

Enhancing Market Readiness for nZEB Implementation

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Abstract. Despite transposing the 2010/31/EU Directive's requirements creates legal responsibilities at the national level, the nearly Zero energy building (nZEB) principle does not appear to be widely adopted just yet in many nations. Previous studies have shown that the most significant barriers include determining the cost-effective ideal integration of the technologies appropriate for nZEB and the skills constraints faced by the construction industry. In order to meet the challenge of an efficient nZEB implementation, existing certification courses and training programs are still insufficient and inadequate, and hiring experienced specialists for building retrofit and new construction is not common practice. The traditionally conservative real estate industry is nevertheless hesitant to adopt the new building standards and practices, notably in the residential sector, despite a significant movement towards nZEB and extensive energy renovation. In this specific situation, this paper provides a preliminary analysis of the European project nZEB Ready Enhancing Market Readiness for nZEB Implementation, which aims to address the issue of the effective implementation of the nZEB and make use of new possibilities to act at the market level in order to boost the market's readiness for a successful implementation of the nZEB and to encourage demand for energy-related skills among construction workers and specialists in the countries involved and beyond.

1. Introduction

1.1. The nZEB Context

The Energy Performance of Buildings Directive (EPBD)'s specific concept [1], "nearly Zero Energy Buildings" (nZEBs), has now become a critical requirement for the building sector, along with the challenge for the architects and designers who are divided between keeping up with indoor environment quality standards and solutions for decreasing energy consumption.

The nearly zero or very low amount of energy required should be covered to a very significant extent from renewable sources, including energy from renewable sources produced on-site or nearby. Some EU countries have already the nZEB concept clearly defined in the national legislation, yet some of



them not. As concrete thresholds or ranges are not defined in the EPBD, these requirements leave room for interpretation and thus allow the member states to define their nZEB requirements in a flexible way, taking into account their country-specific climate conditions, primary energy factors, ambition levels and calculation methodologies.

Even though research community has extensively tried to facilitate nZEB implementation support with scientific publications and research projects, the nZEB concept still does not seem to be easily applied in the member countries: the European Commission financing programs, past and current efforts clearly show that required investments and optimal integration of the technologies suitable for the building's construction and/or renovation into nZEB are among the major barriers [2]. Furthermore, the confidence of both the buildings industry and of the building owners in the real energy performance of the nZEBs and in the real risks associated with new technologies, seems one of the key strategic points. The resolution of these points could possibly solve the problem related to the high investments required in the process.

In order to facilitate and support the implementation of nZEB, the concept needs highly applicable evaluation criteria and indicators, very well documented with specific guidelines, disseminated and proved with real case studies and best practices, in order to raise awareness on the nZEB market including the professionals involved in the construction process. Most stakeholders involved in the construction process are not aware of local and European regulations, nZEB targets, nZEB rules and nZEB guidelines. The nZEB concept needs more awareness among the beneficiaries in order to increase the market demand that will force the construction specialists to develop themselves, thus increasing the awareness among the key specialists and their knowledge. There is also a need for decision tools and solutions that can help the beneficiary to decide whether it is attractive to invest in a highly efficient building. Reliable data on current market activities is essential for policy-makers to evaluate the success of their policies and measures.

According to the European Energy Efficiency Plan 2011[3], the greatest energy saving potential lies in buildings: 75% of the EU's building stock is still energy inefficient and the rate of building renovation remains very low at around 0.4% to 1.2% per year. In order to meet our climate and energy objectives, the current rates of renovations should at least double. Also, the annual new buildings growth rate is assessed at around 1% in the European residential sector [4]. The decrease in the rate of new constructions in the last decade is due mainly to the financial crisis of the construction sector. Moreover, buildings account for 40 % of total energy consumption in the EU and generate 36% of the greenhouse gases in Europe [5].

A significant problem in the nZEB process is the performance gap between the designed and actual energy performance in buildings. The main reasons behind this are: inadequate design, bad quality of the construction work, lack of soft landings, lack of continuous commissioning after the installation has been handed over, lack of proper use of systems and implemented technology, lack of understanding of how the technologies work, too general information in O&M manual, difficulties in changing users' previous behaviour etc. Even if, due to EPBD implementation, the new public buildings shall already be nZEB, the designers still do not know how to apply the nZEB requirements as indicated in the legislation because these are still not clearly linked to the current construction laws.

Results show that feasibility studies will not be focused on nZEB criteria but rather on the classical building functionality. Moreover, based on the feasibility study, tender specifications are further created for design and execution contracts, but usually the design is considered only based on classical construction requirements. Thus, the result is a technical design which is not for nZEB, even if it should be, and being at high risk the during execution phase to be blocked by the beneficiary consultant or inspectors. Moreover, these barriers are considerably more important in the residential field, where the concerned end users do not have the information on materials, construction technologies (or renovation packages) and available funding opportunities. Thus, the market is missing important pieces from the nZEB puzzle, like skilled building professionals, across the whole building design, operation and maintenance value chain, ready to implement nZEB concept.

1.2. The nZEB Ready project

Focused on unblocking the nZEB market, the aim of nZEB Ready research project [6] is to leverage the market drive by responding to 3 key questions: “Why nZEB?”; “Who can provide nZEB?”; and “How to reach nZEB?”. Thus, the nZEB Ready project will prepare ready to use frameworks to answer the needs related to lack of awareness, lack of skilled professionals and lack of support instruments, implementing the nZEB ready labelled procedures in 5 pilot countries with different implementation status (Bulgaria, Croatia, Poland, Portugal and Romania) in order to obtain a broader range of results, representative at European level. The frameworks obtained will be validated by specific stakeholders which are already part of the advisory board of the consortium and will be the starting point for the nZEB readiness roadmap for further replication in a wider use at the European level. The project outcomes will be easily scalable to other member states and easy to implement in any other country, regardless of the nZEB implementation level and knowledge. Therefore, the nZEB ready project has a key role in developing the nZEB market needs and skills all around Europe.

The nZEB Ready project will act on 3 different pillars as crystallized from literature review and relevant stakeholders’ consultation: **awareness, training and support tools**, responding to the critical points of market barriers, as identified in most European countries.

The methodology adopted for the project implementation is illustrated in the Figure 1. The work plan is structured in 7 parts, the management of the project (WP1) and the communications and dissemination (WP7) are transversal activities, the other are design according with the needs for effective implementation of nZEB concept, starting with knowledge bridging (WP2), the awareness process for the key process chain participants (WP3), development of strategic modules and training (WP4), the development of demand-side support tools for implementation of nZEB (WP5) and the Replication Strategy and Roadmap for implementation (WP6), aiming to maximize the project’s impact and wider use, based on its important and comprehensive results in previous activities.

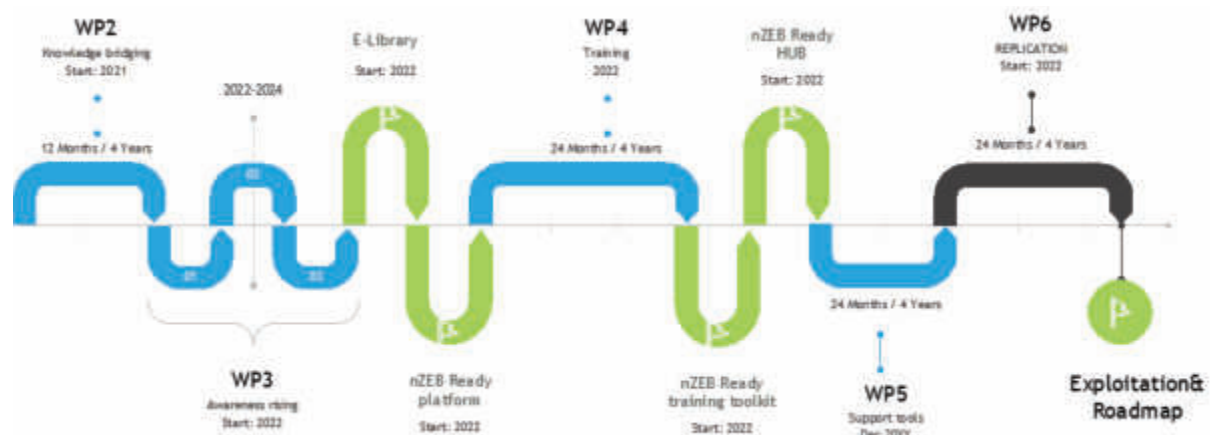


Figure 1. Structure of nZEB Ready project (WPs and the main milestones)

1.3. Objectives and outline of the study

This paper focuses on the preliminary analysis of the nZEB market in participant countries. The main goal is to present the project’s methodological approach regarding nZEB implementation taking into account the national nZEB legislation and market readiness.

The paper is structured in 3 sections. The introduction section is followed by the methodological approach, where the nZEB definition, requirements and market analysis are briefly presented for the pilot countries. This constitutes the starting point of the methodology adopted. Previous initiatives including initiatives for reinforcing the links between skills/education and energy performance are addressed. In the section 3 some real demonstrating nZEB case studies are present for proving the best practice in pilot countries.

The paper ends with the final section of conclusion, where a discussion of the preliminary analysis is presented together with the future steps.

2. Methodology adopted for evaluating nZEB Readiness in pilot countries

2.1. nZEB criteria in the pilot countries

According to several studies [6][7] most of the countries from the European Union already introduced specific concepts regarding the implementation of nZEB buildings in their regulations and national plans. It can be observed that in practice no country fully implemented the principles.

The nZEB awareness level is not high enough within the EU countries, the nZEB implementation status is unclear and also there is no data about how many nZEB buildings are constructed or under construction in EU countries: most European countries are not prepared for the nZEB concepts, even if there are some countries which are more evolved regarding the nZEB principles included in their national regulations.

Romania

EU Directive 2010/31/EU has been transposed into Romanian legislation through updating the Law 372/2005 on the energy performance of buildings (modified by the adoption of the Law 101/2020). Criteria for nearly Zero Energy Building (nZEB) are defined in the Law 101/2020 which defines the terms and Order no. 386/2016 which updates the Technical Regulation C107/2005 named “Standard regarding the thermos-technical calculation of the building construction elements”.

Regarding nZEB definition, “Nearly zero-energy building means a building that has a very high energy performance, where the energy required to ensure the energy performance is almost equal to zero or is very low and it is covered as follows: i) At least 30%, with renewable energy sources, including energy from renewable sources produced on site on the immediate vicinity, within a radius of 30km from the GPS coordinates of the building, starting 2021 and ii) The minimum proportions of the energy used from renewable sources, including energy produced from renewable sources on site or nearby, within a radius of 30km from the GPS coordinates of the buildings, for the periods 2031-2040, 2041-2050 and after 2051 are established by Government decision. It is not clear how and who can validate the technical project documentations to demonstrate the compliance with nZEB requirements.

Bulgaria

nZEB definition was adopted in 2015 and included in the additional provisions of the Energy Efficiency Act [1]. The obligation that all new buildings must be nearly zero energy buildings (nZEB) by 31 December 2020 is described in the National Plan for Nearly Zero Energy Buildings, 2015-2020 [2] but **it is practically not in force yet**. The Ordinance 7 to the Spatial Act on energy efficiency of buildings [3] sets the minimum requirements for energy efficiency and currently **it is still required that the new buildings should be energy class B**, which places Bulgaria in position of practical non-compliance to the EPBD 2010/31/EU, even though the Directive is officially approved as “transposed”. For the existing buildings the minimum requirement when a renovation is undergoing is energy class C. Thus, the current reference values reflect these requirements rather than the ones relevant for reaching nZEB level.

The National Plan for Nearly Zero-Energy Buildings (nZEB), adopted in December 2015, provides the national definition and the technical parameters of nZEB and the national annual targets for construction of new nZEB by 2020.

The definition of nZEB is given in the Energy Efficiency Act of 15 May 2015. A nZEB is a building that simultaneously fulfils the following conditions: i) the energy consumption of the building, defined as primary energy, complies with Class A on the scale of energy consumption classes for buildings of the relevant type; and ii) not less than 55% of the energy consumed (supplied) for heating, cooling, ventilation, domestic hot water and lighting is energy from RES produced on-site or near the building.

Portugal

EU Directive 2010/31/EU has been completely transposed into Portuguese legislation through the adoption of the Decree-Law No. 118/2013 on the energy performance of buildings which added the Energy Certification System for Buildings (SCE), the Energy Performance Regulation for Residential Buildings (REH) and the Energy Performance Regulation for Commercial and Services Buildings (RECS), with ordinances and associated orders. Energy Certification System was adapted for the Autonomous Regions of the Azores and Madeira. The criteria for nearly Zero Energy Building (nZEB) are defined Law (Ordinance) No. 98/2019 of 2 April 2019. The first amendment to Decree Law No. 118/2013 occurred in 2015, through Decree-Law No. 68-A / 2015, of April 30th [2], Decree-Law No. 194/2015, of December 14th September [3], by Decree-Law No. 251/2015, of November 25th [4] and successively by Decree-Law No. 28/2016, of June 23rd. The associated Ordinances and Orders were also, whenever necessary, subject to change. It should be noted that the Building Energy Performance Directive No. 2010/31 / EU was revised, within the scope of the Clean Energy Package for all Europeans, giving rise to the publication of Directive (EU) 2018/844 of 30 May 2018. The transposition of the 2018 Directive will certainly introduce changes in the calculation methodologies since the intention is to adopt the standard EN ISO 52016-1 which contains a (new) simplified hourly calculation method and a calculation method monthly for the calculation of the energy need (sensitive) for heating and cooling and the energy need (latent) for (de) humidification, replacing the standard EN ISO 13790: 2008, previously adopted.

nZEB concept is represented by buildings with high energy performance and where the energy needs to be covered to a large extent from energy from renewable sources, installed on building footprint or near the site, according to the following forms of capture: preferably, in the building footprint or in the area of land where it is built and, in addition, in infrastructures for common use as close to the site as possible, when it is not possible to meet the needs for RES using local funding specifically provided for this purpose.

Poland

EU Directive 2010/31/EU has been completely transposed into Polish legislation through the adoption of the Act on the building energy performance of 29 August 2014 (Journal of Laws of 2014, item 1200). Technical parameters of the nZEB are set in the Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions to be met by buildings and their location (as amended).

The National Plan for nearly-zero energy buildings, adopted by the Polish government in 2015, set the following definition of the nearly-zero energy building (nZEB): *The nZEB should be understood as a building that meets the requirements related to energy saving and thermal insulation included in the technical and construction regulations, in particular section X and Annex 2 to the Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions to be met by buildings and their location, effective from 1 January 2021, and for buildings occupied by the authorities public and owned by them – from 1 January 2019.* Key requirements include Maximum primary energy demand for a building (EP-value), Maximum heat transfer coefficients (U-value) for external walls, floors, and ceilings, and maximum heat transfer coefficients (U-value) for windows and doors. There are no requirements regarding RES share in the energy mix of a building or CO₂ emissions, neither during the construction nor operation phase. Also, there is only a suggestion that for the air tightness the n_{50} parameter should not exceed 3.0 h⁻¹, and for buildings equipped with mechanical ventilation or air conditioning – 1.5 h⁻¹. All requirements are set only for new buildings. There are no specific requirements for renovated ones, which means that if they want to reach the nZEB standard, they need to compliance with rules for new buildings.

Croatia

EU Directive 2010/31/EU has been completely transposed into Croatian legislation through the adoption of the Building Act, which entered into force on January 1, 2014. Criteria for nearly Zero Energy

Building (nZEB) are defined in Technical Regulation on Energy Economy and Heat Retention in Buildings (Official Gazette 128/15, 70/18, 73/18, 86/18, 102/20).

The primary energy requirements for nZEB were established in 2014 as the lowest primary energy values among the analysed systems, providing they do not correspond to high global costs. The least-cost measures have been determined using the cost-optimal analysis, thus setting the optimal level of energy consumption for new and refurbished buildings. In contrast, when determining the requirements for nZEB, the range of options with the lowest primary energy consumption have been chosen to set requirements regardless of the global cost of these options (between the lowest global cost and lowest primary energy requirement).

nZEB definition: Nearly zero-energy building means a building that has a very high energy performance, as determined in accordance with Technical regulation on energy economy and heat retention in buildings (Official Gazette 128/15 - Provisional Translation, 70/18 - Provisional Translation, 73/18, 86/18). The nearly zero or very low amount of energy required should be covered to a very significant extent (min. 30 %) by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

2.2. nZEB market analysis in the pilot countries

Although it is a legal obligation to build at nZEB level, many EU countries are facing challenges related to implementation and increasing the share of highly energy efficient buildings in the building stock. Among many barriers, the most important is the knowledge gap of the workforce implementing the nZEB concept on-site (architects, engineers, blue collars, and even energy auditors), but also the low awareness level of end-users: private investors, public authorities, developers. The market readiness is thus fragile and has several particularities in each pilot country.

Romania

The construction market is one of the main drivers related to the dynamics of the number of workers, and one of the important players in terms of investment sector and market volume.

Romania ranks 3rd in the Central and Eastern Europe region in terms of sustainability certifications, with over 300 real estate projects been certified according to international methodologies for sustainable development, but also using a national certification scheme. Regarding the renewable energy sources use, a highly active field is the one of PV panels as now there is the possibility to inject electrical energy in the grid, avoiding the problems of energy storage. The prosumer market is thus rapidly growing.

Timid steps have been made on the part of BIM implementation or other digitalisation approach in the construction domain, while most of the new technologies do exist on the market, but the use is limited due to high costs and lack of demand.

EPBD is transposed within Romanian national legislation through the Law 372/2005 regarding the energy performance of buildings which was republished in 2020, which defines the nZEB concept. In order to promote nZEB solutions, the government through AFM (Administration of Environmental Fund - Ministry of the Environment) promotes several funding programmes for private and public buildings which covered a part of the investments in thermal insulation, new performant windows and new performant systems such as heat recovery systems, heat pumps, thermal solar systems or photovoltaic systems (ON-GRID and OFF-GRID). Unfortunately, some of the programs are not working as expected, just a small amount of the fundings being granted.

Policy makers, real estate investors, architects, construction companies, designers, energy auditors, manufacturers and suppliers of construction equipment and materials, central and local public authorities, and final clients are all part of Romania's "nZEB market." All these categories have a well-defined role in the "nZEB market," from building conception to completion, but gaps due to a lack of skilled workers, a consistent legal environment, a low awareness level and so on have resulted in a very limited number of actual nZEB projects.

Real estate entrepreneurs and private owners are currently the most interested in investing in nZEBs, but public authorities must raise awareness and invest in local projects for public buildings (schools,

town halls etc.) and apartment buildings in order to reduce a significant amount of energy consumption for which the aforementioned buildings are responsible. Moreover, there is no reliable data on nZEB constructions/renovation in Romania. The Digital Buildings Registry is envisaged to be developed by the Ministry of Development, Public Works and Administration by 2024 only. On the other hand, the revision of the calculation methodology (currently under approval) detail the calculation method and clarifies many aspects, but still maintain some confusion on nZEB requirements and the delay in approval of the new requirements contributes in a large amount to the slower rate of nZEB projects implementation.

According to the National Long-Term Renovation Strategy, Romania intends to go beyond the 3% annual renovation target enshrined in EU legislation (with a gradual increase of the annual renovation rate from 0,69% to 3,39% in 2030) and takes measures to improve the energy performance of at least 18% of the total floor area of all heated and cooled buildings. This would require designing and introducing new financial mechanisms, developing a consolidated national programme, assigning new responsibilities to different government agencies and building market capacities.

Bulgaria

An analysis of the data indicates a general flat trend in the Market Volume of the Construction Sector in Bulgaria. However, the market is up by over 30% in 2020 compared to its levels in 2016. The bulk of the investments appears to be in the residential sector, followed by the non-residential sector and then finally by infrastructure projects.

The green energy market is very underdeveloped and, in principle, the arguments for environmental protection and reducing emissions and harmful impacts are very difficult to push through in business and also in municipalities that are in a dire financial situation. The same applies for the implementation of recycling or more complex circular economy strategies. There is only a recent increase of interest towards small-scale PV installations due to the ongoing energy crisis, but the legislative framework is not favourable in this respect, and is prohibitive as regards the establishing energy cooperatives.

Regarding energy efficiency, in Bulgaria there aren't requirements to seek cost-effective levels of renovation due to the low targets of the financial support programmes, although the renovation strategies are made exclusively on the basis of cost-effectiveness analysis. Bulgaria's Long Term Renovation Strategy states that 19 million m² need to be renovated by 2030, but this does not match the resources and plans that are put in the budget framework for the coming years. Currently, Bulgaria is behind schedule with the nZEB standard and is also not meeting the requirements of the EPBD and have yet to implement the updated energy performance and energy efficiency directives from 2018.

Real estate investors, architects, construction companies, designers, energy auditors, manufacturers and suppliers of construction equipment and materials, central and local public authorities, and final clients have a well-defined role in the "nZEB market" from the conception to completion of the building. However, it can be clearly stated that while the nZEB concept is recognisable, there is distrust from the professionals that it will be applied in practice, which is absolutely reasonable given the huge delay in the adoption of the EU legislation and the common practice for circumventing the legal requirements. Another issue related with the "nZEB market" is the fact that some designers who do not know enough about the requirements of nZEB or who do not comply with the legislation at the request of the beneficiaries from the design phase are performing projects that are not "nZEB ready". Also, another problem is the non-compliance with nZEB legislation for the new constructed buildings due to the lack of control measures effectively applied.

Portugal

The construction sector in Portugal has significant importance in the national economy, with a high impact on employment rate. According to data revealed by AICCOPN (Association of Civil Construction and Public Works Companies), the construction sector will continue to show a growth trend, with a real growth rate between 1.2% and 3.2%, with an average of 2.2%. In terms of Eco-Innovation Index (2019), Portugal performance increased over the past few years, developing two

voluntary mechanisms to support sustainable construction, but also using other international schemes like LEED and BREEAM. The recycling of materials has gained relevance in Portugal, and specific streams have been created for the management of waste such as construction and demolition materials. Natural materials as cork are highly used in Portugal as insulation and in the last years is also used as external coating.

On the other hand, Portugal uses many new or innovative materials and technologies, like phase change materials or vacuum insulation panes. New technologies related with windows frames are verified on the Portuguese market and used with a ventilation system on frame, rain proof and acoustic insulation. Integrated monitoring systems especially in large buildings are highly used in Portugal, giving a clear image not only of the energy consumption parameters but also of the indoor comfort parameters. Other technologies used: BIM, drone cameras, laser scanning etc.

For more comfortable and healthier houses in parallel with low energy consumption, it is necessary to encourage collaboration between architects, installers, main contractors, and manufacturers to recommend, support and implement efficiency measures with lower costs. These categories will not be the main driver of the nZEB market if they do not fully contribute, support, and implement energy efficiency measures. In Portugal, new residential buildings and single-family houses are increasingly outfitted with some of the nZEB market components defined in the preceding section, such as heat pumps or PV panels. Starting with 2019 when the nZEB concept was required, the number of certified buildings has a coherent increase, with a slightly decrease in 2021 due to post pandemic period.

Poland

The economic slowdown and the record-low interest rates in banks increased the interest of investors in buying flats as a safe investment. This caused a situation where developers are able to sell apartments from the very beginning of the construction process, even before the work at the construction site starts. After the short downturn in 2020, the market started growing in 2021 and it is expected to rise between 3 and 5 % by 2027. However, recently increased interest rates on housing loans, related to the rising inflation in Poland, negatively affected the rating scores of many private investors, especially interested in buying their first property.

Environmental issues related to climate change started gaining public awareness only in several past years. Despite growing climate awareness of polish people, higher priority is currently put to air quality improvement, especially in bigger cities. On the other hand, prosumers are playing a more and more important role in the energy mix every year. Most of the construction technologies that are applied in Poland are of foreign origin, while novel building technologies include mainly prefabricated components (e.g., façade panels). The market is however still quite modest.

In the last decade the Polish government has established a set of programs supporting energy efficiency improvement in all economy sectors, dedicated to various bodies and industries, e.g., buildings, public bodies, SMEs, transport, power sector, and horizontal measures. These include, e.g., energy efficiency obligation scheme (white certificates), energy audits and energy management systems in large companies, qualification, accreditation and certification schemes (energy performance of buildings certificate).

In the context of buildings, in 2015 the Polish Government adopted the “The National Plan aimed at increasing the number of nearly zero energy buildings”. The document focuses on legislative changes necessary to increase the number of nZEB in Poland and indicates measures and programs that can be used by bodies interested in the development of nZEB. Despite its name, the document does not include any action plan, understood as a set of tasks that should be performed, with timeline and responsibilities assigned. This resulted in poor recognisability of the nZEB concept in Poland.

While in general the ‘nZEB’ term is not widely known and used, the market participants are actively playing on the level of nZEB ‘sub-markets’, e.g., for small scale RES installations and insulation materials. Compared to the other EU countries, however, Polish requirements on nZEB are moderately ambitious in terms of energy performance. Regarding the use of energy from renewables, it is only obligatory to analyse the cost effectiveness of using RES, and in case of the negative assessment result,

the share of energy from renewables can be lowered to zero. Following the requirements of article 2a of the Directive 2010/31/EU, Polish national Long-Term Building Renovation Strategy was adopted in February 2022. For the purposes of developing the strategy, a review of all buildings in Poland, both public and private, was carried out, which shows that there are 14.2 million buildings in Poland, of which almost 40% are single-family residential buildings. According to the strategy, increasing the scale and depth of renovations of buildings in Poland will also require additional mobilisation of financial resources. In 2019, however, a sharp increase in support for investments in renovation of single-family buildings thanks to the introduction of the tax relief for single-family house owners for renovation costs and the launch of the Clean Air Program. In the following years, efforts should be made to further increase the mobilisation of private funds, and consequently activities promoting the use of the ESCO / PPP formula are planned.

Croatia

The construction market is projected to register an annual average growth of over 2 % between 2022-2025, supported by the government's focus on the development of infrastructure, as well as energy and utilities construction projects.

Installation of PVs on family houses is becoming a new trend or sort of "must have" in Croatia mostly because of the national subsidies which go up to 40 % of the total investment in PVs. Although Croatia is not using the potential it has when it comes to exploitation of sun energy (average sun hours for the country is 2.300), a significant step forward has been made in the last couple of years in that sector. Construction companies in Croatia are lately keen to use recycled or local materials, i.e. materials which are the closest to the construction site in order to eliminate long transportation thus reducing the GHG emissions. Several technologies have been already integrated (however at a slow pace) in the concept or implementation process, like BIM concept, drone on-site inspection, virtual reality technologies, laser scanning or prefabricated houses, which bring a high level of quality in the construction works. Since 2014, a large number of buildings, particularly single and multi-family buildings, have been renovated using incentives provided by the national Environmental Protection and Energy Efficiency Fund (EPEEF). An ESCO model was used to renovate public sector buildings.

Construction companies and their employees, architects and engineers, energy auditors, energy companies, RES manufactures/distributors, DIY stores and building materials stores, SMEs and ESCOs and other service providers represent trustful market operators who will improve trust and awareness of end-users towards nZEB by offering reliable and quality services at each step of the customer journey. Their role is to deploy quality nZEB so they have to be prepared with knowledge and competences on nZEB. In Croatia, the nZEB knowledge frontrunners are mostly architects, engineers and energy auditors who have participated in numerous conferences and workshops on nZEB since the nZEB requirements have been transposed into the national legislative.

As already mentioned earlier, energy companies are one of the most promising investors in nZEB, followed by the real-estate sector, i.e. construction companies and private investors who build multi-apartment buildings for sale. Since there are no requirements for nZEB while performing renovation works in Croatia, private investors are still keen to rather buy an old house and renovate it than build a new one because in that way they can avoid nZEB requirements and big initial investment. The life standard is low for most of the people (especially for those who live in the continental part), so they are not looking for long-term benefits but rather focusing on having as much lower initial investment. Big companies and successful SMEs and also those firms that have a high level of corporate social (environmental) responsibility already started investing in nZEBs but there is still a great potential for them to be frontrunners in the transformation of current building stock to nZEBs. Cities and municipalities could be potential investors or financial supporters of nZEB renovations in the future considering the opportunity of claiming savings in such projects and trading with CO₂ emissions.

The main obstacles for the renovation of the national building stock into nZEB are due to financial constraints, including long periods of return on investment, different priorities for stakeholders, lengthy and complex public tenders for funding, but also the lack of information and motivation for investors,

the public and stakeholders. However, the number of low-energy and passive buildings increases in Croatia on a yearly basis, particularly for single-family houses, multi-residential buildings and recently constructed office buildings. As for the nZEBs, the progress is rather slow, but considering the requirements this number will definitely rise in the near future.

2.3. nZEB initiatives for reinforcing the links between skills/education and energy performance

Analysis of previous project and development of a repository in the area of nZEB has been developed in the pilot countries.

Previous initiatives related to supporting nZEB deployment in the EU were examined. The analysis focused on EU-funded projects that provided learning or awareness raising materials, training for nZEB, or development of Building Knowledge Hubs. The goal of this research was to find out what has already been done in this field and to identify the gap between market needs and resources available for specific target groups. This served as a baseline for future activities related to multiplication.

The first step was to identify previous projects that should have been evaluated and might be possibly relevant. Projects' scanning was done in two stages from partners' database and CORDIS database, using "nZEB" or "deep retrofit" as keywords resulting, 82 projects in total. The projects were assessed in terms of their relevance (*Does the project deal with nZEBs, deep energy retrofit, or energy efficiency of buildings? Does the project include any activities related to Building Knowledge Hubs, or training on nZEB / deep energy retrofit / energy efficiency of buildings; or development of tools / materials supporting nZEB; or awareness or learning activities*), and finally whether have their outputs publicly available and whether they are in English. The assessment showed that out of 82 projects, 42 did not produce any outputs that could be further disseminated or exploited within the nZEB Ready project framework. This is due to many reasons, including: the project timeframe (too early stage of the project, or the opposite: project has been finished a few years ago and no outputs are still publicly available); project aimed at the development of very specific technology or solution and only promotional materials of generic nature are available; or the project focus was a wide range of sustainable development aspects, with the nZEB being only one of them. Finally, 20 projects and their deliverables were analysed.

Each of the analysed projects was unique and had its own very specific objectives. There are however some similarities in terms of the project outcomes and target groups (Figure 2). Five projects delivered training materials on different aspects of nZEB, targeting various groups of professionals from the construction sector. The next five projects focused on the development of the renovation approaches for existing buildings. Four projects were dealing with specific technologies that could be used to reach the nZEB standard, while other developed tools that support the renovation process, a skills registry for the construction sector specialists, a smart city concept, or focused on the nZEB stakeholders' matchmaking and financial issues.

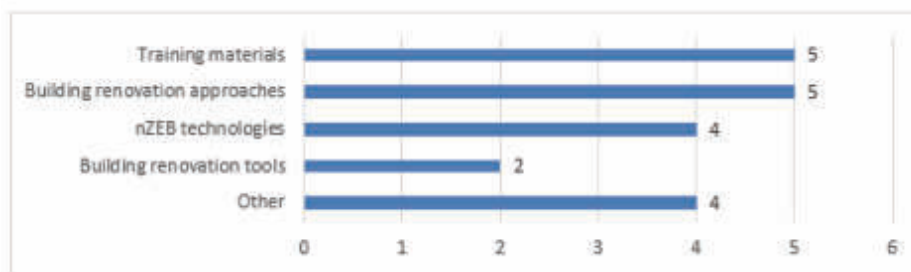


Figure 2. Main focus of the analysed projects (N=20)

Under the framework of the analysed 20 projects, 44 relevant outputs have been delivered (Figure 3). Most of them include training and learning materials for professionals (14), e.g. training programs for blue collars or train-the-trainers programs.



Figure 3. Types of outputs delivered by identified projects (N=20, multiple choice)

The second most popular output types are schemes and frameworks, and reports, eight each. These include e.g. protocols for the evaluation of health and well-being, indoor environmental quality or energy and non-energy benefits of the deep renovation. Reports provide information about e.g. cost-optimal technical solutions that allow for reaching the nZEBs standard in four different climatic zones in Europe, the design process of sustainable neighbourhoods, or the technical and economic mapping of state of the art technology options.

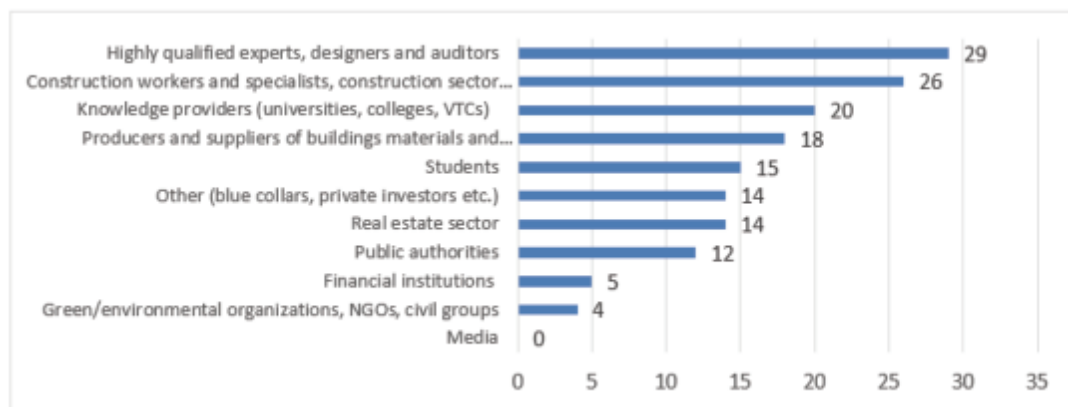


Figure 4. Stakeholders targeted by identified project outputs (N=44, multiple choice)

Websites and online platforms combine such outputs as a marketplace platform for nZEB stakeholders' matchmaking, a toolkit supporting the decision-making process of the renovation of existing buildings. Educational and training materials for non-professionals cover e.g. general introduction to the nZEB in the EU and selected Central European countries, and info brochure with basic information about nZEB benefits. Webinars and videos of educational value present e.g. energy consumption analysis or life cycle cost calculations in the nZEB-renovation of apartment blocks.

Most of the identified outputs target specialists working in the construction sector, including the highly qualified experts such as engineers, architects and auditors (29 outputs) and specialists and their associations (26) (Figure 4). These outputs allow for self-learning and gaining new knowledge about the state-of-the-art technologies and trends. The third most popular target group are knowledge providers and includes mostly train-the-trainers materials. An important part of the nZEB stakeholder chain are non-professionals such as private investors, which are also often targeted by projects. On the other hand, the most neglected stakeholder group is the media – no specific outputs have been proposed specifically to them. They can however use materials and tools for the general public. There is also a gap in outputs dedicated to NGOs and financial institutions – very few projects target them.

3. Conclusions and next steps

Although legal obligations are provided at national level by transposing the provisions of the 2010/31/EU Directive, the nearly Zero Energy Building (nZEB) concept does not seem to be easily applicable yet in many countries. Previous research showed that defining the cost-feasible optimal integration of the technologies suitable for nZEB and the skills gaps experienced by the building sector are among the most important barriers. The demand of materials and technology is low due to lack of awareness, forcing the technology providers to resume to low-cost products which are not the best options for nZEB projects.

On the other hand, there is a critical demand of skilled professionals on the construction market who have the necessary qualifications to build nZEB. Current qualification courses and training schemes are still not satisfactory and underdeveloped to face the challenge of effective nZEB implementation, while the recourse to skilled professionals for renovations and new constructions of buildings is not usual practice.

The authors of this paper, participants in the European project nZEB Ready, intend to share some insights of the preliminary analysis of the project, focused on the state of implementation of nZEB in pilot countries, the market situation, together with the objectives and methodology implementation.

4. Acknowledgements

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