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Development of the NZEBs concept in Member States

Towards Nearly Zero Energy Buildings in Europe

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Abstract

The current energy policy framework foresees a substantial reduction of energy consumption in buildings by 2020. According to the recast of the Energy Performance of Building Directive (EPBD), Nearly zero energy buildings (NZEBs) represent the European building target from 2018 onwards. This report makes an assessment of the development of the NZEB concept in Member States. It analysis NZEBs definitions, intermediate targets and policies towards NZBEs. National Plans and other sources of information have been considered to evaluate the current status of the European progress towards NZEBs. The report shows the main aspects to be further strengthened to successfully implement NZEBs in Member States.

Contents

Executive summary

The improvement of building energy performance is one of the main challenges that Europe is facing. European policies are focused on reducing energy consumption in buildings to achieve the EU 2020 goals. Essential policy instruments that encourage energy efficiency and renewable production are: the Energy Efficiency Directive (EED), the Energy Performance of Building Directive (EPBD and EPBD recast) and the Renewable Energy Directive (RED). According to the EPBD recast, Member States shall ensure that new buildings occupied and owned by public authorities are NZEBs after December 31, 2018 and that all new buildings are NZEBs by December 31, 2020. The NZEBs implementation represents one of the biggest opportunities to increase energy savings and reduce greenhouse gas emissions. To reach this target, Member States have to develop policies and measures to stimulate buildings transformation into NZEBs.

This report evaluates the progress made by Member States towards the establishment of NZEBs. Different sources of information have been taken into account: National Plans, templates developed by ENER, information from the EPBD Concerted Action (CA), Energy Efficiency Action Plans (NEEAP), and National Codes. A literature review is provided to highlight how this topic has been debated in the last decade at international level. In relation to the definition of NZEBs, many aspects have been taken into account in this report, such as building category, typology, physical boundary, type and period of balance, included energy uses, renewable energy sources (RES), metric, normalization, and conversion factors.

This study highlights that progress can be seen in many Member States in developing the NZEB concept. The establishment of national NZEB definitions has improved and consolidated information has been submitted through National Plans and the ENER templates. Apart from NZEB definitions, the report also considers the renewable inclusion, intermediate targets and policies to promote NZEBs. An evaluation is finally given in relation to the NZEBs development and compliance with the EPBD requirements.

1 Introduction

The aim of this report is to provide an EU-wide overview of the status towards the implementation of the national plans for nearly zero energy buildings (NZEBs) carried out to meet the requirements of Article 9 of the recast of the Energy Performance of Building Directive (EPBD), Directive 2010/31/EU. This analysis distinguishes the efforts according to building type and identifies common features and main differences with respect to the national NZEB definitions.

Commercial and residential buildings consume approximately 40% of primary energy and are responsible for 24% of greenhouse emissions in Europe [1]. The greatest energy-related CO_2 mitigation potential from buildings can be achieved if sustainable energy policies and supporting programmes play an effective role in ensuring reductions of emissions from the building sector. By 2050, it is technically possible to reduce building consumption by 30%, and associated CO_2 emissions by approximately 40 %, with a 70% reduction in global energy consumption of the existing building stock for space heating and cooling. This scenario is forecasted in comparison with 2005 values and despite the projected growth in floor area – estimated to be around 130 % over this period – and an increase in comfort levels [2].

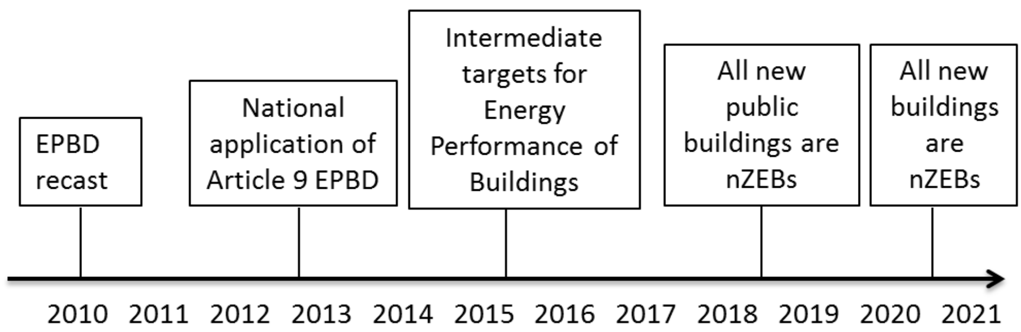
Specific measures to reduce energy consumption in the building sector have been introduced by the European Union (EU) with the EPBD in 2002 [3], and its recast in 2010 [4].

The EPBD, together with the Energy Efficiency Directive (EED) [5] and the Renewable Energy Directive (RED) [6], set out a package of measures that create the conditions for significant and long term improvements in the energy performance of Europe's building stock.

With the entry into force of the EPBD, Member States were required to draw up National Plans for increasing the number of Nearly Zero-Energy Buildings (NZEBs), with targets that may be differentiated for different building categories. According to paragraph 3 of Article 9, these plans shall include NZEB definitions reflecting national, regional or local conditions, and a numerical indicator of primary energy use.

The timeline for the implementation of NZEBs according to the EPBD recast is illustrated in Figure 1.

Figure 1. Timeline for NZEBs implementation according to the EPBD recast.



Article 9 of the EPBD states that Member States shall ensure that new buildings occupied and owned by public authorities are NZEBs after December 31, 2018 and that all new buildings are NZEBs by December 31, 2020. Furthermore, the Directive establishes the assessment of cost optimal levels related to the establishment of minimum energy performance requirements in buildings [7].

Intermediate targets for improving the energy performance of buildings had to be provided by 2015 (Article 9.3) as part of the national plans for increasing the number of nearly zero-energy buildings. Furthermore, paragraph 2 of Article 9 asks Member States to develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into NZEB, and inform the Commission thereof in their national plans.

Articles 6 and 7 of the EPBD state that the Member States have to take the necessary measures to ensure that new and existing buildings (undergoing major renovation) meet minimum energy performance requirements, taking into account the use of high-efficiency alternative systems (e.g. decentralised energy supply systems based on energy from renewable sources; cogeneration; district or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources; heat pumps).

The current energy efficiency framework foresees a substantial reduction of energy consumption in buildings by 2020. The implementation of NZEBs as the building target from 2018 onwards represents one of the biggest opportunities to increase energy savings and minimize greenhouse gas emissions. The EU legislative framework for buildings requires EU Member States to adopt their detailed national application of the EPBD definition on NZEB, supported by national policies for their implementation. Therefore the importance of integrating the NZEB concept into National Building Codes and International Standards is widely recognised [8].

In accordance with the EPBD, a NZEB is a building that "has a very high energy performance with the nearly zero or very low amount of energy required covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". The first part of this framework definition establishes energy performance as the defining element that makes a building an 'NZEB'. This energy performance has to be very high and determined in accordance with Annex I of the Directive. The second part of the definition provides guiding principles to achieve this very high energy performance by covering the resulting low amount of energy to a very significant extent by energy from renewable sources.

The EPBD framework definition of NZEB does not differentiate between new and existing buildings. Having such differentiation may be misleading for consumers, as would be the case if there were separate Energy Performance Certification ratings for new and for existing buildings.

Recognising the different climatic and local conditions, the EPBD does not provide minimum or maximum harmonized requirements (i.e. expressed in $kWh/m^2/y$) for NZEBs. The Directive requires Member States to define the detailed application in practice of "a very high energy performance" and the recommendation of "a very significant extent by energy from renewable sources, in line with their local characteristics and national contexts. This, together with the absence of a harmonised calculation methodology for energy performance, leads to applied national approaches that are not fully comparable.

In line with the requirements of Article 9(5), the Commission published a progress report towards NZEB in 2013. An updated state of play was carried out in 2014 and is available in the website of DG Energy.

In addition, the EPBD Concerted Action (CA) carries out a regular survey on the implementation of the EPBD requirements in EU Member States [9], and the Buildings Performance Institute Europe (BPIE) periodically analyses differences among existing practices in Member States [10]. Furthermore, the Commission has contracted several studies on the matter of NZEBs [11][12][13].

Table 1 summarises the main EPBD requirements that can be related to different NZEB aspects to be defined, such as building typology (new/retrofit building), balance type (which is related to how renewable energy is calculated/included in the energy balance), physical boundary (e.g. single building, building unit), system boundary demand (e.g. space heating, DHW, cooling, lighting) and generation (i.e. both on-site and offsite generation, including nearby), balance period (over which the balance is calculated), normalization (e.g. gross floor area, net floor area), metric (e.g. energy need, delivered energy, primary energy), time dependent weighting (static, quasi static or dynamic conversion factors), and fraction of renewables (proportion of energy demand covered by RES). These arguments are outlined in the next section of the report as reported to the EC by Member States.

Table 1. Summary of the EPBD requirements related to different NZEBs aspects.

EPBD requirements	EPBD reference	NZEBs aspects
Member States shall ensure that by 31 December 2020, all new buildings are NZEBs and after 31 December 2018, new buildings occupied and owned by public authorities are NZEBs	Article 9.1a/b	Private/Public
New, and existing buildings that are subject to major renovation, should meet minimum energy performance requirements adapted to the local climate. Member States shall [...] stimulate the transformation of refurbished buildings into NZEBs.	Preamble recital 15 Article 9.2	New/Retrofit
[...] buildings should be adequately classified into [...] categories.	Annex I	Building category
[...] energy performance of a building means the calculated or measured amount of energy needed to meet the energy demand [...]	Article 2.4	Balance type
The Directive lays down requirements as regards the common general framework for [...] buildings and building units. […] building’ means a roofed construction having walls, for which energy is used to condition the indoor climate.	Article 1.2a Article 2.1	Physical boundary
[...] energy performance of a building means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting.	Article 2.4	System boundary demand
[...] energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. [...] minimum levels of energy from renewable sources [...] to be fulfilled through district heating and cooling.	Article 2.6 (RED - Article 13.4)	System boundary generation
[…] The methodology for calculating energy performance should be based not only on the season in which heating is required, but should cover the annual energy performance […]	Preamble recital 9	Balance period

[…] including a numerical indicator of primary energy use expressed in kWh/m²/y	Article 9.3a	Normalization
The energy performance of a building shall be expressed in a transparent manner and include an energy performance indicator and a numeric indicator of primary energy use, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on- site production. […] primary energy means energy from renewable and non-renewable sources which has not undergone any conversion or transformation process […]	Annex 1 9.3a Article 2.5	Metrics
Primary energy factors […] may be based on national or regional yearly average values and may take into account […] European standards.	Article 9.3a	Time weighting
Member States shall introduce [...] appropriate measures [...] to increase the share of all kinds of energy from renewable sources in the building sector [...], require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings [...] The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources [...]	Article 2.2 (RED Article 13.4)	Fraction of renewables
NZEB means a building that has a very high energy performance [...]. The energy performance [...] shall [...] include an energy performance indicator and a numeric indicator of primary energy use [....] The methodology shall [...] take into consideration: thermal characteristics [...], heating installation, hot water supply, air-conditioning, natural, mechanical ventilation, built-in lighting, the design, positioning and orientation of the building, outdoor climate, passive solar systems and solar protection, [...] internal loads.	Annex 1	Energy performance
This Directive [...] takes into account [...] indoor climate requirements [...] The methodology shall [...] take into consideration [...] indoor climatic conditions [...] that includes […] indoor air-quality, adequate natural light [ ]	Article 1.1 Annex 1 Preamble recital 9	Comfort & IAQ
[…] energy performance of a building means the calculated or measured amount of energy needed […] EU Member States shall encourage the introduction of intelligent metering systems […], the installation of automation, control and monitoring systems […]	Article 2.4 Article 8.2	Monitoring

The implementation of NZEBs is strictly connected to the assessment of cost optimality and high performance technical solutions in buildings. Explanatory Guidelines of Delegated Regulation No.244/2012 of January 16, 2012 of the EC describe a comparative methodological framework to derive a cost efficient configuration to be adopted in a building [14][15]. According to the methodological approach of cost-optimal calculations, alternatives must be considered when buildings are designed, including envelope, fenestration, energy sources, and building systems. Cost-optimality means the choice of energy efficient solutions with minimal life cycle cost. The overall aim of the calculation is to obtain a cost-optimal level to identify the solution that represents the lowest total costs. A graph that reports global costs (€/m^2) on the ordinate and energy consumption (kWh/m^2/y) on the abscissa is derived to identify cost-optimality. The point of the curve that belongs to the lower part is indicative of the optimal configuration. The shape of the cost-curve is influenced by several factors, such as building typology, variants definition, discount rate, energy price, and cost data. Sensitivity analysis is suggested to add robustness to calculations, especially when a relatively flat curve is obtained. The EPBD CA supports Member States by the exchange of experiences along the path of implementing the cost-optimal methodology [16].

In order to help Member States to implement the NZEB concept, several projects have been developed with co-financing from the EC. For instance the ASIEPI project (Assessment and improvement of the EPBD Impact - for new buildings and building renovation) aims to improve the effectiveness of regulations on the energy performance of buildings [17][18]. More recently the ENTRANZE project (Policies to enforce the transition to Nearly Zero-Energy Buildings in the EU-27) supported policy-making procedures by providing data, analysis and guidelines and by connecting building experts from European research institutions and academia to national decision makers and key stakeholders [19]. Several Intelligent Energy Europe (IEE) projects have focused on NZEBs or NZEB renovation starting from 2012 [20]. Furthermore, a number of research studies and pilot projects provided additional examples and testified the interest of the international community in this topic [21][22][23][24][24][25][26][27].

Nevertheless many countries have had problems to develop and implement suitable instruments and measures to reach the NZEB target: by the end of 2012 only eight EU Member States (BE, DK, CY, FI, LT, NL, SE and UK) [1] had provided their National Plans and in mid-2013 only six other EU Member States were added (BG, DE, FR, HU, IE and SK) [28].

According to the analysis, only four EU Member States (BE, CY, DK, and LT) had provided a definition that comprised both a numerical target (in most cases expressed as primary energy, with values between 0 and 220 KWh/m^2/y) and a share of RES. Many Member States had reported that their NZEB definitions and plans are almost ready, and have also reported ongoing preparatory studies or intentions to undertake future actions [29]. Table 3 reports an updated summary around definitions among the EU Member States.

Fifteen Member States (BE, CZ, DE, DK, EE, FI, EL, HU, IE, LV, LT, NL, SE, SI, UK) had set intermediate targets in line with the provisions of the Directive, which leaves flexibility as to the detailed approach to be followed. Many Countries had chosen minimum energy performance requirements (e.g. 50 kWh/m^2/y primary energy in 2015), or a required energy performance certificate level (e.g. class B by 2015) (Table 7). Other EU Member States had defined qualitative targets (e.g. "all new buildings" or "all new public buildings" will be NZEBs by 2015). Intermediate targets for the refurbishment of existing buildings had been set by three Member States (BE, DK, IE), while eight (BE, CZ, DE, DK, EE, IE, NL, UK) had established intermediate targets for public buildings.

Four EU Member States had mentioned objectives that went beyond NZEB requirements (such as positive energy buildings in DK and FR, climate neutral new buildings in DE and zero carbon standards in the UK, although in the latter case they have recently come under review by the UK government), while six Countries (DE, FI, IE, IT, SE, UK) refer to efficient buildings in their regulation rather than NZEBs.

As regards policies and measures in support of the implementation of NZEBs, many Member States had adopted financial instruments and supporting measures, such as tax

[1] Unless otherwise specified, we refer with "BE" to all Belgian regions (Brussels Capital region, Flanders and Wallonia) and with "UK" to England, Wales, Scotland and Northern Ireland.

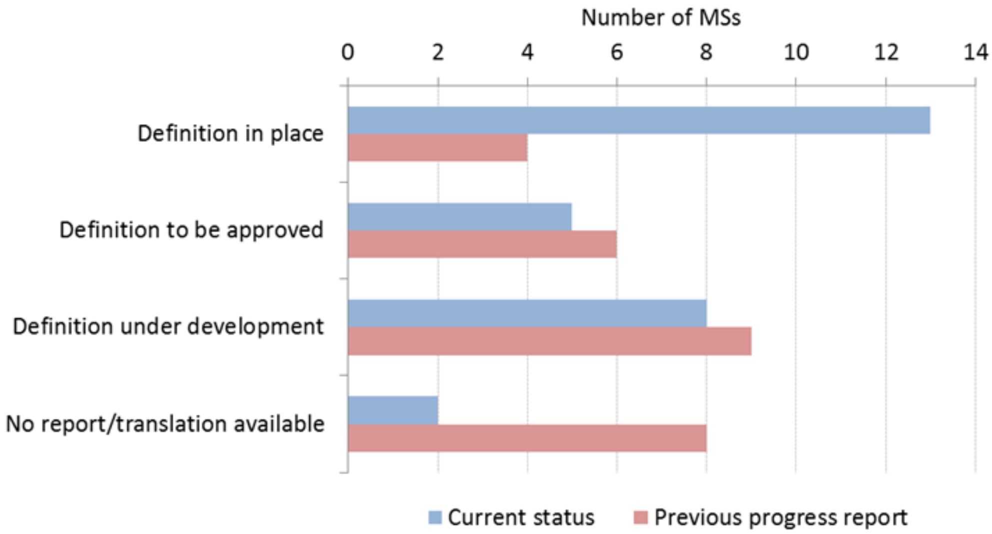
credits for notary fees, subsidised mortgage interest rates for energy efficient homes and low-interest loans for retrofitting. Other measures are: strengthening of building regulations, awareness raising, education and training activities, and pilot or demonstration projects for highly efficient buildings.

Furthermore, those Member States that did report had chosen very different forms of reporting, with the result that National Plans are not easily comparable [30]. Therefore, the Commission with the aid of an external contractor made available two non-mandatory templates to facilitate reporting by Member States in line with the requirements of the EPBD [31] and easier comparability. The first template was designed as a questionnaire to report information on intermediate targets and policies to achieve the NZEB target while the second has the form of as a table. This template considers the most important aspects related to national applications of NZEB definitions and it enables proper evaluation and cross-analysis of Member States plans [32].

After the Commission progress report of 2013 [34], an updated state of play on the basis of the non-obligatory template was published in October 2014. This was commissioned by the Commission, DG ENER [35] and showed positive development since almost all Member States had submitted at the time the national plans and/or consolidated information on NZEB (

Figure 2).

Figure 2. Status of development of the NZEB definition in EU Member States.



According to the October 2014 update, in relation to the detailed practical definition of NZEBs, the majority of Member States presented an applied definition for NZEBs in practice which includes a numerical target of primary energy use: AT, BE (Brussels, Flanders), CY, CZ, HR, DK, EE, FR, IE, LU, LV, LT, NL and SK. The update also reports that 8 Member States (BE (Brussels, Flanders), DK, FR, IE, LV, LT, NL and SK) contain both a numerical target of primary energy use and the share of RES. Compared to the 2013 Commission report, where only 5 Member States had a definition in place, in the October 2014 report progress was assessed in relation to the practical definition of NZEB which include both the numerical target of primary energy use and the share of renewable energy sources (increased from 5 to 8 Member States).

The progress made by the EU Member States towards the establishment of NZEB definitions is evaluated based on the National Plans submitted to the Commission and the indicative templates developed subsequently, the Commission progress report of 2013 and its update of October 2014, as well as information from the EPBD Concerted Action (CA), Energy Efficiency Action Plans (NEEAP), and National Codes. Many aspects to be defined are taken into account, such as building category, typology, physical boundary, type and period of balance, included energy uses, renewable energy sources (RES), metric, normalization, and conversion factors. Ambitious plans and success stories are also highlighted, with special focus to policies and measures designed to target building renovations to NZEB or deep level. In the Annex of this report, a literature review is provided with a special focus on NZEB renovation and NZEB best practices examples.

2 Literature review

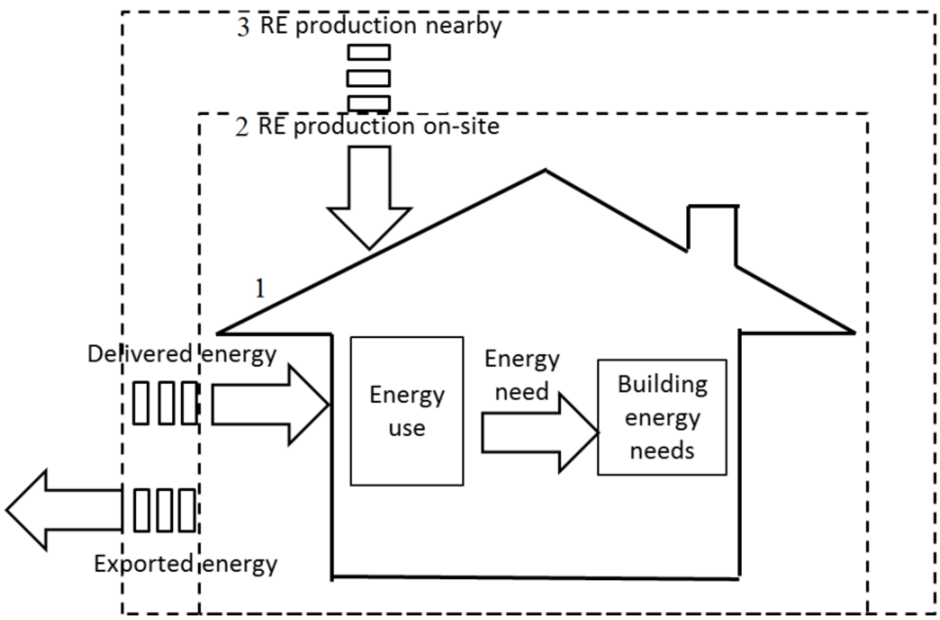
In recent years, the topic of NZEBs has been widely analysed and discussed especially within the EU, but it is still subject to discussion at international level on possible NZEB boundaries and calculation methodologies [37][38][39][40][41][42][43] Furthermore, the U.S. Department of Energy (DOE) releases "A common definition for zero energy buildings, campuses, and communities". The quantification of the word "nearly" is provided in the cost-optimal analysis as based on the calculation methodology set up by Article 3 and Annex I.

The REHVA Task Force "Nearly Zero-Energy Buildings" [44] has published a comprehensive definition of NZEBs based on energy flows to be taken into account in primary energy calculations. Following the EPBD requirements, the system boundary is modified from the Standard EN 15603:2008 "Energy performance of buildings – overall energy use and definition of energy rating" and it is used with the inclusion of on-site renewable energy production [45].

Three system boundaries can be distinguished in reference to energy need, energy use, imported and exported energy (

Figure **3**).

Figure 3. Possible system boundaries for a building.

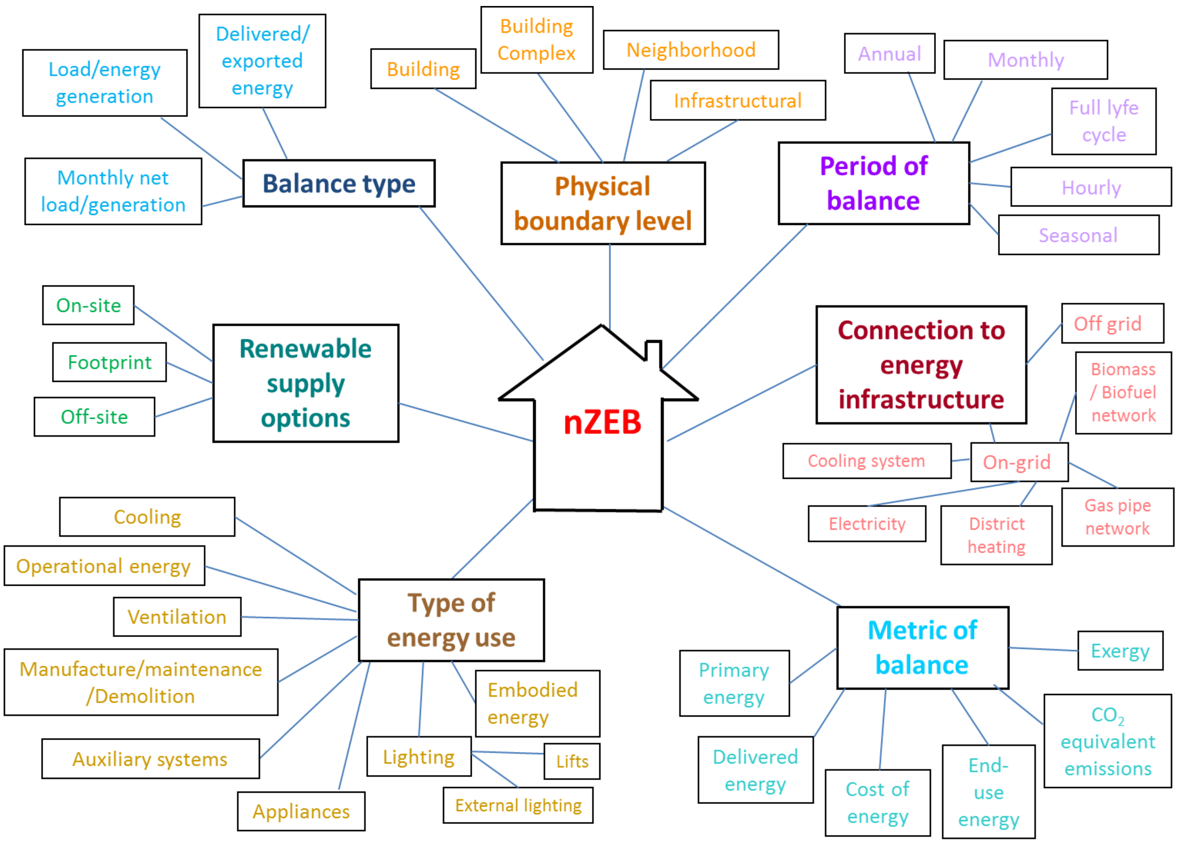


In this diagram the "energy use" considers the building technical system as well as losses and conversions. The system boundary of energy use also applies for renewable energy (RE) ratio calculation with inclusion of energy from solar, geo-, aero- and hydrothermal energy sources for heat pumps and free cooling. The "energy need" is the total energy to satisfy building needs that mainly consist of heating, cooling, ventilation, domestic hot water (DHW), lighting, and appliances. Solar and internal heat gains have to be included in the balance. The "RE production" includes the generation of energy for heating, cooling and electricity that can be produced both on site or off site (e.g. by a plant located nearby). The energy delivered on-site can be given by electricity, fuels, district heating and cooling.

The discussion around NZEBs has become more focused in the last decade especially on some aspects that still need to be properly defined.

The main arguments are schematised in Figure 4 and are related to: physical boundary, period and type of balance, type of energy use, metric, renewable supply options and connection to energy infrastructure.

Figure 4. Main arguments around NZEBs to be established in the definition.



- ***Physical boundary***

The physical boundary level is one of the most discussed arguments as it is linked to the RE inputs that can be included or not in the balance. The boundary of a system may include a single building or groups of buildings. In the latter case it is not necessarily required that every building has a nearly-zero energy balance, but the combined overall energy balance of these buildings does need to meet this requirement. Renewable energy integration into a district thermal energy system is typically at neighbourhood or infrastructural level, while a PV system is mostly taken into account at building or building complex level. If there is PV plant in an area close to a building and the boundary is restricted to the building, this PV would be considered off-site, otherwise, it is on-site as long as the PV plant is connected to the same grid as the building.

- ***Period of the balance***

The period of the balance over which the calculation is performed can vary greatly. While the period of the evaluation can be hourly, daily, monthly or seasonal, the duration of the evaluation can be annual up to the full life cycle of a building or its operating time.

- ***Connection to the energy infrastructure***

Another argument is the connection to the energy infrastructure. Most NZEB definitions implicitly assume connection to one or more utility grids. These can be electricity grid, district heating and cooling system, gas pipe network, or biomass and biofuels distribution network. Therefore, buildings have the opportunity to both import and export energy from these grids and thus avoid on-site electricity storage. While on-grid NZEBs are connected to one or more energy infrastructures using the grid both as a source and a sink of electricity, off-grid NZEBs need an electricity storage system in peak load periods or when RES are not available. Requirements related to energy performance, indoor air quality, comfort level, and monitoring are also mandatory.

- ***Metric of balance***

Another main point of discussion is the metric of balance. More than one unit can be used in the definition or in the calculation methodology. The most frequently applied unit is primary energy while the easiest unit to implement is final or delivered energy. Among the other options there are: final also called delivered, end use or un-weighted energy, CO_2 equivalent emissions, exergy, and the cost of energy. Conversion factors have also to be specified in definitions.

- ***Type of energy use***

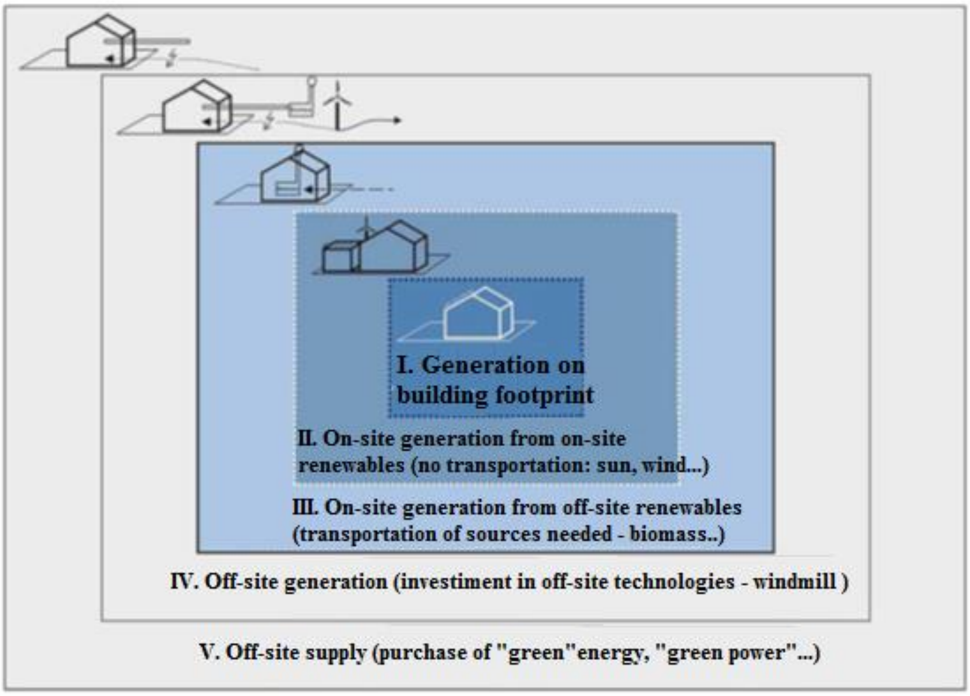
The type of energy use is also subject to debate. The methods for computing the energy use of a building can be diverse and include many options. Many definitions only cover operational energy (heating, cooling, lighting, ventilation, domestic hot water) and omit other energy uses (e.g. cooking, appliances) or embodied energy from the calculation. However, the energy required for building material manufacture, maintenance and demolition can be considerable. According to the Standard EN 15603: 2008 [45], the energy rating calculation should include energy use that does not "depend on the occupant behaviour, actual weather conditions and other (indoor and environment) conditions", such as heating, cooling, ventilation, domestic hot water and lighting (for non-residential buildings). Other options include appliances, central services, and electric vehicles.

- ***Renewable supply***

The renewable supply options can be both on-site or off-site depending on the availability on site (sun, wind) or to be transported to the site (biomass). A ranking of preferred application of different renewable supply side options is proposed by Torcellini [46]**Error! Reference source not found.**. As starting oint, there is a reduction of on-site primary energy demand through low-energy technologies (i.e. adequate insulation, daylighting, high-efficiency HVAC, natural ventilation, evaporative cooling). On-site supply options use RES available within the building footprint or or within the building site (such as PV, solar hot water, low impact hydro, wind). Off-site supply options use RES available off-site to generate energy on-site (such as biomass, wood pellets, ethanol, biodiesel that can be imported, or waste streams used on-site to generate electricity and heat), or purchase off-site RES (such as utility-based wind, PV, emissions credits, or other "green" purchasing options and hydroelectric) (Figure

5). The different RES options and the fraction of RE production to be included have to be also defined.

Figure 5. Overview of possible RES options [46].



With regard balance type, the energy use has to be offset by RE generation in off-grid ZEBs [47]. In grid-connected ZEBs, there are two possible balances: the energy use and the renewable energy generation and the energy delivered to the grid and the energy feed into the grid. The main difference between them is the period of application: the first is preferred during the design phase of a building while the second is more applicable during the monitoring phase as it balances energy delivered with energy feed into the grid.

3 Policy framework

The progress made by EU Member States towards the establishment of NZEBs Plans has been assessed through the analysis of two reporting templates developed by the Commission, DG ENER, and filled in by Member States and submitted to the Commission in the form of a questionnaire and a table in the period between April and October 2014 as well as the additional information and national plans received since. When any discrepancy has been found within the reported information, further material has been searched, considering the most updated source at the time of writing: the available literature, first National Plans, information from the EPBD Concerted Action (CA), Energy Efficiency Action Plans (NEEAP) and National Codes have also been considered. The EPBD CA also includes a list of Key Implementation Decisions (KIDs), a series of indicators that allow EU Member States to evaluate the EPBD implementation in relation to NZEB definition and cost-optimal calculations [36].

The EU Member States that have submitted the consolidated information on the basis of non-binding template[2] are: Austria (AT), Belgium (BE) (Brussels Capital region, Flemish region, Walloon region), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Slovakia (SK), Sweden (SE), and the United Kingdom (UK). Slovenia (SI) submitted the Action Plan for Nearly Zero Energy Buildings Up to 2020 in April 2015. Greece (EL), Romania (RO), and Spain (ES) have not yet finalized their templates, but ES and RO have established NZEBs national plan. However, the ENER templates allow to structure and make the information assessable. Many national plans have missing or vague information, which prevents a consistent and detailed evaluation and comparison across EU Member States.

General information provided by EU Member States on Regulations, Directives, or Certification schemes are summarized in Table 2 and Table 3.

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[2] The guidance document explaining the use of the template is available on http://ec.europa.eu/energy/sites/ener/files/documents/nzeb_ecofys_guidance.pdf

Table 2. General information on EU Member States regulations, Directive, or Certification scheme.

MS	Regulation/ Directive/Certification scheme	Editor	Year of introduction
AT	OIB-Dokument zur Definition des Niedrigstenergiegebäudes und, on the definition of nearly zero-energy building and setting of intermediate objectives (National Plan, the basic document for OIB Guideline 6, Energy economy and heat retention).	OIB/Länder	2012
BE	Brussels Capital: The Brussels Air, Climate and Energy Code (COBRACE), Flemish region: Flemish Action Plan NZEB – Energy Decree, Energy Law, Walloon region: Co-ZEB study – Regional Policy Statement, execution order adopted on 28th of January 2016 settings NZEB definition.	Flemish Energy Agency in Flemish region	2013
BG	National Plan for Nearly zero-energy buildings	Ministry of Investment	2014
CY	Nearly Zero-Energy Buildings Action Plan - Decree 366	Ministry of Energy, Commerce, Industry and Tourism	2012-2014
CZ	The Energy Management Act n. 406/2000 Coll.	Ministry of Industry and Trade	2012
DE	EnEG, EnEV, EEWärmeG	Government	EnEG 2013, EEWärmeG 2011
DK	Building Regulation (BR10)	Ministry of Economic and Business	2010
EE	Minimum requirements for energy performance-VV n. 68: 2012	Ministry of Economic Affairs and Communications	2012
FI	National Building Code of Finland	Ministry of the Environment	2012
FR	Réglementation Thermique 2012 (RT 2012)	Government	2013
HU	7/2006 (V. 24.) TNM degree	Ministry of Interior	2012
IE	Building regulation Part L amendement-Buildings other than Dwellings SI	DECLG	2008

MS	Regulation/ Directive/Certification scheme	Editor	Year of introduction
IT	Decree of June 26th, 2015 concerning new minimum requirements and methodology for calculating energy performance of buildings	Ministry of Economic Development	2015
LT	Building technical regulation STR 2.01.09:2012. Law on Renewable Energy, on Construction, Construction Technical Regulation STR 2.01.09:2012 "Energy Performance of Buildings. Certification of Energy Performance", STR 2.05.01:2003 "Design of Energy Performance of Buildings"	Government	2012
LU	1) RGD 2007: Règlement grand-ducal modifié du 30 novembre 2007 concernant la performance énergétique des bâtiments d'habitation 2) RGD 2010: Règlement grand-ducal modifié du 31 août 2010 concernant la performance énergétique des bâtiments fonctionnels 3) Nationaler Plan Luxemburgs zur Erhöhung der Zahl der Niedrigstenergiegebäude	Ministry of Economy	2007-2010-2013
LV	Cabinet Regulation n.383 from 09.07.2013 "Regulations regarding Energy certifications of Buildings" and amendments adopted on November 10th 2015, entered into force on November 21st, 2015.	Government	2013
MT	LN 376/2012, transposing Directive 2010/31	Ministry for Transport and Infrastructure	2012
NL	EPG 2012 - National Plan to promote nearly zero-energy buildings Bouwbesluit	Government	2011
PL	Resolution No. 91/2015 of the Council of Ministers of 22 June 2015 On the adoption of the National Plan aimed at increasing the number of buildings with low energy consumption (MP pos. 614)	Government	2015
PT	Decreee-Law 118/2013, August 20th	Government	2013
RO	National Plan for Nearly zero-energy buildings – included in the 3rd NEEAP, approved by Governmental Decision no.122/2015	Ministry of Regional Development and Public Administration	2014
SI	Action Plan for Nearly Zero-Energy Buildings Up to 2020 (AN sNES)	Government	2015
SE	Building regulations BBR 2012	The Swedish Board of Housing, Building and Planning	2013

MS	Regulation/ Directive/Certification scheme	Editor	Year of introduction
SK	Act No. 555/2005 Coll. as amended by the act No. 300/2012 Coll.	Ministry of Transport, Construction and Regional Development	2013
UK	Building Regulations Energy Efficiency Requirements: England (Part L); Wales (Part L); Scotland (Section 6); Northern Ireland (Technical Booklet F)	HM Government; Welsh Government; Scottish Government; Northern Ireland Assembly	2013

Table 3. Status of NZEB definition development in EU Member States.

MS	Included in an official document	Under development	To be approved
AT	✓		
BE - Brussels	✓		
BE - Flanders	✓		
BE - Wallonia	✓		
BG			✓
CY	✓		
CZ	✓		
DE		✓	
DK	✓		
EE	✓		
EL		✓	
ES		✓	
FI		✓	
FR	✓		
HR	✓		
HU		✓	
IE	✓		
IT	✓		
LV	✓		
LT	✓		
LU	✓		
MT		✓	
NL	✓		
PL	✓		
PT		✓	
RO	✓		
SI	✓		
SK	✓		
SE		✓	
UK		✓	

3.1 Progress towards definitions

In this section different arguments related to EU progress towards the achievement of NZEB definitions are reported. Results are based on the collected material and focus on the consolidated templates and national plans analysis.

EU Member States define NZEBs for both residential and non-residential buildings. Furthermore, they provide the inclusion of specific subcategories (such as apartment blocks, offices, educational buildings, hospitals, hotels, wholesale and retail buildings) in their national definitions (Table 4).

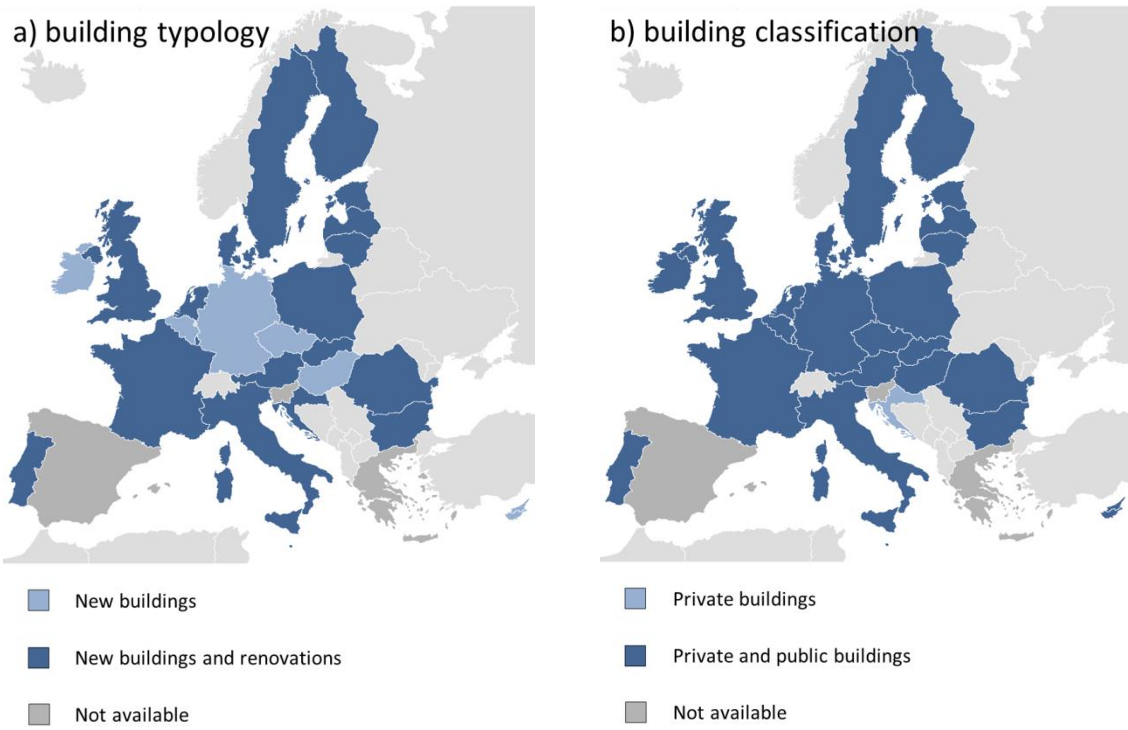
Table 4. Building subcategory as accounted in NZEBs EU Member States definitions (✓= Included in national definition, - = not defined).

MS	Single family houses	Apartment blocks	Offices	Educational buildings	Hospitals	Hotels/ restaurants	Sport facilities	Wholesale and retail
AT	✓	✓	✓	-	-	-	-	-
BE	✓	✓	✓	-*	-*	-*	-*	-*
BG	✓	✓	✓	✓	✓	✓	✓	✓
CY	✓	✓	✓	✓	✓	✓	✓	✓
CZ	-	-	-	-	-	-	-	-
DK	✓	✓	✓	✓	✓	✓	✓	✓
EE	✓	✓	✓	✓	✓	✓	✓	✓
FI	✓	✓	✓	✓	✓	✓	✓	✓
FR	✓	✓	✓	✓	✓	✓	✓	✓
HR	-	-	-	-	-	-	-	-
HU	✓	✓	✓	✓	✓	✓	✓	✓
IT	✓	✓	✓	✓	✓	✓	✓	✓
LV	-	-	-	-	-	-	-	-
LT	✓	✓	✓	✓	✓	✓	✓	✓
LU	✓	✓	✓	✓	✓	✓	✓	✓
MT	✓	✓	✓	✓	✓	✓	✓	✓
NL	✓	✓	✓	✓	✓	✓	✓	✓
PL	✓	✓	✓	✓	✓	✓	✓	✓
PT	-	-	-	-	-	-	-	-
RO	✓	✓	✓	✓	✓	-	-	-
SK	-	-	-	-	-	-	-	-
SE	✓	✓	✓	✓	✓	✓	✓	✓
UK	✓	✓	✓	✓	✓	✓	✓	✓

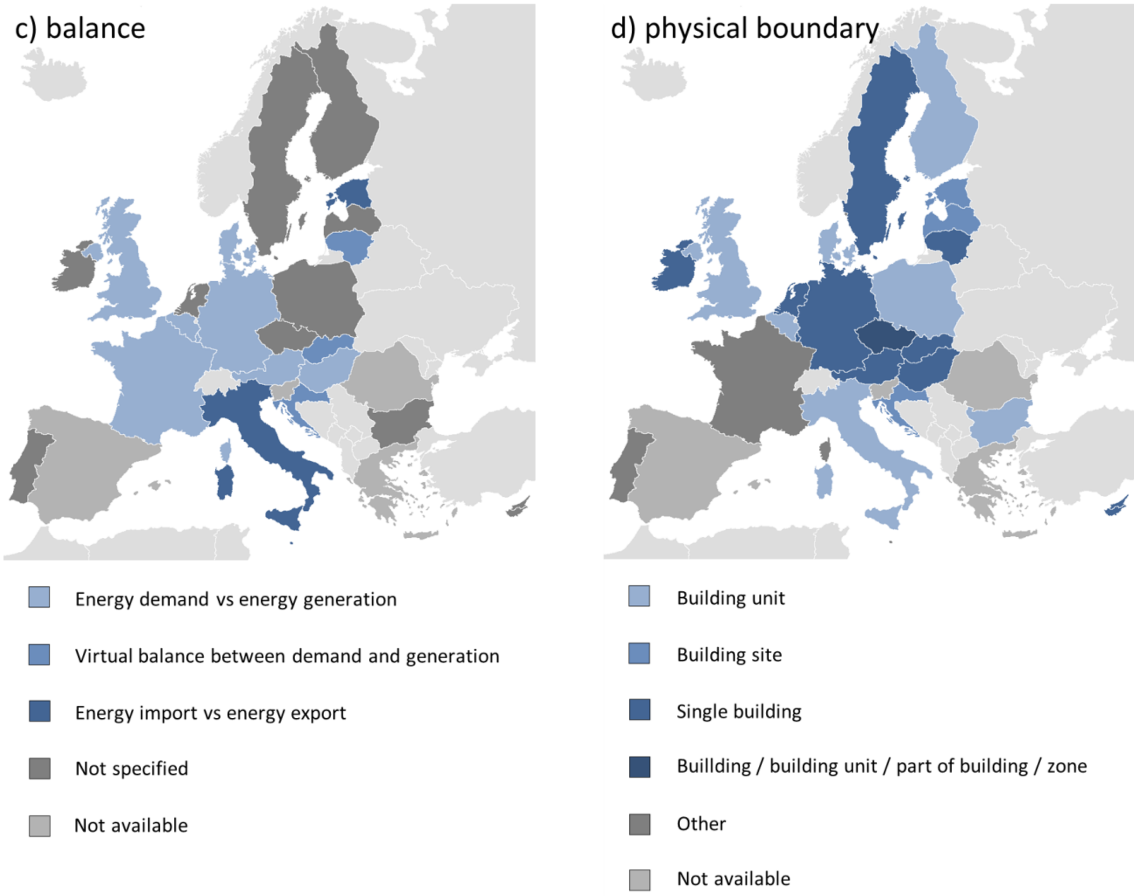
*not def. in Brussels Capital region, Walloon Region, Flemish region.

Table 4 shows that the Countries that have already defined their subcategories tend to include all of them in their definition. NZEB subcategory definition is planned in 2017 in BE Flemish region. DK has two main building subcategories where all the types of buildings fit: dwellings and other buildings. In the last category, the special needs of different buildings are handled. In AT, the National Plan defines requirements for new and major renovation buildings in reference to residential and office buildings. For other building types, analogous requirements are in accordance with National Plan depending on their user profiles.

Figure 6. a) building typology; b) building classification; c) balance; d) physical boundary in NZEBs EU Member States definitions. For explanations on the terms, please go to the guidance on the consolidated template[3].



[3] http://ec.europa.eu/energy/sites/ener/files/documents/nzeb_ecofys_guidance.pdf



According to Figure 6a, the majority of EU Member States include both new and retrofit buildings. At the moment, requirements regarding NZEB are defined only for new buildings in the Wallon Region of BE. NZEB requirements for renovation will be discussed with building stakeholders in 2016. All European Countries consider both private and public buildings, with the exception of HR (Figure 6b). The graph in Figure 6c shows that, even if energy demand against energy generation is the most selected option for balance calculation, many Member States have not yet established a methodology. Figure 6d highlights that the physical boundary adopted by EU Member States in the implementation of their NZEB definition is very variable among European Countries. Most of them retain single building or building unit as boundary. A few EU Member States consider building plot and only one takes into account different physical boundaries ("Building, building unit/part of building, Zone").

Table 5 refers to different energy uses as considered or not in the definition provided by EU Member States. All countries include heating, DHW, ventilation, cooling, and air conditioning within energy uses, both for residential and non-residential buildings. Lighting has always been considered at least for non-residential buildings. In PL, technical and building requirements, established in the Regulation of the Minister of Infrastructure (2002), set up the maximum value of the index ΔEPL (annual calculation demand of the building on non-renewable primary energy for lighting). Some Member States take into account lighting also for residential buildings. Plug loads[4] and appliances have been considered in many cases. In particular, plug loads are considered as an internal heat gain in DK. Auxiliary energy has almost always been included, while central services have been only in some countries. In the energy balance calculations, electrical

[4] Plug load is the energy used by products that are powered by means of an ordinary AC plug (e.g., 100, 115, or 230 V).

vehicle have been considered in a few Member States, and embodied energy has been only considered in one country.

Table 5. Energy uses included in NZEBs EU Member States definitions (✓= Considered, not Cons.= X, not def.= -, / = possible to add).

MS	Heating DHW	Ventilation, Cooling, Air conditioning	Auxiliary energy	Lighting	Plug loads, Appliances, IT	Central services	Electric vehicles	Embodied energy
AT	✓	✓	✓	✓	✓	X	X	X
BE*	✓	✓	✓	✓	X	-	X	X
BG	✓	✓	✓	✓	✓	✓	X	X
CY	✓	✓	✓	✓	X	X	X	X
CZ	✓	✓	✓	✓	X	X	X	X
DE	✓	✓	✓	✓	X	X	X	X
DK	✓	✓	✓	✓	-	-	-	-
EE	✓	✓	✓	✓	✓	✓	-	-
FI	✓	✓	✓	✓	✓	/	-	-
FR	✓	✓	✓	✓	X	X	X	X
HR	✓	✓	✓	✓	X	✓	X	X
HU	✓	✓	✓	✓	/	X	X	X
IE	✓	✓	✓	✓	X	X	X	X
IT	✓	✓	✓	✓	X	✓	X	X
LT	✓	✓	✓	✓	✓	✓	✓	✓
LU	✓	✓	✓	✓	X	✓	X	X
LV	✓	✓	✓	✓	✓	X	X	X
MT	✓	✓	-	✓	X	X	X	-
NL	✓	✓	✓	✓	✓	✓	✓	-
PL	✓	✓	✓	✓	-	-	-	-
PT	✓	✓	-	✓	-	-	-	-
RO	✓	✓	X	✓	X	X	X	X
SE	✓	✓	✓	✓	-	-	-	X
SK	✓	✓	✓	✓	X	✓	X	X
UK	✓	✓	✓	✓	X	X	✓	X

* Plug loads, Appliances, IT, Central services possible to add in Belgium Flemish region, Central services not considered in Belgium Walloon region at the moment.

Table 56 reports possible system boundaries for RES generation as considered by EU Member States in relation to the specification of the generation boundaries in the definition.

Table 6. System boundary generation for RES in NZEBs EU Member States definitions (✓= considered, X = not Considered, - = not defined).

MS	Generation on site	Generation off site (e.g.	External generation	Crediting[5]
AT	✓	✓	X	X
BE*	✓	✓	✓	-*
BG	✓	✓	✓	X
HR	✓	X	X	X
CY	✓	✓	-	-
CZ	✓	✓	✓	X
DK	✓	✓	✓	X
EE	-	-	-	-
FI	✓	✓	-	X
FR	-	-	-	-
DE	✓	✓	✓	X
HU	✓	✓	✓	X
IE	-	X	-	-
IT	✓	✓	✓	X
LV	✓	✓	X	X
LT	✓	X	✓	X
LU	✓	✓	✓	-
MT	✓	✓	✓	-
NL	✓	✓	✓	-
PL	✓	✓	✓	-
PT	-	-	-	-
RO	✓	-	✓	-
SK	✓	✓	X	X
SE	✓	✓	-	-
UK	✓	-	-	-

* In the BE Flemish region, crediting is foreseen in law (investments in nearby renewable energy infrastructure of at least 20 euro/m²).

Table 6 shows that both on-site and off-site generation have been considered (i.e. generation nearby that in some cases has not been defined yet). External generation has been considered in the majority of the countries, but not yet defined in many cases. In PL, according to the Regulation of the Minister of Transport, Construction and Maritime Economy (April 25th 2012), a "mandatory analysis of the use of RES" has to be performed in any prepared building project. Stringent levels of technical and construction requirements will enforce the increasing use of renewable energy sources. Crediting has not yet been defined or considered. Crediting can be referred to emission

[8] Crediting can include: emission trading, external credits by investments in energy infrastructure, external production of renewable energy through biogas plants, green power contracts.

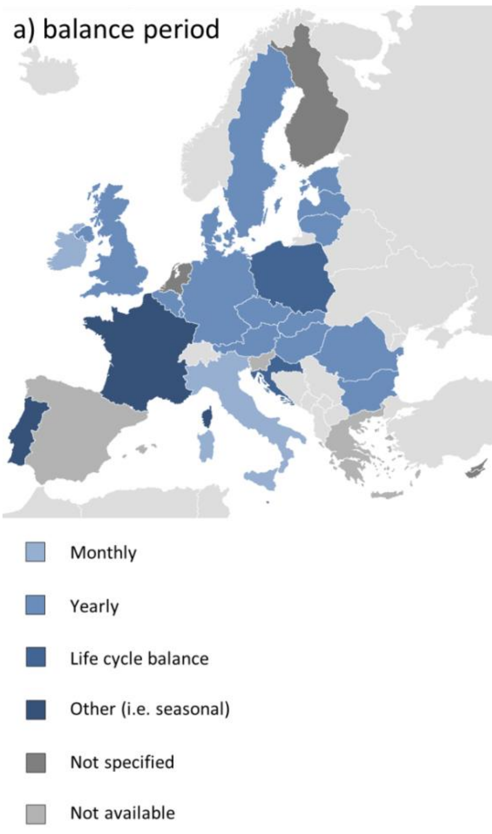
trading, external credits by investments in energy infrastructure, external production of renewable energy through biogas plants, green power contracts.

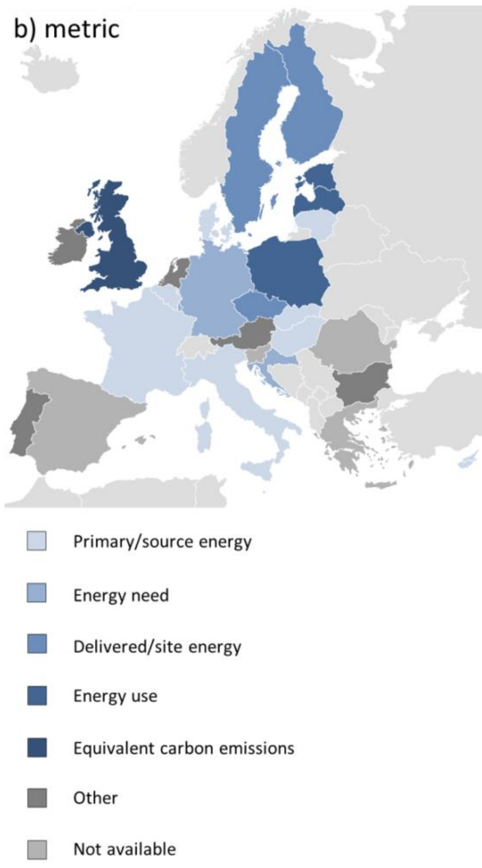
As regards the different options included by RES generation, all countries consider solar thermal, geothermal, passive solar and passive cooling, heat recovery, and PV. Wind power has been included in some countries, while micro-combined heat and power units (CHP) have not been considered only in a few Member States (DK, LT). Waste heat has been included by BE, DE, HU, NL, SE, UK, and sewage water by BE, FI, FR, LT, NL. The selected RES inclusions do not seem to correlate with climatic or local conditions in EU Member States. The choice can be more related to national political decisions not discussed in the plans. MT stated in its National Plan that a limited range of RES (mainly solar-based, PV and thermal) is available in the country due to shading, limited access to roofs, and scarcity of land.

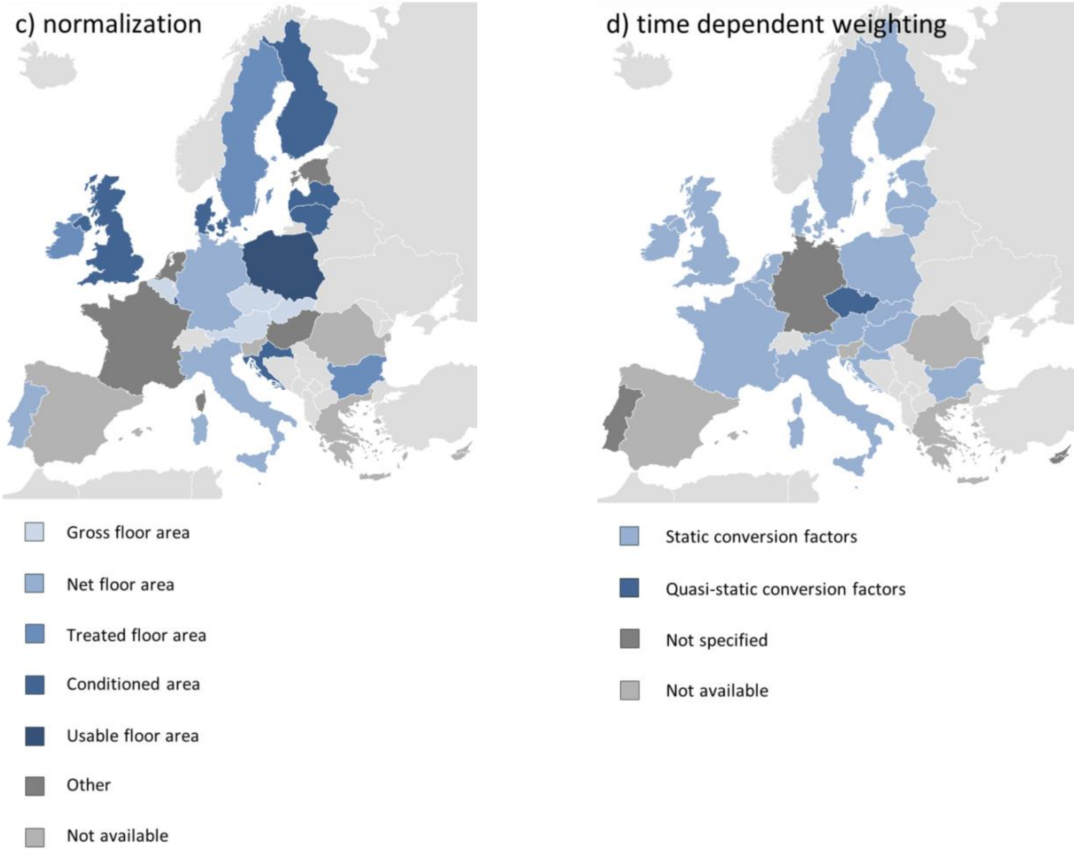
The proportion of renewable energy production has been defined in some EU Member States, among these: BG, CY, DE, DK, FR, HU, IE, IT, LV, LT, LU, RO, SK. The provided values are expressed as a percentage with the exception the Flemish region of Belgium that expresses it as a number (>10 kWh/m^2/y). Percentages vary from 25% (CY) up to 56 % (DK) and 60% (DE). CZ does not set exact percentage of RES production in its National Plan for increasing the number of NZEB.

Figure 7 reports balance periods, normalization, metric and time dependent weighting as chosen up to now by EU Member States in their definitions.

Figure 7. a) balance period; b) metric; c) normalization; d) time dependent weighting in NZEBs EU Member States definitions.







Most Member States take a year as balance period; only one considers a monthly balance, and two life cycle balance (Figure 7a).

According to Figure 7b, the majority of Member States consider primary/source energy (renewable part not included), and delivered/site energy. A few countries refer to energy need or energy use, and only one equivalent carbon emissions (UK). Primary energy needs, heating and DHW are defined as results of energy performance calculations in LU.

Figure 7c highlights that normalization can vary a lot among EU Member States. In most countries it is conditioned area, while other options are equally distributed among the possible alternatives, with some Members State preferring gross floor area, and other treated floor area, and net floor area. The majority of EU Member States consider static conversion factors as time dependent weightings (Figure 7d). All BE regions have the same monthly based calculation methodology while normalization is on gross floor area (with some restrictions under a roof) and in the 'treated' zone of the building unit.

A numeric indicator of energy performance expressed as primary energy in $kWh/m^2/y$ use has been defined in some EU Member States as reported in Table 7. This table collects information that are based on not homogeneous calculation methods and general conditions among Member States. Therefore widely varying computational results can be obtained for primary energy.

Table 7. Energy performance expressed by EU Member States as primary energy (kWh/m2/y).

MS	Residential buildings ($kWh/m^2/y$)		Non-Residential buildings ($kWh/m^2/y$)		Notes
	New	**Existing**	**New**	**Existing**	
AT	160	200	170	250	from 2021
BE	45 + max (0; 30-7.5*C) + 15*max (0; 192/VEPR-1) kWh/m²y (Brussels region) E 30 (Flemish region) E_w45 and E_{spec}85 (equal to 85 kWh_{EP}/m²/y)(Walloon region)	~ 54	95-2.5*C Or (95-2.5*C)+(1.2*(x-15) kWh/m²y (Brussels region) E 40 (Flemish region) E_w45 (Walloon region)	~ 108	Included energy use: Heating, DHW, appliances in Brussels and Walloon regions. Flemish and Walloon region: Maximum E defined as a percentage of a reference primary energy consumption
BG	~30-50	~40-60	~30-50	~40-60	Buildings need to comply with class A. The definitive definition still to be approved.
CY	100	100	125	125	Included energy use: Heating, cooling, DHW, lighting, ventilation, auxiliary systems.
CZ	75-80% PE	75-80% PE	90% PE	90% PE	Maximum PEC defined as a percentage of the primary energy consumption (PE) of a reference building. Reference U-values have also been defined.
DE	40 % PE	55% PE	n/a	n/a	Maximum PEC defined as a percentage of the primary energy consumption (PE) of a reference building
DK	20	20	25	25	Included energy use: Heating, cooling, DHW, ventilation, lighting.
EE	50 (detached houses)	n/a	100 (office buildings)	n/a	Included energy use: Heating, cooling, ventilation, DHW, lighting, HVAC auxiliary appliances.
			130 (hotels, restaurants)		
	100 (apartment buildings)	n/a	120 (public buildings)	n/a	
		n/a	130 (shopping malls)	n/a	
		n/a	90 (schools)	n/a	
		n/a	100 (day care centres)	n/a	
		n/a	270 (hospitals)	n/a	

MS	Residential buildings (kWh/m^2/y)		Non-Residential buildings (kWh/m^2/y)		Notes
	New	**Existing**	**New**	**Existing**	
FR	40-65	80	70 (office buildings without air conditioning)	60% PE	Included energy use: Heating, cooling, ventilation, DHW, lighting, auxiliary systems. Residential values depending on building type and climate.
		n/a	110 (office buildings with air conditioning)	n/a	
HR	33-41	n/a	n/a	n/a	
HU	50-72	n/a	60-115	n/a	Requirements proposed, depending on the reference building.
IE	45 - defined as Energy load	75-150	~ 60% PE	n/a	Included energy use: Heating, ventilation, DHW, lighting.
IT	Class A1	Class A1	Class A1	Class A1	Energy requirements to be calculated; minimum requirements provided as U values divided per climatic zones. Lighting is included in non-residential buildings.
LV	95	95	95	95	Included energy use: Heating, cooling, ventilation, DHW, lighting. The energy demand for heating does not exceed 30 kWh/m^2/y.
LT	Class A++	Class A++	Class A++	Class A++	Building needs to comply with class A++
LU	Class AAA	n/a	Class AAA	n/a	For residential buildings, buildings need to comply with class AAA from Jan 1st 2017. Depending on external factors, such as shading or wind exposure, exceptions exist.
MT	55 (semi-detached and fully detached houses)-75 (terraced houses) – 115 (flatted dwellings)	< 220	220-255	n/a	Included energy use: Heating, cooling, DHW, ventilation, lighting.
NL	0	n/a	0	n/a	
PL	60-75	n/a	45-70-190	n/a	Depending on building type.
RO	93-117	120-230	50-102	120-400	Depending on building type and climate
ES	Class A	n/a	Class A	n/a	Buildings will need to comply with class A

MS	Residential buildings (kWh/m²/y)		Non-Residential buildings (kWh/m²/y)		Notes
	New	Existing	New	Existing	
SE	30-75	n/a	30-105	n/a	Depending on building type and climate.
SI	75 (single family), 80 (multi-family)	95 (single family), 90 (multi-family)	55	65	per unit of conditioned surface, depending on the reference building
SK	32 (apartment buildings)	n/a	60-96 (office buildings)	n/a	Included energy use: Heating, DHW for residential buildings. Heating, cooling, ventilation, DHW, lighting for non-residential buildings
	54 (family houses)	n/a	34 (schools)	n/a	
UK	~ 44	n/a	n/a	n/a	The need to comply with zero carbon emissions is under discussion.

In BE regions, NZEB requirements are based on E-levels. Yearly energy use needs to be lower than a certain reference use value that depends on the building. In residential buildings, a E_{spec}-level, a yearly energy use per square meter, is defined. Requirements for comfort level and indoor air quality have been defined in almost all EU Member States. FR has established requirements for indoor air quality in kindergartens and schools as well as labelling of products and furniture. Many countries have these requirements in their own national regulation. Monitoring procedures have been established in thirteen EU Member States: BE, DE, EE, FI, HR, HU, IT, LT, LU, MT, PL, SK, UK. BE- Flemish region has a mandatory 2 year evaluation while BE-Walloon region at least every 5 years. In LU, a new regulation is in the regulatory procedure for residential buildings. It defines more clearly the NZEB concept and allows PV to be incorporated in the energy balance.

3.2 Evaluation of NZEB definitions

The analysis of National Plans and templates submitted by Member States up to August 2014 reveals a positive development towards the adoption of NZEB definitions. Almost all countries, with the exception of EL, RO, and ES, have submitted consolidated information through the templates. However, ES and RO have submitted national plans. According to the EPBD, each EU Member States should develop its own NZEB definition in compliance with its unique context. One of the main issues highlighted in the Commission report of 2013 [30] is that a consistent and detailed evaluation of the European status in compliance to the EPBD requirements was not possible as information from National Plans was insufficient or missing. According to that report, only four Member States have a definition in place including both a numerical target of primary energy use and a share of RES.

This report shows that more than half Member States currently have a NZEB definition which includes a numerical target of primary energy use and several EU Member States give both a numerical target of primary energy use and a share of RES. Other Member States have a definition under development and a few have not yet adopted an official definition. Different approaches have been followed in national energy building regulations to address the EPBD requirements (Table 1). The new template has considerably helped Member States to provide the correct information and allows it to be made more assessable and comparable.

Not only can progress be seen in the quantity of the collected data, but also in quality. Among the agreed aspects within NZEB definitions is building typology. Most Member States refer to new and retrofit buildings, and to private and public buildings (Figure 6a and Figure 6b).

EU Member States that have submitted a plan, refer both to residential and non-residential buildings in their definitions, including different subcategories (e.g. apartment blocks, offices, hospitals, hotels, educational buildings) (Table 4). Results also illustrate that the most common choice regarding energy balance is energy demand against energy generation. However, more guidance has to be provided as many Member States have not yet specified the selected type of balance (Figure 6c).

Some other agreed aspects are related to the period of balance, that should be performed over a year, and static conversion factors as time dependant weightings (Figure 7a and Figure 7d). Single building or building unit are the most frequent indicated physical boundary, but the overall impression is that the differences among building unit/site/zone/part need to be better addressed (Figure 6d). As regards normalization factors, conditioned area is the most agreed upon choice in EU Member States. Although other options, such as net floor area and treated floor, are selected, this aspect should also be better addressed in the future (Figure 7c).

The renewables to be implemented vary across Member States. The most common considered RES options include on-site generation. However, many countries also consider off-site generation, including nearby (Table 6). The exact meaning of these choices needs to be better defined. Almost all Member States prefer the application of low energy building technologies and available RES. The most used technologies are PV, solar thermal, air- and ground-source heat pumps, geothermal, passive solar, passive cooling, wind power, biomass, biofuel, micro CHP, and heat recovery.

Principal included energy uses are heating, DHW, ventilation, cooling, and air conditioning. Auxiliary energy and lighting are taken into account in almost all EU Member States. Several Member States also include appliances and central services (Table 5).

3.3 NZEBs policies

Nearly all Member States included information on building regulations for new/existing buildings in their templates and national plans and few Member States referred to further improvements in their building codes, strengthening the energy standards to be met during building construction and renovation. Examples include Denmark reporting various upgrades in the energy requirements for new buildings and specific requirements for building envelope, windows and installations and Austria which stated that on-going adjustments are made in building regulations. In the UK, building regulations, first introduced in the 1960's, are being progressively tightened as it moves towards the introduction of the Zero Carbon Homes Standard. France has last updated its thermal building codes in 2012, tightening primary energy consumption requirements for new buildings to an annual threshold of 50 kWh/m^2 for heating, DHW, lighting, cooling and auxiliary systems. In agreement with the analysis carried out by the ENTRANZE Consortium [19] **Error! Reference source not found.**, the EU Member States that ave already established more exhaustive strategies or aims on NZEBs include BE, DE, DK and FR.

DK is one of the first EU Member States to set-up its national NZEB definition and roadmap to 2020. Progressive performance classes will be established. Minimum energy performance requirements will gradually become stricter, starting from the current Standard, BR10, with an intermediate milestone in 2015 (class 2015, mandatory in 2015) and a final target in 2020 (class 2020) **Error! Reference source not found.**. he energy scope includes energy need for heating, ventilation, cooling, DHW, and auxiliary equipment. The improvement of energy performance is done by increasing the requirements for buildings insulation and technical systems. Lighting is also included within the regulated energy for non-residential buildings. A maximum demand is defined for total heating, ventilation, cooling and DHW.

Brussels Capital Region amended in 2011 the Energy Performance of Buildings Ordinance stipulating that from January 2015 onwards, all new public and residential buildings have to fulfill a primary energy need close to Passive House standard **Error! Reference ource not found.**. The requirement establishes that residential buildings will have a primary energy consumption for heating, DHW, and auxiliary energy below 45 kWh/m^2/y and heating below 15 kWh/m^2/y.

In FR low energy requirements are adopted in the EPBD of the French thermal regulation, RT 2012, which is applied to new residential and non-residential buildings, public and private, since January 2013. Energy performance levels are defined in the "Arrêté du 28 décembre 2012 relatif aux caractéristiques thermiques et aux exigences de performance énergétique des bâtiments nouveaux et des parties nouvelles de bâtiments autres que ceux concernés par l'article 2 du décret du 26 octobre 2010". Requirements address a building's energy need for space heating, DHW, cooling, lighting, and auxiliary energy. RT 2012 set the minimum performance requirements to 50 kWh/m²/y primary energy. The minimum energy requirement is adjusted by climatic zone and altitude and varies between 40 kWh/m^2/y and 65 kWh/m^2/y. The calculation methodology for NZEB is provided in the Th-BCE "Arrêté du 30 avril 2013 portant approbation de la méthode de calcul Th-BCE 2012 prévue aux articles 4, 5 et 6 de l'arrêté du 26 octobre 2010". All new buildings will be energy positive in 2020. Renovated buildings are considered NZEB if they reach a higher energy performance than the mandatory level defined in the Thermal Regulation for existing buildings. This level depends on building type (residential or non-residential) and is defined in the "Arrêté du 29 septembre 2009 relatif au contenu et aux conditions d'attribution du label "haute performance énergétique rénovation".

LU is promoting NZEBs via awareness raising and information via "Myenergy", the national structure for the promotion of energy efficiency and renewable energy. Besides financial aid mechanisms, strengthening energy performance will also lead to more NZEBs.

In DE, the government carried out the project "Analysis of the revised EPBD" to research possible NZEB definition and determine the best solution **Error! Reference source not ound.Error! Reference source not found.**. The analysis identified that new buildings in 2020 will have an energy performance by 50% better than the current buildings performance, i.e. according to the EnEV2009 standard. In addition, the current legislation has to be changed including requirements for new buildings to comply with a NZEB target. The Energy Conservation Regulations envisages tightening the energy minimum standard (25% in 2016).

Several national approaches towards the NZEB implementation have been presented. They vary from zero carbon to explicit maximum primary energy values. Besides the primary energy indicator required by the EPBD, many countries also intend to include a list of additional indicators, dealing with building envelope and also with system efficiency as well as generated renewable energy. A gradual approach in form of a roadmap towards the 2020 goals is planned in most countries. BG, PL, and RO have already developed roadmaps for moving towards NZEBs **Error! Reference source not ound.**. Furthermore, LU defined a roadmap towards NZEBs in 2012 for residential buildings with intermediate targets to strengthen building energy performance. For non-residential buildings, a first step towards NZEBs has been defined in 2015.

Starting from current construction practices, existing policy framework and economic conditions, simulations have been carried out on energy performance and economic implications in NZEBs reference buildings. The estimated macro-economic benefits of implementing NZEBs between 2020 and 2050 are remarkable (Table 8).

Table 8. Estimated benefits of NZEBs implementation in some EU Member States.

	PL	**RO**	**BG**
CO_2 savings (million t)	31	68	4.7-5.3
Energy savings (TWh)	92	40	15.3-17
Additional investments (million Euro)	240-365	82-130	38-69
New full time jobs	4100-6200	1390-2203	649-1180
Minimum requirements in 2015/2016			
Primary energy (KWh/m^2/y)	70	100	60-70
Renewable share (%)	>20	>20	>20
CO_2 emissions (KgCO$_2$/m^2/y)	<10	<10	<8
Minimum requirements in 2020			
Primary energy (KWh/m^2/y)	30-50	30-50	30-50
Renewable share (%)	>40	>40	>40
CO_2 emissions (KgCO$_2$/m^2/y)	<3-6	<3-7	<3-5

As shown in Table 8, CO_2 savings are estimated as follows: around 5 million tons in BG, 31 million tons in PL, and 68 million tons in RO. Energy savings are estimated around 16 TWh in BG, 92 TWh in PL, and 40 TWh in RO. New full time jobs will be created: between 649 and 1180 in BG, between 4100 and 6200 in PL, between 1390 and 2203 in RO. Additional investments are expected between 38 and 69 million Euros in BG, between 240 and 365 million Euros in PL, between 82 and 130 million Euros in RO. Minimum primary energy requirements are foreseen between 70 kWh/m^2/y (BG and PL) and 100 kWh/m^2/y (RO) in 2015, but they will become between 30 kWh/m^2/y and 50 kWh/m^2/y in 2020. The percentage of renewable share will pass from 20% in 2015 to

40% in 2020. CO_2 emissions will pass from 8-10 $KgCO_2/m^2/y$ to 3-7 $KgCO_2/m^2/y$ in 2020.

4 Conclusions

According to the EPBD, by the end of 2020 all new buildings should be Nearly Zero Energy Buildings (NZEBs). As a consequence, the attention given to NZEBs increased consistently over the last decade. It is widely recognized that NZEBs have great potential to decrease energy consumption and at the same time to increase the use of renewables, alleviating depletion of energy resources and deterioration of the environment.

Progress may be seen in many EU Member States compared with the very first attempts to establish NZEB definitions. This has been with the assistance of greater guidance provided to EU Countries in the setting of consistent NZEBs requirements.

The current situation towards the establishment of applied national NZEB definitions in European Countries has improved in comparison with the 2013 Commission progress report [30]. In the last year, many NZEB definitions have been implemented at national level. Consolidated and systematic information has been submitted through the templates, and EU Member States benefited from more guidance and clarifications.

Most EU Member States presented only qualitative intermediate targets for improving the energy performance of new buildings by 2015-2016 (e.g. strengthening building regulations, obtaining energy performance certificates by a certain year). The targets appear extremely variable, and the quantitative targets (about the number or share of NZEBs, e.g. the foreseen number of buildings to be NZEBs within the intermediate period of time) are almost never defined. Only NL and SI have set actual numbers for new buildings and/or new public buildings; MT provided an indication only for new public buildings

Regarding NZEB definition, most Member States that have submitted a plan refer both to new and retrofit, private and public, and residential and non-residential buildings in their definitions. Results illustrate that most common choices include demand/generation as balance, performed over a year using conditioned area as normalization factor and static conversion factors as time dependent weighting. Nevertheless, many countries have not yet defined the selected type of balance. Single building or building unit are the most frequent indicated physical boundary, and on-site the most common considered RES options.

Progress at Member States' levels show that Member States use the existing flexibility to adapt to national circumstances. Different system boundaries and energy uses are the cause of high variations within the described definitions. The level of energy efficiency, the inclusion of lighting and appliances, as well as the recommended renewables to be implemented vary from Member State to Member State.

In particular, the requirements provided by EU Member States in terms of primary energy show a significant variability and reflect different national and regional calculation methodologies and energy flows. This report shows that national energy policies have evolved with new legislation and methodologies introduced with technical regulatory measures to improve the energy efficiency of buildings and RES generation.

The reduction of energy demand through energy efficient measures and the utilization of RES to supply the remaining demand have reached common agreement towards the implementation of the NZEB concept across Europe. The approach presented by LU is exemplary, in which the defined energy performance certification scheme includes 3 classes: one for the net heat demand, one for primary energy use and one for the CO_2 emissions. This combination is calibrated in a way that leads in most cases to the use of, at least partially, renewable energy.

In this regard, the authors of the UK NZEB plan point out the recommendation character of the sentence "should be covered to a very significant extent by energy from renewable sources" (Article 2, definition 2) is used as a matter of Community legal practice to signify an aspiration rather than an obligation.

In the last decade most Member States introduced measures addressed to the existing building stock and new forward-looking perspectives have been recently defined within the national renovation strategies, in accordance with Article 4 of EED. However, Member States need to further strengthen and evaluate the adopted measures in order to successfully stimulate cost-effective deep and NZEB renovations. On the one hand only few EU Member States (e.g. SI) are developing measures and obligations specifically addressed to the renovation of the existing buildings to NZEB levels. Furthermore, as a recommendation for the preparation of the next round of the plan, EU Member States could be explicitly asked to provide views on specific measures/policies: for instance, on refurbishment obligations, or incentives to demolition-reconstruction.

In some cases the information provided in the last NZEB plans (using the consolidated template) remains ambiguous and it is not always simple to evaluate the compliance with EPBD requirements. Summarising, some aspects to be improved are listed hereafter.

- ***Numeric indicator of energy performance***

  In addition to the already identified points that need clarification in the view of an effective and uniform policy delivery (e.g. boundary, energy uses, balance, renewables), since calculation procedures at country level differ significantly, there are still limits in a precise cross-comparison of energy performance indicators. Therefore, an open issue is related to the target expressed as a numeric indicator of primary energy use, as required by Annex 1 of the EPBD (Table 1). Moreover, the application of CEN standards leaves flexibility in determining this numeric indicator, for example in relation to different primary energy factors or time steps used in calculations. This uncertainty is reflected in EU Member States metric selection that seems to be variable among countries (Figure 7.c). The most frequent choice is primary/source energy, but energy need, delivered/site energy, and energy use have also been selected. The range of values goes from targets beyond NZEB requirements (such as positive energy buildings) up to 270 kWh/m^2/y. Energy performance indicators can vary remarkably from to 20 kWh/m^2/y to 180 kWh/m^2/y in residential buildings, but usually targets aim at 45 kWh/m^2/y or 50 kWh/m^2/y. Values from 25 kWh/m^2/y to 270 kWh/m^2/y are reported for non-residential buildings with higher values given for hospitals.

- ***NZEB balance***

  Primary energy should not be considered as the only parameter to be used in the assessment of NZEBs. Energy needs can be seen as a starting point in primary energy calculations, where additional steps can be represented by energy use and delivered energy. In each step additional parameters are included which make the result of the calculation more dependent on the chosen factors. Therefore, energy need seems to be a suitable benchmark for NZEBs energy performance assessment.

- ***RES production***

  Common percentages related to renewable production are around 50%, but the share of renewable energy is not yet completely assessed. A few countries give a minimum percentage, ranging from 25 % (CY) to 60% (DE), and the others make qualitative statements. In BE, Brussels region the account of renewable energy is included in the calculation method, but a proportion is not yet defined. Furthermore, some Member States have included the share of renewables in the provided primary energy indicator.

- ***Intermediate targets***

EU Member States status in relation to intermediate targets (provided by six more Member States compared to 2013) appear better defined with information collected in one document, but despite few exceptions quantitative targets have not been defined. It is important to stress this point in order to strengthen the current NZEB roadmaps and to develop monitoring mechanisms in the coming years.

- ***Measures to increase the number of NZEBs.***

In most of the countries a wide range of policies is selected in relation to adopted measures to increase the number of NZEBs (e.g. awareness raising and information, education and training, strengthening building regulations and energy performance certificates). However, policies sometimes seem rather general and addressed to "all buildings". Their specific support is not always sufficiently clear, nor is to what extent they practically contribute to achieving the NZEB target in a country. Therefore, a stronger connection between policies, measures and NZEBs would be required. The lack of information means that the evaluation of the effectiveness of these measures is still problematic.

- ***Renovation at NZEB level***

The number of EU Member States that reported specific measures for refurbishing existing buildings increased significantly (twenty-two, in 2013 only seven). This indicates that Member States are more aware of the huge impact of the existing building stock on overall energy consumption. Financial support schemes remain the most common measure to support renovation. However, also in this case, the information submitted could be better structured and the expected impact better discussed.

- ***Policy support***

Existing sources of renovation funding as well overall investments and mechanisms are not always assessed for residential and non-residential buildings. The effectiveness of existing policies, as well as the need of new ones, should be better evaluated in many countries. Several barriers towards the improvement of energy performance of buildings can prevent the achievement of the European Climate and Energy package goals.

When information remains dispersive, there is a need for further clarifications and improvements. This could be made through a more detailed description of what is required in each aspect, allowing EU Member States to organise their information in a more structured way (e.g. reporting residential and non-residential, new and refurbished buildings separately).

Zero energy districts could effectively overcome physical boundary limitations that are common in the refurbishment of existing buildings at nearly zero level, such as access to on-site renewable energy generation. Many Member States are already implementing low energy building technologies and available RES. The most used RE technologies are PV, solar thermal, air- and ground-source heat pumps, geothermal, and heat recovery.

Finally, especially in view of building refurbishment to NZEB levels, EU Member States should effectively develop detailed strategies both to overcome barriers towards energy efficiency and to guide investment decisions in a forward-looking perspective. Several studies have shown that solutions exist to cover the large investment needs to renovate the building stock. However, Member States need to design consistent mixtures of policy instruments (policy packages), depending only partially on public budgets, in order to provide the required long-term stability to investors in efficient buildings, including deep and NZEB renovations. Reliable data to monitor policy impacts are required above all for building stock refurbishment. In some countries with limited solar RES potential (e.g. northern Europe countries), policies that support alternative measures are needed (e.g.

biomass). The adoption of roadmaps and indicators would be an additional tool suitable to address specific needs and monitor the implementation.

It has to be stressed that the interdisciplinary nature of the NZEB concept needs further cooperation among all the actors involved in the NZEBs area, from policy makers, to economists, researchers, environmental analysts, designers, up to the construction sector. This analysis highlighted the importance of research, innovation and market uptake projects in demonstrating NZEBs and bringing them closer to the mass market in different European climates and regions as well as their widespread implementation into mainstream construction practices.

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