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New Challenge of the Public Buildings: nZEB Findings from IEE RePublic_ZEB Project

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Abstract

Nearly Zero-Energy Buildings (nZEBs) have received increased attention in recent years as a result of constant concerns for energy supply constraints, decreasing energy resources, increasing energy costs and rising impact of greenhouse gases on world climate. The EPBD recast directive [1] requests all new buildings to meet higher levels of performance than before, by exploring more the alternative energy supply systems available locally on a cost-efficiency basis and without prejudicing the occupants' comfort. To this end, after 2020, all new buildings should become "nearly zero-energy" and after 31 December 2018, the same requirement is applied for new buildings occupied and owned by public authorities. Furthermore, the EPBD recast states that MS must ensure that minimum energy performance requirements for buildings are set with a view to achieving cost-optimal levels according to the Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012. In this context, the authors of this paper, who are participants in the recent started European project RePublic_ZEB, are willing to share the initial findings from on-going research work. Public buildings constitute a specific class of buildings that require a complex analysis from the statistic point of view taking into consideration the definition and typologies and other specific parameters related with. Thus, this paper will focus on the analysis of public building stocks in the countries covered by the project consortium with the view to define relevant parameters characterizing the reference public buildings that will be considered in the further analysis regarding the

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assessment of cost-effective packages of solutions towards nZEB levels of performance. A review of nZEB holistic approach, definitions and existing implemented policies in the participant countries, will be presented as well.

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Keywords: nZEB; public buildings; european project; refurbishment

1. Introduction

Zero-energy performance buildings have gained more attention since the publication in 2010 of the EPBD recast [1]. EPBD recast requests all new buildings to meet higher levels of performance than before, by exploring more the alternative energy supply systems available locally on a cost-efficiency basis and without jeopardizing the comfort. To this end, beginning in 2020, all new buildings should become "nearly zero-energy". A "nearly zero-energy building" refers to a high energy performance building of which annual primary energy consumption is covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

The directive requires nearly zero energy buildings, but it does not give minimum or maximum harmonized requirements as well as details of energy performance calculation framework. Furthermore, the EPBD recast states that MS must ensure that minimum energy performance requirements for buildings are set with a view to achieving cost-optimal levels according to the Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 on the cost optimal methodology framework. In this context, MS implementation of the Regulation emphasized the cost-optimal analysis for the residential buildings, at the expense of all the other categories.

The nZEB concept still does not seem to be easily applied in the member countries: the IEE programs past and current efforts clearly show that required investments and optimal integration of the technologies suitable for the buildings construction and/or renovation into nZEB are among the major barriers. Furthermore, the confidence both of the buildings industry and of the building owners in the real energy performance of the nZEBs and in the real risks associated to new technologies, seems one of the most strategic point. The resolution of which could possibly solve the problem related to the high investments required in the process.

1.1. Overview nZEB definitions

The directive EPBD recast requires nearly zero energy buildings, but it does not give minimum or maximum harmonized requirements as well as details of energy performance calculation framework. In such case, it is up to the Member States to define the exact meaning of energy performance requirements and percentage of energy from renewable sources according to local and regional climate and economic conditions. Various experts have called attention on the problem various definition of nearly zero energy building may cause in Europe. Related terms of nZEB definition (balance boundary, weighting systems and metrics, balance period) were studied extensively in order to find a more detailed appropriate definition. Torcellini et al. [2] are one of the first that significantly contributed to the definition of nZEB.

Marszal et al [3] proposed four sub-options within respect of the supply options. For the on-site supply they distinguish between supply within the building footprint and supply within the building site. As for the off-site supply, they indicate that building either uses renewable energy sources available off-site to produce energy on-site, or purchases off-site renewable energy sources (Table 1).

In an effort to synthesize many of the issues covered previously and assess the advantages and disadvantages of different strategies and scenarios of nZEB definitions, a group of experts from IEA SHC Task 40 - ECBCS Annex 52 [4] developed and propose a tool that allows checking annual energy or emission balances as well as characterizing the load match and the grid interaction profile of a building by simplified indicators on the basis of four energy balance approaches (Table 2).

Table 1. Definitions - renewable energy supply option [3, 5].

RES-footprint	RES-on site	RES-off site	
Use renewable energy sources available within the building's footprint.	Use renewable energy sources available at the building site.	Use renewable energy sources available off site to generate energy on site.	Purchase off-site renewable energy sources.

Table 2. Definitions [4].

Net ZEB limited	Net ZEB primary	Net ZEB strategic	Net ZEB emission
Weighted energy use for heating, DHW, cooling, ventilation, auxiliaries and built-in lighting (for non-residential buildings only) vs. weighted energy supplied by on-site generation driven by on or off-site sources. Static and symmetric primary energy factors are possible.	Weighted energy use for heating, DHW, cooling, ventilation, auxiliaries and lighting and every kind of plug loads (electrical car possibly included), vs. weighted energy supplied by on-site generation driven by on- or off site sources. Static and symmetric primary energy factors.	Weighted energy use for heating, DHW, cooling, ventilation, auxiliaries, built-in lighting and every kind of plug loads vs. weighted energy supplied by on- and off-site generation systems driven by on- or off-site sources. Weighting factors could be static and asymmetric, varying on the basis of the energy carrier, the technology used as energy supply system and its location.	Balance between building CO2 equivalent emissions due to energy use for heating, DHW, cooling, ventilation, auxiliaries, built-in lighting, every kind of plug loads and the weighted energy supplied by on-site generation systems driven by on- or off-site sources. Static emission factors can be symmetric or asymmetric, depending on the energy carrier, technologies used as energy supply systems and their location.

According to EPBD Annex 1, the methodology for calculation the energy performance of buildings should take into account European standards. A framework for energy performance calculation, including references to the definition of system boundaries and share of renewable is identified in EN 15603 as can be observed in Table 3, proposed by Kurnitski et al [6].

Table 3. Related terms for definitions [6].

energy performance (EN15316-1:2007)	delivered energy (EN15603:2008)	exported energy (EN15603:2008)	Net delivered energy (EN15603:2008)	system boundary (EN15603:2008)
Calculated or measured amount of energy delivered and exported actually used or estimated to meet the different needs associated with a standardized use of the building, which may include, inter alia, energy used for heating, cooling, ventilation, domestic hot water, lighting and appliances.	Energy, expressed per energy carrier, supplied to the technical building systems through the system boundary, to satisfy the uses taken into account (e.g. heating, cooling, ventilation, domestic hot water, lighting, appliances etc.) or to produce electricity.	Energy, ex-pressed per en-ergy carrier, delivered by the technical building systems through the system boundary and used outside the system boundary.	Delivered minus exported energy, both expressed per energy carrier. Net delivered energy values are expressed separately for each energy carrier, i.e. for electricity, fuels, district heat, etc	Boundary that includes within it all areas associated with the building (both inside and outside of the building) where energy is used or produced. All areas associated with the building typically refers to footprint of the building site.

1.2. RePublic_ZEB IEE Project

The European project RePublic_ZEB focuses in the refurbishment of the public building stock towards nZEB in the countries of the South-East of Europe in line with the EU's Energy Performance of Building Directive and its energy targets for 2019 and 2021. The project's main objective is to support the participant countries to develop and promote on the market a set of concrete technical solutions for the refurbishment of the public building stock towards nZEB. To achieve this goal, RePublic_ZEB's includes an assessment of the current public sector building stock and the determination of reference buildings. The expected output is the definition of cost optimal and low-risk packages of measures for the refurbishment of the public buildings towards nZEB which will be included in guidelines and the promotion activities addressed to national and regional authorities as well as construction industry, housing organizations, owners of large building stock and developers. A crucial aspect of the project is the involvement of the key actors as well as the development of a bottom-up approach to promote the building renovation initiatives. The RePublic_ZEB project is funded by the Intelligent Energy Europe programme of the European Union.

2. Public building stock

The analysis of the public building stock performed in the first stage of RePublic_ZEB project aimed at collecting key data concerning the general features and total energy consumption of public buildings in the countries or regions covered by the project consortium. The objective was to define classes of buildings to be used as a basis for the definition of reference building classes. The buildings stock categories considered for analysis are the following in line with EPBD Annex 1: Residential (e.g. social housing, service housing, student/campus housing etc.), offices, education buildings, hospitals, hotels and restaurants, Sports facilities, wholesale and retail trade services buildings, other types of energy-consuming buildings. Based on a defined common methodology (including a comprehensive template with detailed data required for the evaluation of energy performance of the existing public building stock), the starting point of the analysis was the collection of useful data from European and Regional projects, publications and technical bibliography on this topic as well as other sources of statistical data or summarised information (e.g. inventories of existing central government building stock recently undertaken in some participant countries), with the aim to build a realistic image of the public building stock and its performance in the selected countries. National EPC databases in the selected countries, EUROSTAT and Statistical offices in each country lacked relevant data on non-residential building stock in general and public building stock in particular. The biggest share of the analysed building stock in terms of total floor area and primary energy consumption is occupied by Italy and UK, due to the size of the considered stock and partially to the consideration of a part of building categories which are shared between private and public ownership or occupation (which could also be the case of Slovenia). On the other hand, the low values reported for Portugal could be explained by the lack of reliable data for the overall building stock, as only a limited sample of public buildings are available through the inventory of the existing buildings at the National Energy Certification System (SCE) and in Spain the analysis was focused in the Catalan region. At country level, the analysis of primary energy consumption share per building category is presented in Figure 1, enabling a first evaluation of representative classes for further analysis.

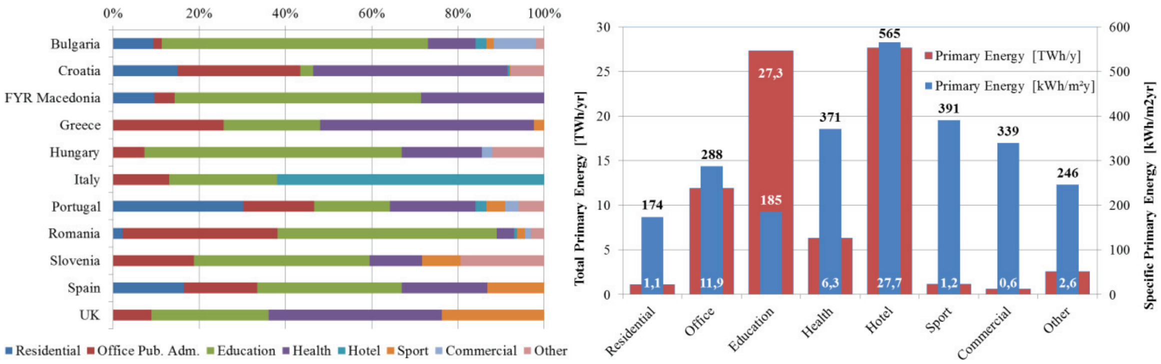

Fig. 1. (a) Impact assessment for preliminary selection of reference buildings; (b) Total primary energy per building category in analysed countries.

The performed analysis allowed the definition of the most relevant classes of buildings (in terms of major renovation impact) to be analyzed further during the project implementation. For the selected reference buildings in each country the corresponding necessary geometrical data, building energy use, base heat supply regime (type of the heating system, energy resource/carrier etc.) will be further detailed, allowing the simulation of the energy consumption and the estimation of different major renovation strategies and packages of solutions.

3. nZEB definitions applications, drivers and barriers of transformation of existing buildings into nZEB level

3.1. RePublic_ZEB project - existing nZEB definitions and applications

Within RePublic_ZEB project a state of the art of the existing nZEB definition in participant countries legislation was developed. It was found that the the nZEB definition is referred in almost all countries, except Macedonia and Spain. Although Spain has transposed by the Royal Decree 235/2013, the obligation that all the new buildings as per 31 December 2020 (2018 for public buildings) will be nZEB, being the minimum requirements established in the Technical Building Code (CTE) which will be in force by then. In Greece and Portugal the nZEB definition has been transposed to national legislation, establishing in general terms the concept nearly zero energy building, for new construction from 2020 or 2018, in the case of new buildings owned or occupied by public entities and for major renovations in the existing building (Portugal). This pattern combines reducing, to the greatest extent possible and supported on cost-benefit analysis; the energy needs the building and use energy from renewable sources. However no specific nZEB indicators were defined for building energy demand and RES, neither real application. In UK was introduced the term ‘nearly zero carbon building’, instead of nearly zero energy building. Use of renewable technologies is not obligatory, but one requirement that has been introduced in light of the recast EPBD is that proper consideration is given to the use of ‘high-efficiency alternative systems’, such as renewables, district heating, heat pumps or CHP. From the target countries of RePublic_ZEB project, five participant countries (Slovenia, Romania, Croatia, Hungary and Bulgaria) have introduced the numerical primary energy requirement of nZEB into the national legislation (Figure 2). In the same figure are presented the energy demand indicators variations for various building types and the RES share indicators. In Croatia, for each building type, the energy demand indicator varies according with climatic zone.), in Slovenia the variation of energy demand indicator is according with type of building-new or existing buildings undergoing major renovation, in Hungary is depending on A/V of the building, whilst in Romania depending on the climate zone, and type of the building.

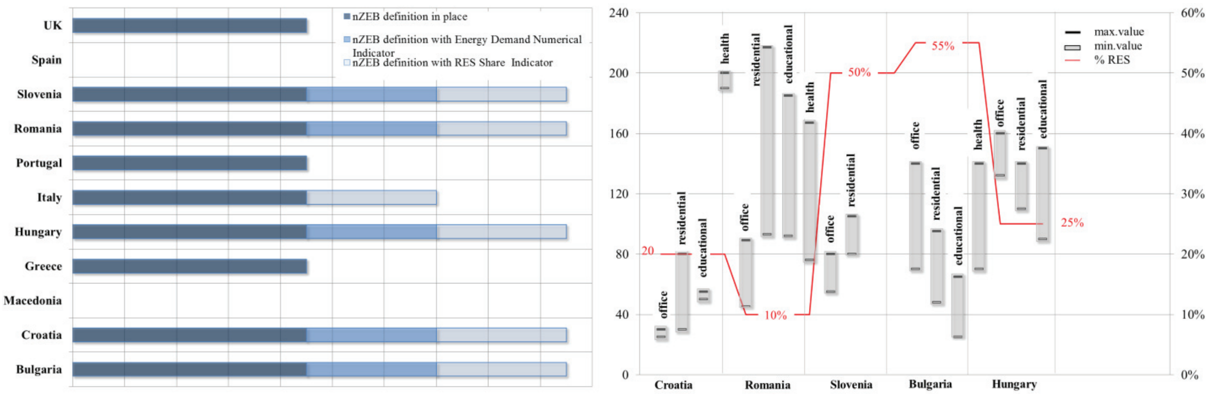

Fig. 2. (a) nZEB definition in place in target countries; (b) nZEB energy indicators.

Bulgaria introduced in their legislation that nZEB means a building with primary energy consumption of class “A” and associated energy indicators.

3.2. nZEB – drivers and barriers

In order to accomplish the building legislation requirements, it is important to identify the main drivers and barriers in each target country in which respect nZEB level of performance. As regards the drivers of refurbishment the existing buildings towards nZEB level, the first precondition is the transposition of the nZEB definition into the national legislation. Energy costs savings, lower dependence on energy suppliers, and improved comfort in the buildings are major common drivers for renovation and nZEB in several countries. The inclusion of energy aspects into planned renovations seems to depend greatly on government support programmes, such as grants, tax deductions and low-interest loans. The Energy Performance Certification database exists in each country (except Croatia), which can ease the energy experts to choose the potential buildings for major renovations.

Within the main common barriers some specific technical issues were identified as no specific boundary in NZEB balance definition and no energy demand and share RES indicators in some countries. High initial investments costs together with lack of financial instruments and limited technical skills are as well important barriers to be considered. In the Figure 3 it can be observed the identified drivers and barriers in each RePublic_ZEB participant country.

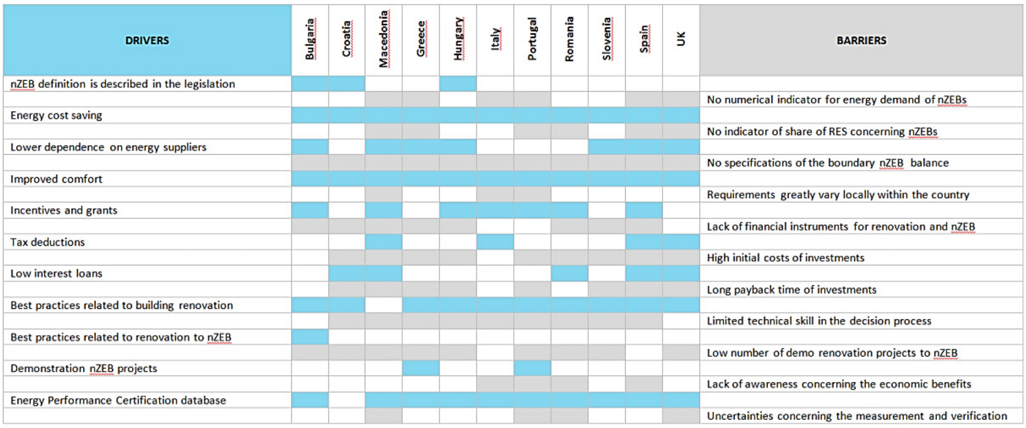

Fig. 3. nZEB drivers and barriers.

4. Conclusions

In this work the authors shared initial findings of a European Project recently approved. These findings addressed an analysis of public building stock in each target countries, nZEB definitions and applications and the main drivers and barriers for the refurbishment of the public buildings towards nZEB performance levels. The results of this first step will be used in the second part of the RePublic_ZEB project where the cost optimal methodology will be applied for identified existing public reference buildings in each target country towards nZEB performance levels.

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