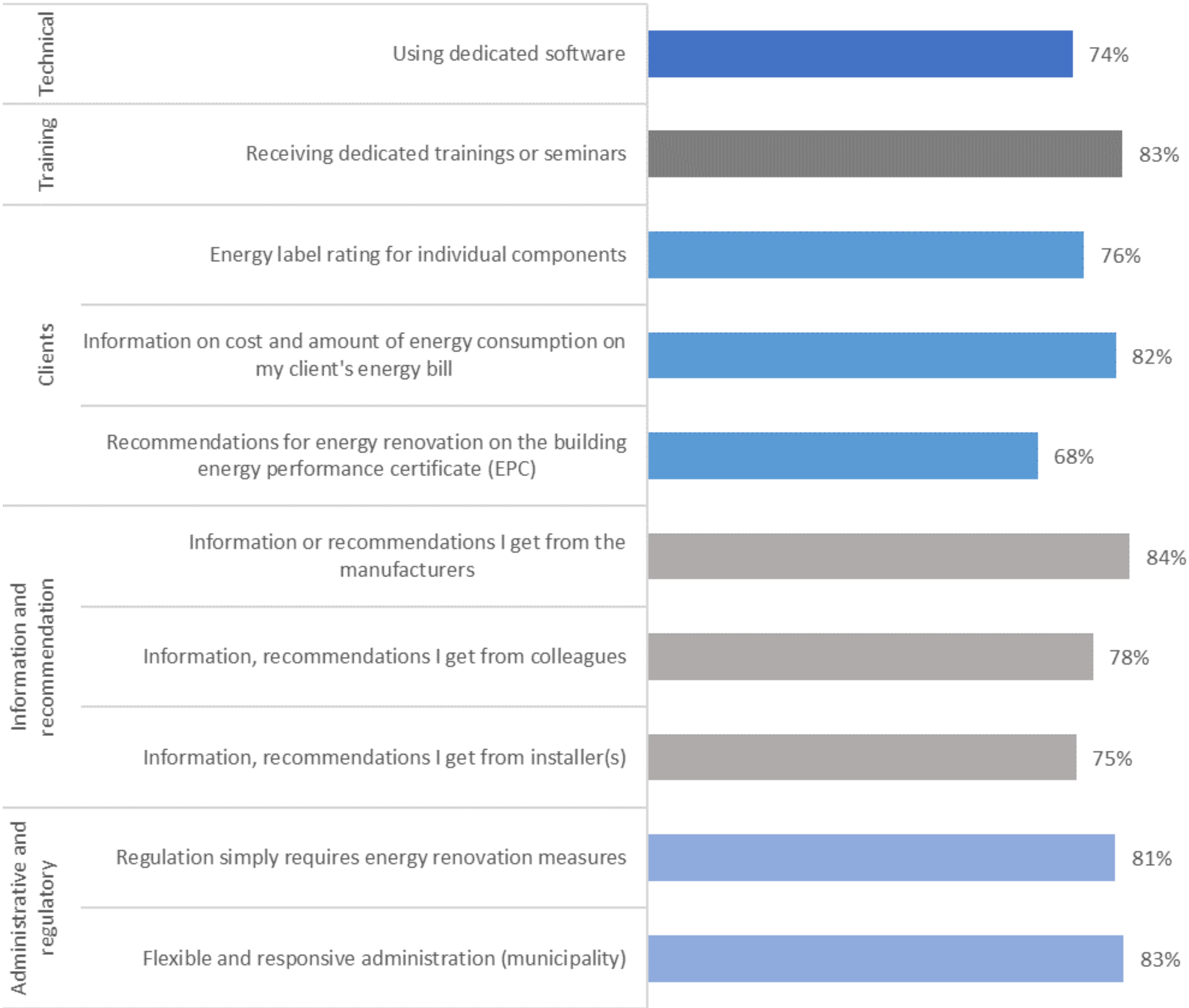


59 Question to architects and main contractors: "How important were the following aspects to help your [non-residential/residential single-family house/residential multi-family house] clients overcome the barriers to perform energy renovation?"

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



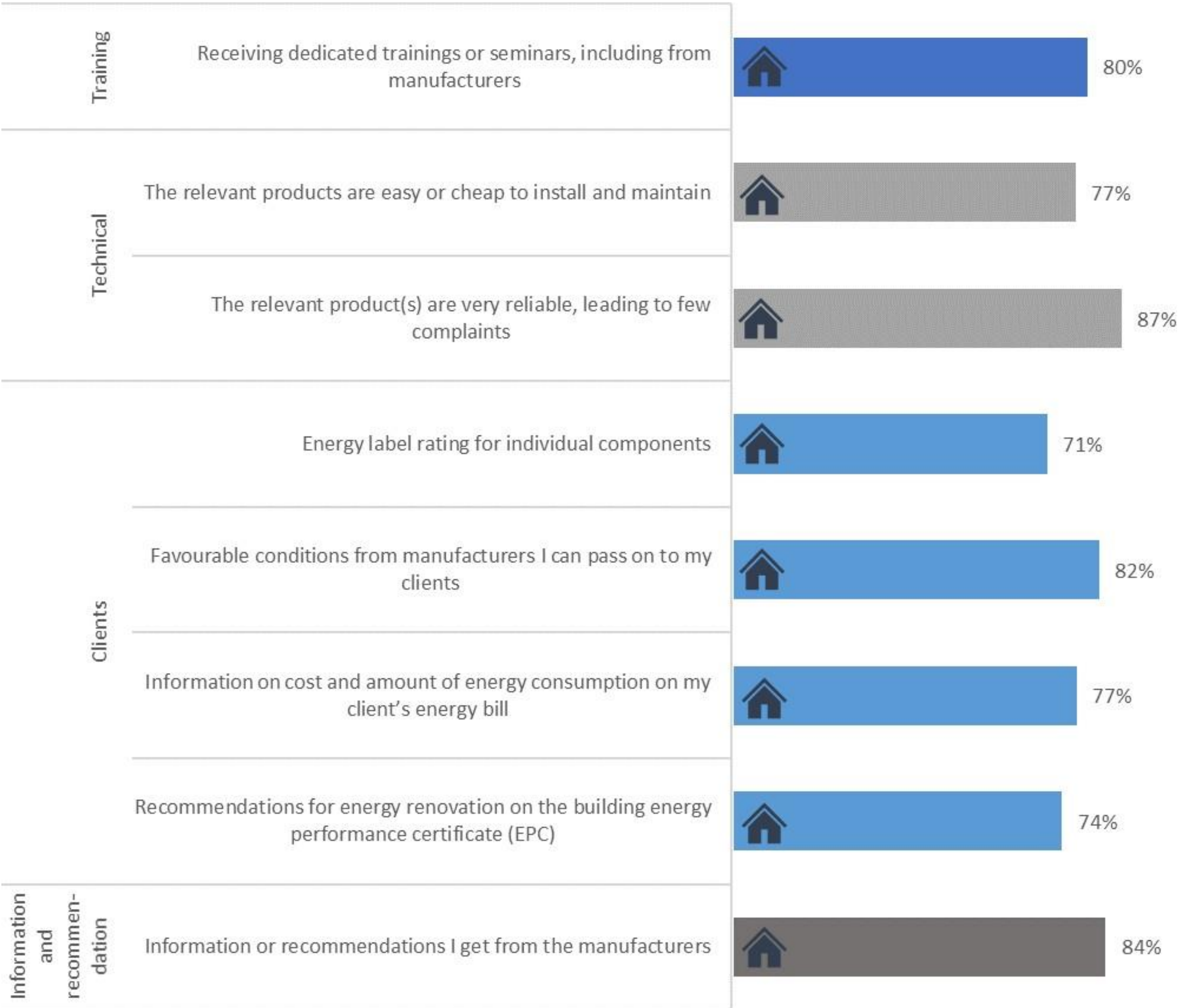
60 Question to architects, main contractors and installers: "How important are the following aspects to help you to overcome barriers to recommend energy renovations?"

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

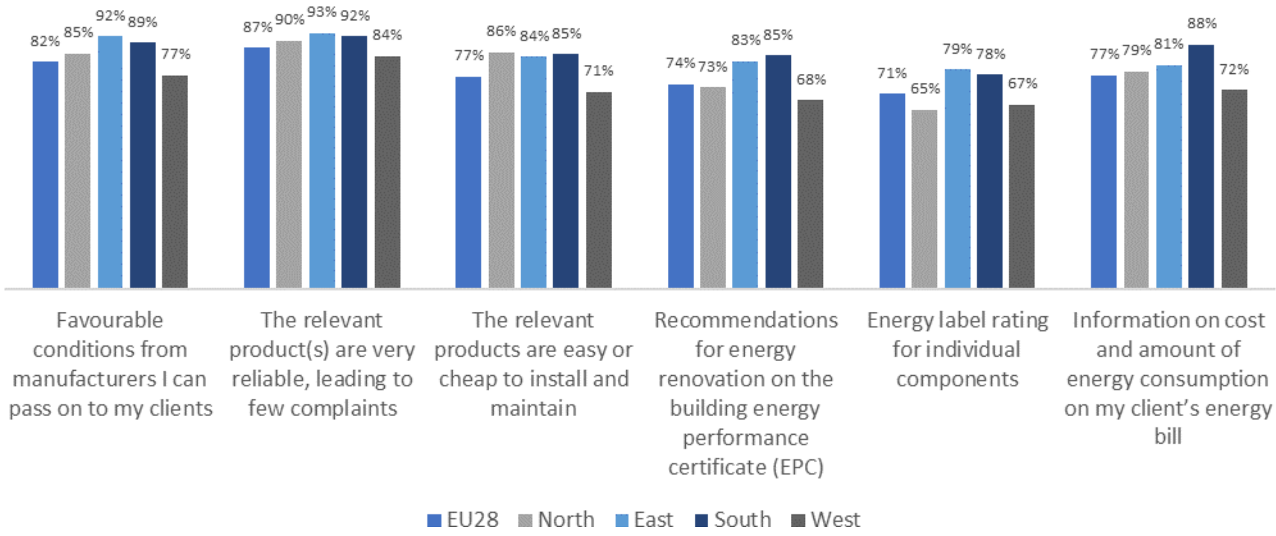


Table 18: Summary box - incentives

- 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.

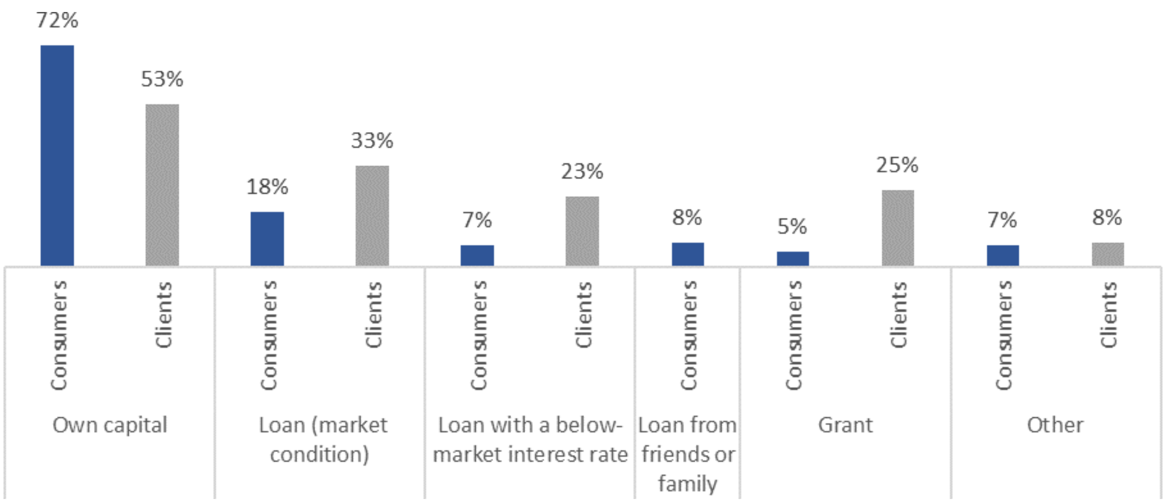
4.3.5 Funding sources

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.

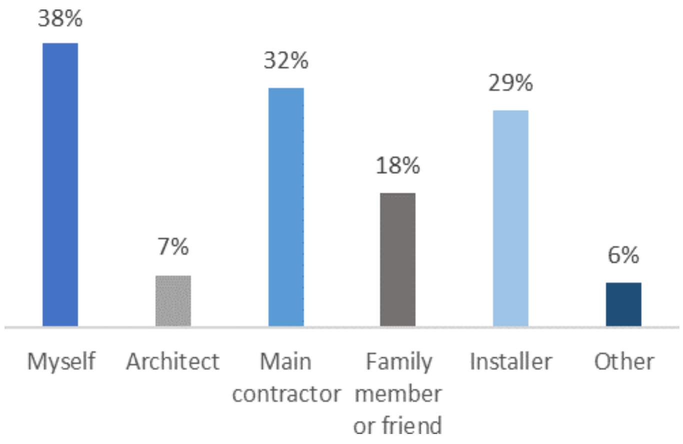
In general, there is a **significantly negative attitude towards loans**, the older the cohort the stronger. This clearly explains the high shares of own capital used for financing energy renovation measures and its increase with increasing age of respondents. On the other hand "grants, loans etc." are 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

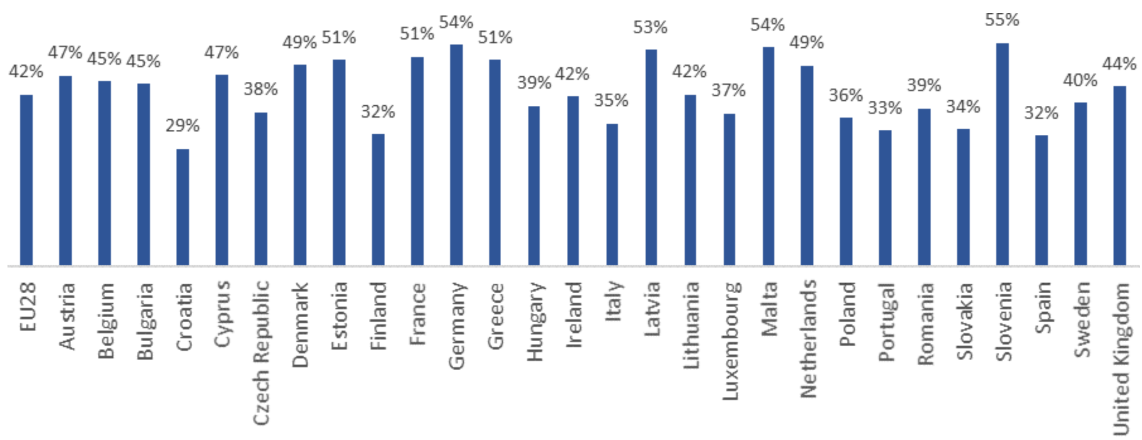


Figure 56: Proportion of owners reporting architects to be responsible for the quality of renovation works by country

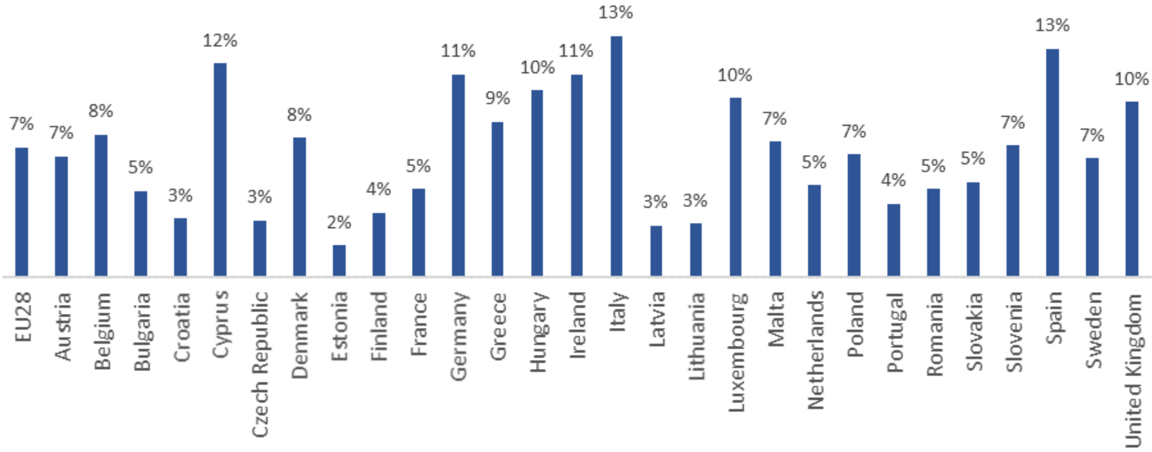


Figure 57: Proportion of owners reporting main contractors to be responsible for the quality of renovation works by country

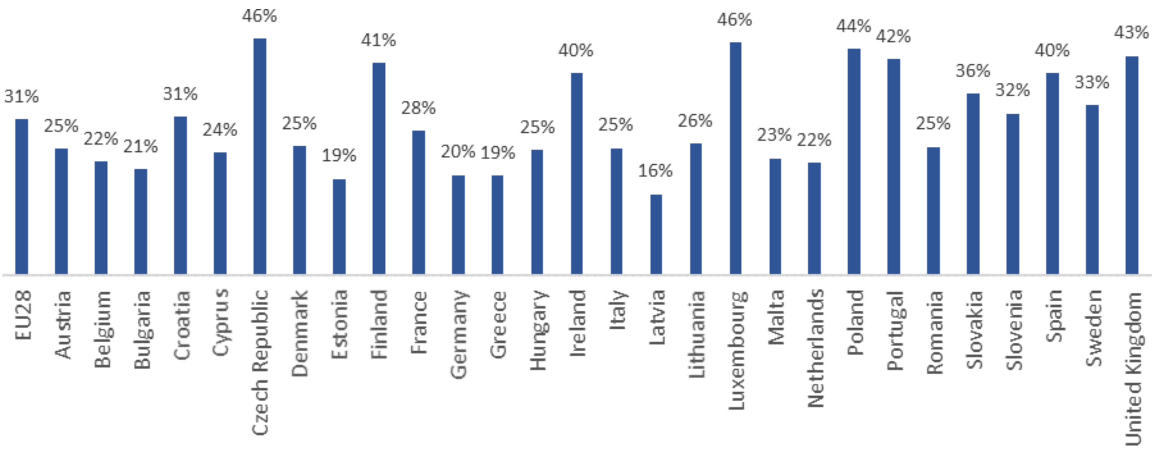
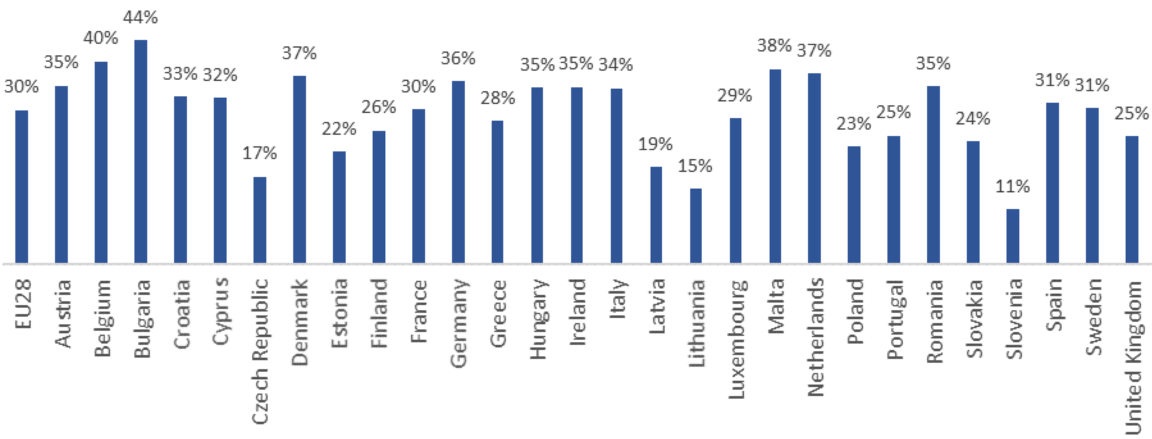


Figure 58: Proportion of owners reporting installers to be responsible for the quality of renovation works by country



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.

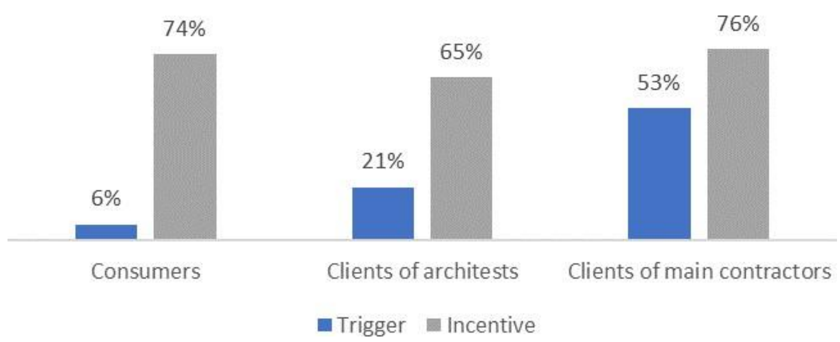
The first stage in the decision process is to be *triggered* to do an energy renovation *at all*. For consumers who are owners or tenants of their dwelling, EPCs only have a modest trigger function compared to e.g. maintenance and repair, available budget, shortcomings that cause poor health, recommendations 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

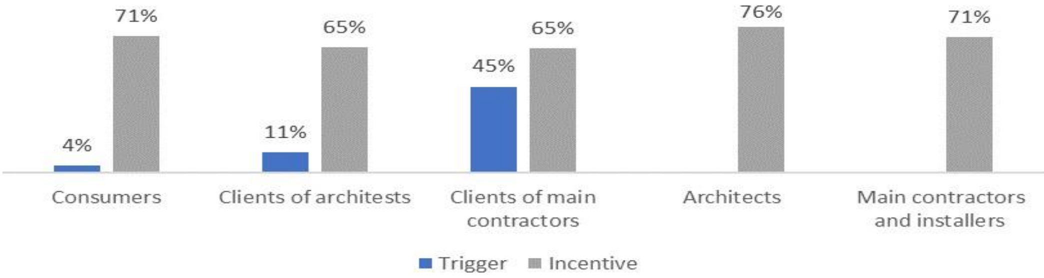
Necessary maintenance and inspection is the strongest trigger of consumers to undertake energy renovations (Figure 18). Therefore, information on potential energy renovation measures should be closely linked to these inspections. In this context, it might be surprising that architects see energy audits 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

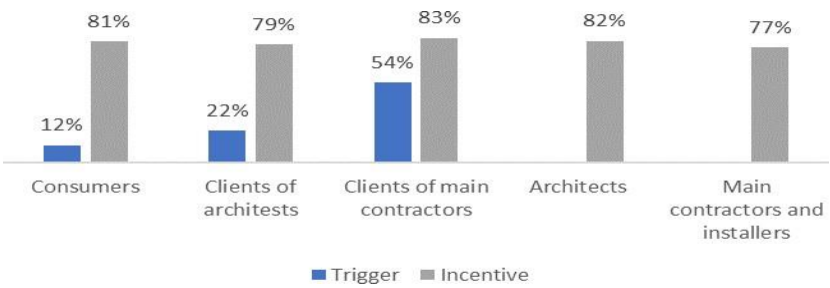
Amongst consumers, information provided on energy bills has a strong impact on *triggering* energy renovation, stronger than EPCs (Figure 18) or energy labels. This is different for clients of architects (Figure 23) and main contractors/installers (Figure 24) for whom the impact is equally strong, although 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 ($3\% \le x \le 30\%$ savings)
- Medium renovations ($30\% < x \le 60\%$ 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.

COUNTRY REPORTS

Introduction

This report presents findings from the 2018-2019 "comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU" at EU Member State level.

The overall aim of this study is to deliver a comprehensive analysis of the renovation activities and nearly zero-energy buildings (NZEB) uptake in the EU and Member States from 2012 to 2016. For this purpose, a combination of sound statistical analyses was applied, including the conduction of surveys with consumers, architects, installers and main contractors, and the purchase and analysis of market data on sales of relevant components. A set of quantitative and qualitative indicators was developed in line with the indicators of the Building Stock Observatory (BSO). The development of a EU28 building stock inventory and the collection of new construction data in the EU further informed the analysis. Data was collected and analysed separately for residential and non-residential buildings. The findings will be used to inform the design, monitoring and evaluation of energy efficiency policies.

Each Member State report includes the following:

- **Population size** (Eurostat, demo_pjan)
- **Cooling/heating degree days**: "Heating degree day (HDD) index is a weather-based technical index designed to describe the need for the heating energy requirements of buildings. Cooling degree day (CDD) index is a weather-based technical index designed to describe the need for the cooling (air-conditioning) requirements of buildings. HDD and CDD are derived from meteorological observations of air temperature, interpolated to regular grids at 25 km resolution for Europe." (Eurostat, nrg_chdd_a)
- **Dampness damages in buildings as percentage of the population**: This information is based on the EU statistics on income and living conditions (EU SILC question HH040): "Do you have any of the following problems with your dwelling/accommodation? A leaking roof; damp walls/floors/foundation; rot in window frames or floor". As different sources such as Eurostat (mdho01) and the Healthy Homes Barometer 2017 have shown, adults living in a damp dwelling have a significantly higher probability to report poor health.
- **Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)**: This is the average reduction of all residential / non-residential building stock's total annual GHG emissions - from heating, cooling, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy - that was achieved compared to the previous year during the period 2012-2016 by means of energy renovation.
- **Jobs maintained by building renovations [FTEs], residential and non-residential (average 2012-2016)**: This number indicates the total number of fulltime employees (FTE) in the construction sector involved in renovations per year on average for the period 2012-2016. A factor of 8.52 FTE per million Euro spent has been applied based on Janssen and Staniaszek (2012) and Amélie Cuq et al. (2011).

- **Total building stock [floor area, m²] shares (2016)**: Different sources were used to determine the EU and Member State building stock, obtaining data per building floor area and number of buildings.

- **Renovation rate [%/stock] (average 2012-2016)**: This is the cumulated affected building floor area [m2] of all buildings that underwent an energy renovation in calendar year x (e.g. 2013) divided by the total floor area [m2] of the building stock in the same period. The unit is [%]. The total energy renovation rate is defined as the sum of all renovation rates of the covered depths: "below threshold" ($x < 3\%$ savings), "light" ($3\% \leq x \leq 30\%$ savings), "medium" ($30\% < x \leq 60\%$ savings) and "deep" ($x > 60\%$ savings).

- **Total investments [Euro in million] (average 2012-2016)**: The approach for calculating the investment costs is based on the investment cost database for building construction products, and direct cost information obtained from the surveys.

- **Primary energy savings total [TOE] (average 2012-2016)**: This is the average reduction of all residential / non-residential building stock's total annual primary energy use - from heating, cooling, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy - that was achieved compared to the previous year during the period 2012-2016 by means of energy renovation.

- **Specific primary energy savings [kWh/(m².y)] (average 2012-2016)**: This is the average improvement of the energy performance of a residential / non-residential building through an average energy renovation (before- after comparison). It is expressed as kWh primary energy savings per m2 floor area and year.

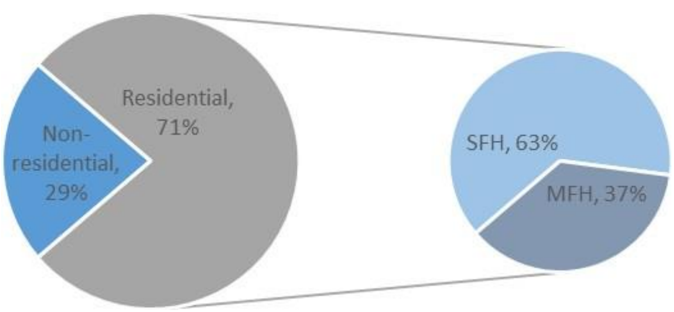
- **Definition of nearly-zero energy buildings (NZEB)**: The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero-energy building". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for this Member State based on different sources.

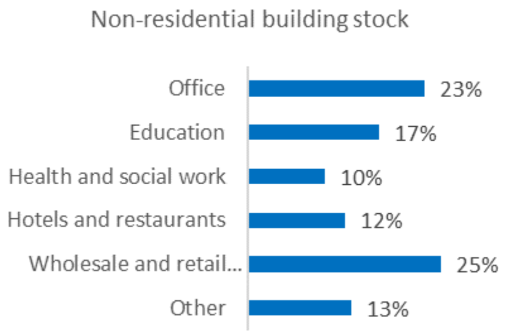
- **Total number of nearly-zero energy buildings and their share of the construction market [%] by year**: This information is based on survey data and represents the perceived uptake from the perspective of architects. This may differ from an uptake based on current definitions of NZEB by Member States.

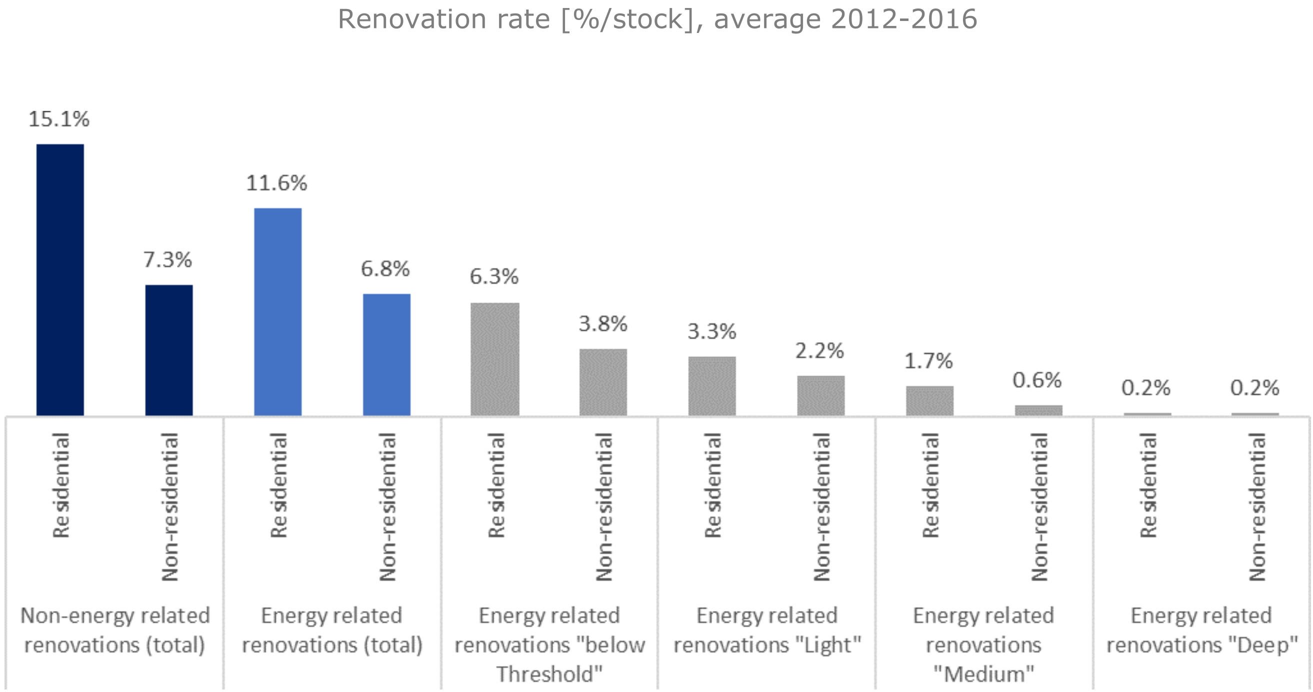
Austria

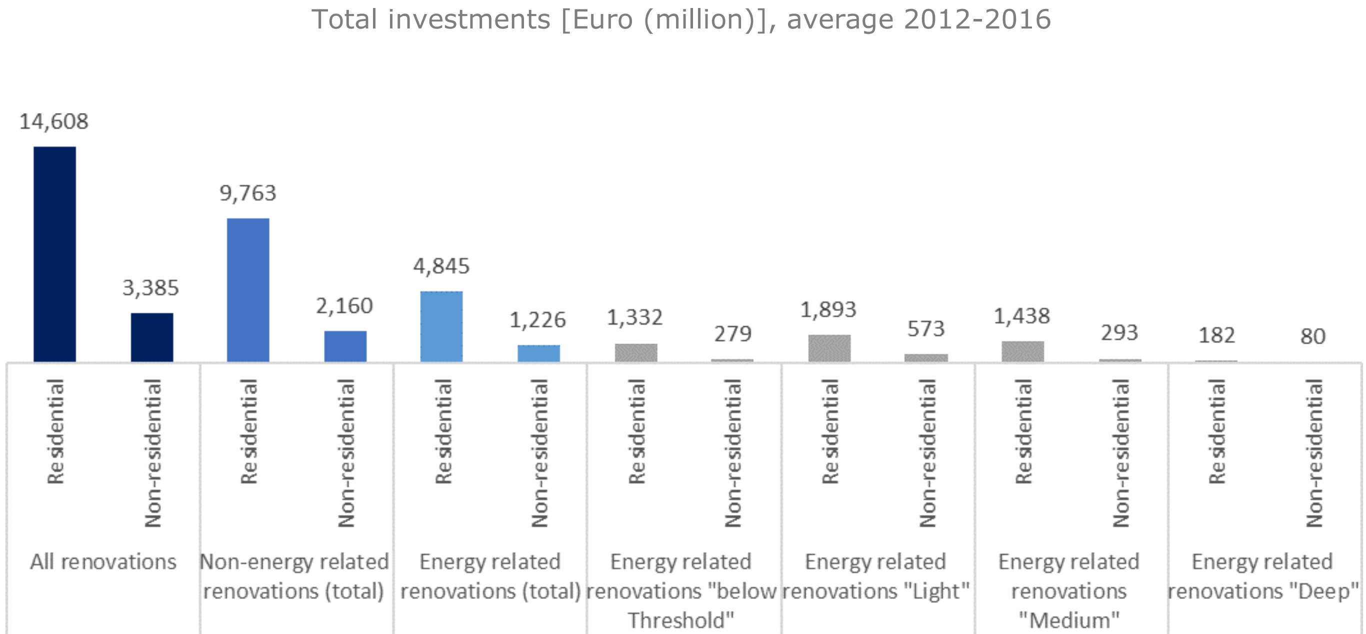
Population (2018)	8,822,267
Cooling/heating degree days (2018)	32.6/3196.5
Dampness damages in buildings [% of population]	12%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	310/180
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	125,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	29,000

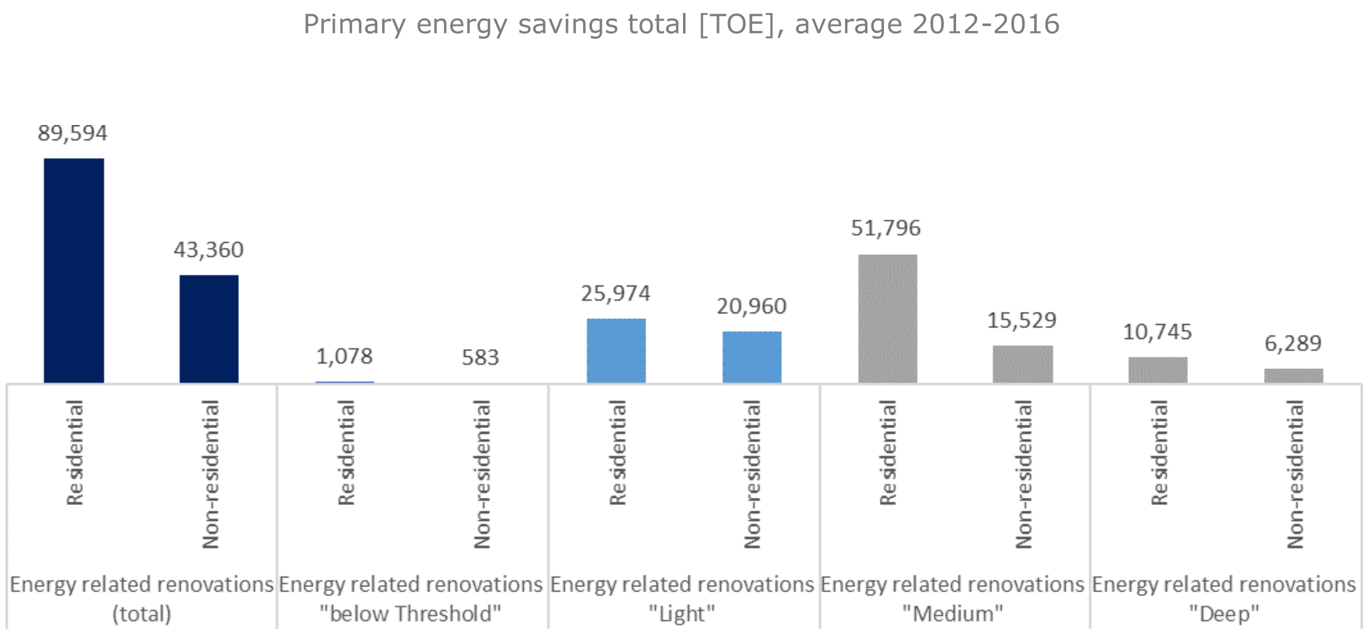
Total building stock [floor area, m²] shares, 2016

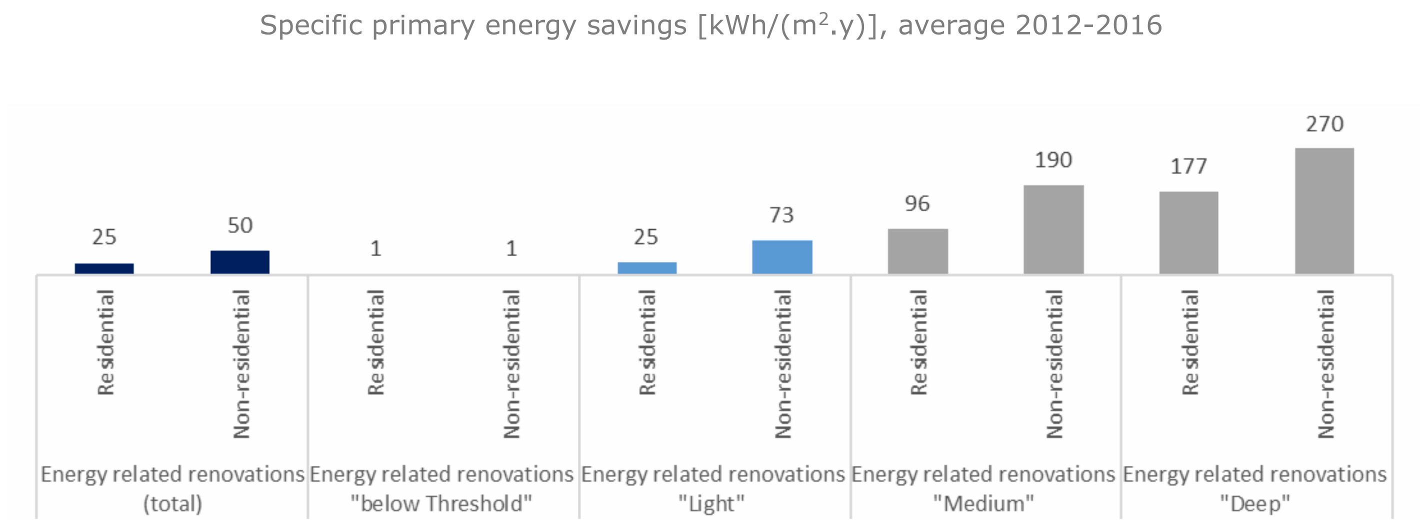





Renovation rate [%/stock], average 2012-2016
15.1%
7.3%
11.6%
6.8%
6.3%
3.8%
3.3%
2.2%
1.7%
0.6%
0.2%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
14,608
3,385
9,763
2,160
4,845
1,226
1,332
279
1,893
573
1,438
293
182
80
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
89,594
43,360
1,078
583
25,974
20,960
51,796
15,529
10,745
6,289
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m2.y)], average 2012-2016
25
50
1
1
25
73
96
190
177
270
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[1]

Indicative numerical indicator of primary energy use:

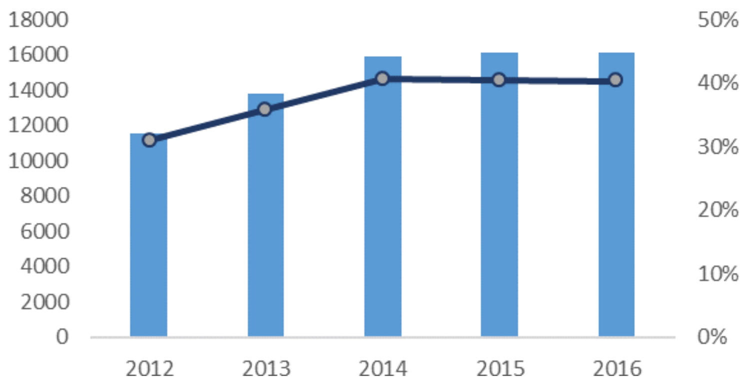
Residential:

125 kWh/(m².y)

Non-residential:

125 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

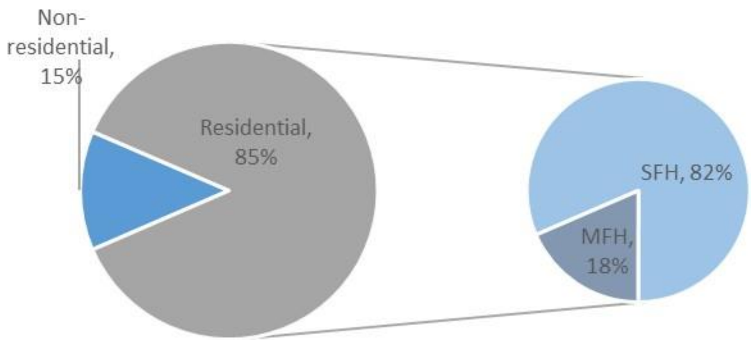


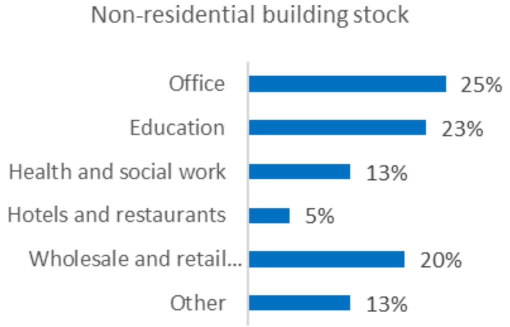
[1] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

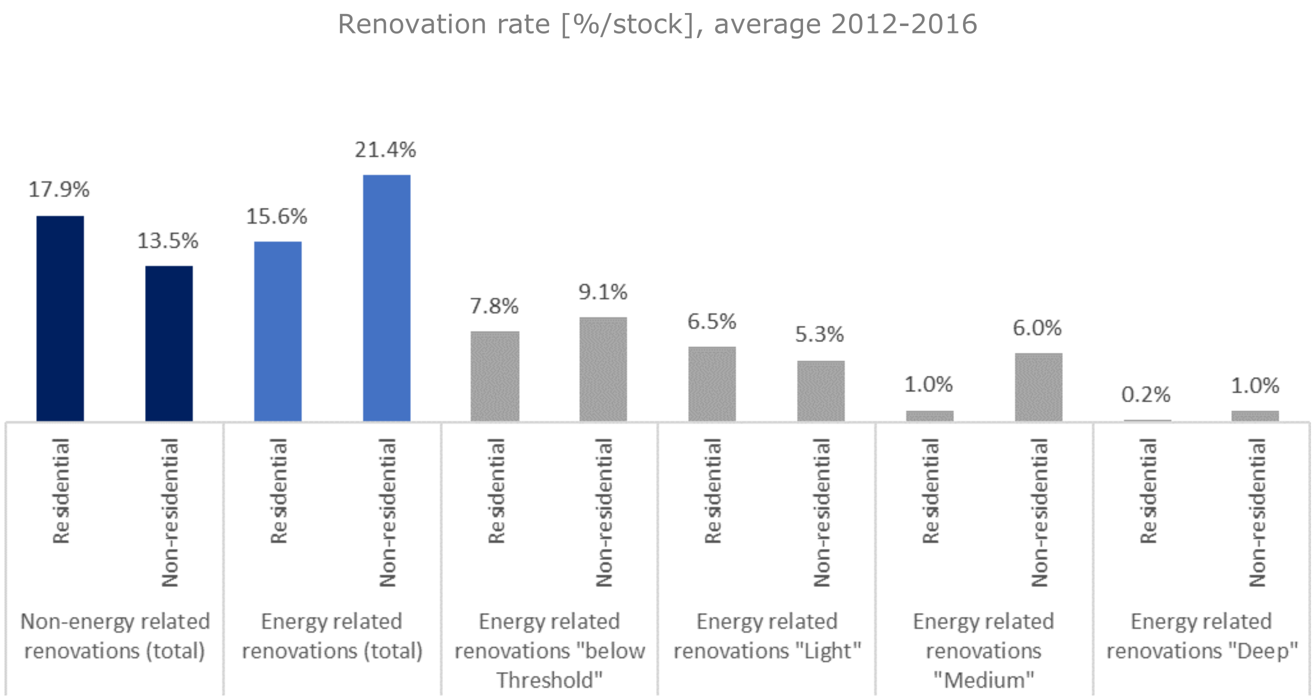
Belgium

Population (2018)	11,398,589
Cooling/heating degree days (2018)	33.1/2513.9
Dampness damages in buildings [% of population]	18%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	394/580
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	152,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	51,000

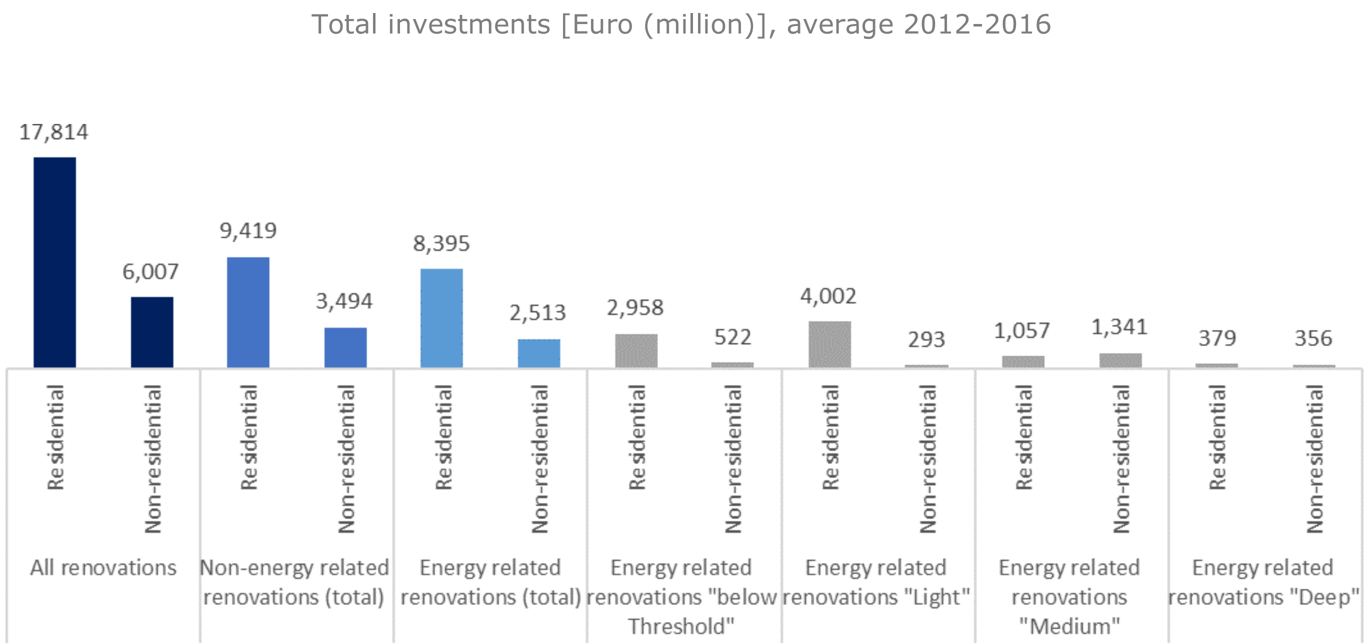
Total building stock [floor area, m²] shares, 2016



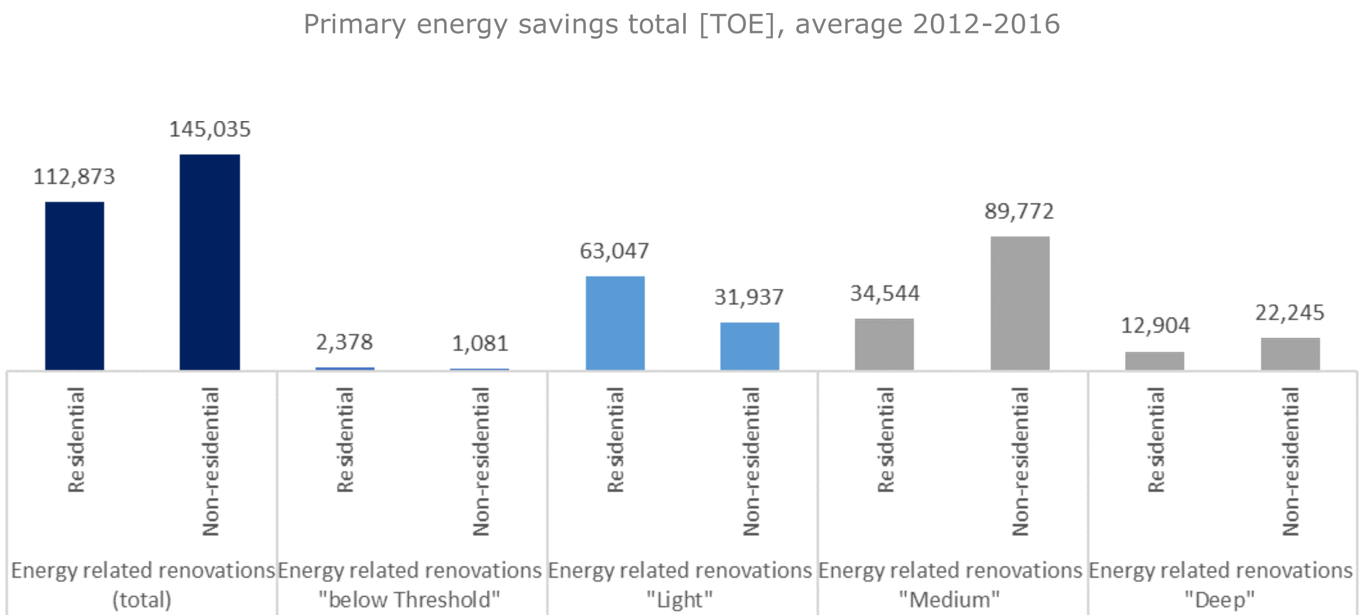


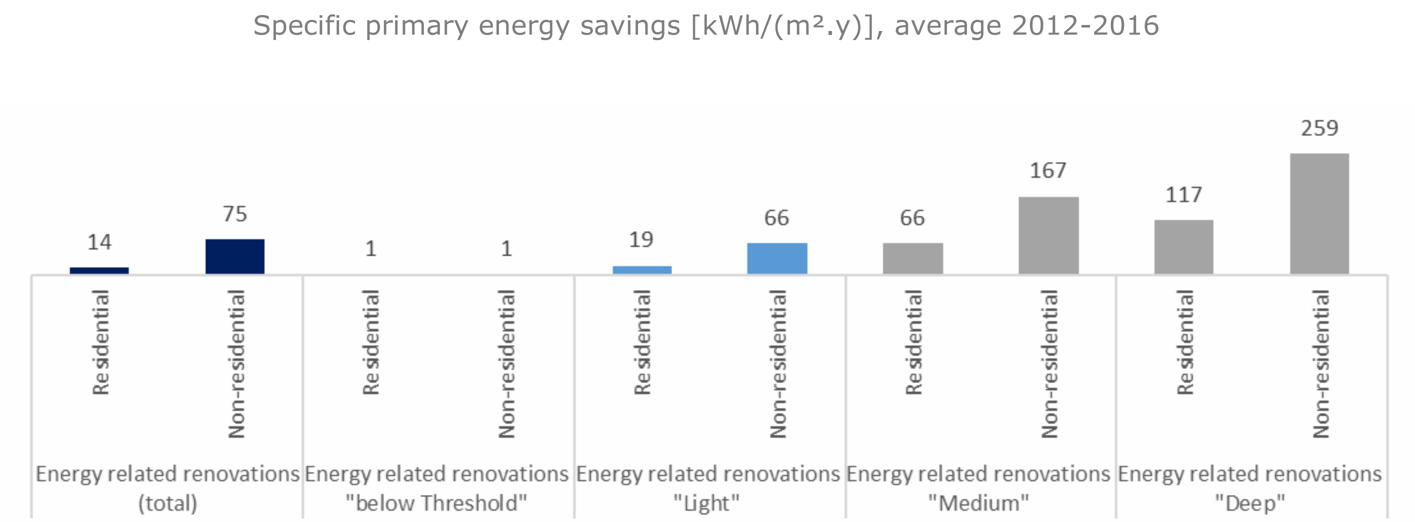


Renovation rate [%/stock], average 2012-2016
17.9%
13.5%
15.6%
21.4%
7.8%
9.1%
6.5%
5.3%
1.0%
6.0%
0.2%
1.0%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Total investments [Euro (million)], average 2012-2016
17,814
6,007
9,419
3,494
8,395
2,513
2,958
522
4,002
293
1,057
1,341
379
356
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
112,873
145,035
2,378
1,081
63,047
31,937
34,544
89,772
12,904
22,245
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
14
75
1
1
19
66
66
167
117
259
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[2]

Indicative numerical indicator of primary energy use:

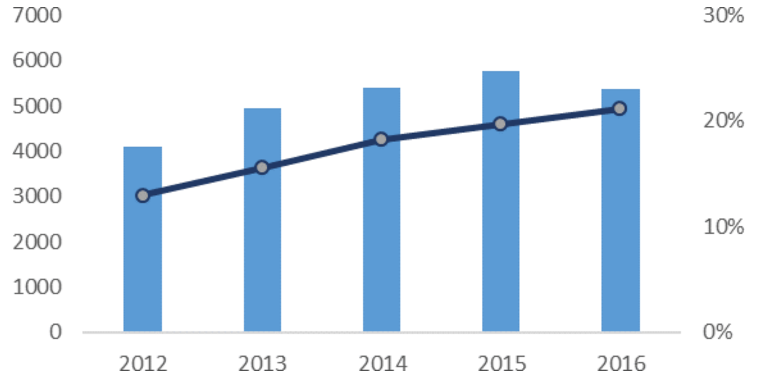
Residential:

30-70 kWh/(m².y)

Non-residential:

45-100 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

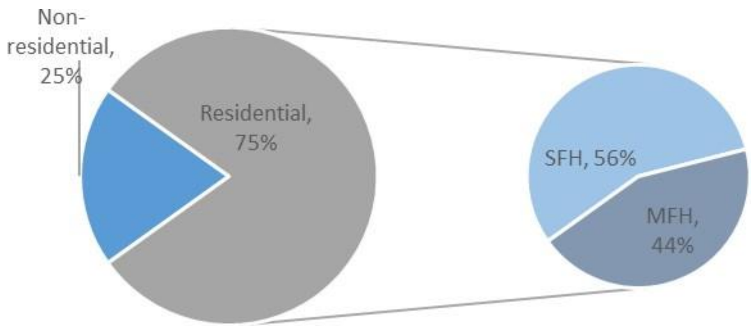


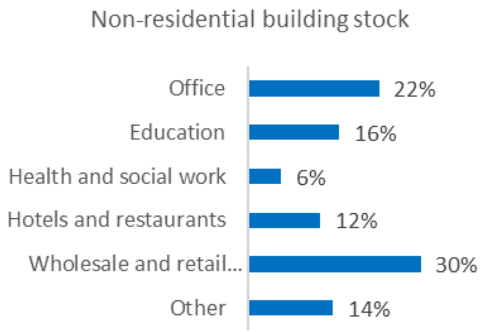
[2] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

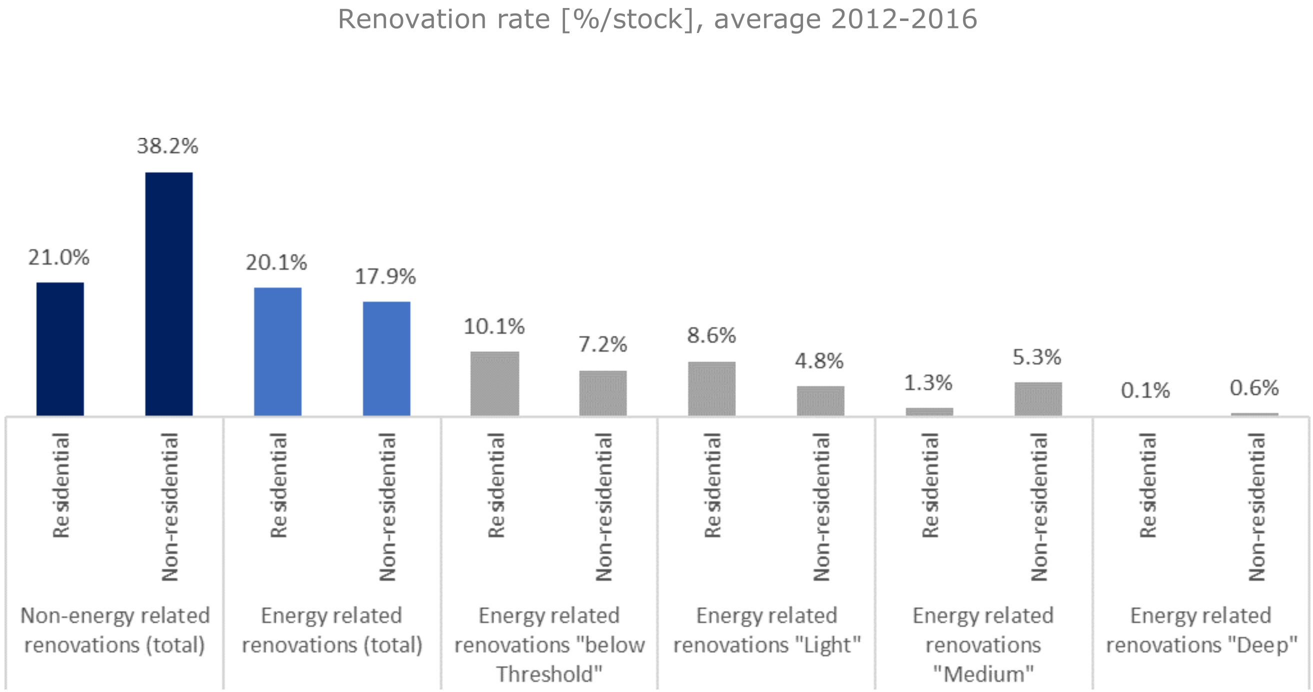
Bulgaria

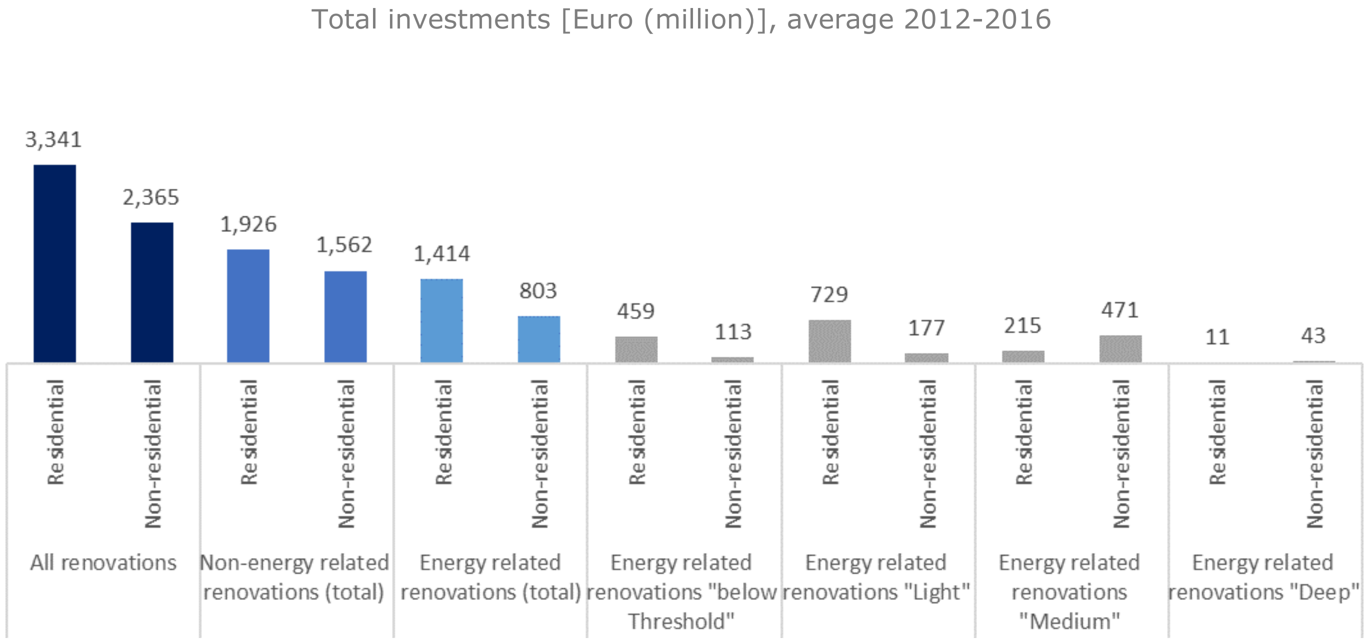
	Population (2018)	7,050,034		Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	28,000
	Cooling/heating degree days (2018)	125.5/2357.9		Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	20,000
	Dampness damages in buildings [% of population]	14%			
	Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	151/214			

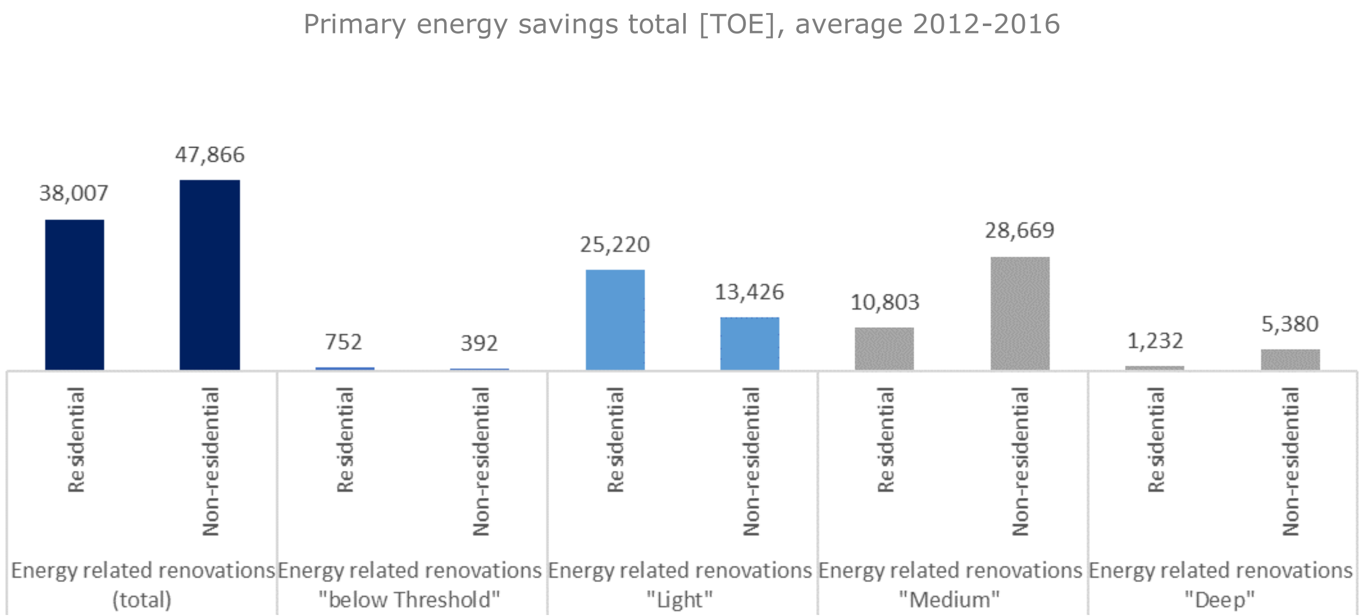
Total building stock [floor area, m²] shares, 2016

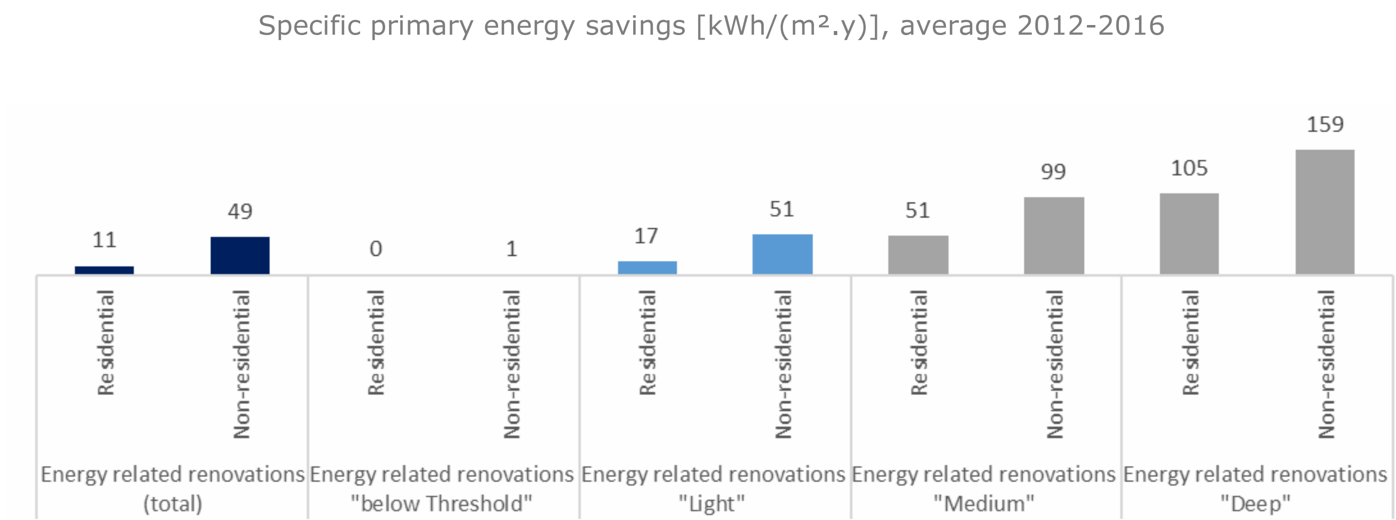





Renovation rate [%/stock], average 2012-2016
21.0%
38.2%
20.1%
17.9%
10.1%
7.2%
8.6%
4.8%
1.3%
5.3%
0.1%
0.6%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
3,341
2,365
1,926
1,562
1,414
803
459
113
729
177
215
471
11
43
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
38,007
47,866
752
392
25,220
13,426
10,803
28,669
1,232
5,380
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
11
49
0
1
17
51
51
99
105
159
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[3]

Indicative numerical indicator of primary energy use:

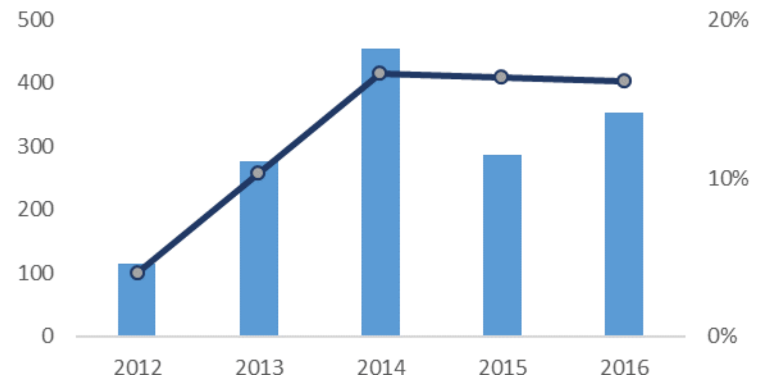
Residential:

40 kWh/(m².y)

Non-residential:

40 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

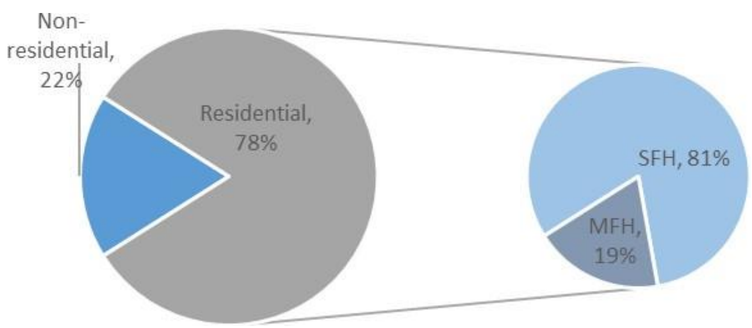


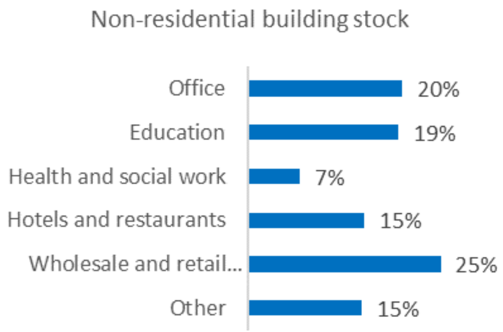
[3] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

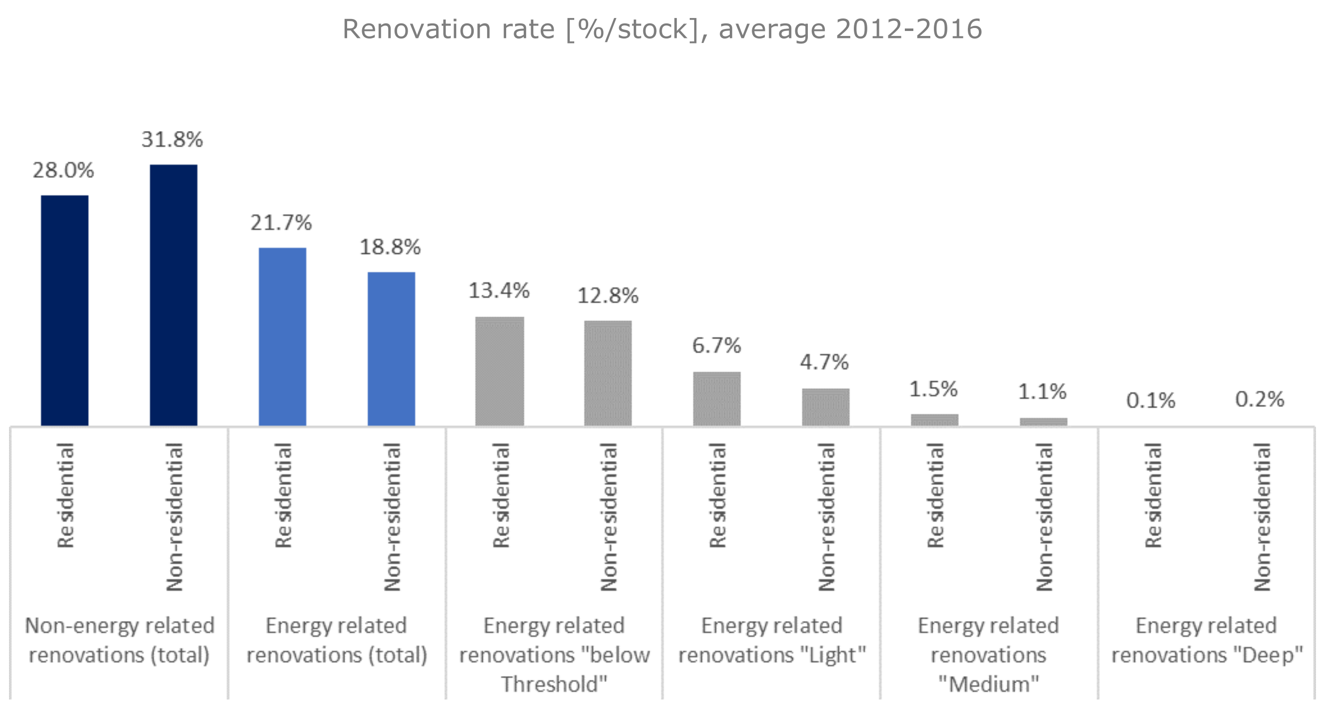
Croatia

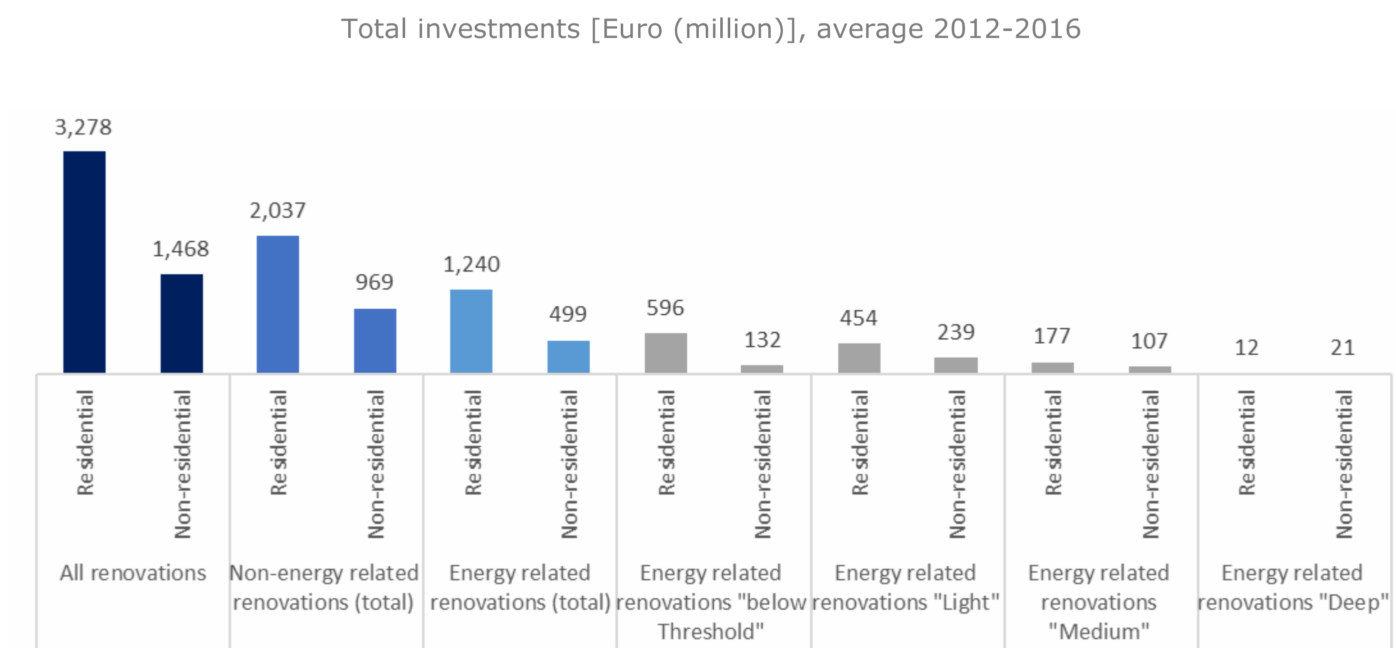
Population (2018)	4,105,493
Cooling/heating degree days (2018)	144.6/2148.2
Dampness damages in buildings [% of population]	13%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	142/118
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	28,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	13,000

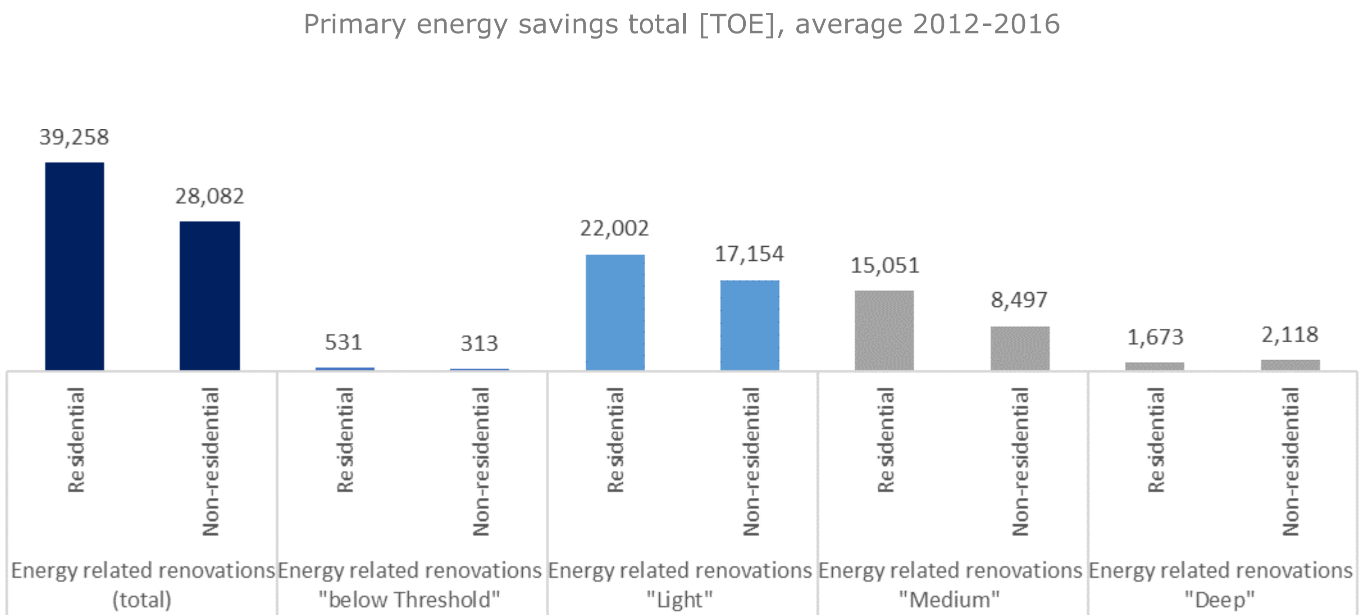
Total building stock [floor area, m²] shares, 2016

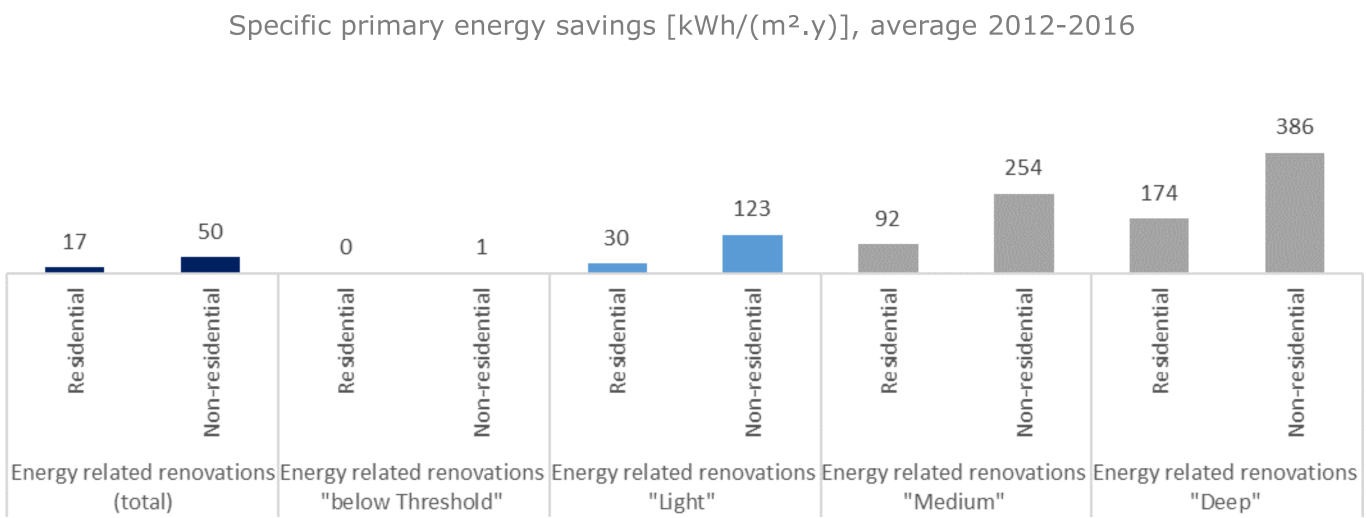





Renovation rate [%/stock], average 2012-2016
28.0%
31.8%
21.7%
18.8%
13.4%
12.8%
6.7%
4.7%
1.5%
1.1%
0.1%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
3,278
1,468
2,037
969
1,240
499
596
132
454
239
177
107
12
21
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
39,258
28,082
531
313
22,002
17,154
15,051
8,497
1,673
2,118
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
17
50
0
1
30
123
92
254
174
386
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[4]

Indicative numerical indicator of primary energy use:

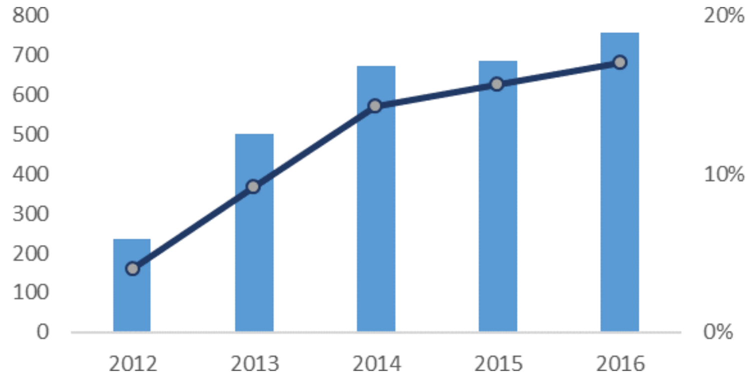
Residential:

55 kWh/(m².y)

Non-residential:

90 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

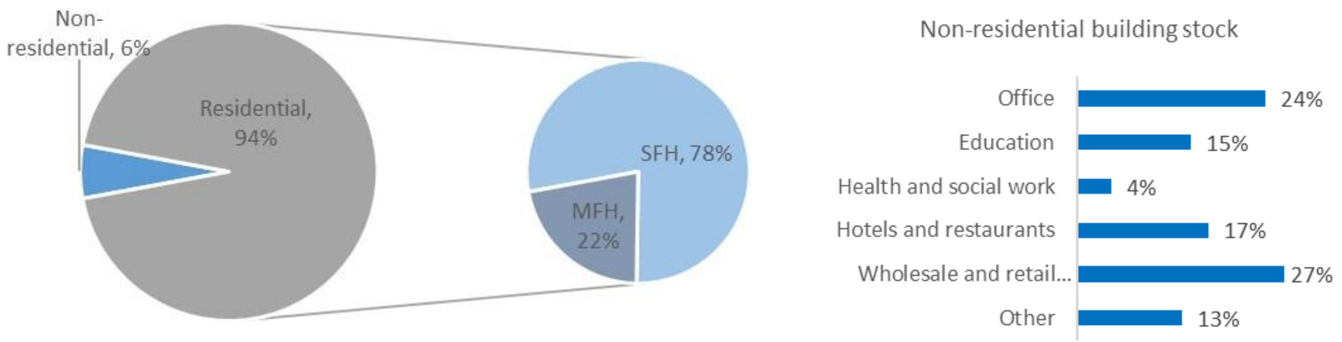


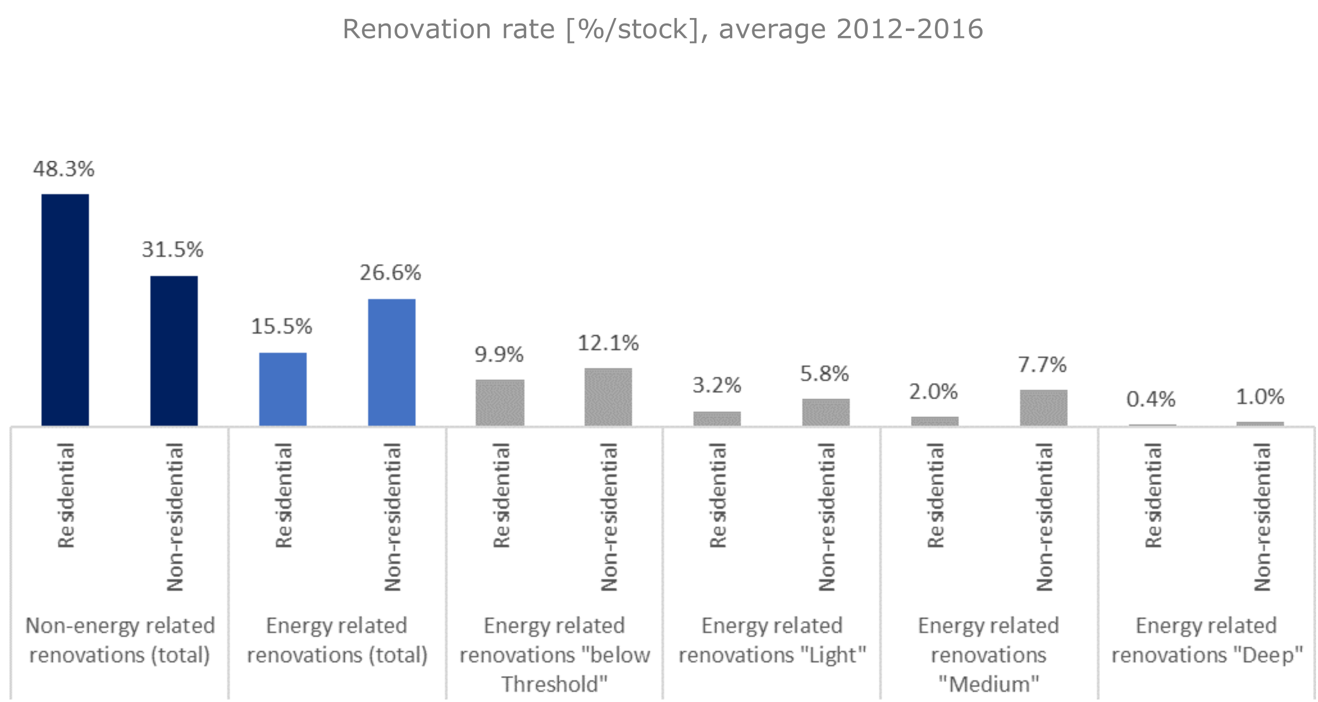
[4] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

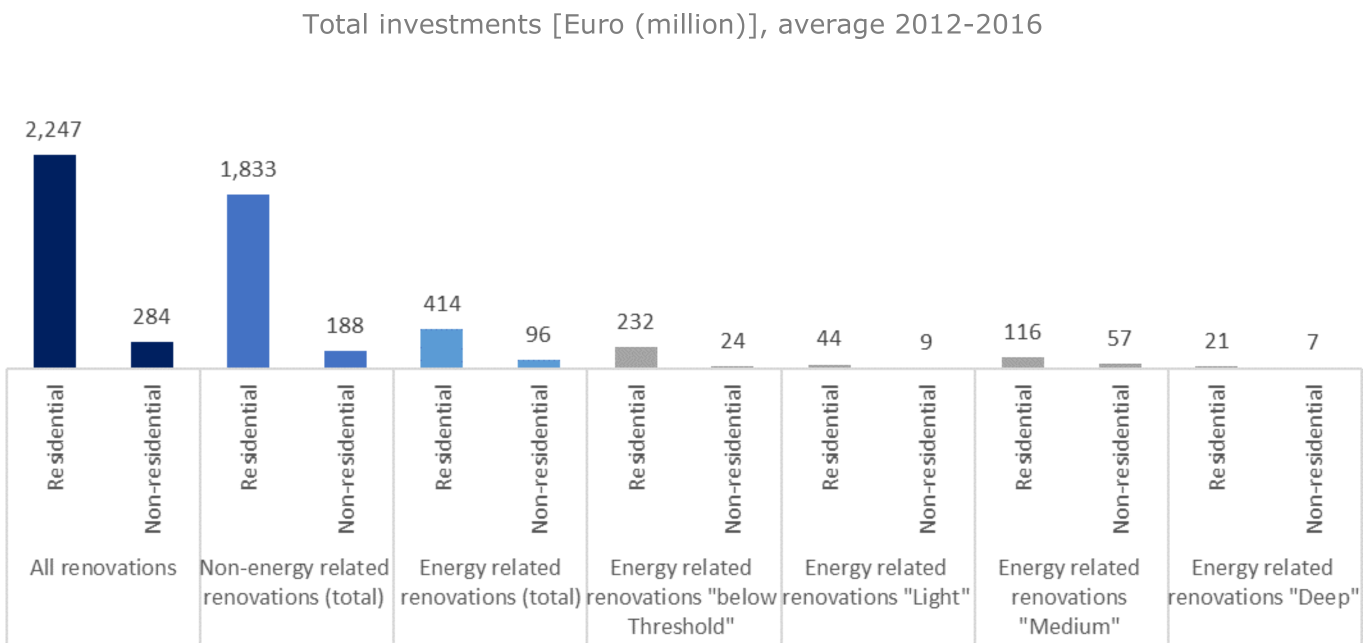
Cyprus

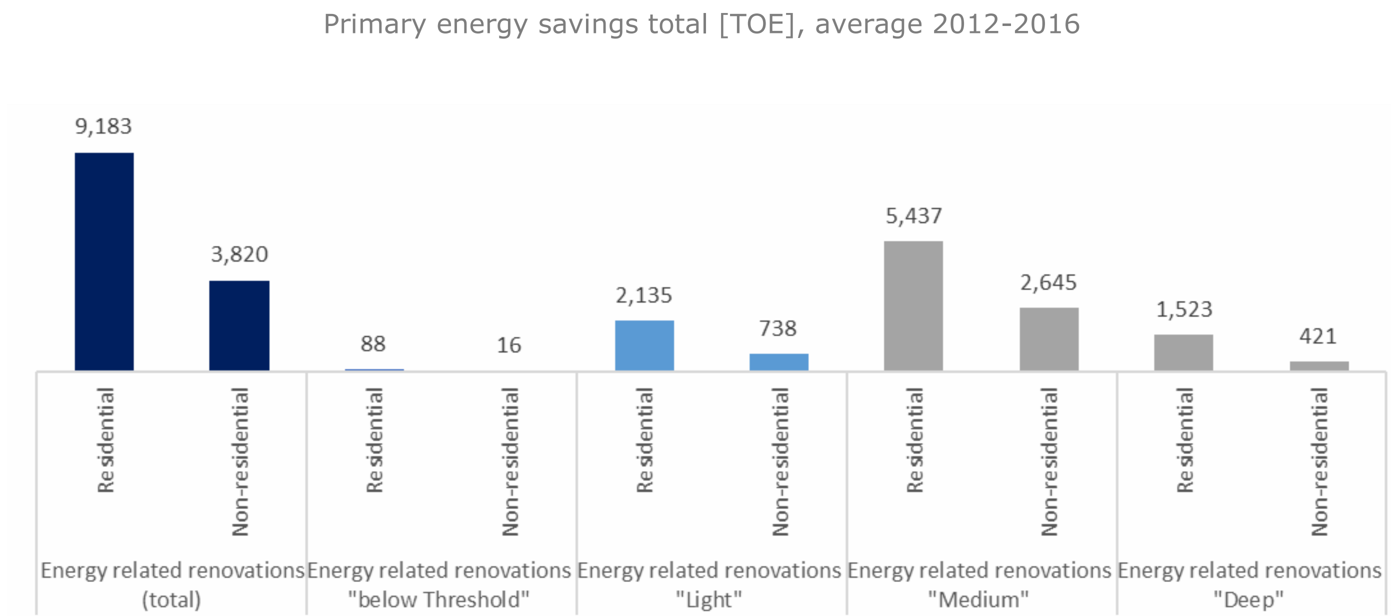
Population (2018)	864,236
Cooling/heating degree days (2018)	805.7/476.9
Dampness damages in buildings [% of population]	30%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	37/17
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	19,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	2,000

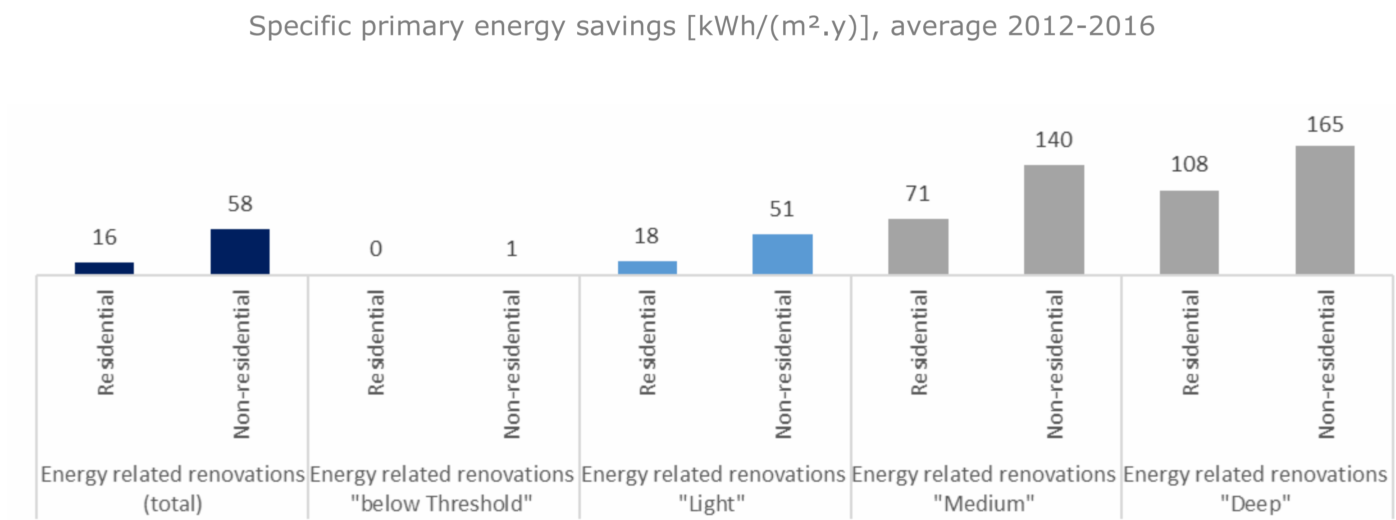
Total building stock [floor area, m²] shares, 2016




Renovation rate [%/stock], average 2012-2016
48.3%
31.5%
15.5%
26.6%
9.9%
12.1%
3.2%
5.8%
2.0%
7.7%
0.4%
1.0%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
2,247
284
1,833
188
414
96
232
24
44
9
116
57
21
7
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
9,183
3,820
88
16
2,135
738
5,437
2,645
1,523
421
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
16
58
0
1
18
51
71
140
108
165
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[5]

Indicative numerical indicator of primary energy use:

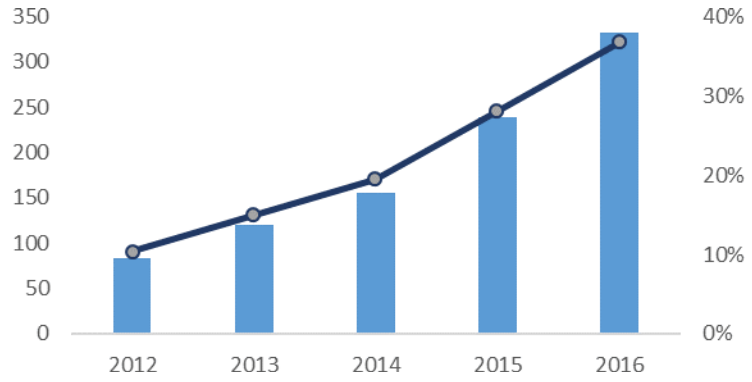
Residential:

100 kWh/(m².y)

Non-residential:

125 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

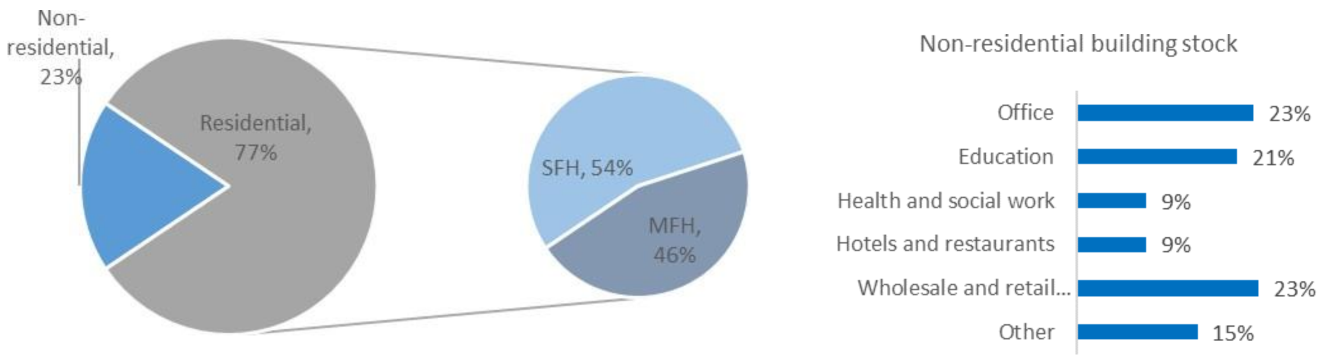


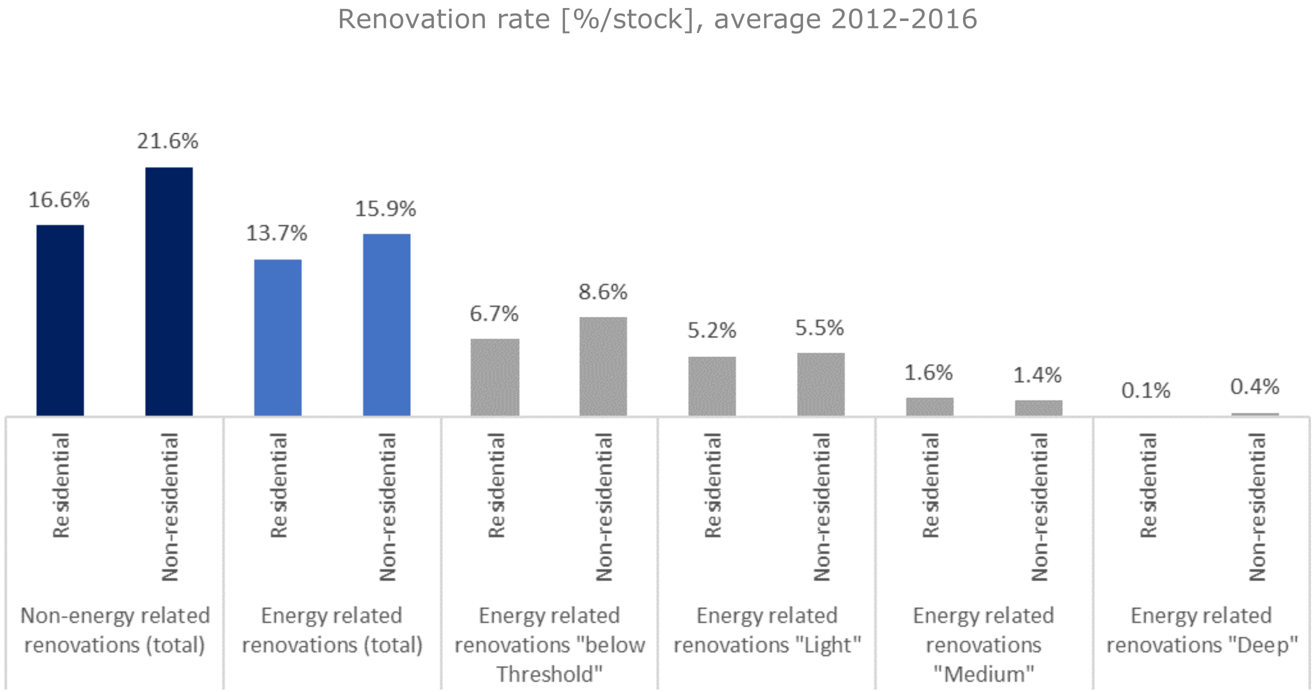
[55] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

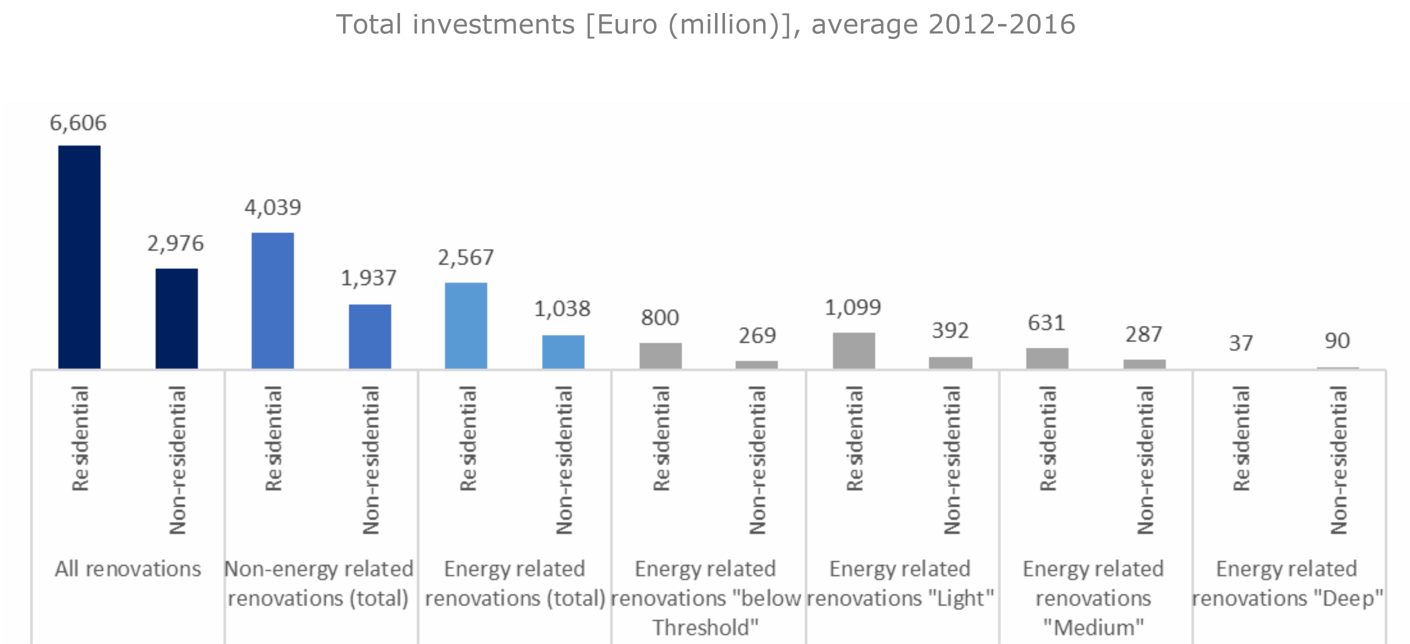
Czech Republic

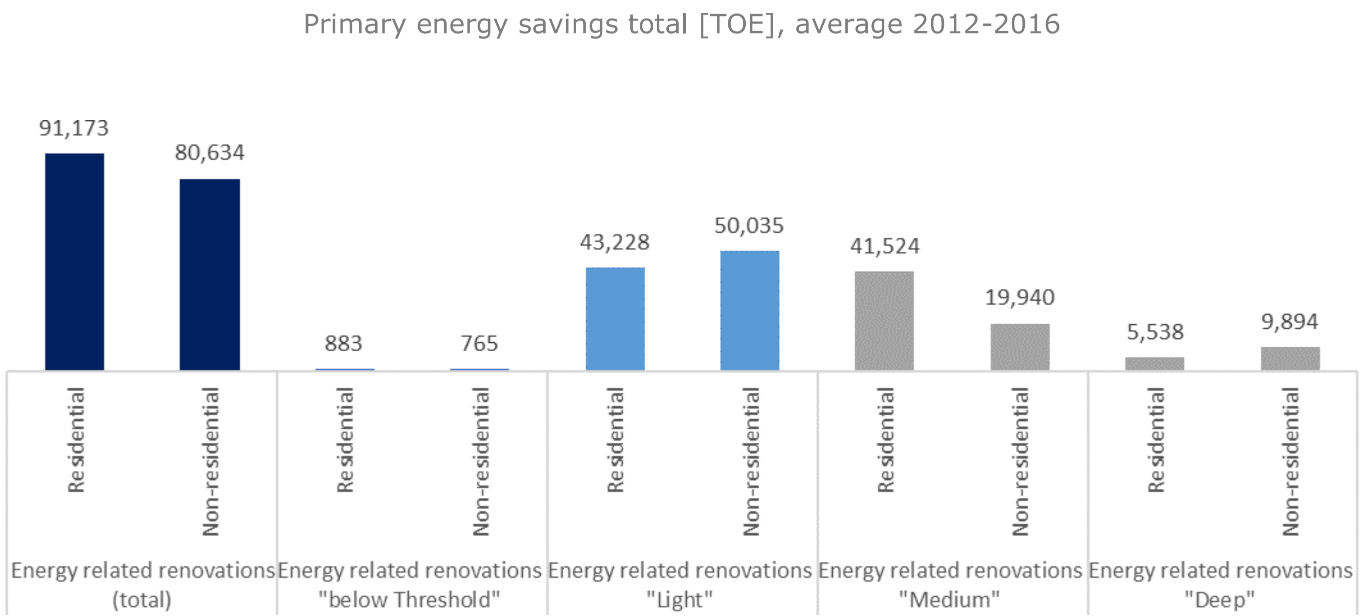
Population (2018)	10,610,055
Cooling/heating degree days (2018)	45.8/2996.4
Dampness damages in buildings [% of population]	11%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	314/312
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	56,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	25,000

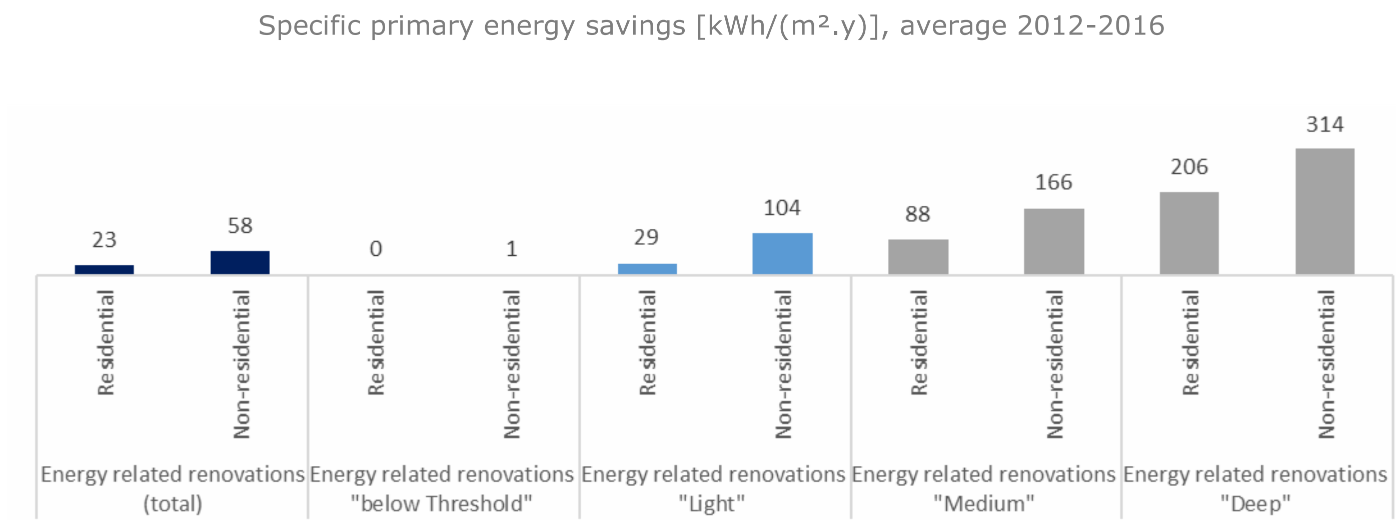
Total building stock [floor area, m²] shares, 2016




Renovation rate [%/stock], average 2012-2016
16.6%
21.6%
13.7%
15.9%
6.7%
8.6%
5.2%
5.5%
1.6%
1.4%
0.1%
0.4%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
6,606
2,976
4,039
1,937
2,567
1,038
800
269
1,099
392
631
287
37
90
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
91,173
80,634
883
765
43,228
50,035
41,524
19,940
5,538
9,894
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
23
58
0
1
29
104
88
166
206
314
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[6]

Indicative numerical indicator of primary energy use:

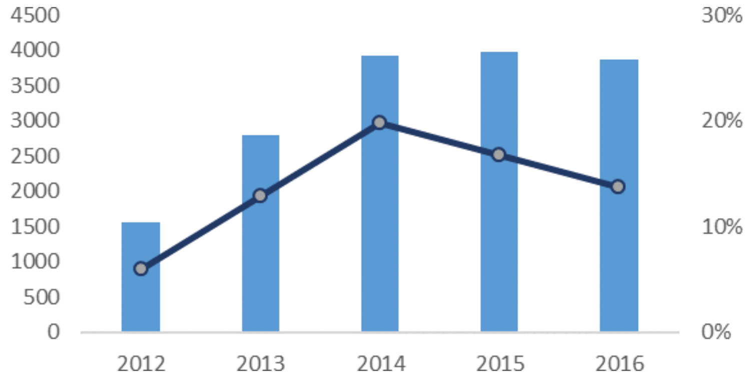
Residential:

50 kWh/(m².y)

Non-residential:

75 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

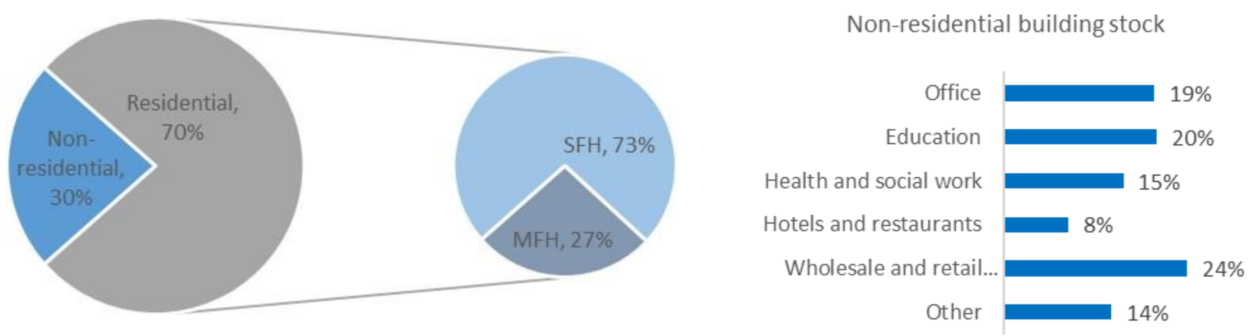


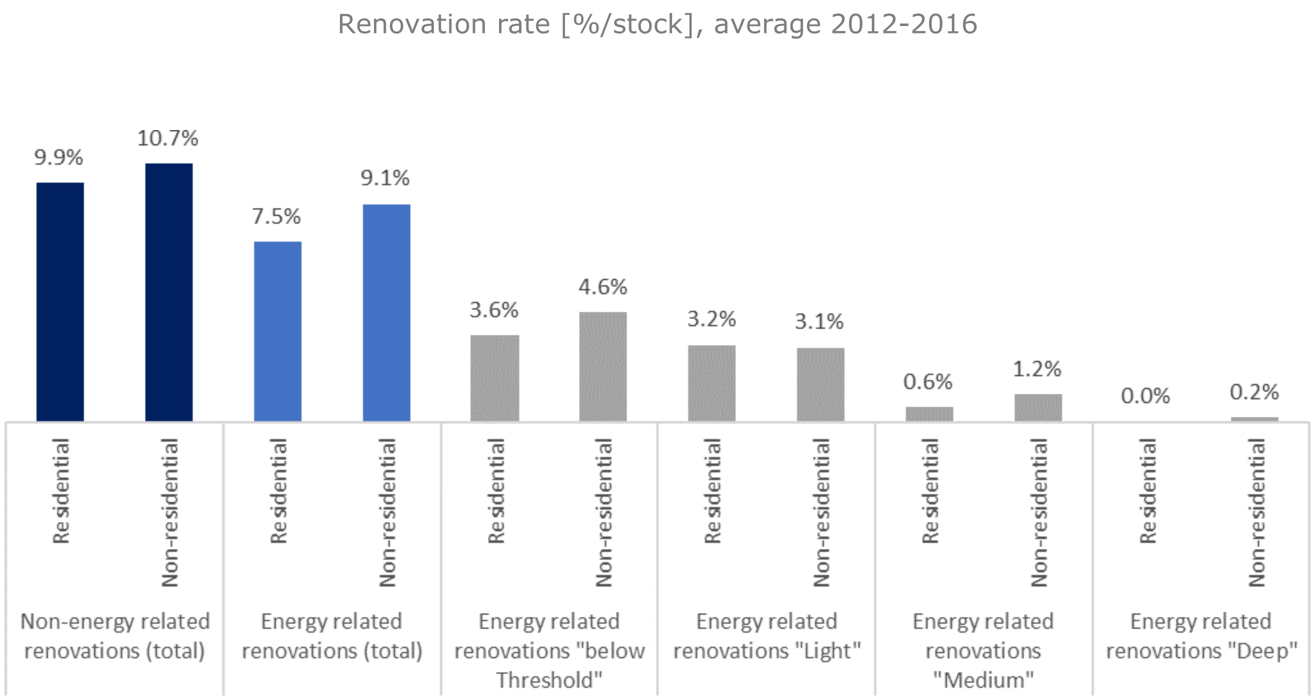
[6] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

Denmark

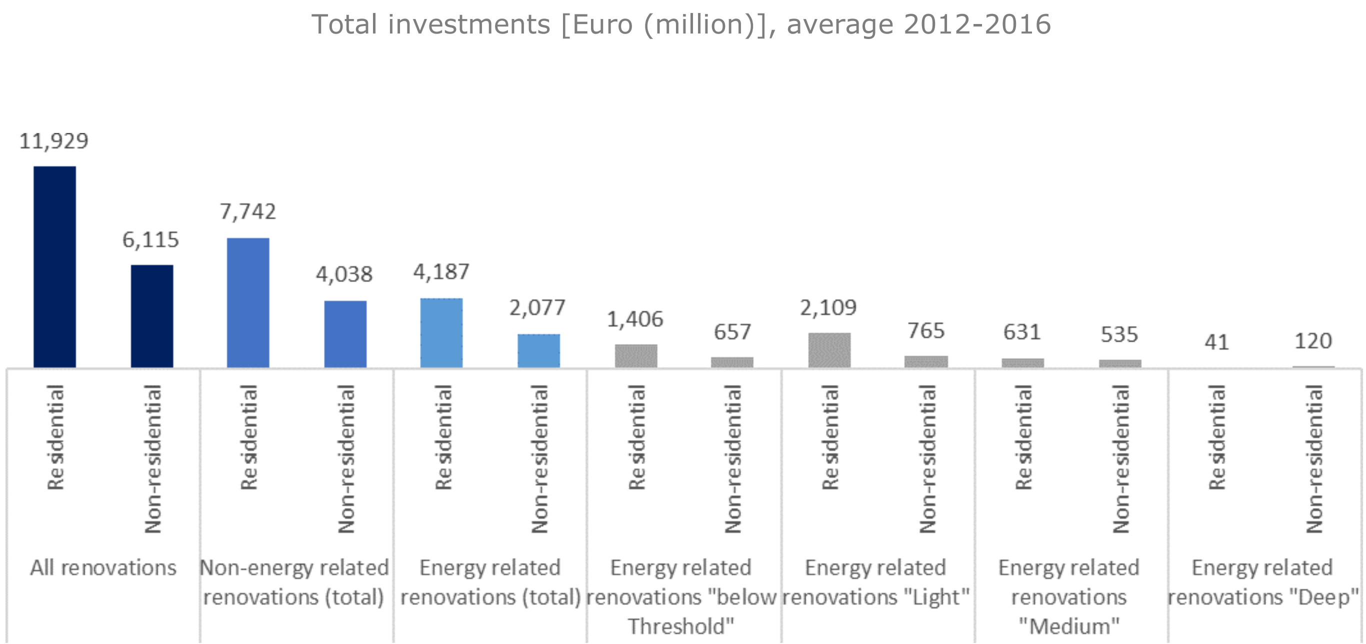
Population (2018)	5,781,190	Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	102,000
Cooling/heating degree days (2018)	14.0/3051.1	Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	52,000
Dampness damages in buildings [% of population]	18%		
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	137/235		

Total building stock [floor area, m²] shares, 2016

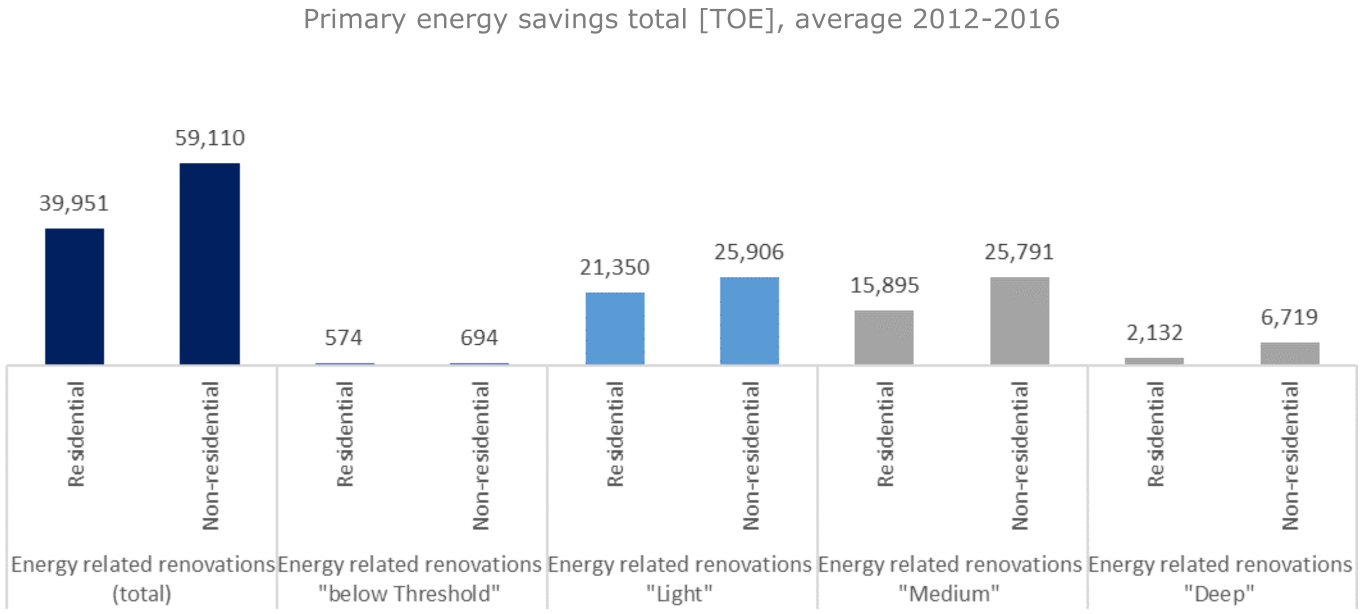




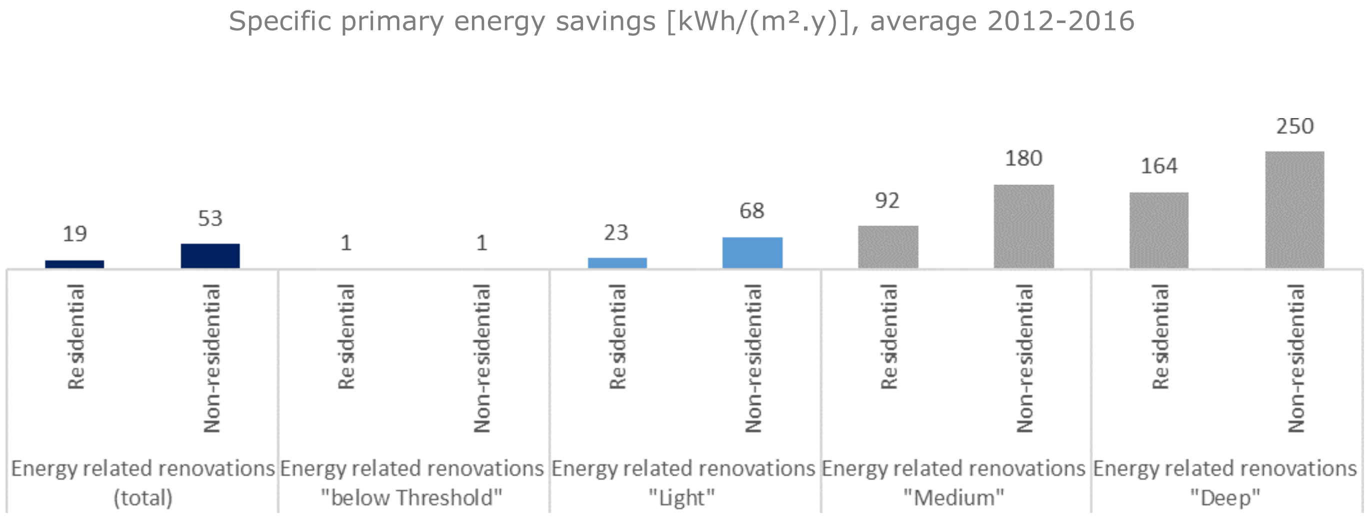
Renovation rate [%/stock], average 2012-2016
9.9%
10.7%
7.5%
9.1%
3.6%
4.6%
3.2%
3.1%
0.6%
1.2%
0.0%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Total investments [Euro (million)], average 2012-2016
11,929
6,115
7,742
4,038
4,187
2,077
1,406
657
2,109
765
631
535
41
120
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Primary energy savings total [TOE], average 2012-2016
39,951
59,110
574
694
21,350
25,906
15,895
25,791
2,132
6,719
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Specific primary energy savings [kWh/(m².y)], average 2012-2016
19
53
1
1
23
68
92
180
164
250
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[7]

Indicative numerical indicator of primary energy use:

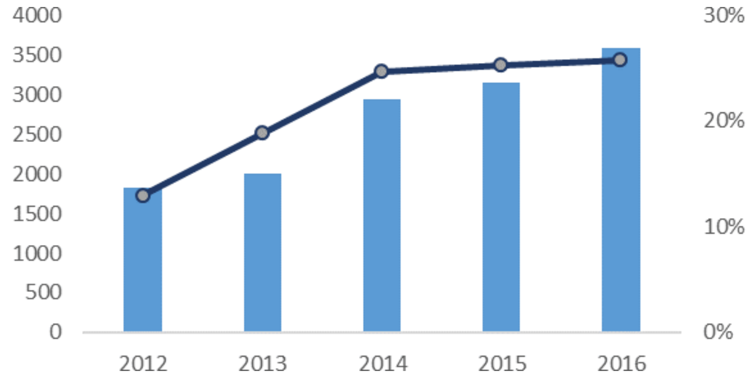
Residential:

20 kWh/(m².y)

Non-residential:

25 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

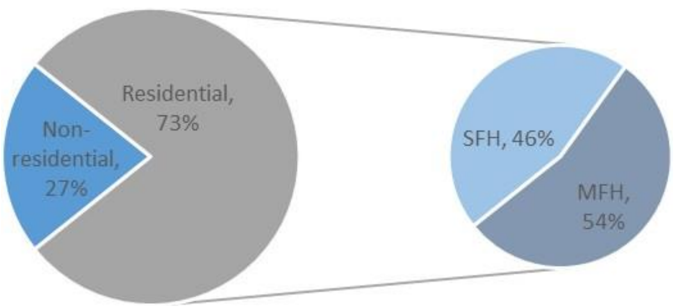


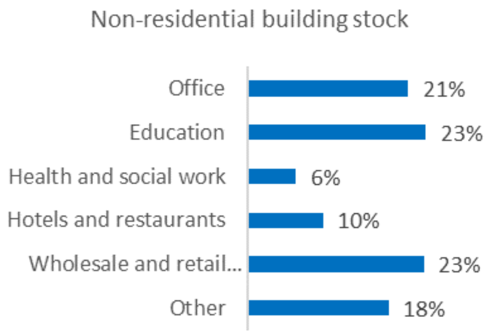
[7] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

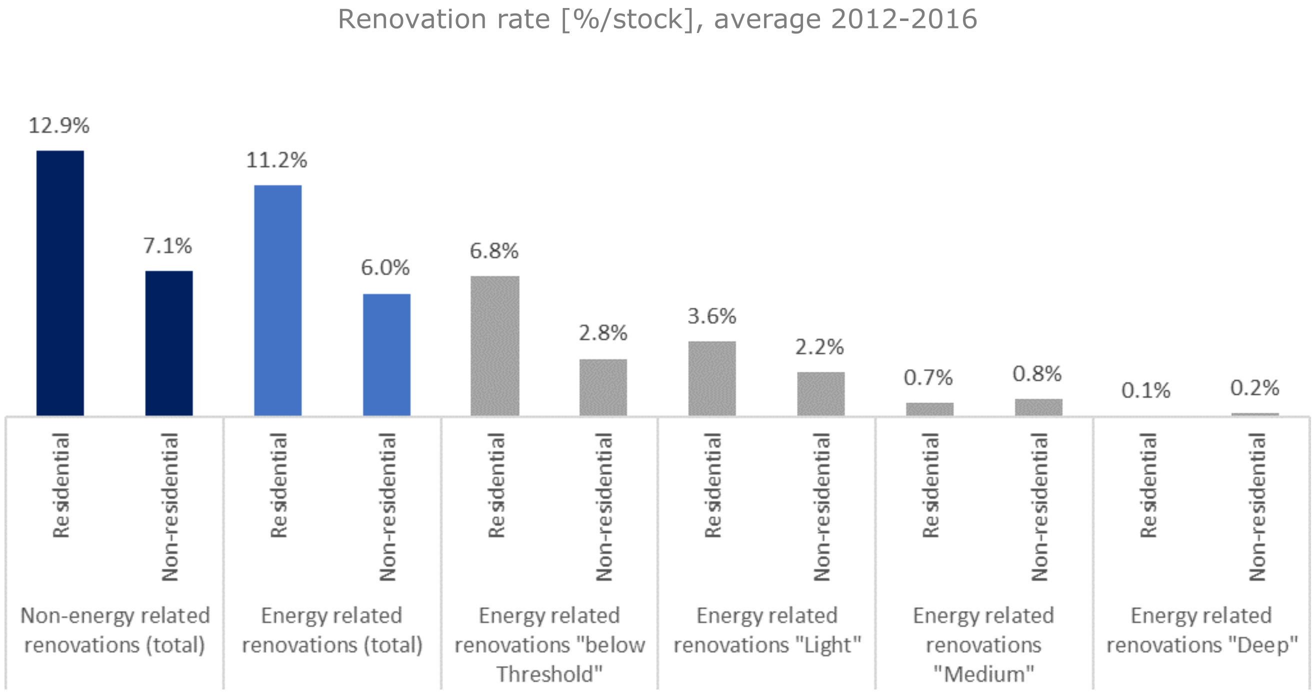
Estonia

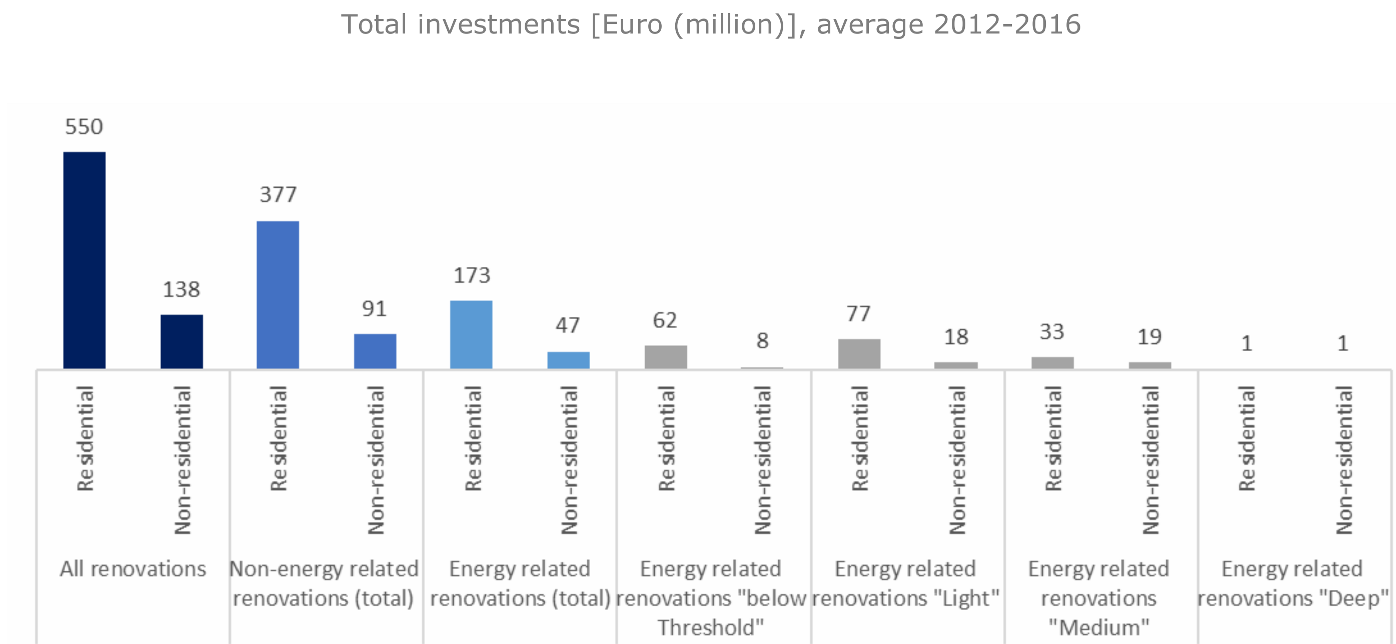
Population (2018)	1,319,133
Cooling/heating degree days (2018)	25.6/4064.7
Dampness damages in buildings [% of population]	19%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	33/29
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	5,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	1,000

Total building stock [floor area, m²] shares, 2016

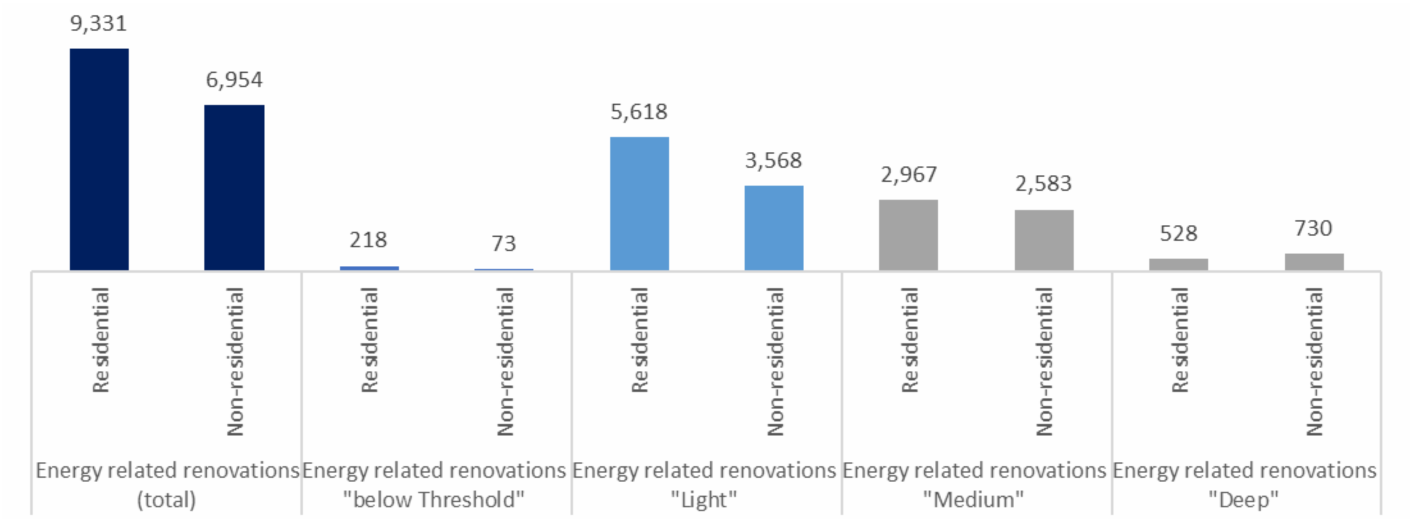




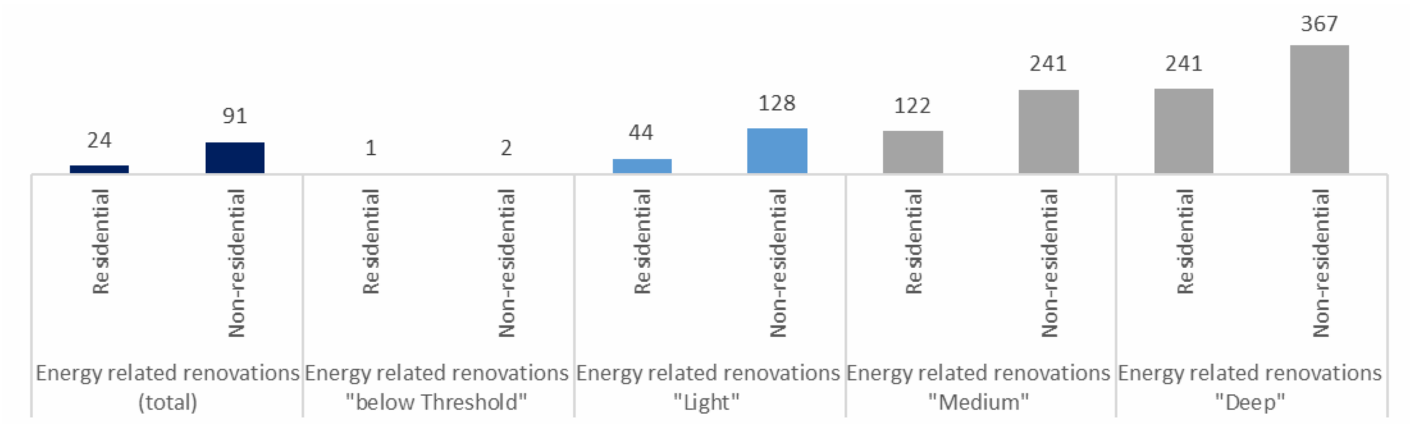

Renovation rate [%/stock], average 2012-2016
12.9%
7.1%
11.2%
6.0%
6.8%
2.8%
3.6%
2.2%
0.7%
0.8%
0.1%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
550
138
377
91
173
47
62
8
77
18
33
19
1
1
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[8]

Indicative numerical indicator of primary energy use:

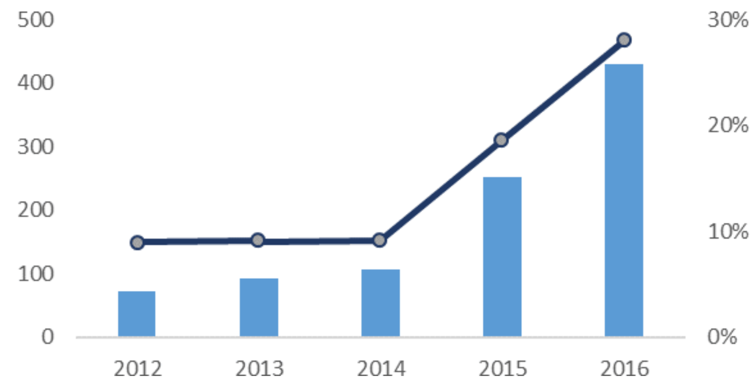
Residential:

65 kWh/(m².y)

Non-residential:

110 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

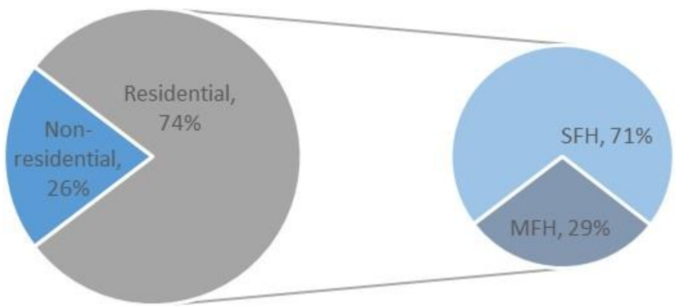


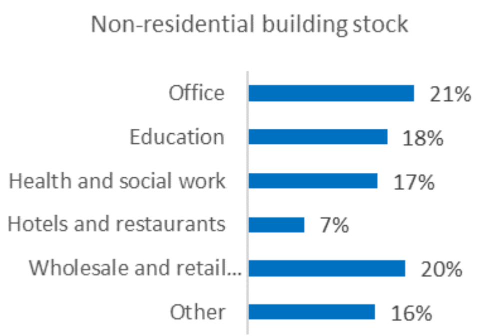
[8] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

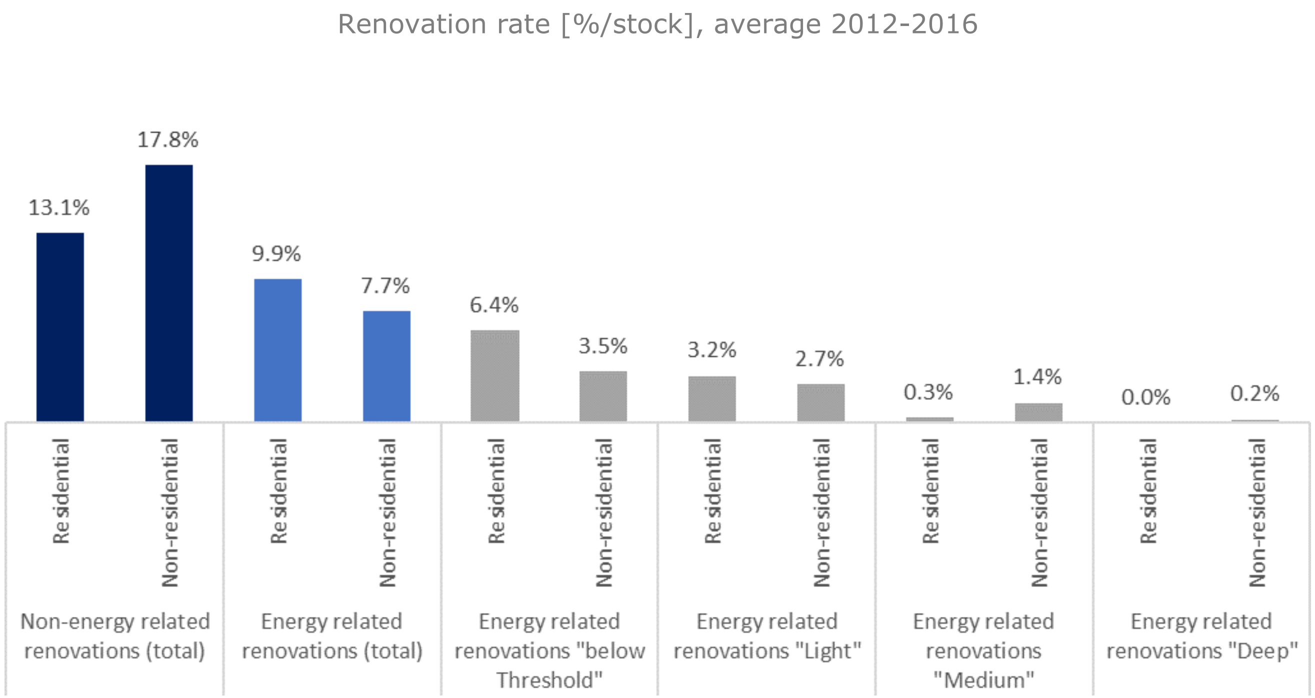
Finland

Population (2018)	5,513,130
Cooling/heating degree days (2018)	8.8/5363.5
Dampness damages in buildings [% of population]	6%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	118/209
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	98,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	41,000

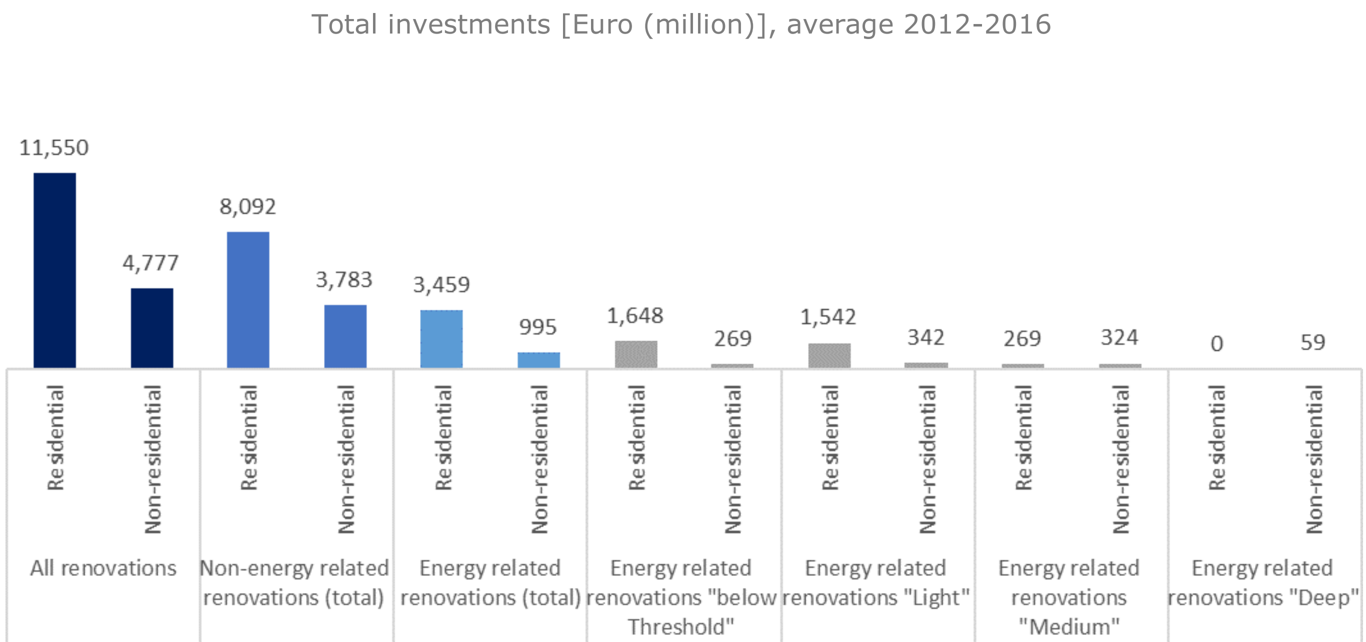
Total building stock [floor area, m²] shares, 2016





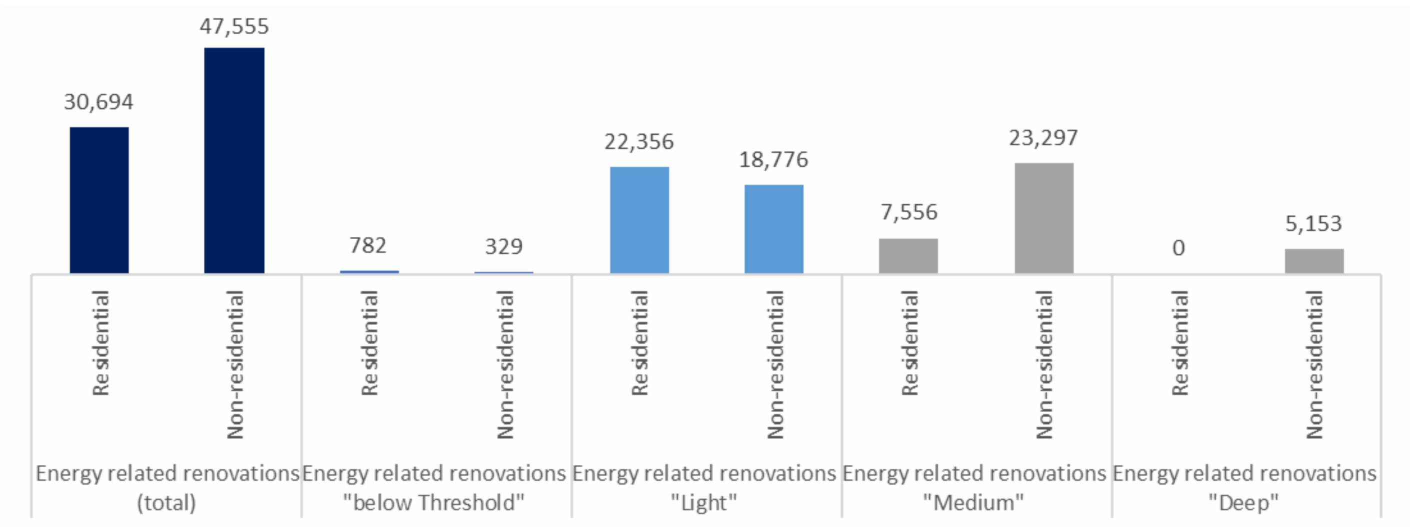


Renovation rate [%/stock], average 2012-2016
13.1%
17.8%
9.9%
7.7%
6.4%
3.5%
3.2%
2.7%
0.3%
1.4%
0.0%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

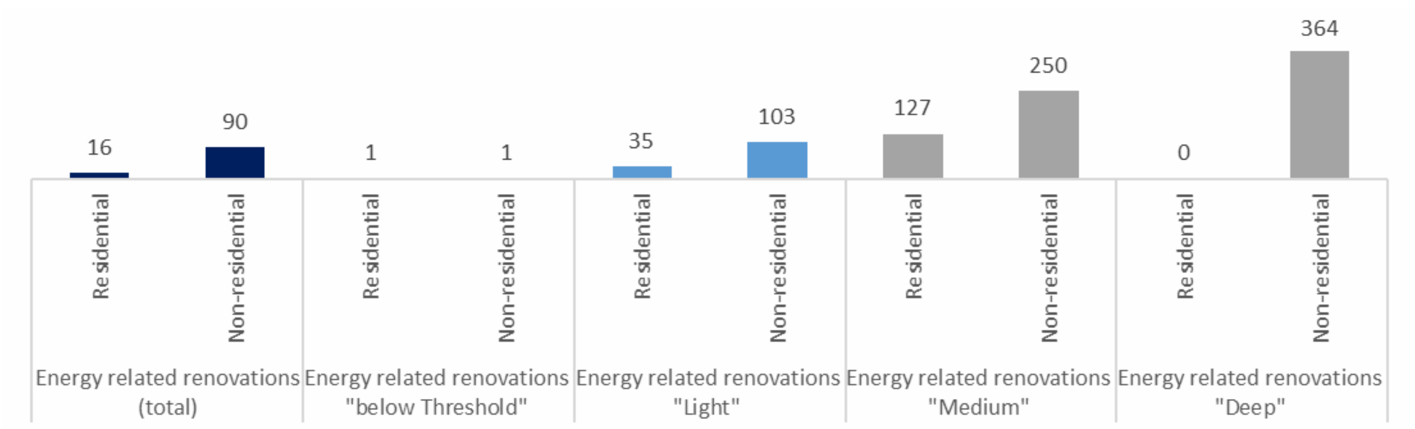


Total investments [Euro (million)], average 2012-2016
11,550
4,777
8,092
3,783
3,459
995
1,648
269
1,542
342
269
324
0
59
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[9]

Indicative numerical indicator of primary energy use:

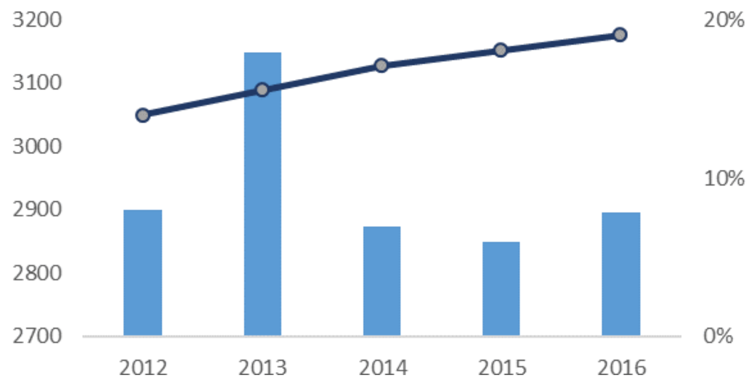
Residential:

90 kWh/(m².y)

Non-residential:

100 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

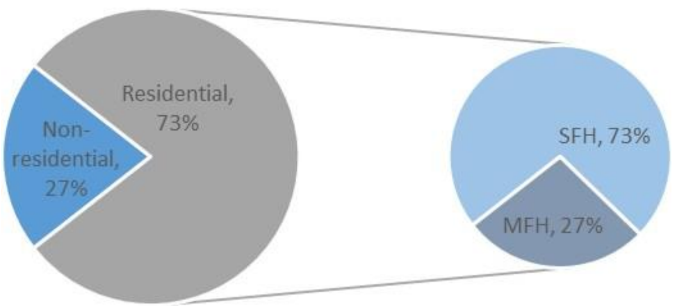


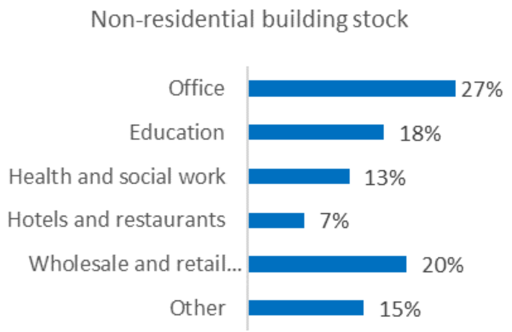
[9] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

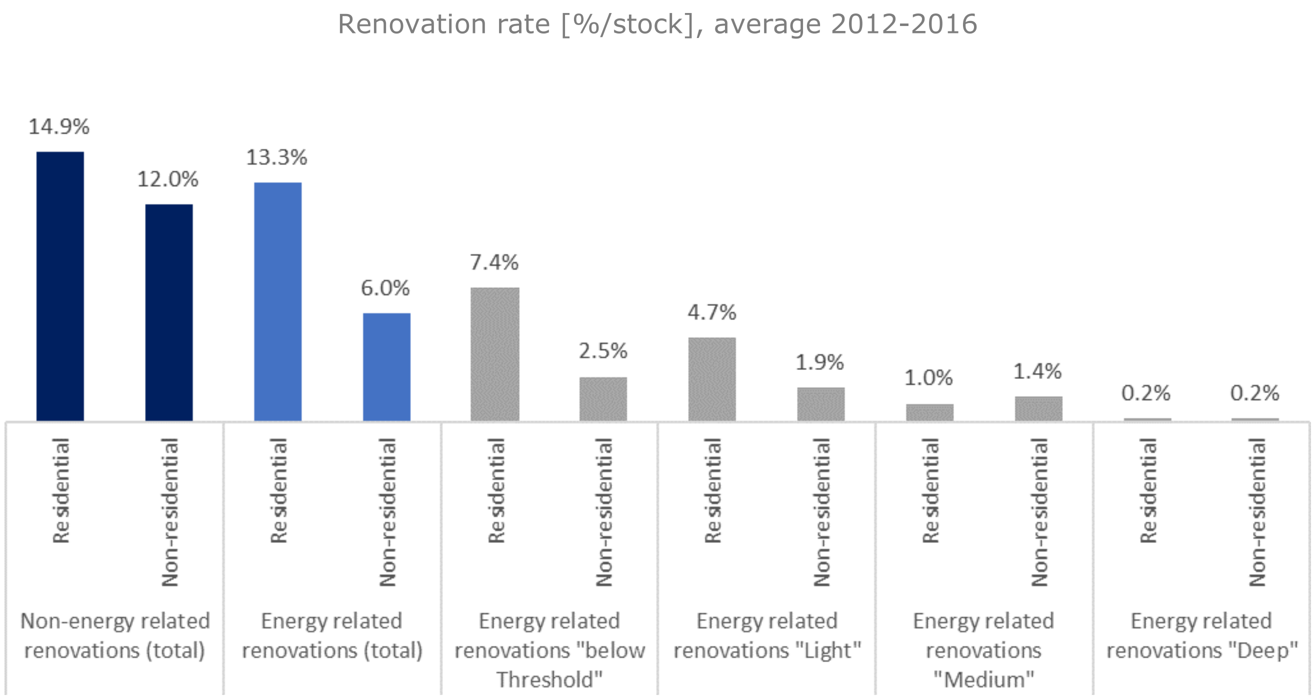
France

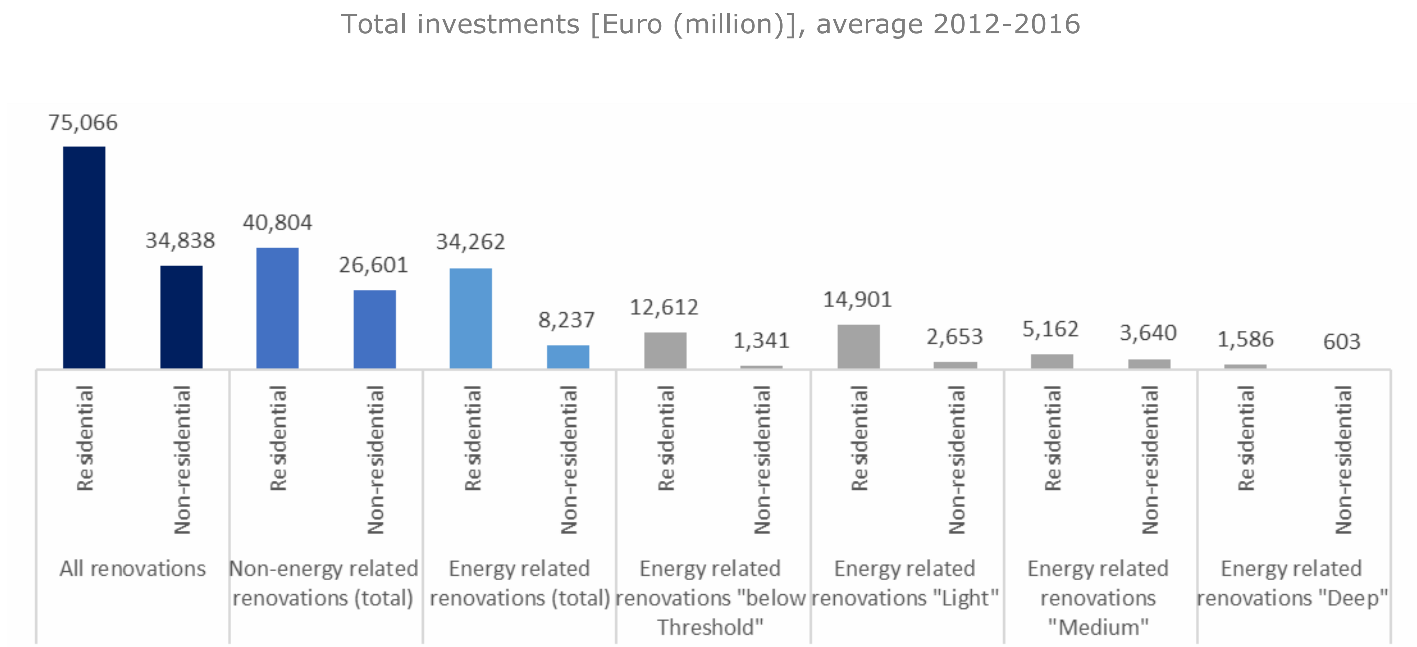
Population (2018)	66,926,166
Cooling/heating degree days (2018)	64.9/2183.6
Dampness damages in buildings [% of population]	13%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	1,670/1,148
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	640,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	297,000

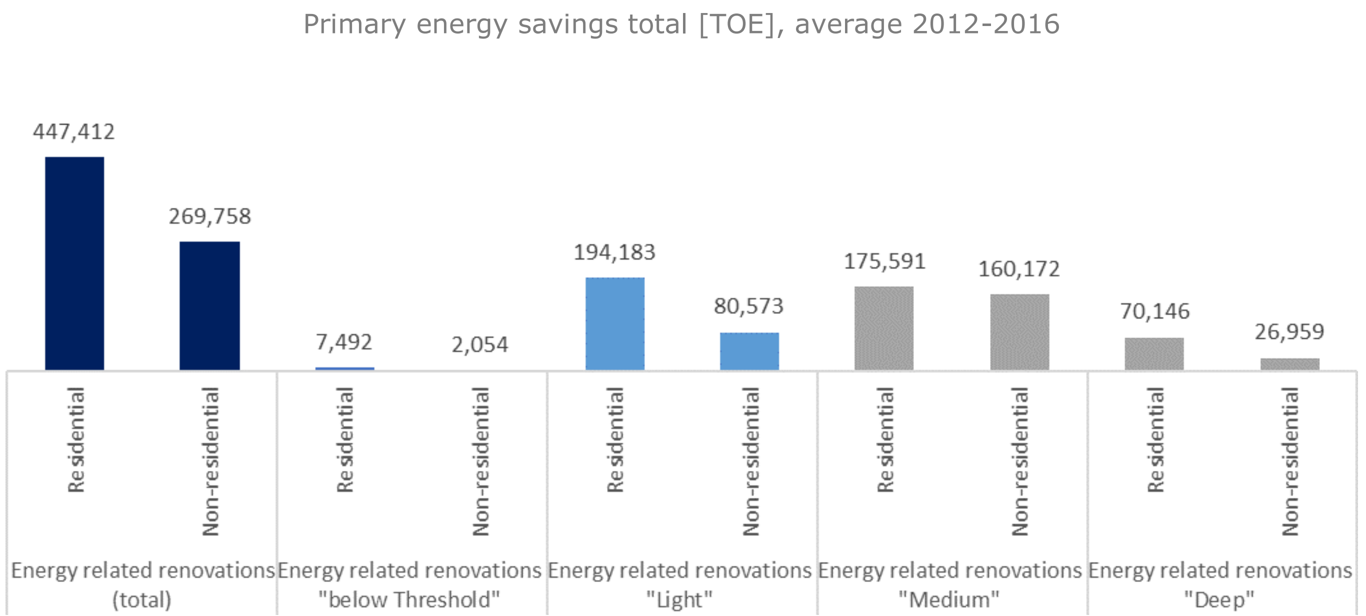
Total building stock [floor area, m²] shares, 2016

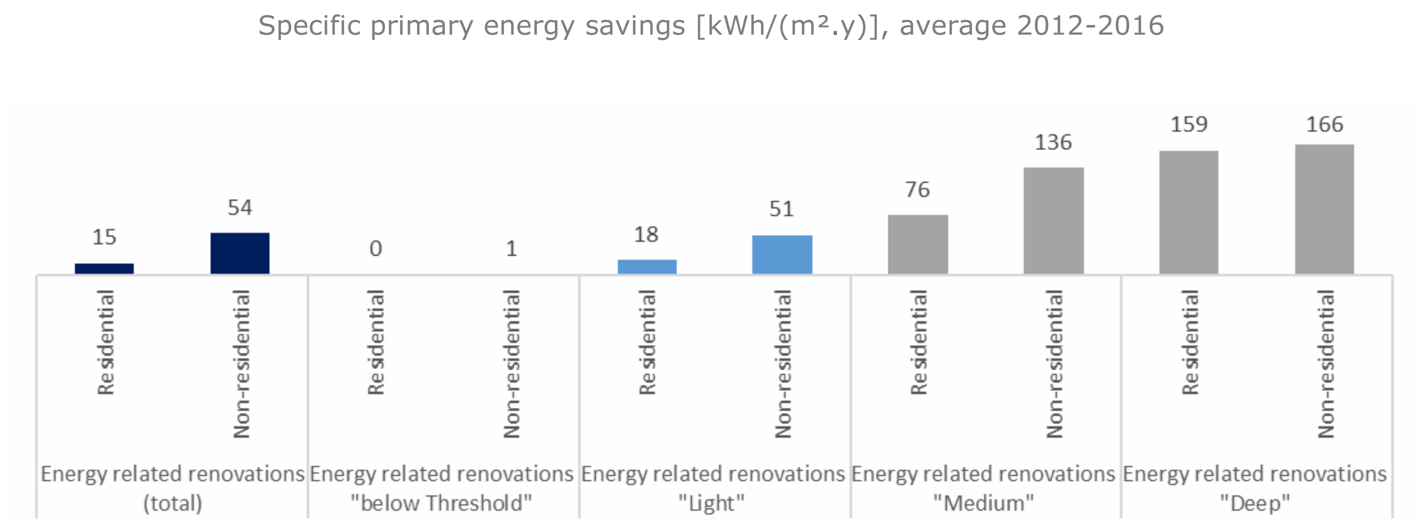





Renovation rate [%/stock], average 2012-2016
14.9%
12.0%
13.3%
6.0%
7.4%
2.5%
4.7%
1.9%
1.0%
1.4%
0.2%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
75,066
34,838
40,804
26,601
34,262
8,237
12,612
1,341
14,901
2,653
5,162
3,640
1,586
603
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
447,412
269,758
7,492
2,054
194,183
80,573
175,591
160,172
70,146
26,959
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
15
54
0
1
18
51
76
136
159
166
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[10]

Indicative numerical indicator of primary energy use:

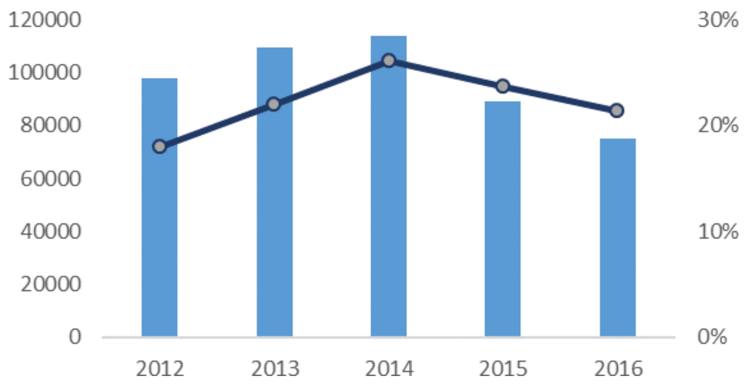
Residential:

80 kWh/(m².y)

Non-residential:

110 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

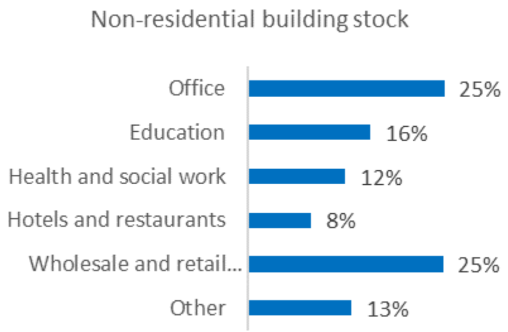


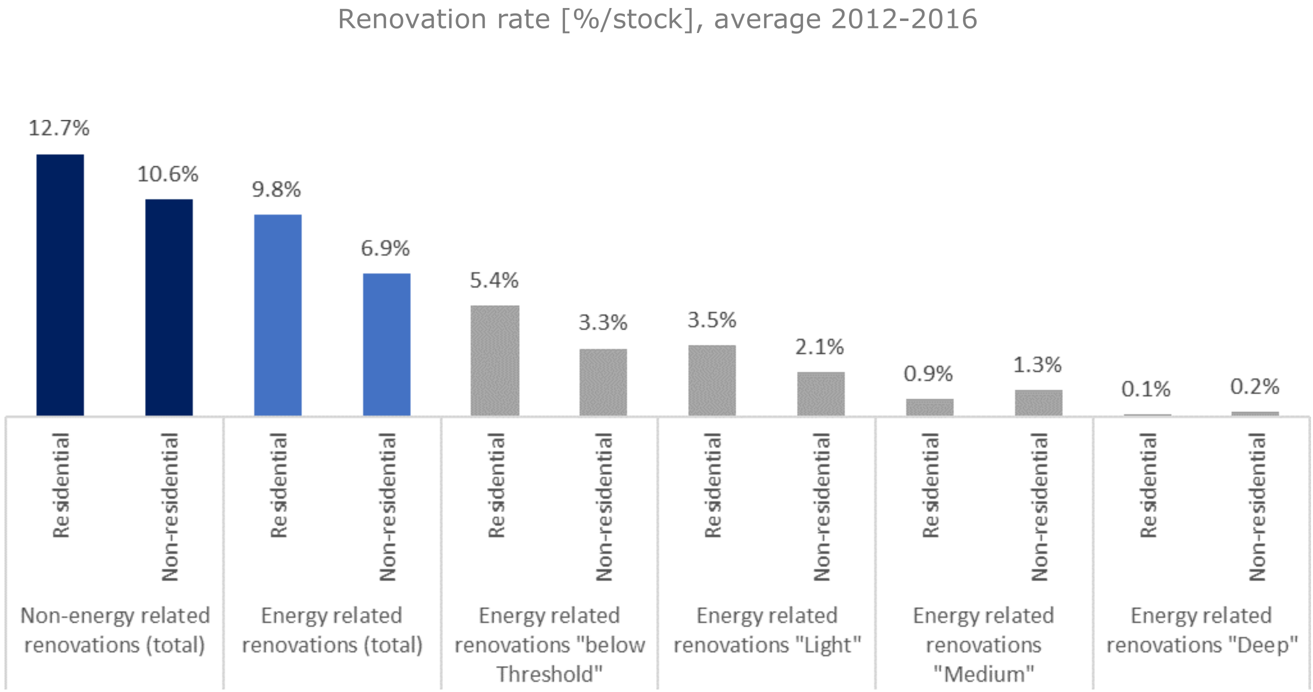
[10] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

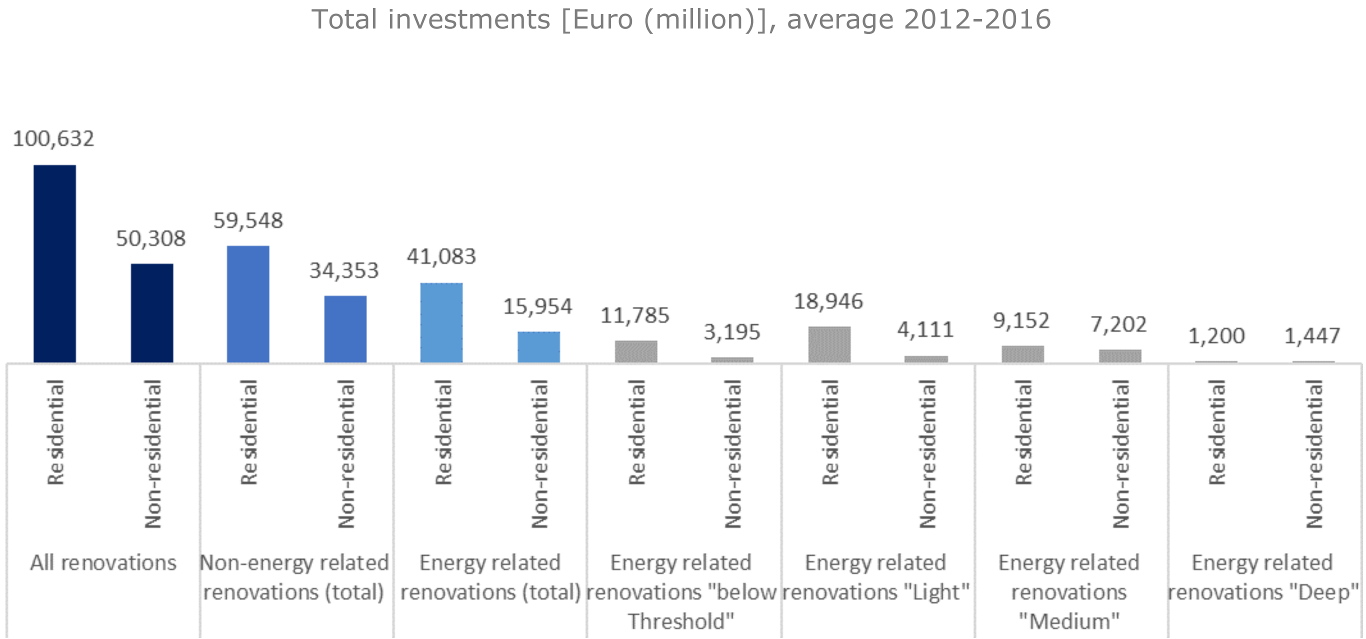
Germany

Population (2018)	82,792,351	
Cooling/heating degree days (2018)	51.2/2775.8	
Dampness damages in buildings [% of population]	14%	
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	1,988/1,966	
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	858,000	
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	429,000	

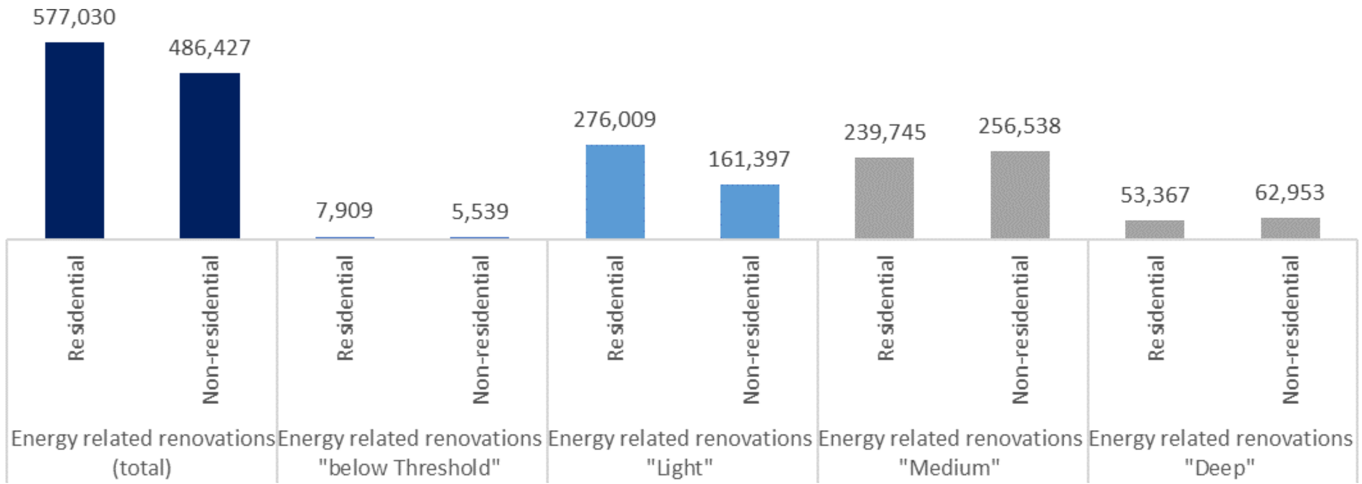
Total building stock [floor area, m²] shares, 2016



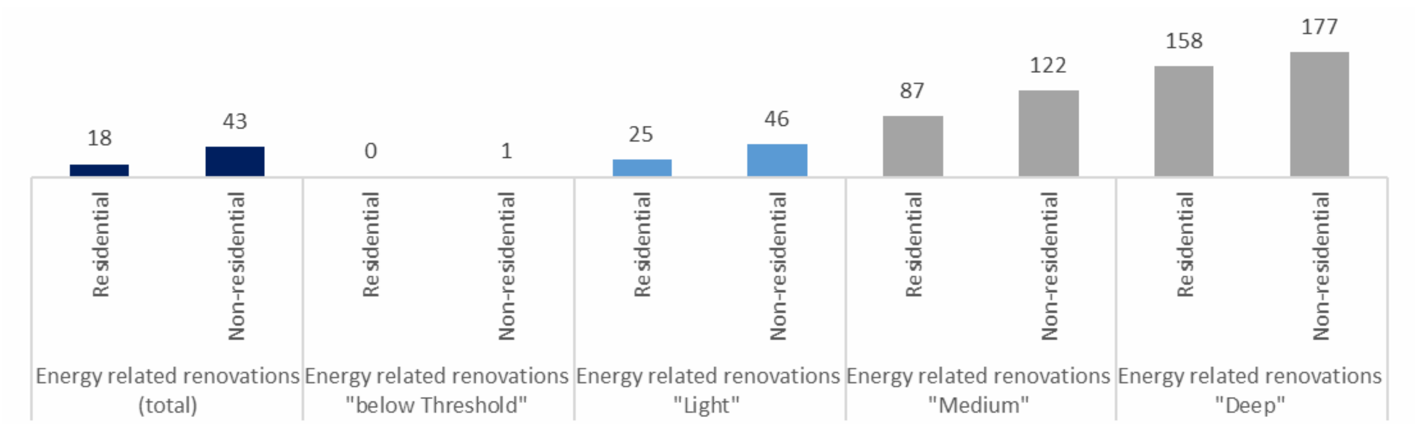

Renovation rate [%/stock], average 2012-2016
12.7%
10.6%
9.8%
6.9%
5.4%
3.3%
3.5%
2.1%
0.9%
1.3%
0.1%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
100,632
50,308
59,548
34,353
41,083
15,954
11,785
3,195
18,946
4,111
9,152
7,202
1,200
1,447
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[11]

Indicative numerical indicator of primary energy use:

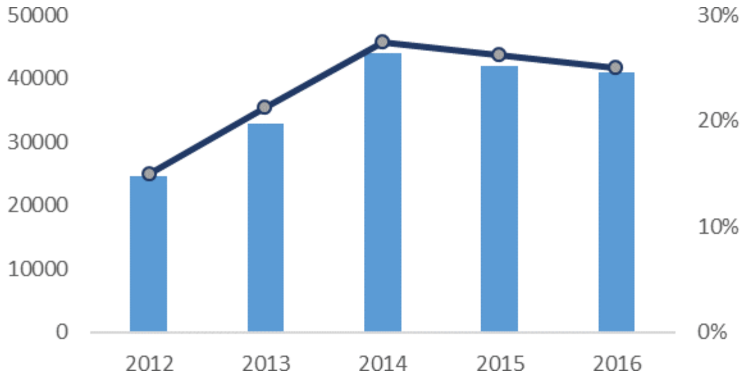
Residential:

40 kWh/(m².y)

Non-residential:

75 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

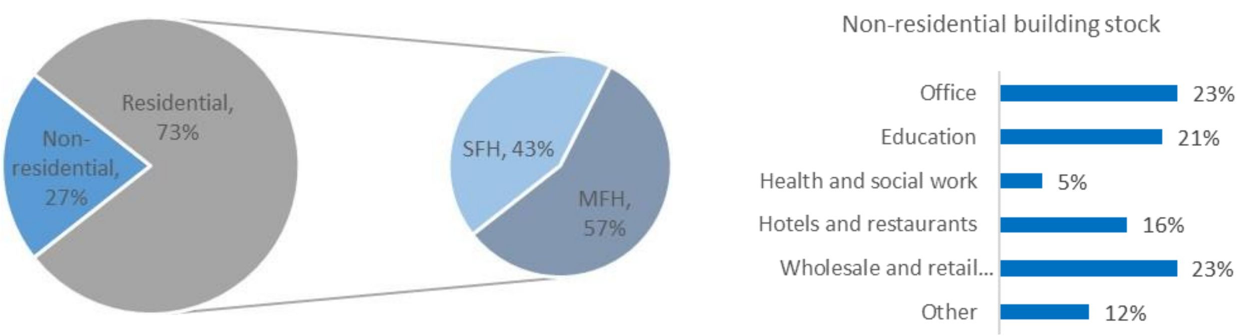


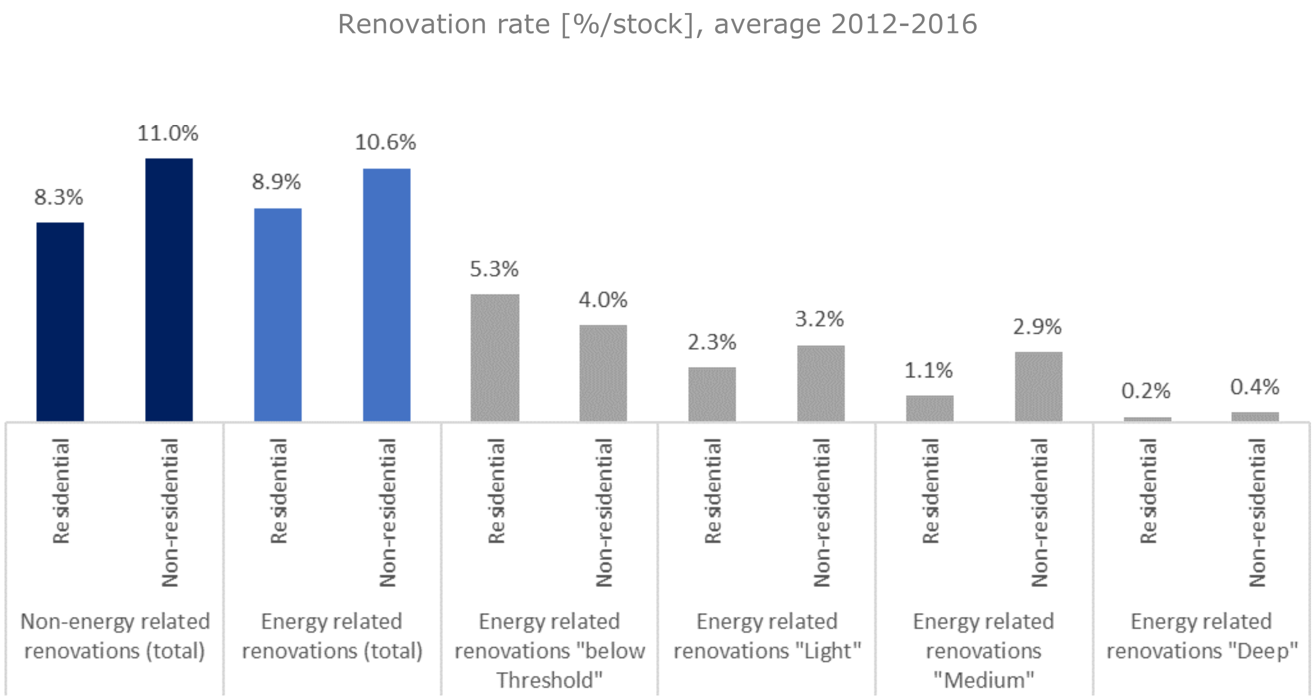
[11] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

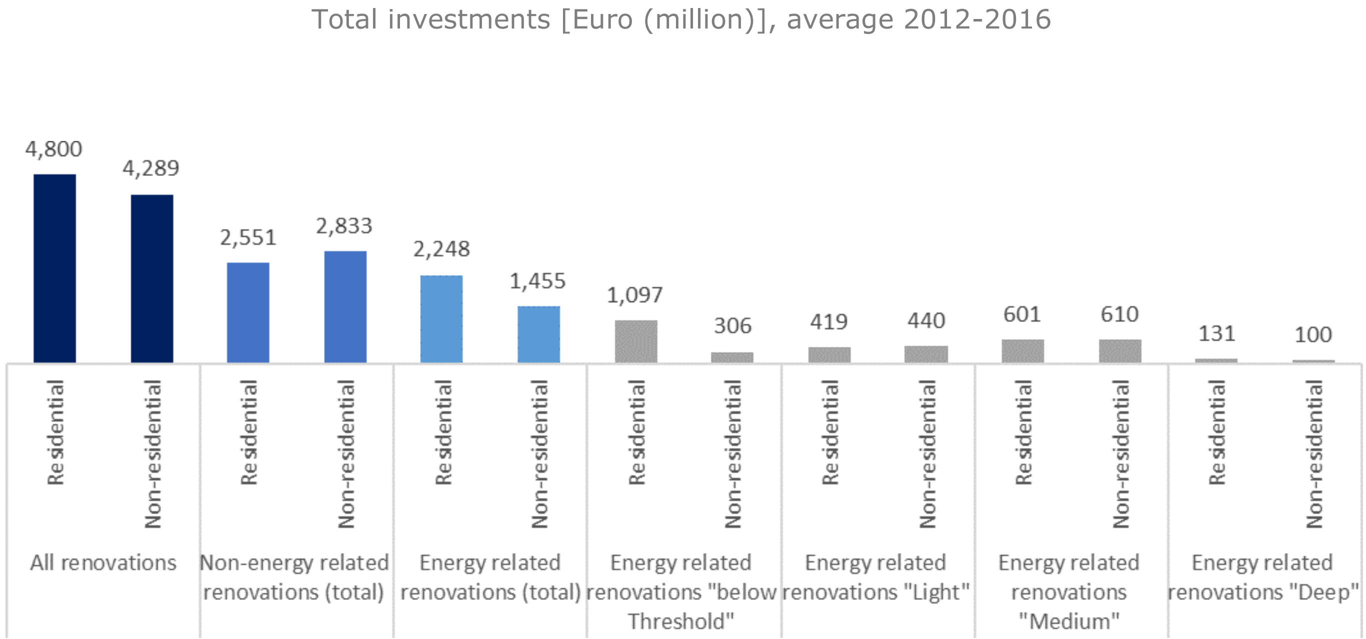
Greece

Population (2018)	10,741,165
Cooling/heating degree days (2018)	306.2/1382.7
Dampness damages in buildings [% of population]	15%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	171/457
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	41,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	37,000

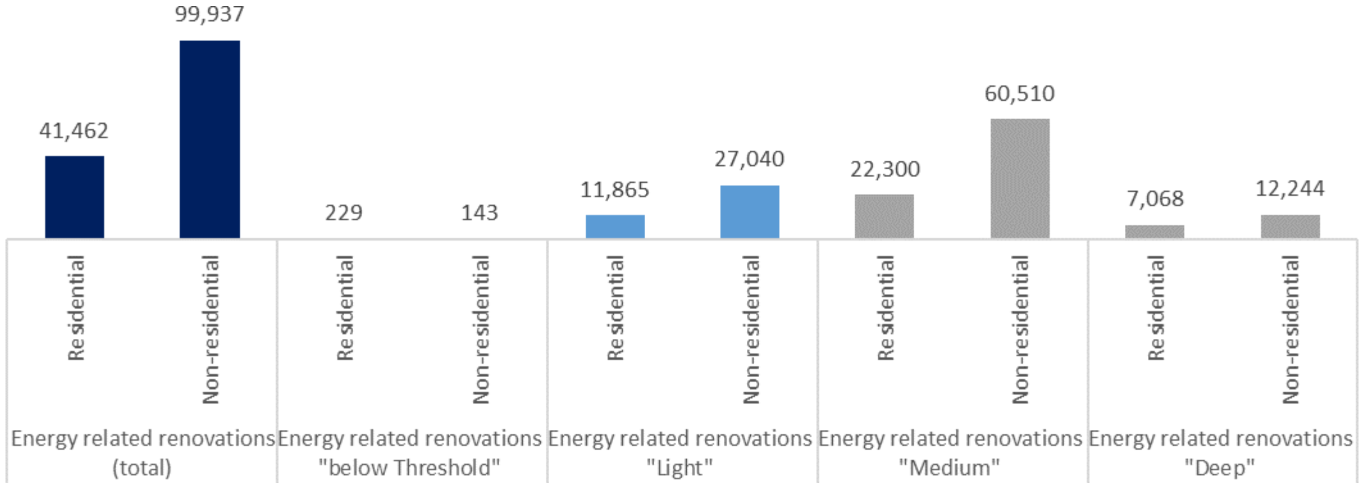
Total building stock [floor area, m²] shares, 2016



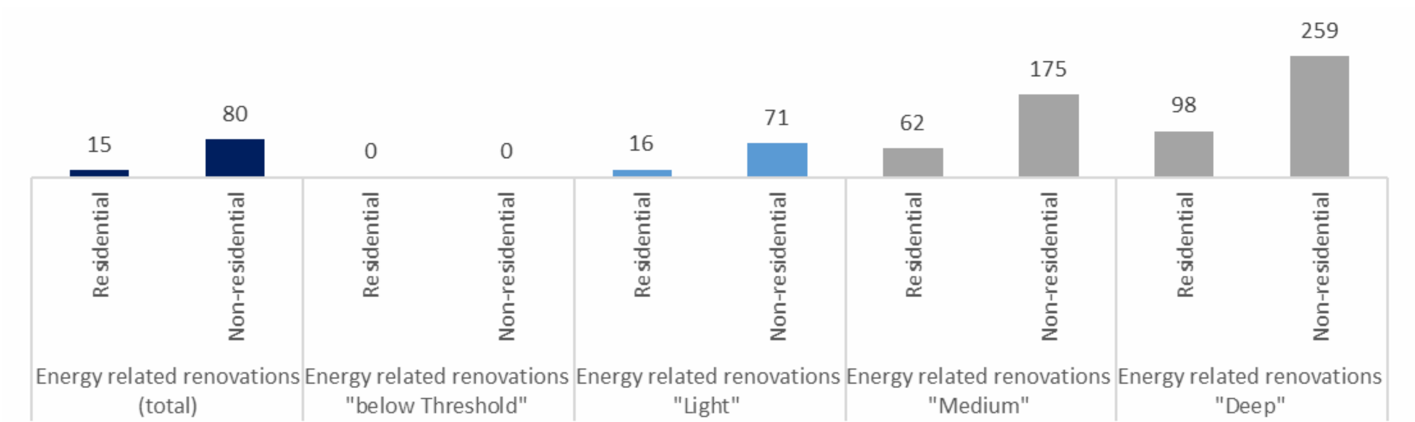

Renovation rate [%/stock], average 2012-2016
8.3%
11.0%
8.9%
10.6%
5.3%
4.0%
2.3%
3.2%
1.1%
2.9%
0.2%
0.4%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
4,800
4,289
2,551
2,833
2,248
1,455
1,097
306
419
440
601
610
131
100
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[12]

Indicative numerical indicator of primary energy use:

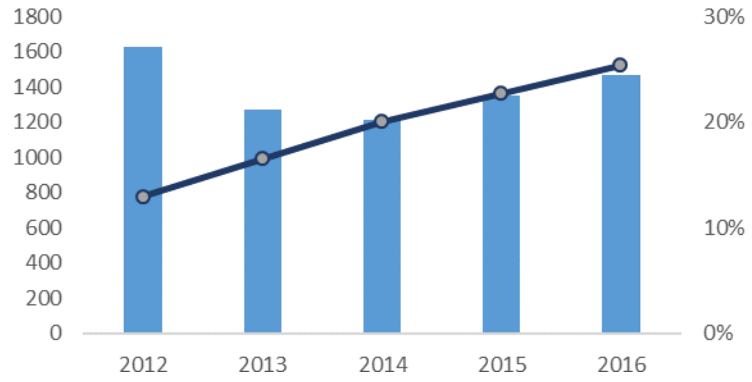
Residential:

80 kWh/(m²\.y)

Non-residential:

85 kWh/(m²\.y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

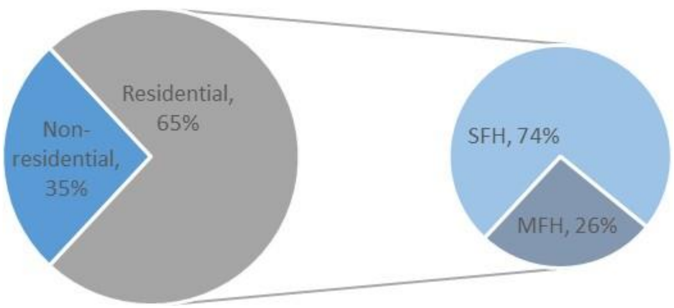


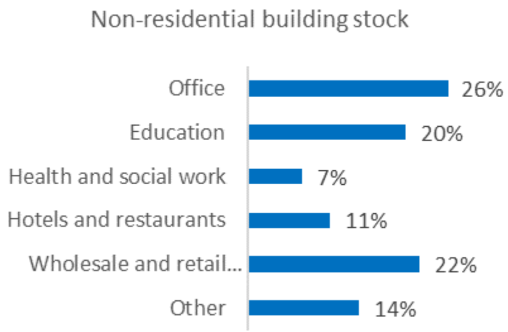
[12] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be “nearly zero”. Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State’s definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

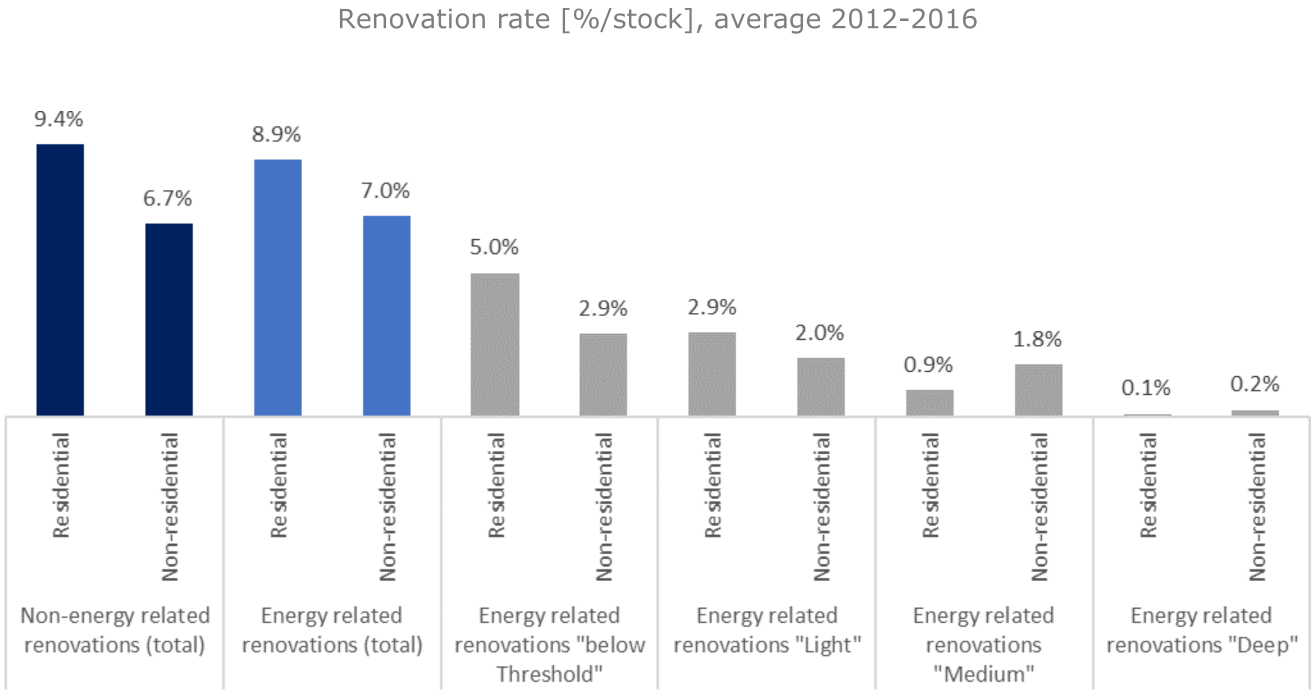
Hungary

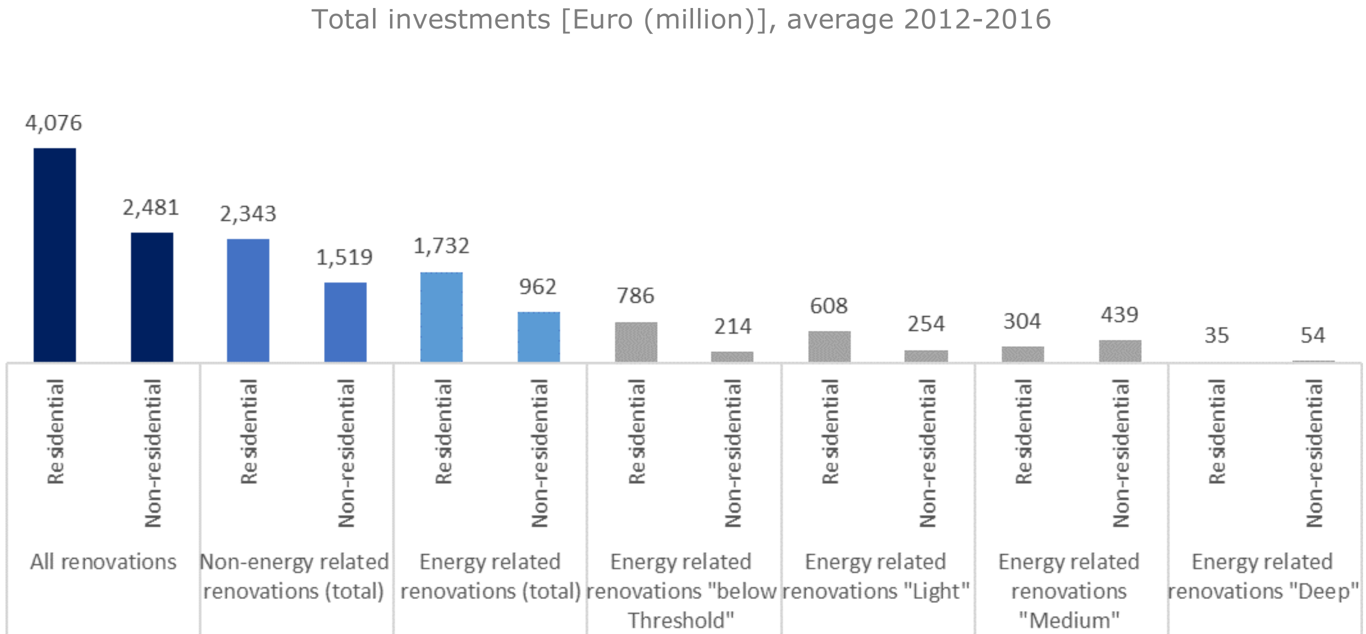
Population (2018)	9,778,371
Cooling/heating degree days (2018)	124.5/2471.6
Dampness damages in buildings [% of population]	24%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	153/335
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	35,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	21,000

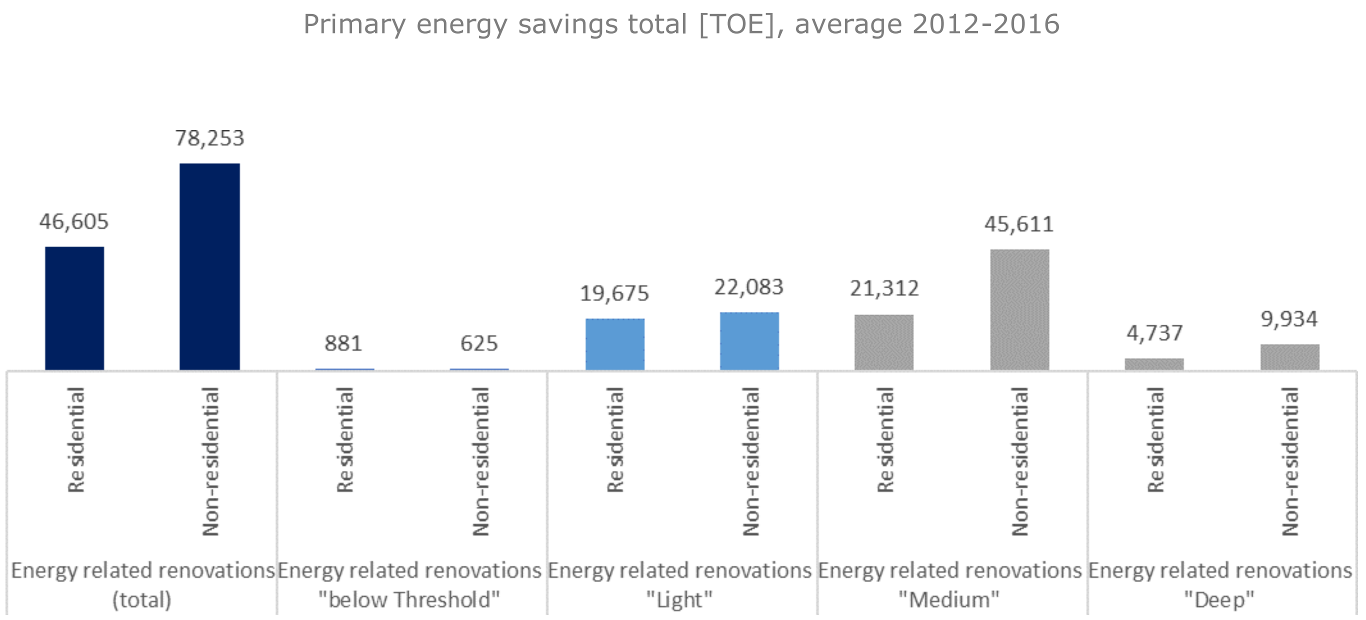
Total building stock [floor area, m²] shares, 2016

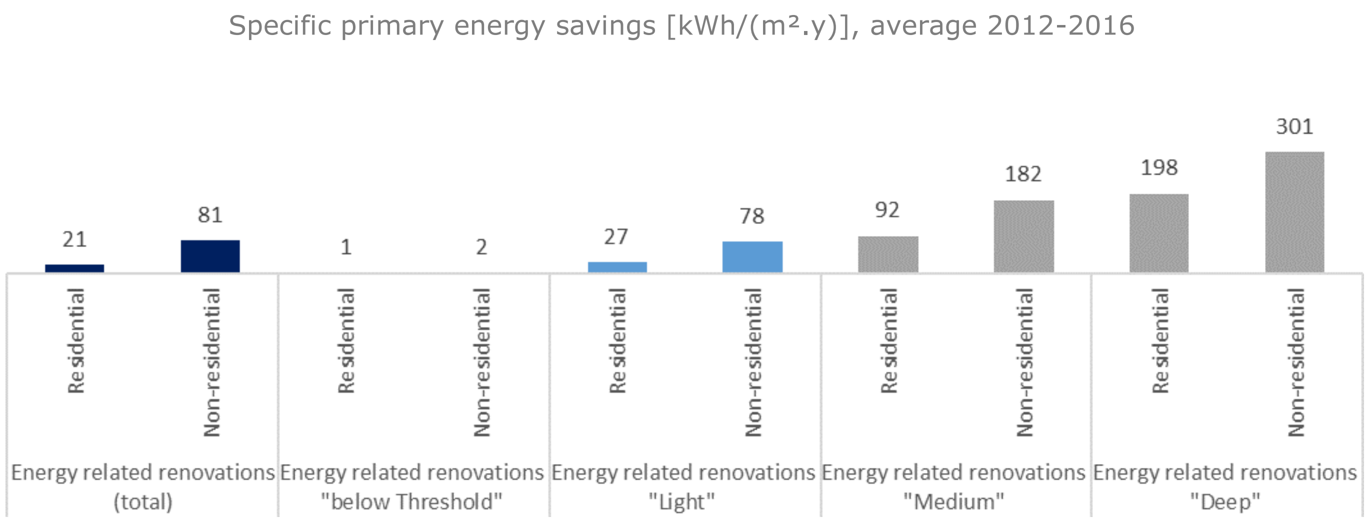





Renovation rate [%/stock], average 2012-2016
9.4%
6.7%
8.9%
7.0%
5.0%
2.9%
2.9%
2.0%
0.9%
1.8%
0.1%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
4,076
2,481
2,343
1,519
1,732
962
786
214
608
254
304
439
35
54
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
46,605
78,253
881
625
19,675
22,083
21,312
45,611
4,737
9,934
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
21
81
1
2
27
78
92
182
198
301
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[13]

Indicative numerical indicator of primary energy use:

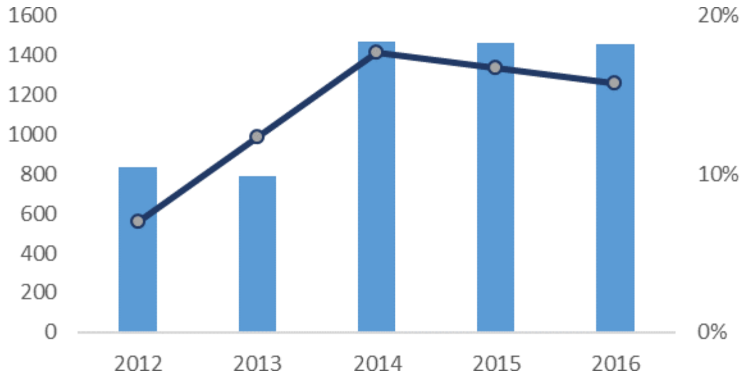
Residential:

105 kWh/(m².y)

Non-residential:

90 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year



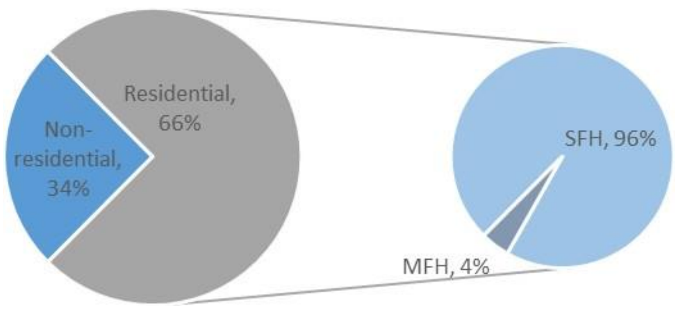
[13] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

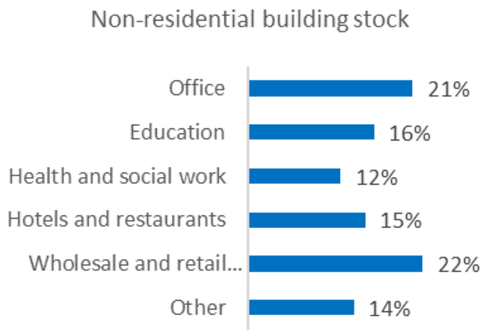
Ireland

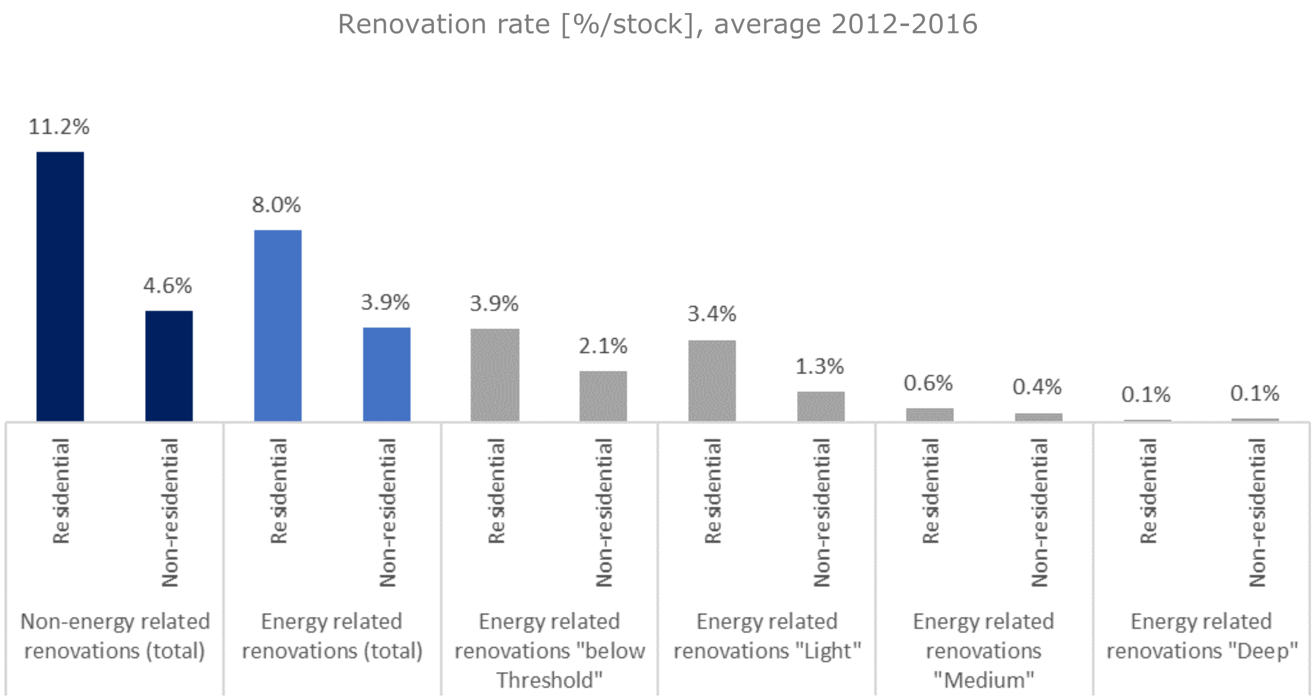
Population (2018)	4,830,392
Cooling/heating degree days (2018)	0.0/2756.0
Dampness damages in buildings [% of population]	13%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	75/54

Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	28,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	9,000

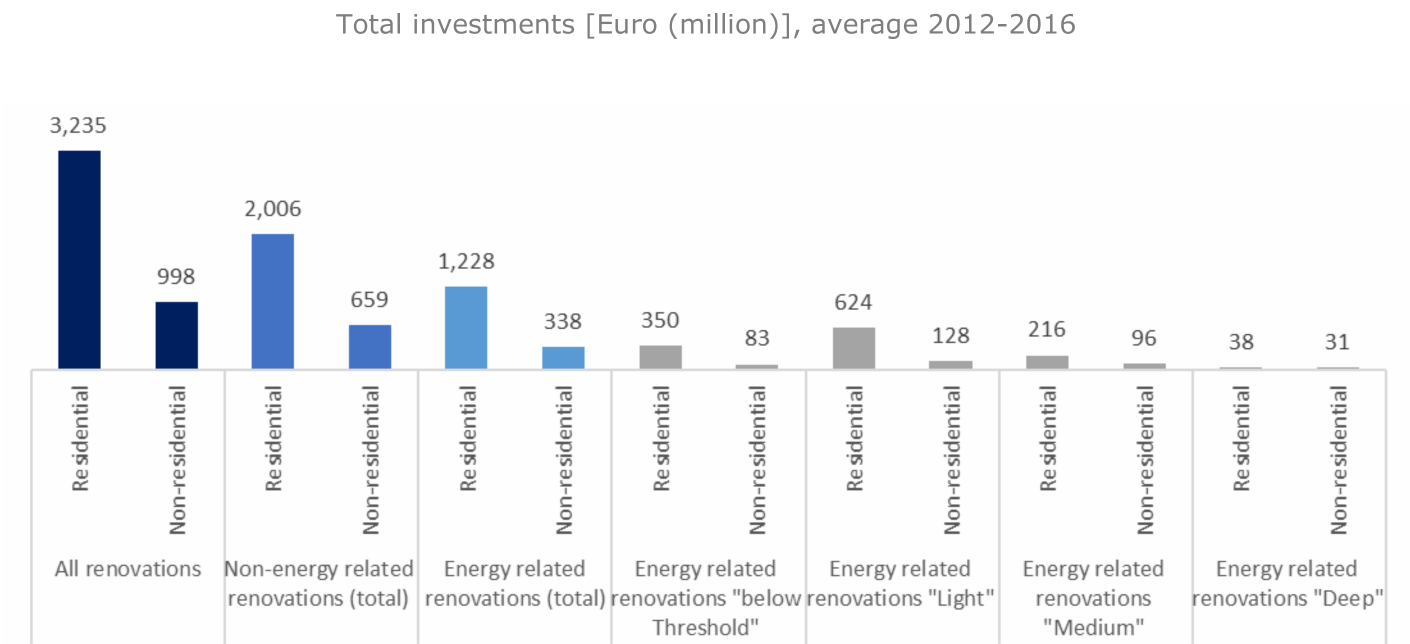
Total building stock [floor area, m²] shares, 2016



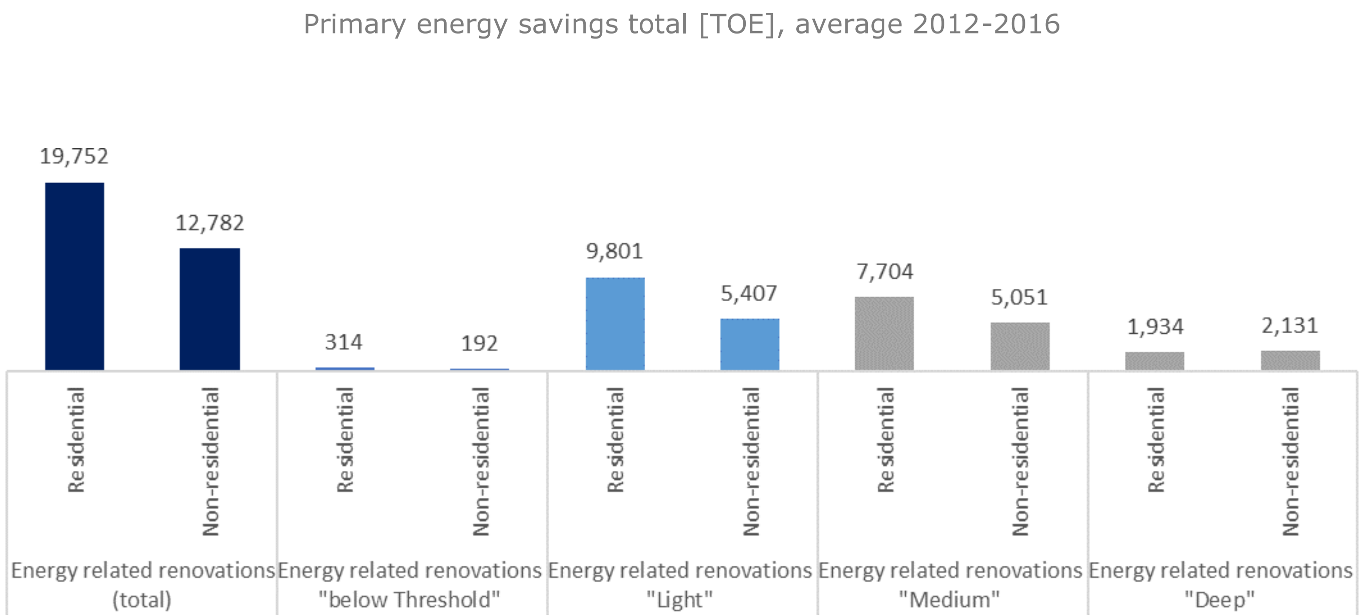




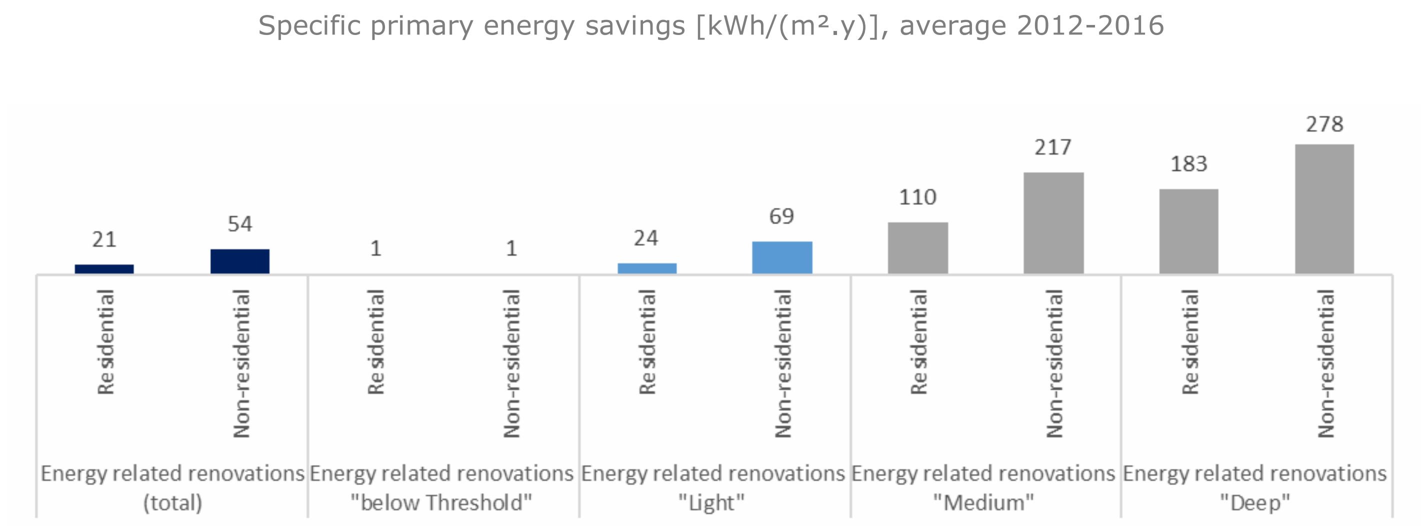
Renovation rate [%/stock], average 2012-2016
11.2%
4.6%
8.0%
3.9%
3.9%
2.1%
3.4%
1.3%
0.6%
0.4%
0.1%
0.1%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Total investments [Euro (million)], average 2012-2016
3,235
998
2,006
659
1,228
338
350
83
624
128
216
96
38
31
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Primary energy savings total [TOE], average 2012-2016
19,752
12,782
314
192
9,801
5,407
7,704
5,051
1,934
2,131
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Specific primary energy savings [kWh/(m².y)], average 2012-2016
21
54
1
1
24
69
110
217
183
278
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[14]

Indicative numerical indicator of primary energy use:

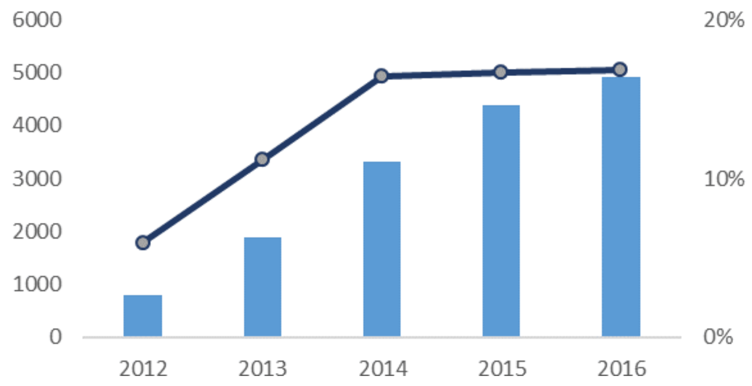
Residential:

15-30 kWh/(m².y)

Non-residential:

40-55 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

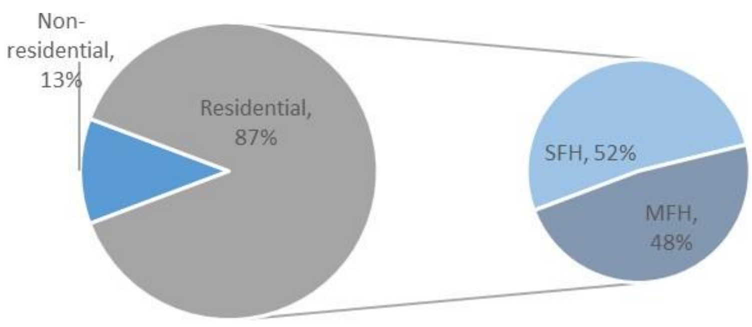


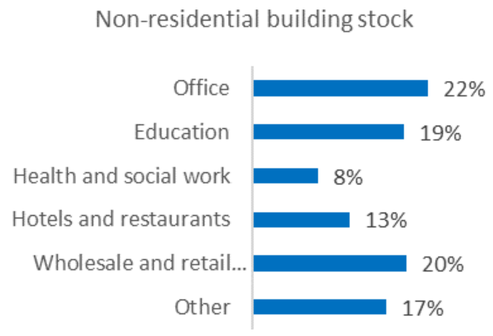
[14] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

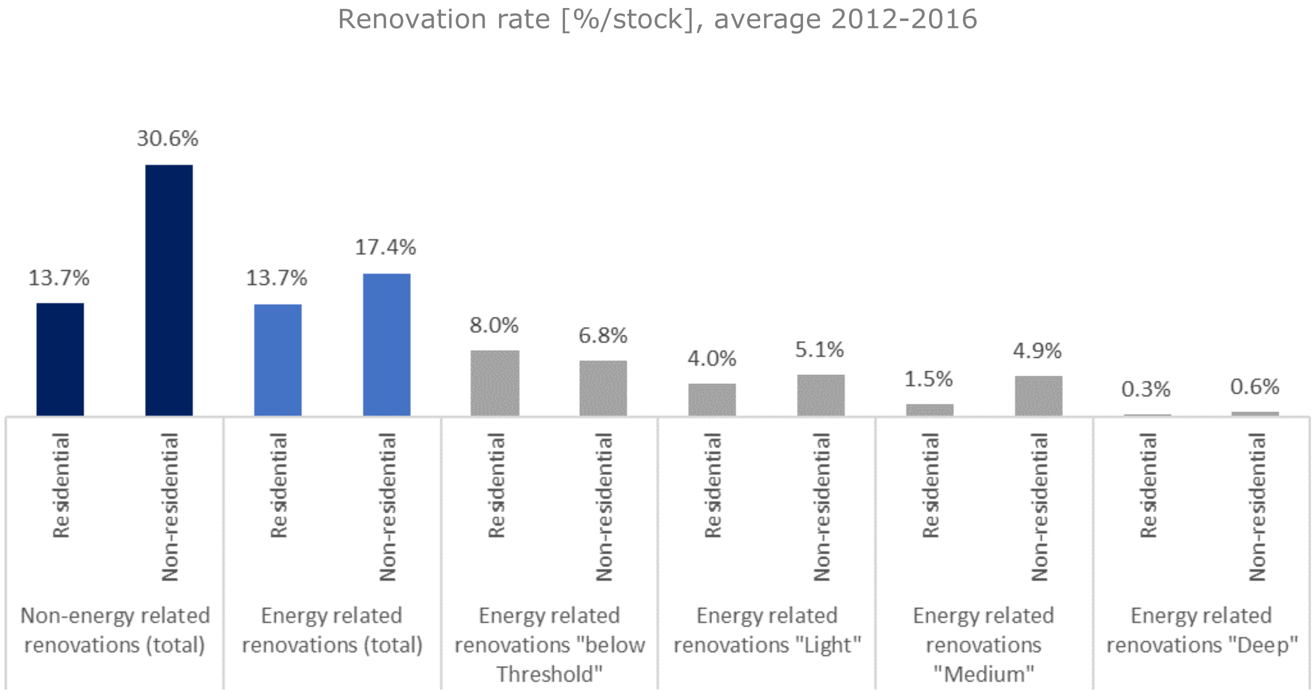
Italy

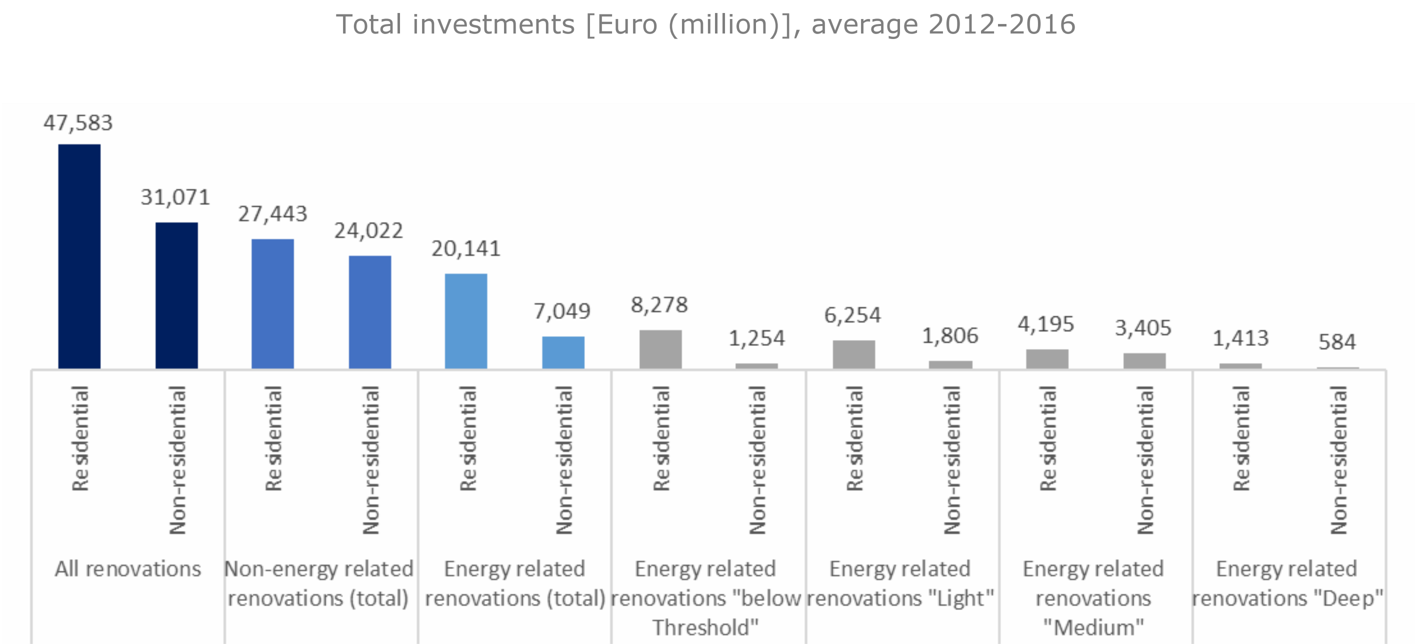
Population (2018)	60,483,973
Cooling/heating degree days (2018)	232.7/1753.7
Dampness damages in buildings [% of population]	21%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	893/1,038
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	405,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	265,000

Total building stock [floor area, m²] shares, 2016

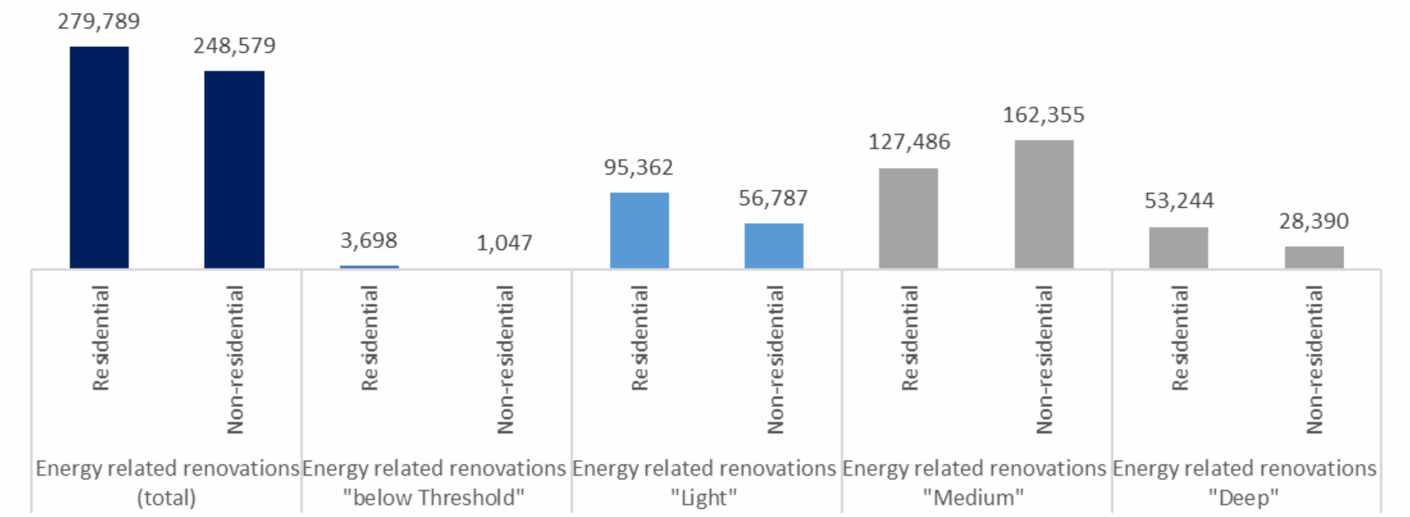




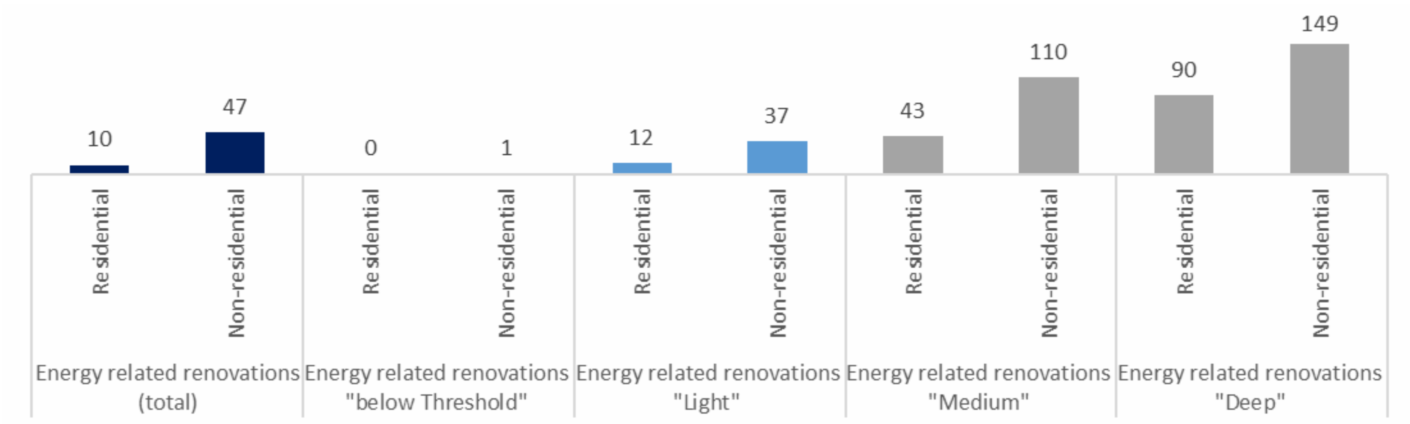

Renovation rate [%/stock], average 2012-2016
13.7%
30.6%
13.7%
17.4%
8.0%
6.8%
4.0%
5.1%
1.5%
4.9%
0.3%
0.6%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
47,583
31,071
27,443
24,022
20,141
7,049
8,278
1,254
6,254
1,806
4,195
3,405
1,413
584
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[15]

Indicative numerical indicator of primary energy use:

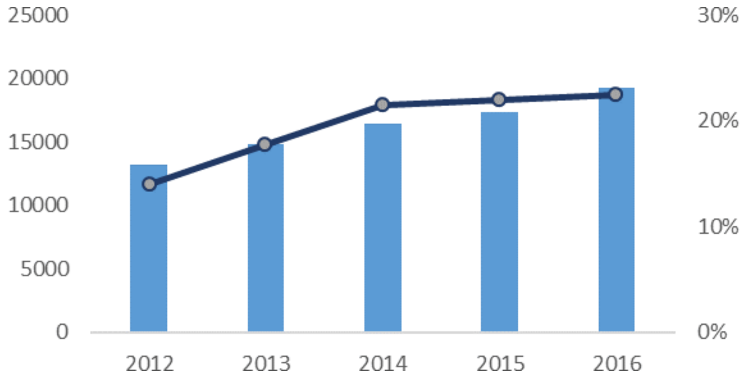
Residential:

45 kWh/(m².y)

Non-residential:

60 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year



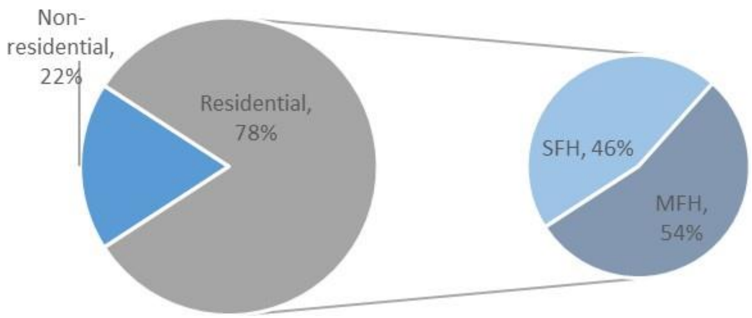
[15] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

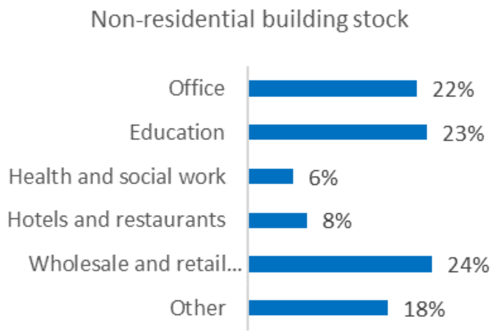
Latvia

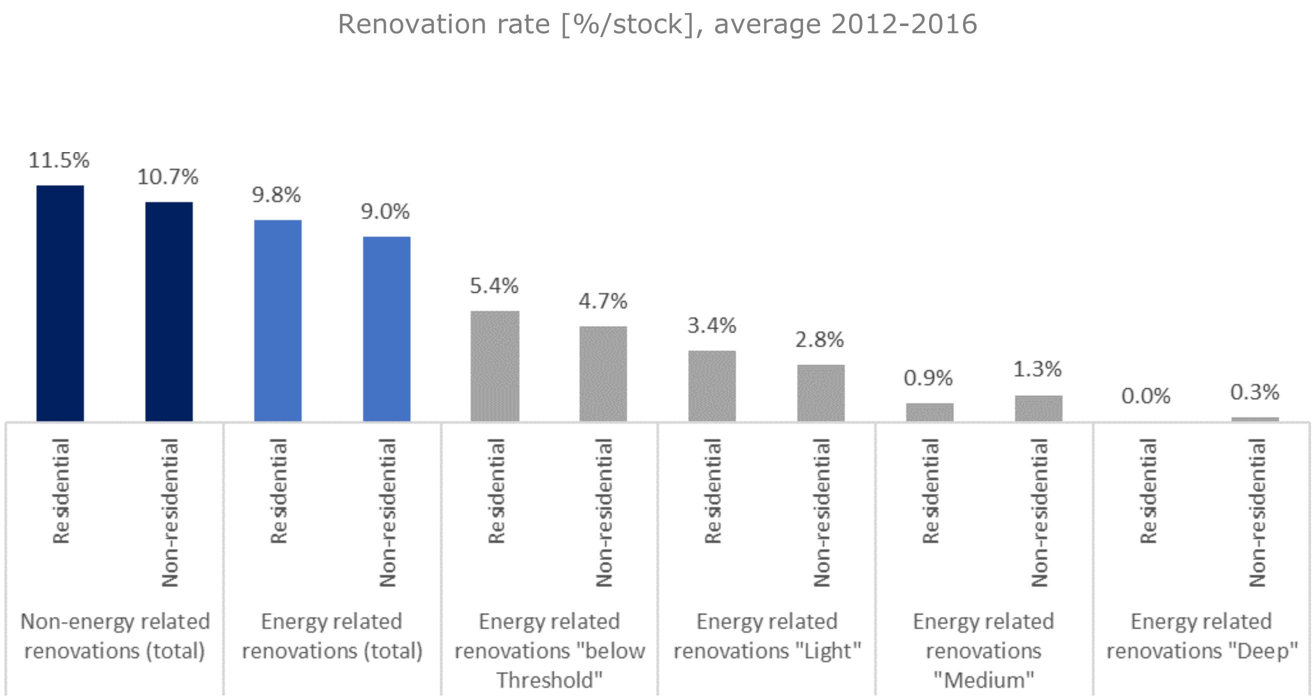
Population (2018)	1,934,379
Cooling/heating degree days (2018)	23.5/3890.7
Dampness damages in buildings [% of population]	28%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	51/51

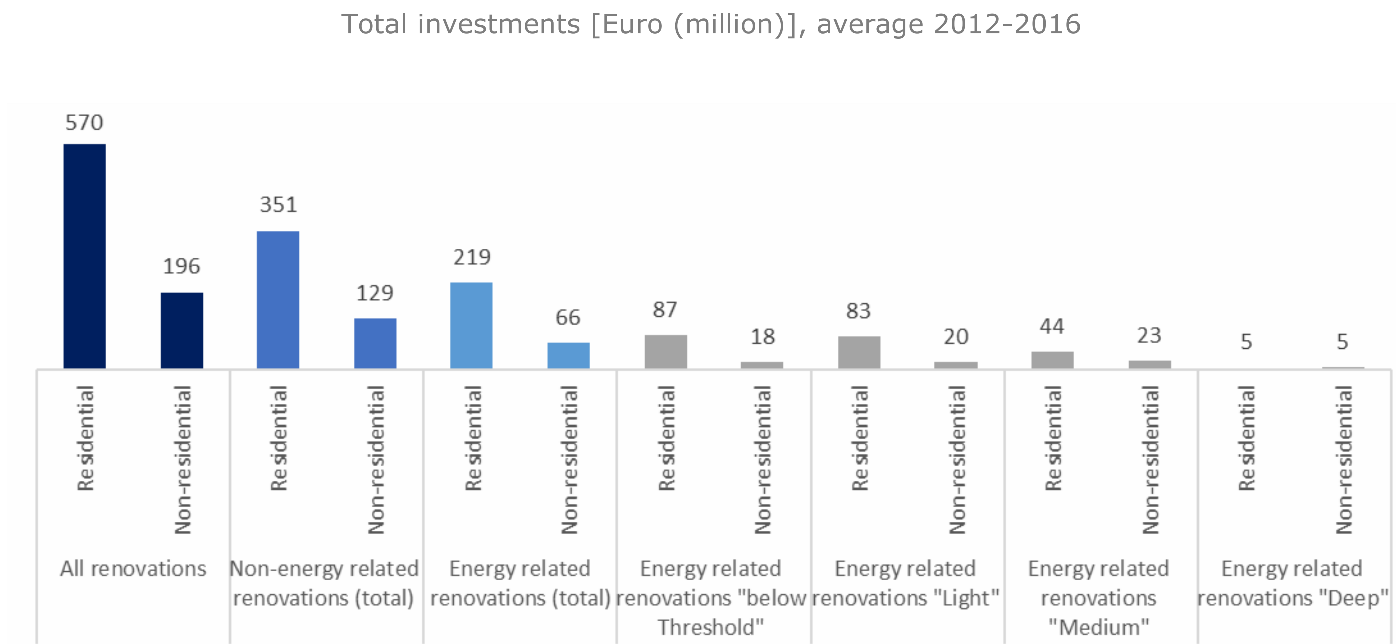
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	5,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	2,000

Total building stock [floor area, m²] shares, 2016

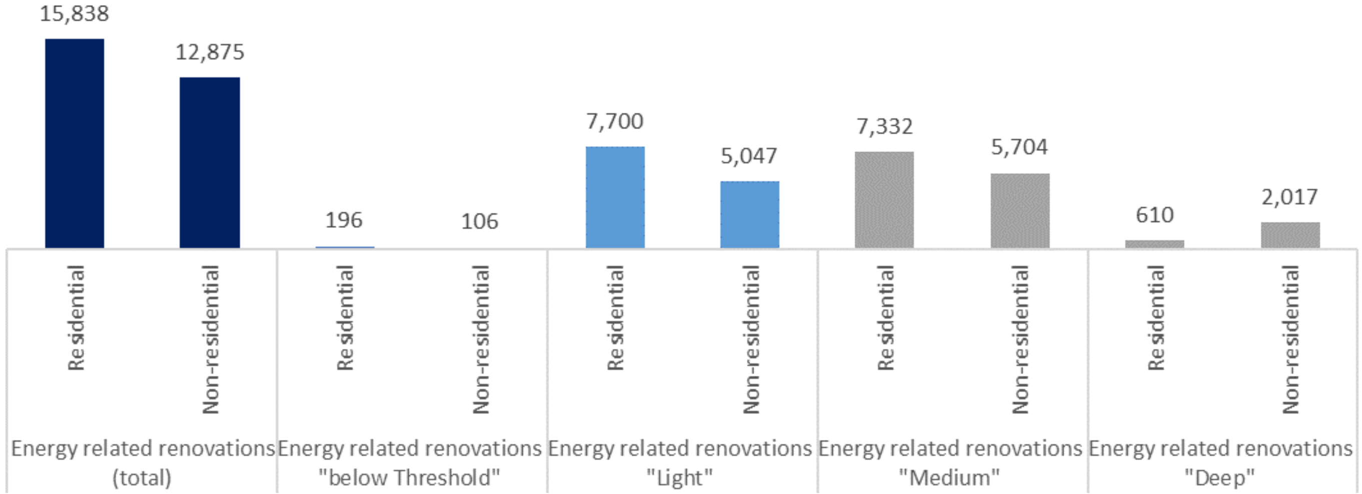




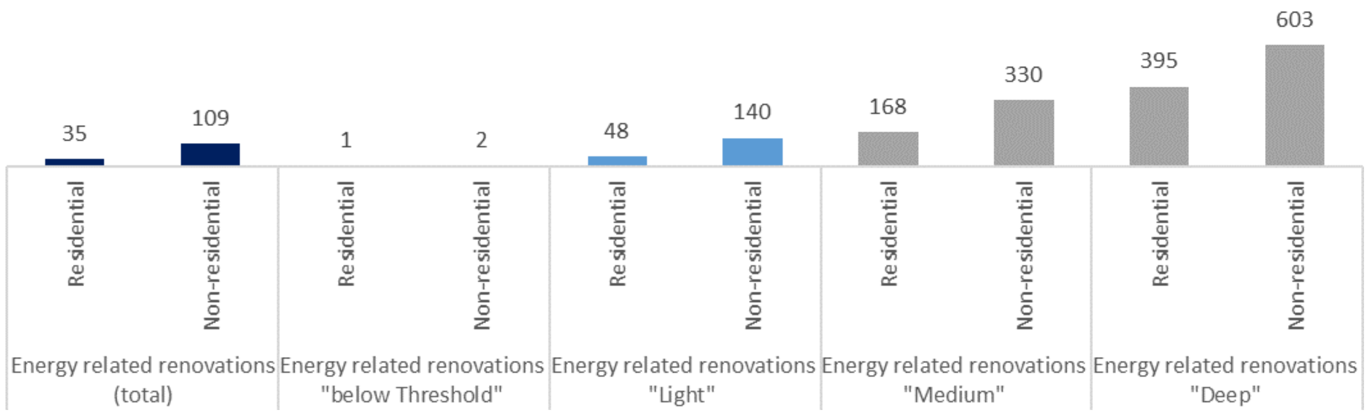

Renovation rate [%/stock], average 2012-2016
11.5%
10.7%
9.8%
9.0%
5.4%
4.7%
3.4%
2.8%
0.9%
1.3%
0.0%
0.3%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
570
196
351
129
219
66
87
18
83
20
44
23
5
5
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[16]

Indicative numerical indicator of primary energy use:

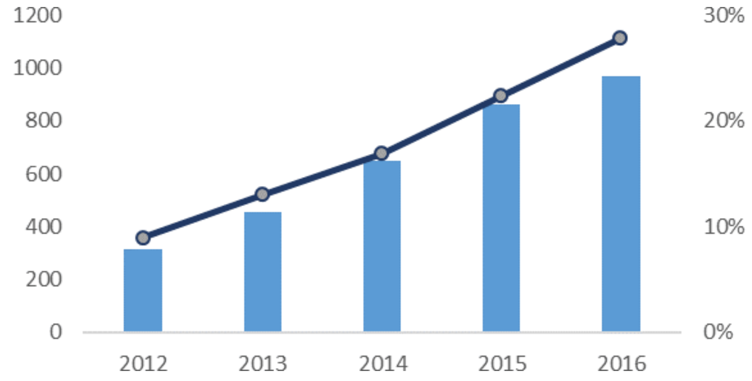
Residential:

95 kWh/(m².y)

Non-residential:

95 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year



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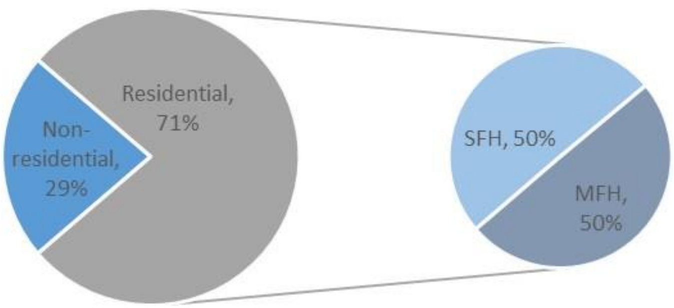
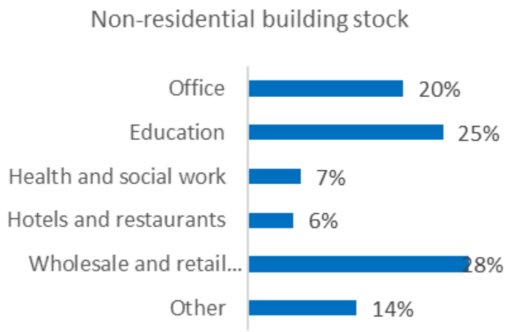
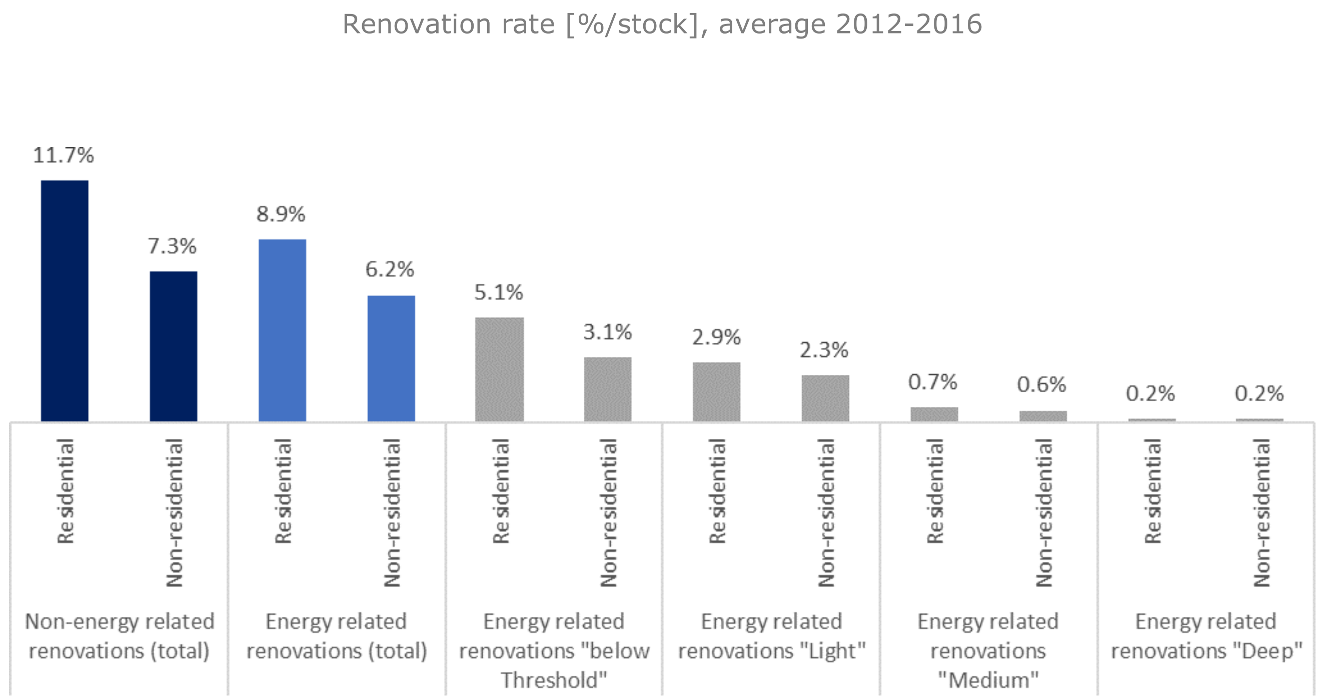
Lithuania

Population (2018)	2,808,901		Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	11,000
Cooling/heating degree days (2018)	24.7/3696.1		Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	3,000
Dampness damages in buildings [% of population]	18%			
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	85/65			

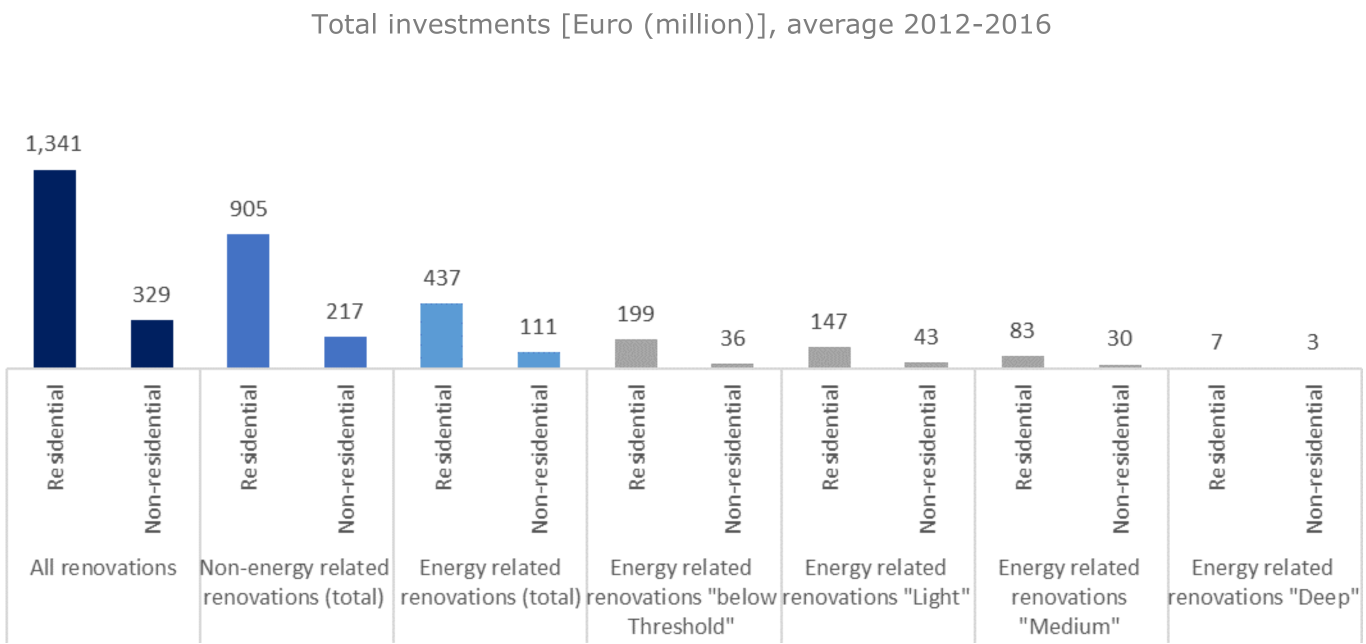
Total building stock [floor area, m²] shares, 2016



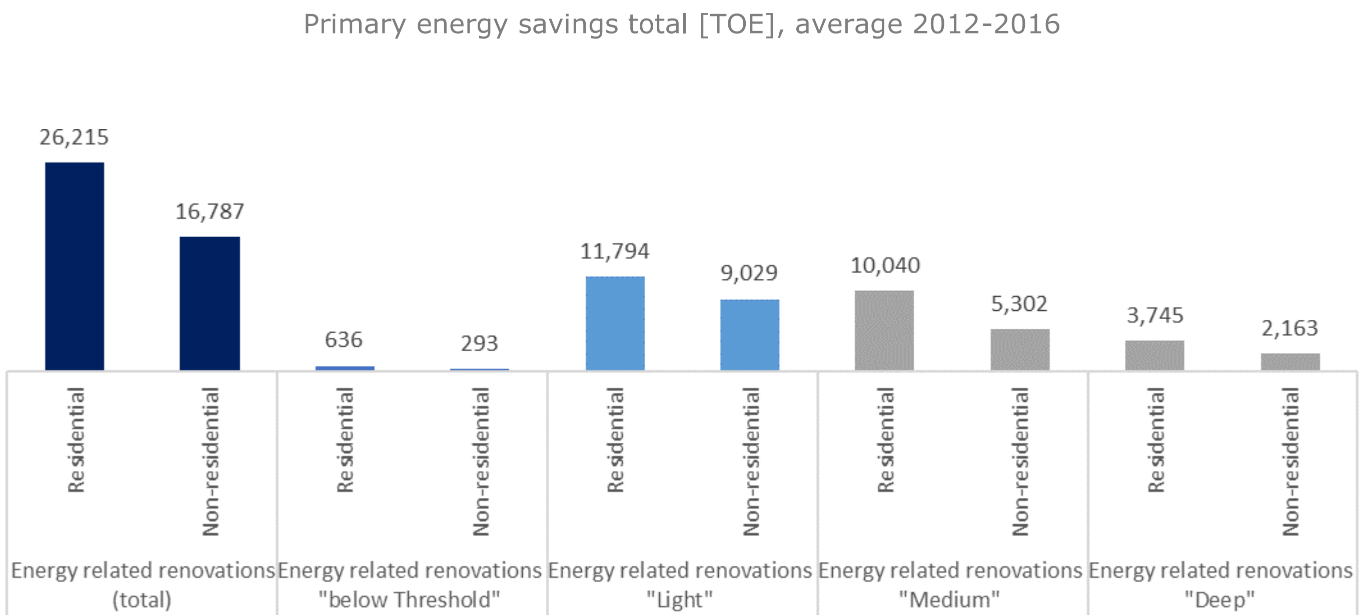


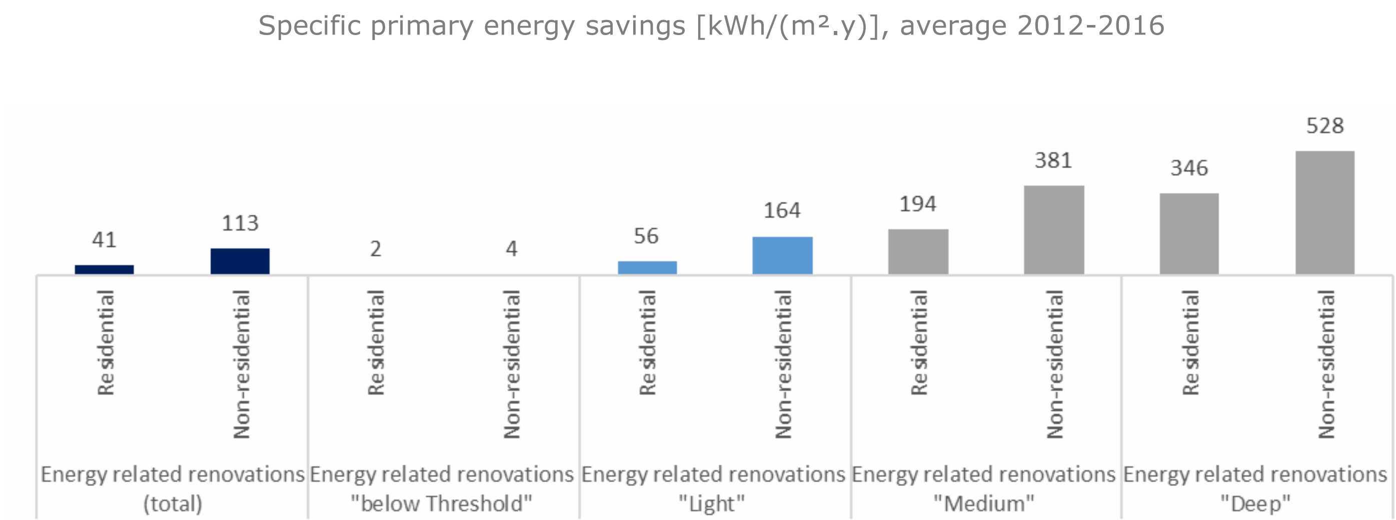


Renovation rate [%/stock], average 2012-2016
11.7%
7.3%
8.9%
6.2%
5.1%
3.1%
2.9%
2.3%
0.7%
0.6%
0.2%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Total investments [Euro (million)], average 2012-2016
1,341
329
905
217
437
111
199
36
147
43
83
30
7
3
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
26,215
16,787
636
293
11,794
9,029
10,040
5,302
3,745
2,163
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
41
113
2
4
56
164
194
381
346
528
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[17]

Indicative numerical indicator of primary energy use:

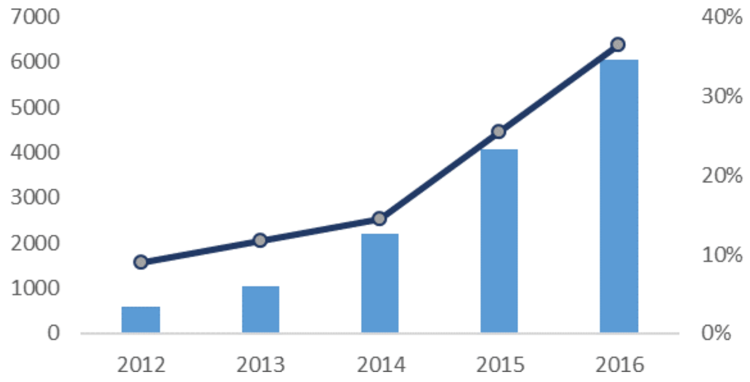
Residential:

60 kWh/(m².y)

Non-residential:

80 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year



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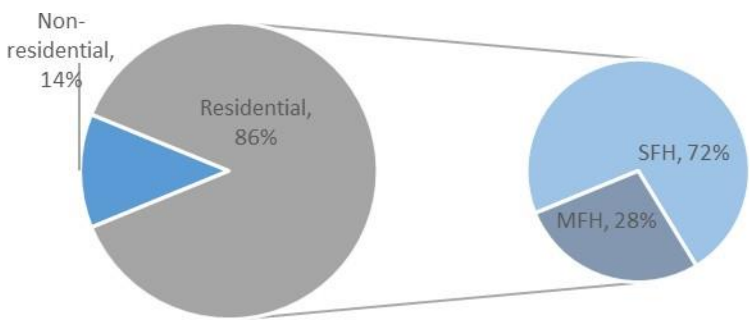
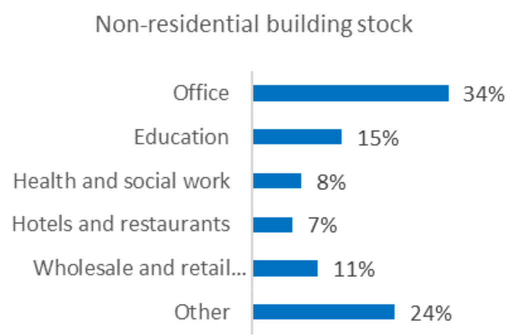
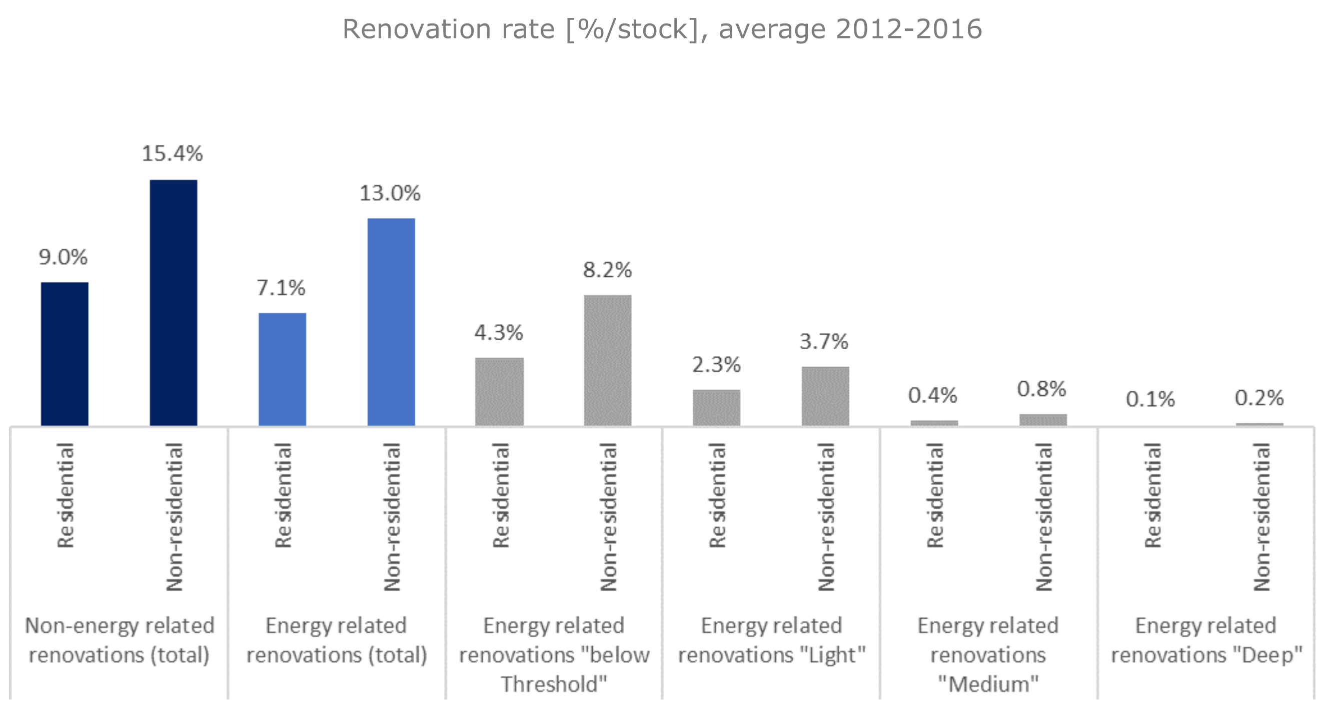
Luxembourg

Population (2018)	602,005
Cooling/heating degree days (2018)	47.2/2669.6
Dampness damages in buildings [% of population]	17%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	7/5
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	5,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	2,000

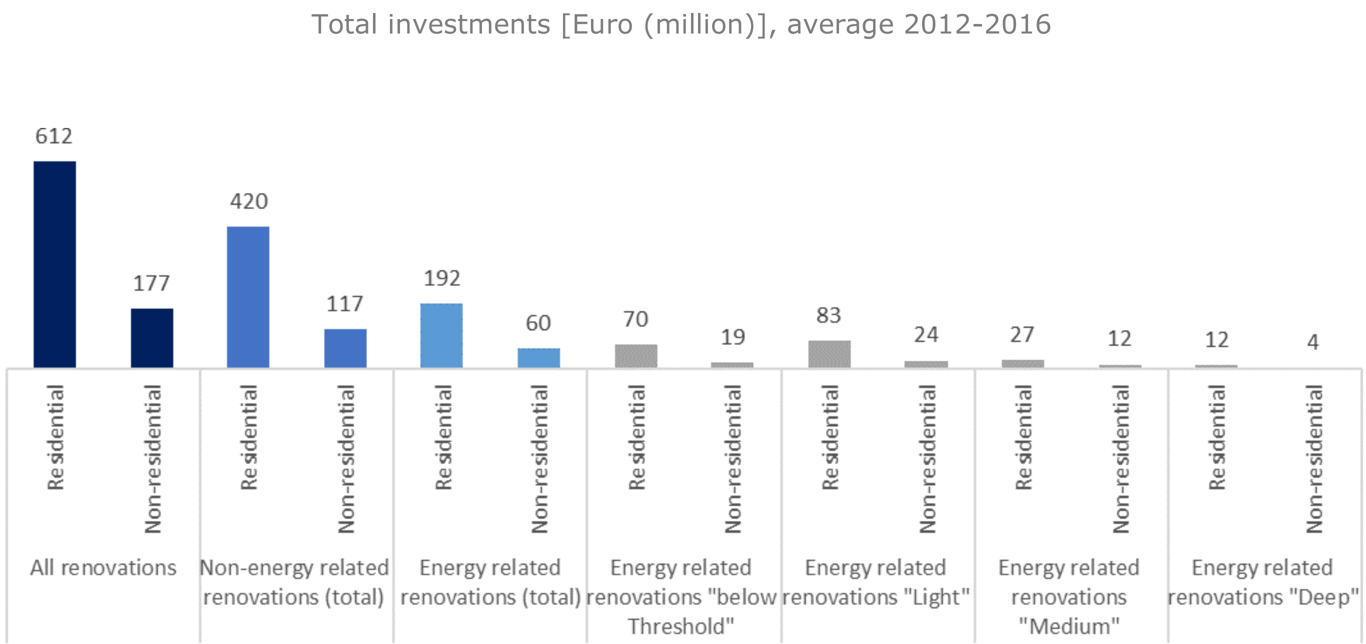
Total building stock [floor area, m²] shares, 2016



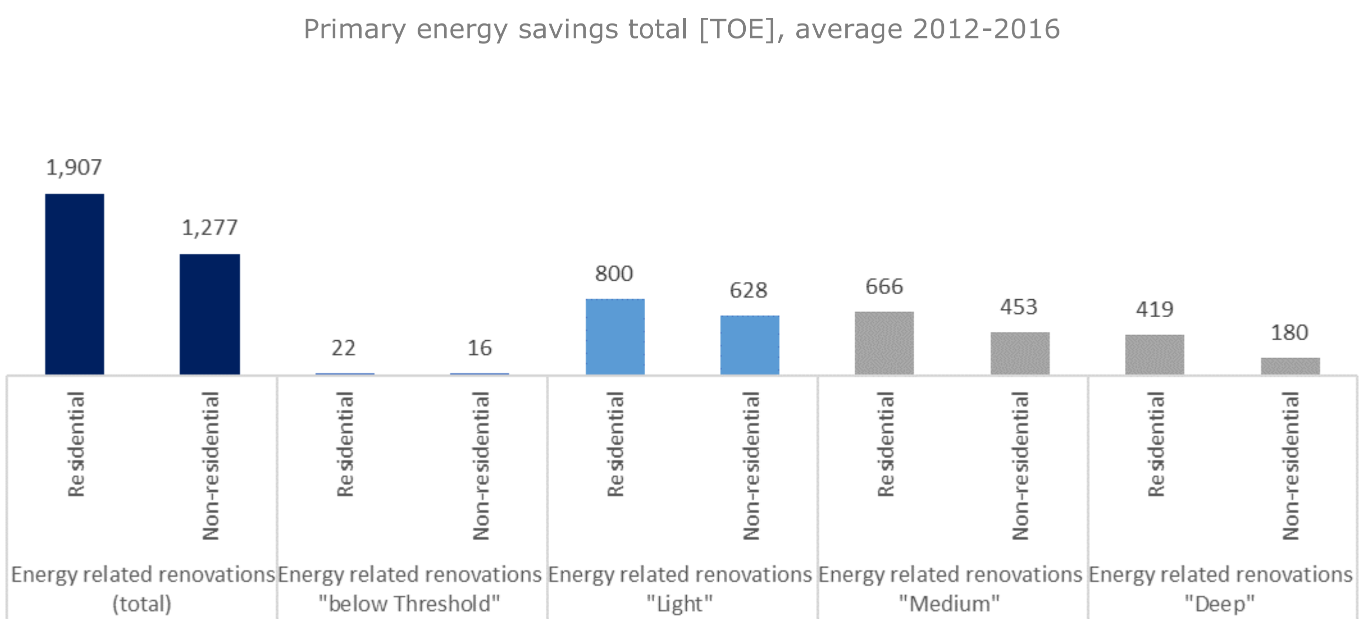


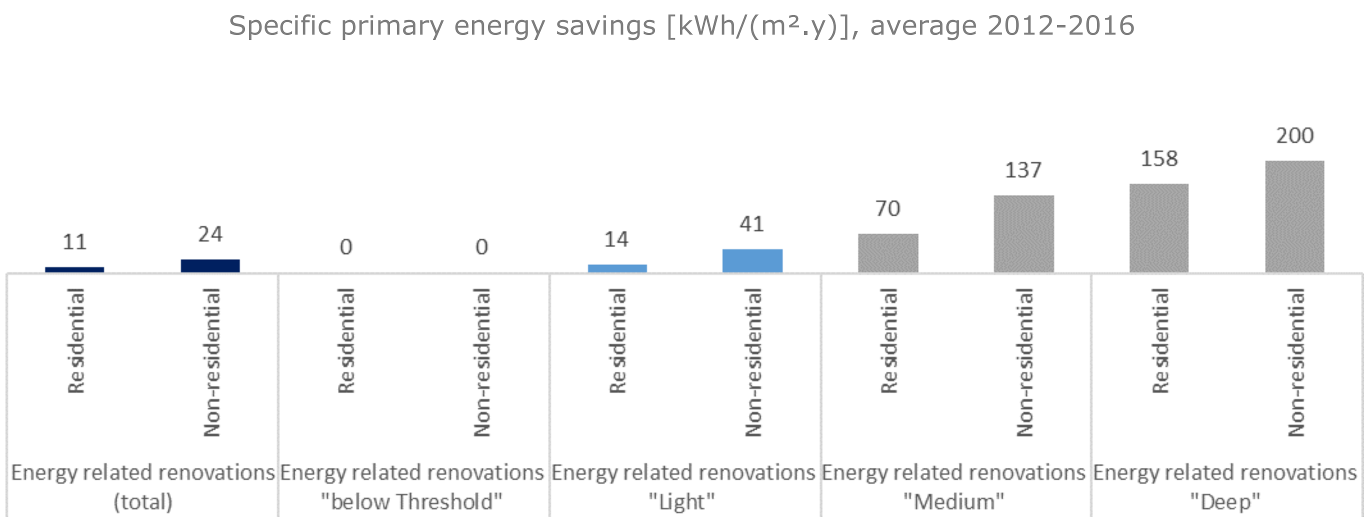


Renovation rate [%/stock], average 2012-2016
9.0%
15.4%
7.1%
13.0%
4.3%
8.2%
2.3%
3.7%
0.4%
0.8%
0.1%
0.2%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Total investments [Euro (million)], average 2012-2016
612
177
420
117
192
60
70
19
83
24
27
12
12
4
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
1,907
1,277
22
16
800
628
666
453
419
180
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
11
24
0
0
14
41
70
137
158
200
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[18]

Indicative numerical indicator of primary energy use:

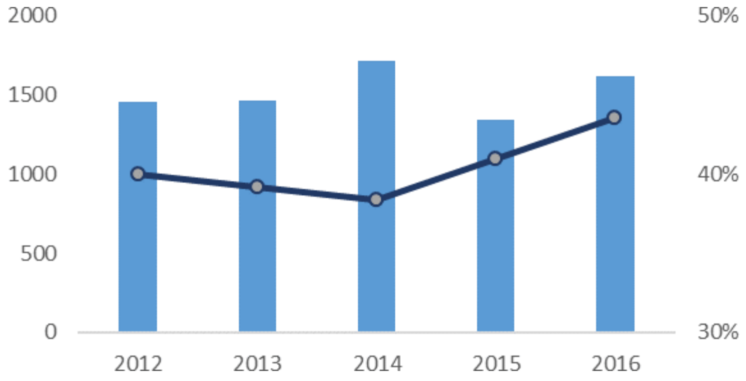
Residential:

45 kWh/(m².y)

Non-residential:

60 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year



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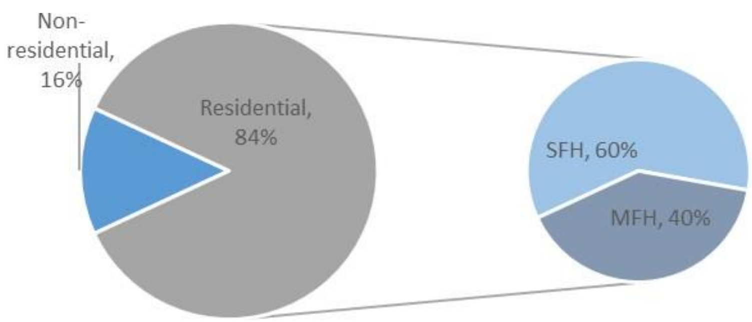
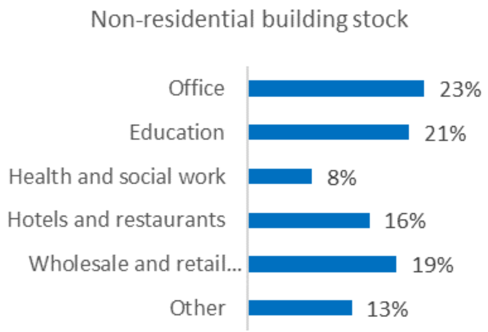
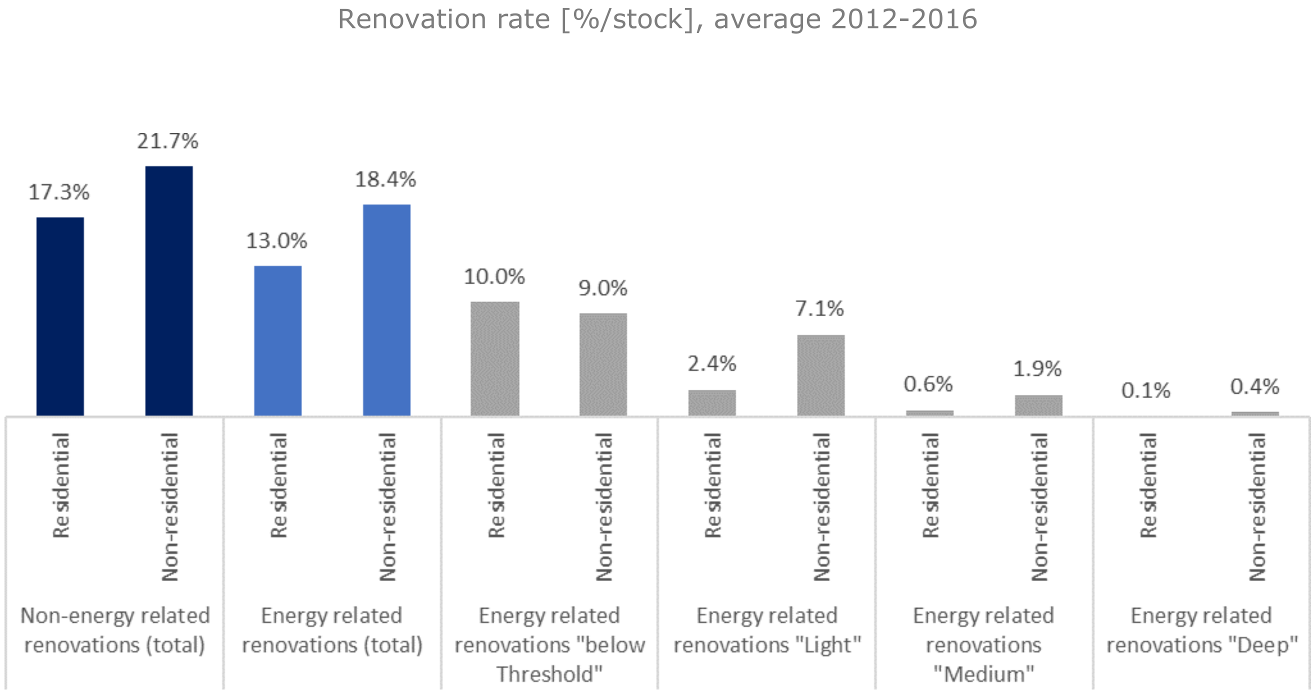
Malta

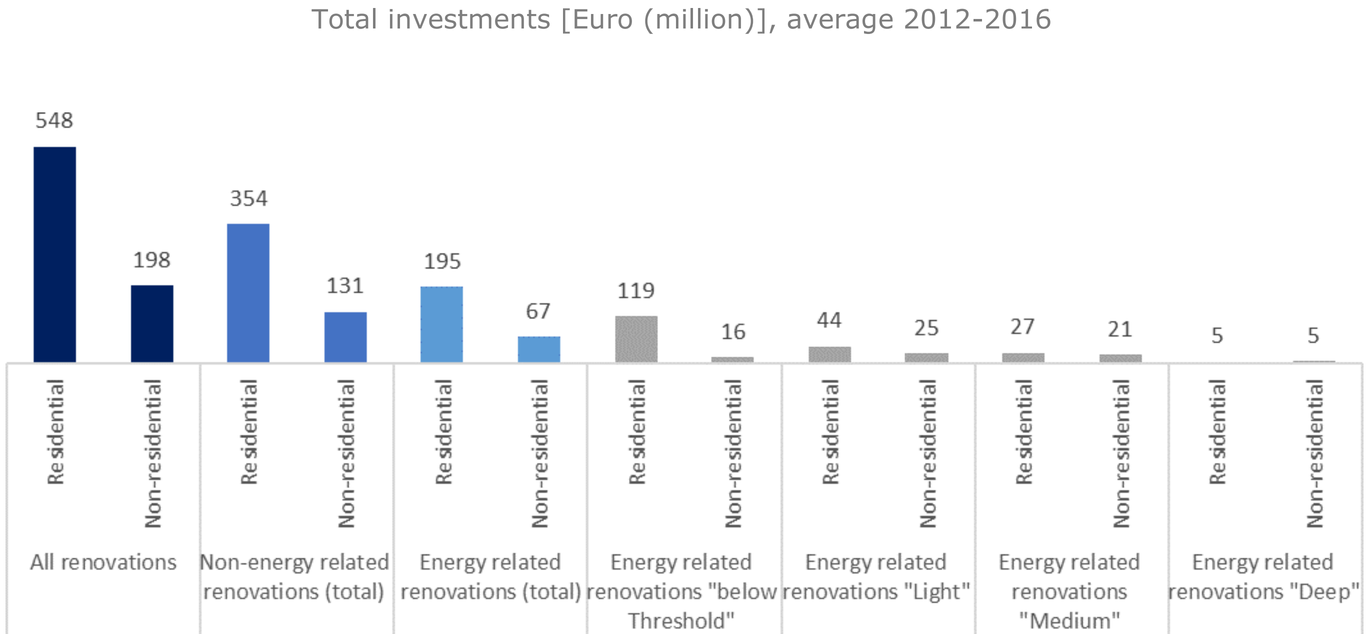
Population (2018)	475,701	Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	5,000
Cooling/heating degree days (2018)	625.7/366.1	Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	2,000
Dampness damages in buildings [% of population]	11%		
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	9/13		

Total building stock [floor area, m²] shares, 2016

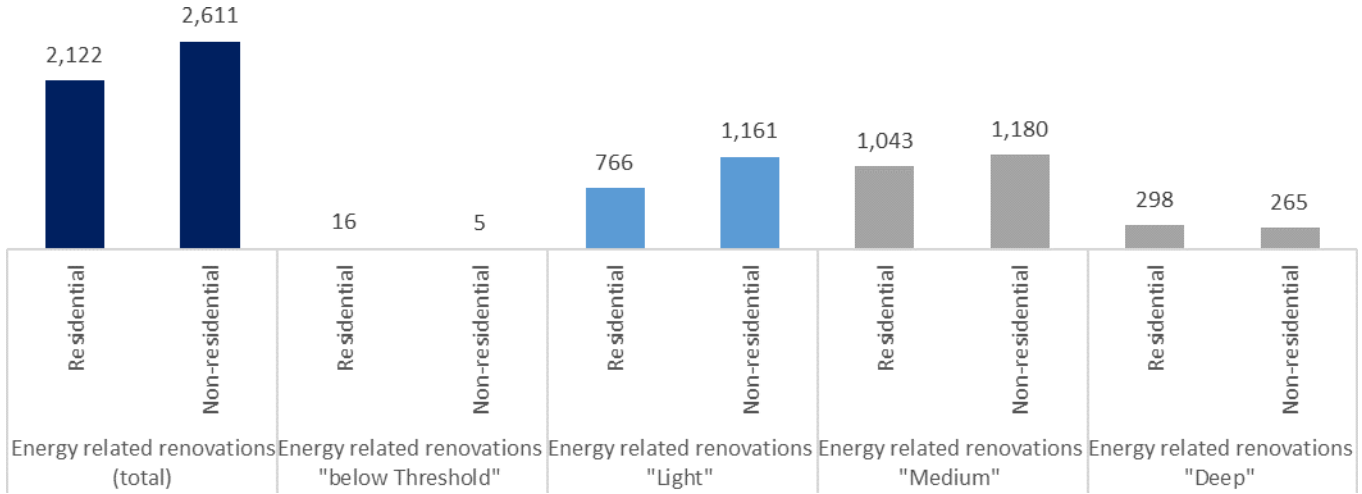




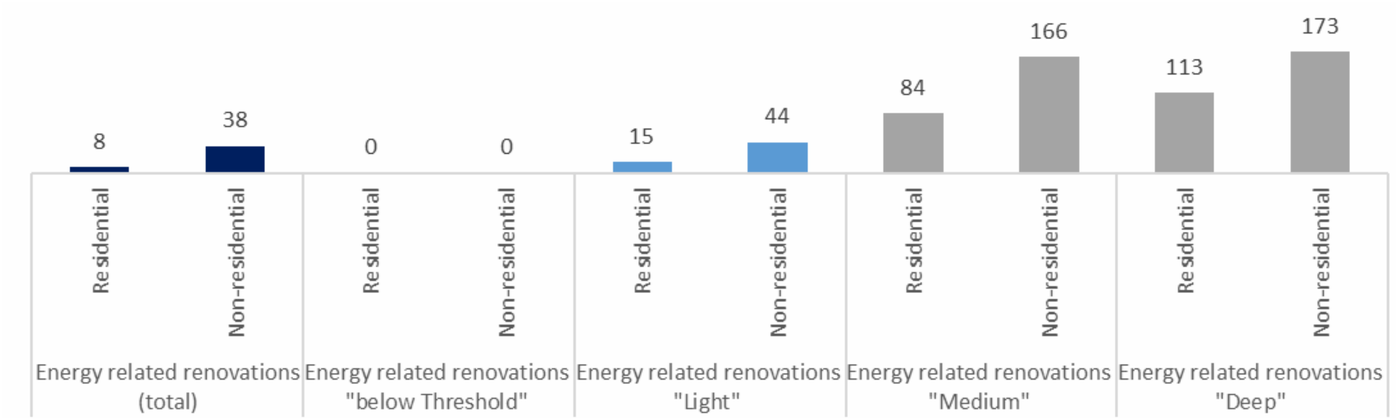

Renovation rate [%/stock], average 2012-2016
17.3%
21.7%
13.0%
18.4%
10.0%
9.0%
2.4%
7.1%
0.6%
1.9%
0.1%
0.4%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
548
198
354
131
195
67
119
16
44
25
27
21
5
5
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[19]

Indicative numerical indicator of primary energy use:

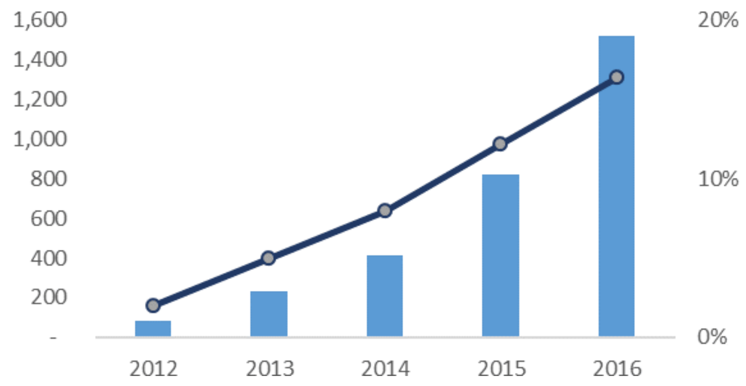
Residential:

55 kWh/(m².y)

Non-residential:

175 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

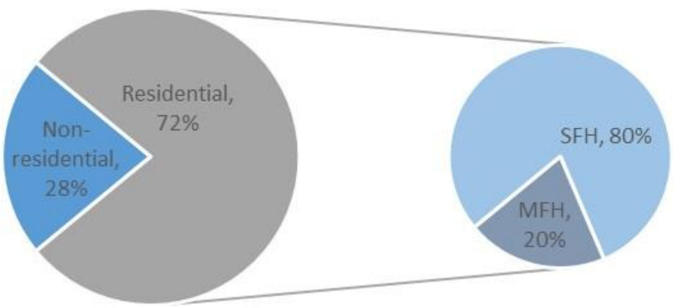


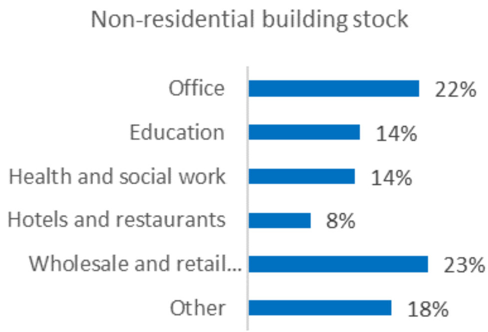
[19] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

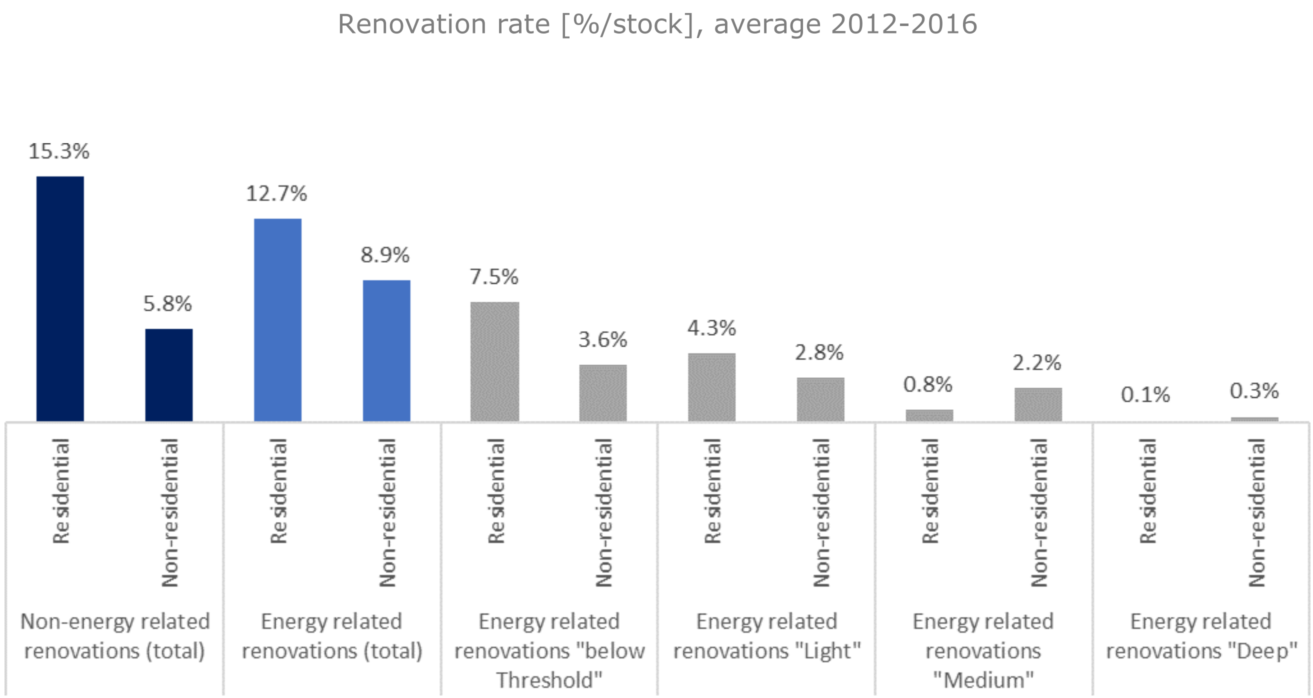
Netherlands

Population (2018)	17,181,084
Cooling/heating degree days (2018)	31.4/2526.8
Dampness damages in buildings [% of population]	16%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	277/494
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	271,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	96,000

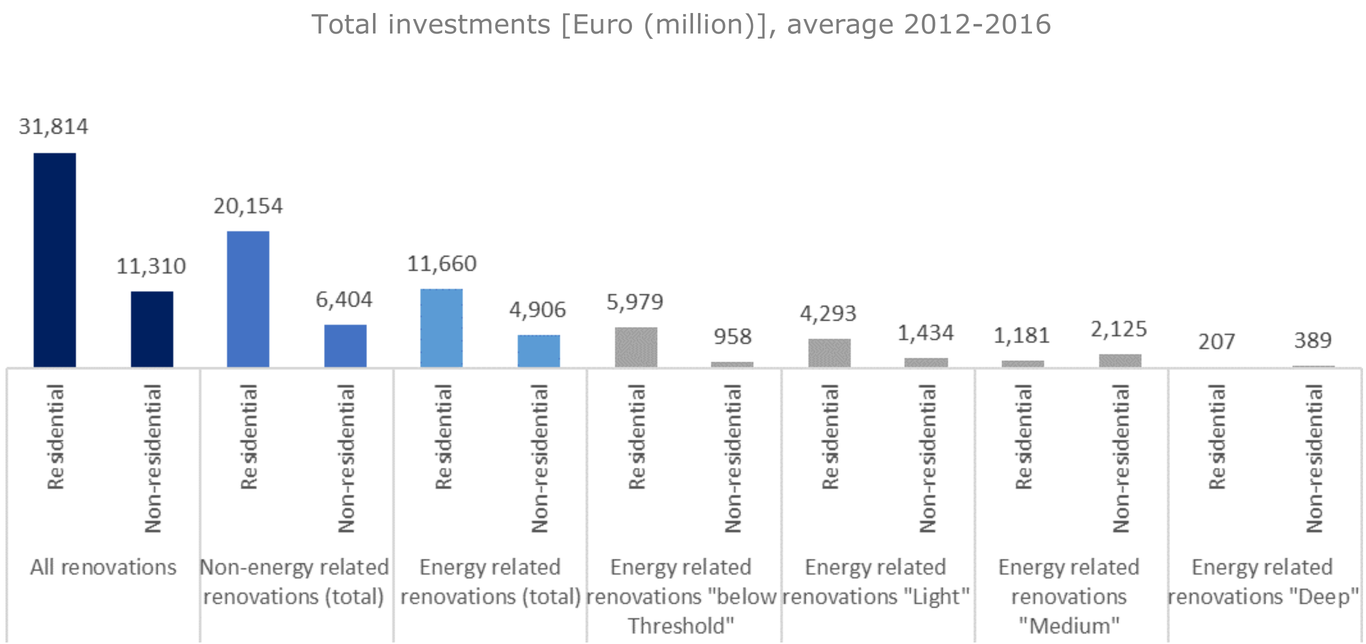
Total building stock [floor area, m²] shares, 2016



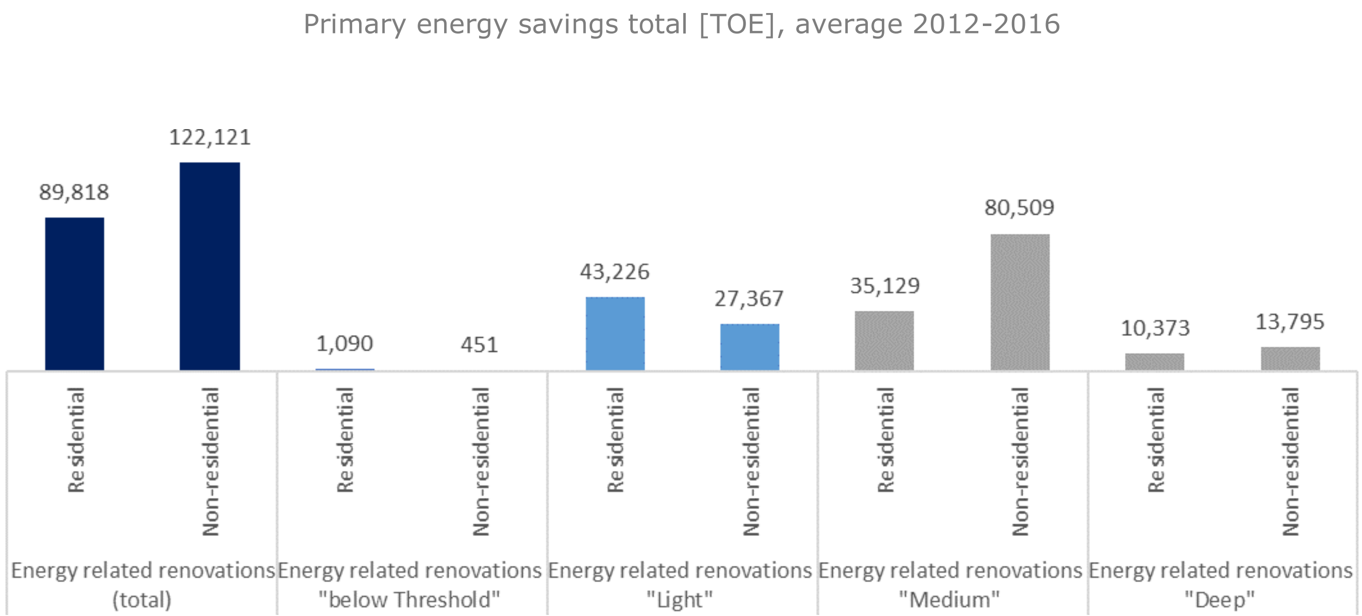


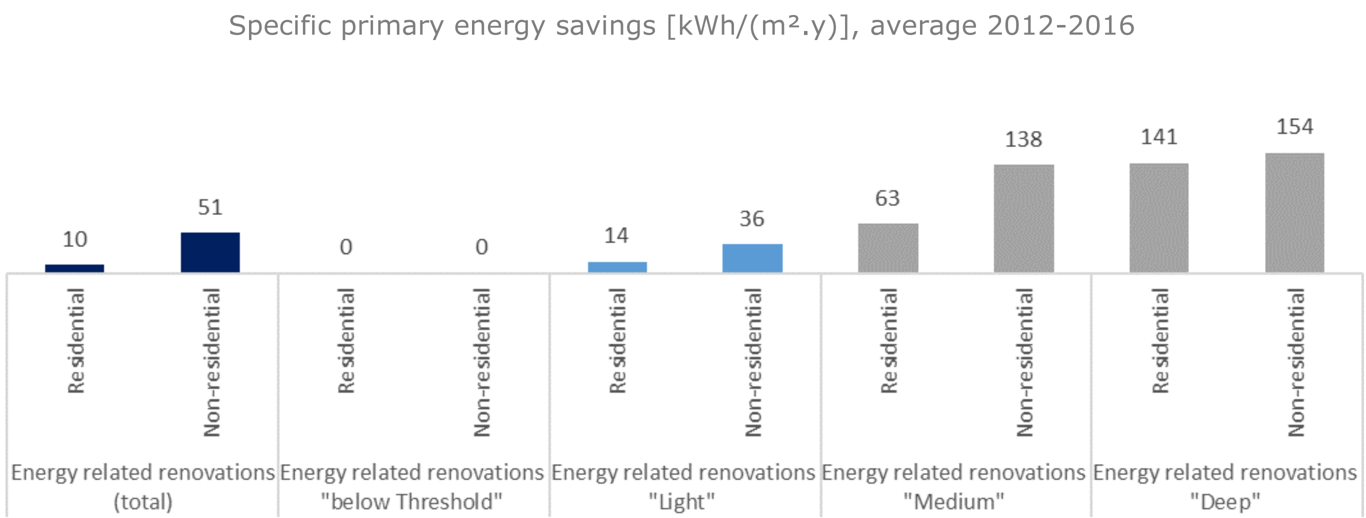


Renovation rate [%/stock], average 2012-2016
15.3%
5.8%
12.7%
8.9%
7.5%
3.6%
4.3%
2.8%
0.8%
2.2%
0.1%
0.3%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Total investments [Euro (million)], average 2012-2016
31,814
11,310
20,154
6,404
11,660
4,906
5,979
958
4,293
1,434
1,181
2,125
207
389
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
89,818
122,121
1,090
451
43,226
27,367
35,129
80,509
10,373
13,795
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
10
51
0
0
14
36
63
138
141
154
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[20]

Indicative numerical indicator of primary energy use:

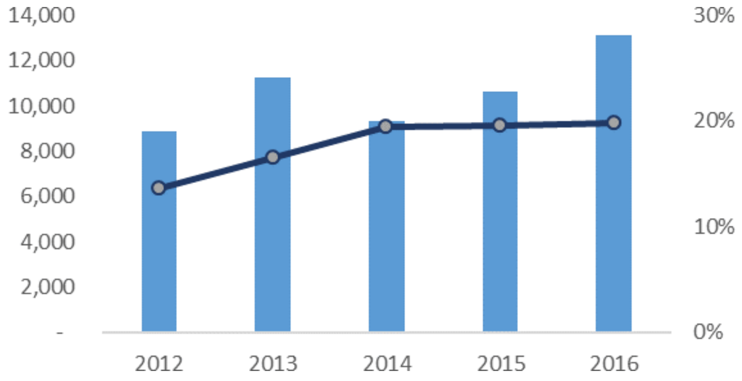
Residential:

25 kWh/(m².y)

Non-residential:

40 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

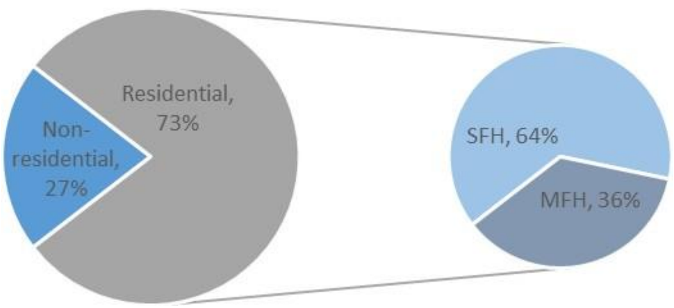


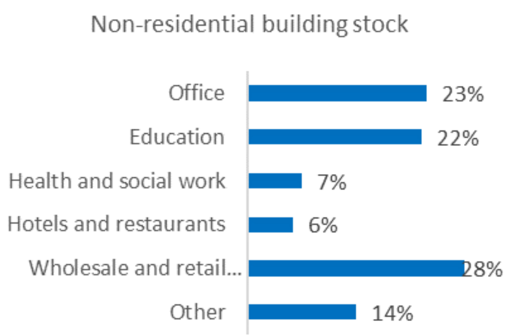
[20] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

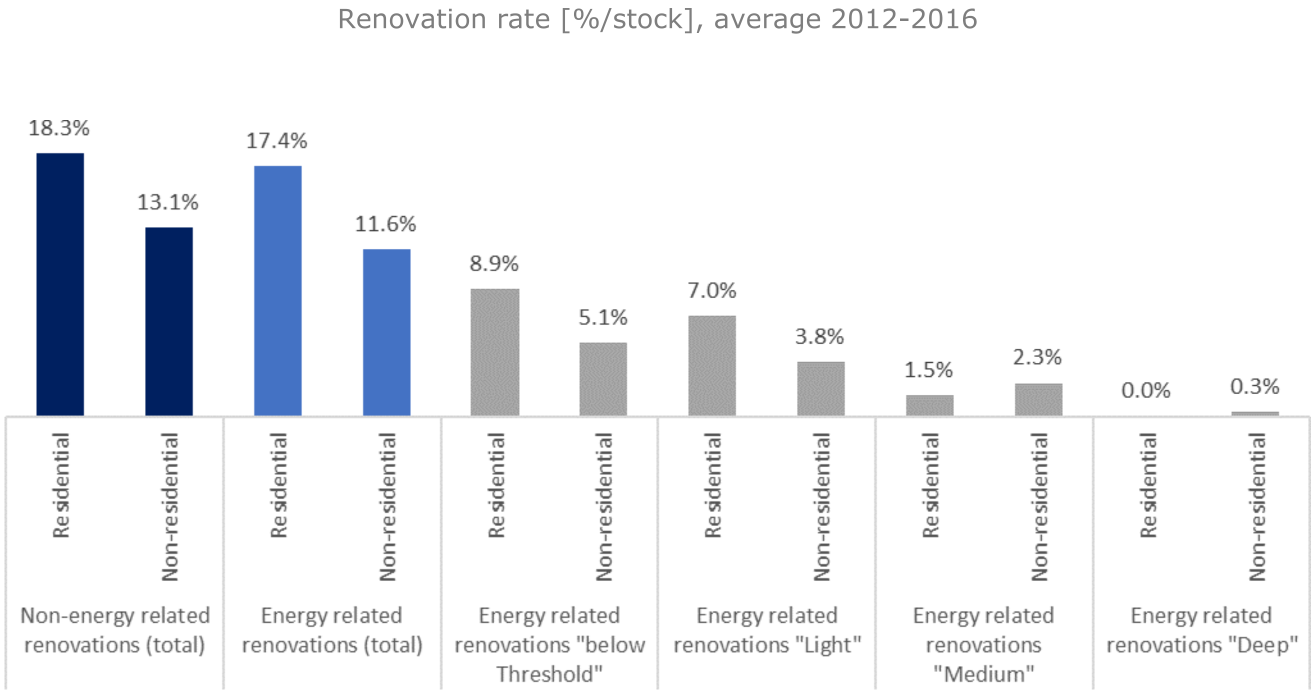
Poland

Population (2018)	37,976,687
Cooling/heating degree days (2018)	29.7/3125.4
Dampness damages in buildings [% of population]	11%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	1,027/925
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	188,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	67,000

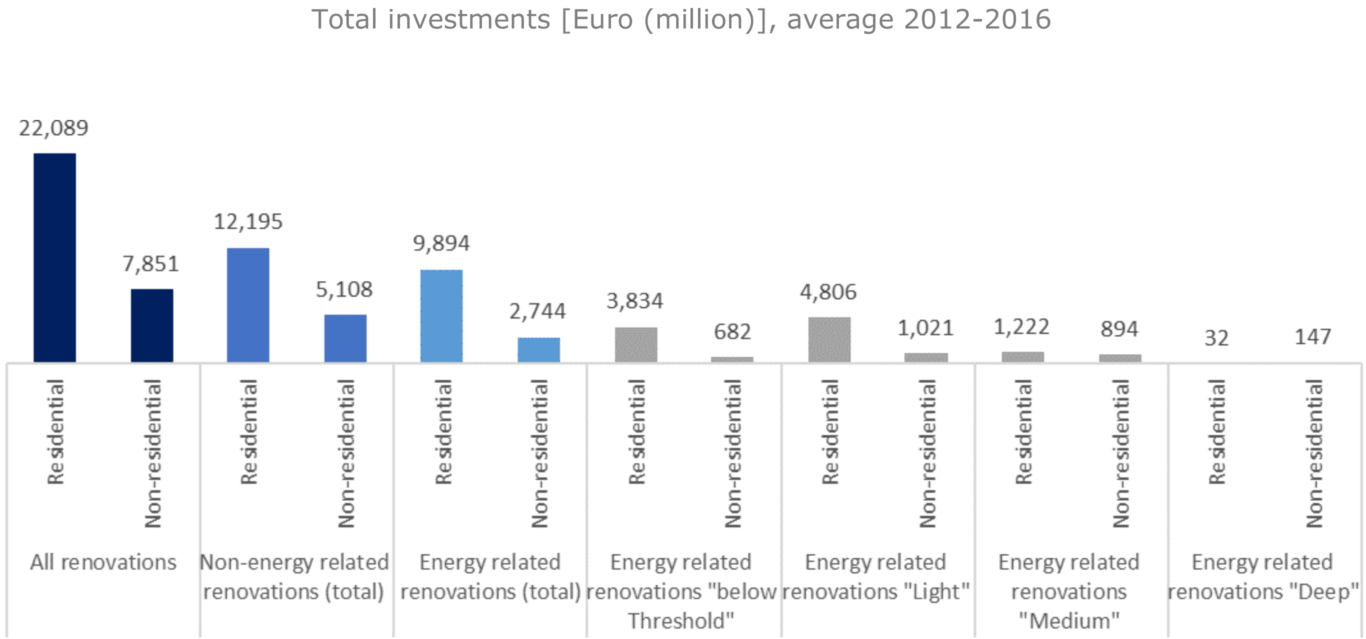
Total building stock [floor area, m²] shares, 2016





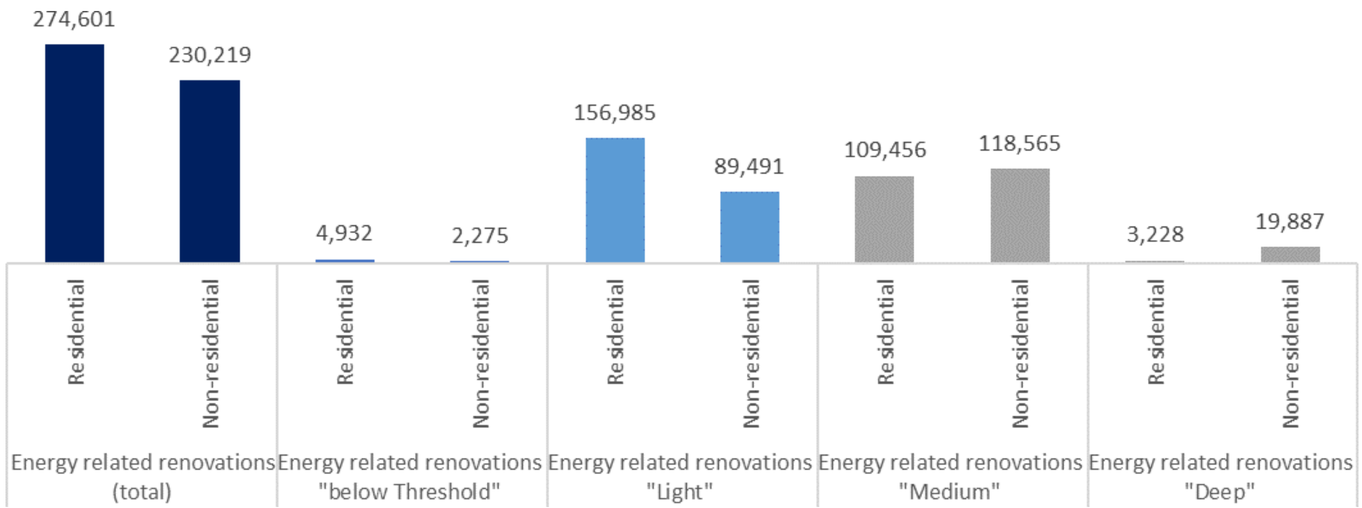


Renovation rate [%/stock], average 2012-2016
18.3%
13.1%
17.4%
11.6%
8.9%
5.1%
7.0%
3.8%
1.5%
2.3%
0.0%
0.3%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

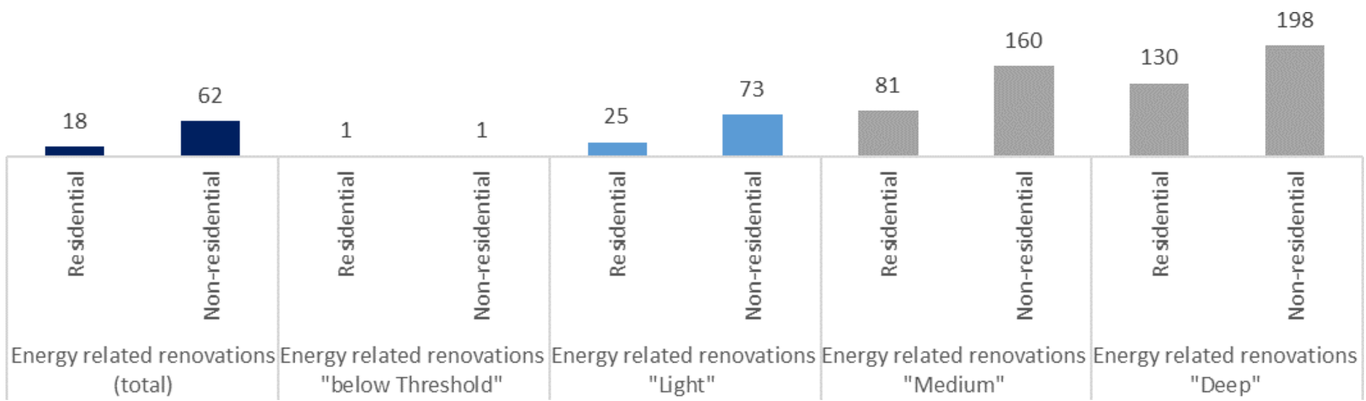


Total investments [Euro (million)], average 2012-2016
22,089
7,851
12,195
5,108
9,894
2,744
3,834
682
4,806
1,021
1,222
894
32
147
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[21]

Indicative numerical indicator of primary energy use:

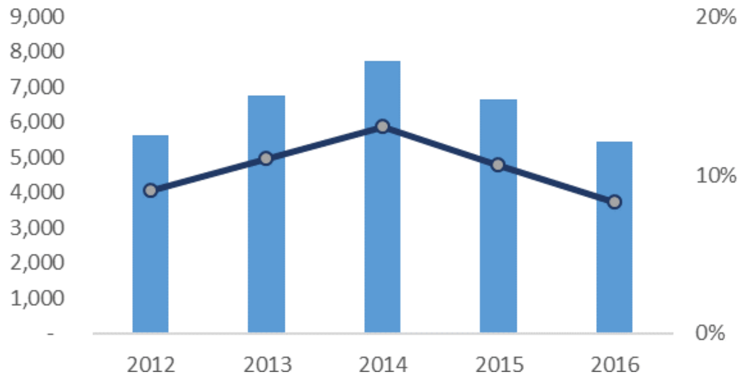
Residential:

75 kWh/(m².y)

Non-residential:

125 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

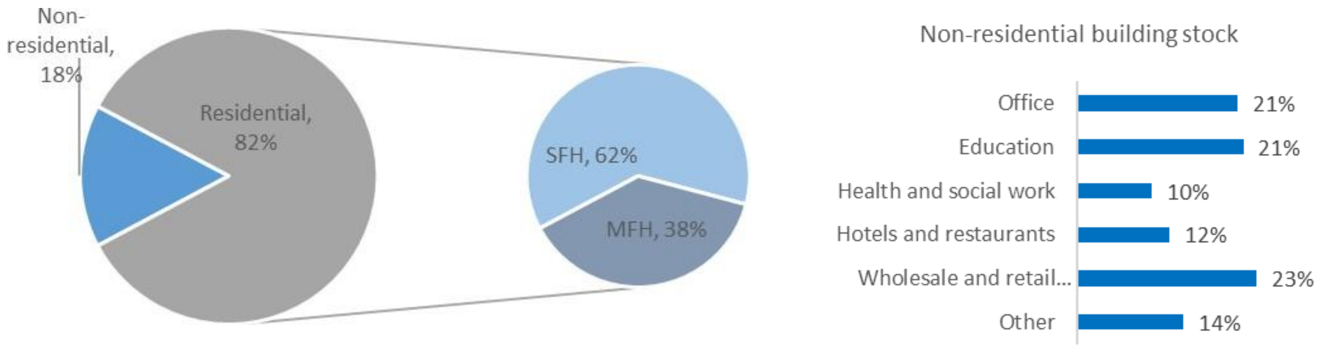


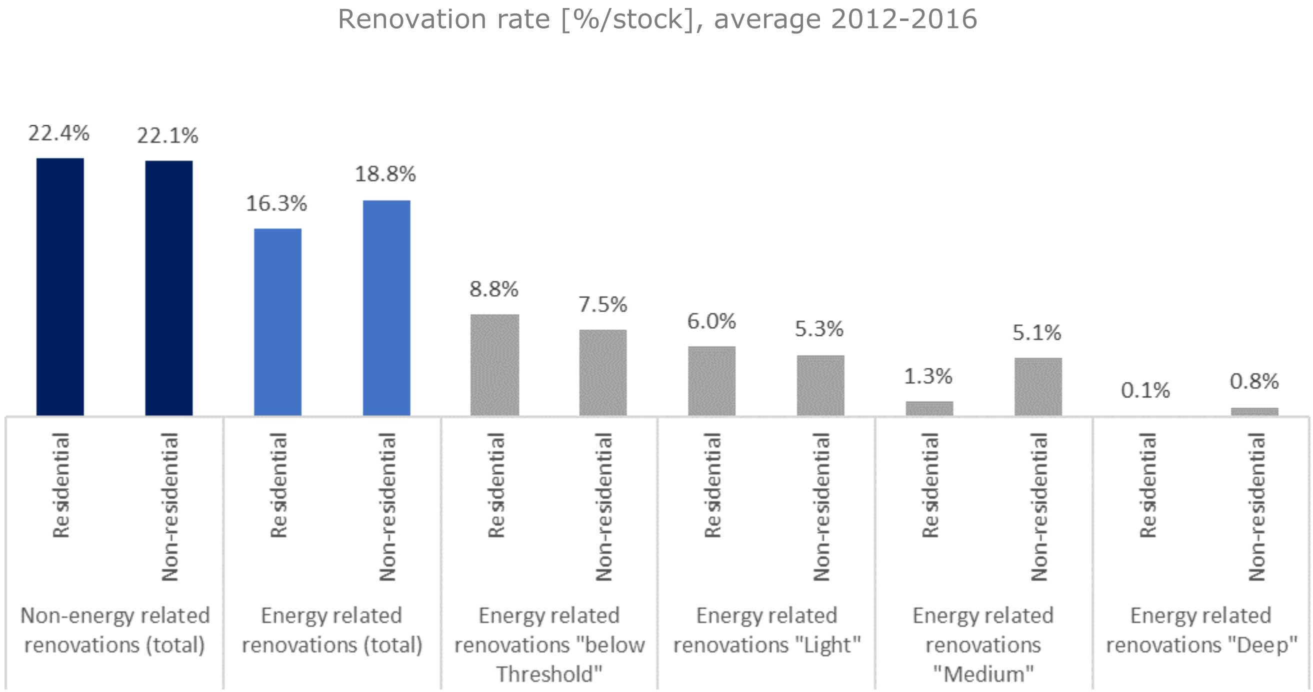
[21] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

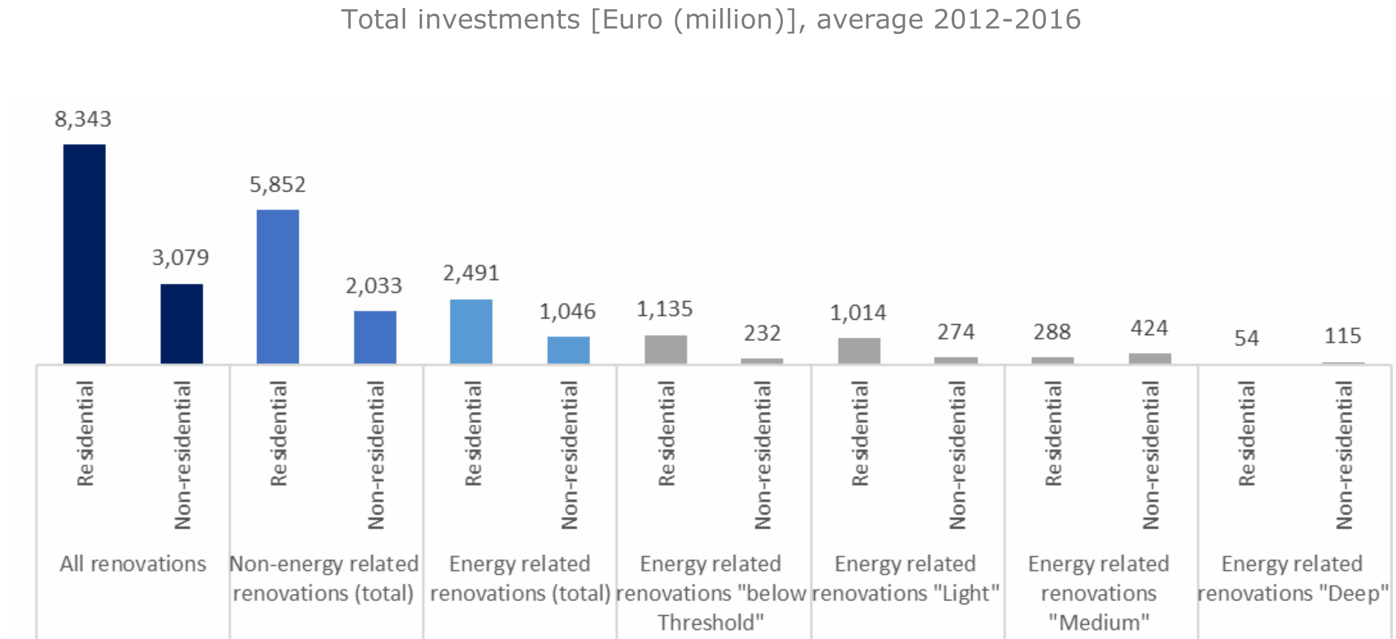
Portugal

Population (2018)	10,291,027
Cooling/heating degree days (2018)	233.2/1304.6
Dampness damages in buildings [% of population]	22%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	73/111
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	71,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	26,000

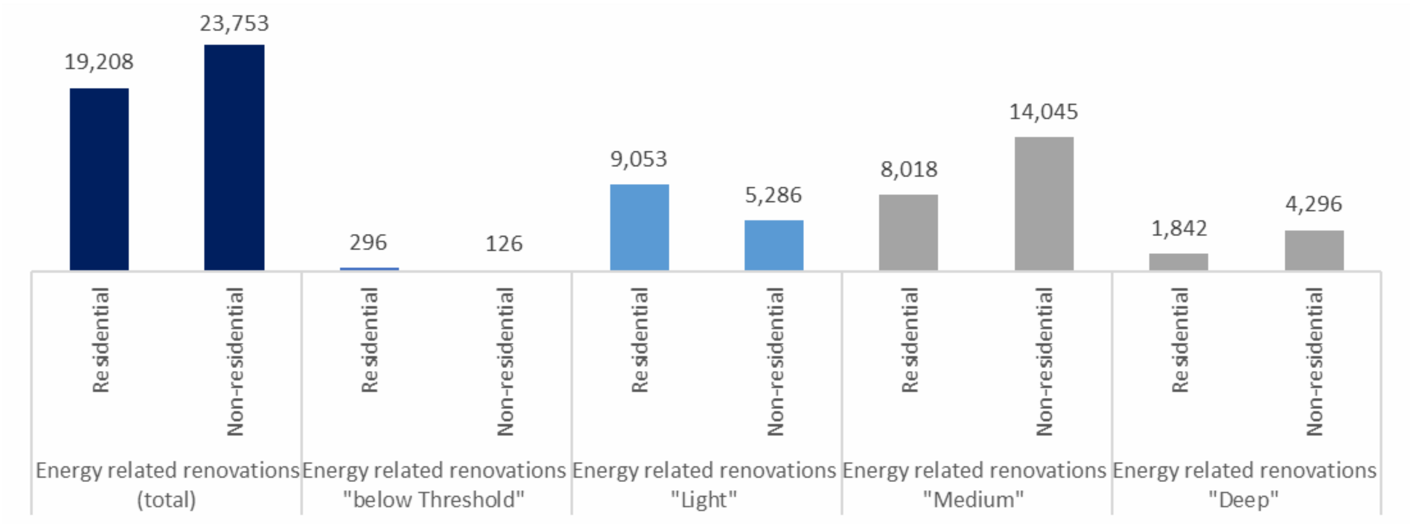
Total building stock [floor area, m²] shares, 2016



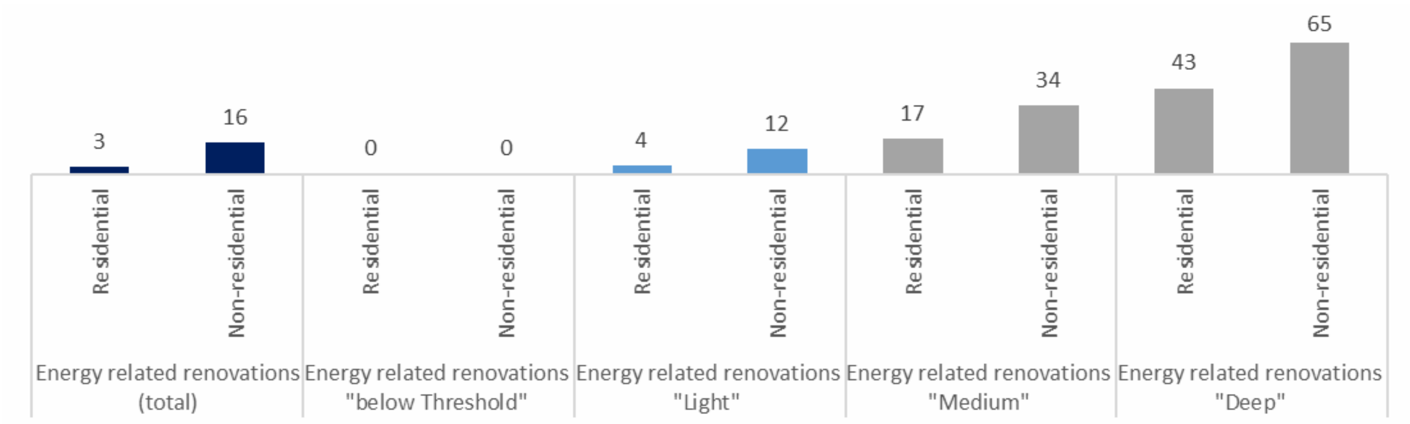

Renovation rate [%/stock], average 2012-2016
22.4%
22.1%
16.3%
18.8%
8.8%
7.5%
6.0%
5.3%
1.3%
5.1%
0.1%
0.8%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
8,343
3,079
5,852
2,033
2,491
1,046
1,135
232
1,014
274
288
424
54
115
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[22]

Indicative numerical indicator of primary energy use:

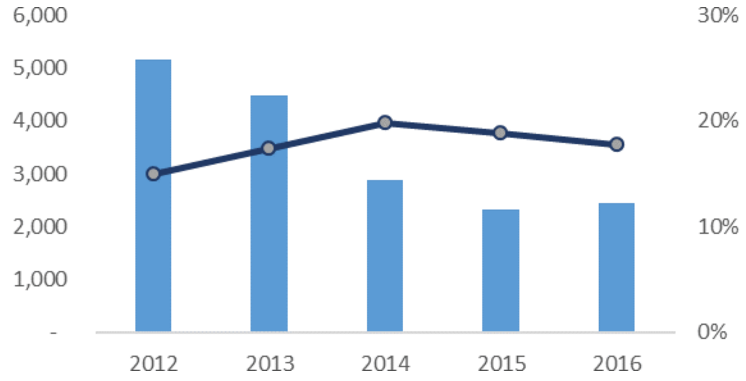
Residential:

35 kWh/(m².y)

Non-residential:

130 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

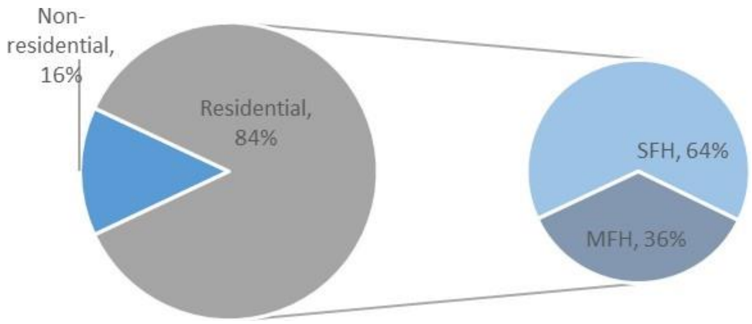


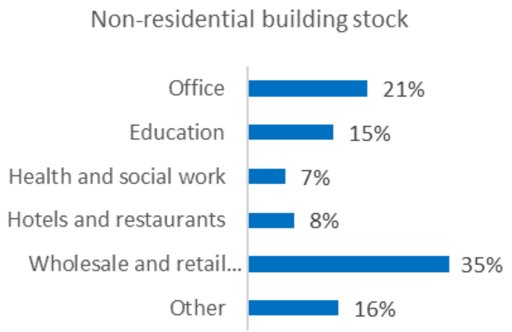
[22] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

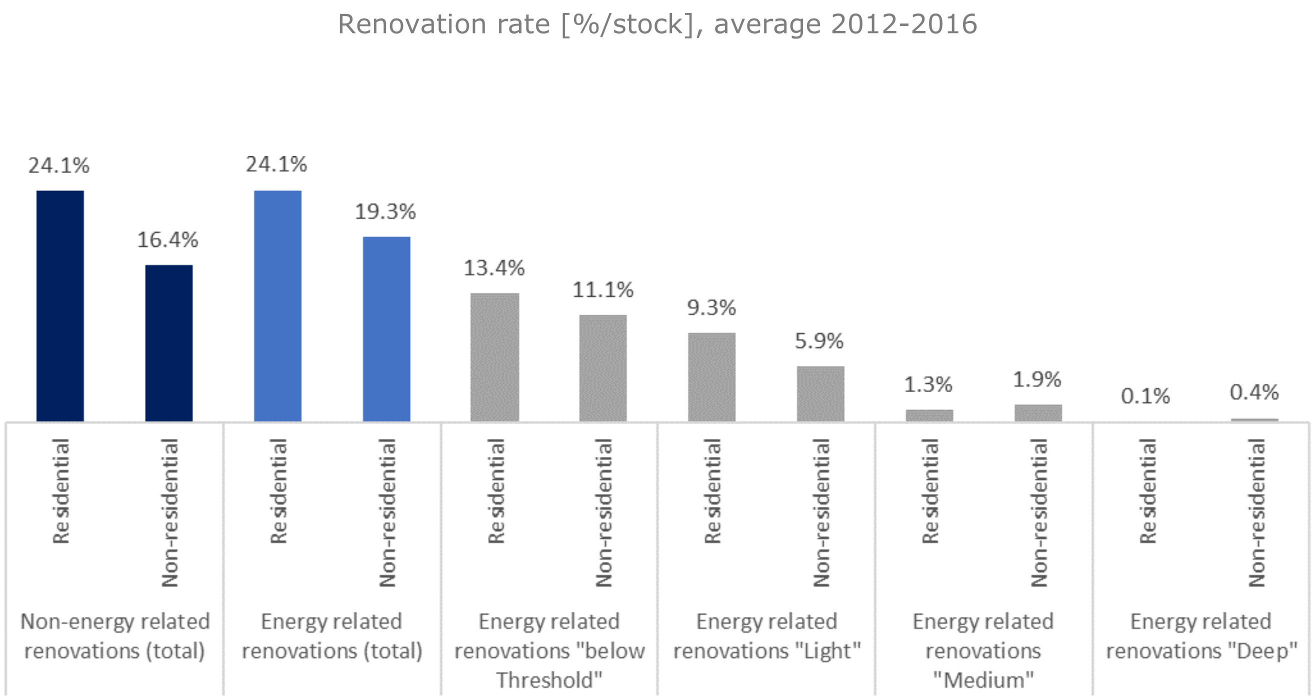
Romania

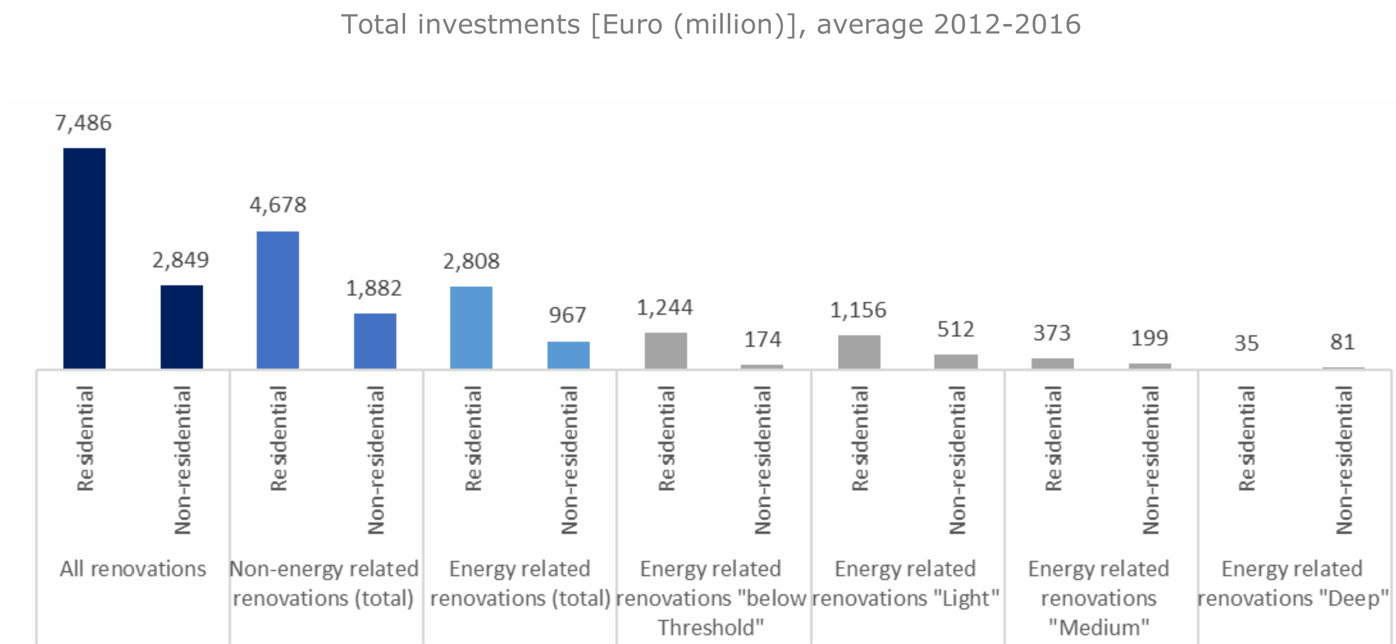
Population (2018)	19,530,631		Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	64,000
Cooling/heating degree days (2018)	84.9/2749.1		Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	24,000
Dampness damages in buildings [% of population]	15%			
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	336/96			

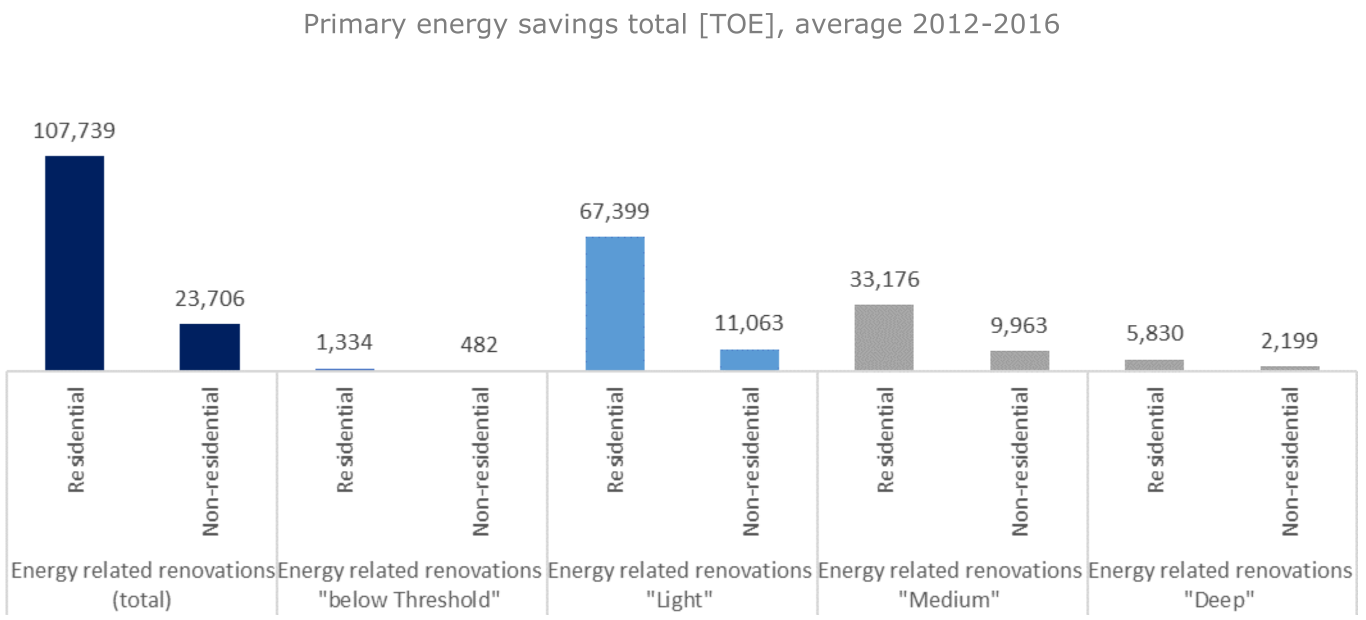
Total building stock [floor area, m²] shares, 2016



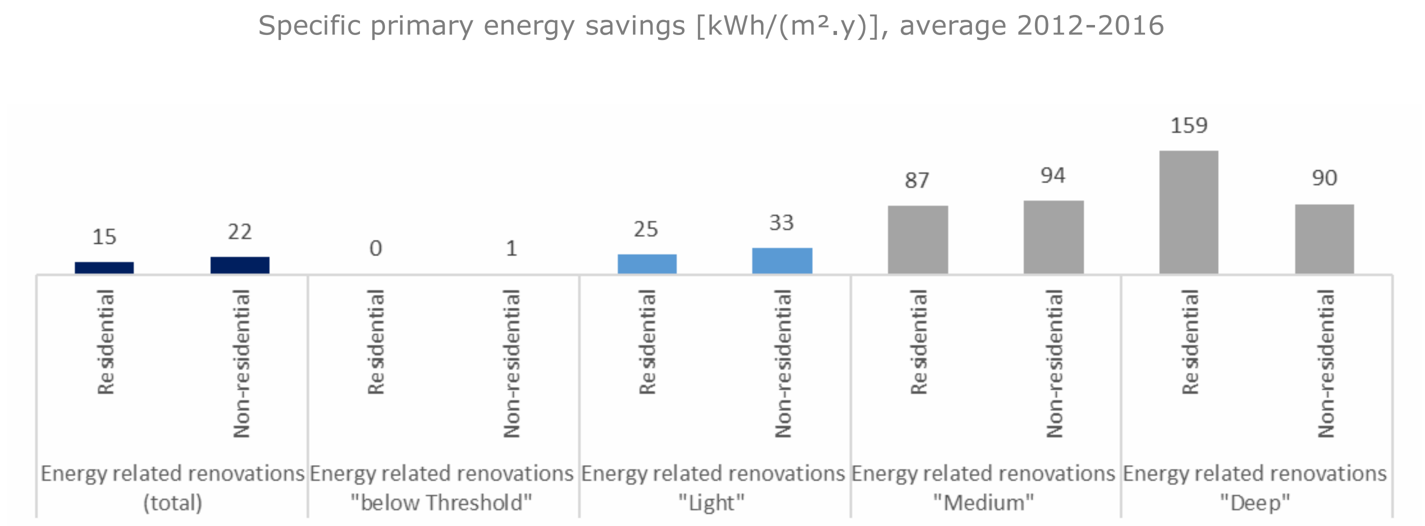



Renovation rate [%/stock], average 2012-2016
24.1%
16.4%
24.1%
19.3%
13.4%
11.1%
9.3%
5.9%
1.3%
1.9%
0.1%
0.4%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
7,486
2,849
4,678
1,882
2,808
967
1,244
174
1,156
512
373
199
35
81
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Primary energy savings total [TOE], average 2012-2016
107,739
23,706
1,334
482
67,399
11,063
33,176
9,963
5,830
2,199
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Specific primary energy savings [kWh/(m².y)], average 2012-2016
15
22
0
1
25
33
87
94
159
90
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[23]

Indicative numerical indicator of primary energy use:

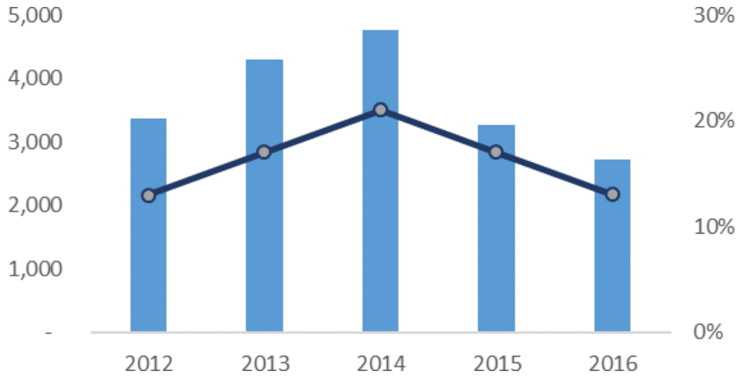
Residential:

120 kWh/(m².y)

Non-residential:

90 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

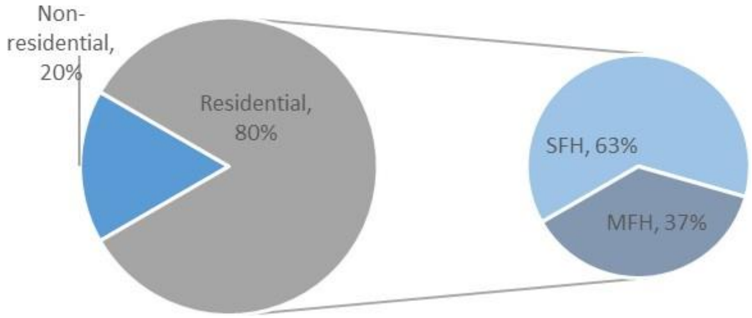


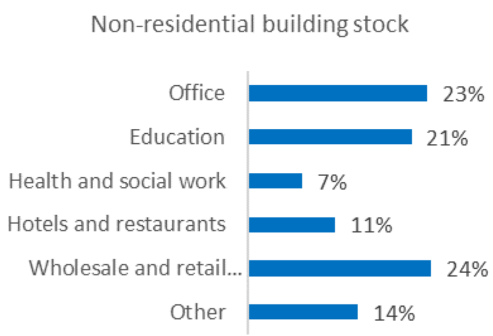
[23] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

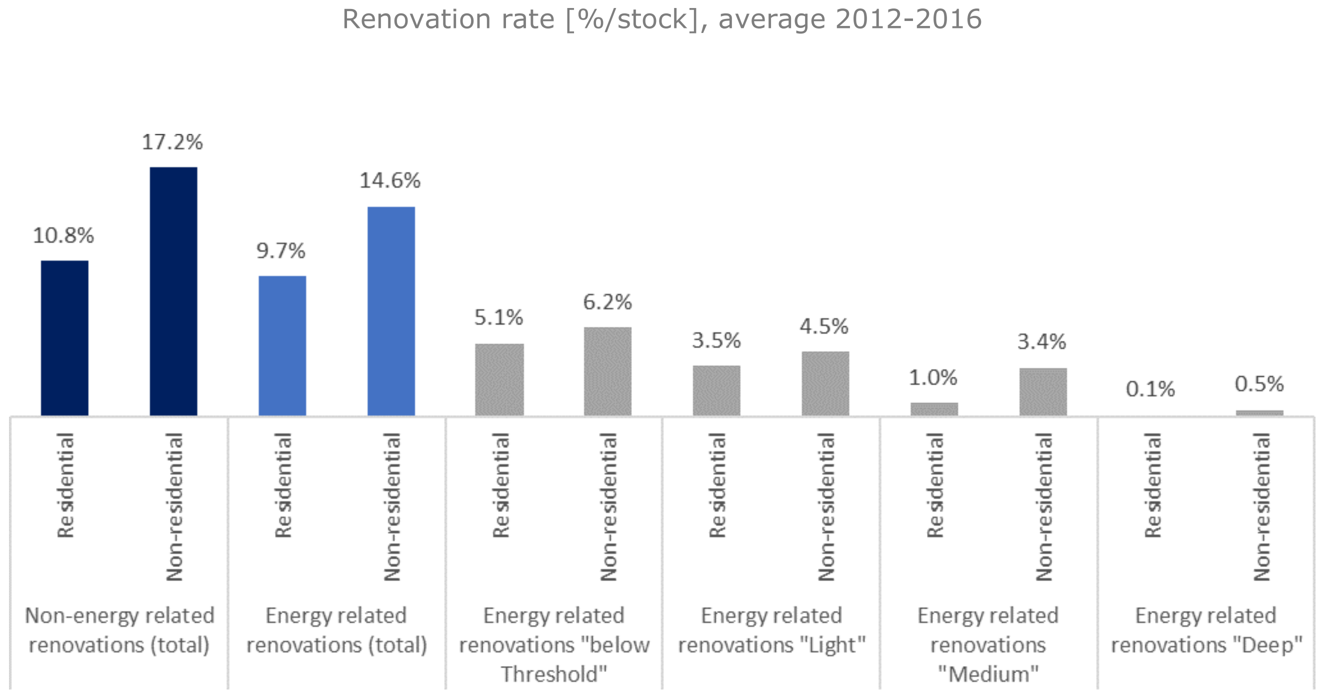
Slovakia

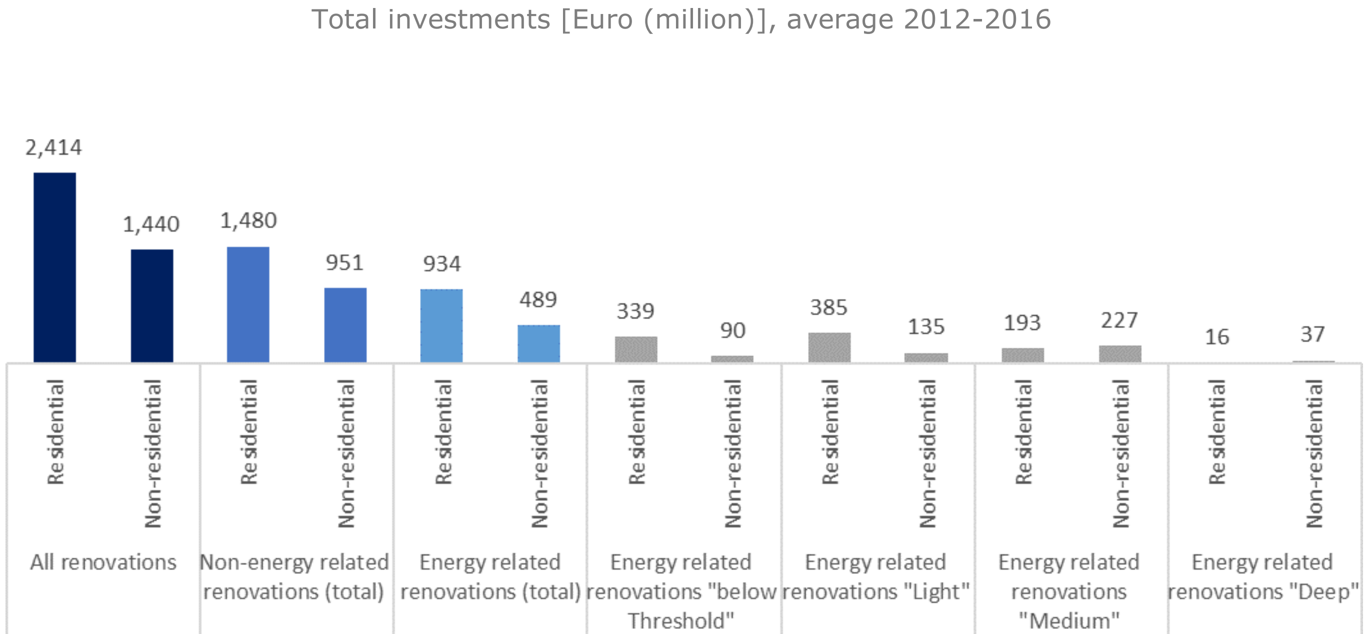
Population (2018)	5,443,120
Cooling/heating degree days (2018)	53.0/2922.0
Dampness damages in buildings [% of population]	9%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	77/126
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	21,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	12,000

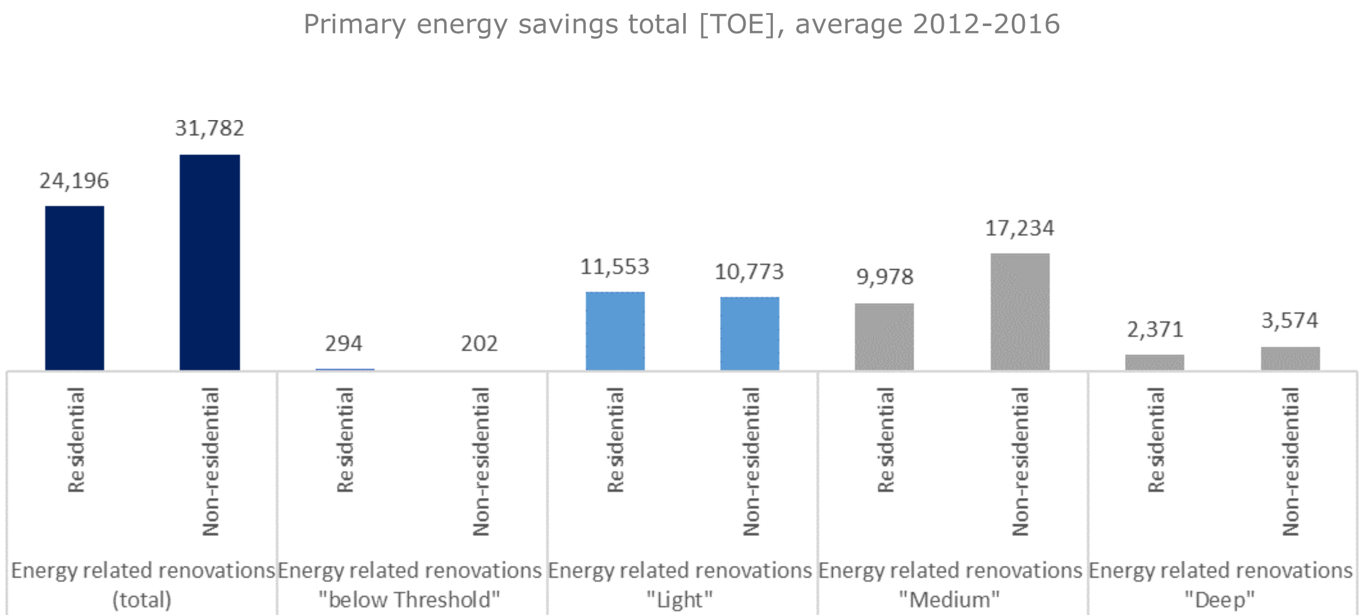
Total building stock [floor area, m²] shares, 2016

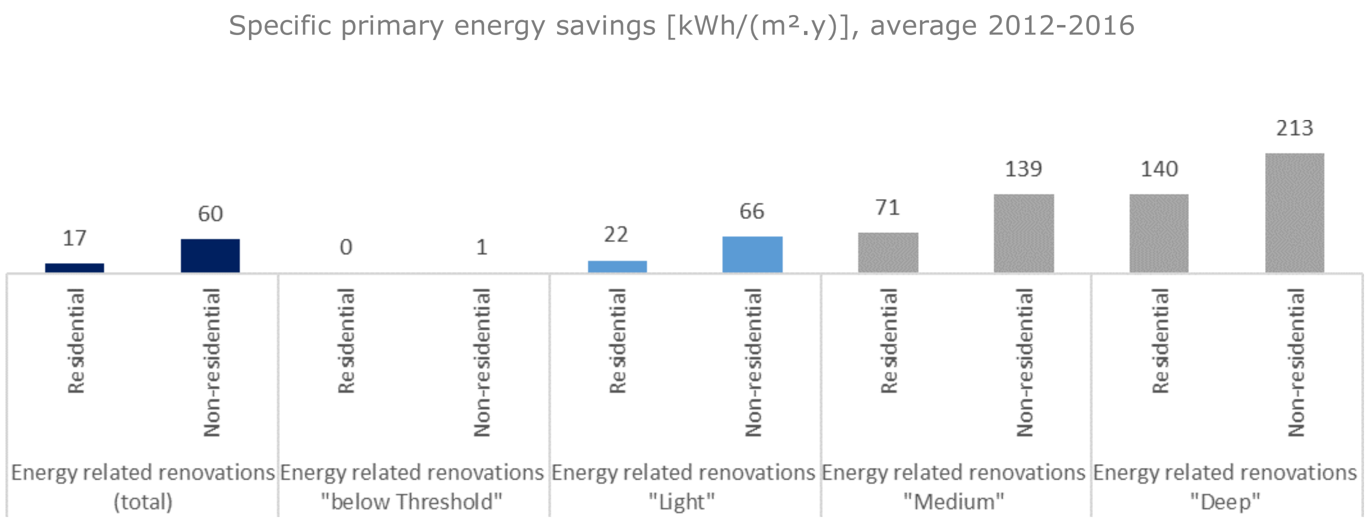





Renovation rate [%/stock], average 2012-2016
10.8%
17.2%
9.7%
14.6%
5.1%
6.2%
3.5%
4.5%
1.0%
3.4%
0.1%
0.5%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
2,414
1,440
1,480
951
934
489
339
90
385
135
193
227
16
37
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
24,196
31,782
294
202
11,553
10,773
9,978
17,234
2,371
3,574
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
17
60
0
1
22
66
71
139
140
213
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[24]

Indicative numerical indicator of primary energy use:

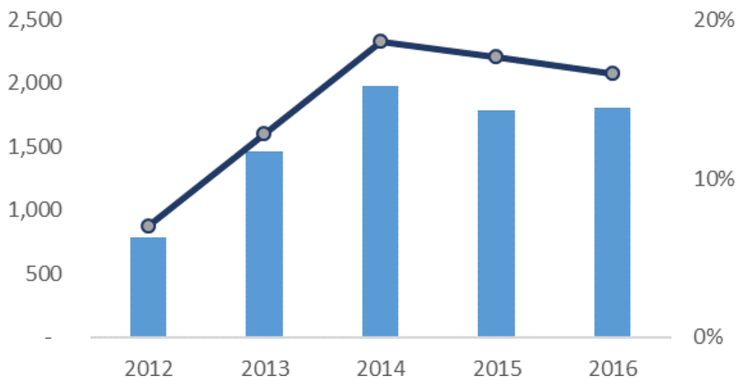
Residential:

45 kWh/(m².y)

Non-residential:

65 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

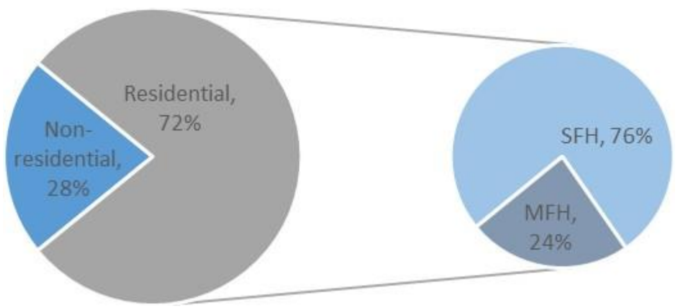


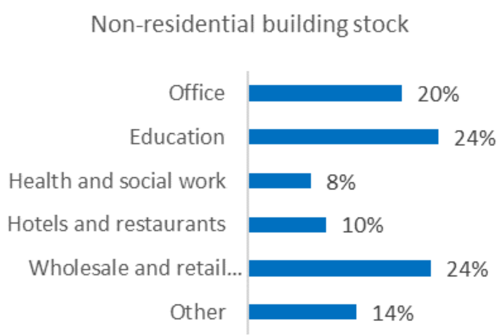
[24] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

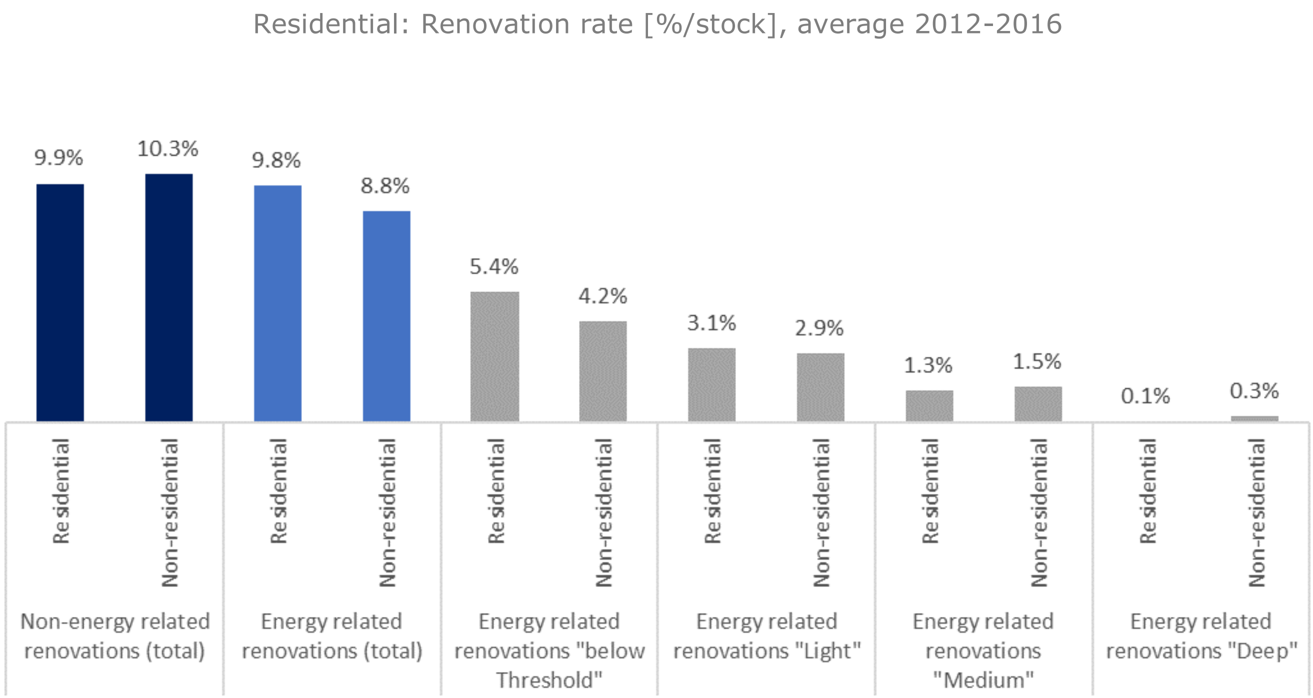
Slovenia

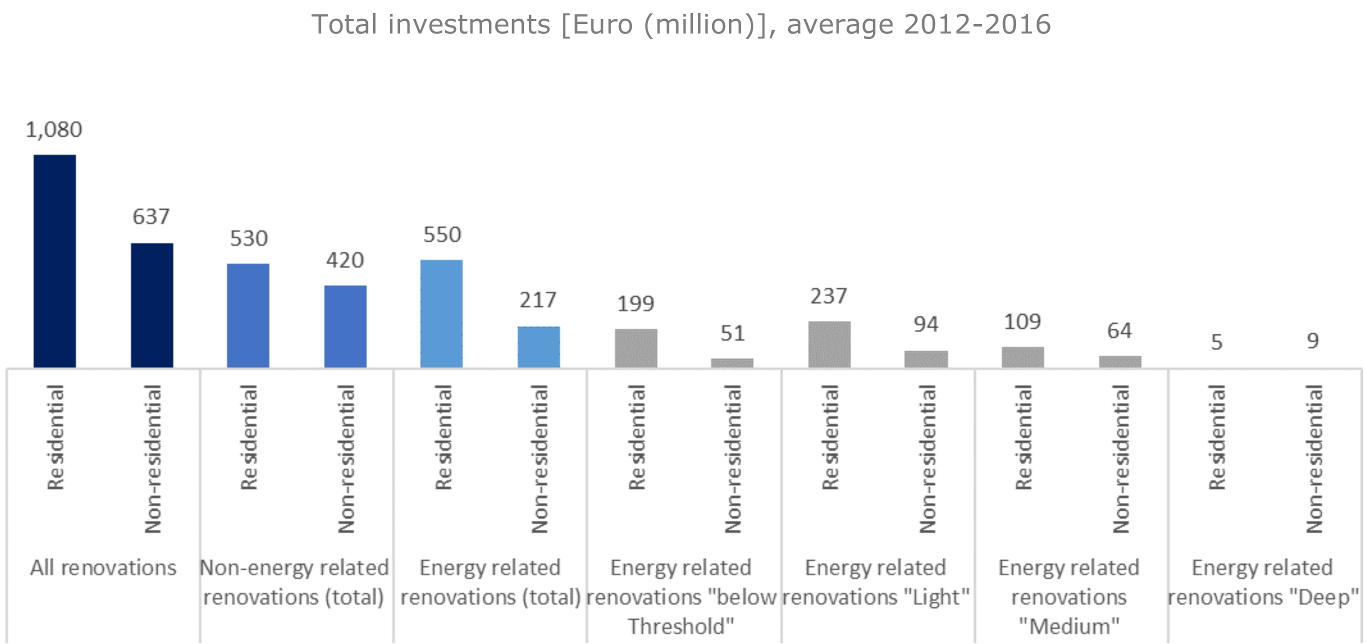
Population (2018)	2,066,880
Cooling/heating degree days (2018)	51.1/2583.8
Dampness damages in buildings [% of population]	32%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	50/59
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	9,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	5,000

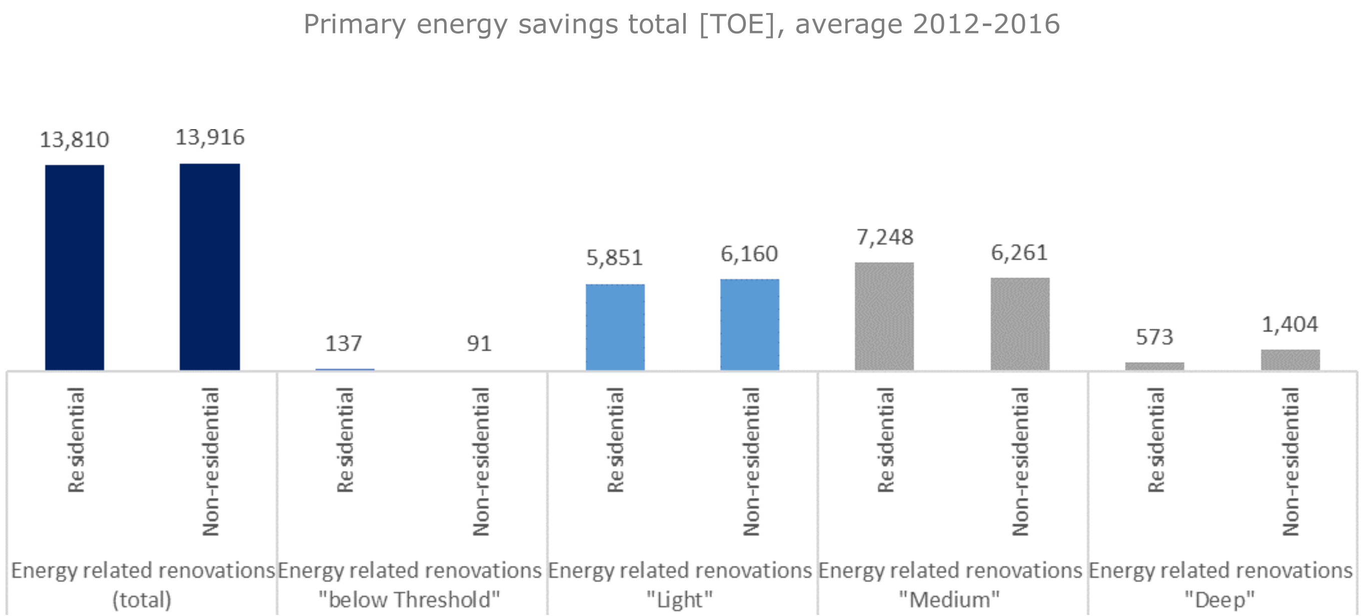
Total building stock [floor area, m²] shares, 2016

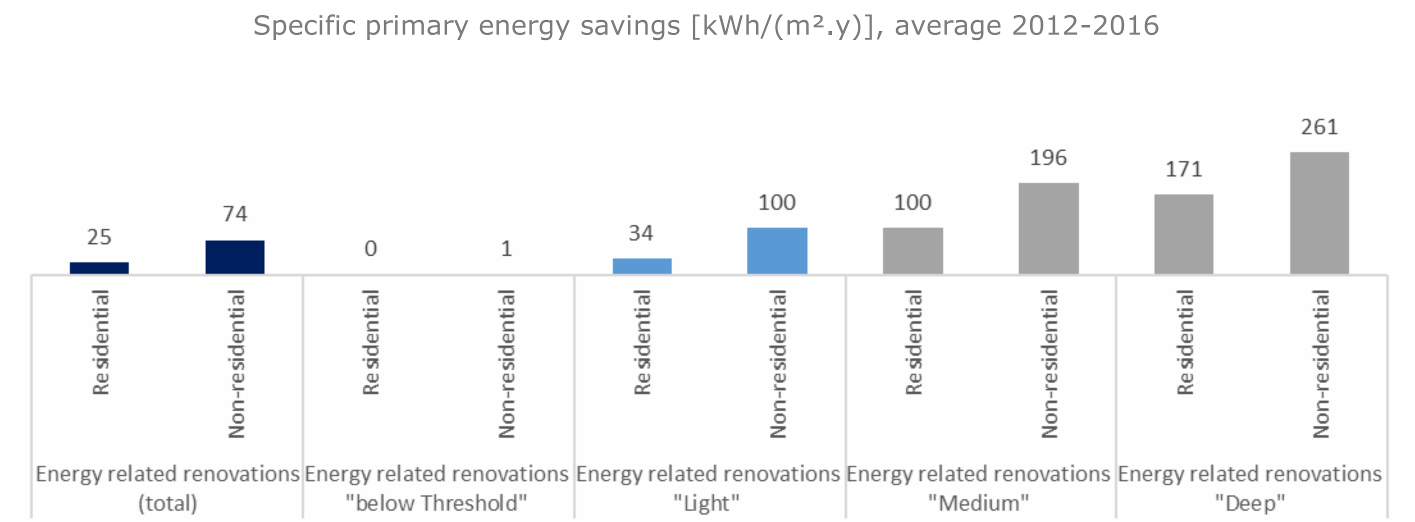





Residential: Renovation rate [%/stock], average 2012-2016
9.9%
10.3%
9.8%
8.8%
5.4%
4.2%
3.1%
2.9%
1.3%
1.5%
0.1%
0.3%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
1,080
637
530
420
550
217
199
51
237
94
109
64
5
9
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Primary energy savings total [TOE], average 2012-2016
13,810
13,916
137
91
5,851
6,160
7,248
6,261
573
1,404
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Specific primary energy savings [kWh/(m².y)], average 2012-2016
25
74
0
1
34
100
100
196
171
261
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[25]

Indicative numerical indicator of primary energy use:

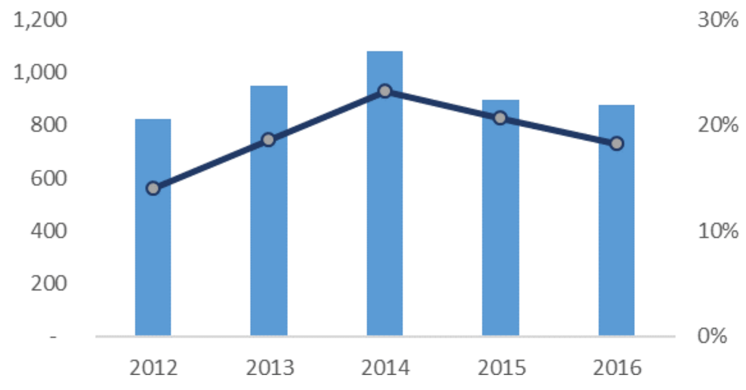
Residential:

80 kWh/(m².y)

Non-residential:

55 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

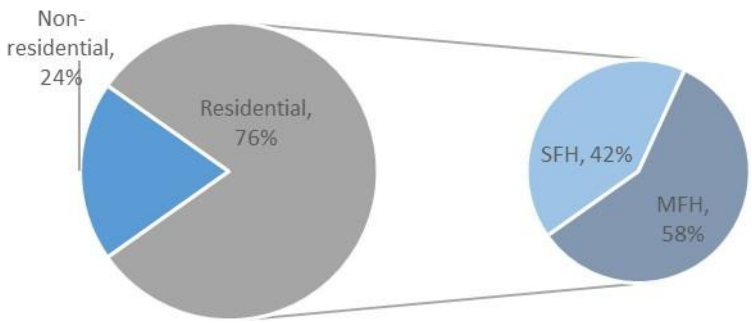


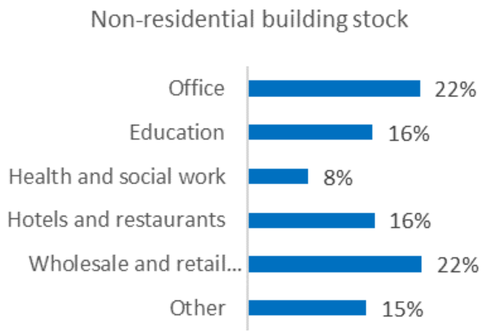
[25] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

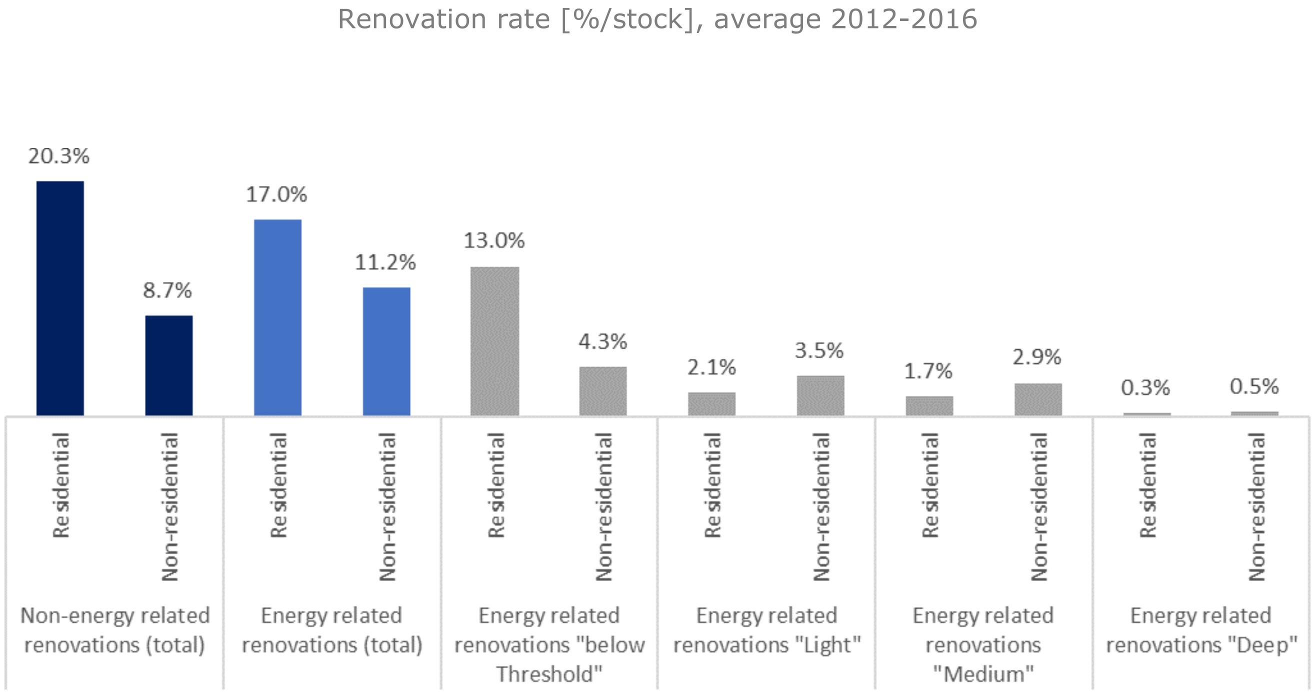
Spain

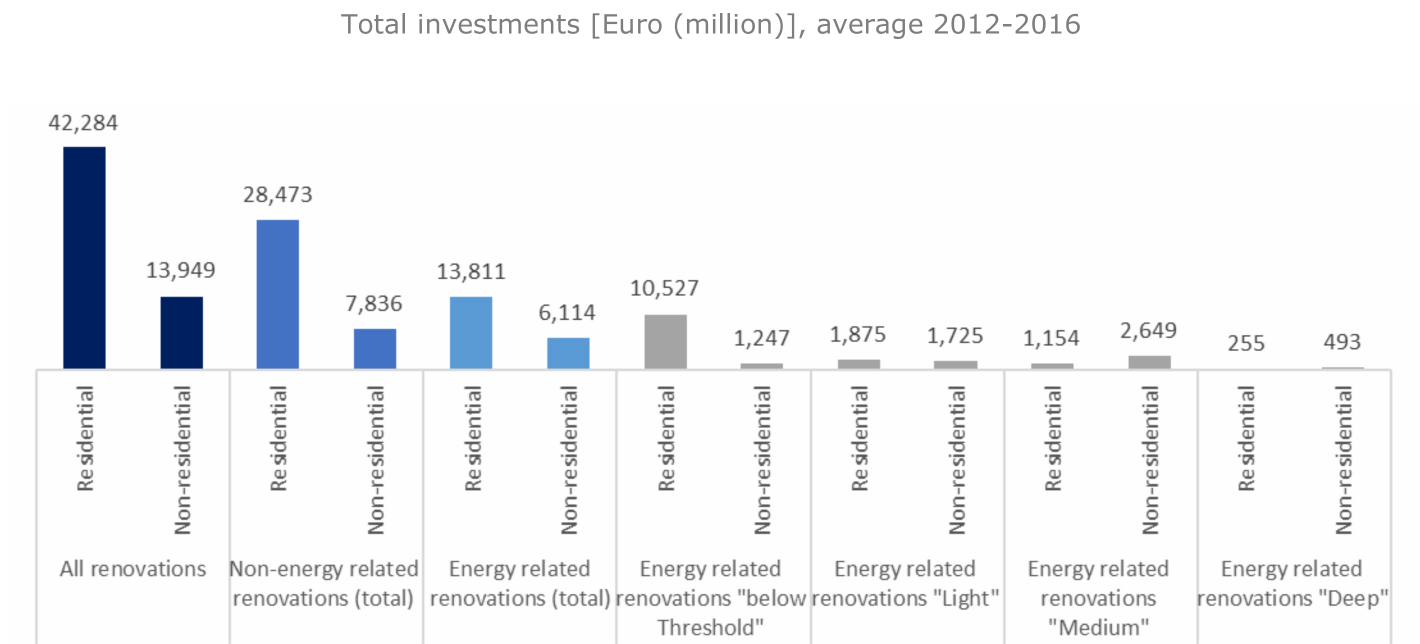
Population (2018)	46,658,447		Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	360,000
Cooling/heating degree days (2018)	239.2/1799.7		Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	119,000
Dampness damages in buildings [% of population]	12%			
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	641/719			

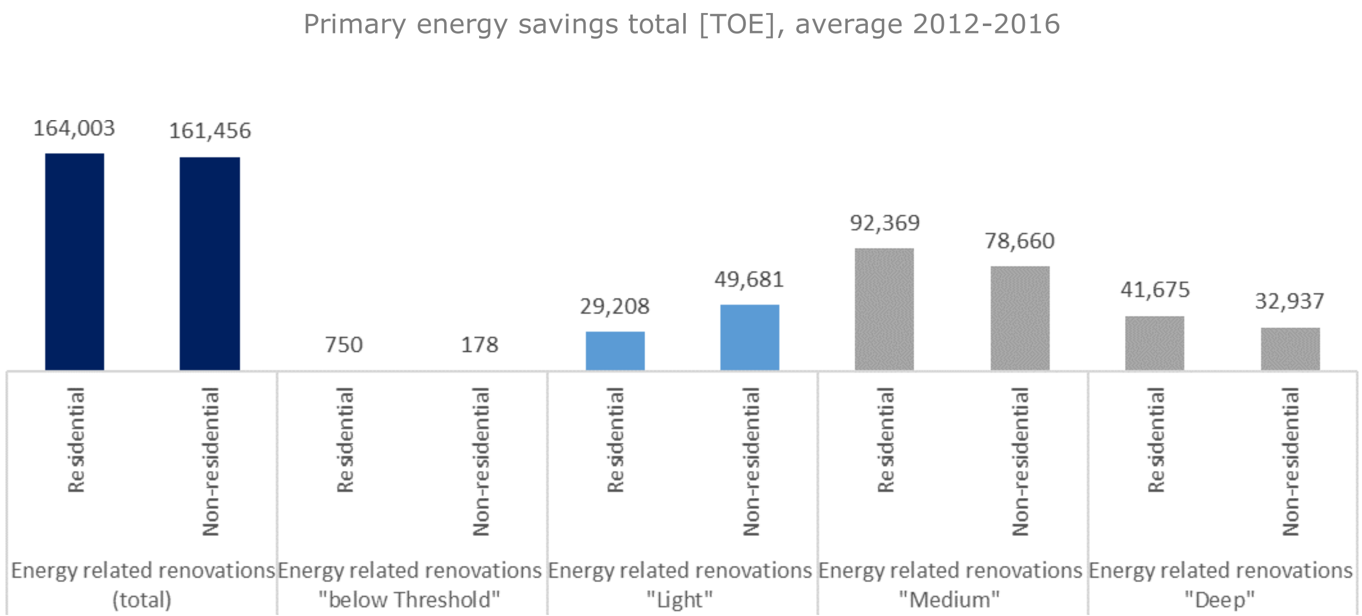
Total building stock [floor area, m²] shares, 2016



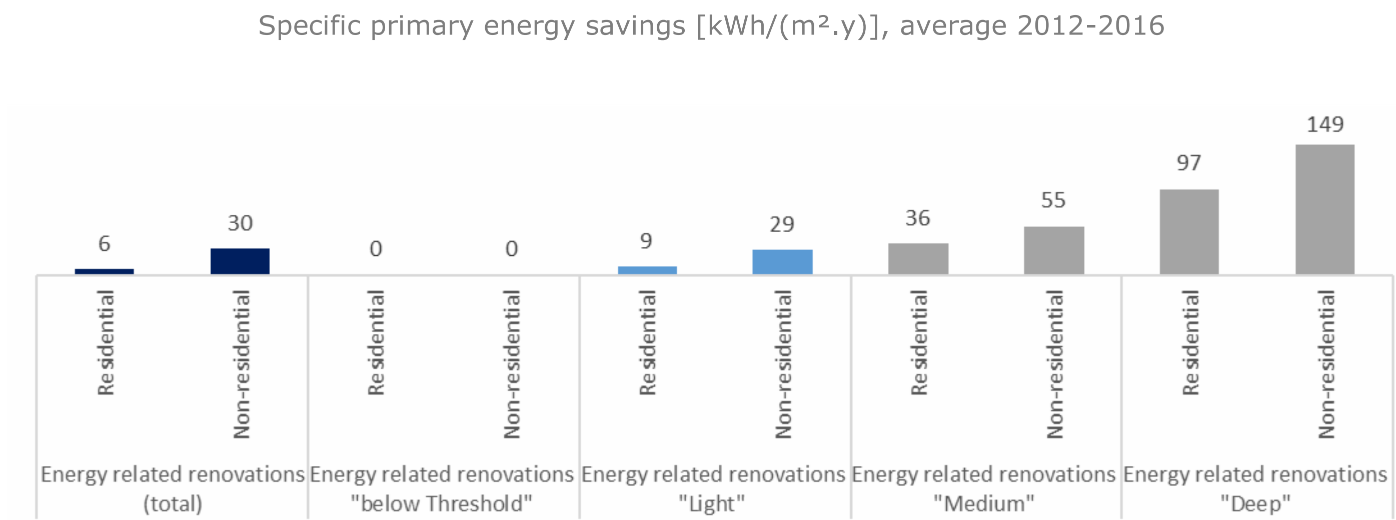



Renovation rate [%/stock], average 2012-2016
20.3%
8.7%
17.0%
11.2%
13.0%
4.3%
2.1%
3.5%
1.7%
2.9%
0.3%
0.5%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
42,284
13,949
28,473
7,836
13,811
6,114
10,527
1,247
1,875
1,725
1,154
2,649
255
493
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Primary energy savings total [TOE], average 2012-2016
164,003
161,456
750
178
29,208
49,681
92,369
78,660
41,675
32,937
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Specific primary energy savings [kWh/(m².y)], average 2012-2016
6
30
0
0
9
29
36
55
97
149
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[26]

Indicative numerical indicator of primary energy use:

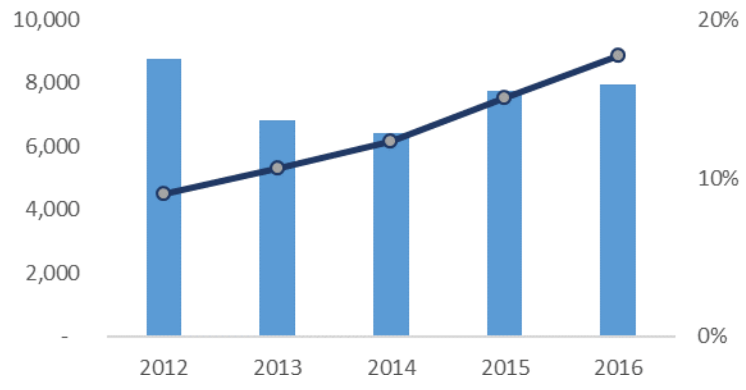
Residential:

50 kWh/(m².y)

Non-residential:

100 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

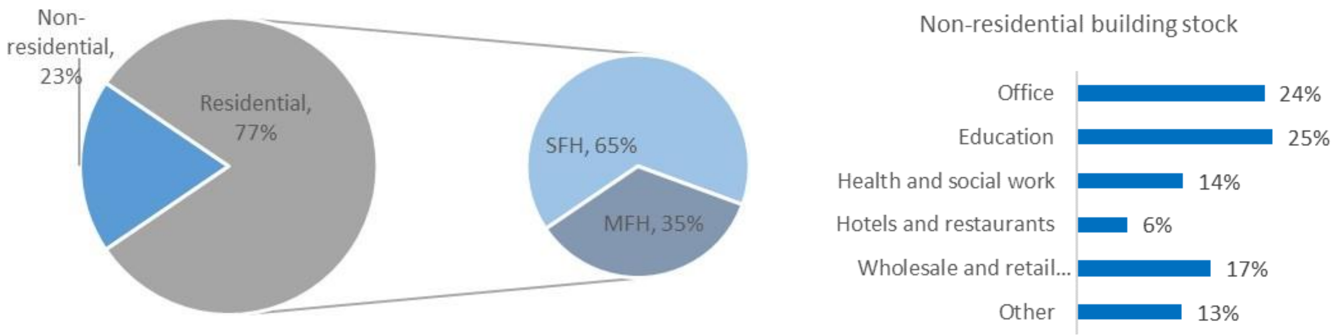


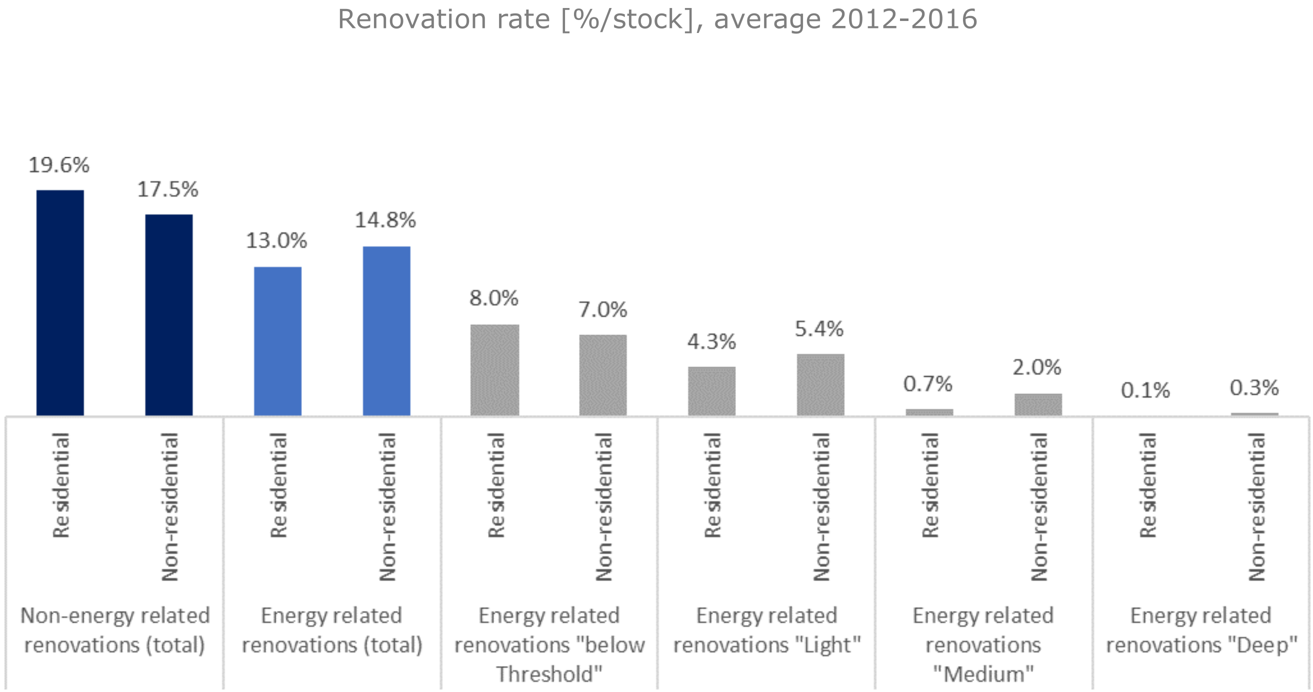
[26] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

Sweden

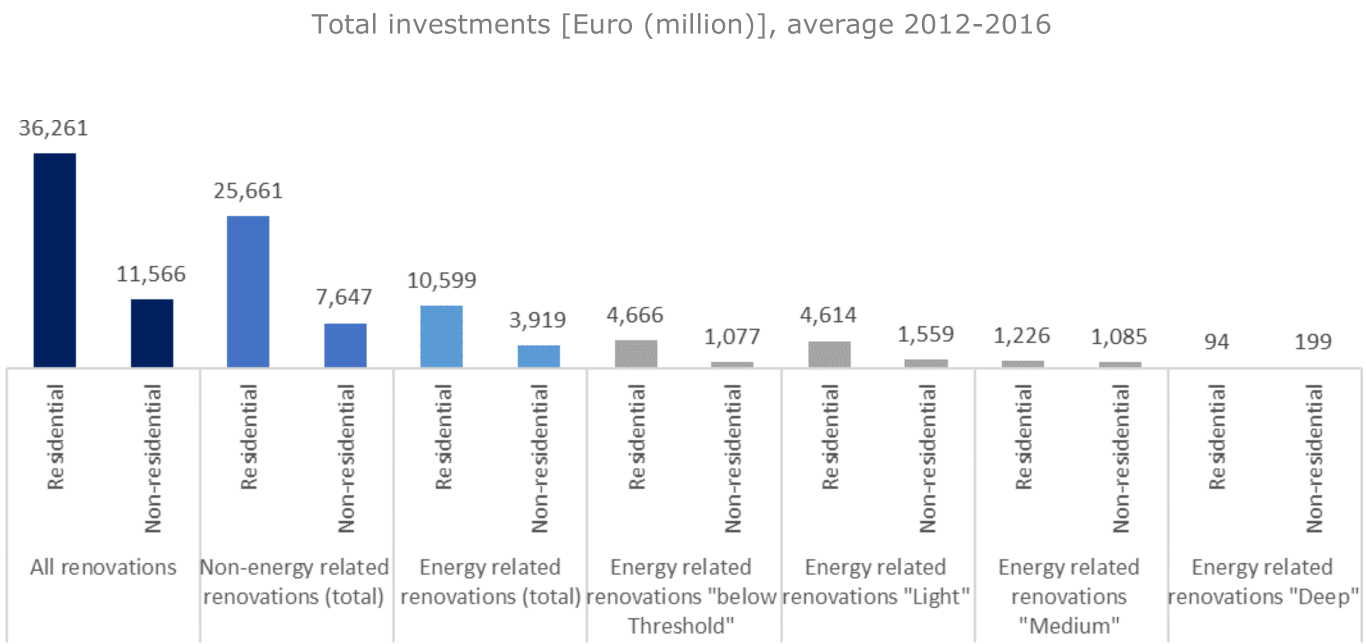
Population (2018)	10,120,242
Cooling/heating degree days (2018)	4.5/5162.8
Dampness damages in buildings [% of population]	8%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	253/408
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	309,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	99,000

Total building stock [floor area, m²] shares, 2016



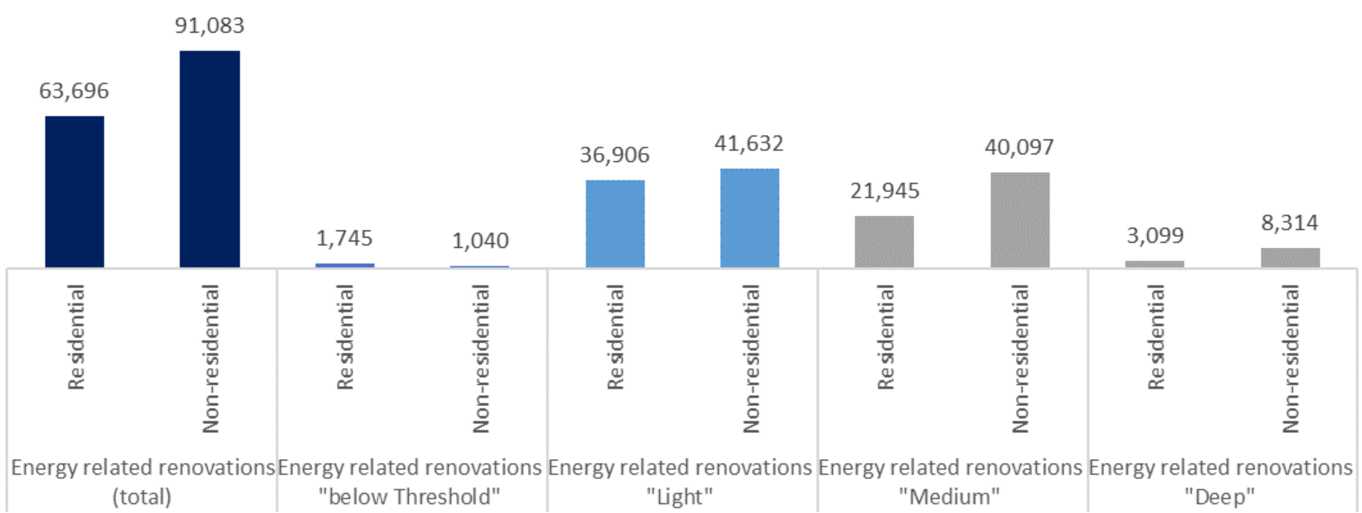


Renovation rate [%/stock], average 2012-2016
19.6%
17.5%
13.0%
14.8%
8.0%
7.0%
4.3%
5.4%
0.7%
2.0%
0.1%
0.3%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

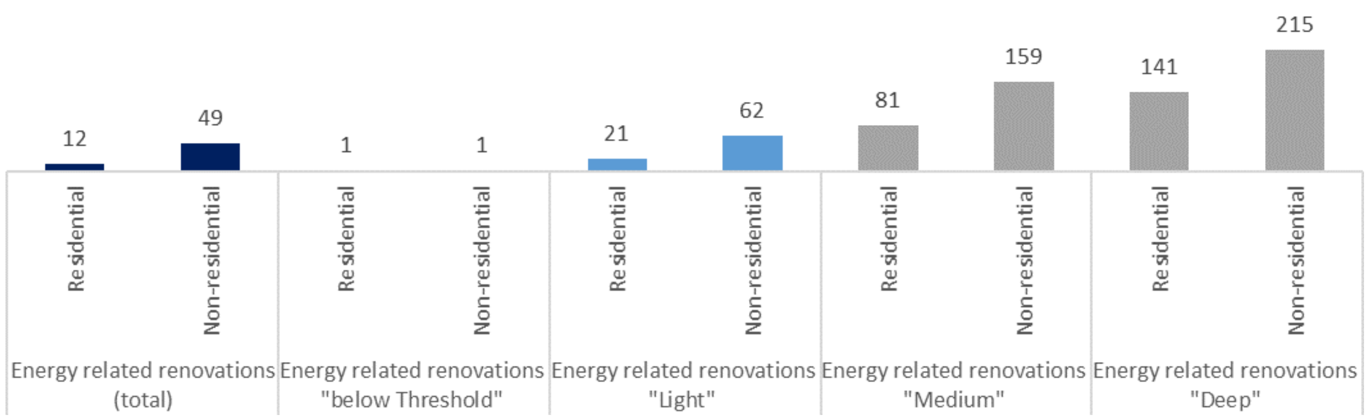


Total investments [Euro (million)], average 2012-2016
36,261
11,566
25,661
7,647
10,599
3,919
4,666
1,077
4,614
1,559
1,226
1,085
94
199
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

Primary energy savings total [TOE], average 2012-2016



Specific primary energy savings [kWh/(m².y)], average 2012-2016



NZEB[27]

Indicative numerical indicator of primary energy use:

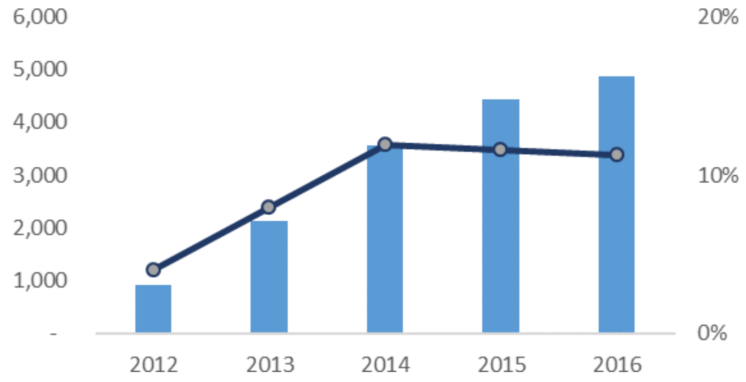
Residential:

85 kWh/(m².y)

Non-residential:

100 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year

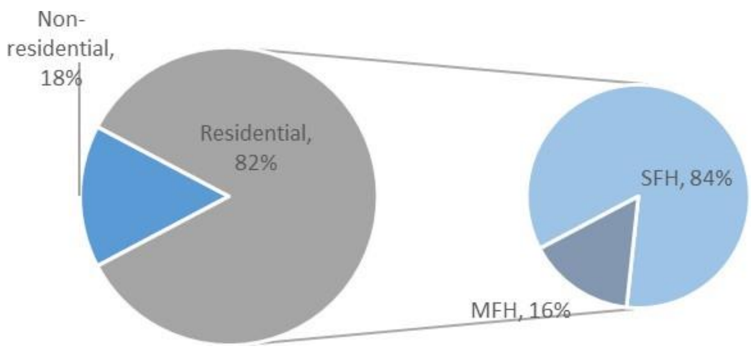


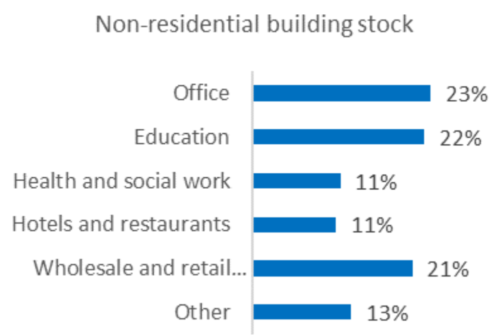
[27] The numbers presented reflect a market perspective, meaning how market players perceive the uptake of a building standard, which in the local market is commonly understood to be "nearly zero". Therefore, the numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

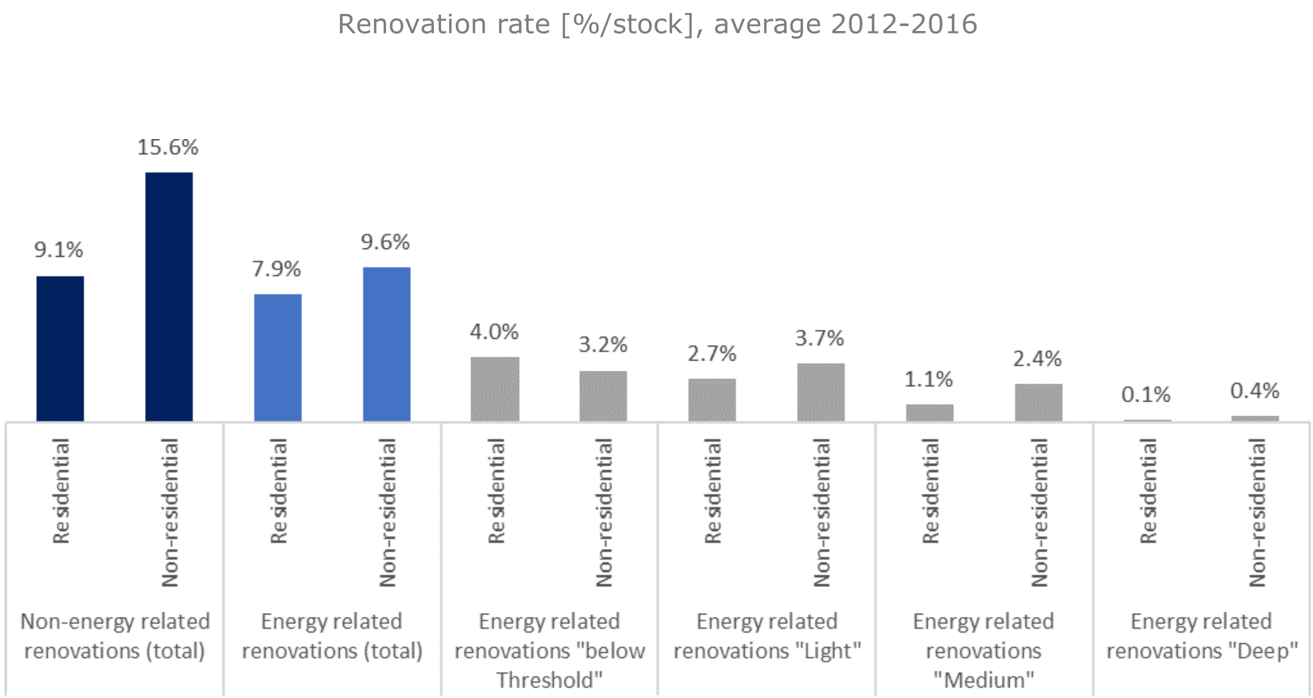
United Kingdom

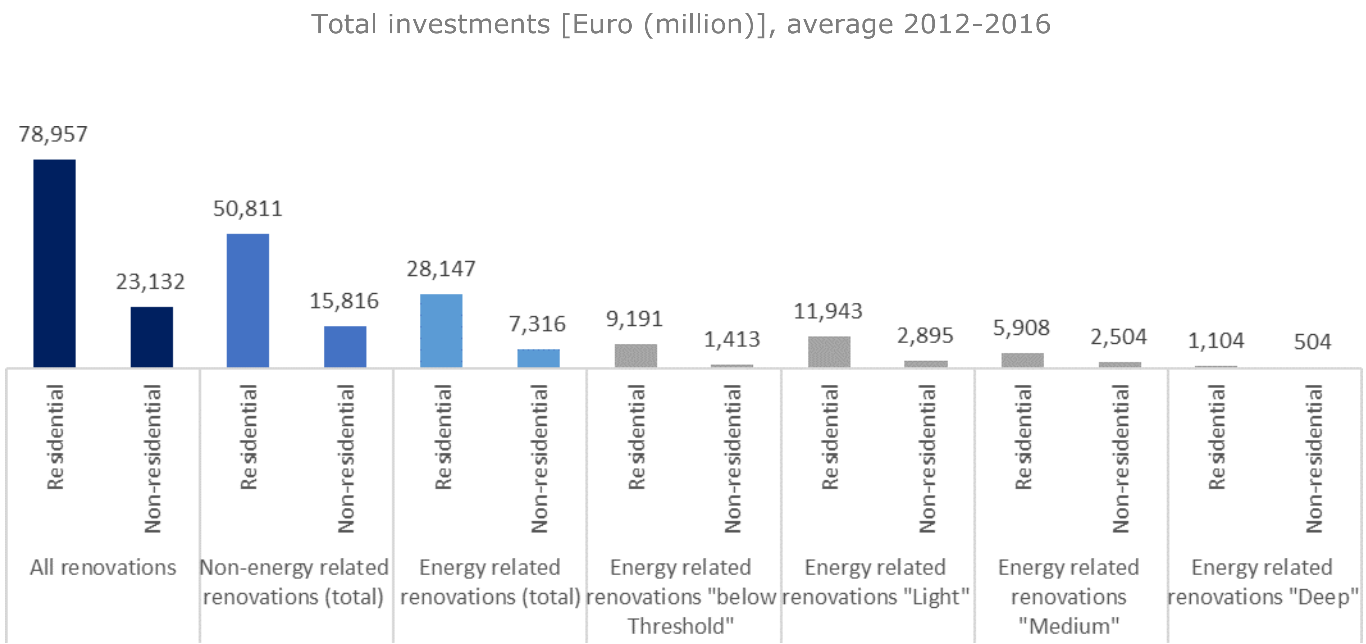
Population (2018)	66,273,576
Cooling/heating degree days (2018)	1.1/2936.3
Dampness damages in buildings [% of population]	17%
Emission mitigation [ktCO2e/a], residential/non-residential (average 2012-2016)	1,112/824
Jobs maintained by building renovations [FTEs], residential (average 2012-2016)	673,000
Jobs maintained by building renovations [FTEs], non-residential (average 2012-2016)	197,000

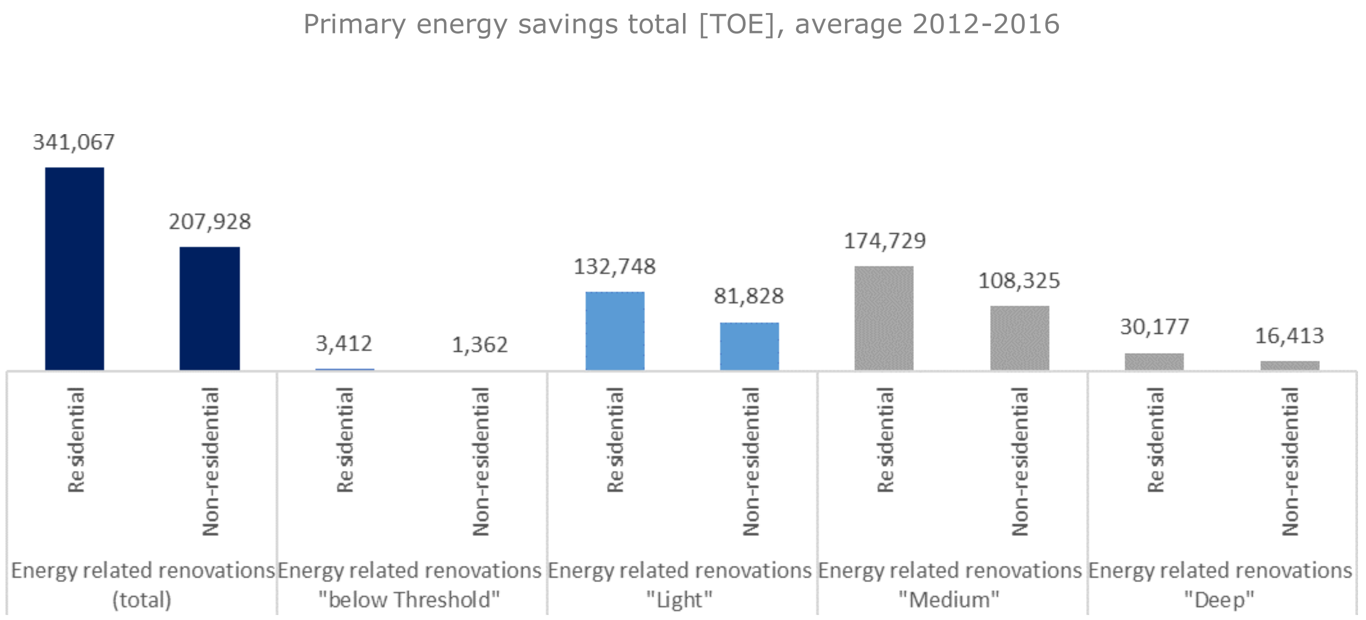
Total building stock [floor area, m²] shares, 2016



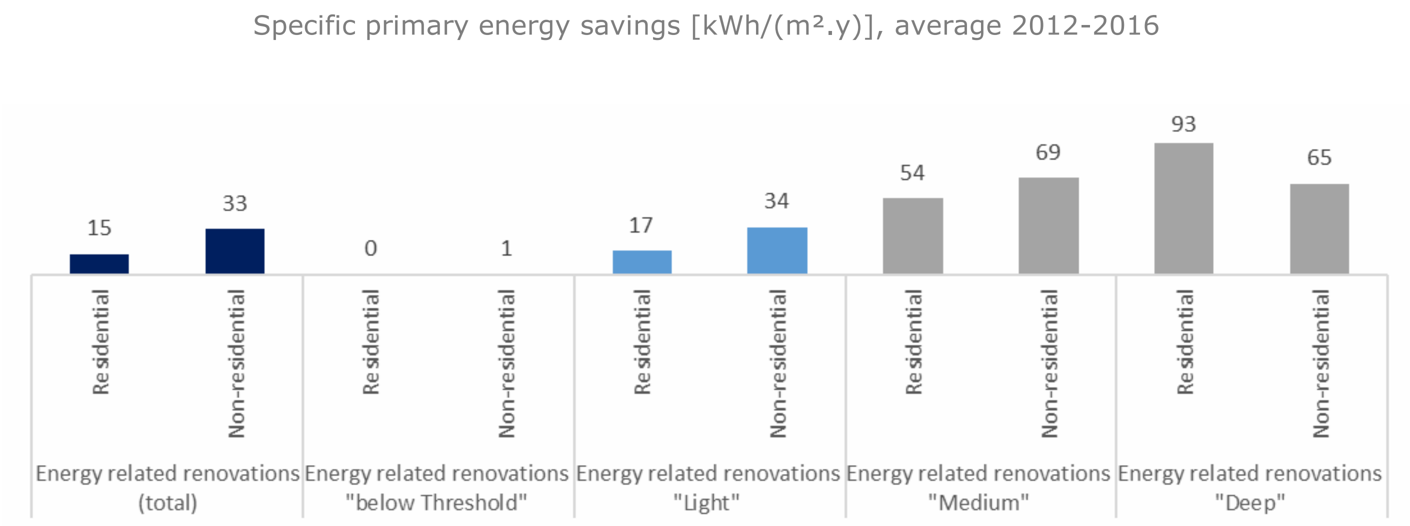



Renovation rate [%/stock], average 2012-2016
9.1%
15.6%
7.9%
9.6%
4.0%
3.2%
2.7%
3.7%
1.1%
2.4%
0.1%
0.4%
Residential
Non-residential
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"


Total investments [Euro (million)], average 2012-2016
78,957
23,132
50,811
15,816
28,147
7,316
9,191
1,413
11,943
2,895
5,908
2,504
1,104
504
Residential
Non-residential
All renovations
Non-energy related renovations (total)
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Primary energy savings total [TOE], average 2012-2016
341,067
207,928
3,412
1,362
132,748
81,828
174,729
108,325
30,177
16,413
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"



Specific primary energy savings [kWh/(m².y)], average 2012-2016
15
33
0
1
17
34
54
69
93
65
Residential
Non-residential
Energy related renovations (total)
Energy related renovations "below Threshold"
Energy related renovations "Light"
Energy related renovations "Medium"
Energy related renovations "Deep"

NZEB[28]

Indicative numerical indicator of primary energy use:

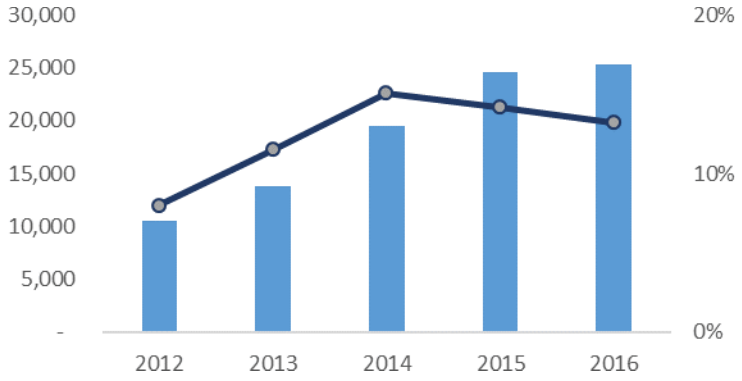
Residential:

45 kWh/(m².y)

Non-residential:

150 kWh/(m².y)

Total number of nearly-zero energy buildings and their share of the construction market [%] by year



[28] The numbers presented reflect 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 numbers should not be understood as the rate of buildings being compatible with an official NZEB definition that may exist today. The factsheets also provide a numerical indicator of primary energy use for NZEB which could reflect the official Member State's definition or be representative for what is expected for that Member State based on different sources. For further information see annex to the final report, section 1.3.

ANNEXES

1. Definitions

This section provides insights into the partial overhaul of definitions which partly already existed from the EU Building Observatory. For the purpose of this study, also new definitions were developed.

1.1. Renovation & uptake of NZEB

<table>
<tr><th colspan="2">Renovation & uptake of NZEB</th></tr>
<tr><td>Energy renovation</td><td>An energy renovation means the change of one or more building elements, according to EPBD Art. 2, 9 (i.e. building envelope and technical building systems), having the potential to significantly affect the calculated or measured amount of energy needed to meet the energy demand associated with one or several of the following building services (according to ISO 52000-1) which correspond to a typical use of the assessed building;
▪ Space heating and cooling;
▪ Hot water;
▪ Ventilation (incl. humidification and dehumidification);
▪ (built-in) Lighting
▪ Auxiliary energy needed by TBS to provide these services is also included.

In the following we call such change of a building element a “technical measure”.

Affected building floor area: The building floor area affected by an energy renovation is the floor area affected by a specific technical measure. For a proper use of this indicator in subsequent calculations of renovation rates, it needs to be known whether a technical measure just affects one (or more) building unit(s) (e.g. one apartment) or the whole building, as the respective floor area needs to be considered.

Effective date of energy renovation: A renovation measure is assigned to the calendar year, where the measure has been completed. In case one measure is completed in January of a calendar year and another measure in December of the same calendar year, the cumulated impact of both measures is assigned to that calendar year and treated as one package, even if both measures are decoupled from a technical perspective.

Depth of energy renovation: Four renovation depths are defined that represent different ranges of primary energy savings achieved with a specific measure or package of measures that has/have been implemented in a calendar year:
▪ Below threshold (x < 3% savings)
▪ Light renovations (3% ≤ x ≤ 30% savings)
▪ Medium renovations (30% < x ≤ 60% savings)
▪ Deep renovations (x > 60% savings)

The different depths by definition do not necessarily need to cover a specific minimum number of measures but are just classified depending on the savings achieved compared to the primary energy performance level of the building in the calendar year before the energy renovation.</td></tr>
</table>

	Step-by-step energy renovations: In case a building or building unit undergoes energy renovation measures in one calendar year that represent only a part of a multi-calendar year renovation (e.g. following an individual building energy renovation roadmap, i.e. a package consisting of a series of technical measures aiming at higher savings), only the technical measures and its specific savings will be assigned to the calendar year x where that individual technical measure has been completed. Measures realised in other calendar years will also just be counted in the year the measures have been completed. **Rate of energy renovation:** This is the cumulated affected building floor area [m^2] of all buildings that underwent an energy renovation in calendar year x (e.g. 2013) divided by the total floor area [m^2] of the building stock in the same period. The rate of energy renovation can be further split up geographically (e.g. EU28, each EU Member State), by building type (e.g. residential and non-residential buildings) or by depth of energy renovation. The unit is [%]. The total energy renovation rate is defined as the sum of all renovation rates of the covered depths "below threshold", "light", "medium" and "deep". Other measures for the rate of energy renovation can be derived from that approach: the cumulated affected building floor area [m^2] of all buildings that underwent an energy renovation in calendar year x (e.g. 2013) can be transformed into an estimation of the number of buildings/building units that underwent an energy renovation when there is useful information or reasonable assumptions can be made about the average floor area of all buildings that underwent an energy renovation.
Non-energy renovation	Non-energy renovations are those that do not affect building elements according to EPBD Art. 2, 9 (i.e. building envelope and technical building systems) and thus do not have the potential to significantly affect the calculated or measured amount of energy needed as described for "energy renovation". Examples: electric installations, interior wall painting and plastering, interior flooring, new tiles, new kitchen, new bathroom, new carpets etc.
Energy renovations below threshold	An energy renovation is classified as a renovation "below threshold" in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by $x < 3\%$ savings compared to the primary energy demand of the building in the calendar year before the energy renovation. It was decided to include this minimum threshold in order to a) avoid misleadingly large numbers of light renovations (caused by including technical measures like e.g. replacing a few light bulbs in a non-residential building) and b) separate out and highlight those renovations, where significant lost-opportunities have been created as for improving the energy performance (e.g. full painting of all exterior walls without using the opportunity to improve the energy performance by adding /thick enough) insulation).
Light renovation	An energy renovation is classified as light renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by $3\% \leq x \leq 30\%$ savings compared to the primary energy demand of the building in the calendar year before the energy renovation.
Medium renovation	An energy renovation is classified as medium renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by $30\% < x \leq 60\%$ compared to the primary energy demand of the building in the calendar year before the energy renovation.

Deep renovation	An energy renovation is classified as deep renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by x > 60% compared to the primary energy demand of the building in the calendar year before the energy renovation.
Weighted energy renovation rate	This is the cumulated saved primary energy consumption [kWh] of all buildings that underwent an energy renovation (i.e. the sum of all "below threshold", "light", "medium" and "deep" renovations) in calendar year x (e.g. 2013) divided by the total primary energy consumption [kWh] of the building stock in the same period. The weighted energy renovation rate can be further split up geographically (e.g. EU28, each EU Member State), or by building type (e.g. residential and non-residential buildings). The unit is [%]. The total energy renovation rate is defined as the sum of all renovation rates of the covered depths "below threshold", "light", "medium" and "deep".
NZEB uptake	To respect official national definitions for NZEB (new buildings and renovations) that might be available in the Member States, NZEB are not defined based on a specific uniform primary energy saving threshold (like above with light, medium and deep renovation), but official national NZEB renovation definitions will be used to track NZEB renovations under "NZEB uptake". Official NZEB definitions are considered as such when there has been an official Member States publication until 31 December 2017 which includes the final national NZEB definition. Also, similar definitions if their specifications are unambiguously covered by the official national NZEB definition will be included within NZEB uptake if published before 31 December 2017. In countries without a NZEB definition in place till 31 December 2017, market actors will be asked for proxy standards that in their view meet the definition given in EPBD (2010) Art. 2, 2: "a building that has a very high energy performance […] The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". Due to the period covered by the survey (2012—2016) when almost no official definitions have been in place and market actors have not been familiar with the NZEB concept, NZEB uptake will be quantified rather based on qualitative information sources (such as the surveys undertaken). However, in cases in which the number of NZEBs has been tracked on an official level and this information is available until end of 2018, this data will be used as well.

1.2. Building type characterisation and used reference buildings for measuring renovation activities

Residential building types and information on reference buildings used

As further described in section 3.5, each of the surveyed persons (residential cases) has been allocated to a reference building from the TABULA/EPISCOPE project. By taking this approach, several questions about the building or dwelling the respective respondent is referring to could be avoided. The TABULA/EPISCOPE project provides a complex database of different residential building types of different construction periods in the majority of EU countries. The database contains information about the geometry of these buildings, including window fractions, number of dwellings and floor area, but also about the energetic reference situation. Accordingly, in the surveys, the respondent is asked to select the main building category s/he is referring to, including the construction period. This information has later been used to clearly allocate each case to one of the TABULA/EPISCOPE reference buildings. The main building types provided as options in the questionnaires are presented in the overview below.

Building type	Description	Example pictures [IWU, 2015 & VITO, 2011] [1]
Single family house (SFH), detached	Detached residential buildings with one or two dwelling units.	  
Semi-detached SFH	One-sided attached residential building type with one or two dwelling units constructed as row end house, duplex house or similar.	  
Terraced / row single-family house (TH)	Two-sided attached residential building type with one or two dwelling units constructed as row house.	 
Small multi-family house (MFH)	Residential building type with 3-6 dwellings	  
Medium MFH	Residential building type with 7-12 dwellings	 

1 http://www.building-typology.eu/downloads/public/docs/brochure/DE_TABULA_TypologyBrochure_IWU.pdf

http://episcope.eu/fileadmin/tabula/public/docs/scientific/BE_TABULA_ScientificReport_VITO.pdf

Large MFH / Apartment Block (AB)	Residential building type with 13 or more dwellings	

Table 1 presents which residential reference buildings have been used during the data processing stage for the calculations. The different construction periods per country have been embedded in the questionnaires to be able to directly allocate the specific case (respondent) to a specific reference building according to the TABULA/EPISCOPE building typology. In case of countries that are not covered in TABULA/EPISCOPE, based on an analysis of the climate (heating degree days) and GDP, the most suitable TABULA/EPISCOPE target country with data has been identified. The reference buildings of this "comparable" country have later been used for data processing for this country.

Table 1: List of addressed reference building parameters used in the surveys

Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
Austria	... 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 ...	-	... 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 ...	-	... 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 ...	... 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 ...	
Belgium	... 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 ...	.. 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 ...	... 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 ...	... 1945 1946-1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 ...	... 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 ...	... 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 ...	
Bulgaria	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	.. 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	
Croatia	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	.. 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	Bulgaria 1) HDD per year: Croatia = 2798; Bulgaria = 2953
Cyprus	... 1980 1981 -2006 2007 - 2013 2014 ...	-	... 1980 1981 -2006 2007 - 2013 2014 ...	-	... 1980 1981 -2006 2007 - 2013 2014 ...	-	
Czech Republic	... 1920 1921 - 1945 1946 - 1960	-	... 1920 1921 - 1945 1946 - 1960	-	... 1920 1921 - 1945 1946 - 1960	... 1920 1921 - 1945 1946 - 1960	

Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
	1961 - 1980 1981 - 1994 1995 - 2010 2011 ...		1961 - 1980 1981 - 1994 1995 - 2010 2011 ...		1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	
Denmark	... 1850 1851 - 1930 1931 - 1950 1951 - 1960 1961 - 1972 1973 - 1978 1979 - 1998 1999 - 2006 2007 - 2010 2011 ...	-	... 1850 1851 - 1930 1931 - 1950 1951 - 1960 1961 - 1972 1973 - 1978 1979 - 1998 1999 - 2006 2007 - 2010 2011 ...	-	-	... 1850 1851 - 1930 1931 - 1950 1951 - 1960 1961 - 1972 1973 - 1978 1979 - 1998 1999 - 2006 2007 - 2010 2011 ...	
Estonia	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	Poland 1) GDP per capita: Estonia = 13651; Poland = 12409 2) HDD per year: Estonia = 4731; Poland = 3725
Finland	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	-	-	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	Sweden 1) GDP per capita: Finland = 43052; Sweden = 49587 2) HDD per year: Finland = 5251; Sweden = 4496
France	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	-	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	-	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	
Germany	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	-	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	-	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	
Greece	...1980 1981 - 2000 2001 - 2010 2011 ...	-	-	-	...1980 1981 - 2000 2001 - 2010 2011 ...	-	
Hungary	...1944 1945 - 1979 1980 - 1989 1990 - 2005 2006 ...	-	-	-	...1944 1945 - 1979 1980 - 1989 1990 - 2005 2006 ...	...1944 1945 - 1979 1980 - 1989 1990 - 2005 2006 ...	

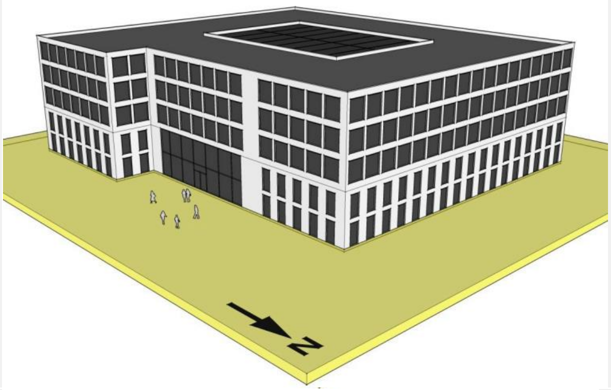
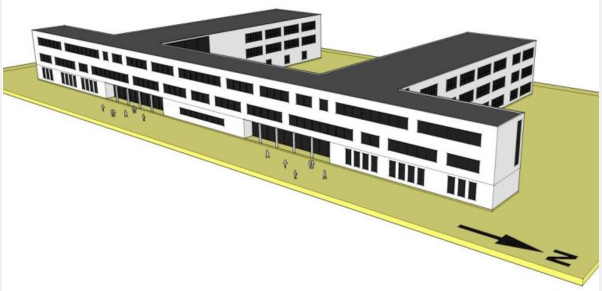
Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
Ireland	... 1899 1900 - 1929 1930 - 1949 1950 - 1966 1967 - 1977 1978 - 1982 1983 - 1993 1994 - 2004 2005 - 2010 2011 ...	-	... 1899 1900 - 1929 1930 - 1949 1950 - 1966 1967 - 1977 1978 - 1982 1983 - 1993 1994 - 2004 2005 - 2010 2011 ...	-	-	... 1899 1900 - 1929 1930 - 1949 1950 - 1966 1967 - 1977 1978 - 1982 1983 - 1993 1994 - 2004 2005 - 2010 2011 ...	
Italy	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	-	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	-	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	
Latvia	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	Poland 1) GDP per capita 2018: Latvia = 10731; Poland = 12409 2) HDD per year: Latvia = 4566; Poland = 3725
Lithuania	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	Poland 1) GDP per capita: Lithuania = 11671; Poland = 12409 2) HDD per year: Lithuania = 4311; Poland = 3725
Luxem-bourg	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1946 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	-	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	Netherlands 1) HDD per year: Luxembourg = 3290; Netherlands = 3125
Malta	...1980 1981 - 2000 2001 - 2010 2011 ...	-	-	-	...1980 1981 - 2000 2001 - 2010 2011 ...	-	Greece 1) GDP per capita 2018: Malta = 18473; Greece = 20485
Nether-lands	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1946 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	-	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	
Poland	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	

Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
Portugal	...1980 1981 - 2000 2001 - 2010 2011 ...	-	-	-	...1980 1981 - 2000 2001 - 2010 2011 ...	-	Greece 1) GDP per capita 2018: Portugal = 19629; Greece = 20485 2) HDD per year: Portugal = 1364; Greece = 1644
Romania	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	.. 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	Bulgaria 1) GDP per capita 2018: Romania = 5844; Bulgaria = 7079 2) HDD per year: Romania = 3320; Bulgaria = 2953
Slovakia	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	-	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	-	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010	Czech Republic 1) GDP per capita 2018: Slovakia = 17630; Czech Republic = 16650 2) Used to be one country until 1992 3) HDD per year: Slovakia = 3864; Czech Republic = 3794
Slovenia	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	-	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	-	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	
Spain	... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...		... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...		... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...	... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...	
Sweden	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	-	-	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	
United Kingdom	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	-	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	-	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	

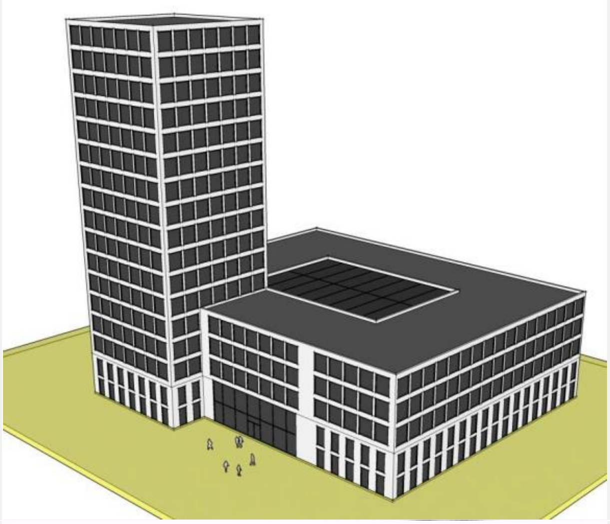
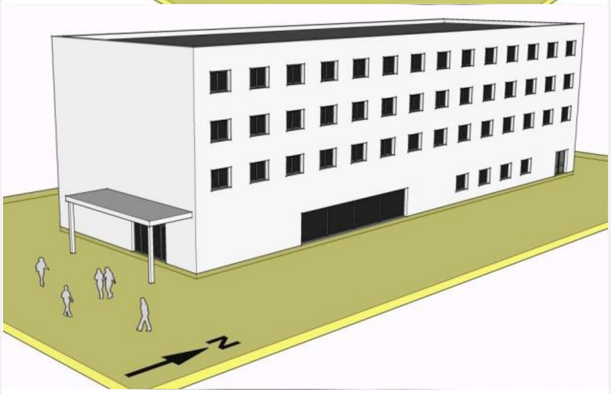
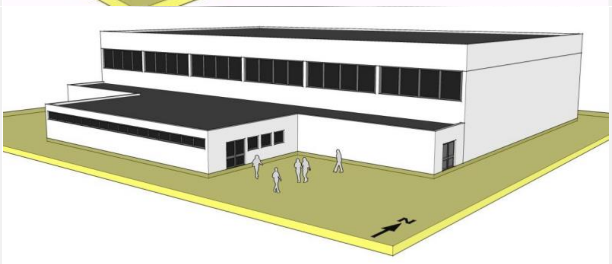
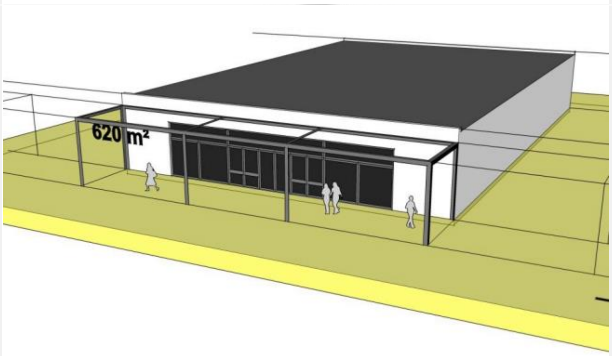
Non-residential building types and information on reference buildings used

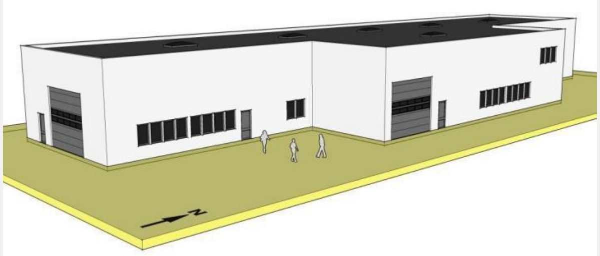
Based on EPBD Annex I, the following non-residential building types are used in this study:

- Offices;
- Educational buildings;
- Hospitals;
- Hotels and restaurants;
- Sports facilities;
- Wholesale and retail trade services buildings;
- Other types of energy-consuming buildings.

Building type	Abbreviation used in indicator list	Examples of model buildings for the different types[2]
Offices;	Office	
Educational buildings;	Education	

2 Source of pictures: Klauß & Maas (2010). It should be considered that the here presented picture for hospitals is used for the illustration of a specific type of office building in the original source

Hospitals;	Hospital		
Hotels and restaurants;	Hotel		
Sports facilities;	Sport		
Wholesale and retail trade services buildings;	Trade		

Other types of energy-consuming buildings.	Other	

For each of these building types, different reference building information exists on Member State level. Good guidance to deal with the complexity of this task is provided by Tsitsanis et al. (2017)[3]. Accordingly, there are two main horizontal sources of appropriate non-residential reference buildings; commercial reference building models as defined by the U.S. Department of Energy 4 and the reference buildings as used in the national cost-optimality calculations according to EPBD Article 4. For the purpose of this study, we focused on the European reference buildings as used in the national cost-optimality calculations.

Tsitsanis et al. (2017) analysed available non-residential reference building specifications from the 2013 round of cost-optimality reports.[5] Through an analysis of all published cost-optimality reports (country reports only available in national language have not been considered), useful reference building information has been collected but it became obvious that no consistency is provided from one MS to the other and in most cases, relevant details of the geometries were missing. Therefore, it was decided to use average building floor spaces per MS and building type from the H2020 project "Hotmaps Toolbox"[6] and combine them with average ratios of floor area to component area per building type from the cost-optimality reports to obtain the required level of detail.

1.3. Nearly zero-energy building definitions as used in the surveys

The following sources have been used for the compilation of NZEB definitions:

- BPIE (2015): Nearly zero-energy buildings definitions across Europe. Factsheet. S. 4-5
- EPBD (2016): Overview of national applications of the Nearly Zero-Energy Building (NZEB) definition. Detailed report. S. 6-9
- JRC (2017): Towards Nearly Zero-Energy Buildings in Europe: A Focus on Retrofit in Non-Residential Buildings. S. 7
- JRC (2016): Synthesis Report on the National Plans for Nearly Zero-Energy Buildings (NZEBs). S. 12-15
- CA EPBD (2015): Implementing the Energy Performance of Buildings Directive (EPBD). Featuring Country Reports.
- EPISCOPE (2014): Inclusion of New Buildings in Residential Building Typologies.

3 Tsitsanis Anastasios, Tsatsakis Konstantinos, Oxizidis Simeon, Bucur Mircea, Ring Daniel, Milne Caroline (2017). Report on typology of buildings suitable for dual energy services. Deliverable from Horizon 2020 project "New Buildings Energy Renovation Business Models incorporating dual energy services (Task 5.1)

4 https://www.energy.gov/eere/buildings/commercial-reference-buildings

5 However, also first reports from the 2018 round became available at https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

6 https://gitlab.com/hotmaps/building-stock/tree/master

- Attia et al. (2017): Overview and future challenges of nearly zero-energy buildings (NZEB) design in Southern Europe.
- JRC (2017), Country sheets for EU28 reflecting progress in implementing the EPBD and improving energy performance of buildings,
- D'Agostino et al., Synthesis Report on the National Plans for NZEBs; EUR 27804 EN
- Building Stock Observatory (for the year 2015 as historical data only. Maximum primary energy performance of nZEB)
- ZEBRA (2020): indicators for a sample of nZEB buildings and high efficient buildings estimated to be at NZEB level, built recently in selected European countries [Existing buildings only]
- Tzortzaki, A., Nearly Zero-Energy Buildings: Comparison of the targets set by the European countries and analysis of their diffusion

NZEB Definitions for new constructions

The following list summarises all information on national NZEB definitions for new constructions, status April 2018. Although the objective of the study was not to define national NZEBs in detail, for completeness reasons the last column in the table also contains indicative information about the range of primary energy requirements for new buildings based on a literature review. However, it should be noted that different calculation approaches might exist on national level, therefore values cannot easily be compared to each other.

Member state	Official NZEB definition declared by MS?	Applicability of NZEB definition on new construction s?	Overall regulation	Year of enforcement		Explanations	Official indicators (If no official NZEB definition in place)	Primary energy requirements according to literature review in kW·h/(m²•a) (Source indication 1-5)
				Public buildings	Non-public buildings			
Austria	Yes	Yes	1) OIB Guidelines 6; 2) National Plan	01.01.2019	01.01.2021	EPBD text of NZEB is implemented in OIB Guidelines 6 of 2015-03. NZEBs have been defined in the National Plan of 2014-03 and the negotiations with the Austrian Provinces are completed (OIB Guidelines 6).	-	160 – 170 1/2/3/5
Belgium-Brussels	Yes	Yes	The Brussels Air, Climate and Energy Code (COBRACE)	01.01.2019	01.01.2015	The NZEB definition is included in "The Brussels Air, Climate and Energy Code (COBRACE)". The 2015 in Brussels implemented "EPB-Passive Requirements 2015" is the transposition of the NZEB definition, which is based on the Passive House Standard and adapted to the Brussels context.	-	45 - 85 2/3/5

Belgium-Flanders	Yes	Yes	Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings	01.01.2019	01.01.2021	The NZEB definition is included in the "Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings". On November 29, 2013, the Flemish Government gave its final approval to the definition on NZEB level for residential buildings and offices and schools, called BEN (Bijna Energie Neutraal) which determined an E-Level at lower or equal to 30.	-	32 – 45 2/3
Belgium-Wallonia	Under development	Under development	National Plan	01.01.2019	01.01.2019	Interpretation of EPBD text in national plan, study contracted, definition will evolve. According the National Plan the energy performances will be close or equivalent to those of the passive standard in terms of the building envelope and by the renewable energy coverage as part of the consumption.	NZEB definition acc. National Plan (p.21): "Energy performances that are close or equivalent to those of the passive standard in terms of the building envelope and by the renewable energy coverage of part of the consumption"	95 (1)
Bulgaria	Yes	Yes	National Plan	01.01.2019	01.01.2021	Draft definition in National Plan for Nearly zero-energy buildings (BPIE study); national	-	30 – 50 2/3/5

						requirements defined by "Ordinance for heat retention and energy efficiency in buildings" (updated in 2009)		
Croatia	Yes	Yes	1) Technical regulation on energy and energy performance of buildings. (OG No. 97/14, 130/14); 2) National NZEB Plan	01.01.2019	01.01.2021	Definition for SFH in National Plan. Definition for various building categories in Technical Regulation on Energy Economy and Heat Retention in Buildings	-	30 – 80 1/2/3/5
Cyprus	Yes	Yes	Decree 366/2014 (Law for the Regulation of the Energy Performance of the Buildings of 2012, N.210 (I)/2012)	01.01.2019	01.01.2021	NZEB definition included in Decree 366/2014 (issued on 1 August 2014). NZEBs must have an Energy Performance Certificate class A according to the preliminary national methodology for energy performance of buildings.	-	100 1/2/3/5
Czech Republic	Yes	Yes	Regulation 78/2013 Coll. (Energy Performance of Buildings decree)	2016-2018 (depending on size)	2018-2020 (depending on size)	A provisory definition of NZEB is included in the new legislation (Regulation No. 78/2013 Coll.). The Czech Housing development fund (SFRB) is currently synchronizing the subsidy scheme with the new legislation and energy performance requirements.	-	43 – 51 (5)
Denmark	Yes	Yes	Building Regulations 2010 (BR10)	01.01.2019	01.01.2021	The Danish NZEB definition is implemented in the current Danish Building	-	20 1/2/3/5

						Regulations 2010 BR10.		
Estonia	Yes	Yes	Regulation 68:2012	01.01.2019	01.01.2021	NZEB definition included in regulation VV No 68:2012 “Energiatõhususe miinimumnõuded”.	-	50 – 100 1/3/5
Finland	Under development	Under development	National Building Code of Finland	01.01.2018	01.01.2021	The detailed definition was planned to be finalised in the course of 2015 and the aim was to present the legislative proposal to the parliament in autumn 2016. It could not be finally clarified whether an official NZEB definition was adopted.	n/a	78 – 150 1/5
France	Yes	Yes	1) Méthode de calcul Th-BCE 2012; 2) Réglementation Thermique 2012 (RT 2012)	28.10.2011	01.01.2013	The calculation methodology for NZEB is provided in the Th-BCE 2012. All new buildings will be energy positive in 2020. Renovated buildings are considered NZEB if they reach a higher energy performance than the mandatory level defined in the Thermal Regulation for existing buildings (RT 2012).	-	40 – 105 1/2/3/5
Germany	Under development	Under development	Energy Conservation Regulation (EnEV 2009)	01.01.2019	01.01.2021	EPBD text implemented in energy saving act, detailed definition is being developed. Nearly zero-energy buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that the best standard	KfW Efficiency House 40, 55 and 70	36 – 43,75 1/3

						currently supported by the KfW banking group may be an appropriate benchmark.		
Greece	Under development	Under development	Law 4122/2013	01.01.2019	01.01.2021	The NZEB definition was introduced to national legislation by amendment of the Law 3661 in June 2010 and is identical to the EPBD definition. This definition is also included in Law 4122/2013, which specifies that, after 1 January 2019, every new building of the public sector should be a NZEB. This obligation applies also to all new buildings constructed after 1 January 2021. However, the national NZEB definition has not yet been applied.	n/a	-
Hungary	Yes (Still to be approved)	Under development	Amended decree 7/2006 (V. 24.)	01.01.2019	01.01.2021	Draft definition included in Decree about Determination of Energy Efficiency of Buildings of 7/2006 (V.24), detailed definition is being developed. Nearly Zero-Energy Building (NZEB) requirements will come into force in 2019 and 2021 for public buildings and all new and majorly renovated buildings respectively.	-	50 – 72 1/2/5

Ireland	Yes	Yes	Technical Guidance Document (TGD) Part L (Conservation of Fuel and Energy - Dwellings)	01.01.2019	01.01.2021	The Irish Department of Environment, Community and Local Government set out the Irish NZEB definition for residential buildings in its policy document "Towards Nearly Zero Energy Buildings in Ireland – Planning for 2020 and beyond". A draft definition is included in the national NZEB plan. NZEB standard will achieve 70% re-duction in energy demand compared to reference dwelling set out in 2005 Building Regulations (TGD Part L).	-	45 2/3/5
Italy	Yes	Yes (Still to be approved)	1) Decree Law no. 63/90 of 2013; 2) Decree 26/06/2015			EPBD text in Decree Law no. 63/90 of 2013, new energy decree of June 26th includes detailed definition concerning new minimum requirements and methodology for calculating energy performance of buildings. Same requirements for new constructions and renovations.	-	15 – 20 & Class A1 2/3/5
Latvia	Yes	Yes	Regulation 383/2013 ("Regulations regarding Energy certifications of Buildings")	01.01.2019	01.01.2021	NZEB definition included in Cabinet Regulation No. 383/2013.	-	95 1/2/3/5
Lithuania	Yes	Yes	Regulation STR	01.01.2019	01.01.2021	NZEB definition	-	Energy Class

			2.01.09 :2012			included in Construction Technical Regulation STR 2.01.09:2012.		A++ 1/2/5
Luxembourg	Yes	Yes	1) RGD 2007, 2010, 2014; 2) National Plan	01.01.2019	01.01.2021	Interpretation of EPBD text included in national plan and in national legislation (RGD 2014), detailed definition not yet fixed. From 2017, all new residential buildings will have to fulfil in principle the A-A standard which is aimed to represent the NZEB standard once the proposed regulation enters into force. The fine-tuning of the exact calculation methodology and the NZEB definition for non-residential buildings is still in progress.	-	45 & Class A / Class AAA 1/2/5
Malta	Yes	Yes	LN 376/2012 (transposing Directive 2010/31)	01.01.2019	01.01.2021	NZEB definition included in LN 376/2012 (transposing Directive 2010/31).	-	55 – 115 2/5
Netherlands	Yes	Yes	NEN 7120: Energy performance of buildings - Determination method	01.01.2019	01.01.2021	A specific building performance assessment method according the NEN 7120 (2012) standard is used in the Netherlands. The resulting energy demand is shown in an energy performance coefficient (EPC) which must be nearly zero in 2018/2020.	-	0 – 25 2/3/5

Poland	Yes	Yes	Resolution No. 91/2015 of the Council of Ministers of 22 June 2015	01.01.2019	01.01.2021	Translation of the EPBD text in national plan. Detailed definition included in "Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location" (Journal of Laws No 75, pos. 690), amendment in 2013. The proposed definition of NZEB is based on an EP index and U values for building envelope elements.	-	65 – 75 1/2/5
Portugal	Under development	Under development	Decree-Law 118/2013, August 20th			Translation of the EPBD text in Decree law 118/2013, Article 16. Detailed definition not yet available.	n/a	33 (5)
Romania	Yes	Yes	National NZEB Plan	01.01.2019	01.01.2021	NZEB definition included in updated National Plan for NZEB (included in the 3rd National Energy Efficiency Action Plan (NEEAP)), approved by Governmental Decision no.122/2015. Content based on BPIE study "Implementing Nearly Zero-Energy Buildings (NZEB) in Romania"	-	93 – 117 1/2/3/5
Slovakia	Yes	Yes	MDVRR SR 364/2012 Coll.	01.01.2019	01.01.2021	Translation of EPBD text in Act No. 555/2012, NZEB requirements in MDVRR SR 364/2012 Coll.	-	32 – 54 1/2/5

Slovenia	Yes	Yes	1) Energetski zakon, Uradni list RS, št. 17/14; 2) National Action Plan for Nearly Zero-Energy Buildings Up to 2020 (AN sNES)			Translation of EPBD text in Energy Act of March 2014 (Energetski zakon, Uradni list RS, št. 17/14). National plan includes a detailed NZEB definition (approved by the Government on 22 April 2015).	-	50 – 80 1/2/3/5
Spain	Under development	Under development	Decree 235/2013			Translation of EPBD text in RD 235/2013 (pending final approval). Nearly zero-energy buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that NZEB buildings would be equivalent to A class.	It is foreseen that buildings will need to comply with class A.	40 – 70 & Class A 2/5
Sweden	Yes	n/a	Building regulations BBR 2012 (BFS 2015:3, 1 March 2015)			Current energy performance requirements are based on BBR 22 (BFS 2015:3, 1 March 2015). Nearly-zero energy rules are introduced in the Building Agency's Building Regulations, BBR Section 9 Energy Conservation since July 1, 2017. Sharp requirements come into force in 2020.	-	30 – 75 2/3/5
United Kingdom (England)	Yes	Yes	Building Regulations Energy Efficiency Requirements: England (Part L); Wales (Part L);	01.01.2018 (from 2016 for residential buildings)	01.01.2019 (from 2016 for residential buildings)	The United Kingdom Government consider that the approach they are adopting for Zero Carbon Homes from 2016 will meet the	-	39 – 46 2/5

			Scotland (Section 6); Northern Ireland (Technical Booklet F)			definition of NZEB.		

NZEB Definitions for existing buildings

The following list summarises all information on national NZEB definitions for existing buildings, status April 2018. Although the objective of the study was not to define national NZEBs in detail, for completeness reasons the last column in the table also contains indicative information about the range of primary energy requirements for existing buildings based on a literature review. However, it should be noted that different calculation approaches might exist on national level, therefore values cannot easily be compared to each other.

Member state	Official NZEB definition declared by MS?	Applicability of NZEB definition on renovations?	Overall regulation	Year of enforcement		Explanations	Official indicators (If no official NZEB definition in place)	Primary energy requirements according to literature review in kW·h/(m²•a) (Source indication 1-5)
				Public buildings	Non-public buildings			
Austria	Yes	Yes	1) OIB Guidelines 6 2) National Plan	01.01.2019	01.01.2021	EPBD text of NZEB is implemented in OIB Guidelines 6 of 2015-03. NZEBs have been defined in the National Plan of 2014-03 and the negotiations with the Austrian Provinces are completed (OIB Guidelines 6).	-	85 – 260 1/2/4/5
Belgium-Brussels	Yes	Yes	The Brussels Air, Climate and Energy Code (COBRACE)	01.01.2019	01.01.2015	The NZEB definition is included in "The Brussels Air, Climate and Energy Code (COBRACE)". The 2015 in Brussels implemented "EPB-Passive Requirements	-	54 – 75 2/4

						2015" is the transposition of the NZEB definition, which is based on the Passive House Standard and adapted to the Brussels context.		
Belgium-Flanders	Yes	Yes	Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings	01.01.2019	01.01.2021	The NZEB definition is included in the “Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings". On November 29, 2013, the Flemish Government gave its final approval to the definition on NZEB level for residential buildings and offices and schools, called BEN (Bijna Energie Neutraal) which determined an E-Level at lower or equal to 30.	-	No distinction
Belgium-Wallonia	Under development	Under development	National Plan	01.01.2019	01.01.2019	Interpretation of EPBD text in national plan, study contracted, definition will evolve. According the National Plan the energy performances will be close or equivalent to those of the passive	Unofficial NZEB definition acc. National Plan (p.21): "Energy performances that are close or equivalent to those of the	No distinction

						standard in terms of the building envelope and by the renewable energy coverage as part of the consumption.	passive standard in terms of the building envelope and by the renewable energy coverage of part of the consumption"	
Bulgaria	Yes	Yes	National Plan	01.01.2019	01.01.2021	Nearly zero-energy buildings (BPIE study); national requirements defined by "Ordinance for heat retention and energy efficiency in buildings" (updated in 2009)	-	40 – 60 2/5
Croatia	Yes	Yes	1) Technical regulation on energy and energy performance of buildings. (OG No. 97/14, 130/14) 2) National NZEB Plan	01.01.2019	01.01.2021	Definition for SFH in National Plan. Definition for various building categories in Technical Regulation on Energy Economy and Heat Retention in Buildings	-	-
Cyprus	Yes	Yes	Decree 366/2014, Law 210(I)/2012 (Nearly Zero-Energy Buildings Action Plan)	01.01.2019	01.01.2021	NZEB definition included in Decree 366/2014 (issued on 1 August 2014). NZEBs must have an Energy Performance Certificate class A according to the	-	100 -125 1/2/5

						preliminary national methodology for energy performance of buildings.		
Czech Republic	Yes	Yes	Regulation 78/2013 Coll. (Energy Performance of Buildings decree)	2016-2018 (depending on size)	2018-2020 (depending on size)	A provisory definition of NZEB is included in the new legislation (Regulation No. 78/2013 Coll.). The Czech Housing development fund (SFRB) is currently synchronizing the subsidy scheme with the new legislation and energy performance requirements.	-	47 – 106 4/5
Denmark	Yes	Yes	Building Regulations 2010 (BR10)	01.01.2019	01.01.2021	The Danish NZEB definition is implemented in the current Danish Building Regulations 2010 BR10.	-	20 – 115 2/4
Estonia	Yes	No	Regulation 68:2012	01.01.2019	01.01.2021	NZEB definition included in regulation VV No 68:2012 “Energiatõhususe miinimumnõuded”.	-	90 – 270 (5)
Finland	Under development	Under development	National Building Code of Finland	01.01.2018	01.01.2021	The detailed definition will be finalised in the course of 2015 and the aim is to present the legislative proposal to the	n/a	136 – 335 1/5

						parliament in autumn 2016. It could not be finally clarified whether an official NZEB definition was adopted.		
France	Yes	Yes	1) Méthode de calcul Th-BCE 2012 2) Réglementation Thermique 2012 (RT 2012)	28.10.2011	01.01.2013	The calculation methodology for NZEB is provided in the Th-BCE 2012. All new buildings will be energy positive in 2020. Renovated buildings are considered NZEB if they reach a higher energy performance than the mandatory level defined in the Thermal Regulation for existing buildings (RT 2012).	-	67 – 120 1/2/4/5
Germany	Under development	Under development	1) EnEG 2) EnEV 3) EEWärmeG	01.01.2019	01.01.2021	EPBD text implemented in energy saving act, detailed definition is being developed. Nearly zero-energy buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that the best standard currently supported by the KfW banking group may be an appropriate benchmark.	KfW Efficiency House	27 (4)
Greece	Under	Under	Law	01.01.2019	01.01.2021	The NZEB definition	n/a	

	development	development	4122/2013			was introduced to national legislation by amendment of the Law 3661 in June 2010 and is identical to the EPBD definition. This definition is also included in Law 4122/2013, which specifies that, after 1 January 2019, every new building of the public sector should be a NZEB. This obligation applies also to all new buildings constructed after 1 January 2021. However, the national NZEB definition has not yet been applied.		
Hungary	Yes (Still to be approved)	Under development	Amended decree 7/2006 (V. 24.)	01.01.2019	01.01.2021	Draft definition included in Decree about Determination of Energy Efficiency of Buildings of 7/2006 (V.24), detailed definition is being developed. Nearly Zero-Energy Building (NZEB) requirements will come into force in 2019 and 2021 for public buildings and all new and majorly renovated buildings respectively.	-	72 (1)

Ireland	Yes	Under development	Technical Guidance Document (TGD) Part L (Conservation of Fuel and Energy - Dwellings)	01.01.2019	01.01.2021	The Irish Department of Environment, Community and Local Government set out the Irish NZEB definition for residential buildings in its policy document "Towards Nearly Zero-Energy Buildings in Ireland – Planning for 2020 and beyond". A draft definition is included in the national NZEB plan. NZEB standard will achieve 70% reduction in energy demand compared to reference dwelling set out in 2005 Building Regulations (TGD Part L).	-	75 – 150 (2)
Italy	Yes	Yes	1) Decree Law no. 63/90 of 2013 2) Decree 26/06/2015			EPBD text in Decree Law no. 63/90 of 2013, new energy decree of June 26th includes detailed definition concerning new minimum requirements and methodology for calculating energy performance of buildings. Same requirements for new constructions and renovations.	-	16 & Class A1 2/4
Latvia	Yes	Yes	Regulation	01.01.2019	01.01.2021	NZEB definition	-	95

			383/2013 ("Regulations regarding Energy certifications of Buildings")			included in Cabinet Regulation No. 383/2013.		1/2/5
Lithuania	Yes	Yes	Regulation STR 2.01.09 :2012	01.01.2019	01.01.2021	NZEB definition included in Construction Technical Regulation STR 2.01.09:2012.	-	89 & Class A1 2/4
Luxembourg	Yes	No	1) RGD 2007, 2010, 2014 2) National Plan	01.01.2019	01.01.2021	Interpretation of EPBD text included in national plan and in national legislation (RGD 2014), detailed definition not yet fixed. From 2017, all new residential buildings will have to fulfil in principle the A-A standard which is aimed to represent the NZEB standard once the proposed regulation enters into force. The fine-tuning of the exact calculation methodology and the NZEB definition for non-residential buildings is still in progress.	-	60 – 93 4/5
Malta	Yes	n/a	LN 376/2012 (transposing Directive 2010/31)	01.01.2019	01.01.2021	NZEB definition included in LN 376/2012 (transposing Directive	-	< 220 (2)

						2010/31).		
Netherlands	Yes	Under development	NEN 7120: Energy performance of buildings - Determination method	01.01.2019	01.01.2021	A specific building performance assessment method according the NEN 7120 (2012) standard is used in the Netherlands. The resulting energy demand is shown in an energy performance coefficient (EPC) which must be nearly zero in 2018/2020.	-	76 (4)
Poland	Yes	n/a	Resolution No. 91/2015 of the Council of Ministers of 22 June 2015	01.01.2019	01.01.2021	Translation of the EPBD text in national plan. Detailed definition included in "Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location" (Journal of Laws No 75, pos. 690), amendment in 2013. The proposed definition of NZEB is based on an EP index and U values for building envelope elements.	-	65 – 95 1/4
Portugal	Under development	Under development	Decree-Law 118/2013,			Translation of the EPBD text in Decree	n/a	140

			August 20th			law 118/2013, Article 16. Detailed definition not yet available.		(5)
Romania	Yes	n/a	National NZEB Plan	01.01.2019	01.01.2021	NZEB definition included in updated National Plan for NZEB (included in the 3rd National Energy Efficiency Action Plan (NEEAP)), approved by Governmental Decision no.122/2015. Content based on BPIE study "Implementing Nearly Zero-Energy Buildings (NZEB) in Romania"	-	98 – 230 1/2/4
Slovakia	Yes	n/a	MDVRR SR 364/2012 Coll.	01.01.2019	01.01.2021	Translation of EPBD text in Act No. 555/2012, NZEB requirements in MDVRR SR 364/2012 Coll.	-	82 (4)
Slovenia	Yes	Yes	1) Energetski zakon, Uradni list RS, št. 17/14 2) National Action Plan for Nearly Zero-Energy Buildings Up to 2020 (AN sNES)			Translation of EPBD text in Energy Act of March 2014 (Energetski zakon, Uradni list RS, št. 17/14). National plan includes a detailed NZEB definition (approved by the Government on 22 April 2015).	-	65 – 95 1/2/5
Spain	Under development	Under development	Decree 235/2013			Translation of EPBD text in RD 235/2013 (pending final approval). Nearly zero-energy	It is foreseen that buildings will need to comply with class A.	87 (4)

						buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that NZEB buildings would be equivalent to A class.		
Sweden	Yes	n/a	Building regulations BBR 2012 (BFS 2015:3, 1 March 2015)			Current energy performance requirements are based on BBR 22 (BFS 2015:3, 1 March 2015). Nearly-zero energy rules are introduced in the Building Agency's Building Regulations, BBR Section 9 Energy Conservation since July 1, 2017. Sharp requirements come into force in 2020.	-	64 (4)
United Kingdom (England)	Yes	Under development	Building Regulations Energy Efficiency Requirements: England (Part L); Wales (Part L); Scotland (Section 6); Northern Ireland (Technical Booklet F)	01.01.2018 (from 2016 for residential buildings)	01.01.2019 (from 2016 for residential buildings)	The United Kingdom Government consider that the approach they are adopting for Zero Carbon Homes from 2016 will meet the definition of NZEB.	In the United Kingdom, building regulations, first introduced in the 1960's, are being progressively tightened as it moves towards the introduction of the Zero Carbon Homes Standard.	99 (4)

2. Indicators

2.1. Approach of the quantitative indicator development

Although the different variables for creating the final grid of quantitative indicators was quite clear from the beginning, some details still needed to be elaborated and discussed in more detail. Such details especially comprise the exact definition of energy and non-energy renovations but also the different renovation depths to be considered and how to deal with the different definitions of nearly zero-energy buildings in the EU28 Member States or in MS where no definition has been implemented yet. For these aspects, the project team conducted an extensive analysis of existing definitions and their suitability to be adapted for this project. Part of this analysis was an evaluation of existing variables used in the "Building Stock Observatory" (BSO) project. The characteristics of covered quantitative indicators can be found in the data annex.

After having achieved clarity on the needed indicators and their definitions, the next task was to identify potential sources to be able to fill the indicators with content. For this purpose, the following approach was used:

1) Development of a methodology to create the information needed for filling the indicators with content (a detailed description of this methodology is presented in section 3).

2) Identification of relevant information that is available from publicly accessible literature, other projects (such as the BSO) and other potential sources.

3) Identification of relevant information that is available from sources that are not free of charge.

4) As a result, identification of data gaps that remain and therefore need to be filled with data from the surveys (new primary data).

This approach allowed to identify all relevant sources to be used later in the project to fill the indicators with content.

The full list of covered quantitative indicators can be found in the data Annex provided as separate Excel file.

2.2. Approach of the qualitative indicator development

The general approach of the qualitative indicator development is as follows.

<u>In a first step</u>, an extensive desk research has been conducted to get an up-to-date status of the discussion and theory about relevant drivers and barriers and to create a first inventory of relevant drivers and barriers and other determinants. For this study, the decision model based on Stieß et al. [Stieß et al., 2010] and the behavioural model based on Hermelink [Hermelink, 1996] have been used. Further studies have been consulted to enlarge the theoretical background and to identify a broad range of possible qualitative indicators which are suited for the analysis. These inputs have been synthesised and categorised to feed into the further development of the qualitative indicators.

<u>In a second step,</u> the scope of the current study (for the assessment of current drivers and barriers for energy renovation) has been identified. The current study covers various building types, clients and owners, landlords and tenants. This step is key to

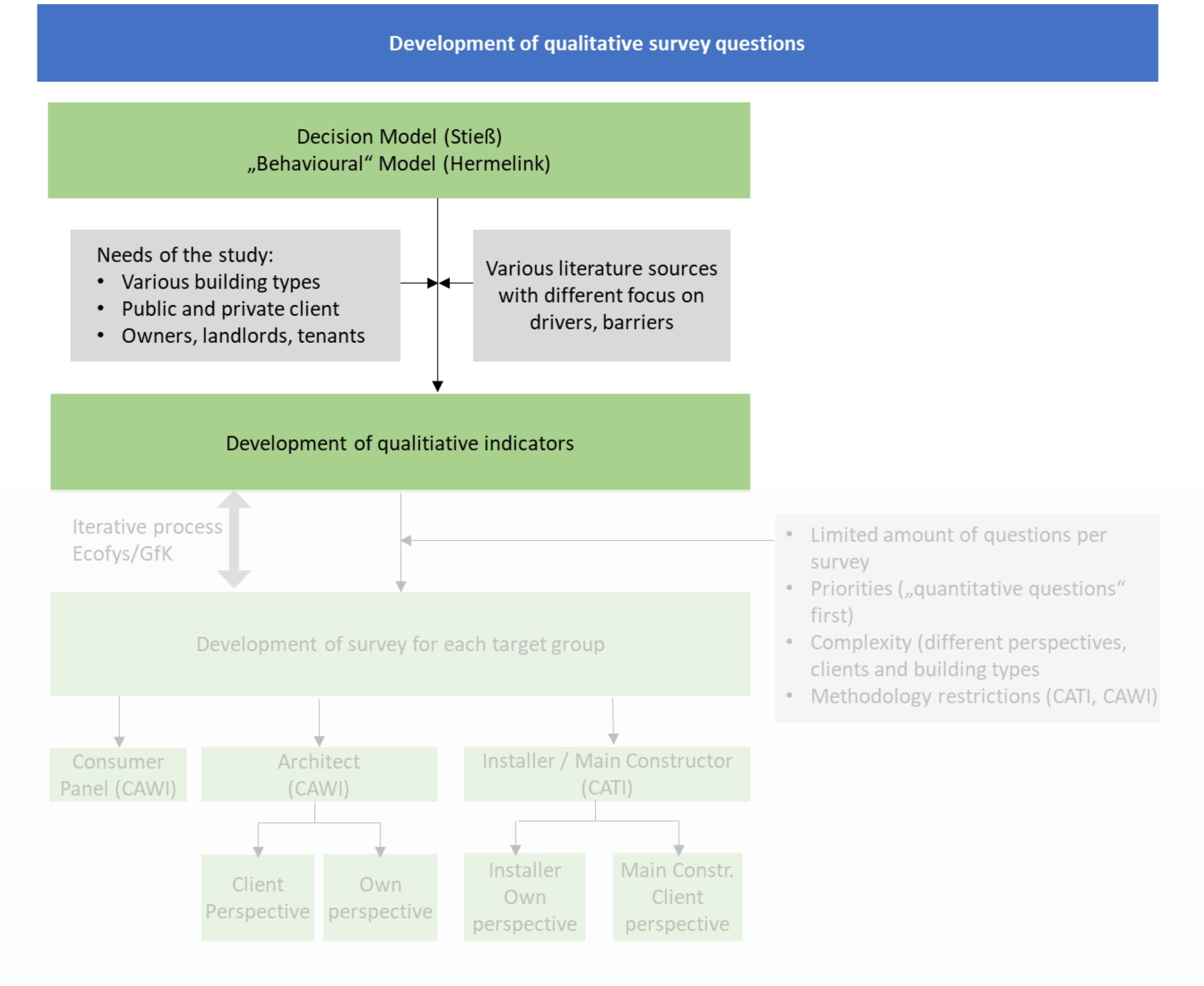
facilitate filtering and the adaptation of drivers and barriers to finally arrive at a tailor-made (if needed) set of qualitative indicators for different stakeholders and building types.

In a third step, the qualitative indicators have been elaborated.

In a fourth step, the different survey questions and the logic of each of the different questionnaires have been elaborated. The third and fourth steps have been an interactive process in which Ipsos and Navigant worked closely together.

The process is visu alised in the following graphic (Figure 1).

Figure 1: Illustration of the qualitative indicator development approach



A further explanation of the illustrated steps is given in the subsequent sections.

2.3. Theoretical background for the development of the qualitative indicators

This section summarises the theoretical background which has been set up to evaluate the drivers and barriers for energy renovation.

Several studies show that investment decisions regarding renovations is a complex strategic situation which is not only taken based on economic considerations. For this study the following literature has been used to investigate the determinants for energetic renovations:

JRC Science and policy reports (2014): Financing building energy renovations. Current experiences & ways forward. [JRC, 2014]

D'Agostino, Delia; Cuniberti, Barbara; Bertoldi, Paolo (2017): Data on European non-residential buildings. [D'Agostino et al., 2017]

Pillen, Nicole; Bertoldi, Paolo; Grether, Stefanie (2007): GreenBuilding - Europe wide renovations of non-residential buildings. DENA; JRC (ECEEE SUMMER STUDY). [Pillen et al., 2007]

GBPN (2014): Reducing energy demand in existing buildings: learning from the best practice renovation policies. Technical report. [GBPN, 2014]

Interreg Europe (2017): Improving energy efficiency in buildings. A policy brief from the Policy Learning Platform on low-carbon economy. [Interreg Europe, 2017]

Artola, Irati; Rademaekers, Koen; Williams, Rob; Yearwood, Jessica (2016): Boosting Building Renovation: What Potential and Value for Europe? [Artola et al., 2016]

Hermelink, Andreas (1996): Kosten-Nutzen-Analysen von DSM-Programmen im Sektor der privaten Haushalte unter besonderer Berücksichtigung des Anwenderverhaltens. Ergebnisse aus der Evaluierung des EU-PHARE-Fernwärmepilotprojektes in Eger (Ungarn). [Hermelink, 1996]

Krémer, Zsolt; Liebernickel, Thomas; Ebert, Volkmar; Moosreiner, Stefan (2005): Abbau von Hemmnissen bei der energetischen Sanierung des Gebäudebestandes. [Krémer et al., 2005]

Stieß, Immanuel; van der Land, Victoria; Birzle-Harder; Babara; Deffner, Jutta (2010): Handlungsmotive, -hemmnisse und Zielgruppen für eine energetische Gebäudesanierung. Ergebnisse einer standardisierten Befragung von Eigenheimsanierern. [Stieß et al., 2010]

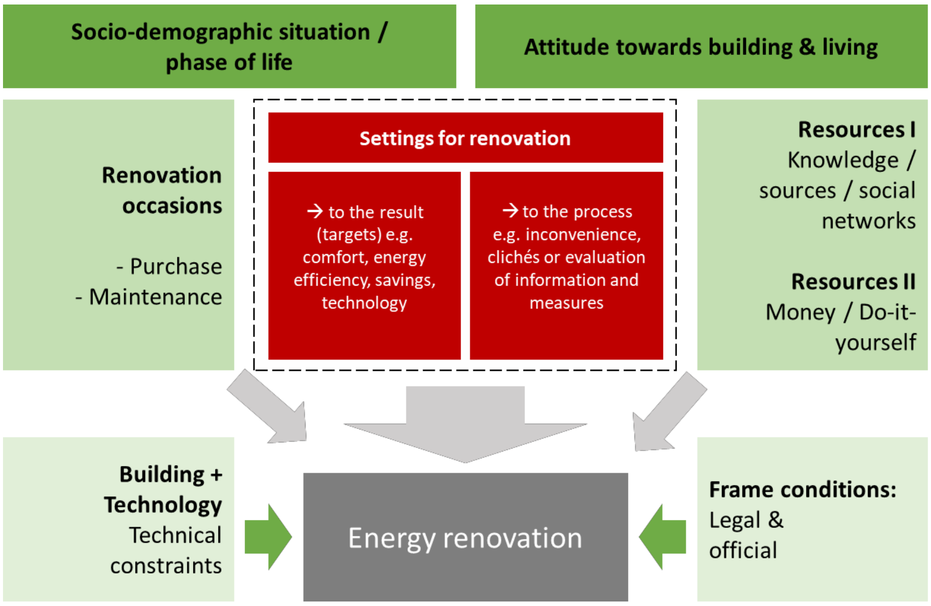
Maby, Catrin; Owen, Alice (2015): Installer Power - The key to unlocking low carbon retrofit in private housing. [Maby and Owen, 2015]

The studies focus on different topics, for example financial barriers and incentives, specific building types (e.g. residential building, non- residential buildings), building owners or landlords. Some studies analyse the whole range of policy instruments available.

The core of our theoretical framework for this analysis is based on two studies; the decision model from Stieß et al. [Stieß et al., 2010] and the "behavioural" model from Hermelink [Hermelink, 1996]. Stieß developed a decision model for energetic renovation and he focuses on residential buildings and building owners. Hermelink elaborated on the whole set of behavioural determinants for individual decisions about energy efficiency investments and (subsequent) energy efficient use of technology.

According to Stieß, the self-perception of the own situation and the resulting attitudes towards the process and the result of an energetic renovation are central for understanding these decisions. Stieß et a.l elaborate on the significance of the social situation as well as individual motivations for the renovation decision which is not solely based on objective economic criteria. Factors such as the socio-demographic situation and the respective phase of life as well as the attitudes toward building and living, which are closely linked with lifestyles, form the framework of the renovation decision. Limits are given by technical and structural constraints and the legal and regulatory framework. Triggers for (energy) renovation origin from an external impulse such as e.g. contact with an installer during maintenance, but also from circumstances such as the purchase of a building. Not only economic resources have an impact on the decision about (energy) renovation but also (access to) knowledge and sufficient information about energy recovery options and own capabilities [Stieß et al., 2010]. The described decision model is illustrated in Figure 2.

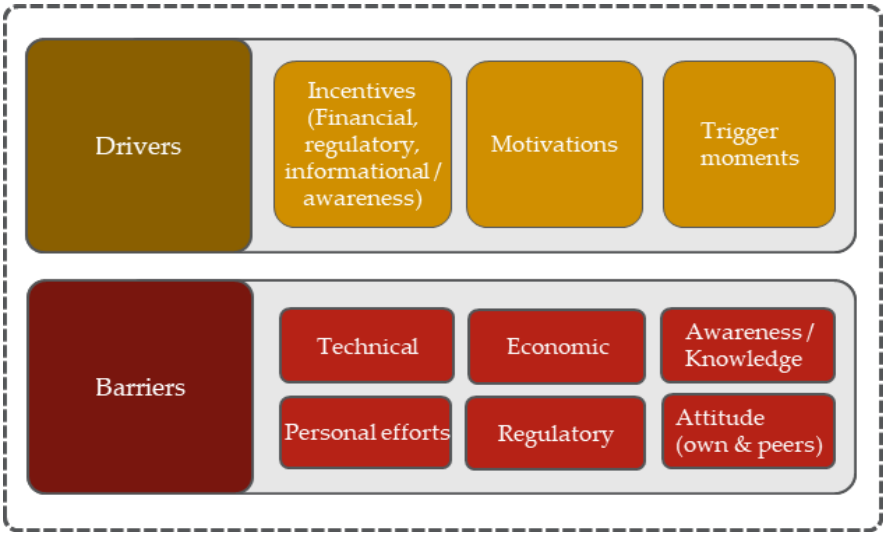
Figure 2: Decision model for energetic renovation (Source: Navigant adaptation from [Stieß et al., 2010])



Hermelink [Hermelink, 1996] explicitly builds his theory on the well-known Fishbein & Ajzen psychological theory of planned behaviour. According to this theory, behaviour is a function of "personal" variables (e.g. demographic variables (age, sex), psychological variables (attitudes, norms), skills …) and "ambient" variables (e.g. social environment (peer groups, regulations, prices …) and physical environment (the building, building systems, climate …). While Stieß provides a rather practical approach – yet focusing only on owners of single-family homes – Hermelink provides a broader theoretical framework that helped to transfer Stieß' insights to different combinations of stakeholders (architects, installers, owners, tenants) and building types as needed in this project.

The decision model based on Stieß et al. [Stieß et al., 2010] and Hermelink [Hermelink, 1996] was adapted considering the different studies mentioned above and was synthesised into a more flexible universal model. This model distinguishes drivers by incentives (financial, regulatory and informative), triggers and motivations. Furthermore, it distinguishes barriers by technical, economic, regulatory and informative barriers and also by attitude (own & peers) and personal efforts (which in the literature is also called transaction costs [JRC, 2014]). The approach is illustrated in Figure 3.

Figure 3: Applied categorisation of qualitative indicators ("drivers and barriers")



In addition to the above-mentioned drivers and barriers, the study analysed more aspects related to the process of energy renovation investments that do not directly belong to drivers and barriers but provide additional information about the context of the investment decision or the implementation of the measure: the involvement of stakeholders, the quality assurance and the funding of renovation projects. Apart from that, at a later stage some of these indicators were specifically dedicated to "very high energy performance" buildings (NZEB).

A major outcome of the models of Stieß et al. [Stieß et al., 2010] and Hermelink [Hermelink, 1996] is that questions about drivers and barriers should be asked as specifically as possible about energy renovation measures the respondent was involved in, rather than e.g. about general believes about environmental protection without concrete relation to energy renovation measures.

2.4. Needs of the current study related to qualitative indicators

While having the general assessment framework for barriers and drivers, it is important to understand that it had to be applied to various configurations of stakeholders and building types.

This project covers the energy renovation

- of the whole building stock (i.e. all building types covered within EPBD Annex I)
- including different stakeholders who take decisions or influence decisions (owners, tenants, architects, installers, public investors, corporate investors)
- collecting information according to the contract from surveys with consumers (household panel: owners and tenants), architects, installers and main contractors.

It can be assumed that depending on the building type – investor type combination, different divers and barriers will be relevant. Based on the desk research, an adequate selection of indicators from the inventory of drivers and barriers was performed that a) reflected the variety of building-investor combinations as good as possible, while b) keeping the differences between the different surveys and building-investor combinations as small as possible to be able to compare results also between different groups.

2.5. Development of qualitative indicators

Drivers

Drivers refer to incentives, triggers and motivations. From a more classical social science perspective, we identified indicators that allow us to map potentially relevant qualitative aspects. This basically follows the theory of planned behaviour (Fishbein/Ajzen) in its elements. This theory derives the intention to do something (e.g. to invest in new windows) from a person's attitude versus this specific action and the person's perceived social norm and the readiness to act according to that norm.

Motivations

Regarding the analysis of motivations, several aspects were included such as environmental or economic motivations, e.g. the increase of profit and reputation or the contribution to the protection from global warming and of the local environmental by energy renovation measures. Also, the long list of potential aspects for each target group were adapted or filtered. For instance, the set of an architects' major motivations to recommend energy renovation will most probably differ from a landlord's major motivations to invest in energy renovation. Motivations were split into major categories which were based on the literature (economic, personal (attitudes) and environmental and these key motivations were split up into various sub-aspects along the lines of Maslow's well-known hierarchy of motivations (economic, self-realisation & prestige, social/security/psychological desires), environmental, comfort & health benefits, knowledge about renovation works, and ability to do things (do it yourself).

Triggers

Triggers for (energy) renovation may origin from various events, e.g. the urgent repair of a defective component (boiler in winter), but also the change of a tenant or a recent purchase of a building. Different kinds of potential trigger moments for energy renovation were investigated such as repair, purchase of a building, but also the effect of different policies on renovation rate and depth. The study set up indicators for evaluating the role of European policies articles of the EPBD, the EED, the Eco-Design and the Energy Labelling Directives.

Incentives

Incentives are kind of a counterpart to the motivations and barriers as incentives mainly have two objectives: Foster favourable motivations or weaken unfavourable motivations, respectively, to enable overcoming barriers. The study distinguishes incentives by financial, regulatory and informational respective awareness incentives, i.e. the categories policy instruments are usually split into. As a follow-up to the questions on barriers, incentives to overcome these barriers were selected in a way that logically corresponded to the previous selection of barriers that were presented to the respondent.

Within the set of triggers and incentives to overcome barriers, a few very specific items were included which directly result from selecting the most prominent energy renovation related requirements from those EU Directives potentially having an impact on energy renovation:

Energy Performance of Buildings Directive:
- Did a national legal requirement for energy efficiency improvements (e.g. in case of major renovation) trigger energy renovation?

- Did (bad) rating on building energy performance certificate / desire to achieve better rating trigger energy renovation?

- Did recommendations on building energy performance certificate help overcome uncertainty about which energy renovation measures to take?

Energy Labelling Directive:

- Did (bad) rating on energy label of a component trigger energy renovation?

Energy Efficiency Directive:

- Did information (about high energy cost) on energy bill trigger energy renovation?

Barriers

In contrast to aspects that motivate or drive people to perform energy renovation, barriers address the various aspects that may hinder implementation of energy renovation. Like drivers, barriers may have their origin in "personal" (negative) determinants or "ambient" (negative) determinants. Consequently, technical, economic and regulatory barriers were investigated as well as (lack of) awareness or knowledge, (critical) attitudes or perceived norms (own & peers) and personal effort related to energy renovation, such as e.g. noise or dirt during renovation, administrative difficulties, etc.

Process related aspects and involved stakeholders

To complete the picture on drivers and barriers, several facts related to the concrete energy renovation measure that results from the individual context of the respondent were included in the set of indicators (where appropriate). Relative to installers, more specific questions on their drivers and relevance of energy renovation were included. They were identified as major influences for investors' decisions during desk research [Maby and Owen, 2015].

Sources of funding: Own capital, Loan (market condition), Loan with a below-market interest rate (soft loan), Loan from friends & family, Grant

Main involved stakeholders

- for implementation: Professional installers, "do it yourself" - with family and/or friends

- for quality assurance: respondent, architect, main contractor (offers all installer services incl. planning services from architects and civil engineers, family member or friend, installer, other

Prominence of energy renovation: Main activities architects/installers spend most time on, including consultancy on energy renovation, frequency of requests from clients for energy innovation

Reasons for recommendations (of certain products/measures by installers such as e.g. reliability of product, easiness of installation, familiarity with product).

The full list of covered qualitative indicators can be found in the data Annex provided as separate Excel file.

3. Methodology

3.1. Renovation rates

The following table presents a summary of the approach for calculating the energy and non-energy related renovation rates per EU MS for the residential and non-residential building sector (for the residential sector, steps are numbered as Rx and for the non-residential sector NRx to allow clear references). More detailed descriptions of the more complex steps are provided in separate sub-sections following the table.

Table 2: Summary of the approach for calculating renovation rates

	Residential sector	**Non-residential sector**
Overall energy related renovation rate	R1) Calculation of component-specific renovation rates based on sold market volume in existing residential buildings. R2) Calculation of component-specific renovation rates based on household panel surveys and socio-demographic scaling factors. R3) Calculation of the ratio of the sum of component-specific renovation rates according to household panel survey to overall energy-related renovation rate considering overlaps of measures in the surveys. R4) Due to non-representativeness of household panel surveys, application of ratio to sum of component-specific renovation rates based on sold market volume in existing buildings (step R3).	NR1) Calculate component-specific renovation rates using total sales volume in existing non-residential buildings. NR2) Due to very small samples in the architect surveys, application of ratio to sum of component-specific renovation rates based on sold market volume in existing residential buildings (step R3) to the result of NR1.

Split of overall energy related renovation rate into renovation depths	R5) Use floor area shares per renovation depth from surveys.	NR3) Calculation of total investments in the non-residential renovation market using total sales volume per technology/measure and investigated costs per unit (see chapter 3.3). NR4) Combining results from steps NR5 and NR2 allows the calculation of average specific energy related renovation casts per m² [€/m²]. NR5) For countries with a minimum sample size (non-residential renovation cases) of 30, calculate the average specific renovation costs per renovation depth and calculate the ratios to the costs of the same depth in the residential sector. Calculate the average of the country specific ratios and apply to all EU28 MS using the specific renovation depth costs as basis. NR6) Using a developed solver model provides realistic indications about how the different depths need to be weighted to result in the before calculated overall average specific renovation costs (R5). NR7) These weighting shares are used to split the before calculated overall renovation rate (NR2) into different depths.

Non-energy related renovation rate	R6) Calculation of the ratio of non-energy related renovation rates according to household panel survey to overall energy-related renovation rate considering overlaps of measures in the surveys. R7) Application of ratio to overall energy related renovation rate calculated according to R4.	NR8) The before calculated total renovation costs for energy related renovations (NR3) have been compared with non-residential renovation runover from Euroconstruct & EECFA to calculate the average share of energy related renovation costs on all renovation costs for those countries covered by Euroconstruct & EECFA. This average share has been applied to all EU MS with the aim to calculate the total investments for non-energy related renovations. NR9) From the architect surveys, it was possible to calculate the average ratio of non-energy related specific renovation costs to energy related specific renovation costs (from countries with sample size >30). This average ratio has been applied to the specific energy related renovation costs as calculated under NR4 to calculate the specific non-energy related renovation costs for each EU MS. NR10) Dividing the results of NR8 by the results of NR9 allow the calculation of non-energy related renovation rates.

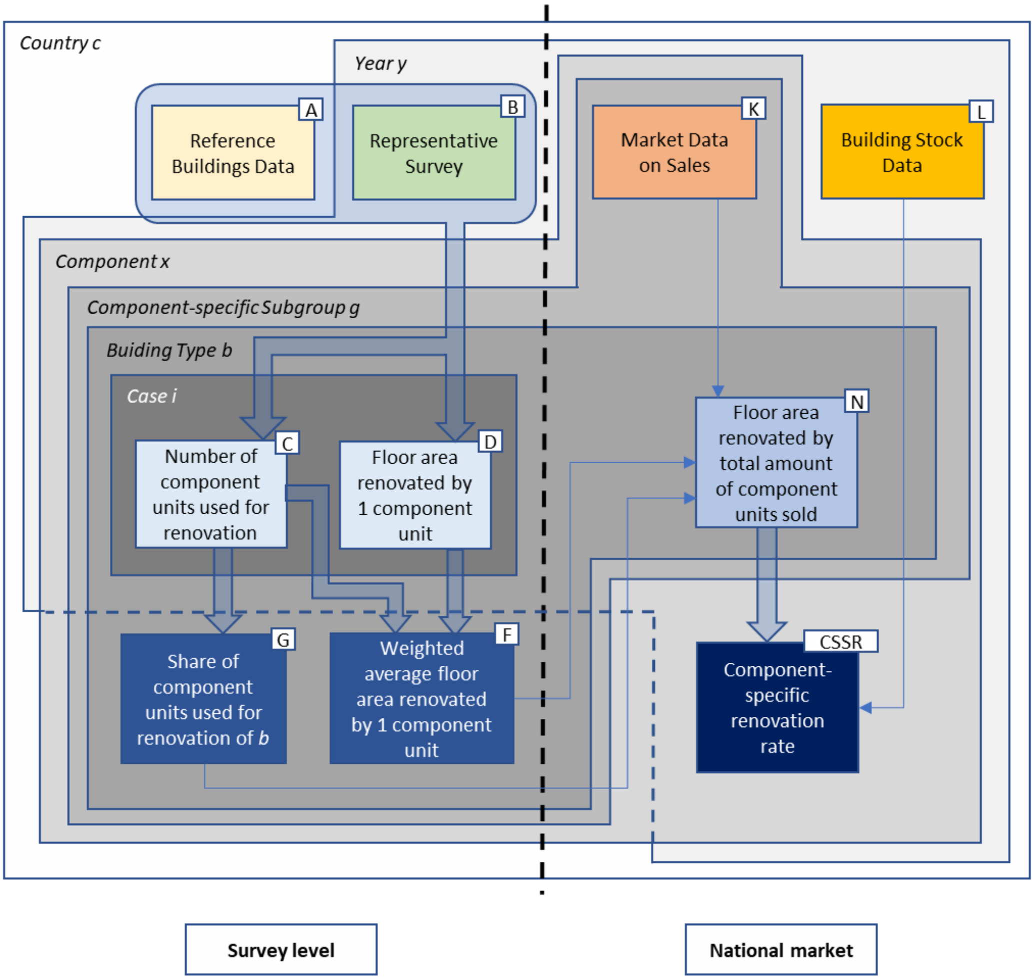
R1) Calculation of component-specific renovation rates based on sold market volume in existing residential buildings

The component-specific renovation rates (CSRR) have been calculated by combining a bottom-up with a top-down analysis. The basic idea of combining the two analysis methods is to link two independent data sources with each other in order to minimize biases that arise when only one data source is used. On the one hand, representative survey data is needed to calculate component specific indicators within a bottom-up analysis (e.g. average floor area renovated by one m^3 wall insulation). These indicators then need to be extrapolated to national level using market data on renovation activities (e.g. sold wall insulation volume). Depending on the level of detail of the linkage of both data sources, market data may need to be split by a top-down analysis. For example, if the resulting indicators of the survey are split into renovations in different building types, market data should be available for renovations in different building types as well. In order to do so, representative survey data on installed components in different building types can be used to split market data within a top-down analysis. As there is no literature on this approach, it was developed in the framework of this project.

The used model has been developed during the Master Thesis work of Johannes Becker and is based on a combination of multiple data sources and therefore multiple analysis methods. On the one hand, the representative survey conducted by Ipsos has been used to collect information on renovation activities. In combination with reference building specifications, a bottom-up analysis enabled the calculation of values that represent renovation activities in residential buildings, such as the average floor area renovated by one component unit of each component. On the other hand, these values are extrapolated to whole market level using national market data on sold component units. Since this data does not provide any information on the installation of components in households of different residential building types, the representativeness of the survey allows to split up market data using a top-down approach. Finally, the floor area renovated by the total number of sold component units is put into relation to residential building stock data in order to calculate the CSRRs.

A visualisation of the approach is presented in the figure below.

Figure 4: Main Calculation Processes and Overview of the Calculation Approach



Data Sources

The model is based on four main data sources, which need to be linked to each other for generating CSRRs:

- Representative survey on renovation activities in the residential building stock (conducted by Ipsos within the course of the project)
- Reference building data for the usage of specific building characteristics [TABULA / EPISCOPE see section 1.2]
- Market data on sales for the extrapolation of survey data to country level
    - Windows: Interconnection Consulting, Windows in Europe
    - Façade: Interconnection Consulting, Thermal insulation market study
    - Roof: Interconnection Consulting, Thermal insulation market study
    - Ground Plate : Interconnection Consulting, Thermal insulation market study

- Basement & Attics : Interconnection Consulting, Thermal insulation market study
- Space heaters: BRG Building Solutions, European HVAC market study
- Water heaters: BRG Building Solutions, European HVAC market study
- Radiators : BRG Building Solutions, European HVAC market study
- Mechanical ventilation systems: BRG Building Solutions, European HVAC market study
- Space cooling systems: „Review of Regulation 206/2012 and 626/2011 Air conditioners and comfort fans", task 2 report prepared by Viegand Maagøe and ARMINES
- Photovoltaics: Solar Power Europe`s annual "Global Market Outlooks for Solar Power"
- Lighting: Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'), task 2 report prepared by VITO in cooperation with VHK

▪ Building stock data for the comparison with the total floor area (see 4)

R2, R3 and R6 – Extracting information from household panel surveys

General observations

⇨ Altogether there are 30,118 data records (or HH = households)

⇨ Energy/non-energy renovation:

- 1,426 energy renovations only
- 16,876 energy and non-energy renovations => i.e. altogether 18,302 HH did some energy renovation between 2012-2016
- 5,962 non-energy renovations only => i.e. altogether 22,838 HH did some non-energy renovation
- 5,854 did not do anything => i.e. altogether 11,816 HH were screened out

Calculation of energy renovation rate

The sub-sample that did energy renovation is divided into two main groups based on the variable "Tenure_status"

A. People who occupy the building/apartment they report about: (3,164 + 13,536) / 18,302 = 91.25% of households in the sub-sample

B. People who rent out the building they report about. (1,602 / 18,302) = 8.75% of households in the sub-sample.

Based on a conducted analysis, only group A has been used for the calculations of energy renovation rates, as this group deemed to be representative for the renovation activities in the total population of households.

Upscaling of results from group "A" to total population

The standard approach to upscale the number of households (HH) in the sample to the total number of households in a country was as follows:

a. the shares of different household types in the sample deviate from the known distribution of household types in the total population

b. For each type of household it had to be assessed which number of households in the total population can be assigned to 1 household in the sample. Below an example for Germany:

c. For 2017, EU statistics provide a number of 40,722,600 households in Germany.

d. The total sample size for Germany was 2141 households.

e. Example for type SD = 2 (single adult without children). In the sample, this type is under-represented. The formula for calculating the "weighting factor" is: target % / reached % * total number of HH in Germany / number of German HH in sample, i.e. 41.2% / 28.0 % * 40,722,600 HH / 2,141 HH = 28,009.53 HH in total population per HH in sample.

Using this approach individual weighting factors have been calculated for all 6 different household groups in all 28 EU countries in the sample.

As only group A has been taken for doing this exercise another set of weighting factors had to be calculated after procedure that was just explained. For this purpose, factors from previous step need to be multiplied with a

- New variable A_B_factor = (A+B) / A

- Example for Germany (continuing above example):

  - 1,058 energy renovators in total, of which 113 landlords.

  - A_B_factor = 1,058 / (1,058 – 113) = 1.120;

  => all weighting factors as explained above have to be multiplied with this factor due to the virtually smaller size of the sample (2,141 * (1,058 – 113) / 1,058 = 1,912 (i.e. A_B_factor could also be calculated as 2,141 / 1,912).

It should be noted that respondents clearly struggled to properly remember when exactly between 2012-2016 individual measures had been implemented when being confronted with the complex matter of building energy renovations. Therefore validity of results would increase by applying a similar approach (panel survey) on an annual or bi-annual basis.

3.2. Energy savings

In recent years, Navigant developed and refined an in-house Building Energy Performance (BEP) Model based on ISO EN 13790, the relevant standard used in Europe for the calculation of heating and cooling energy demands of buildings. In several projects, the Navigant BEP Model provided realistic results based on a solid internationally applicable methodology. For the present project, the calculation core of the model has been updated to the new international standard ISO EN 52016:2017 "*Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads*". ISO 52016 has superseded ISO 13790:2008 in 2017 and also incorporates aspects from other standards related to the energy performance of buildings.

The whole model is developed with MS Excel and contains several modules (illustrated in Figure 5) to serve all required aspects of this assignment. The model calculates the energy demand for heating and cooling on an hourly basis, leading to 8760 single calculations using hourly climate data extracted from METEONORM, considering the precise building specifications such as geometry and orientation of surfaces and local climate following the complex algorithms provided in the standard.

The calculation of energy needs according to ISO EN 52016 is complemented by a calculation module for technical building systems (HVAC-Model) to allow for the calculation of final energy demands for space heating, space cooling, hot water generation and air ventilation. Using national primary energy factors, the model converts the final energy demand per energy carrier into primary energy. The used primary energy factors have been extracted from ISO 52000-1[7] and for the sake of comparability of results applied to all Member States. The factors are presented in the following table.

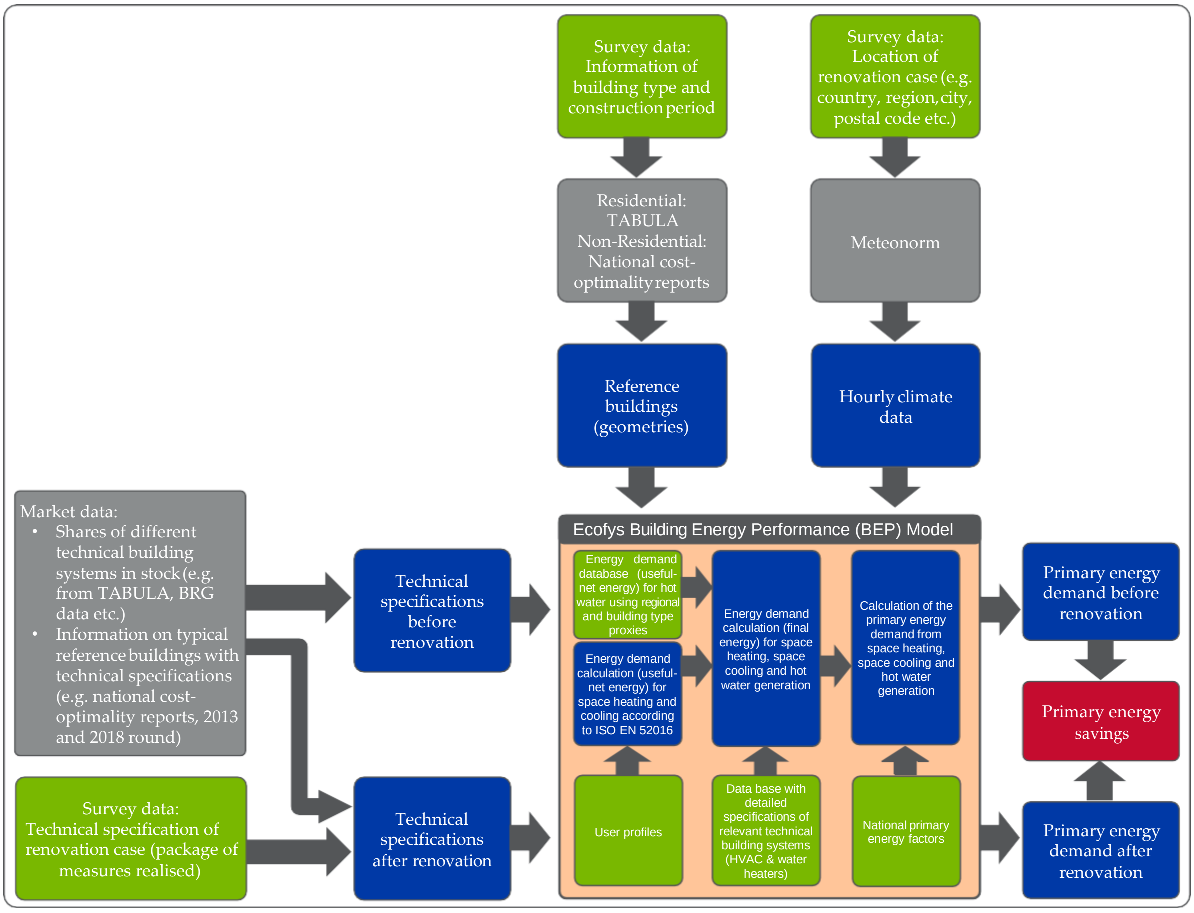
Table 3: Used primary energy and CO2e emission factors

	Electricity	Gas	Oil	Biomass	DH	Coal
Primary energy	2.3	1.1	1.1	0.2	1.3	1.1
CO2e	420	220	290	40	260	360

The entire overall approach of this task is illustrated in Figure 5 below, followed by a detailed description, including the specification of assumptions made.

7 Final Draft ISO/prFDIS 52000-1 - Energy performance of buildings — Overarching EPB assessment – Part 1: General framework and procedures - as forwarded for Formal Vote. Date of document: 2016-09-15

Figure 5: Approach for calculating energy savings



First, an additional Excel tool was used to extract the energy related data from the survey results. The relevant data for the energy savings calculation is which measures have been conducted and, if known, what types of new systems, insulations, windows, etc. were installed in the years 2012 to 2016. To consider the energy savings per year, each case of the consumer survey was evaluated in every year, hence five data sets per case were created. Additionally, a reference base is used to represent the building's condition before 2012, which leads to a total of six data sets per household.

This method not only allows to display the energy savings before and after the period under consideration but also the detailed development during these years. Therefore, the data set for each year is calculated individually, starting with the reference base. Subsequent years are calculated applying the renovation measures which have been conducted in the respective year. The impact of once implemented measures is continued in the following years. Since survey data is limited to systems and geometries renovated, the remaining components must be derived from the given information, hence default systems and reference geometries are used.

Data preparation

The survey delivers a classification of the building types and the construction time. This information is matched with the TABULA/EPISCOPE database which provides representative building geometries and U-values for each country. Therefore, the geometry of the reference buildings (before 2012) and U-values are taken from the TABULA/EPISCOPE database. If renovations were conducted, this part of the geometry is updated with the specific survey information, while the unrenovated components stay with the TABULA/EPISCOPE values. This allows the tool to consider only the measures recorded in the survey and calculate their energy savings impact. For residential buildings, the survey did not ask for specific U-values, but the types of windows or thickness of insulation installed. These qualitative answers were converted into typical specific numbers, whereas the non-residential survey directly provides the U-values for each renovated component.

Building geometries are used to calculate the useful energy demand. For this purpose, the team has used the reported climate locations that were used for the cost-optimality calculations of EU member states. In consequence, for the calculations of each country, the model used a country specific climate with different parameters for each of the 8760 hours per year. The data has been extracted from Meteonorm. Consequently, the heating, ventilation and air-conditioning systems (HVAC) are implemented as well to calculate the final energy demand. The Navigant Building Energy Performance (BEP) Model takes the energy needs following ISO 52016 standard and calculates the hourly energy use of all relevant heating, cooling and ventilation systems. The result is the final energy demand per energy carrier that is converted into primary energy demand using the primary energy factors as reported above. Depending on the calculated primary energy savings per renovation case and considering the definitions of renovation depths, each renovation case can directly be declared as "below threshold", "light", "medium" or "deep renovation".

3.3. Investment costs

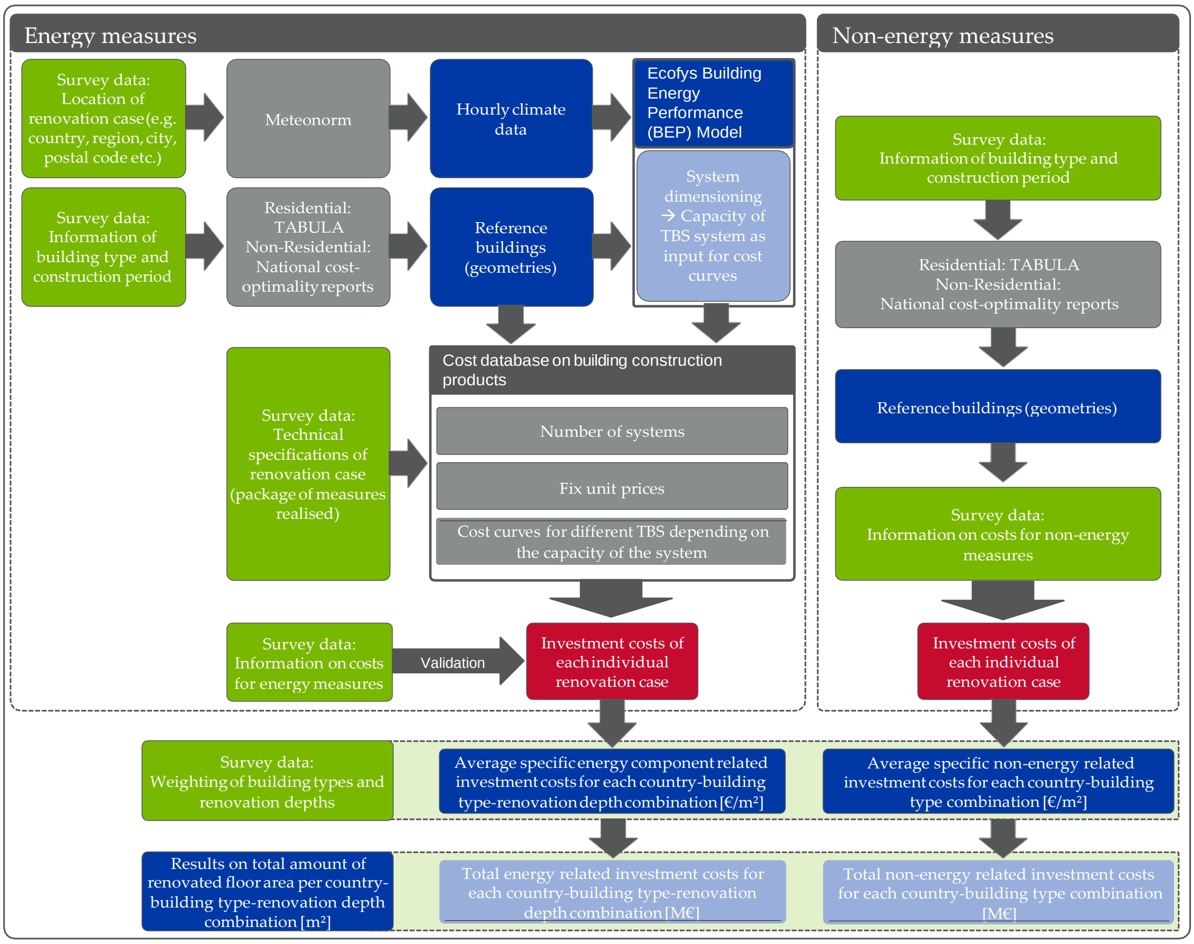
The approach for calculating the investment costs for each renovation case and later for calculating average investment costs for each combination of country, building type and renovation depth is based on two main sources:

1) Investment cost database for building construction products, and
2) Direct cost information obtained from the questionnaires.

For calculating the investments per renovation case, clear information on the renovation measures undertaken is required as well as information to determine the most appropriate reference building to be used for the calculations. For each installed technology, considering the building unit, number of components (e.g. 5 windows per building unit), etc the average investment costs are calculated.

The whole approach is illustrated in Figure 6.

Figure 6: Total approach for calculating investment costs



The following average product costs have been used for the analysis.

Table 4: Envelope measures

	Windows					Doors	Facade		Roof		Attic		Basement		Ground plate	Solar shading
	Single glazing	Double glazing	Double glazing with solar protection	Triple glazing	Triple glazing with solar protection	Average	Fixed costs	Variable costs	Fixed costs	Variable costs	Fixed costs	Variable costs	Fixed costs	Variable costs	Fixed costs	Average costs
	EUR/ m²	EUR/ m²	EUR/m²	EUR/ m²	EUR/m²	EUR/m²	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/m²
Austria	183	270	294	337	452	1,068	70	1.61	139	1.45	21	1.53	33	1.21	32.98	752
Belgium	212	305	332	376	503	966	63	1.46	126	1.31	19	1.38	30	1.09	29.83	680
Bulgaria	60	117	130	171	241	379	25	0.57	49	0.51	7	0.54	12	0.43	11.70	267
Croatia	88	154	171	214	297	445	29	0.67	58	0.60	9	0.64	14	0.50	13.75	313
Cyprus	117	155	202	243	295	616	40	0.93	80	0.83	12	0.88	19	0.70	19.01	433
Czech Republic	93	158	174	174	301	585	38	0.88	76	0.79	11	0.84	18	0.66	18.06	412
Denmark	217	313	341	385	515	1,380	90	2.08	180	1.87	27	1.98	43	1.56	42.63	972
Estonia	89	153	169	213	294	679	45	1.02	89	0.92	13	0.97	21	0.77	20.98	478
Finland	185	273	298	341	460	1,383	91	2.08	180	1.87	27	1.98	43	1.56	42.70	973
France	195	283	308	350	469	1,087	71	1.64	142	1.47	21	1.56	34	1.23	33.56	765
Germany	181	266	296	332	447	1,333	87	2.01	174	1.81	26	1.91	41	1.51	41.16	938
Greece	107	177	194	238	328	559	37	0.84	73	0.76	11	0.80	17	0.63	17.26	393
Hungary	78	143	158	202	282	488	32	0.73	64	0.66	10	0.70	15	0.55	15.06	343
Ireland	174	257	280	324	436	930	61	1.40	121	1.26	18	1.33	29	1.05	28.73	655
Italy	164	246	268	311	420	696	46	1.05	91	0.94	14	1.00	21	0.79	21.50	490
Latvia	72	133	148	191	268	608	40	0.92	79	0.82	12	0.87	19	0.69	18.79	428
Lithuania	71	133	148	191	267	585	38	0.88	76	0.79	11	0.84	18	0.66	18.06	412
Luxembourg	193	278	303	344	460	1,070	70	1.61	139	1.45	21	1.53	33	1.21	33.05	753
Malta	100	166	184	226	311	658	43	0.99	86	0.89	13	0.94	20	0.74	20.33	463
Netherlands	189	275	300	342	460	1,089	71	1.64	142	1.48	21	1.56	34	1.23	33.63	767
Poland	81	145	160	204	283	521	34	0.78	68	0.71	10	0.75	16	0.59	16.09	367
Portugal	99	167	184	228	315	507	33	0.76	66	0.69	10	0.73	16	0.57	15.65	357
Romania	68	130	144	188	264	357	23	0.54	47	0.48	7	0.51	11	0.40	11.04	252
Slovak Republic	83	146	161	204	284	580	38	0.87	76	0.79	11	0.83	18	0.66	17.91	408
Slovenia	109	178	196	239	327	530	35	0.80	69	0.72	10	0.76	16	0.60	16.38	373
Spain	137	211	231	273	370	675	44	1.02	88	0.91	13	0.97	21	0.76	20.84	475
Sweden	229	327	356	401	536	1,612	106	2.43	210	2.19	32	2.31	50	1.82	49.79	1,135
United Kingdom	140	217	237	280	380	919	60	1.38	120	1.25	18	1.31	28	1.04	28.37	647

Table 5: Technical building systems (1)

	Cooling systems						Photovoltaics			
	Centralised chiller (whole building, replacement)	Centralised chillers (whole building, new installation)	Centralised multi-split system (whole building)	Centralised multi-split system (for appartment)	Mounted single-split/window AC	Movable AC systems	0-10 kWp	10-15 kWp	15-20 kWp	>20 kWp
	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR
Austria	72,215	541,612	28,591	9,198	1,793	379	2,344	2,374	2,405	2,435
Belgium	73,244	716,299	29,892	9,529	1,754	398	2,362	2,408	2,454	2,501
Bulgaria	60,755	537,560	28,019	8,626	1,221	379	1,904	1,997	2,091	2,184
Croatia	75,472	590,056	35,000	10,759	1,502	474	2,362	2,481	2,601	2,720
Cyprus	61,971	535,040	26,831	8,407	1,372	360	1,972	2,037	2,103	2,168
Czech Republic	66,904	588,641	29,575	9,213	1,437	398	2,119	2,200	2,281	2,362
Denmark	91,027	902,989	35,777	11,536	2,279	474	2,959	2,993	3,027	3,061
Estonia	65,757	513,991	28,269	8,876	1,470	379	2,096	2,162	2,228	2,294
Finland	88,343	839,401	34,394	11,122	2,236	455	2,877	2,904	2,932	2,959
France	72,530	574,329	28,607	9,214	1,809	379	2,356	2,385	2,413	2,442
Germany	73,903	554,270	27,426	9,003	1,968	360	2,430	2,430	2,430	2,430
Greece	74,639	559,794	33,709	10,438	1,551	455	2,351	2,454	2,556	2,659
Hungary	92,866	696,497	37,806	11,625	1,628	512	2,555	2,684	2,812	2,940
Ireland	104,920	786,896	32,633	10,331	1,815	436	2,505	2,568	2,630	2,692
Italy	76,486	573,644	31,053	9,721	1,575	417	2,273	2,350	2,427	2,504
Latvia	76,558	574,185	29,595	9,232	1,457	398	2,134	2,213	2,291	2,370
Lithuania	78,485	588,641	29,575	9,213	1,437	398	2,119	2,200	2,281	2,362
Luxembourg	86,858	651,436	24,438	7,953	1,659	322	2,096	2,107	2,118	2,129
Malta	62,645	469,839	25,481	8,027	1,362	341	1,916	1,971	2,026	2,081
Netherlands	93,863	703,971	29,994	9,631	1,856	398	2,440	2,475	2,510	2,545
Poland	73,226	549,197	32,293	9,991	1,474	436	2,244	2,344	2,443	2,543
Portugal	84,189	631,417	32,281	9,979	1,463	436	2,235	2,336	2,437	2,538
Romania	67,376	505,318	26,616	8,193	1,158	360	1,807	1,896	1,985	2,074
Slovak Republic	90,427	678,203	28,186	8,793	1,388	379	2,032	2,108	2,183	2,258
Slovenia	80,171	601,279	30,915	9,583	1,437	417	2,167	2,259	2,352	2,444
Spain	85,386	640,393	29,650	9,287	1,512	398	2,176	2,249	2,322	2,394
Sweden	121,045	907,836	35,970	11,728	2,472	474	3,107	3,120	3,132	3,145
United Kingdom	67,086	503,148	28,467	9,074	1,669	379	2,248	2,293	2,337	2,381

Table 6: Technical building systems (2)

	Space heaters	Other heat emitters than radiators	Radiators	Ventilation		Domestic hot water systems		Lighting
	Average	Average	Average	Central	Local	Central	Decentral	Average
	EUR	EUR/m²	EUR	EUR/m²	EUR	EUR	EUR	EUR/m²
Austria	15,547	33	497	36	2,058	5,087	857	16
Belgium	9,424	30	349	33	1,191	2,692	12,045	14
Bulgaria	4,232	12	154	13	557	2,206	821	6
Croatia	3,839	14	125	15	1,350	1,537	192	7
Cyprus	4,393	19	202	21	254	1,206	146	9
Czech Republic	5,407	18	134	20	1,774	1,676	404	9
Denmark	13,547	43	749	46	5,083	6,927	1,777	21
Estonia	5,431	21	172	23	2,062	1,428	327	10
Finland	13,172	43	674	47	2,305	6,709	2,110	21
France	9,074	34	392	37	1,989	3,332	1,084	16
Germany	15,024	41	585	45	1,340	3,632	991	20
Greece	4,035	17	200	19	1,695	1,052	267	8
Hungary	5,687	15	101	16	1,480	1,356	12,071	7
Ireland	9,027	29	240	31	203	3,945	558	14
Italy	4,968	22	229	23	288	1,364	165	10
Latvia	4,802	19	171	20	1,846	1,317	297	9
Lithuania	4,460	18	161	20	1,774	1,300	303	9
Luxembourg	8,935	33	386	36	1,958	3,281	1,068	16
Malta	8,935	20	216	22	272	1,290	156	10
Netherlands	9,270	34	352	37	2,770	3,683	1,325	16
Poland	4,709	16	146	18	767	1,290	133	8
Portugal	4,836	16	233	17	1,537	1,393	356	8
Romania	3,688	11	89	12	1,085	913	205	5
Slovak Republic	4,607	18	120	20	1,760	1,482	292	9
Slovenia	4,308	16	217	18	1,609	985	180	8
Spain	5,289	21	137	23	291	1,525	287	10
Sweden	1,7582	50	765	54	3,401	6,425	4,435	24
United Kingdom	8,195	28	142	31	201	2,885	906	14

The investment cost calculation of renovation measures is based on following literature sources:

Renovation measure	Source
Windows	• VHK (2015): Final report, consolidated version of 22 June 2015. LOT 32 / Ecodesign of Window Products. TASK 7 – Policy Options & Scenarios
Doors	• IWU (2015): Kosten energierelevanter Bau- und Anlagenteile bei der energetischen Modernisierung von Altbauten
Insulation	• ifeu (2014): 100 % Wärme aus erneuerbaren Energien? Auf dem Weg zum Niedrigstenergiehaus im Gebäudebestand.
Solar shading	• ift (2015): LOT 32 / Ecodesign of Window Products Task 2 – Market Analysis.
Cooling	• ARMINES (2018): Review of Regulation 206/2012 and 626/2011. Air conditioners and comfort fans Task 2 report. • BMVBS (2012): BMVBS-Online-Publikation, Nr. 08/2012: Ermittlung von spezifischen Kosten energiesparender Bauteil-, Beleuchtungs-, Heizungs- und Klimatechnikausführungen bei Nichtwohngebäuden für die Wirtschaftlichkeitsuntersuchungen zur EnEV 2012.
Heating and Domestic Hot Water Ventilation	• VHK (2019): Space and combination heaters. Review Study. Task 2 Market Analysis.
Lighting	• Navigant (2015): Energieaudit nach DIN EN 16274-2
Photovoltaics	• Schlitzberger (2018): Kurzgutachten zur Aktualisierung und Fortschreibung der vorliegenden Wirtschaftlichkeitsuntersuchung sowie zu Flexibilisierungsoptionen.

In the case of insufficient data on country-specific investment costs, existing data sources were used to close data gaps with the help of Eurostat country specific price level indices. The respective price levels and VAT differences in the EU28 member states were considered. The investment cost calculations are also inflation-adjusted and show end-user costs including VAT and installation costs.

3.4. Uptake of nearly-zero energy buildings

The uptake of nearly-zero energy buildings (NZEB) has been calculated by using mainly three sources:

a) "The architectural professions in Europe 2018. A Sector Study" by the Architect's Council of Europe (ACE) (in the following we are referring to the dataset as "ACE dataset"): The study gives a comprehensive overview of the architecture sector and its practitioners, as well as activities referring to the overall construction sector. It collects and presents statistical data on the market by surveying architects in in various European Countries; overall in 2016 more than 27.000 architects from 27 countries participated and completed the questionnaires. The study has been conducted in two-years intervals.

For our analysis, ACE studies from 2012, 2014 and 2016 has been used to examine the role of nearly-zero energy buildings in the EU and its member states. Among others, the study reveals on country level

- how often architects are being asked to build to nearly-zero energy standards,
- the proportion of work undertaken by building type, i.e. for new and refurbishment projects, and
- the proportion of work undertaken by building sector, i.e. differentiated by residential and non-residential building types.

The results offer valuable input for the analysis and hence the outcomes have been incorporated into the approach to quantify the uptake of nearly-zero energy buildings in the EU and its member states.

b) The architect survey which has been conducted in this assignment (in the following we are referring to the dataset as "survey dataset"): The survey conducted within this assignment represents another source of valuable input to identify the role of nearly-zero energy buildings. Among others, the data shows the share of nearly-zero energy buildings within each of the following groups for the years 2012 and 2016:

- new residential buildings
- new non-residential buildings
- renovated residential buildings
- renovated non-residential buildings

Another important source for the analysis was the statistics on new construction activities in the EU28 and its member states (in the following we are referring to the dataset as "survey dataset").

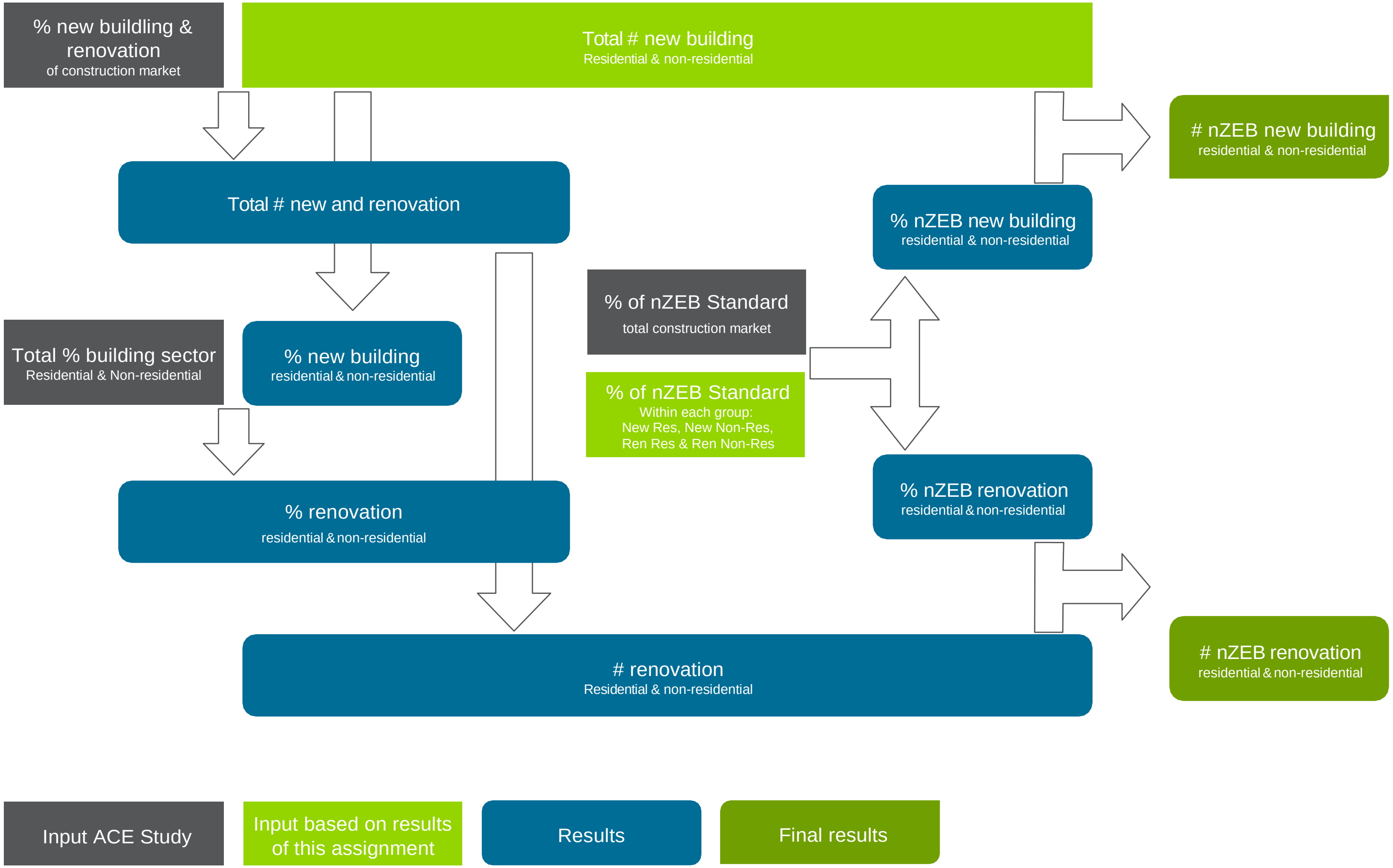
Based on the above-mentioned sources, following approach as has been developed and implemented; the approach has been illustrated in a flow chart (see Figure 7):

- The ACE dataset on "proportion of work undertaken by building type, i.e. for new and refurbishment projects" and the survey dataset "total number of new buildings differentiated by residential and non-residential" has been used to calculate the "total number of renovated and new buildings".
- The "total number of renovated and new buildings" and the survey dataset "total number of new buildings differentiated by residential and non-residential" has

been used to derive the "share of new residential and non-residential buildings of the total construction market".

- Based on the ACE dataset "proportion of work undertaken by building sector, i.e. differentiated by residential and non-residential building types" and the previously revealed "share of new residential and non-residential buildings of the total construction market" the difference has been calculated leaving the "share of renovated residential and non-residential of the total construction market" as result
- The calculated "share of renovated residential and non-residential of the total construction market" has then been multiplied with the calculated "total number of renovated and new buildings" resulting in the "total number of renovated buildings differentiated by residential and non-residential".
- In the next step, the ACE dataset on the "share of nearly-zero energy buildings on the total construction market" and the survey dataset on "share of nearly-zero energy buildings within each of the following groups: new residential buildings, new non-residential buildings, renovated residential buildings and renovated non-residential buildings" has been used to calculate the (i) "share of nearly-zero energy buildings for new residential and non-residential buildings" and the (ii) "share of nearly-zero energy buildings for renovated residential and non-residential building"
- Finally, the "share of nearly-zero energy buildings for new residential and non-residential buildings" respectively the "share of nearly-zero energy buildings for renovated residential and non-residential building" has been multiplied with the "total number of new buildings differentiated by residential and non-residential" respectively "total number of renovated buildings differentiated by residential and non-residential" resulting in the "total number of new buildings in NZEB standard" and "total number of renovated buildings in NZEB standard"

Figure 7 : Flowchart of the approach to calculate number of new and renovated buildings in nearly zero energy standard



The following assumptions have been made:

- Since ACE input data are only available for 2012, 2014 and 2016, interpolations have been conducted to identify an appropriate starting point for the analysis for 2013 and 2015.
- The ACE study 2012 does not provide information in same granularity as in the following years for the dataset "how often architects are being asked to build to nearly-zero energy building". Therefore, deviations between the available data for 2012 and 2014 has been calculated and applied to estimate the "share of nearly-zero energy buildings on the total construction market".
- The ACE study 2012 does not provide information on "proportion of work undertaken by building type, i.e. for new and refurbishment projects". After comparing the share of new and refurbished buildings of the year 2014, 2016 and 2018, it can be stated that the numbers are in a comparable range. Based on this finding we estimated the "proportion of work undertaken by building type, i.e. for new and refurbishment projects" by calculating averages based on the years 2014, 2016 and 2018.
- Since the 2016 ACE dataset on "how often architects are being asked to build to nearly-zero energy building" does not contain information for the Germany, interpolations based on available number for 2014 and 2018 has been conducted.
- The survey dataset "share of nearly-zero energy buildings within each of the following groups: new residential buildings, new non-residential buildings, renovated residential buildings and renovated non-residential buildings" showed gaps in few categories and countries. These gaps have been filled by using EU averages for further calculations. The following countries per category are affected:
  - New Residential: Estonia, Slovakia and Finland
  - New Non-Residential: Luxembourg, Slovakia and Malta
  - Renovation Residential: Denmark, Slovakia and Finland
  - Renovation Non-Residential: Cyprus, Slovakia and Ireland
  - In the ACE publications 2012 to 2016, few countries were not included, which resulted in missing data regarding the dataset "how often architects are being asked to build to nearly-zero energy building". For these countries averages have been built based on geographical proximity and considering economical comparability. The following table provides an overview of missing countries in each publication.

Table 7: Overview of countries which are not covered in the ACE publication

Country	ACE publication 2012	ACE publication 2014	ACE publication 2016
Cyprus	x	x	
Estonia	x		
Greece			x
Hungary		x	x
Lithuania	x	x	
Latvia	x		x
Netherlands	x		

Poland	x	x	
Slovakia	x		

3.5. Survey methodology

Three different surveys were conducted to generate primary data on energy renovation activities and NZEB, covering both residential and non-residential buildings both on EU28 and on country level:

- Consumer survey
- Architect survey
- Construction companies survey: main contractors and installers

This section describes the key aspects in the design and the fieldwork of the three survey questionnaires. The table below illustrates the coverage, sample size and complementary objectives of the three surveys. The large-scale online consumer survey covering each Member State of the EU28 gathered project-relevant data related to residential buildings. The two B2B surveys among relevant stakeholders also cover the EU28 but are more limited in terms of scale. The architect survey focuses on the demand side both for residential and non-residential buildings (e.g. offices, schools, hospitals, etc.), while a second B2B survey is tailored towards the supply side targeting both construction companies (main contractors) and suppliers (installers) of construction materials.

Table 8: Overview of the surveys

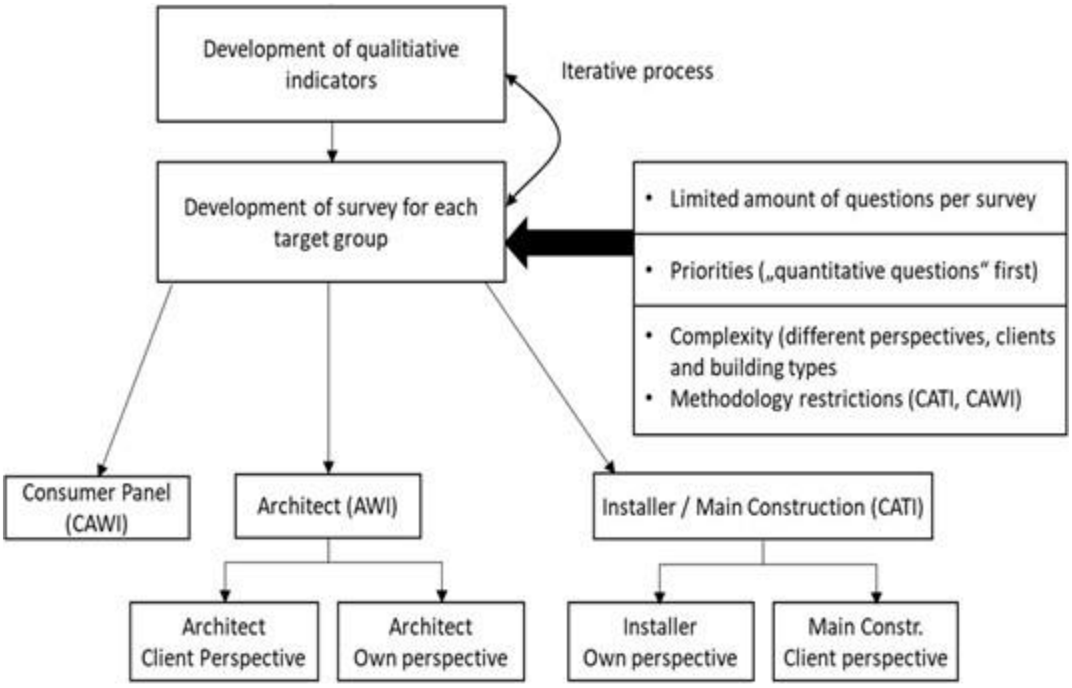
	Consumer survey	Architects survey	Survey of construction companies (main contractors) and suppliers (installers) of construction materials
Coverage		EU28	
Method	CAWI	CAWI	CATI
Target sample size	N =1 6,800	N = 5,000 (best effort, relying on cooperation of ACE's member organizations)	N = 1,990
Achieved sample size	N = 30,118 (all) N = 18,302 (energy renovations)	N = 1,581	N = 2,009
Sampling	A representative sample of national population 18+	Convenience sample	Sample based on Dun & Bradstreet (D&B) company database
Target respondents	Consumers with renovation experience	The European Architects Council's (ACE) member organizations	Construction companies involved in renovation activities + suppliers of construction materials
Objective	Collect data on renovation	Collect data on the demand side both for	Collect data on the supply chain and quality of the

	of residential buildings	residential and non-residential buildings covering renovation and NZEB	works both for residential and non-residential buildings covering renovation and NZEB
Timing fieldwork	16 August – 28 September 2018	27 August 2018 – 15 March 2019	13 August – 6 November 2018

Development of the surveys

Ipsos and Navigant worked closely together in designing the questionnaires to translate the development of indicators into three different yet complementary survey questionnaires. Ipsos has extensive experience in developing the methodology for conducting large-scale multi-country surveys that target consumers, companies and/or other relevant stakeholders in a variety of sectors. Navigant provided the expertise in the project subject-matter as well as in the development of the methodology outlined in the previous sections. As a result, each of the three surveys was conducted based on a questionnaire that has been very specifically tailored to the target group and the data that needs to be obtained with only minimal overlap with the other questionnaires. Figure 8 below illustrates the close interaction.

Figure 8: Approach for survey development



Each questionnaire was developed starting with a discussion of the final methodology and creation of a general outline of the key topics to be covered. The relevant indicators described in the previous sections served as an initial basis for the questionnaire design approach. For each of the selected indicators, the concrete data points identified as those feasible to be gathered via a consumer and/or B2B survey were discussed and defined in detail. In doing so, Ipsos and Navigant carefully considered previous projects and conducted desk research to estimate which data points would fit each target group. At this stage, any potential data collection issues that emerged, e.g. data points which were likely to be difficult for target respondents to recall without aid, data points which target respondents would not feel at ease sharing, etc., was flagged and tackled a priori when designing the survey questions by adjusting the approach as needed.

The final list of data points served as the basic input for the questions' design and as the general structure of the three draft questionnaires. The questionnaires are intended to provide the main methodological instrument for data collection from both the consumer and business stakeholder perspectives within the project.

Consumer survey

The objective of the consumer survey was to collect data that feeds into indicators describing the state of play for residential renovations. The consumer survey was conducted using a computer assisted web interview (CAWI) methodology in all 28 EU Member States. As internet penetration has progressed in all EU Member States, online surveys are seen as a robust way to conduct surveys among the general public. The main fieldwork launched on 16 August 2018 and continued without interruption until 28 September 2018.

Target group, sampling and weighting approach

The target group of the consumer survey is consumers with knowledge/experience with renovation, or energy renovators. Because of the specific nature of this target group, a slightly different approach to questionnaire design and data collection compared to a standard multi-country survey was needed. Concretely, a two-tier approach was used to identify the relevant target group.

The first tier (Part 1) of the survey served as a respondent "recruitment" or "screening" tool, identifying relevant consumers who have experience with energy renovations. As such, it measured the incidence of renovations in each EU Member State. The screener also covered household composition, region, type of renovation done and the overall costs of the renovations, which will allow clustering the results into market segments, based on these indicators.

Using a random sampling approach, a representative sample per country was invited to participate in the survey. All respondents had to fill in the first part of the questionnaire (screener) and were screened based on energy renovations.

The second tier (Part 2) of the survey focused only on consumers who have engaged in energy-related renovation during 2012-2016. This was the main instrument used to gather the relevant data needed for analysis which will segment renovation based on a pre-defined set of criteria (e.g. the depth of renovation, materials used, costs and benefits, drivers and motivation etc.). Only respondents who qualified to take part in this survey based on their answers to questions in Part 1 were allowed to answer Part 2.

Table 9 below summarises the number of interviews achieved per country and compares them with the number of completes including and excluding the screen-outs, as well as the resulting incidence rates. The table shows that a total of 18,302 respondents completed the questionnaire and that the targets have been achieved in all countries.

Table 9: Overview of the achieved sample of the Consumer Survey

Country	# total interviews (incl. screen-outs)	# completed interviews	Incidence rate	Target sample
Austria	974	560	57.5%	500
Belgium	969	560	57.8%	500
Bulgaria	743	621	83.6%	500

Croatia	521	360	69.1%	300
Cyprus	1267	211	16.7%	200
Czech Republic	721	540	74.9%	500
Denmark	1023	546	53.4%	500
Estonia	514	329	64.0%	300
Finland	1153	559	48.5%	500
France	1802	1051	58.3%	1000
Germany	2141	1058	49.4%	1000
Greece	762	564	74.0%	500
Hungary	677	509	75.2%	500
Ireland	562	351	62.5%	300
Italy	1598	1148	71.8%	1000
Latvia	491	348	70.9%	300
Lithuania	535	344	64.3%	300
Luxembourg	269	150	55.8%	100
Malta	268	212	79.1%	200
Netherlands	1899	1022	53.8%	1000
Poland	1319	1008	76.4%	1000
Portugal	1766	1020	57.8%	1000
Romania	1337	1161	86.8%	1000
Slovakia	686	540	78.7%	500
Slovenia	474	379	80.0%	300
Spain	1757	1100	62.6%	1000
Sweden	2236	1015	45.4%	1000
United Kingdom	1654	1036	62.6%	1000
Total	30,118	18,302	60.8%	16,800

The overall sample (Tier 1) was weighted to be representative on household composition. Due to the nature of the survey, household composition is a more relevant indicator compared to gender and age of the overall sample. As such, all Tier 1 respondents were weighted representative on household composition (see Table 10 below) and not age and gender as suggested in the tender. Concretely this means that in Tier 1 of the survey, the household composition of all Tier 1 respondents was measured rather than age and gender. The household composition of the survey respondents was then compared with the target based on Eurostat and a weighting factor was calculated to adjust the reached sample to be equal to this target. For example, in Austria, 3% of the population consists of single adults with children (the 'target'), while this was the case for 4.8% of the Austrian Tier 1 respondents (the 'unweighted sample'). A weighting factor is then applied to correct this imbalance and to 'downweight' this proportion from 4.8% of the sample to 3% of the sample (the 'weighted sample').

By adopting this weighting approach, the results illustrate the ratio of household compositions that have conducted energy renovations, which is more relevant compared to the renovation rate divided over age and gender (of course, general information on the age and gender of the respondents is available for the Tier 2 sample).

Table 10: Household composition: target sample vs. reached sample (unweighted) vs. reached sample (weighted)

	Single adult with children			Single adult without children			Couple with children			Couple without children			Other type of household with children			Other type of household without children		
	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)
Austria	3.0%	4.8%	3.0%	37.0%	22.5%	37.0%	17.6%	27.2%	17.6%	23.9%	32.0%	23.9%	5.3%	3.7%	5.3%	13.2%	9.8%	13.2%
Belgium	3.9%	10.7%	3.9%	32.0%	23.5%	32.0%	22.1%	34.8%	22.1%	25.6%	25.2%	25.6%	4.7%	1.8%	4.7%	11.7%	4.0%	11.7%
Bulgaria	2.6%	6.1%	2.6%	37.4%	11.4%	37.4%	14.5%	42.3%	14.5%	20.7%	18.2%	20.7%	7.6%	8.6%	7.6%	17.2%	13.5%	17.2%
Croatia	1.9%	7.1%	1.9%	23.3%	12.3%	23.3%	19.1%	43.6%	19.1%	17.8%	16.1%	17.8%	13.0%	10.4%	13.0%	24.9%	10.6%	24.9%
Cyprus	4.3%	3.6%	4.3%	23.5%	19.4%	23.5%	24.9%	53.7%	24.9%	21.9%	16.0%	21.9%	7.6%	4.5%	7.6%	17.9%	2.8%	17.9%
Czech Republic	4.6%	5.8%	4.6%	30.8%	14.6%	30.8%	22.3%	38.0%	22.3%	27.6%	27.3%	27.6%	4.1%	6.2%	4.1%	10.6%	8.0%	10.6%
Denmark	8.6%	9.7%	8.6%	44.4%	25.1%	44.4%	18.7%	30.1%	18.7%	24.1%	28.9%	24.1%	1.7%	2.2%	1.7%	2.4%	4.0%	2.4%
Estonia	6.6%	8.6%	6.6%	39.9%	19.6%	39.9%	20.3%	38.7%	20.3%	20.2%	23.9%	20.2%	3.9%	2.7%	3.9%	9.0%	6.4%	9.0%
Finland	1.8%	7.6%	1.8%	41.3%	29.8%	41.3%	18.2%	26.8%	18.2%	31.8%	28.9%	31.8%	1.9%	1.1%	1.9%	5.0%	5.7%	5.0%
France	6.0%	7.5%	6.0%	35.1%	26.4%	35.1%	21.2%	34.6%	21.2%	26.2%	27.5%	26.2%	3.8%	1.3%	3.8%	7.7%	2.6%	7.7%
Germany	3.6%	4.4%	3.6%	41.2%	28.0%	41.2%	15.7%	25.0%	15.7%	28.4%	33.9%	28.4%	2.9%	2.1%	2.9%	8.1%	6.7%	8.1%
Greece	2.3%	3.5%	2.3%	31.0%	25.2%	31.0%	21.9%	44.4%	21.9%	25.2%	16.0%	25.2%	4.0%	5.8%	4.0%	15.7%	5.1%	15.7%
Hungary	3.8%	8.9%	3.8%	32.5%	18.8%	32.5%	18.4%	28.7%	18.4%	23.0%	16.0%	23.0%	6.7%	10.9%	6.7%	15.6%	16.8%	15.6%
Ireland	6.3%	7.5%	6.3%	24.4%	18.0%	24.4%	27.3%	42.5%	27.3%	20.7%	23.0%	20.7%	6.7%	2.8%	6.7%	14.7%	6.2%	14.7%
Italy	2.8%	6.9%	2.8%	33.1%	19.7%	33.1%	20.9%	46.5%	20.9%	20.7%	19.0%	20.7%	5.9%	4.3%	5.9%	16.5%	3.6%	16.5%

Latvia	6.0%	9.0%	6.0%	35.4%	17.3%	35.4%	15.7%	42.0%	15.7%	18.4%	17.1%	18.4%	8.0%	6.7%	8.0%	16.5%	7.9%	16.5%
Lithuania	7.2%	4.3%	7.2%	42.5%	16.8%	42.5%	14.3%	37.9%	14.3%	16.6%	28.2%	16.6%	6.3%	3.6%	6.3%	13.1%	9.2%	13.1%
Luxembourg	3.7%	5.9%	3.7%	35.3%	14.1%	35.3%	23.7%	49.8%	23.7%	22.6%	22.3%	22.6%	5.6%	2.2%	5.6%	9.1%	5.6%	9.1%
Malta	3.1%	5.6%	3.1%	19.7%	10.4%	19.7%	21.6%	51.1%	21.6%	21.9%	22.8%	31.1%	9.7%	0.4%	0.5%	24.0%	9.7%	24.0%
Netherlands	4.2%	7.1%	4.2%	37.5%	14.6%	37.5%	20.9%	31.1%	20.9%	29.0%	29.3%	29.0%	2.8%	3.4%	2.8%	5.6%	14.5%	5.6%
Poland	3.6%	7.4%	3.6%	23.5%	12.7%	23.5%	24.3%	44.0%	24.3%	23.8%	23.7%	23.8%	9.5%	4.3%	9.5%	15.3%	7.9%	15.3%
Portugal	4.5%	9.6%	4.5%	22.1%	20.6%	22.1%	23.0%	43.4%	23.0%	23.9%	12.2%	23.9%	7.4%	7.6%	7.4%	19.1%	6.6%	19.1%
Romania	2.5%	6.3%	2.5%	27.9%	12.7%	27.9%	20.3%	46.1%	20.3%	20.5%	23.3%	20.5%	12.1%	5.2%	12.1%	16.8%	6.4%	16.8%
Slovakia	2.9%	5.5%	2.9%	22.5%	7.7%	22.5%	21.5%	43.3%	21.5%	22.0%	18.5%	22.0%	12.0%	10.8%	12.0%	19.1%	14.1%	19.1%
Slovenia	3.4%	11.6%	3.4%	32.8%	8.9%	32.8%	22.2%	33.5%	22.2%	21.5%	19.8%	21.5%	5.3%	8.0%	5.3%	14.8%	18.1%	14.8%
Spain	3.4%	5.5%	3.4%	25.6%	17.3%	25.6%	23.1%	47.9%	23.1%	21.8%	20.3%	21.8%	7.2%	4.7%	7.2%	19.0%	4.3%	19.0%
Sweden	6.4%	7.5%	6.4%	51.4%	28.5%	51.3%	18.9%	26.3%	18.9%	19.4%	29.1%	19.4%	1.6%	2.9%	1.6%	2.4%	5.6%	2.4%
United Kingdom	6.6%	11.7%	6.6%	31.1%	23.6%	31.1%	19.6%	30.7%	19.6%	27.0%	27.4%	27.0%	4.4%	2.1%	4.4%	11.3%	4.5%	11.3%

Using the two-tier approach, a screener identified the energy-renovators. The screener collects the most important information needed to select energy renovators and the ratio of energy renovation within a country.

To define consumers as energy renovators and non-(energy) renovators the correct way, question A5[8] was developed. From this question, we were able to identify energy renovators, the type of renovations done and the year the renovation was completed (2012-2016).

Respondents that have done any of the following energy renovations (option 1 – 16) between 2012 and 2016 are considered energy renovators. It needs to be noted, however, that new lighting installations (lamps) (option 16) were only counted as energy-related renovations when combined with other energy-renovations.

Table 11: Types of energy and non-energy renovations included in question A5

Energy renovations	Non-energy renovations
1. Replacement of windows	17. Facade renovation without applying insulation (e.g. just new plaster and/or painting)
2. Replacement of the/a building entrance door	18. Roof renovation without applying insulation (e.g. new wood construction, roof tiles or other roof sealing as e.g. bitumen)
3. Installation of thermal insulation on the facade (incl. cavity wall insulation)	19. Building extensions without applying insulation (e.g. extension of the living room or adding a new bedroom or transforming attic into living space)
4. Installation of thermal insulation of the roof	20. Electric installations (incl. replacement of switches and sockets)
5. Installation of thermal insulation on the ground plate (floors)	21. Interior wall painting and plastering
6. Installation of thermal insulation inside basements	22. Interior flooring (incl. baseboards)
7. Installation of thermal insulation on the attic's floor	23. Renovation of the bathroom or toilet
8. Replacement or first-time installation of a space heat generator	24. Renovation of the kitchen
9. Replacement or first-time installation of a water heater (incl. solar thermal collector on the roof)	25. Wallpapering
	26. Grinding & painting doors or window

8 In the timeframe 2012-2016, were one of the following renovations/installations completed for the residential building you rent out or your residence? Please consider all renovations done, including renovations/installations done by yourself, professionals, your landlord, etc. (You can tick multiple renovations).

Always tick the year, in which the renovation/installation was completed (2012 – 2016). Example; you started replacing your windows end of December 2013 and the renovation was completed in January 2014, please only tick 2014.

(The answer options are presented in the table above)

10. Replacement or first-time installation of a radiator 11. Replacement or first-time installation of a floor heating system 12. Replacement or first-time installation of a mechanical ventilation system 13. Replacement or first-time installation of a space cooling system (air-conditioner) 14. Installation of a photovoltaic system (solar modules for electricity generation on the roof) 15. (Automatic) shading system for windows to avoid overheating in summer 16. New lighting installations (lamps)	frames 27. Renovation of stairs 28. Dry-wall or ceiling constructions 29. Renovation or replacement of elevator
30. I built my house recently and don't need to do energy renovations	

The following table shows the proportion of the respondents in Tier 1 (weighted on household composition) that have performed energy renovations, non-energy renovations and no renovations in the period between 2012 and 2016.

The results in Table 12 show that that the incidence rate of energy renovations is relatively high (above 40%) in all countries, with the exception of Cyprus, where only 13.1% of the respondents performed energy renovations. Particularly high incidence rates are noticed in Romania (85.1%) and in Bulgaria (82.3%).

Table 12: Overview of the incidence for energy renovations, only non-energy renovations and no renovations

	ALL YEARS (2012 – 2016)		
Country	Energy Renovations (2012 - 2016)	Only non-energy Renovations (2012 - 2016)	No renovations (2012 - 2016)
Total	59.8%	19.1%	21.1%
Austria	55.2%	25.1%	19.7%
Belgium	55.3%	20.7%	24.0%
Bulgaria	82.3%	9.8%	7.9%
Croatia	65.4%	20.9%	13.7%
Cyprus	13.1%	36.8%	50.1%
Czech Republic	73.4%	13.4%	13.2%

Denmark	49.7%	24.1%	26.2%
Estonia	64.6%	19.8%	15.6%
Finland	46.6%	23.6%	29.8%
France	55.6%	18.6%	25.8%
Germany	47.1%	23.9%	29.0%
Greece	70.8%	17.3%	11.9%
Hungary	74.2%	14.5%	11.3%
Ireland	60.7%	26.4%	12.9%
Italy	68.1%	16.3%	15.6%
Latvia	67.7%	18.8%	13.5%
Lithuania	61.5%	19.0%	19.5%
Luxembourg	52.9%	24.5%	22.6%
Malta	76.4%	17.4%	6.2%
Netherlands	51.3%	21.5%	27.2%
Poland	74.4%	13.9%	11.7%
Portugal	55.7%	28.9%	15.4%
Romania	85.1%	7.4%	7.5%
Slovakia	75.3%	12.5%	12.2%
Slovenia	77.0%	13.0%	10.0%
Spain	58.4%	18.8%	22.8%
Sweden	42.4%	26.7%	30.9%
United Kingdom	60.7%	18.8%	20.5%

Sample description

As explained above, the target respondent of the consumer survey is those who are energy renovator. The following three large groups of energy renovators are defined:

Owners

Tier 2 respondents who own the residence they live in, with no other residential property that is rented out to individuals. Owners will have done the renovations themselves or will have commissioned the renovations.

Tenants

Tier 2 respondents who rent the residence they live in, with no other residential property that is rented out to individuals. We identify two types of energy renovations for tenants:

1. Energy renovations done by or commissioned by the tenants themselves;

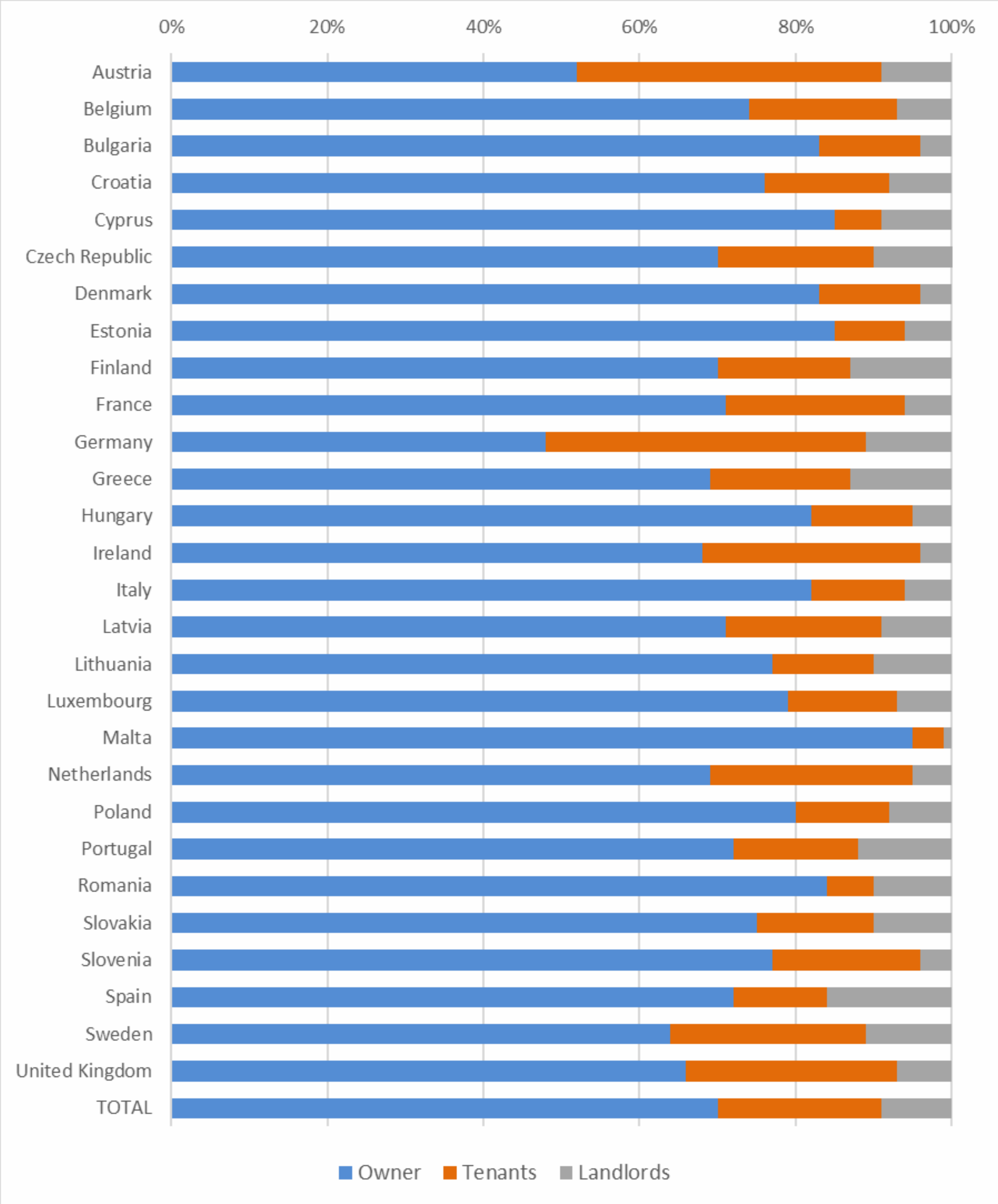
2. Energy renovations done by or commissioned by the landlord.

Landlords

Tier 2 respondents who rent out residential dwellings.

The figure below (Figure 9) shows the (weighted) distribution of respondents across owners, tenants and landlords. Most respondents currently own the residence (house, apartment, etc.) they live in, a trend that is consistent across all countries. This is followed by respondents that currently rent their residence. Landlords of a residential building (or units) or dwelling that they rent out to others represent only a relatively small share of the respondents of the consumer survey.

Figure 9: Distribution of sample across owners, tenants and landlords



Apart from the distribution of energy renovators in owners, tenants and landlords, additional questions were included in the questionnaire in order to further break down the Tier 2 data. A description of the sample across these breakdowns is presented for each question in the tables below.

a) Gender

Table 13: Overview of Tier 2 sample by gender

	Male	Female
Total	50%	50%
Austria	54%	46%
Belgium	57%	43%
Bulgaria	50%	50%
Croatia	33%	67%
Cyprus	52%	48%
Czech Republic	52%	48%
Denmark	51%	49%
Estonia	45%	55%
Finland	53%	47%
France	48%	52%
Germany	51%	49%
Greece	52%	48%
Hungary	52%	48%
Ireland	44%	56%
Italy	46%	54%
Latvia	49%	51%
Lithuania	45%	55%
Luxembourg	57%	43%
Malta	55%	45%
Netherlands	56%	44%
Poland	53%	47%
Portugal	47%	53%
Romania	52%	48%
Slovakia	56%	44%
Slovenia	53%	47%

Spain	49%	51%
Sweden	52%	48%
United Kingdom	52%	48%

b) Age

Table 14: Overview of Tier 2 sample by age categories

	18-34 years	35-54 years	55 or older
Total	31.6%	35.6%	32.8%
Austria	32.4%	36.6%	31.0%
Belgium	28.2%	33.5%	38.3%
Bulgaria	30.5%	35.2%	34.3%
Croatia	53.3%	32.7%	13.9%
Cyprus	33.0%	37.0%	30.0%
Czech Republic	23.5%	38.4%	38.1%
Denmark	24.8%	38.5%	36.7%
Estonia	30.2%	31.6%	38.2%
Finland	28.2%	37.4%	34.5%
France	28.0%	33.5%	38.5%
Germany	25.4%	34.7%	39.9%
Greece	35.1%	46.7%	18.2%
Hungary	24.9%	36.9%	38.3%
Ireland	29.2%	42.4%	28.4%
Italy	36.4%	37.7%	25.9%
Latvia	38.2%	30.6%	31.3%
Lithuania	42.6%	27.2%	30.2%
Luxembourg	29.2%	41.7%	29.1%
Malta	39.2%	35.0%	25.8%
Netherlands	24.8%	35.0%	40.1%

Poland	33.9%	35.3%	30.7%
Portugal	38.1%	39.3%	22.6%
Romania	44.7%	37.8%	17.5%
Slovakia	37.3%	41.4%	21.3%
Slovenia	29.8%	44.2%	26.0%
Spain	31.3%	40.0%	28.7%
Sweden	27.6%	34.7%	37.7%
United Kingdom	33.1%	29.7%	37.2%

c) Household composition

Table 15: Overview of Tier 2 sample by household composition

	Single adult with children	Single adult without children	Couple with children	Couple without children	Other type of household with children	Other type of household without children
Total	4.2%	29.7%	23.9%	24.9%	5.7%	11.7%
Austria	2.3%	30.6%	21.4%	25.4%	6.7%	13.6%
Belgium	3.7%	26.1%	26.8%	28.1%	5.0%	10.3%
Bulgaria	2.3%	36.9%	15.3%	20.9%	7.9%	16.7%
Croatia	2.1%	22.3%	22.3%	16.2%	12.9%	24.2%
Cyprus	5.1%	24.8%	39.6%	14.8%	8.1%	7.6%
Czech Republic	4.2%	29.2%	23.7%	29.2%	4.2%	9.5%
Denmark	10.5%	36.6%	24.8%	23.3%	2.2%	2.6%
Estonia	5.3%	39.8%	19.7%	21.1%	5.2%	8.9%
Finland	1.8%	35.8%	23.7%	31.6%	2.2%	4.9%
France	5.0%	30.4%	27.8%	25.2%	4.8%	6.8%
Germany	4.1%	34.5%	19.2%	31.3%	2.5%	8.3%
Greece	2.6%	28.2%	24.9%	27.7%	3.5%	13.1%
Hungary	3.4%	30.7%	19.8%	23.0%	7.1%	16.0%

Ireland	6.4%	26.2%	29.9%	19.5%	5.5%	12.4%
Italy	2.8%	33.8%	23.5%	21.0%	5.4%	13.4%
Latvia	6.4%	33.2%	17.3%	19.4%	8.6%	15.0%
Lithuania	8.6%	38.4%	16.0%	16.8%	7.5%	12.6%
Luxembourg	5.2%	28.1%	25.4%	22.8%	7.1%	11.5%
Malta	3.2%	18.4%	23.5%	30.0%	0.7%	24.2%
Netherlands	4.1%	30.1%	26.5%	31.6%	3.6%	4.1%
Poland	3.7%	20.8%	26.7%	23.0%	10.1%	15.8%
Portugal	4.1%	22.8%	25.9%	20.9%	7.6%	18.8%
Romania	2.5%	26.6%	21.0%	21.2%	12.4%	16.3%
Slovakia	2.9%	18.0%	23.3%	22.8%	14.2%	18.8%
Slovenia	3.9%	30.4%	23.0%	20.5%	5.3%	17.0%
Spain	3.6%	25.9%	27.4%	20.7%	6.1%	16.3%
Sweden	6.0%	43.7%	25.8%	19.4%	2.6%	2.6%
United Kingdom	6.7%	27.4%	23.7%	26.4%	4.7%	11.2%

d) Household income

Table 16: Overview of Tier 2 sample by household income

	Lowest income group	Lower middle income group	Upper middle income group	Highest income group
Total	23.3%	26.8%	28.7%	21.1%
Austria	16.1%	29.0%	29.4%	25.5%
Belgium	15.2%	31.0%	30.1%	23.7%
Bulgaria	48.0%	31.7%	15.1%	5.3%
Croatia	34.0%	33.2%	25.4%	7.5%
Cyprus	12.0%	35.8%	25.4%	26.8%
Czech Republic	30.2%	30.5%	30.8%	8.5%

Denmark	28.9%	20.0%	20.4%	30.7%
Estonia	27.4%	37.4%	26.6%	8.6%
Finland	22.6%	24.4%	24.7%	28.3%
France	14.9%	23.6%	31.4%	30.1%
Germany	15.2%	23.1%	32.8%	29.0%
Greece	38.1%	33.4%	21.5%	7.0%
Hungary	49.3%	31.4%	15.8%	3.5%
Ireland	24.1%	24.3%	24.7%	27.0%
Italy	20.3%	29.3%	31.5%	19.0%
Latvia	45.3%	30.9%	18.2%	5.6%
Lithuania	50.4%	30.4%	13.0%	6.2%
Luxembourg	2.8%	7.2%	22.8%	67.1%
Malta	10.2%	24.5%	29.6%	35.7%
Netherlands	18.1%	24.8%	34.4%	22.6%
Poland	23.7%	30.9%	32.4%	13.0%
Portugal	24.5%	35.2%	27.9%	12.5%
Romania	37.6%	32.0%	19.5%	10.9%
Slovakia	21.1%	41.9%	26.7%	10.3%
Slovenia	39.0%	36.2%	16.1%	8.7%
Spain	19.8%	27.3%	30.9%	22.1%
Sweden	30.9%	20.6%	23.7%	24.8%
United Kingdom	27.2%	21.7%	26.3%	24.9%

e) Tenure status

Table 17: Overview of Tier 2 sample by tenure status

	Outright owner	Owner paying mortgage	Tenant or subtenant paying rent at prevailing or market rate	Accommodation is rented at a reduced rate (lower price that the market price)	Accommodation is provided free
Total	52.9%	25.7%	14.3%	5.5%	1.5%
Austria	38.5%	22.2%	25.8%	11.9%	1.6%
Belgium	43.1%	37.9%	12.0%	6.3%	0.8%
Bulgaria	78.3%	8.8%	6.0%	3.8%	3.0%
Croatia	64.8%	19.5%	5.5%	3.7%	6.5%
Cyprus	64.5%	29.4%	0.3%	5.8%	0.0%
Czech Republic	52.4%	28.1%	12.0%	6.3%	1.2%
Denmark	23.6%	44.2%	22.6%	8.1%	1.4%
Estonia	69.7%	21.3%	4.6%	3.4%	1.0%
Finland	42.5%	40.8%	11.8%	3.5%	1.3%
France	46.0%	31.3%	16.4%	4.6%	1.6%
Germany	40.2%	19.1%	28.1%	11.7%	0.9%
Greece	63.5%	18.9%	11.9%	4.2%	1.5%
Hungary	68.7%	18.0%	5.4%	4.5%	3.4%
Ireland	43.6%	28.3%	14.4%	12.6%	1.0%
Italy	68.4%	20.0%	8.3%	2.0%	1.4%
Latvia	68.2%	11.7%	8.5%	6.7%	4.9%
Lithuania	69.2%	17.4%	6.6%	4.0%	2.8%
Luxembourg	44.2%	41.8%	6.0%	3.7%	4.4%
Malta	63.1%	33.0%	1.8%	1.1%	0.9%
Netherlands	19.5%	54.4%	20.0%	5.4%	0.7%
Poland	69.4%	18.4%	6.5%	3.6%	2.2%
Portugal	43.7%	40.8%	10.4%	4.7%	0.4%
Romania	80.4%	13.9%	2.8%	1.2%	1.8%

Slovakia	56.9%	27.7%	8.4%	3.7%	3.2%
Slovenia	71.0%	9.7%	9.7%	6.9%	2.7%
Spain	55.6%	31.9%	8.1%	3.8%	0.5%
Sweden	28.5%	46.4%	19.8%	4.7%	0.6%
United Kingdom	42.9%	29.8%	19.0%	6.6%	1.7%

f) Type of residence

Table 18: Overview of Tier 2 sample by type of residence

	Detached building with 1 or 2 dwellings	Semi - detached building with 1 or 2 dwellings	Attached building (row house) with 1 or 2 dwellings	Apartment building with 3-6 dwelling units	Apartment building with 7 – 12 dwelling units	Apartment building with 13 or more dwelling units
Total	34.8%	11.8%	9.6%	11.8%	11.6%	20.4%
Austria	38.0%	5.2%	6.4%	12.3%	17.3%	20.8%
Belgium	35.7%	22.9%	23.8%	9.0%	3.4%	5.1%
Bulgaria	24.7%	1.7%	0.5%	6.1%	12.4%	54.5%
Croatia	48.1%	6.6%	5.4%	9.4%	10.5%	20.0%
Cyprus	56.5%	15.9%	8.5%	8.3%	6.9%	3.9%
Czech Republic	29.3%	5.9%	6.2%	8.6%	13.7%	36.1%
Denmark	49.9%	9.2%	14.2%	7.6%	6.3%	12.8%
Estonia	31.6%	2.7%	2.5%	6.7%	9.8%	46.7%
Finland	42.3%	5.4%	12.8%	5.4%	6.7%	27.4%
France	50.0%	6.3%	9.4%	8.3%	10.2%	16.0%
Germany	37.1%	11.6%	7.8%	20.8%	13.4%	9.3%
Greece	28.8%	6.1%	4.0%	22.8%	21.0%	17.3%
Hungary	53.6%	3.0%	1.6%	4.8%	9.1%	27.8%
Ireland	43.4%	31.9%	13.6%	5.1%	2.1%	3.8%
Italy	33.1%	8.8%	7.0%	17.0%	16.7%	17.4%

Latvia	29.9%	0.9%	1.5%	7.1%	4.7%	55.9%
Lithuania	27.2%	1.3%	1.0%	3.4%	6.3%	60.8%
Luxembourg	49.5%	15.9%	15.6%	5.9%	7.8%	5.3%
Malta	8.6%	16.9%	42.2%	21.5%	8.7%	2.1%
Netherlands	20.6%	24.3%	33.1%	8.4%	2.8%	10.8%
Poland	36.7%	4.5%	3.4%	6.6%	12.5%	36.2%
Portugal	33.0%	6.4%	5.7%	15.2%	20.7%	19.0%
Romania	35.6%	5.2%	3.3%	4.1%	10.2%	41.6%
Slovakia	38.9%	4.6%	2.7%	7.6%	10.8%	35.3%
Slovenia	60.9%	2.9%	3.1%	3.6%	9.8%	19.7%
Spain	17.1%	5.0%	7.5%	14.3%	19.8%	36.2%
Sweden	46.8%	4.9%	7.6%	8.8%	8.9%	22.9%
United Kingdom	27.9%	35.7%	20.7%	8.7%	2.4%	4.6%

g) Legal status landlord

Table 19: Overview of Tier 2 sample by legal status of the landlord

	Housing association providing low-cost (social) housing	Housing association providing housing at market price	Local authority or government department	Private landlord (including family members)
Total	17.0%	17.5%	11.3%	54.3%
Austria	20.4%	25.0%	9.2%	45.4%
Belgium	21.8%	14.1%	7.1%	57.0%
Bulgaria	2.8%	15.0%	3.4%	78.9%
Croatia	6.1%	8.2%	10.2%	75.5%
Cyprus	12.0%	0.0%	4.6%	83.4%
Czech Republic	10.1%	25.4%	13.7%	50.8%
Denmark	31.2%	42.1%	2.2%	24.4%

Estonia	4.9%	31.6%	15.3%	48.3%
Finland	29.6%	20.7%	4.5%	45.2%
France	20.8%	15.7%	11.7%	51.8%
Germany	12.1%	23.3%	5.3%	59.3%
Greece	0.6%	0.9%	3.5%	95.0%
Hungary	8.8%	6.3%	14.4%	70.5%
Ireland	11.9%	9.3%	11.6%	67.2%
Italy	9.6%	2.4%	12.4%	75.6%
Latvia	14.0%	6.8%	30.5%	48.7%
Lithuania	25.7%	5.4%	0.0%	68.9%
Luxembourg	0.0%	2.4%	0.0%	97.6%
Malta	0.0%	0.0%	5.3%	94.7%
Netherlands	56.4%	21.8%	6.3%	15.5%
Poland	11.8%	23.6%	22.6%	42.0%
Portugal	3.7%	15.9%	3.5%	76.9%
Romania	8.7%	7.9%	7.1%	76.2%
Slovakia	8.0%	27.7%	7.1%	57.2%
Slovenia	17.5%	4.3%	15.9%	62.3%
Spain	5.0%	15.8%	6.9%	72.2%
Sweden	3.1%	18.6%	27.8%	50.5%
United Kingdom	26.3%	12.6%	21.3%	39.8%

Architects survey

The architect survey was also conducted online (CAWI) and focused both on residential and non-residential renovation projects and NZEB, thus complementing the results of the consumer survey.

As an EU-wide panel of architects is not available surveying this target group within other available sources (e.g. consumer panels) would not have been efficient. The survey was therefore carried out via the European Architects Council (ACE) who distributed the questionnaire to its national member organisations.

The ACE was contacted at an early stage by Ipsos and expressed its willingness to fully collaborate in the survey execution. Besides, the ACE shared with Ipsos their last published Sector Study, a biennial survey that collects and analyses statistical, sociological and economic data on the European Architects, the architectural market and the architectural practices. Based on responses from 27.000 Architects in 27 European countries, the 2016 Study is reportedly the most comprehensive on the architectural profession in Europe. The Study allows to draw comparisons between the European countries and helps to better understand the national situations. The ACE also contributed questions to the draft questionnaire.

Based on the number of members in each country and the sample size of past ACE surveys, a sample size of n = 5,000 architects was estimated. The original strategy relied on the participation of the ACE's member organisations as well as the personal willingness of the architects to participate. Therefore, while all reasonable efforts are made to achieve this sample size, the data collection was performed on best effort.

Taking the above into account, as agreed with the European Commission, the following response enhancement measures have been undertaken to maximise the response:

- An official letter of intent was provided to respondents, which clearly outlines the objectives of the study and serves to motivate participation in order to achieve a higher response rate;
- A dedicated email address and mailbox were set up to which respondents could send enquiries or request (technical) support if necessary;
- Reminders were sent out throughout the fieldwork period

The survey was launched on 28 August 2018. On that date, the e-mail invitations and background information were shared with the ACE, which in turn shared it with its member organisations. Throughout the fieldwork period, several additional initiatives were undertaken to further boost the response:

- Based on a discussion with Ipsos, the ACE sent reminder e-mails to its network;
- Ipsos took the initiative to directly contact the ACE (national) network members;
- The survey invitation was further disseminated via social media (LinkedIn and Twitter);
- Through web-scraping and manual desk research, an additional 12,411 unique e-mail addresses were collected based on publicly available information. Ipsos sent out the invitation e-mails to these addresses as well as reminder e-mails at a later stage.
- Ipsos contacted multiple architect associations and related organisations, to aid in promoting the survey.
- Additional data was collected through an external panel and additional contact details were purchased. E-mail invitations were sent out to all these contacts.
- Target group, sampling and weighting approach

The respondents who were reached through the ACE member organisations consist of independent architects (e.g., those who are self-employed) as well as architects working in an architect firm.

When an independent architect is reached, this person was asked to fill in the questionnaire. In case the survey reached an architect firm, the aim was to survey the individual who has the best overview of the types of projects that the company works on, as well as the specific technical measures taken in recent projects. The following types of positions are targeted within architect firms:

- Managing director or top-level manager
- Team manager or top-level project manager
- Project manager of several projects

In addition, the survey aimed to reach architects and architect firms that have performed renovations during the period 2012-2016. These renovations may be performed on residential and/or non-residential buildings. Architects who did not perform any renovations between 2012 and 2016 were screened out. Table 20 below provides an overview of the number of interviews achieved per country.

Table 20: Overview of the achieved sample for the Architects survey

Country	# completed interviews
Austria	8
Belgium	61
Bulgaria	28
Croatia	53
Cyprus	34
Czech Republic	35
Denmark	5
Estonia	13
Finland	2
France	147
Germany	378
Greece	53
Hungary	5
Ireland	17
Italy	210
Latvia	23
Lithuania	16
Luxembourg	2

Malta	12
Netherlands	41
Poland	3
Portugal	19
Romania	82
Slovakia	15
Slovenia	13
Spain	155
Sweden	12
United Kingdom	139
Total	1,581

A large section of the survey consisted of technical questions on a reference project. The reference project is intended as the architect's last project of a particular type in the reference period.

Architects who worked on non-residential buildings provided information on a non-residential reference project (Section A in the questionnaire), whereas architects who worked only on residential buildings, received questions on a residential reference project (Section B). This approach allowed maximizing the information collected on non-residential projects, which is not collected through the consumer survey.

The specific type of building for which the respondent provided information (e.g., office or educational building) was assigned based on a least-filled basis. It implies that the respondents answer questions on their most recent renovation of specific buildings for which the number of responses is the lowest. An overview of the categorisation is provided in Table 21 below.

Table 21: Categorisation of reference project

Non-residential reference project	Residential reference project
If any of the following options were selected, the architect received questions on a non-residential project: Office Educational building Hospital Hotel or restaurant Sports facilities Wholesale or retail buildings Other non-residential buildings	If either of the following residential options were selected (and neither of the non-residential), the architect received questions on a residential project: Single family house Multi-family house (apartment block)

Further filtering was applied in Section F of the questionnaire. In this section, the drivers, barriers and incentives were measured both from the perspective of the respondent (architect's perspective) as well as from the perspective of the respondent's client (client's perspective). The latter implies that the architects estimated which drivers, barriers and incentives played a role in their client's decisions on energy-related renovation. The respondents were randomly assigned to either block of questions, ensuring that 25 percent of the architects received the questions from the architect perspective and 75 percent received questions from the client's perspective.

The overall sample was weighted to be representative of the total building stock on EU28-level. As such, each country was given a weight which represents the proportion of that country in the total EU28 building stock (which includes both residential & non-residential buildings).

As part of the analysis of the architect survey focusses solely on non-residential buildings, a second weighting scheme was constructed which weights the responses to be representative of the total non-residential building stock.

Description of the sample

Table 22 below provides an overview of the sample broken down across three key variables: type of renovation project, type of architect and type of client. Due to the low sample size in several countries, only an overall breakdown is provided.

Table 22: Description of Architects survey sample across three key variables

Type of renovation projects (all respondents)		Type of architect (all respondents)[9]		Type of clients (non-residential renovation only)	
Residential	Non-residential	Independent architect	Part of an architect firm	Mainly private clients	Mainly public clients
24%	76%	69.4%	36.4%	75.7%	24.3%

Construction companies survey

The goal of this third survey was to understand the demand and supply chain as well as the quality of the works related to energy-efficiency and NZEB. The survey was carried out via Computer-Assisted Telephone Interviewing (CATI) in all 28 EU Member States. Similar to the architect survey, this survey also focused on both residential and non-residential renovation projects and NZEB.

Since the survey with construction companies used CATI methodology, it was of particular importance to be able to obtain contact details of companies within the scope of the study. Therefore, the Dun & Bradstreet (D&B) company database was used. The D&B company database provides the highest coverage of companies within the European Union and allowed to obtain information on country, sector and size level. The information on country and sector was used during the fieldwork to pre-target potential respondents.

Before the start of the fieldwork, a live pre-testing of the questionnaire took place to assess the understanding, item response, potential drop-out and length of the telephone interview. This pre-testing took place during the beginning of July 2018 and consisted of 10 interviews with actual respondents. The questionnaire was finalized based on the feedback from this pre-test and focused on revisions to improve the overall user-friendliness of the questionnaire. This included:

- Rephrasing questions and/or answer options to make the questions/answer options better understandable and less complex
- Removing similar and/or overlapping answer options
- Rephrasing instructions interviewers and/or respondents, for questions where the pre-testing showed that respondents were unsure how to answer

Besides these changes, no structural adaptations to the questionnaire were made.

Following the finalization of the survey material, the main fieldwork ran from 13 August 2018 until 6 November 2018. Overall, the fieldwork took longer than originally planned due to a low efficiency of the sample, as it turned out to be much more difficult than initially anticipated to pre-target the subgroups of Installers and Main Contractors. Concretely, this means that a substantial amount of companies that were contacted during the study were not eligible to take part in the survey. As such,

9 Respondents could indicate both answer options

considerably more companies than foreseen had to be contacted to reach the target sample size.

Target group, sampling and weighting approach

As already mentioned above, the survey targeted two main groups of construction companies: installers and main contractors. These subgroups were defined as follows:

1. Installers

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.

2. Main contractors

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

Several screening questions, in addition to the identification of the target group described above, were included in the questionnaire. The purpose of the screening questions was two-fold:

1. Ensuring that the companies that are being contacted are indeed included in the target group of the survey;

2. Identifying the areas in which the enterprise was significantly active between 2012 and 2016, to be able to ask targeted questions to subgroups of respondents (see also the section on the description of the sample below).

To ensure a sound distribution of the subgroups within every country sample, quota targets for the distribution of interviews were defined. This entails that the interviews on country level would aim to be distributed as follows:

Installers – 75% of the country sample
Main contractors – 25% of the country sample

Table 23 below provides a complete overview of the number of completed interviews in each subgroup, as well as the distribution of interviews between the subgroups on country level. The total sample shows a distribution of 74% Installers and 26% Main contractors, which is indeed extremely close to the aimed distribution. On country level, the proportion of Installers in the sample ranges from 77.6% to 65.2% for Installers, and 22.4% and 34.8% for Main contractors (in Bulgaria and Ireland, respectively). In 20 out of the 28 Member States included in the scope of the survey, the deviation from the targeted distribution does not exceed 5%. The sole exception is Cyprus, where the distribution is almost equal between the two target groups (53.8% for Installers and 46.2% for Main contractors). This is mostly due to the extremely low amount of sample available for this country. As such, to maximise the overall response for this country, it was decided to obtain interviews from both target groups on a best-effort approach.

Table 23: Overview of the achieved sample for the Construction companies survey

		Installers		Main contractors	
		Number of interviews	Proportion	Number of interviews	Proportion
Total	Number of interviews	1491	74%	523	26%
Austria	66	47	71.2%	19	28.8%
Belgium	75	56	74.7%	19	25.3%
Bulgaria	98	76	77.6%	22	22.4%
Croatia	32	22	68.8%	10	31.3%
Cyprus	13	7	53.8%	6	46.2%
Czech Republic	64	43	67.2%	21	32.8%
Denmark	76	57	75.0%	19	25.0%
Estonia	56	43	76.8%	13	23.2%
Finland	81	59	72.8%	22	27.2%
France	148	113	76.4%	35	23.6%
Germany	118	90	76.3%	28	23.7%
Greece	88	64	72.7%	24	27.3%
Hungary	101	77	76.2%	24	23.8%
Ireland	23	15	65.2%	8	34.8%
Italy	151	116	76.8%	35	23.2%
Latvia	32	22	68.8%	10	31.3%
Lithuania	34	24	70.6%	10	29.4%
Luxembourg	25	19	76.0%	6	24.0%
Malta	16	11	68.8%	5	31.3%
Netherlands	59	40	67.8%	19	32.2%
Poland	95	73	76.8%	22	23.2%
Portugal	74	56	75.7%	18	24.3%
Romania	77	57	74.0%	20	26.0%

Slovakia	68	46	67.6%	22	32.4%
Slovenia	49	37	75.5%	12	24.5%
Spain	151	116	76.8%	35	23.2%
Sweden	68	49	72.1%	19	27.9%
United Kingdom	76	56	73.7%	20	26.3%

For the Construction companies survey a similar weighting approach as the one adopted in the Architects survey was developed, where the sample is weighted to be representative of the total building stock.

Description of the sample

a) Type of building project

One of the survey questions identified the different areas of projects in which the company was active between 2012 and 2016. As such, the target groups were further broken up into installers or main contractors active in:

- Residential new construction projects;
- Residential renovation projects;
- Non-residential new construction projects;
- Non-residential renovation projects.

The table below (Table 24) provides an overview of respondents per category, spread across the two subgroups, and indicates the proportion of respondents that are active in each category (based on the total sample).

Table 24: Overview of respondents active per type of building project

	Residential new construction	Residential renovation	Non-residential new construction	Non-residential renovation
Total	42.2%	76.3%	36.4%	55.3%
Installers	41.3%	73.1%	34.0%	49.2%
Main contractors	48.6%	100.0%	7.1%	100.0%

b) Type of services offered (installers only)

In order to have a comprehensive overview of the market, several subgroups of construction companies were defined within the two main target groups. Whereas the main contractors include those at least active in non-residential construction project, the subgroup of installers focused on installers offering services for one or more of the following core sectors:

- Performing works on the façade (including insulation works);
- Installing windows;
- Installing heating systems (including solar thermal);
- Installing photovoltaic systems, air-conditioning or electric heating;
- Performing works for the roof;
- Installing mechanical ventilation.

The table below (Table 25) provides an overview of the proportion of respondents active in each of the core sectors included in the scope of the study.

Table 25: Proportion of installers in the sample offering each type of service

Type of service	Proportion of the sample offering this type of service
Performing works on the façade (including insulation works)	29.9%
Installing windows	28.3%
Installing heating systems (including solar thermal)	55.9%
Installing photovoltaic systems, air-conditioning or electric heating;	34.6%
Performing works for the roof;	34.2%
Installing mechanical ventilation.	39.8%

c) Company size

A final breakdown looks at the size of the company of the respondents, which is based on the amount employees.

Table 26: Overview of respondents per company size

	Company size				
	1 (one-man business)	2 – 9 employees	10 – 49 employees	50 – 249 employees	>249 employees
Total	21.9%	48.7%	22.8%	4.7%	1.8%
Installers	22.5%	49.9%	22.1%	3.8%	1.6%
Main contractors	17.7%	39.5%	28.4%	11.2%	3.2%

3.6. Limitations

An enormous effort in activating architects to participate in the survey still resulted in a small sample size of architects (1,581), which does not enable a reliable split of the renovation of non-residential buildings into different building types such as educational buildings and wholesale/retail buildings. During the detailed analysis of the survey results, a significant deviation of the SFH/MFH shares in the samples from the real distribution in the stock has been identified. Because of this uncertainty, the renovation of residential buildings was not split into different building types such as single-family homes and multi-family homes. Note that consumers were asked to report investments between 2012 and 2016 in a survey that took place in summer 2018. It must be expected that not all respondents may have been able to accurately reproduce activities during that period. Therefore, sometimes the average for the whole period from 2012-2016 may be closer to reality than findings for individual years. Many findings are derived from purchased market data, which have been checked thoroughly by data providers and aligned to the needs of this project but could not be further verified within this project. Finally, altogether considerably less data for non-residential buildings was available than for residential buildings. For some sources the level of uncertainty is unclear. Therefore, all results should be understood as best estimates, in the case of non-residential buildings rather as an indication.

4. EU28 building stock inventory

For calculating the renovation rates, it is necessary to first develop a EU28 building stock inventory in a level of detail that is needed to allow results for each considered building type to be presented separately. According to the developed methodology and scope of the project, the following building types according to EPBD Annex I had to be covered:

- Single family houses;
- Multi-family houses;
- Offices;
- Educational buildings;
- Hospitals;
- Hotels and restaurants;
- Sports facilities;
- Wholesale and retail trade services buildings;
- Other types of energy-consuming buildings.

As the renovation rates should be calculated based on building floor area and buildings, the inventory needs to contain both types of information for the years 2012-2016. The initial idea was to directly use the data that is collected in the new EU BSO project (ENER/C3/2014-543), however this information was not available early enough to be usable for this task. In consequence, an own approach had to be developed, which is presented below.

4.1. Approach residential buildings

Basis for the residential building stock inventory is the EU-SILC 2012 Module on Housing Conditions. It contains detailed information on the number of households per dwelling type (detached house, semi-detached and terraced house, apartment or flat in a building w/ less than 10 dwellings, apartment or flat in a building w/ more than 10 dwellings) and for each type the average floor area per country. This information has been used to calculate the 2012 baseline.

Using the Navigant's GLObal BUilding Stock Model GLOBUS and considering the analysed new constructions as described above, the building stock development until 2016 has been projected ex-post.

To convert these floor area numbers into number of buildings, two main sources have been used:

- For single family houses: The 2011 Census database
- For multi-family houses: Entrance average number of dwellings per building (http://www.entranze.enerdata.eu/#/average-number-of-dwellings-per-building.html) combined with EU-SILC, own modelling plausibility checks and assumptions to close gaps

4.2. Approach non-residential buildings

The development of a non-residential building stock inventory builds upon the conducted work within the impact assessment (IA) of the EPBD. The following sources have been used during the IA to compile an overview of the 2012 EU non-residential building stock in terms of gross floor area (m^2) per country:

Table 27: Sources – approach to non-residential building stock

Country	Source building stock base year
Austria	Statistik Austria - Mikrozensus
Belgium	BPIE 2011
Bulgaria	BPIE 2011
Croatia	ENTRANZE
Cyprus	(Schimschar, 2015)
Czech Republic	ENTRANZE
Denmark	Statistics Denmark
Estonia	ENTRANZE
Finland	Statistics Finland
France	Objectifs Bâtiments 2012 - 2020, Hubert Despretz – Ademe/DBU
Germany	Statistisches Bundesamt / Fraunhofer [BMWi, 2015]
Greece	BPIE 2011
Hungary	Panorama of the European non-residential construction sector
Ireland	(Schimschar, 2015)
Italy	Statistics Italy (CENSUS)
Latvia	BPIE 2011
Lithuania	BPIE 2011
Luxembourg	BPIE 2011
Malta	BPIE 2011
Netherlands	ENTRANZE
Poland	BPIE 2011
Portugal	BPIE 2011
Romania	BPIE 2011
Slovakia	ENTRANZE
Slovenia	BPIE 2011
Spain	Panorama of the European non-residential construction sector
Sweden	Statistics Sweden (SCB) / Energimyndigheten
United Kingdom	ENTRANZE

These sources have been updated considering the published Long-Term Renovation Strategies of the EU MS and other updated national sources. Missing data and also to calculate the development of the building stock over time, the Navigant Globus model has been used.

To convert these floor area numbers into number of buildings, building stock numbers of the H2020 project "Hotmaps Toolbox" has been used[10]. Accordingly, it was possible to calculate average building sizes per non-residential sub-category, see the following table.

Used non-residential reference buildings for converting floor area into number of buildings

	Floor area [m²]					
	Office	Education	Health and social work	Hotels and restaurants	Wholesale and retail trade	Other
Austria	744	996	200	624	674	1,371
Belgium	914	1,550	416	846	1,339	853
Bulgaria	823	1,292	1,618	1,011	1,328	1,025
Croatia	276	598	140	200	200	909
Cyprus	185	1,201	1,337	107	112	200
Czech Republic	715	998	574	329	428	1,286
Denmark	890	1,170	703	100	984	767
Estonia	3,481	15,813	14,460	2,892	815	10,075
Finland	216	1,263	830	281	954	5,931
France	664	1,209	929	389	432	369
Germany	1,850	2,422	1,460	1,725	656	1,329
Greece	6,673	4,233	284	709	200	283
Hungary	1,063	1,131	1,267	7,539	863	1,524
Ireland	4,635	1,392	304	597	1,147	296
Italy	1,171	1,256	690	217	108	9,530
Latvia	701	1,684	2,212	238	275	719
Lithuania	233	1,292	2,170	723	126	867
Luxembourg	297	1,310	560	870	870	890
Malta	141	3,573	839	454	115	213
Netherlands	553	502	375	1,059	1,963	4,130
Poland	139	2,141	512	1,704	355	21,400
Portugal	347	1,325	561	585	200	711
Romania	158	218	227	101	217	1,681
Slovakia	2,954	1,986	6,190	5,131	25,915	1,091
Slovenia	1,213	2,264	1,611	557	106	496
Spain	398	820	380	250	200	421
Sweden	110	2,316	1,510	710	249	24,308
United Kingdom	641	1,174	1,349	393	789	234

10 https://gitlab.com/hotmaps/building-stock/tree/master

5. New construction activities in the EU28

Similar to the information needed on the total amount of buildings and floor area in the stock for being able to calculate the renovation rate, also the total amount of newly constructed buildings and floor area is needed to calculate the share of NZEB buildings on all new constructions. EUROCONSTRUCT and EECFA provide the number of completed dwellings for many EU countries divided by 1+2 family dwellings as well as flats. For the non-residential sector, the new built surface (in m²) is provided, however not for all countries. The following table provides an overview of the provided information from EUROCONSTRUCT and EECFA.

Country	Information on new dwellings	Infomation on newly constructed non-residential floor area partly in line with required data
Austria	x	
Belgium	x	
Bulgaria	x	
Croatia	x	x
Cyprus		
Czech Republic	x	x
Denmark	x	x
Estonia		
Finland	x	x
France	x	x
Germany	x	x
Greece		
Hungary	x	
Ireland	x	
Italy	x	x
Latvia		
Lithuania		
Luxembourg		
Malta		
Netherlands	x	x
Poland	x	x
Portugal	x	x
Romania	x	
Slovak Republic	x	x
Slovenia	x	x
Spain	x	x
Sweden	x	x
United Kingdom	x	
EU28	21/28	14/28

5.1. Approach for calculating the newly constructed floor area and buildings in the residential sector

For those countries EUROCONSTRUCT and EECFA do not provide the number of new dwellings (Cyprus, Estonia, Greece, Latvia, Lithuania, Luxembourg, Malta), a set of three other sources has been used to calculate these numbers:

1) The State of Housing in the EU 2017, Housing Europe (European Federation of Public, Cooperative and Social Housing),
2) Housing Statistics in the European Union 2010, Ministry of the Interior and Kingdom Relations,
3) EUROSTAT Building permits - annual data [sts_cobp_a].

In the next step, the number of dwellings has been combined with the average size of new dwellings in square metres. Where possible, this information was collected from the ZEBRA2020 data tool[11], EECFA and Housing Statistics in the European Union 2010. Missing data for some years was linearly interpolated. At this stage, the EU BSO (ENER/C3/2014-543) could not provide other useful data.

In the next step, the resulting floor area has been converted into number of newly constructed buildings by using average building sizes of single and multi-family houses. For this purpose, data has been extracted from TABULA/EPISCOPE considering the newest construction period covered per country. The resulting average building sizes per EU MS are presented in Table 28.

5.2. Approach for calculating the newly constructed floor area and buildings in the non-residential sector

As already described above, the main source for new non-residential construction data is EUROCONSTRUCT and EECFA. However, as data is not available for all EU member states, some other sources and assumptions had to be applied.

The ZEBRA2020 data tool and BSO for instance provide some non-residential construction numbers. Other potential sources are EUROSTAT's "Building permits - annual data" (sts_cobp_a), "Annual detailed enterprise statistics for construction" (sbs_na_con_r2) or "Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates" (prc_ppp_ind). Gaps can also be filled with a research on national level. For countries where no information was available, the amount of new non-residential constructions has been calculated with the Navigant Global Building Stock (GLOBUS) model.

For the conversion of the floor area into number of newly constructed buildings, the reference buildings from the national cost-optimality reports according to article 4 EPBD have been used. The cost-optimality reports provide information for more than 50% of the MS in a sufficient level of detail to calculate the size of an average non-residential reference building to be used for converting floor area into number of buildings. For countries, where this information was not available, an average building size of the other countries has been applied. The resulting average building sizes per EU MS are presented in Table 28.

5.3. Used reference building sizes of new constructions

Table 28: Reference building sizes of new constructions

2012	Newly constructed SFH	Newly constructed MFH	Average new residential building (2012-2016)	Newly constructed non-residential building
	m²/building	m²/building	m²/building	m²/building
Austria	174	448	237	3,602
Belgium	224	2,556	344	3,602
Bulgaria	229	1,091	448	3,602
Cyprus	193	1,350	246	5,792
Czech Republic	196	2,396	251	2,250
Germany	236	1,977	345	1,773

11 http://www.zebra-monitoring.enerdata.eu/overall-building-activities/share-of-new-dwellings-in-residential-stock.html#average-size-of-new-dwellings.html

Denmark	162	6,988	307	3,283
Estonia	235	5,853	867	5,820
Greece	308	808	406	3,602
Spain	140	3,449	357	5,544
Finland	120	1,207	241	4,880
France	109	1,096	169	5,023
Croatia	235	1,091	438	2,100
Hungary	136	816	178	1,777
Ireland	198	3,804	214	1,887
Italy	171	1,261	325	3,602
Lithuania	236	5,853	582	804
Luxembourg	187	3,100	332	3,766
Latvia	233	5,853	478	2,677
Malta	208	638	252	3,432
Netherlands	180	3,100	244	3,602
Poland	249	5,853	338	3,602
Portugal	136	3,449	183	3,602
Romania	215	1,091	261	3,602
Sweden	108	1,207	264	3,602
Slovenia	278	3,256	320	1,290
Slovakia	152	2,396	201	3,602
United Kingdom	191	2,011	230	4,500

The calculated floor areas in square metres [m²] have been divided by the respective building size (e.g. 1000m²/per building) to get the number of new buildings.

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