Accelerating Energy renovation solution for Zero Energy buildings and Neighbourhoods

D8.2 1st RenoZEB Market Assessment

Version number: 1.0
Dissemination Level: PU
Lead Partner: SOLINTEL
Due date: 30/09/2018
Type of deliverable: R
STATUS: Delivered

Published in the framework of:

RenoZEB - Accelerating Energy renovation solution for Zero Energy buildings and Neighbourhoods

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 768718
RenoZEB website: [www.renozeb.eu](http://www.renozeb.eu)

**Authors:**

*E. Duce* - RINA-C

*H. Grasset* - Solintel

*M. Vavallo* - Solintel

*A. Pracucci* – Focchi

*A. Rathmell* – Energypro LTD.

*E. Causse* – UIPI

*S. Pantelis* - UIPI

*J. Biosca* – Symelec

*A. Ferreiro Sistiaga* – CYPE

*P. Sabatakos* – HIT Hypertech Innovations

---

**Revision and history chart:**

<table>
<thead>
<tr>
<th>VERSION</th>
<th>DATE</th>
<th>EDITORS</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>05/07/2018</td>
<td>Hugo Grasset</td>
<td>TOC</td>
</tr>
<tr>
<td>0.2</td>
<td>26/07/2018</td>
<td>Hugo Grasset</td>
<td>First Draft</td>
</tr>
<tr>
<td>0.3</td>
<td>12/09/2018</td>
<td>Hugo Grasset</td>
<td>Text improvement on the basis of first round partner’s contribution</td>
</tr>
<tr>
<td>0.4</td>
<td>26/09/2018</td>
<td>Hugo Grasset</td>
<td>Text improvement on the basis of second round partner’s contribution</td>
</tr>
<tr>
<td>1.0</td>
<td>27/09/2018</td>
<td>Hugo Grasset</td>
<td>Final version</td>
</tr>
</tbody>
</table>
Disclaimer:

The project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 680517.

The content of this report does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the therein lies entirely with the author(s).
Table of content

1 Executive summary.............................................................................................................. 7
2 Objectives of the report ....................................................................................................... 10
3 Overview of the Zero-energy Buildings industry ............................................................... 11
   3.1 General renovation and nZEB market trends ................................................................. 11
      3.1.1 General renovation market trends ............................................................................. 11
      3.1.2 nZEB market trends ................................................................................................ 14
   3.2 Drivers and barriers to residential nZEBs ..................................................................... 16
      3.2.1 Market drivers .......................................................................................................... 17
      3.2.2 Market barriers ........................................................................................................ 24
      3.2.3 Dynamics in Renozeb markets of interest ................................................................. 28
   3.3 Current trends and impacts of NZEB and deep retrofits in property value ................. 35
      3.3.1 EPC and energy efficiency impact on property prices .............................................. 36
      3.3.2 Real estate stakeholders perception of NZEBs and EPCs ...................................... 43
4 Reference Markets analysis ................................................................................................. 55
   4.1 Prefabricated multifunctional modular “plug and play” systems for building renovations market segment ........................................................................................................ 55
      4.1.1 Multifunctional insulation system ............................................................................. 59
      4.1.2 Window and roller shutter ......................................................................................... 60
      4.1.3 PV system ................................................................................................................ 61
      4.1.4 Thermal energy system ............................................................................................ 63
   4.2 ICT toolset market segment ............................................................................................ 64
   4.3 Smart control & monitoring systems market segment .................................................. 67
5 Potential customers and stakeholders .............................................................................. 74
6 Conclusions ......................................................................................................................... 78
7 References .......................................................................................................................... 79

List of tables

Table 1 BPIE Depth of Renovations 2011 ............................................................................ 14
Table 2 Growth factors of relevant nZEB product and materiel categories to satisfy future demand ................................................................. 16
Table 3 Status of National nZEB definitions for Residential buildings within scope of EPBD .................................................................................................................. 21
Table 4 National Renewable Energy integration targets for 2020 (% of energy consumption from renewables) ................................................................. 23
Table 5 Typical financial barriers to nZEB renovations .................................. 25
Table 6 Typical behavioral barriers to nZEB renovations ............................... 26
Table 7 Typical technological barriers to nZEB renovations ................................ 26
Table 8 Typical political/structural/societal barriers to nZEB renovations .......... 27
Table 9 Typical informational barriers to nZEB renovations ........................... 27
Table 10 Typical embedded market structure barriers to nZEB renovations ..... 28
Table 11 Identified drivers for nZEB renovations in the Spanish market .......... 29
Table 12 Identified barriers for nZEB renovations in the Spanish market ........ 29
Table 13 Identified drivers for nZEB renovations in the Italian market .......... 30
Table 14 Identified barriers for nZEB renovations in the Italian market .......... 31
Table 15 Identified drivers for nZEB renovations in the French market .......... 32
Table 16 Identified barriers for nZEB renovations in the French market .......... 33
Table 17 Identified drivers for nZEB renovations in the German market .......... 34
Table 18 Identified barriers for nZEB renovations in the German market ........ 35
Table 19 Residential status overview 2008-2012 ........................................... 38
Table 20 Residential status overview 2013-2015 ......................................... 39
Table 21 Residential status overview 2016 .................................................. 40
Table 22: competitors in prefabricated multifunctional modular “plug and play” systems ........................................................................................................ 58
Table 23: Porter’s competitive force for RenoZEB prefabricate "Plug & Play" envelope system ......................................................................................... 59
Table 24. Global market BIPV development and forecast from 2014-2020 (in MW) .............................................................................................................. 61
Table 25 Porter’s competitive force for RenoZEB PV system ....................... 62
Table 26 PV system competitors .................................................................. 62
Table 27 Porter’s competitive force for RenoZEB Thermal energy system ...... 63
Table 28 Thermal energy system competitors .............................................. 64
Table 29 Porter’s competitive force for RenoZEB ICT toolset ..................... 66
Table 30 ICT tools competitors .................................................................... 66
Table 31 SWOT for ICT toolset ................................................................... 67
Table 32 Porter’s competitive force for RenoZEB BEMS ............................ 72
Table 33 BEMS competitors ....................................................................... 73
Table 34 RenoZEB SWOT analysis .............................................................. 73
Table 35 RenoZEB key Stakeholder list ....................................................... 75
Table 36 Stakeholder analysis ..................................................................... 77
List of figures

Figure 1 Trends in European building stock .............................................................. 12
Figure 2 Recent percentages of Major Renovation per Member State ................ 13
Figure 3 Expansible polystyrene regional market sales in 2013 .......................... 15
Figure 4 multiple layered glass sales 2013 .............................................................. 16
Figure 5 Status of nZEB definitions .................................................................... 19
Figure 6 Age profile of residential floor space in Spain (BPIE 2011) ............... 29
Figure 7 Age profile of residential floor space in Italy (BPIE 2011) .................. 30
Figure 8 Age profile of residential floor space in France (BPIE 2011) ............. 32
Figure 9 Age profile of residential floor space in Germany (BPIE 2011) ....... 33
Figure 10 Importance rating of factors for the choice of property (ZEBRA2020) . 46
Figure 11 Belief in existence of rent/price surplus coming from high energy performance ratings (ZEBRA2020) ................................................................. 47
Figure 12 BEMS Functional Analysis .................................................................. 68
Figure 13 BEMS Taxonomy ................................................................................. 68
Figure 14 BEMS Market Analysis ....................................................................... 70
Figure 15 BEMS Market Analysis ....................................................................... 71
Figure 16 nZEB stakeholder map ........................................................................ 76
1 Executive summary

This report is the deliverable D8.2 of Task 8.4 of the RenoZEB Project, titled “1st RenoZEB Market assessment”. The aim of Work Package 8 is to contribute to boost the take-up of Near Zero Energy Buildings (NZEBs) and their systems in the market by defining and planning in detail the go-to-market strategy of the project results. The market analysis in the present report is the first stage of support to companies planning to exploit the project’s outputs to expand their participation in this market.

In particular, this deliverable has been aimed to provide a detailed overview of the dynamics of the nearly Zero Energy Buildings sector and renovations in the European Union. The objective was to acquire a deep understanding of the observed drivers and barriers of NZEB construction and renovations in order to optimise the introduction of RenoZEB solutions and packages into the market, overcoming foreseen obstacles.

The main document defining Nearly Zero Energy Buildings (NZEBs) in the European Union is Directive 2010/31/EU of the European Parliament and of the council of 19 May 2010 on the energy performance of buildings (the EPBD) (European Parliament, 2010). According to the EPBD, within the end of 2018, public authorities that occupy and own a new building shall ensure that the building is a “nearly zero energy building” and by the end of 2020, all new buildings must be “nearly zero energy buildings”.

The ageing EU building stock, together with the priorities for the European Union to comply with its objective to reduce greenhouse gases by 80–95% in 2050 and energy consumption by 20% in 2020, represent a large market for RenoZEB solutions.

Today, renovation rates of all types and depths in the EU are oscillating between 0.5% and 2.5% per year. With long term averages at about 1%, about 250 million square meters of floor space are renovated each year1

The political momentum with regard to the renovation market should favour market-penetration for the RenoZEB consortium.

Drivers and barriers for the implementation of RenoZEB solutions have been identified.

The key drivers may be categorised in a number of areas:

- Legislation – the EPBD and other EU directives and their transposition to national legislation;
- Demand – where demand exists, this can drive the market. However, if there is a lack of demand this may be seen as a barrier;
- Financial drivers – a number of different financial drivers may exist. First is the fact that NZEBs have lower energy costs, secondly there may be incentives for their construction or for consumers who buy such houses;
- Public sector support – as distinct from pure legislation;

1IPOL study.
Key barrier categories are as follows:

- **Technological barriers** - there is a wide lack of skills and expertise in the construction sector, as well as uncertainty as to how new and innovative technologies can perform;
- **Financial barriers** - the lack of access to affordable financing programmes to carry out deep renovation actions meeting nearly-Zero standards is the main barrier, and higher costs can also be a factor;
- **Regulatory and legislative barriers** - the unclear definition of NZEB and a lack of policy coherence;
- **Market barriers** - the numerous players involved (architects, engineers, specifiers, purchasers, contractors, lenders, owners, and tenants) in deep renovation process have different financial motivations that discourage investment in innovative energy-efficient solutions.
- **Informational barriers** - a lack of knowledge with existing solutions by professionals is exacerbated by the lack of mainstream examples of good practice and robust data from nearly zero energy homes, which has fostered an atmosphere of confusion and misunderstanding.
- **Behavioural barriers** - saving energy is not simply a technical issue, but it also depends on the lifestyle of residents.

A clear understanding of the barriers, the correct identification of drivers, potential competitors, customers and stakeholders - that are different in the various countries - are the key to ensuring the commercial success of RenoZEB solutions.

In order to understand how market dynamics in terms of barriers and drivers play out in some of the most interesting regions for the RenoZEB project, we have observed which drivers and barriers are most prevalent in specific geographic markets that are most represented in the consortium - i.e. Spain, Italy, France, Germany.

By having observed these 4 important markets for the RenoZEB project, it has been possible to identify the most recurring types of drivers and barriers. In most cases, financial packages and innovative approaches are starting to emerge and create growth in the nZEB sector. Moreover, all countries have fixed objectives in terms of nZEB compliant with the EPBD. Nevertheless, in many cases the lack of clear nZEB definitions or roadmaps as well as regulatory overlap between regional and national bodies hinders the growth process.

A careful analysis of the three main reference markets prefabricated multifunctional modular “plug and play” systems for building renovations, ICT toolsets/BIM, Smart control & monitoring systems market segment has been performed in order to ensure that all RenoZEB solutions are aligned and respond to market demands.

A stakeholder map has been produced in order to identify the key stakeholders that can influence or impact the deployment of a RenoZEB-type solution.

These key stakeholders are from the supply side, technology vendors, maintenance and construction companies that are involved in reconfiguring business models and supply chains.
around the nZEB paradigm. While from the demand side, key actors such as housing portfolio managers and real estate sales agents have a major role in creating a sufficient volume of demand to incentivise the necessary supply-side shifts.

It is important to note that given the focus and objectives of the project, all of these observations and studies have been carried with particular emphasis given on residential buildings.
2 Objectives of the report

The deliverable D8.2 is included in the WP8 (Replication, Exploitation and Business Plan), whose objective is to define an exploitation strategy to penetrate the market, and is part of the task 8.4 (Market Intelligence Activities) which aims to identify current and future competitors and to detect new trends to make sure that RenoZEB will not be overcome by out-of-the-radar market evolutions.

The objectives of the report are:

- The identification of emerging market trends and threats imposed by political, economic, and social conditions;
- The identification RenoZEB potential competitors, customers, stakeholders;
- The identification Market barriers and drivers;
- The description of the most relevant geographical markets for RenoZEB Project;
- The identification and description of the three main RenoZEB reference markets.
3 Overview of the Zero-energy Buildings industry

As the European Union is trying to reduce the GHG emissions and energy consumption of its building stock through the implementation of the Energy Performance of Buildings Directive (EPBD, 2010/31/EC), its objective is for all buildings built post 2020 to be nZEB – with public buildings required to achieve this milestone by the end of 2018 (2019 onwards). In this framework and in the RenoZEB project, nZEB buildings are considered to be very high energy performant buildings for which nearly zero or very low amount of energy required can be covered by onsite or nearby renewable energy sources. Article 9 of the EPBD requires member states to set national nZEB definitions and promote the market uptake of such solutions by developing national plans including precise measures, policies and financial incentives that will be put in place in order to achieve these objectives.

This section will focus on providing a detailed overview of the dynamics of the nearly Zero Energy Buildings (nZEB) sector and renovations in the European Union. The objective is to acquire a deep understanding of the observed drivers and barriers of nZEB construction and renovations in order to optimise the introduction of RenoZEB solutions and packages into the market, overcoming foreseen obstacles. Moreover, obtaining information on market size from a current revenue perspective, as well as market potential, growth rates and trends will enable the partners to start establishing reasonable market penetration objectives over time. Finally, the relationship between property value and energy efficient renovations of an extensive nature such as the ones implied by nZEB will also be explored. Since part of the project focuses on offering tools for revaluating real estate, it is crucial to comprehend impacts on property value of deep/nZEB renovations and in which circumstances they offer the higher benefits in that respect.

It is important to note that given the focus and objectives of the project, all of these observations and studies will be carried with particular emphasis given on residential buildings.

3.1 General renovation and nZEB market trends

3.1.1 General renovation market trends

One of the priorities for the European Union to comply with its objective to reduce greenhouse gases by 80-95% in 2050 and energy consumption by 20% in 2020 is to spur the currently low renovation rates situated around 1% to 3% of the 25 billion m² in building stock which account for 40% of the EU’s energy consumption, 36% of its CO2 emissions and 55% of its electricity consumption. As demonstrated in the following figure which illustrates main trends in the European building stock, more than 80% of residential floor space in all three regions, as determined on the map, dates back to the pre-1990’s and among these same buildings, more than 30% of the floor space dates back to the pre-1960’s (BPIE 2011).
This data demonstrates that the ageing EU building stock represents a large market for RenoZeb solutions and offer economic opportunity for the European Union as a whole, already worth approximately EUR 109 billion and consisting of 882,900 jobs in 2015 (IPOL study). Moreover, in order to maximize the potential for savings and comply with the EPBD requirements and EU overall objectives, the growth in renovation rates must come through a larger scale deployment of nearly zero-energy buildings technologies and approaches.

Currently, renovation rates of all types and depths in the EU are oscillating between 0.5% and 2.5% per year. The variation of this figure is in part due to the sporadic and time limited nature of certain renovation programmes and aids for renovations. With long term averages at about 1%, about 250 million square meters of floor space are renovated each year (IPOL study).
According to Article 2 of the EPBD Recast, “major renovations” are defined as renovations where the total cost of the renovation relating to the envelope or its systems is more than 25% of the value of the building, or where more than 25% of the surface of the building envelope undergoes renovation. The ZEBRA2020 project eliminates the disparities that exist in defining these renovations between member states by stating that with major renovations, a building’s final energy demand for heating can be reduced by 50 to 80% (range depending on the country defined by national experts according to the current efficiency of the building stock). The following figure summarizes the most recent statistics obtained by member states adopting the ZEBRA2020 definition, reflecting well the average 1% renovation rate (ZEBRA2020).

These particular kinds of semantics on renovation depths are extremely important as they enable experts and analysts to differentiate categories and then establish market share and penetration rates of each type. The following table summarizes the BPIE’s take on renovation typologies from 2011.
Table 1 BPIE Depth of Renovations 2011

| Minor renovations: the implementation of 1 or 2 measures (e.g. a new boiler) resulting in a reduction in energy consumption of between 0% and 30% | ~€60/ m² |
| Moderate renovations: involving 3-5 improvements (e.g. insulation of relevant parts of the dwelling plus a new boiler) resulting in energy reductions in the range of 30%-60% | ~€140/ m² |
| Extensive renovations: in this approach the renovation is viewed as a package of measures working together leading to an energy reduction of 60%-90% | ~€330/ m² |
| Almost Zero-Energy Building renovations: the replacement or upgrade of all elements which have a bearing on energy use, as well as the installation of renewable energy technologies in order to reduce energy consumption and carbon emission levels to close to zero | ~€580/ m² |

Although the current dynamics in the EU in terms of the age of the building stock, as well as environmental policies and regulations would tend to indicate a positive environment for the full development of nZEB renovations as a standard, it becomes obvious observing the BPIE 2011 definitions, that this is not the case and that they still represent a niche. Of course, since this research was published in 2011 and that new standards and obligations in relation to nZEB are introduced, it is likely that these rates have slightly evolved. The scarcity of data and reported statistics in this respect makes it extremely difficult to obtain an updated and accurate figure. Nevertheless, the political momentum with regard to the nZEB and renovation market should favour market-penetration for the Renozeb consortium, as long as the market barriers identified during the project are all addressed during the commercialization phase of the product.

3.1.2 nZEB market trends

In relation to more sector specific nZEB trends, Grand View Research Inc. has lead investigations that have estimated the future global market size of the Zero net energy buildings sector at $78.8 billion in 2025 accounting for a CAGR of around 28.9%.

Beyond the simple macro trends associated to nZEB renovations which are a clear representation of the market potential for Renozeb retrofits and compatible systems, the technological and material orientations as well as necessities for complying with the anticipated volume of demand have also been studied. From the current availability of documented nZEB cases, a clear set of trends in materials, systems and approaches can be identified although with certain levels of variability in practice

according to the climatic area, the local building codes, the height of the building and prevailing fire safety laws. As far as the materials for residential buildings are concerned, starting with envelope solutions, the most common and diffused material seems to be expanded polystyrene. The following graph which shows national sales levels of the material clearly demonstrates climatic effects on renovation practices with higher sales levels in colder climates where thickness will often be substantial compared to milder climates (ZEBRA2020 tool).

**Figure 3 Expansible polystyrene regional market sales in 2013**

In terms of window installations, windows are more often triple glass or low emission double glass in colder climates than in warmer climates. This is supported by the fact that the observed average U-values in windows are at 0.85 W/m²K for colder winter climates and 1.15 W/m²K for warmer more temperate climates. Furthermore, as demonstrated by the following table, multiple layered glassed installations seem to take up a larger share of buildings in cold climates (ZEBRA2020 tool).
Figure 4 multiple layered glass sales 2013

From a systems or technological point of view, more than 80% of nZEBs use mechanical ventilation with heat recovery systems. The main difference in that respect at a country level is the type of system for heat recovery, which is also a result of the climatic zone as well as national specificities such as the use/deployment or not of district heating systems. The most common renewable energy systems in warmer climates with higher levels of radiation are photovoltaic panels as well as thermal solar systems. Local regulations related to renewable energy sources as well as current system subsidies also explain discrepancies in the implementation and propagation of certain technologies.

Certain markets for materials, heat pumps, ventilation systems and other implements will have to develop in order to support and comply with the future increases in renovation demand. In 2011, the BPIE has estimated the needed market growth rates of relevant nZEB sectors in order to respond to greater market evolutions and demand that would emerge in the EU. The following table recapitulates these estimations.

<table>
<thead>
<tr>
<th>Markets</th>
<th>Required growth factor in 2011</th>
<th>2011 market size</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation materials</td>
<td>2-3</td>
<td>2010</td>
<td>Millions €</td>
</tr>
<tr>
<td>Ventilation with HR</td>
<td>8-10</td>
<td>130,000</td>
<td>Units</td>
</tr>
<tr>
<td>Triple glazed windows</td>
<td>&gt;10</td>
<td>1,500,000</td>
<td>m²</td>
</tr>
<tr>
<td>Heat pumps</td>
<td>2-3</td>
<td>185,000</td>
<td>Units</td>
</tr>
<tr>
<td>Pellet boilers</td>
<td>2-3</td>
<td>43,000</td>
<td>Units</td>
</tr>
<tr>
<td>Solar thermal systems</td>
<td>2-3</td>
<td>3,700,000</td>
<td>m²</td>
</tr>
</tbody>
</table>

Table 2 Growth factors of relevant nZEB product and materiel categories to satisfy future demand

In order to explore these relevant reference markets more in depth, this document will provide a deeper analysis in Section 4 with insights on potential competitors, features and trends.

3.2 Drivers and barriers to residential nZEBs

Several projects like Energiesprong, Szybinska-Matusiak and FosterREG have pointed out a mismatch between demand and supply in the energy retrofit industry. In order to better understand how the main market players perceive nZEB and EPCs, it is essential to get a closer look on what is their view of the energy efficiency market. On one hand, the demand side finds it hard to realise opportunities that are not considered too expensive while on the other, the

---

supply side supports the idea that attractive and cheaper opportunities would exist if the demand was higher⁶.

Outlining the profile of homeowners as potential investors in energy efficiency, EEFIG underlined the key elements that are expected to increase the demand for such investments in energy efficiency. Tailored-made financing offers with low interest rates and fast-track procedures accompanied by low transaction costs, would offer an attractive and investment-friendly environment. Of course, these measures should be shaped to address householders’ priorities and preferences⁷.

The main drivers perceived by actors on the supply side of energy efficiency investments, are mainly: a. standardisation of energy efficiency investment processes, to enable a common understanding and better communication between stakeholders and financial institutions and b. regulatory stability based on a strong and stable regulatory framework supported by ESI (European Structural and Investment Funds) funds to leverage private investments and provide technical expertise⁸.

### 3.2.1 Market drivers

The main categories of drivers are legal, financial, technological and informational drivers.

#### Legal drivers

The relevant legislation at EU level is mainly based on two pillars: the EPBD (as mentioned previously) as well as the Renewable Energy Directive. Both are currently under revision. Both of them require transposition and national strategies on part of Member States to foster the penetration of nZEB buildings for new constructions as well as renovations, an objective which is closely related to the Renozeb project’s objectives.

The revised Energy Performance of Buildings Directive (EPBD) introduces in Article 9 the concept of nearly Zero -Energy buildings (nZEB) as a future requirement to be implemented from 2019 onwards for public buildings and from 2021 onwards for all new buildings.

In this Directive, a nearly Zero-Energy Building is defined as a “building that has a very high energy performance. The nearly zero or very low amount of energy required should to a very significant extent be covered by energy from renewable sources, including renewable energy produced on-site or nearby.” This definition remains relatively open and is not defined by quantitative or more specific values in order acknowledge the variety of building typologies, energy systems and climate throughout the EU. Therefore, no uniform approaches for implementing nearly Zero-Energy Buildings or for calculating the energy balance are prescribed. That is why Article 9 of the

---

⁶ Ibid
⁸ Ibid
EPBD provides for flexibility by requiring Member States to establish national including the following (Article 9 Paragraph 3):

- A definition of nearly Zero-Energy Buildings, reflecting national, regional or local conditions and include a numerical indicator of primary energy use, expressed in kWh/m² per year.
- Intermediate targets for improving the energy performance of new buildings by 2015.
- Information on policies, financial or other measures adopted for the promotion of nearly Zero-Energy Buildings, including details on the use of renewable sources in new buildings and existing buildings undergoing major renovation (Article 13(4) of Directive 2009/28/EC and Articles 6 and 7 of Directive 2010/31/EU).

Taking this into consideration, it becomes clear that one of the clear drivers to be observed for the nZEB market is the existence of precise definitions at national level that impose certain performance based measures for new buildings and also, more importantly for the sake of this project, for existing buildings. The following map and table indicate the progress of nZEB definitions so far throughout Member States for residential buildings. The map gives a general overview of the situation from a national program point of view whereas the table provides more details.

---

### Figure 5 Status of nZEB definitions

<table>
<thead>
<tr>
<th>Country</th>
<th>Status of definition</th>
<th>Year of enforcement</th>
<th>EPBD scope of nZEB definition</th>
<th>Maximum primary energy [kWh/m²y]</th>
<th>Share of renewable energy</th>
<th>Other indicators</th>
<th>Status of definition</th>
<th>Maximum primary energy [kWh/m²y]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td></td>
<td>2019/2021</td>
<td></td>
<td>160</td>
<td>C02, EP</td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Belgium - Brussels</td>
<td></td>
<td>2015/2015</td>
<td></td>
<td>45</td>
<td>Qualitative</td>
<td>EP, OH</td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Belgium - Flanders</td>
<td></td>
<td>2019/2021</td>
<td>30% PE consumption of reference building</td>
<td>Quantitative with requirements depending on RES in place</td>
<td>EP, OH</td>
<td>Under development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Still to be approved</td>
<td>2019/2021</td>
<td>~30-50 (still to be approved)</td>
<td>Quantitative</td>
<td>EP</td>
<td>Same as new buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Croatia</td>
<td></td>
<td>2019/2021</td>
<td>33-41 (location dependant)</td>
<td>Minimum share in current requirements</td>
<td>EP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Year/Status</td>
<td>Minimum Share of PE of Reference Building</td>
<td>Qualitative Requirements</td>
<td>Additional Details</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------</td>
<td>-------------------------------------------</td>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyprus</td>
<td>2019/2021</td>
<td>100</td>
<td>EP</td>
<td>Same as new buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2018-2020 (size dependent)</td>
<td>75-80% PE consumption of reference building only considering non-renewable PE</td>
<td>EP, TS</td>
<td>Same as new buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>2019/2021</td>
<td>20</td>
<td>EP, OH, TS</td>
<td>Same as new buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>2019/2021</td>
<td>50-100 depending on reference building</td>
<td>Qualitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>Under development</td>
<td>Consumption of appliances is included as well</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>Definition of positive energy buildings ongoing 2020</td>
<td>40-65 depending on reference building and location</td>
<td>Quantitative with requirements depending on RES in place</td>
<td>80 depending on location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>Under development</td>
<td>40% PE consumption of reference building</td>
<td>Minimum share in current building requirements</td>
<td>Under development 55% PE consumption of reference building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>Under development</td>
<td>50-72 depending on reference building</td>
<td>Quantitative</td>
<td>Under development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>Under development</td>
<td>Included in upcoming nZEB national plan but will depend on location and reference building</td>
<td>Quantitative with requirements depending on RES in place</td>
<td>75-150</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>2019/2021</td>
<td>45</td>
<td>C02</td>
<td>Under development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>Still to be approved</td>
<td>95</td>
<td></td>
<td>Same as new buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latvia</td>
<td>2019/2021</td>
<td>95</td>
<td>EP</td>
<td>Same as new buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lithuania</td>
<td>2019/2021</td>
<td>Comply with class A++</td>
<td>Quantitative</td>
<td>EP, TS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luxembourg</td>
<td>Details to be fixed</td>
<td>No cooling for residential buildings</td>
<td>Comply with class A-A-A</td>
<td>EP, C02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malta</td>
<td>Under development</td>
<td>Building needs to comply with energy performance coefficient=0</td>
<td>Qualitative</td>
<td>EP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>2019/2021</td>
<td></td>
<td></td>
<td>EP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3 Status of National nZEB definitions for Residential buildings within scope of EPBD

For the countries that do not have a precise definition of nZEB standards, this lack obviously constitutes a barrier for the full implementation and market penetration of nZEBs. A closer analysis of this table shows that the nZEB national requirements, plans and definitions are focused on standards and performance measures for new residential constructions. For these buildings, most standards set a limit of 50kWh/m²/year in primary energy use although there are regional variances according to building type (multi-family or single family for instance) as well as building location (colder climates etc...).

What is of particular interest to this project is the status of existing buildings and nZEB national definitions within the scope of the EPBD methodology. As seen in the map and table, currently only 13 Member States have put in place clear criteria for nZEB renovation guidelines with some – such as Austria, France and Brussels – having higher tolerances in primary energy use requirements than for new buildings. Although the focus for nZEBs for 2020 is on new...
constructions, Article 9 of the EPBD still sets requirements for policy development that should stimulate renovations of this type. However, considering the uniformity of standards generally observed between new buildings and existing buildings for nZEBs, the Renozeb consortium can most of the time use the already existing criteria for new buildings.

The Renewable Energy Directive (RED) also sets requirements related to buildings with specific mention of integrating renewables to cover energy needs as well as a direct reference to zero energy buildings. The Article 13 of the Renewable Energy Directive stipulates that:

- By 31 December 2014 Member States shall, in their building regulations and codes, where appropriate, require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation. Member States shall permit those minimum levels to be fulfilled, inter alia, through district heating and cooling produced using a significant proportion of renewable energy sources. Moreover, in establishing such measures or in their regional support schemes, Member States may take into account national measures relating to substantial increases in energy efficiency and relating to cogeneration and to passive, low or Zero-Energy Buildings.” (Article 13.4)
- Member States shall ensure that new and existing public buildings that are subject to major renovation, at national, regional and local level fulfil an exemplary role in the context of this Directive from 1 January 2012 onwards. Member States may, inter alia, allow that obligation to be fulfilled by complying with standards for zero-energy housing, or by providing that the roofs of public or mixed private public buildings are used by third parties for installations that produce energy from renewable sources. (Article 13.5)

All of these provisions are set in place with the objective of achieving a consolidated 20% energy consumption share of renewables in the EU by 2020. The renewable Energy Directive recast sets national targets for renewables integration within the grid taking into consideration country specific factors such as its starting point and overall potential for renewables. The following table summarizes the targets for each MS.

<table>
<thead>
<tr>
<th>National overall targets</th>
<th>2020 target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>34%</td>
</tr>
<tr>
<td>Belgium</td>
<td>13%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>16%</td>
</tr>
<tr>
<td>Cyprus</td>
<td>13%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>13%</td>
</tr>
<tr>
<td>Denmark</td>
<td>30%</td>
</tr>
<tr>
<td>Estonia</td>
<td>25%</td>
</tr>
<tr>
<td>Finland</td>
<td>38%</td>
</tr>
<tr>
<td>France</td>
<td>23%</td>
</tr>
<tr>
<td>Germany</td>
<td>18%</td>
</tr>
</tbody>
</table>
### Table 4 National Renewable Energy integration targets for 2020 (% of energy consumption from renewables)

<table>
<thead>
<tr>
<th>Country</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greece</td>
<td>18%</td>
</tr>
<tr>
<td>Hungary</td>
<td>13%</td>
</tr>
<tr>
<td>Iceland</td>
<td>72%</td>
</tr>
<tr>
<td>Ireland</td>
<td>16%</td>
</tr>
<tr>
<td>Italy</td>
<td>17%</td>
</tr>
<tr>
<td>Latvia</td>
<td>40%</td>
</tr>
<tr>
<td>Lithuania</td>
<td>23%</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>11%</td>
</tr>
<tr>
<td>Malta</td>
<td>10%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>14%</td>
</tr>
<tr>
<td>Norway</td>
<td>67.5%</td>
</tr>
<tr>
<td>Poland</td>
<td>15%</td>
</tr>
<tr>
<td>Portugal</td>
<td>31%</td>
</tr>
<tr>
<td>Romania</td>
<td>24%</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>14%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>25%</td>
</tr>
<tr>
<td>Spain</td>
<td>20%</td>
</tr>
<tr>
<td>Sweden</td>
<td>49%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>15%</td>
</tr>
</tbody>
</table>

### Financial drivers

One of the most important market drivers to boost nZEB building market penetration are the financial incentives that are available on the market for these types of constructions and renovations. Financial incentives exist at two levels. The first level is for building owners and/or end-users and the second is for construction companies themselves who now have at their disposal certain financial mechanisms that can alleviate the higher costs associated to nZEB renovations or constructions in general. Financial incentives in the traditional sense of the word have become more available. For instance, end users can benefit from national aid programs for energy efficient renovations. This driver can obviously become a barrier when taken from an opposite end and there is a lack of financing options as will be seen later in the report.

### Technological drivers

Technological improvements in the field of energy efficient and nZEB refurbishments are likely to drive the market forward. As technologies improve so do the potential savings in energy bills which should make renovations more attractive for building/home owners. Of course, this is...
dependent on these technological solutions being sufficiently scaled in the market in order to be implemented at reasonable costs. Moreover, ICT innovations can lead to more precise simulations of operational energy consumption and greatly reduce the performance gaps and thus alleviate some of the general uncertainties that were traditionally associated with energy efficient buildings in terms of the actual returns on investment and lower energy bills obtained post-retrofit.

**Informational drivers**

From a general point of view, and probably also as a result of the two previous drivers mentioned, awareness and knowledge in terms of green buildings and energy efficient renovations is increasing. This should inevitably impact the nZEB market sector. All buildings or properties are now obliged to have an energy rating and more and more certifications are available and being used such as HQE Exploitation, BREEAM or LEED although these are more relevant to the commercial sector and performed most often on new constructions. Furthermore, training programs for the implementation of the most modern systems are flourishing.

**3.2.2 Market barriers**

At this point in time, there are more identified barriers or categories of barriers compared to drivers, partly due to the fact that studies so far have principally focused on identifying these and also because from a general point of view, nZEB and high energy performance buildings still do not benefit from full market standardization and normalization especially in terms of the residential sector which ultimately is the problem this project aims to alleviate and bring solutions to. As a result of this asymmetry, a more in depth and detailed nomenclature of barriers is presented in this section of the deliverable.

After having consolidated the information, observations and analysis of prior reports from the European Union, BPIE and various EU funded projects such as ZEBRA2020 project and others along with the analysis carried out by the Renozeb partners as well, six main barrier typologies can be distinguished: Financial, Technological, Behavioural, Political/Structural/Societal, Informational, and finally embedded market structures and deficiencies.

The following section provides in the form of tables a more descriptive account of the types of barriers observed within each typology as well as a brief description or example and potential policies that could alleviate them. Even though the listed barriers below provide a general picture of the nZEB market in EU countries, country specific barriers (chapter 3.2.3) to depict national and local specificities testify a diverse and rather complex nZEB market environment.

**Financial Barrier Typology**
<table>
<thead>
<tr>
<th>Barrier</th>
<th>Example/Description</th>
<th>Policy solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment approach</td>
<td>• Lack of integration of life cycle costs in financial decisions as well as other</td>
<td>Financial instruments, tax rebates, subsidized loans, subsidies to energy</td>
</tr>
<tr>
<td></td>
<td>external costs, e.g. relocation and vacancy costs10</td>
<td>efficiency improvements, regulations, removal of energy price subsidies, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>market based mechanisms.</td>
</tr>
<tr>
<td>Split incentive</td>
<td>It stems from the misplacement of incentives between different actors (e.g. landlords</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and tenants), which discourage energy efficiency improvements to come into effect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>in reality</td>
<td></td>
</tr>
<tr>
<td>Uncertainty in asserted</td>
<td>• Paybacks periods and ROIs vary and can be long.</td>
<td></td>
</tr>
<tr>
<td>KPIs and metrics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Externalities</td>
<td>• Price of energy and its volatilities and energy price subsidies.</td>
<td></td>
</tr>
<tr>
<td>Financing</td>
<td>• High upfront financing is required11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lack of incentives and third party financing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Imperfect mortgage market for EE12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loan eligibility of condominium owner associations13</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5 Typical financial barriers to nZEB renovations**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Example/Description</th>
<th>Policy solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospect theory and bounded rationality and risk aversion</td>
<td>• Even with complete information, decisions are often the product of individual</td>
<td>Support, information and voluntary action, voluntary agreements, information and</td>
</tr>
<tr>
<td></td>
<td>perspective and bias even in the case of rational utility maximizing decisions.</td>
<td>training programs, market-based mechanisms.</td>
</tr>
<tr>
<td></td>
<td>If the probability of profitability is 95% for a certain investment – such as</td>
<td></td>
</tr>
<tr>
<td></td>
<td>choosing very energy efficient windows rather than ordinary windows when</td>
<td></td>
</tr>
<tr>
<td></td>
<td>renovating – less than 95% of households (facing the choice) will invest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>because of their innate risk averse nature.14</td>
<td></td>
</tr>
</tbody>
</table>


• Focus on price and costs rather than returns
• Tendency to ignore small energy saving opportunities
• Other factors than financial gains, like emotional factors, aesthetics, ambience are more important on decision to renovate\(^{15}\)

**Poor citizenship**
• Energy theft and non-payment, corruption

**Table 6 Typical behavioral barriers to nZEB renovations**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Example/Description</th>
<th>Policy solutions</th>
</tr>
</thead>
</table>
| Performance Gap and uncertainty | • Difference between simulated or predicted savings with savings during actual building operation  
• Hinders the appeal and formulation of financial approaches and incentives such as EPCs. | Subsidies and loans for appropriate R&D and technological outputs, market based mechanisms |
| Research, development and demonstration of energy efficiency measures | Lack of technologies adapted to a certain combination of building typology and climate | |

**Table 7 Typical technological barriers to nZEB renovations**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Example/Description</th>
<th>Policy solutions</th>
</tr>
</thead>
</table>
| Structural | • Lack of support at the regional and local levels  
• Gaps in wealth between regions/Member States  
• Lack of nZEB definition in certain nations (as seen in map and table presented in drivers) | Enhanced implementation of command and control mechanism, policy incentives to encourage energy efficiency building design, enhanced international cooperation and technology transfer, public leadership programs. |
| Political | • Lack of incentive for investment  
• Lack of political motivation for needed market initiatives  
• Long and slow legislative process | |
| Regulatory | • Rent control, limited increase in rent possible in some national residential markets and sub-market – e.g. social housing, tense area in | |

[The literature is abundant. This particular paper shows that risk aversion in Swedish households is very high, and increasing with age.]

France, modernisation cost only in Germany
- Legal constraints on property value increase of post-renovation buildings\textsuperscript{16}
- Condominium law: require sufficient majority and sometimes unanimity

**Table 8 Typical political/structural/societal barriers to nZEB renovations**

<table>
<thead>
<tr>
<th>Informational Barrier Typology</th>
<th>Example/Description</th>
<th>Policy solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of knowledge dissemination</td>
<td>Lack of information and knowledge about EE products in markets on part of diverse parties. Lack of information and communication in relation to non-energy and non-financial benefits that result from refurbishments. This includes comfort, spillovers on productivity, health...</td>
<td>Awareness raising campaigns, training of building professionals, command and control instruments.</td>
</tr>
</tbody>
</table>

| Lack of knowledge of local market conditions | Deep understanding of the local market is needed to design customised solutions\textsuperscript{17} |

**Table 9 Typical informational barriers to nZEB renovations**

<table>
<thead>
<tr>
<th>Embedded Market Structures and inefficiencies</th>
<th>Example/Description</th>
<th>Policy solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragmentation of the construction and renovation market</td>
<td>Short term coalitions and ad-hoc subcontracting leads to: Lack of communication and poor coordination Adversarial relationships Inhibited learning opportunities Short term vision with lack of life cycle cost integration in project process Country specific cultural, industry and standardized processes Contract structures (PPPs...)</td>
<td>Market-based mechanisms, better repartition of duties, responsibilities and costs. Create national definitions of nZEB and threshold KPIs to eliminate cookie cutter tender and bid approaches.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Split Incentives and conflicts of interest</th>
<th>Oversizing of equipment Tenant vs owners interest</th>
</tr>
</thead>
</table>

| Time and pressure on profit margins | Contractors are selected through competitive tendering with price being one of the main drivers |


It goes without saying that this overview and nomenclature of market barriers may be missing certain elements that have been observed in certain situations. Nevertheless, these tables generally cover in one way or the other the most important barriers in the nZEB renovation market at the moment.

### 3.2.3 Dynamics in Renozeb markets of interest

In order to understand how market dynamics in terms of barriers and drivers play out in some of the most interesting regions for the Renozeb project, we will observe which drivers and barriers are most prevalent in a few of the geographic markets that are most represented in the consortium—i.e. Spain, Italy, France, Germany; and in line with the nomenclature of barriers and drivers performed previously.

#### 3.2.3.1 Spain

Most steps for the implementation of nZEB standards are established through the “National plan for increasing the number of nZEBs” from June 2014. After gathering information on the building stock, the plan sets intermediate targets for energy performance and also draws out legislation and financial initiatives along with educational programs that are needed for the long term implementation of nZEBs in the market. Moreover, the Código Técnico de la Edificación (Technical Energy Code) from 2009 establishes general guidelines. It requires a performance based reference building calculation to show compliance. Moreover, it focuses on thermal envelope requirements and energy efficiency standards in calculations with HVAC, hot water, lighting and auxiliary systems. Finally, it includes requirements on renewables integration such as PV systems, post occupancy testing of boilers and HVAC systems and mandatory performance requirements for existing buildings.\(^\text{19}\)

From a building typology point of view, the Spanish building stock is mainly composed of pre 1980’s buildings (+60%) and most are privately owned and occupied on a year round basis.
It is important to note that technical and qualitative standards for buildings before the 1980’s (1979/ first prescriptive energy efficiency requirements) were inexistent, reflecting a need for extensive renovations within the country in order to comply with EPBD. The organization in charge of working on these issues is the “Energy Diversification and Savings Institute” more commonly known as simply IDAE.

- **Commonly identified drivers in Spain**

<table>
<thead>
<tr>
<th>Driver Typology</th>
<th>Driver</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Economic support measures</td>
<td>Several ongoing economic support measures targeting mainly renovation of existing buildings, both non-residential and private houses and dwellings</td>
</tr>
<tr>
<td></td>
<td>Tax deductions</td>
<td>21% to 10% tax reduction for completing energy efficient renovations in residential buildings</td>
</tr>
<tr>
<td></td>
<td>New funding available</td>
<td>Long term investment funds, energy service companies (ESCO) and “Green Investment Funds” are emerging</td>
</tr>
<tr>
<td>Legislative</td>
<td>National/regional and local legislation</td>
<td>Supportive legislation being drafted</td>
</tr>
<tr>
<td></td>
<td>Environmental Action Plans</td>
<td>The Ministry of Agriculture, Food and Environment (MAGRAMA) designed to reduce greenhouse gas and improve efficient use of energy and resources with a specific section on the building sector.</td>
</tr>
</tbody>
</table>

**Table 11 Identified drivers for nZEB renovations in the Spanish market**

- **Commonly identified barriers in Spain**

<table>
<thead>
<tr>
<th>Barrier Typology</th>
<th>Barrier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Financing</td>
<td>Low income and lack of available funding. As seen in drivers, some support programs are in play but there is still a lack of funding opportunities or mechanisms. It will be important to see how emerging funding opportunities as described in the drivers section will fill in this gap.</td>
</tr>
<tr>
<td>Financial/behavioral</td>
<td>Investment approach/Prospect theory and bounded rationality</td>
<td>The high initial cost of implementing nZEB compliant energy systems without taking into consideration the potential long term life cycle cost savings discourages most. The lack of cost-benefit ratios for HVAC or DHW systems force customers to base their investments on the initial price.</td>
</tr>
<tr>
<td>Technological</td>
<td>Performance gap and uncertainty</td>
<td>Spain is conservative and shows skepticism toward implementing the use of new and uncertain energy saving systems available on the market. Moreover, there is a general reluctance to study the profitability for different energy efficient solutions for different typological situations, accentuating the uncertainty in potential savings (performance gap) and returns on investment after implementing certain technologies.</td>
</tr>
<tr>
<td>Informational</td>
<td>Lack of knowledge dissemination</td>
<td>Shortage of educational and training offers targeting the market of energy efficient measures with a lack of qualifications for installing the most innovative systems.</td>
</tr>
</tbody>
</table>

**Table 12 Identified barriers for nZEB renovations in the Spanish market**
3.2.3.2 Italy

Most of the feedback obtained for the market dynamics of the Italian market are from six European projects with different relevant organizations, owners, representatives of public nZEB buildings and property owners/developers for nZEB buildings in Italy.

From a building stock point of view, 40% of the residential building stock was built before the 1960’s whilst around 93% of the residential building stock was built before the 1990’s meaning that there is a great need and potential for renovations due to the absence of stringent and clear standards regarding construction during those years compared to what is now required by the EPBD.

Having created the Common Energy Law in 2015, a nationally adopted regulation for compliance with EPBD objectives and in which nZEB definitions and frameworks are stipulated\textsuperscript{20}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{age_profile_italy.png}
\caption{Age profile of residential floor space in Italy (BPIE 2011)}
\end{figure}

- Commonly identified drivers in Italy

\begin{table}[h]
\centering
\begin{tabular}{|l|l|p{12cm}|}
\hline
Driver Typology & Driver & Description \tabularnewline \hline
Legislative & Common Energy Law & Came into effect in October 2015 and includes the regionally adapted official nZEB definition for Italy. Within this legislation comes compliance with the EPBD through established methodologies on energy performance calculations using renewable energy sources in buildings and minimum requirements for energy performance of refurbishments with a 5 year revision cycle of these. \tabularnewline \hline
Technological & Common Energy Law & The Common Energy Law has also established the best technological solutions for nZEB renovations and construction in terms of envelope and technical systems. \tabularnewline \hline
Financial & Common Energy Law & Definition of the best contracting measures available nationally. \tabularnewline \hline
\end{tabular}
\caption{Identified drivers for nZEB renovations in the Italian market}
\end{table}

- Commonly identified barriers in Italy

\begin{table}[h]
\centering
\begin{tabular}{|l|p{12cm}|}
\hline
Barrier Typology & Barrier & Description \tabularnewline \hline
Informational & Lack of knowledge dissemination & Not many professionals are trained and knowledgeable on nZEB systems and technologies. Moreover, owners and building end-users themselves are suspicious on the actual efficiency gains and \tabularnewline \hline
\end{tabular}
\caption{Identified barriers for nZEB renovations in the Italian market}
\end{table}

\textsuperscript{20}Mellegard, Sofie, et al. Market Acors’ NZEB Uptake - Drivers and Barriers in European Countries. Market Acors’ NZEB Uptake - Drivers and Barriers in European Countries.
possibilities offered by nZEB solutions or even energy efficient renovations and improvements as a whole.

<table>
<thead>
<tr>
<th></th>
<th>Structural issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political/Structural/Societal</td>
<td>This barrier has been resolved through the previously mentioned Common Energy Law of 2015. Nevertheless, it is still of importance to note it down for understanding potential dynamics in other markets. Before the implementation of this law in Italy, there was no national standards for nZEB definitions and processes. Eleven regions of the 21 in Italy had their own transposition of the EPBD while the rest followed a national legislation. This created a situation with two levels of standards and performance requirements which could lead to eventual conflicts with some regional legislations having higher ambitions or vice versa with regard to nZEB renovations.</td>
</tr>
</tbody>
</table>

Table 14 Identified barriers for nZEB renovations in the Italian market

3.2.3.3 France
The strategy for nZEB and energy efficient renovations and construction in France are pushed through by the Ministry for the Ecological and Inclusive Transition. The ministry has set a great deal of emphasis on energy efficient and sustainable renovations through the following main axes:

- Before 2025, all privately owned residential buildings with primary energy consumption levels superior to 330 kWh/m²/year must be renovated.
- 500,000 dwellings per year must be renovated starting in 2017 with half of these corresponding to low income homes.
- Have a 100% high energy performance building stock by 2050

In order to complete these objectives, the Ministry for the Ecological and Inclusive Transition has the French Environment & Energy Management Agency, also commonly known as ADEME, at its hand which can serve as an investment, educational and advisory arm.

Furthermore, the RT2012, created after the recast of the EPBD, includes mandatory renewable energy requirements, mandatory computer simulation, mandatory air-tightness testing for residential buildings, bio-climatic design considerations, extensive training of assessors, well established labelling and certification schemes and a target to build energy positive buildings by 2020.

France’s residential building stock, much like the rest of Europe and the European Union, is mainly comprised of pre-1990’s buildings. More specifically, 43% of residential buildings were built in the pre-1960’s while 37% were built between 1961 and 1990 making for a grand total of 80% of residential buildings dating back to the pre 1990’s. Despite having building energy efficiency requirements dating back to 1955, a performance based standard was only implemented in 2005. Naturally, and considering the presence of a continental type climate over much of the
territory with cold winters and hot summers, this should be a market with needs in renovations and potential traction for nZEBS\(^{21, 22}\).

![Age profile of residential floor space in France](image)

**Figure 8** Age profile of residential floor space in France (BPIE 2011)

- Commonly identified drivers in France

<table>
<thead>
<tr>
<th>Driver Typology</th>
<th>Driver</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong></td>
<td>Financing</td>
<td>The ministry implements tools allowing to model financial instruments in line with the different types of work or thermal equipment to calibrate tax credits (amount, rates, period, etc.).</td>
</tr>
</tbody>
</table>
| **Informational** | Knowledge | Training programs and platforms to train professionals are being created. (RGE, Plateforme PRIS, etc...)
| | Awareness | The Building Social Union (Union Sociale pour l’Habitat) has positive returns from renters on increased comfort levels from nZEB renovations. |
| **Legislative** | Mandatory renovation | Renovation should become mandatory in case of transaction between 2020-2030 |
| | Law on Energy Transition | Enforces thermal insulation of collective dwellings in case of maintenance of facade |
| | RT2012 and EPBD compliance strategy | Regulatory frameworks for energy efficiency and nZEB ambitions as described in the paragraph before the table respective to France. |

**Table 15** Identified drivers for nZEB renovations in the French market

- Commonly identified barriers in France

<table>
<thead>
<tr>
<th>Barrier Typology</th>
<th>Barrier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong></td>
<td>Financing/Investment approach/Prospect theory and bounded rationality</td>
<td>Investment costs are too high and unaffordable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difficulties to evaluate the renovation investment payback time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Financing models shall be more adapted or designed in relation to the different building types, i.e. collective or individual dwellings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EPC’s are mainly targeted towards large tertiary</td>
</tr>
</tbody>
</table>

\(^{21}\) Mellegard, Sofie, et al. *Market Acors’ NZEB Uptake - Drivers and Barriers in European Countries. Market Acors’ NZEB Uptake - Drivers and Barriers in European Countries.*

### 3.2.3.4 Germany

The relevant public institutions working on sustainability, renewable energy and buildings in Germany are principally the German Federal Ministry of Environment, the German Federal Ministry of Economic Affairs and Energy, the Federal Environment Agency and the Federal Office for Energy Efficiency. From a regulatory and strategic point of view with regard to EPBD objectives, two different regulations can be identified, the EnEV or energy saving ordinance as well as the EEWärmeG or renewable heat law.

The most pertinent one to our analysis is the EnEV which is a performance based code that requires mandatory energy frame calculation to establish the expected primary energy consumption of residential buildings. Specifically the regulation addresses thermal envelope requirements and energy using or producing systems with specific focus on HVAC, hot water, bio climatic design and renewable energy\(^\text{23}\)\(^\text{24}\).

Germany’s residential building stock is broken down as follows:

![Figure 9 Age profile of residential floor space in Germany (BPIE 2011)](image)

\(^{23}\) Mellegard, Sofie, et al. Market Acors´ NZEB Uptake - Drivers and Barriers in European Countries. Market Acors´ NZEB Uptake - Drivers and Barriers in European Countries.

The country has had prescriptive building energy efficiency requirements since 1977. However, these requirements are obviously not as stringent as the ones implied by the EPBD as well as the ones coming from the 2009 version of the EnEV.

- **Commonly identified drivers in Germany**

<table>
<thead>
<tr>
<th>Driver Typology</th>
<th>Driver</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislative</td>
<td>EnEV and the EEWärmeG</td>
<td>The policies have established low maximum u-values relevant to climate, mandatory computer simulation, air-tightness requirements, well established incentive schemes, frequent boiler and HVAC testing. The limits fixed in this framework are not necessarily pertinent to nZEB buildings. Nevertheless, they should have the effect of incentivizing energy efficient renovations which in turn should spill over to nZEB development. This is positively coupled with the fact that despite not having a clear roadmap for achieving this, a national target for carbon free buildings (nZEB) is established for 2020.</td>
</tr>
<tr>
<td>Financial</td>
<td>Kreditanstalt für Wiederaufbau (KfW)</td>
<td>The KfW promotes energy savings and CO2 reduction in the building sector through subsidies. Between 1990 and the end of 2009, more than 3.1 million homes benefited from subsidies with a total of €16.9 billion, with €10.6 billion for energy efficiency and €6.3 billion for renewable energies.</td>
</tr>
<tr>
<td>Financing</td>
<td></td>
<td>The EnEV provides a framework for EPC contracts.</td>
</tr>
<tr>
<td>Informational</td>
<td>Knowledge</td>
<td>On 4 May 2017, Germany introduced a new tool for the energy-efficient retrofitting of buildings, a renovation road map tailored to individual buildings. This software-based tool is used by energy advisors on efficiency in buildings (in German language) to give owners a clear overview of the modernisation work that their building needs. The tool points to untapped possibilities for energy conservation and the use of renewables, and also gives an estimate of the relevant investment costs and of the savings that could be achieved in terms of heating costs and carbon emissions.</td>
</tr>
</tbody>
</table>

**Table 17 Identified drivers for nZEB renovations in the German market**

- **Commonly identified barriers in Germany**

<table>
<thead>
<tr>
<th>Barrier Typology</th>
<th>Barrier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness</td>
<td></td>
<td>The EnEV focuses on awareness and informative programs. Germany is known as a country within the EU with higher levels of awareness in terms of energy efficient buildings and possibilities for retrofitting.</td>
</tr>
</tbody>
</table>
Although the EnEV set standards and supportive frameworks for energy efficient buildings and renovations, there are still certain limitations to the regulations. A target for buildings operating without fossil fuels is set for 2020. Moreover, by 2050 Germany is committed to reducing its primary energy demand of buildings by 80%. Nevertheless, there is no clear framework or more importantly no roadmap in place for the promotion/market penetration of nZEB renovations. Since the regulations concerning nZEBs are separated in two (EnEV and EEWärmeG), there is a need for harmonization between the two.

Table 18 Identified barriers for nZEB renovations in the German market

Performing a continuous and progressive observation of these country level market dynamics, the RenoZeb consortium should be able to draw out macro level or country level strategies for leveraging the different drivers and also overcoming barriers.

So far, by having observed these 4 important markets for the RenoZeb project, it is also possible to identify the most recurring types of drivers and barriers. In most cases, financial packages and innovative approaches are starting to emerge and create growth in the nZEB sector. Moreover, all countries have fixed objectives in terms of nZEB compliant with the EPBD. Nevertheless, in many cases the lack of clear nZEB definitions or roadmaps as well as regulatory overlap between regional and national bodies hinders the growth process.

3.3 Current trends and impacts of NZEB and deep retrofits in property value

The main objective of the RenoZeb project is to make nZEB renovations and retrofits for residential buildings attractive through property value increase as prices are a key mechanism for ‘harnessing market forces’. As a result of this, it is important to explore the current market dynamics and practices that exist in the overlap between energy efficiency renovations and the real estate sector.

As energy performance certificates (EPC) have become the norm in Europe for buildings at the point of construction completion, sale or rent, they constitute a common tool to assess energy efficiency renovation effect on prices in the European Union and therefore in the countries under scrutiny in this project. Such an approach is obviously limited to the assessment on the intrinsic potential energy efficiency as revealed by a certificate rather than realised performance outcome. Yet, with EPC becoming more prevalent, our objective is to observe the relationship between EPC rating and their influence on the perceived value of property by market professionals, owners and tenants. In order to do so we will assess the level of public understanding and awareness of EPC labels, the extent to which EPCs have been taken into consideration in transactions and home improvements and the effect that EPCs have had on property value (how much does value increase for an increment in EPC or what do particular brackets stand for in terms of valuation).

EPCs assign energy classes to individual buildings in order to inform a potential purchaser or tenant about the energy quality and consumption. In Austria, France, Norway, Romania, Italy and Spain, the EPC shows the energy performance of real estate on a scale from A to G. In contrast to this, Poland and Germany use a rating scale that goes from 0 to over 1000.
Yet, aware of the fact that the EPC can be used only as an imperfect benchmark to assess the potential increased of property value after energy efficiency renovation and the impact those renovations might have on market’s behaviour, we will try to enlarge the scope of our assessment to other factors than the EPC.

**3.3.1 EPC and energy efficiency impact on property prices**

There has been a growing set of research examining the relationship, if any, between a property’s EPC rating and its market or/and rental value. Several recent and ongoing EU funded projects conducted by leading and well-established valuers’ bodies together with key lending actors have made a full and near to exhaustive review of the existing literature on the topic. In this phase of the project and in this deliverable, we have compiled their findings as well as the conclusion of some of existing research on the issue. Most research use multiple regression analyses to test the hypothesis that a rating above the average (normally taken at a D rating) results in either a higher transaction price, or in the case of investment stock, higher rents.

**Literature review in relation to energy efficiency and value**

RICS, one of the leading world body of property valuers, notes in the Technical Report of the EeMAP project – Energy efficiency Mortgage Action Plan – that a review of the literature supports the view that in some sub-markets there is beginning to be evidence of linkage. “This linkage is gaining traction since the penetration of EPCs deepened following the recovery of housing markets some while after the global financial crash. However, the evidence in terms of a ‘brown discount’ for inefficient stock is beginning to be stronger than evidence of a ‘green premium’.” This, according to them, points to a market movement in which the general market requirement in terms of energy efficiency is increasing as standing stock has to compete with newer, more efficient, stock. Hedonic pricing studies using actual transaction data regressed against a number of known value drivers and energy labels indicate evidence of a strong “general” argument supporting differential values in which at the high end there a slightly enhanced value for energy efficient and a rather larger discounting of those which have poor energy efficiency.”

The following tables compiled in the framework of the EeMAP and REVALUE EU funded projects recapitulate the review of the existing literature on the topic. This review includes non-European research and expand beyond the EPC and its impact (especially for research conducted before 2012). Some of the survey and studies included use as benchmark other types of labelling schemes as well as energy efficiency improvements per se. Note that the authors of this review

---


26 Ibid
also have taken into account the existing meta-studies on the economic advantages of energy efficient / sustainable buildings.\textsuperscript{27,28,29}

Overview of studies on linking energy efficiency and sustainability to value\textsuperscript{30,31,32}

Residential Studies: overview, 2008- 2012

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
Study/Author & Year & Country & Sustainable features & Impact & Positive(v) or not (x) & Magnitude \\
\hline
Australian Dept. Environment, Water etc. & 2008 & Australia & Energy Efficiency star rating 0.5 increments 1-10 & Sales price & \checkmark & 1.23% to 1.91% per 0.5 star \\
Salih et al. & 2008 & Switzerland & MINERGIE label & Sales price & \checkmark & 7% houses; 3.5% flats \\
Griffin et al. & 2009 & USA (Portland/Seattle) & Variety: Built Green; Earth Advantage; Energy Star; LEED & Time to sell & \checkmark & Reduced by 18 days \\
Salih et al. & 2010 & Switzerland & MINERGIE label & Rental & & 6% \\
Wameling & 2010 & Germany & Primary energy demand per m\textsuperscript{2} & Sales price & \checkmark & €1.4 per reduced kWh/m\textsuperscript{2} \\
Brouen &ok & 2010 & Netherlands & EPC (grades A, B, C) & Sales price & \checkmark & 2.90% \\
Yoshida and Sugihara & 2010 & Japan & Tokyo Green Labelling system & Sales price & \checkmark & minus 6% - 11% \\
Wuerst and Partner & 2011 & Switzerland & MINERGIE label & Sales price & \checkmark & 4.90% \\
Muriel et al. & 2011 & Switzerland & Noise Exposure & Rental & \checkmark & 0.19% per decibel \\
Amecke & 2012 & Germany & Impact of EPC on purchasing decisions & Consumer preference & \checkmark & does not influence decision-making \\
Feige et al. & 2012 & Switzerland & Economic Sustainability Indicator (E3) & Rental & \checkmark & 15% (resource use); 11% health/comfort; 11% security \\
Ong and Quek & 2012 & Singapore & Green Mark & Sales Price & \checkmark & 4% to 6% \\
City of Darmstadt & 2012 & Germany & Primary energy value below 250 kWh/m\textsuperscript{2} or below 175 kWh/m\textsuperscript{2} & Rental & \checkmark & €0.38 to €0.50 per m\textsuperscript{2} \\
\hline
\end{tabular}
\end{table}

\textsuperscript{27} Sayce S. et al. (2010), Is sustainability reflected in commercial property prices: an analysis of the evidence base, Retrieved from: http://eprints.kingston.ac.uk/15747/1/Sayce-S-15747.pdf

\textsuperscript{28} Bio Intelligence Service et al. (2013), Energy performance certificates in buildings and their impact on transaction prices and rents in selected EU countries, Final report prepared for European Commission (DG Energy).


### Table 19 Residential status overview 2008-2012

Residential studies: overview 2013-2015
### Table 20 Residential status overview 2013-2015

**Residential studies: overview 2016**

<table>
<thead>
<tr>
<th>Study/Author</th>
<th>Year</th>
<th>Country</th>
<th>Sustainable features</th>
<th>Impact</th>
<th>Positive((v)) or not ((x))</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyland et al.</td>
<td>2013</td>
<td>Ireland</td>
<td>EPC rating</td>
<td>Rental/Sales</td>
<td>(v)</td>
<td>generally positive but more likely to matter when economy poor</td>
</tr>
<tr>
<td>Cajias &amp; Piazolo</td>
<td>2013</td>
<td>Germany</td>
<td>Energy consumption/EPC category</td>
<td>Rental/Sales/Return</td>
<td>(v)</td>
<td>1% decline in energy use leads to 0.15% increase in return; 0.08% increase in rents and 0.45% increase in CV</td>
</tr>
<tr>
<td>Stanley et al.</td>
<td>2015</td>
<td>Ireland</td>
<td>Energy Performance Indicators</td>
<td>Sales price</td>
<td>(v)</td>
<td>increase of 1% per grade - but need to be careful on interpretation re age of building</td>
</tr>
<tr>
<td>Yang et al.</td>
<td>2015</td>
<td>Denmark</td>
<td>Energy source and products</td>
<td>N/a</td>
<td>N/A</td>
<td>Different types of consumers adopt differing approaches - depending on their priorities (VFM; green etc)</td>
</tr>
<tr>
<td>Fuerst et al.</td>
<td>2015</td>
<td>UK (England)</td>
<td>Energy efficiency</td>
<td>Sales price</td>
<td>(v)</td>
<td>positive influence - but more for flats/terraced than detached</td>
</tr>
<tr>
<td>de Ayala et al.</td>
<td>2016</td>
<td>Spain</td>
<td>Energy efficiency judged through household surveys</td>
<td>Sales price</td>
<td>(v)</td>
<td>5.4% and 9.8%</td>
</tr>
<tr>
<td>Bond and Devine</td>
<td>2016</td>
<td>USA</td>
<td>LEED</td>
<td>Rental</td>
<td>(v)</td>
<td>8.90%</td>
</tr>
<tr>
<td>Brouwen and Aydin</td>
<td>2016</td>
<td>Netherlands</td>
<td>transparent EPC on sales</td>
<td>Sales price</td>
<td>(v)</td>
<td>A label quicker to sell and 2% premium against a D; G rated slower and 13% brown discount</td>
</tr>
<tr>
<td>Fuerst et al.</td>
<td>2016</td>
<td>UK (Wales)</td>
<td>EPC grade</td>
<td>Sales price</td>
<td>(x)</td>
<td>higher grade sell for more - but not necessarily due to EPC label</td>
</tr>
<tr>
<td>Wahlström</td>
<td>2016</td>
<td>Sweden</td>
<td>Energy efficiency feature /energy consumption</td>
<td>Sales price</td>
<td>mixed</td>
<td>Consumption has no impact; presence of construction features that lead to efficiency are desired</td>
</tr>
</tbody>
</table>
Table 21 Residential status overview 2016

The authors of the EeMAP Project Technical Report\textsuperscript{33} have identified the following main findings from their literature review and experience:

- There are as yet no studies which link the quantum of any “brown discount” to the costs of renovation to upgrade to labels of A/B. Hedonic regression requires accurate isolation of value into the appropriate component factors. However, they do not provide full ‘fit’ and in some studies the level of variation (i.e. possible statistical inaccuracy) outweighs the observed price differential.

- Furthermore, all such studies work on factors such as construction, age and location and cannot accommodate emotional influences and factors that are known to drive residential purchase decisions.

- Purchasers of residential property may work to an agenda that stretches beyond the economic. This applies also to decisions to upgrade. Some key studies point to the complexity of residential decision making in relation to improvement decisions.

- Strong conclusions from the research to date are hampered by extreme heterogeneity of the stock being considered. Whilst hedonic studies can help with trends, it is important to consider decision making at the individual level and not only policy. For this, the authors explain, fine grained value reporting is required as well as local market knowledge.

- Whilst EPCs may at first glance appear to measure the same thing – efficiency at the asset level – they do not. Even within countries, the regulations vary, and this means again

that it is the specific impact in the specific sub-market which is critical. Climatic variations across Europe mean that the types and cost of works required to upgrade properties will vary which will influence the potential impact on value.

- Empirical results vary significantly across and even within national markets. Results for one particular country or regional market cannot be conveyed to another property market. This is, amongst others, due to the large differences in average construction and quality standards across countries.

- Behavioural studies show a variation in response depending on demographic type, type of energy and how the possibilities for refurbishment are presented.

- Value advantage of energy efficiency is increasingly recognised in places such as Germany, Switzerland, Netherlands and Denmark.

- There is a connection with the state of the overall market conditions.

- The research is focused on sales and rent – but far less on the residential investor issue.

This literature review demonstrates that several academic studies found a link between energy ratings, normally measured by EPCs and market rents and values of residential properties in a range of European countries – even if the literature was more advanced in relation to the commercial property markets than the residential one. However, these evidences are not straightforward. Strong conclusions from the research are hampered by extreme heterogeneity of the stock being considered. Whilst hedonic studies can help with trends, it is important to consider decision making at the individual level and not only policy. For this, the authors explain, fine grained value reporting is required as well as local market knowledge.

Relevance of market specificities

First of all, there are some distinctions to be done between commercial and residential markets. If the commercial market is not the focus of this report, the authors of the EeMAP literature review also conducted review of research focusing on the commercial sector. They concluded that the yield case is based on easier to sell, reduced likelihood of early ‘obsolescence’ of the property. They also point at the ‘split incentive’: tenants get a cost saving – but are they prepared to pass it on as a constant concern in the commercial sector? They also questioned the fact that it might all be about stock shortage or branding. Finally, they mentioned that most recent evidence coming through suggest that tenants/buyers of highly efficient buildings are maybe paying more than they should.

Distinctions are also important between rental and sale market. The ZEBRA project made a key observation in the literature that has been confirmed for a wider number of countries in this report is the existence of a greater surplus for sales transactions than rental transactions.34 This has also been confirmed in a survey conducted by BPIE for Austria, the Czech Republic, Denmark, France, Germany, Luxembourg, the Netherlands, Norway, Slovakia, Spain, Sweden and the United Kingdom. In this survey, estimations about the added value for any “one-letter” improvement indicate that the surpluses in rental prices are lower than surpluses in sales prices. The split-incentive dilemma was quoted as the most important reason for this discrepancy and more specifically, the fact that tenants most usually bear the post-renovation maintenance

costs. In the same line, property valuers agree that if the tenant (and not the landlord) enjoys the cost savings derive from optimised energy performance, it is less likely to result in higher rental prices. The same trend was found in all of the investigated countries apart from the Netherlands. In that case, price deficits were found rather than surpluses. Even though studies point out a lack of trust due to a negative public reception against EPBD implementation as the main cause, BPIE argues that finding price deficits are more likely the outcome of inaccurate calculating methods which didn’t take into account variables like location and quality.\textsuperscript{35}

Segments and local markets with higher house prices also seem to factor a higher monetary value for energy efficiency standards. In a study conducted by Danish Energy Agency, looking at different market segments in Denmark, found that the pricing of energy standards is higher for high-income groups, more expensive houses, and in the capital region (competed to other regions). The authors conclude that this might indicate that buyers have different constants, information available or different preferences for current vs. future savings.\textsuperscript{36}

The type of property in question can also influence the price effects of superior energy performance. Some research in the UK have identified that the price effects tend to be higher for terraced dwellings and flats compared to detached and semi-detached dwellings.\textsuperscript{37}

Climatic variations across Europe can also have an impact. The types of works required to upgrade properties will vary: This is likely to influence the potential impact on value. For instance, in EU countries with colder climates, a property may face a price decrease in the absence of double-glazed windows, as it is an expected feature in the market\textsuperscript{38}. In contrary, heat pumps that aim to increase energy efficiency, are less trusted by customers – mainly due to high costs and less performance than anticipated – and they are not always considered as a “value added feature”\textsuperscript{39}.

\textbf{Visual and non-visual characteristics}

Another interesting distinction for the RenZEB project came from the conclusion of the valuers’ roundtables organized in the framework of the REVALUE project. It showed that the energy-related characteristics that are readily available and visible like an efficient heating system or double-glazed windows, can easier affect valuer’s judgement and have higher adding value potential. In contrary, characteristics which are less readily detected during an inspection, and/or for which data is not provided will not feed through directly into the valuation as the

\begin{flushleft}
\end{flushleft}

\begin{flushleft}
\textsuperscript{36}\textit{Danish Energy Agency} (2016), Copenhagen Economics - Do homes with better energy efficiency ratings have higher house prices? - Econometric approach Retrieved from: https://www.copenhageneconomics.com/dyn/resources/Publication/publicationPDF/5/335/1448874436/econometric-approach.pdf
\end{flushleft}

\begin{flushleft}
\end{flushleft}

\begin{flushleft}
\end{flushleft}

\begin{flushleft}
\textsuperscript{39} Ibid
\end{flushleft}
Valuer seeks only to reflect items which will influence a potential market player. However, some newer technologies are as yet unproven in terms of performance and are not sought after by tenants and purchasers. They will therefore not add value, and, as with some technologies that have been seen to fail, can in some cases lower the value. From the above, it seems that individual components are as important to impact the value.

Take away for RenoZEB Project: Energy efficiency’ impact on value relies on local market peculiarities

All in all, strong conclusions from the research to date are hampered by extreme heterogeneity of the stock being considered. Empirical results vary significantly across and even within national markets. Results for one particular country or regional market cannot be conveyed to another property market. This is, amongst others, due to the large differences in average construction and quality standards across countries. This variation of the retrofit costs is one more evidence that a potential impact of an EPC on property value is reliant on the local market characteristics. Although, in some particular sub-markets there is some evidence that relates an above the average EPC rating with increased property value (green premium), in principle, EPCs do not measure the “efficiency at the asset level”. As mentioned before, there is more evidence of the existence of the “brown discount” - which is the reduced price of a dwelling due to poor energy performance - than that of a “green premium”.

Valuation experts stress that the extent to which energy efficiency and other sustainability features result in price differentiation will always depend on the conditions within a given local (sub-) market. This is an extremely important consideration to be taken into account in the RenoZEB project. If the objective is to ensure market penetration for RenoZEB solutions, this can only be done with a strong business plan to convince the investors. Such a business plan is highly dependent on the local real estate market (value often vary from one block to the other). Failing to understand that and take this into consideration would impede and diminish the chances to make a strong case for RenoZEB products and systems.

3.3.2 Real estate stakeholders perception of NZEBs and EPCs

In addition to identified market trends reported in various research and analysis, the assessment of the attitude and perception as well as market practices of real estate stakeholders with respect to EPCs is also another important factor to investigate in order to understand the potential impacts of nZEB renovations on property value. Yet, as mentioned in the previous chapter, focusing exclusively on EPC would not reflect market attitude. Therefore, if the EPC can be a common benchmark to identify market trends as well as real estate actors’ perception regarding energy efficiency, EPCs are only an assessment parameter that might not fully reflect

---

40 Ibid
42 Ibid
market actors’ attitude about energy efficiency improvements. This is particularly the case if the EPC is not considered to be fully reliable, if market actors do not value it or are not aware about it or, on the contrary, if the market use more sophisticated auditing and certification schemes that includes other sustainability parameters – e.g. BREEAM, LEED. Therefore, in this paragraph we look at market practice and stakeholders’ attitude more broadly.

We also need to consider the heterogeneity of the real estate market’s stakeholders and their role. Therefore, before trying to identify some general market trends, it is useful to identify specific sub-segment attitudes.

Looking at the residential segment only and for the purpose of this report, market actors can roughly be divided as following (this list is not exhaustive)

- Owners/investor
  - owner-occupiers/end-users
  - co-owners in multi-apartment buildings
  - Private individual landlords
  - Large (to very large) real estate companies
- Tenant/end-users
- Valuation professionals
- Real estate agents
- Banks/lending institutions

Considering owners as one single and homogeneous group is a profound misunderstanding of the real estate market and may lead to strategic mistakes in marketing RenoZEB solutions. There is indeed a crucial distinction between owner-occupiers, who invest in the property they live in and are those that will harvest the direct benefits of energy efficiency; and landlords who own and rent out one or more properties and often face the so-called split-incentive when it comes to energy efficiency renovation. Landlords are bearing the risks to invest but it is the tenant that enjoys the benefits of an energy efficient house. In this case, the choice to invest in energy retrofits would heavily depend on:

a. The rental yields the owners can expect through the years  
b. The extent that tenants are satisfied with the planned interventions  
c. Tenants’ willingness to stay longer in the property  
d. How attractive the renovated property will be to the market

Considering landlords as a homogeneous market actors’ group would also be too restrictive, even looking solely at the residential sector. Landlords range from private individuals, who rent out one or two apartments to have an additional source of income, to large private landlords and global real estate investment funds. Even if they all expect some sort of profit on their real estate investments, the rationality, professionalism and drivers of their actions and decisions will greatly vary.

Next to them, there is also the social housing sector, which might have different objectives, limitations and funding sources. Understanding this tremendous heterogeneity and the similarities or disparities in the way these different categories perceive energy efficiency improvements, can help to better tailor the products and solutions developed under RenoZEB project.
It is also important to notice that the legislators and construction actors could have been included to this list as their impact on the real estate sector can be important. Whether or not they are real estate actors per se is a matter of definition. The role of the legislator, and potentially the impact of their energy efficiency related decisions on the real estate market, has already been addressed in chapters 3.2.1. and 3.2.2. of the report. The role of construction actors, such as construction companies, products providers, architects, etc. is also not neglectable when it comes to promote energy efficiency. Their current practices, the importance they give to energy efficient measures, the products and services they propose, the prices they ask and so on and so forth will impact the real estate market. The same argument is valid for the banking institutions. Yet, in this chapter we choose to also include the latter, while we left out construction actors, judging that we needed to focus principally on real estate agents, their clients and their financiers rather than their providers of construction products.

As property valuers and real estate agents reflect the market situation, investigating their perception of the market also gives a good picture of the up to date market trends. They can also be considered as intermediaries and actors of the real estate sector; yet, the main focus of this chapter will be on real estate owners (distinction will be made according to the type of owners). We will also look at tenants’ attitude and expectations as they have an impact on the acceptance and requirements for energy efficiency on the rental markets.

Some relevant researches have already focused on some specific segments of the sector. The following paragraphs compile together some of their input additional to that provided by market actors.

**Property Valuers reflect the market**

The core principle of the valuation profession is that valuers do not make markets, they reflect them. Valuation profession’s guidelines, notably in the European Valuation Standards 2016 issued by the European Group of Valuers’ Associations (TEGoVA), the other large valuation body next to RICS, clearly translates the relative role of the EPC in property valuation: “The valuer will take account of the [EPC] rating and recommendations so far as relevant, reflecting market circumstances, in providing his opinion as to the value of the property on a recognised basis of valuation.”

Since, as mentioned in the previous chapter, professional valuers have found little evidence that EPCs’ rating impact the market value of residential assets, they call for a word of caution, in particular, when it comes to the value of energy efficiency retrofitting. RICS certified valuers when they perform an appraisal are strongly advised to gather and record sustainability data when available and their role is to reflect the market conditions, not to influence or lead it. However, at the moment and as highlighted before, green features play a minor role on the decision to purchase/rent property. EPC will therefore gain importance on property value calculations if and when energy efficiency aspects will gain momentum in buyers/tenants’ decision to buy a property.

**Real estate agents’ perception of the market**

Like property valuers, real estate agents reflect market trends. Agents are potentially key intermediaries between the seller and buyer or landlord and tenant. They act as conveyors of
buildings’ features and point out those that are considered more relevant to the buyer, where energy efficiency might be one of them. Even though their role is not to be neglected, their impact on buyer’s/tenant’s final decision is rather limited.

The ZEBRA2020 project performed a survey among 618 real estate agents divided between 8 Member States exploring the impact of EPC and energy efficiency providing interesting insights for the Renozeb project (ZEBRA2020 property value and EPCs) in particular in relation to market perception of energy efficiency.

The following figures offer the most interesting and important insights for the Renozeb project.

The first figure presents the most important factors for the choice of property according to the surveyed real estate agents. The main factors in this part of the survey that could refer indirectly to EPCs and Renozeb are running costs, technical condition of the building, cost of electricity-heating and building construction technology ordered from highest ranked to lowest ranked starting at 7/14 for running costs and finishing at 13/14 for building construction technology.

For all of these pertinent factors, they are most often rated as being rather important. The one which is most relevant to Renozeb, cost of electricity and heat, received 57% of positive votes reflecting the importance of the factor with 44% claiming it as being “rather important” and 13% claiming it as being “definitely important”. Nevertheless, more traditional structural characteristics and factors of property such as location, size and surrounding area are perceived as being significantly more important and relegate the factors indirectly correlated with EPCs and potential renovations to “mid-table” factors. As a consequence of this secondary nature of EPC related factors, real estate agents are less likely to encourage renovations and the market penetration of nZEB approaches just as much as owners will not renovate on their own account.
This observed effect is very much correlated with their belief in a rent/price surplus originating from high energy performance ratings as shown in the following figure.

### Figure 11 Belief in existence of rent/price surplus coming from high energy performance ratings (ZEBRA2020)

This outcome confirms similar conclusions to the research and market perception conducted among property valuers: the lack of direct relationship between incremental property value in rent or sales with high energy performance ratings. This means less attractiveness for building owners to perform retrofits and implement nZEBs.

The real estate market agents and valuers’ perception of the market are a reflection of the market itself. Market prices reflect market demand and the importance key market actors give to specific elements. Therefore, an analysis of the market cannot be complete without understanding the perception of investors and clients. This includes tenants willing to find appropriate accommodation, prospective owners willing to acquire a new property to live into it or to rent it out, existing owners renting a building out who want to optimise its investments and potentially financing institutions, which will lend to buy or renovate and want to secure their investments.

### Tenants/end-users

The understanding and perception of energy efficiency measures by a prospective or sitting tenant, potentially translated in the EPC, is also important for the RenoZEB project. Identifying what they value the most when they rent an apartment, in particular aspects linked to energy efficiency improvements, will help to assess how RenoZEB outcomes and products can attract
the targeted customer groups and how these improvements can translate into rental monetary value. It will also help RenoZEB partners to communicate better project goals and outcomes.

Among this group of stakeholders there is not a common understanding on the benefits associated with the term of “green building” or “A class” houses. Technical terms to describe energy efficient buildings like “deep renovation” and “zero energy housing” are considered unattractive for tenants and it is not clear in what extent they fully understand them. Investigations in the housing market have tended to find that EPCs play a minor role in the consumer decision-making processes. A report from the UK, reveals that tenants have reported difficulties on readily relating EPC rating with the respective monetary saving — as a result of better energy performance. The 2013 Bio Intelligence Report commissioned by the European Commission recognises that EPCs are not yet considered as an important parameter in the decision-making process once the building is rented — as well as sold. Lack of awareness about EPCs’ usefulness and suspicion against the quality of the energy audits have also been cited as important barriers towards more effective use of EPCs in the market.

The Revalue consortium concluded from their research, workshops and literature review that energy efficiency is perceived as a favourable feature, but it rarely comes first when deciding to rent or buy a property. In Germany, the Netherlands and the UK, location is considered as the most important factor when selecting a residence and net rent costs as second. Yet, some studies show that tenants might care about energy efficiency improvements and sometimes even claim to be ready to pay more. For example, a research study conducted in Switzerland surveyed 264 tenants from apartment buildings indicating that energy efficiency measures are

---


significantly valued, with comfort and energy savings being the most expected benefits, while another study from Ireland demonstrates that some tenants would be willing to pay a slightly higher rent if this would translate to lower energy bills. However, once getting deeper into this topic and practical field, feedback tends to call for a word of caution for such linear conclusions.

All in all, there is still a lack of a coherent understanding on the benefits that an energy efficient house will bring to the tenants. Yet, a possible take away for RenoZEB is the fact that some sources hint that they might be sensible to comfort, functionality and energy savings aspects.

**Owner-occupiers**

Property owners are the ones who will buy and invest into energy efficient solutions to renovate their properties. They are those that need to be convinced to invest in innovative renovation concepts, such as the ones developed in the RenoZEB project. Therefore, their perception towards energy retrofits and their willingness or hesitations to invest is very important for RenoZEB project. Yet, as mentioned in the introduction of this chapter, a distinction is to be done between owners that live in their property and might grasp the direct benefits of the energy efficiency improvements and the ones who rent out properties.

If we look more specifically at the home ownership market, potential property buyers give higher importance to location, size and other personal parameters than energy savings when they consider to purchase property. Lessons learned from the Revalue project show that energy efficiency is perceived as a favourable feature, but it rarely comes first when deciding to buy a property (the same is valid for the rental market as mentioned in the previous sub-chapter). A blend of economic and emotional factors seem to be the most relevant drivers in the decision to purchase a property, where energy savings and financial gains are far less considered. Even though economic factors like available budget may determine the range of the sought property, final decisions are mainly driven by non-economic drivers. The same applies to decisions for an energy upgrade.

These evidences are also reflected in the way EPCs are considered. According to Jensen et al, in Norway and Poland, EPCs are not considered as relevant elements in the decision to buy/rent property. This claim is verified by property owner representative in Norway. 

---


2018), stating further that EPC rating scheme does not explain directly the benefits in terms of comfort, cost savings and environmental performance, which is what tenants understand and care about. Yet, in some more mature markets, visibility of the EPC label may be considered by potential buyers as a comparison indicator when choosing property. This is the case at least in the Danish market where energy efficiency is increasingly recognised. It is believed that by increasing the visibility of EPCs at the time of rental or sale, it would potentially add an additional parameter to be weighted on the decision to choose a property. Especially, when potential buyers have to make a choice between two comparable properties, energy certificate may play a part on the decision. At the moment, EPCs are used as a qualitative benchmark with no impact on property value, but with some potential to constitute a valuable driver to invest in energy upgrades of the European building stock. Even though at the moment EPCs are perceived as an additional administrative burden, it is estimated that better knowledge and information on the risks and benefits associated with energy renovations, would make investors and owners less reluctant to invest in energy efficiency measures.

If we look more specifically at what might influence owner-occupiers to renovate, factors such as comfort and the reduction of energy costs are certainly important. Yet they might be counter-balanced by financial limitation as well as genuine uncertainties regarding cost-effectiveness, mainly due to conflicting information on the costs and benefits or energy efficient or renewable energy solutions in buildings and mistrust of information, uncertainties concerning savings and how to measure them and lack of information and skills. The lack of information and skills has also been acknowledged. Owners are reputed to be usually “boundedly rational”, i.e., they try to be rational, but in fact, they usually follow simple ‘rules of thumb’. Because of this, unsophisticated calculation rules (such a short simple payback periods) are often used instead of more sophisticated financial analyses. Added to the level of risk aversion of individual households, which usually increases with age, people may prefer status quo or simplify decision by only considering commonly used solutions. In addition to this, owners are often discouraged by

55 Gyldenskog K. (2018), [Interview with UIPI and Gyldenskog K. from Huseiernes Landsforbund in 20/06/2018]
57 Ibid
63 Anne-MariePålsson (1996), Does the degree of relative risk aversion vary with household characteristics?, *Journal of Economic Psychology, Volume 17, Issue 6*, Pages 771-787
transaction costs. This includes the costs of information and the costs of monitoring and controlling the contracted renovation work, the difficulty to find skilled service providers or the right information or the need for relocation or the stress caused by disruption.\textsuperscript{64} Recognising these factors help to better understand the attitude of home owners and to factor them in the development of RenoZEB solutions and the way they will be marketed.

Landlords/investors

As mentioned in the introduction of this chapter, considering landlords as one single group would be too restrictive. Drivers, knowledge and financial means for individual landlords, large real estate companies and social housing providers might differ. The information below needs to be read with such distinctions in mind.

When it comes to understand landlords’ perception and attitudes towards energy efficiency and what deters or motivates them to act, the first factor widely recognised by the market, policy-makers, experts and the literature is the so-called ‘split-incentive’ problem, also referred as the ‘tenant-landlord dilemma’. Literature\textsuperscript{65,66,67} on the topic is abundant and policy-makers, including European ones, have acknowledged the issue\textsuperscript{68,69,70}. These concepts are used to describe a situation whereby the landlord (the agent) determines the level of energy performance within a building, while the tenant (the principal) pays the energy bills. In other words, the landlords lack incentives for investing in energy efficiency upgrades as they do not directly reap the benefit and often find it hard to capitalise these upgrades into higher rents due to the uncertainty about the impact of an upgrade over property value and lack of experience on estimating rent premiums.

This concept still reflects the reality of the market. If the principals (the tenants) are poorly informed about energy efficiency – as we have reported in the subchapters on tenants’ perception – then it is unlikely to be willing to pay a premium for an energy efficient property. The lack of strong evidences that tenants are ready to pay more explains why the agent (the landlord) is unwilling to invest, who might choose to underinvest in energy efficiency knowing that he will not recoup the cost of his investment. Field experience from the project partners largely confirms that this perception is still widely shared by private landlords.

\textsuperscript{64} Matschoss, K., Heiskanen, E., Atanasiu, B. & Kranzl, L., 2013.
\textsuperscript{68} Luca Castellazzi, Paolo Bertoldi, Marina Economidou (2017), Overcoming the split incentive barrier in the building sector: Unlocking the energy efficiency potential in the rental & multifamily sectors, http://publications.jrc.ec.europa.eu/repository/bitstream/JRC101251/idne28058enn.pdf
\textsuperscript{69} Article 19(1)(a) of the Energy Efficiency Directive (Directive 2012/27/EU) recognises the importance of addressing the barrier of split incentives in the building sector.
Another dimension to this debate is the knowledge and understanding amongst landlords regarding energy efficiency.\textsuperscript{71} This is particularly important for small private landlords. If landlords are not aware of the deficiencies of their properties and the associated consequences for both tenants and the physical fabric of the property, then, there will of course be no impetus to act. Moreover, even if landlords are aware of such deficiencies they may be deterred from acting by a lack of knowledge of the potential solutions and by misconceptions about cost or practical feasibility.\textsuperscript{72}

A study based on thirty field interviews conducted in a city in the North of the UK, among landlords owning anything from 1 to 200 property, sheds light on the perceptions of landlords.\textsuperscript{73} Given the limited size of the sample conducted on one location only, it cannot claim to be representative of the entire European market. Yet, it highlights through examples the potential reasons underpinning landlords’ attitudes and perceptions of energy efficiency. This study shows that often the landlords (around 70 per cent) were aware of the energy performance ratings of their properties as detailed in the EPC. If they also understood that their properties performed poorly (rated as E or below on the EPC scale), they considered this to be the norm as there were very little competition within the market from better performing properties.

This research also provided evidence of the landlords’ prioritization of appearance and function, including: decorations, new carpets, replacement of kitchens and bathrooms and the installation of new windows and doors. There were two primary motivations for such improvements: the need for a general periodical upgrade and requests from tenants. This research, even conducted in a very specific geographical area, confirms nonetheless that landlords ‘actions are driven by the requests of their tenants, in other words, the market demand, and that, since for the tenants visible improvements are more tangible, the landlords would privilege such improvements over energy efficiency ones. This research confirms the information collected among valuers by the Revalue project and the feedback property owners’ associations collected from their members. This is also very valuable information for the RenoZEB project even if we, once again, need to stress the heterogeneity that characterises the rental market landlords.

\textbf{Co-owners}

Co-owners are either owner-occupiers or landlords. Their perception and attitude towards energy efficiency is likely to reflect the ones of the category they belong to. Yet, multi-owner buildings face an additional challenge associated with collective decision-making between various actors. Condominium owners are the main decision makers in the case of energy renovations. They can be supported or hindered in this by other parties, such as house managers or administrators in charge of daily management of the building, external experts such as municipal officials, energy advisors or consultants. They are usually represented by an elected

\textsuperscript{71} Hope JH and Booth A. (2014), Attitudes and behaviours of private sector landlords towards the energy efficiency of tenanted homes, Energy Policy
\textsuperscript{72} Jakob M. (2006), Marginal costs and co-benefits of energy efficiency investments. The case of the Swiss residential sector, Energy Policy
board or chairperson, who prepares decisions (often with the help of the house administrator). However, the ultimate decision and financial responsibility for the investment – and indeed the overall maintenance of the building – lies with the owners themselves. Hence, in the case of owner-occupied multifamily buildings, lay people are ultimately responsible for a very large and complex technical system with a very long lifespan. Energy efficiency projects in these buildings can only be realized if consensus is reached by all decision-making parties. Yet, in multi-owner buildings, the benefits and costs of an energy efficiency upgrade may vary from apartment to apartment, which further complicates the situation.

**Banks and lending institutions**

There is a gradually increasing interest from financial institutions about sustainability and energy efficiency that seek to incorporate them more and more into their lending practices. Even though the present market of “green mortgages” is currently immature, there are several “green concepts” under development and testing by a handful number of banking players. For instance, “green tagging” is an emerging strategy where banks identify sustainability attributes of their products (loans, collateral etc) to scale up energy efficiency financing. Evidence from Spain for example indicates a growing attention to EPCs by financial institutions that they use to base some of their assessment on.

**In conclusion**

It seems that there is a lack of strong evidence of the existence of rent/price surpluses in both rental and sales markets which are always reliant on the local peculiarities of the addressed sub-market. As intermediaries, real estate agents and property valuers are holding a non-negligible position in promoting the importance of EPCs in the market, and even though their role is to reflect market trends, they could potentially play a role on increasing the visibility of EPCs.

Currently, energy efficiency and EPCs are not considered as important in the decision to rent/buy a property but the accompanied benefits (i.e. higher comfort, lower energy bills etc) might play a role in turning the tide. RenoZEB partners should be aware that there are different levels of understanding of energy efficiency and EPCs among the various stakeholders in the

---


energy renovation market and each of them observes different values in an energy retrofit. Each of the demonstration sites belong to markets in different countries and particular attention should be paid on understanding each of these markets separately and identify their special characteristics. This is particular relevant when contemplating RenoZEB’s replication strategy, where local costs (materials, construction methods, labour cost etc) might widely differ. Renozeb consortium will have to clearly communicate the potential surpluses emanating from the energy efficiency improvement and, eventually how they are translated in the EPCs and orient their dissemination strategies beyond the framework of ESCOs and construction companies, also addressing stakeholders in real estate. In such complex and niche environment, Renozeb solution should generate as cost effective solutions as possible so that become visible and attractive to the energy renovation market.

Currently, through the plug and play system which includes criteria and variables on property valuation and the high level of focus on cost optimality, it seems as though the consortium is headed in the appropriate direction. Nevertheless, in the development of these elements, the relevant market stakeholders will have to be consulted to ensure these provisions are taken in the correct direction. The International Union of Property Owners will provide a great amount of assistance with this.
4 Reference Markets analysis

The following section provides details and observations on the relevant markets of the components and systems that will be used and developed in the RenoZEB project. The objective is to provide insights on current market trends, evolutions and general market mechanisms so that the developed solution is aligned and adapted to market requirements. In order to perform this task, systems will be separated into three main reference markets: prefabricated multifunctional modular “plug and play” systems for building renovations, ICT toolsets/BIM, Smart control & monitoring systems market segment. Relevant market assessment tools such as porter’s five forces, SWOT analyses and competitive landscaping will be applied in order to get a full picture.

4.1 Prefabricated multifunctional modular “plug and play” systems for building renovations market segment

This section analyses the potential market for prefabricated multifunctional modular “plug and play” systems for building renovations at the general European market level of analysis.

Despite the lack of consistent and accurate data on building renovation rates across Europe, the renovation market is estimated to account for 57% of all construction activity; within this value a large part 65% is accounted for residential buildings, the main target of the RenoZEB project.

In this scenario, considering that existing buildings are the most energy consumptive, renovation is the key strategy to achieve EU energy targets, with one of the following building strategies as mentioned previously in chapter 3.1.1. (Artola et al., n.d.):

- **Minor renovations** – 85% of the market: the implementation of 1 or 2 measures (e.g. a new boiler) resulting in a reduction in energy consumption of between 0% and 30% (with average costs of €60/m²).
- **Moderate renovations** – 10% of the market: involving 3-5 improvements, (e.g. insulation of relevant parts of the dwelling plus a new boiler) resulting in energy reductions in the range of 30%-60% (with average costs of €140/m²).
- **Extensive renovations** – 5% of the market: in this approach the renovation is viewed as a package of measures working together leading to an energy reduction of 60% - 90% (with average costs of €330/m²).
- **Almost Zero-Energy Building renovations** - negligible: the replacement or upgrade of all elements which have a bearing on energy use, as well as the installation of renewable energy technologies in order to reduce energy consumption and carbon emission levels to close to zero (with average costs of €580/m²).

For the target expected in RenoZEB, the project is transversal to the above mentioned possibilities because prefabricated modules are studied to offer different levels of renovation and with an estimated share of 20-40% in the whole renovation of existing building. Indeed, the design and manufacture of prefabricated and customizable modules offer the opportunity to control costs and energy efficiency results to answer to on-demand specifications.

This percentage demonstrates the potential of RenoZEB in the market. The EU energy renovation market was worth approximately EUR 109 billion in 2015 and it has been estimated that the
annual investment in the energy renovation of the building stock will need to grow from EUR 12 billion (2014) to EUR 60 billion in order to meet the EU target of a 20% energy efficiency improvement by 2020. In addition to this perspective, the desired market scenario is even more ambitious for the 2020-2030 decade. Indeed, the size of the EU energy renovation market could increase by half the current levels if a 40% energy savings target was adopted for 2030. However, meeting this target would require renovation rates to rise to almost 3% rather than the current of 1%; prefabricated solutions could catch part of the potential revenue of the renovation market and increase its potential. (Artola et al., n.d.)

Despite this favorable market scenario for the prefabricated modules, there are many different barriers to market entry, typical to the characteristics of the renovation market. Costs, technical, normative, cultural aspects are elements to be considered that affect the introduction of prefabricated solutions in a local market as well as the module application in a specific building. The design and manufacture of the prefabricated modules, their characteristics and their potential of installation, are affected by the following barriers (Artola et al., n.d.; “Renovating the EU building stock,” n.d.):

- **Financial barriers:**
  - Renovation costs;
  - Access to finance;
  - Low energy price.

- **Technical barriers:**
  - Different buildings characteristics (materials, dimensions, performances);
  - Lack of technical solutions;
  - Cost of technical solutions;
  - Collaborative software used by actors involved (architects, manufacturers and contractors);
  - Lack of knowledge of construction professionals.

- **Process barriers:**
  - Fragmentation of the supply chain;
  - Burdening of home owners.

- **Regulatory barriers:**
  - Varying ambition of performance requirements;
  - Multiple definitions for renovation;
  - Different MSs framework.

- **Awareness barriers:**
  - Lack of awareness.

All these barriers differ within EU Member States and need to be considered by the construction industry to define the specificities of the local market of reference in order to create commercial and technical structures that could face each specific issue. This consideration is also applicable to the RenoZEB prefabricated envelope system; despite its potential for being a valuable solution at general European scale, its application will differ in consideration of the barriers mentioned and the specifics of the market where it is used.

If the construction industry should define the most proficient market for prefabricated modules, removing market barriers is also up to institutions in the Member States to promote these models
of renovation. There should be a planned strategy of action inside the different Member States to open the market creating favorable conditions for renovation, facing existing barriers and their local declinations.

These actions could be strategic also in the perspective of the future renovation market outside of Europe. Renovating the existing building stock is currently a main issue in the European Union alone and not a central theme of interest in the American or Asian construction agenda. If European enterprises could successfully achieve market maturity for prefabricated interventions in construction refurbishments in Europe in the next years, in the future they could be ready to become leaders in the export market outside of Europe opening wider opportunities for the market of prefabricated modules. Markets outside of Europe are lacking in renovation strategies and Europe could anticipate their future needs.

At this point, it appears interesting to focus on possible competitors of RenoZEB envelope systems. The identification of main competitors/market players is hard to set. Indeed, the construction market for renovation works is mainly composed of small and diffuse enterprises that operate in specific geo-clustered locations, answering to on-demand projects. The construction market is traditionally composed by numerous micro/small companies with specific technological solutions for the market of reference, the building typology and its dimension, the ownership model, the technological systems adopted, mainly based on customized on-site solutions. To be in line with the purpose of the RenoZEB project with its prefabricated envelope system, these small-enterprises active as on-site workforces should reposition themselves to capture a complete new market segment based on off-site prefabrication with initial high investment costs. For this reason, the main competitors considered for the RenoZEB module are those operators that are already working on prefabricated solutions and have the economic capacity to compete in this market thanks to their:

- current commercial structure able to work into large construction project;
- technical expertise to manufacture prefabricated systems;
- off-site manufacturing asset.

The Table 22 reports the main competitors identified for the RenoZEB envelope system.

<table>
<thead>
<tr>
<th>Competitor</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gartner</td>
<td><a href="http://josef-gartner.permasteelisagroup.com/">http://josef-gartner.permasteelisagroup.com/</a></td>
</tr>
<tr>
<td>Permasteelisa SpA</td>
<td><a href="http://www.permasteelisagroup.com/">http://www.permasteelisagroup.com/</a></td>
</tr>
<tr>
<td>Seele</td>
<td><a href="https://www.seele.com/">https://www.seele.com/</a></td>
</tr>
<tr>
<td>Stahlbaupichler</td>
<td><a href="http://www.stahlbaupichler.com/it">http://www.stahlbaupichler.com/it</a></td>
</tr>
<tr>
<td>Riko</td>
<td><a href="http://www.riko-hise.si">http://www.riko-hise.si</a></td>
</tr>
<tr>
<td>Webo</td>
<td><a href="https://www.webo.nl/">https://www.webo.nl/</a></td>
</tr>
<tr>
<td>Weelement</td>
<td><a href="http://weelement.ee/">http://weelement.ee/</a></td>
</tr>
</tbody>
</table>
Table 22: competitors in prefabricated multifunctional modular “plug and play” systems

A comparison between these competitors is difficult to be assessed because they work in different countries with their markets and context; for this reason this comparison is not performed. Also the identification of price and product descriptions is not assessable because of tailored projects that use on demand materials and products such as aluminum, steel, glass, stones, metal plates, PV panel, etc. In this scenario, each manufacturer creates tailor made solutions that are more of a single market product, answering to architectural and technical specifications, and consequently a unique product characterized by undefinable price ranges. Considering this particular reference market of RenoZEB that offers a combination of modules with mostly existing products, a SWOT is not required.

The last considerations for the RenoZEB prefabricated envelope systems in this market analysis is related to the classification of Porter’s 5 forces to define the industry competitiveness. The considerations previously presented are resumed in Table 23.

<table>
<thead>
<tr>
<th>Porter`s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of new entrants</td>
<td>“2” for micro/small-enterprises active on on-site construction processes</td>
<td>Micro/Small enterprises:</td>
</tr>
<tr>
<td></td>
<td>“4” for companies working on prefabricated new building construction</td>
<td>• technical know-how should be reassessed for off-site processes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• manufacturing process should be completely created with high cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• currently construction industry is not a high profit market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Companies in pre-fabricated sector:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• high technical know-how in prefabricated construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• performing manufacturing process is already an asset</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• commercial structure to be redefined to target renovation market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• renovation has a potential, but it is a low profit market in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>comparison with new building</td>
</tr>
<tr>
<td>Bargaining power of buyers</td>
<td>3</td>
<td>• Many manufacturers guarantee a large possibility of choice in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>products, in line with financial resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• relatively low profitability of renovation market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• building stock owners have different</td>
</tr>
</tbody>
</table>
### Threat of Substitute Products

<table>
<thead>
<tr>
<th>Threat of substitute products</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Before performing renovations there are many substitutes that can replace with similar performances and appeal the RenoZEB envelope system solution. The cheapest solution is usually considered the most valuable to be used.</td>
<td></td>
</tr>
<tr>
<td>• After the renovation, it is meaningless to change prefabricated systems before the return on investment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bargaining power of suppliers</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers have a low bargaining power because RenoZEB uses commercial components easy to be substituted (window, PV, thermal collector, finishing, etc.)</td>
<td></td>
</tr>
</tbody>
</table>

Table 23: Porter’s competitive force for RenoZEB prefabricate “Plug & Play” envelope system

If this is the market of reference for the RenoZEB envelope system, in the next paragraphs an in depth focus is on the components included in the final prefabricated solution. Despite the fact that WP3 tasks are ongoing, a set of first considerations is possible to understand the market of the RenoZEB envelope. One of the main focus areas of the RenoZEB project is to use existing commercially available products and consolidate them to be part of a unique envelope system. With this target, the identified solutions have been selected following a Multi Criteria Decision Analysis, but they are here analyzed within their specific industries. This is done in order to understand their market position, which of course affects the complex RenoZEB envelope system’s market position. With this purpose, a Porter’s forces analysis of each component is conducted in the next paragraphs. The following RenoZEB envelope system components are considered:

- Multifunctional insulation system
- Window and roller shutter
- PV system
- Thermal energy system

#### 4.1.1 Multifunctional insulation system

<table>
<thead>
<tr>
<th>Porter’s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of new entrants</td>
<td>5</td>
<td>There are several big insulation board manufacturer on the market with different types of materials. For them they can easily change their product to have the “click in” functionality</td>
</tr>
</tbody>
</table>
for air ducts etc. and can offer a complete insulation system for the wall. So the threat is high.

| Bargaining power of buyers | 2 | Because there are no product on the market which have the multifunctionality, there is no substitute product. All multifunctional façade systems mentioned in RenoZEB faceda concept baseline definition are developed in research projects. So the bargaining power of the customer is low because he is also not well informed.
|
| Threat of substitute products | 2 | As mentioned before, there are no substitute products available on the market, so the threat is low.
|
| Bargaining power of suppliers | 4 | The bargaining power of the supplier is high, because it’s a unique system without any market participants.

<table>
<thead>
<tr>
<th>Competitor</th>
<th>Description of product offering and State of Technology</th>
<th>Pricing intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Competitors with product on the Market</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.1.2 Window and roller shutter

<table>
<thead>
<tr>
<th>Porter’s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of new entrants</td>
<td>3</td>
<td>The Competitors on the market have the manufacturing tools to build a similar product. But don’t focus on the retrofittting market</td>
</tr>
<tr>
<td>Bargaining power of buyers</td>
<td>4</td>
<td>Instead of using the RenoZEB System, the customer can use standard Components like decentralized ventilation systems, Venetian blinds, which are available as stand alone solutions on the market.</td>
</tr>
<tr>
<td>Threat of substitute products</td>
<td>4</td>
<td>By combining stand-alone solutions available on the market, the customer is able to have similar functionalities. The systems have to installed seperately by different installers, but the RenoZEB envelope system can be substituted.</td>
</tr>
<tr>
<td>Bargaining power of suppliers</td>
<td>3</td>
<td>Because of the products on the market, the customer know the prices for the different systems.</td>
</tr>
</tbody>
</table>
So he has a idea of the prices and can compare it to the RenoZEB solution.

<table>
<thead>
<tr>
<th>Competitor</th>
<th>Description of product offering and State of Technology</th>
<th>Pricing intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hella TRAV Frame</td>
<td>Windowframe insulation element with integrated shading system for installation in new buildings. No ventilation</td>
<td></td>
</tr>
<tr>
<td>ILLBRUCK Vorwandmontage</td>
<td>Modul for Window installation in insulation area. No Shading, no ventilation.</td>
<td></td>
</tr>
</tbody>
</table>

### 4.1.3 PV system

According to the study of Global Industry Analysts [Global Industry Analysts, The global building integrated photovoltaics (BIPV) market, 2015], the BIPV market is growing in the last years: it is estimated to grow at a Compounded Annual Growth Rate (CAGR) of 39% over the analysis period 2014-2020, thus annual installation capacity of the BIPV market is projected to further surpass 11 GW by the year 2020.

![Table 24. Global market BIPV development and forecast from 2014-2020 (in MW)](table)

In Table 24 it can be seen that the Compounded Annual Growth Rate (CAGR) specifically expected for Europe is of 39.7%.

This implies according to the other BBC Research report [Building-Integrated Photovoltaics (BIPV): Technologies and Global Markets. BBC Research 2016, ID: 3984223] a growth from $2.4 billion in 2016 to $4.3 billion by 2021, with an increase from $690.5 million in 2016 to $754.2 million by 2021 for the specific facades market.
According to Tabakovic [M. Tabakovic et al. Status and outlook for building integrated photovoltaics (BIPV) in relation to educational needs in the BIPV sector. 2017 Energy Procedia 111; 993:999], the growth is due to the rapidly decreasing installed cost per watt, as well as the enhanced aesthetics of BIPV, the improved efficiency of the modules, and the “green conscience” of building owners which need to be supported by attractive incentives at local and federal level to ensure cost-effectiveness of BIPV products.

The following table describes the Porter’s forces for the Building Integrated PV systems:

<table>
<thead>
<tr>
<th>Porter’s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of new entrants</td>
<td>4</td>
<td>The introduction into the market is relatively easy, since the PV technology is already developed and the only requirement is to integrate the cells in the panels of the façade, as well as the cables for the energy transport.</td>
</tr>
<tr>
<td>Bargaining power of buyers</td>
<td>4</td>
<td>Buyers have the alternative of installing conventional PV systems added to the roof, which is a simple and mature solution. However for cases with limited available roof surface or where the integration of the PV panels on the façade is desired for any reason, then this is the only solution as the offer is not as comprehensive as for the conventional PV systems.</td>
</tr>
<tr>
<td>Threat of substitute products</td>
<td>5</td>
<td>The alternative is the installation of conventional PV panels placed on roofs, a solution that is very mature and developed, having even the possibility in some cases of optimizing the orientation. The advantages of the BIPV are then based on their multi-functionality as façade and PV system which is interesting in cases of reduced roof surface availability for the PV system or due to aesthetic aspects.</td>
</tr>
<tr>
<td>Bargaining power of suppliers</td>
<td>2</td>
<td>The production of PV cells is very developed and only an adaption to the integration in the façade modules is required. Thus, many of the already existing PV cells producers could become a supplier.</td>
</tr>
</tbody>
</table>

Table 25 Porter’s competitive force for RenoZEB PV system

<table>
<thead>
<tr>
<th>Competitor</th>
<th>Description of product offering and State of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflaresolar</td>
<td>Sunflare produce light, thin, and flexible CIGS panels. This panels do not need glass, frame or mounting system, therefore they are suitable for BIPV solutions.</td>
</tr>
<tr>
<td>Polysolar</td>
<td>Polysolar offers 4 different products using thin-film PV technology to manufacture their BIPV solar glass, enabling them to produce transparent or opaque solar PV panels.</td>
</tr>
<tr>
<td>Avancis</td>
<td>PowerMax® SKALA is the AVANCIS architecture module, scalable in size and color, for solar facades and building integrated applications. AVANCIS offers frameless glass to glass CIGS modules with an adhesively bonded mounting system bearing also the dead weight of the modules without any mechanical support for the glasses.</td>
</tr>
<tr>
<td>OnyxSolar</td>
<td>OnyxSolar offers two kind of products with amorphous and crystalline silicon photovoltaic glass. They are able to manufacture glass 100% tailored to the client’s design intent. They can produce virtually infinite options with different builds, dimensions, colors, shapes and cell density.</td>
</tr>
</tbody>
</table>

Table 26 PV system competitors
4.1.4 Thermal energy system

A specific market analysis for the building integrated solar thermal (BIST) systems has not been found, however we can see that Franz Mauthner et al. [Franz Mauthner, Werner Weiss, Monika Spörk-Dür. Solar Heat Worldwide-Markets and Contribution to the Energy Supply 2014. IEA Solar Heating & Cooling Programme, May 2016] indicate in their study that from the total solar thermal installed capacity in 2014, 6.3% correspond to unglazed water collectors and 0.4% to glazed and unglazed air collectors, where the market sectors of the integrated thermal systems in façades with air and water are comprised, though there are also some glazed solar modules for façades.

In this study, they also indicate that the new installations in 2014 of unglazed water collectors was of 1.6 GWth (2.3 million m²) and for glazed and unglazed air collectors was 0.08 GWth (0.11 million m²).

For the total solar thermal capacity installations, the main European markets have been suffering significant market decreases in the last years. In the period 2013/2014 only Spain (9.9%), Greece (19.1%) and Denmark (72.3%) reported a positive growth rate, while important markets as Germany, Italy and Austria dropped. A decrease of –3.4% was reported for all of Europe.

In their study, Franz Mauthner et al. point out that “in North America building integrated solar air collectors are the most popular form of solar thermal systems in the commercial, industrial and institutional markets due to their low cost and architectural integration into buildings”, however they are not so expanded in Europe.

The following table shows the porter’s forces for the Building Integrated Solar Thermal systems.

<table>
<thead>
<tr>
<th>Porter’s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of new entrants</td>
<td>3</td>
<td>The introduction on the market is not very difficult since high technology materials or designs are not required. However since the system is integrated in the façade modules, experience in the production of façade components will be required.</td>
</tr>
<tr>
<td>Bargaining power of buyers</td>
<td>2</td>
<td>Although being a solution which does not require a high technical development, commercially available products are not very developed.</td>
</tr>
<tr>
<td>Threat of substitute products</td>
<td>5</td>
<td>The conventional thermal energy systems are fully developed along with the solar thermal collectors and the HVAC systems including even heat recovery systems. The advantage of this solution in front of the alternatives is a matter of available space and surface or aesthetics.</td>
</tr>
<tr>
<td>Bargaining power of suppliers</td>
<td>2</td>
<td>The components of the system are technically unadvanced, no special material nor technologies required.</td>
</tr>
</tbody>
</table>

Table 27 Porter´s competitive force for RenoZEB Thermal energy system
The optimum thermal delivery of the WAF solar facade lies within that of low-temperature range. In order to achieve the facade’s highest efficiency, the fluid temperature should be between 35°C and 45°C.

**Table 28 Thermal energy system competitors**

<table>
<thead>
<tr>
<th>WAF Solar facade</th>
<th>The optimum thermal delivery of the WAF solar facade lies within that of low-temperature range. In order to achieve the facade’s highest efficiency, the fluid temperature should be between 35°C and 45°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energie Solaire</td>
<td>Flat plate STS absorber is made from two sheets of cushion stainless steel which are bonded together and the working fluid flows in the gaps formed between the two cushion sheets. Its hidden face is thermally insulated and the absence of glazing allows this collector to be integrated with ease on a wide range of building roofs including non-flat (curved) ones and facades. The collector is ideally suited to large installations requiring water up to 50 °C.</td>
</tr>
</tbody>
</table>

### 4.2 ICT toolset market segment

To understand the European market for the RenoZEB ICT toolset we consider its two primary elements: (i) a BIM (Building Information Modelling) platform, and (ii) a collaborative workflow management platform (in RenoZEB, this will comprise a model generation tool, a project designer, a smart logistics and construction management tool, and a smart building-centric human control module.)

**The European opportunity for BIM**

BIM has been identified at a European and national government level as a key strategic opportunity for improving the productivity of Europe’s construction industry. Traditionally the sector has experienced low productivity due to the fragmentation of supply chains and a prevalence of small specialist contractors. The widespread rollout of BIM (and digitalisation more generally) is seen as a general solution to this problem. The *Handbook for the introduction of Building Information Modelling by the European Public Sector* (2017) identifies savings to Europe’s €1.3 trillion construction sector from digitalisation of 10-20%, equating to at least €130 billion. Further cost savings in the operations phase of a building’s life cycle could range from 14% to 23%.

This figure, €130 billion, provides a good estimate of the potential market size for BIM solutions in Europe. However, unlocking this opportunity requires broad action across a range of stakeholder groups. At a European level, the EU BIM Task Group is comprised of public sector clients, infrastructure owners and policy makers from over 20 countries across Europe. It is focused on creating enabling conditions for the development of the BIM sector by encouraging public procurements across Europe to use BIM standards and applications.

There are a number of established players in the European BIM sector (see table 29), but there is also a strong focus on industry standards, interoperability and the use of open protocols.

---


European Committee for Standardisation is working towards the harmonisation of regulation of standards related to BIM, and several standards have emerged in recent years\textsuperscript{82}.

Globally, the ‘OpenBIM’ movement, led by buildingSMART International promotes a standardised approach to BIM based around the IFC (Industry Foundation Classes) file format. In turn this approach lower barriers to entry for new vendors and providers of BIM solutions, and is experiencing adoption in Europe.\textsuperscript{83}

The European market for online collaborative workflow management

The collaborative environment proposed by the RenoZEB solution is also focused on solving the fragmentation issue of the construction and renovation sectors.

“Collaboration is the new buzzword and fragmentation, for which the industry is frequently criticised, is an obstacle to progress, which has to disappear.”
FIEC Annual Report 2018\textsuperscript{84}

The BIM industry has developed a standard (forming a layer above the ICF standard) called BCF (Building Collaboration Format), which facilitates communication between collaborating parties. The BIMcollab platform offered by KUBUS is an example of a software solution based around the BCF standard. These platforms intersect with the long-established and large global market for Project Portfolio Management (PPM) software, which stood at c. US$ 2.74 bn in 2016\textsuperscript{85} and is forecast to grow quickly to c. $6 bn by 2025. As software providers offer more holistic solutions for construction project management by integrating collaborative BIM into their products, the BIM sector should share in this rapid growth.

- Porter’s forces:

<table>
<thead>
<tr>
<th>Porter’s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
</table>
| Threat of new entrants     | [5: high threat; 1: low threat] 2>Low threat | • BIM is a very large field that goes from simple visualization of 3D models to high performance information deployment; from energy efficiency to structures calculation.  
• BIM deploys a wide range of ICT tools (from support tools to software) for the AEC sector not only at the construction phase but in all the building life cycle.  
• AEC sector is the second one less digitalized only after the Agriculture and hunting sector |

\textsuperscript{83} BuildUp, The raise of the openBIM with buildingSMART international (bSI), 2018, http://buildup.eu/en/node/55768
BIM ICT market requires a high technology performance and implementation that is difficult to target by new small and medium companies.

Examples:
- There’s a low existence of substitute products.
- There’s a market need of development and creation of a lot of products for BIM AEC customers.
- A lot of the products of BIM AEC market are unique due to the differences between countries construction codes and norms.

Substitute products exist but with a low technology level. 3D modelling and CAD technologies. BIM develops high performance technologies that are difficult to substitute. Use of IFC standard allows making compatible different software solutions.

BIM is not directly connected with suppliers.

Identification and characterization of main competitors/market players

<table>
<thead>
<tr>
<th>Competitor</th>
<th>Description of product offering and State of Technology</th>
<th>Pricing intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autodesk Revit</td>
<td>BIM for Architecture, structures, MEP, sustainability, budget</td>
<td>2970.55 €/year</td>
</tr>
<tr>
<td>Graphisoft</td>
<td>Architecture, sustainability</td>
<td>3480 € + 480 €/year</td>
</tr>
<tr>
<td>Nemetschek</td>
<td>Architecture, structures</td>
<td>??</td>
</tr>
<tr>
<td>Bentley</td>
<td>Architecture, structures, sustainability, MEP, management</td>
<td>Depending on the software you acquire.</td>
</tr>
</tbody>
</table>

SWOT analysis of RenoZeb offering with regard to this market

**Strengths**
- Big existing renovation market with the need of specific tools and technologies
- Need for guidelines and methodologies for the use of BIM in renovation
- Holistic vision of the renovation market not only focus in software solutions but in the entire process of renovation.
- Advanced knowledge of building performance, cost and savings.

**Weaknesses**
- Slow adoption of technologies due to its complexity.
- Difficulty in bringing the technology to the different users of AEC industry due to its great variety
- Difficulty when implementing the process due to its holistic approach

**Opportunities**
- Growing concern for building energy consumption by both users and authorities.

**Threats**
- Use of the technologies doesn’t reduce time of renovation.
- Use of technologies is inefficient
4.3 Smart control & monitoring systems market segment

BEMS is an encompassing term for technology and service offerings that deliver business improvements, including cost savings and strategic capital planning, due to the more effective management of energy consumption and building operations. Building energy management systems (BEMSs) are the data-driven decision support tools that define the next generation in facilities and operations management. They enable the strategic management of operations and maintenance, investment in building system upgrades, and resource utilization within a facility or across a portfolio. There is debate among industry stakeholders on what solutions fall inside the BEMS boundary but in general BEMSs are IT-based solutions that extend the capabilities of sensing, control, and automation hardware to direct both automated and manual improvements to system operations.

BEMS offerings deliver efficiency in one of two ways: via focused improvements in heating, ventilation, and air conditioning (HVAC), lighting, plug loads, or fire and security systems; or via the integrated management of multiple systems.

A well-designed and implemented BEMS provides energy, cost, and maintenance savings while supporting strategic corporate objectives such as sustainability or climate-related goals. In other words, BEMSs can change the energy management paradigm to deliver strategic and holistic management of facilities and equipment.

By considering the importance of BEMS solutions as defined in current regulation, we have to further proceed with the dimensional analysis of the functionalities offered by BEMS tools. These systems can be categorized in terms of functional offerings, but in the same way the architecture may vary, the solution maturity may vary in terms of integration complexity and capabilities. In terms of solution architecture, BEMS offerings can include software, services, and/or hardware in an array of combinations designed to address the customer’s specific needs based on the existing infrastructure and human capital. A more detailed presentation of BEMS solutions dimensions is provided in WP2 towards RenoZEB BEMS development, though a high level taxonomy of BEMS functionalities is provided in this document.
The common denominator for all BEMS tools is:

- Monitoring of building status and contextual conditions:
  - Energy consumption and set points of HVAC, lighting, other devices
  - Environmental conditions, e.g. temperature, humidity, luminance, occupancy etc..
- Provision of energy management information
- Remote monitoring and control of services and functions of one or several buildings
- Possibility of automatic control of services and functions. For instance, automatic switch-on, switch-off of appliances
- Optimization of building operations

The last points about optimization is the focus of analysis in WP2, on a way to incorporate BEMS functionality as part of the RenoZEB solution. Considering the optimization feature as the anchor point of our system, we proceed with high level taxonomy of the optimization processes as defined in commercial solutions:
The aforementioned analysis highlights the main objectives to be met by a BEMS tool. This high level taxonomy will further trigger the specifications analysis for BEMS Component (as part of the Management phase of RenoZEB in D2.3).

The cost of the BEMS solution is an aspect to be examined as part of the analysis, considering both the cost of the technology itself and the revenue streams through energy savings. Towards this direction, a market analysis on current BEMS solutions and trends is provided as part of the market analysis for BEMS tools.

The aforementioned analysis provides a brief overview of the BEMS as a Service. We are starting the analysis with the existing status of BEMS installations, and we further proceed with the definition of the core functionalities and high level objectives of the technology. BEMS are IT solutions that interface with the physical devices and implement a Decision making considering:

1) The energy consumption and the need for energy efficient operation
2) The cost of energy and the need for cost efficient operation
3) The comfort of building occupants and the need for the establishment of a sustainable environment
4) Additional energy market driven models, e.g. DR and DSM strategies triggered by ESCOs, Aggregators or 3rd party companies

We have presented above the details over Building Energy Management Solutions, highlighting the core functionalities of the technology. The BEMS requirements analysis is provided as an Appendix along with the short market analysis of the BEMS industry. We have to point out that a more detailed presentation of the BEMS technology will be available in WP2 and WP6.

Along with the description of the technical functionalities associated with BEMS operation, a market analysis for BEMS industry is provided. The positioning of BEMS vendors in this Leader board Report, provided by Navigant Research, reflects the multidimensional assessment of both Strategy and Execution. The group of vendors assessed in this report have distinct strengths and weaknesses, but this analysis is intended to highlight the overall position of 15 key industry players.

While revenue was not used as one of the criteria, most of the companies active in this market are selling at least $5 million per year of BEMS software and the associated services and hardware. In some cases, BEMSs represent just a small fraction of a company’s revenue; in others, they represent virtually all of a company’s revenue.

Companies are rated relative to each other using the following point system. The ratings are a snapshot in time, showing the current state of the company. These scores are likely to be fluid as new competitors enter the market and customer requirements evolve.

- Very Strong 91 – 100
- Strong 76 – 90
- Strong Moderate 56 – 75
- Moderate 36 – 55
- Weak Moderate 21 – 35
- Weak 11 – 20
- Very Weak 1 – 10
It is a common understanding nowadays that a transition to cloud based solution is the future in BEMS solutions. Schneider Electric, a dominant partner in BEMS solutions, highlights the six key benefits of Cloud-based BMSs:

- **Continuous Improvement** – Take a peek into individual or overall building operations to evaluate energy costs and compare performance across sites.
- **Proactive Maintenance** – Cut problems off at the pass. Things like declining performance in a chiller could indicate equipment failure. You now have the power to dispatch maintenance before a crisis occurs.
- **Occupant Comfort** – Continuously monitoring local conditions ensures comfort can be maintained.
- **Real-Time Alerts**. Unexpected events and out-of-spec conditions can trigger automatic alerts that give you the time needed to take swift action and solve problems.
- **Crowd Sourcing**. The Cloud makes it easier to share information and enable “bottom-up” solutions.
- **Improved Services**. Overall building services are improved when decision makers, from local maintenance to corporate planners, are kept in the loop.

Another trend is the IoT transition. Adding IoT-based controls and monitoring to a building (~7500 square foot) can cost around $5000, which is a fraction of traditional BMS costs. IoT is still a new industry, but CANDI sees IoT energy management system prices averaging around $0.75 per square foot, which is at least 5x less expensive than traditional approaches. The process typically requires a systems integrator or in-house electrician and IT network professional. An energy engineering specialist is recommended to analyse the data and make recommendations on process optimization and automation in order to maximize savings.

Focusing on HVAC, lighting, and some types of electrical loads, it is reasonable to expect savings in the range of 10% to 25% when implementing proactive energy management programs in mid-sized buildings. For a typical 7500 square foot building, this equates to an annual potential savings of $1500 to $5000 per year and ROI can occur in one to three years. Beyond the pure
monetary savings, additional benefits related to sustainability and environmental stewardship can also be realized, with detailed data to support them.

According to Navigant Research, BEMS revenue is estimated to $2.4 billion in 2015 and is expected to grow to $10.8 billion by 2024 at compound annual growth rate (CAGR) of 18.2%.

![Figure 15 BEMS Market Analysis](image)

Considering this vast expansion of the BEMS market, we are examining the integration of BEMS functionality in the project, by providing a coordinated management framework addressing energy, contextual (as defined in E.U. legislation) and financial (market analysis of existing BEMS technologies) parameters.

<table>
<thead>
<tr>
<th>Porter’s competitive force</th>
<th>Rating [1-5]</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat of new entrants</td>
<td>4</td>
<td>• Lower cost solutions offered by under-the-radar competitors i.e. technology giants like Apple, Google</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Integrated solutions offering not only energy management functions but overall smart home/building functionality and automation functions, directly targeting the millennials.</td>
</tr>
<tr>
<td>Bargaining power of buyers</td>
<td>4</td>
<td>• The wealth of products available in the market increases the bargaining power of customers. However, traditional building managers are keen to prefer vertical solutions offered by established market.</td>
</tr>
</tbody>
</table>
Table 32 Porter’s competitive force for RenoZEB BEMS

- Identification and characterization of main competitors/market players

<table>
<thead>
<tr>
<th>Competitor</th>
<th>Description of product offering and State of Technology</th>
<th>Pricing intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schneider / Struxure Ware</td>
<td>StruxureWare Building Operation software provides integrated monitoring, control and management of energy, HVAC, lighting and fire safety. It is a centralized system with scalability from a single building to a global enterprise.</td>
<td>Dependent on the size of the building: From €25/ m² for small-sized buildings down to €10/ m² for very large ones</td>
</tr>
<tr>
<td>Siemens / Navigator</td>
<td>Comprehensive energy and operational performance platform that encompasses both energy supply and demand analyses, going beyond energy management into key building analytics.</td>
<td>Dependent on the size of the building: From €25/ m² for small-sized buildings down to €10/ m² for very large ones</td>
</tr>
</tbody>
</table>
Johnsen Controls’ / Panoptix | Company offering products and services to optimize energy and operational efficiencies of buildings | Dependent on the size of the building: From €25/ m² for small-sized buildings down to €10/ m² for very large ones.

Verisae / vx Connect | Cloud-based, integrated platform, comes from correlating business information, people, processes, and analytics across traditionally disconnected operations. Supports maintenance management, energy management, mobile workforce, remote asset management, etc. | Dependent on the size of the building: From €25/ m² for small-sized buildings down to €10/ m² for very large ones.

IBM Smarter Building / Tririga | Gives facilities managers and real estate executives the tools to better manage facility energy and space utilization, reduce operating costs, and prepare for new lease accounting standards. | Dependent on the size of the building: From €25/ m² for small-sized buildings down to €10/ m² for very large ones.

EnerNoc | EnerNOC is among the largest providers of energy intelligence software and services for commercial, institutional, and industrial customers, as well as electric power grid operators and utilities. N/A

Table 33 BEMS competitors

- SWOT analysis of RenoZEB offering with regard to this market

**Strengths**
- Introduction of the dynamic aspects of the buildings in real-time optimization
- Comfort-preserving solution, based on accurate inference of occupants’ comfort preferences.
- Low-cost BEMS affordable for small-sized buildings.

**Weaknesses**
- Long-term development process
- Need for additional investment by clients for sensors purchase and installation

**Opportunities**
- Advent of smart building technologies and change in the mentality of consumers
- Increased need for energy optimization
- High growth potential of the smart controls market
- High importance given to human-centric solutions
- Segment requirements pose significant entry barriers for dominant suppliers

**Threats**
- Limited investment capacity in some EU Member States due to the economic recession
- Need to build benefit awareness to potential clients
- Long decision time especially in the case of public sector clients

Table 34 RenoZEB SWOT analysis
5 Potential customers and stakeholders

This section considers and maps the stakeholders in the nZEB landscape and identifies those requiring a deeper analysis and better understanding. The analysis provides a general overview of market dynamics and is not focused on any particular member state or region. The needs of particular actors in particular markets will be considered in more detail in future editions of this market report.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Key issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution providers</td>
<td>Key issues</td>
</tr>
<tr>
<td>Construction companies</td>
<td>Key actors - interest very high; power is high, but ultimately they will respond to customer demand and regulatory changes</td>
</tr>
<tr>
<td>Maintenance companies</td>
<td>High interest but largely respond to customers' requirements and specifications</td>
</tr>
<tr>
<td>Technology vendors</td>
<td>High interest in providing new and innovative solutions, or in protecting their existing offer, but cannot shape the market alone</td>
</tr>
<tr>
<td>Consultants</td>
<td>High interest, but cannot shape the market alone</td>
</tr>
<tr>
<td>Architects</td>
<td>High interest, but cannot shape the market alone</td>
</tr>
<tr>
<td>Residents</td>
<td>Key issues</td>
</tr>
<tr>
<td>Owner occupiers</td>
<td>High interest in energy savings and improved quality of residence; require a viable nZEB offer to be on the market in order to adopt it</td>
</tr>
<tr>
<td>Private tenants</td>
<td>High interest in energy savings and improved quality of residence; require landlord to act in order to adopt nZEB solutions</td>
</tr>
<tr>
<td>Social tenants</td>
<td>High interest in energy savings and improved quality of residence; limited influence on adoption of nZEB</td>
</tr>
<tr>
<td>Portfolio owners</td>
<td>Key issues</td>
</tr>
<tr>
<td>Private portfolio owners</td>
<td>Interest in resident retention and attractiveness of stock (in some markets); influential as an adopter or blocker of new nZEB approaches</td>
</tr>
<tr>
<td>Social housing portfolio managers</td>
<td>High interest in resident retention and attractiveness of stock</td>
</tr>
<tr>
<td>Utilities</td>
<td>Key issues</td>
</tr>
<tr>
<td>Electricity utility</td>
<td>High interest (threat to revenue); limited influence</td>
</tr>
<tr>
<td>Gas utility</td>
<td>High interest (threat to revenue); limited influence</td>
</tr>
<tr>
<td>Trade associations</td>
<td>Key issues</td>
</tr>
<tr>
<td>Construction trade associations</td>
<td>Interested in new industry paradigms, but also in status quo; some influence (dissemination)</td>
</tr>
<tr>
<td>Technology trade associations</td>
<td>High interest in new industry paradigms; some influence as a blocker or driver depending on tech</td>
</tr>
<tr>
<td>Professional networks</td>
<td>High interest in new industry paradigms; some influence (dissemination)</td>
</tr>
</tbody>
</table>
A stakeholder map is used to identify the key actors for deeper consideration and analysis, where ‘interest’ denotes the degree to which the stakeholder will be affected or impacted by the deployment of a RenoZEB-type solution; ‘power’ denotes the ability to influence the decision whether to proceed with a RenoZEB-type solution for refurbishing a building or portfolio of buildings. Figure 16 shows such a map, highlighting a shortlist of key stakeholders in the upper-right quadrant.

These key stakeholders span the supply and demand sides of the nZEB market, but also extend to enablers such as regional (or city), national and European-level regulators and legislators. On the supply side, the key stakeholders (technology vendors, maintenance and construction

### Table 35 RenoZEB key Stakeholder list

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Key Stakeholder</th>
<th>Interest and Power Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community</td>
<td>Community groups</td>
<td>Medium interest - may benefit from improvement in local area and increased property values; limited influence in most contexts</td>
</tr>
<tr>
<td></td>
<td>Neighbours</td>
<td>Medium interest - may benefit from improvement in local area and increased property values; low influence in most contexts</td>
</tr>
<tr>
<td>Legislators and regulators</td>
<td>European level govt</td>
<td>High interest (energy performance targets); med-high influence (setting directives, product standards etc)</td>
</tr>
<tr>
<td></td>
<td>National govt</td>
<td>High interest (implemented energy performance targets); high influence (setting regulations, providing finance)</td>
</tr>
<tr>
<td></td>
<td>Local authority / city govt</td>
<td>High interest (local housing standards, environmental objectives); high influence (planning, finance)</td>
</tr>
<tr>
<td>Media</td>
<td>Industry media</td>
<td>Medium interest and influence - dissemination of nZEB concepts</td>
</tr>
<tr>
<td></td>
<td>Local media</td>
<td>Medium-low interest and low influence - may report on local projects</td>
</tr>
<tr>
<td>Civil society</td>
<td>Environmental groups / NGOs</td>
<td>High interest (carbon and environment), medium-low influence</td>
</tr>
<tr>
<td>Finance</td>
<td>Public investors</td>
<td>High interest in investing funds in low carbon projects with good returns; limited influence - need to stimulate projects</td>
</tr>
<tr>
<td></td>
<td>Private investors</td>
<td>High interest in investing funds in low carbon projects with good returns; limited influence acting alone - need a pipeline of viable projects</td>
</tr>
<tr>
<td>Real estate</td>
<td>Real estate valuation surveyors</td>
<td>Medium interest but high influence as the valuers of housing stock</td>
</tr>
<tr>
<td></td>
<td>Real estate sales</td>
<td>Medium-high interest in new housing concepts; medium influence in promoting nZEB buildings in the market</td>
</tr>
<tr>
<td>Academic</td>
<td>Universities, technical and research</td>
<td>Academic interest but minimal influence on market</td>
</tr>
<tr>
<td></td>
<td>establishments</td>
<td></td>
</tr>
</tbody>
</table>
companies) are those involved in reconfiguring business models and supply chains around the nZEB paradigm. While on the demand side, key actors such as housing portfolio managers and real estate sales agents have a major role in creating a sufficient volume of demand to incentivise the necessary supply-side shifts.

Figure 16 nZEB stakeholder map
Having mapped and identified the key stakeholders – described in table 35 below – these will be subject to further analysis in the next edition of the market report.

<table>
<thead>
<tr>
<th>Key stakeholder group</th>
<th>Significant drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction companies</td>
<td>Profit; compliance; market share</td>
</tr>
<tr>
<td>Maintenance companies</td>
<td>Cost and risk management; winning and retaining clients (property portfolio managers)</td>
</tr>
<tr>
<td>Technology vendors</td>
<td>Profit; market share</td>
</tr>
<tr>
<td>Owner occupiers</td>
<td>Energy costs; value of home; health and comfort</td>
</tr>
<tr>
<td>(Social) housing portfolio managers</td>
<td>Tenant retention (wellbeing, satisfaction and ability to pay rent); need trust in nZEB solutions, technologies and business models, and the RenoZEB concept</td>
</tr>
<tr>
<td>European level government</td>
<td>Decarbonisation commitments requires rapid, widespread adoption of high-quality nZEB solutions</td>
</tr>
<tr>
<td>National government</td>
<td>Transposition of EU Directives on decarbonisation into national law; energy cost; energy security; fuel poverty</td>
</tr>
<tr>
<td>Local authority / city level government</td>
<td>Local energy system constraints; local welfare issues (low income, fuel poverty); planning process issues; community wellbeing</td>
</tr>
<tr>
<td>Real estate valuation surveyors</td>
<td>Property value; saleability through differentiation and quality</td>
</tr>
<tr>
<td>Real estate sales</td>
<td>Property value; saleability through differentiation and quality</td>
</tr>
</tbody>
</table>

Table 36 Stakeholder analysis
6 Conclusions

The political momentum, the ageing EU building stock and the priorities for the European Union can offer a great opportunity to RenoZEB project.

Nevertheless, investments in nZEB renovation are generally still a niche. The request is growing, so the market, but to exploit this opportunity it has been critical to study, beyond the macro trends, the technological and material orientations as well as necessities for complying with the anticipated volume of demand.

A clear set of trends in materials, systems and approaches has been identified, with certain levels of variability in practice according to the climatic area, the local building codes, the height of the building and prevailing fire safety laws.

Furthermore, it has emerged that the point of view of the players, who generally consider investments in the energy efficient market too expensive, constitutes a barrier to face and to be overcome: tailored-made financing offers with low interest rates and fast-track procedures accompanied by low transaction costs would offer an attractive and investment-friendly environment.

On the supply side of energy efficiency investments, actors perceive as the main drivers:

- a standardisation of energy efficiency investment processes, to enable a common understanding and better communication between stakeholders and financial institutions;
- a regulatory stability based on a strong and stable regulatory framework supported by European funds to leverage private investments and provide technical expertise.

Some of the stakeholders considered in the nZEB landscape requires a deeper analysis and better understanding. The analysis provides a general overview of market dynamics and is not focused on any particular member state or region. The needs of particular actors in particular markets will be considered in more detail in the future editions of this market report.
References


• Anne-Marie Pålsson (1996), Does the degree of relative risk aversion vary with household characteristics?, Journal of Economic Psychology, Volume 17, Issue 6, Pages 771-787

• Article 19(1)(a) of the Energy Efficiency Directive (Directive 2012/27/EU) recognises the importance of addressing the barrier of split incentives in the building sector.


• Danish Energy Agency (2016), Copenhagen Economics - Do homes with better energy efficiency ratings have higher house prices? - Econometric approach Retrieved from:


• Gyldenskog K. (2018), [Interview with UIPI and Gyldenskog K. from Huseiernes Landsforbund in 20/06/2018]

• Hope JH and Booth A. (2014), Attitudes and behaviours of private sector landlords towards the energy efficiency of tenanted homes, Energy Policy


• Incentives. Report for the University of Waikato Centre for Environmental, Jakarta M. (2006), Marginal costs and co-benefits of energy efficiency investments. The case of the Swiss residential sector, Energy Policy


