European Commission

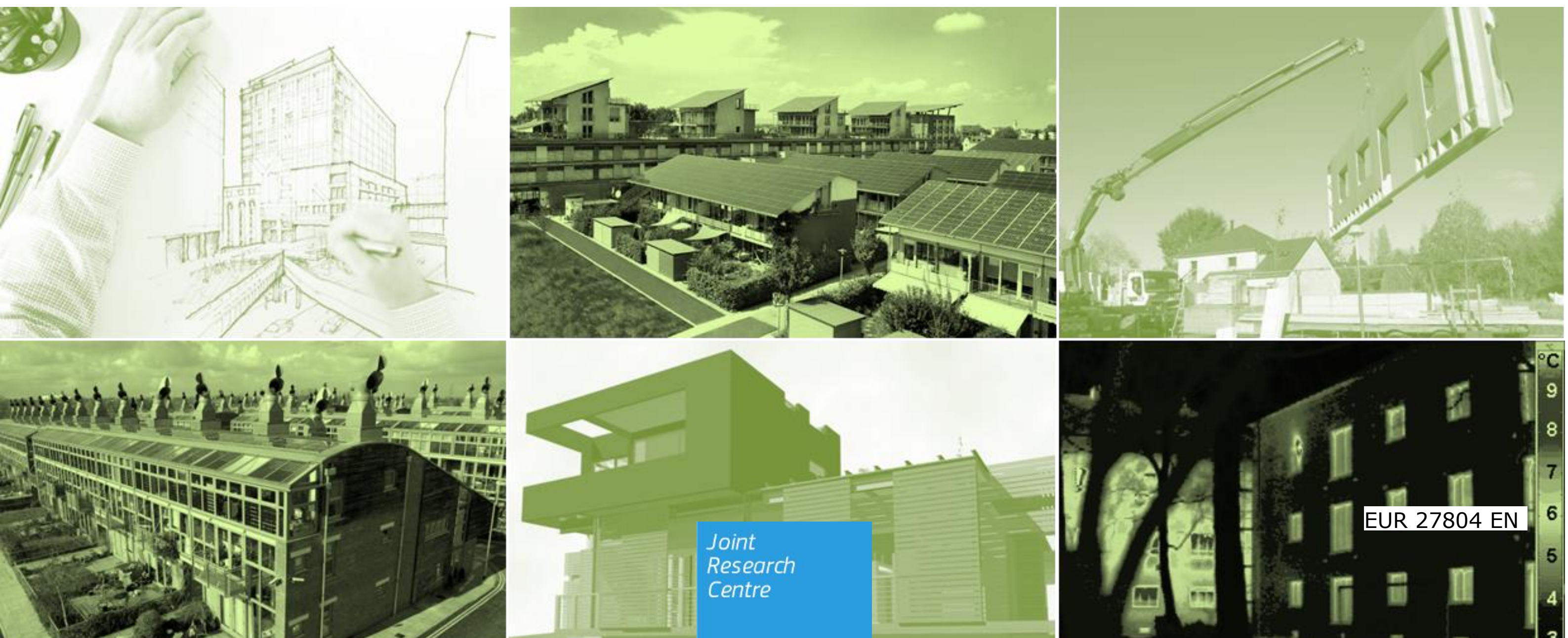
JRC SCIENCE FOR POLICY REPORT

Synthesis Report on the National Plans for Nearly Zero Energy Buildings (NZEBs)

Progress of Member States towards NZEBs

Delia D'Agostino
Paolo Zangheri
Barbara Cuniberti
Daniele Paci
Paolo Bertoldi

2016



Joint Research Centre

EUR 27804 EN

Contact information
Delia D'Agostino
Joint Research Centre, Via E. Fermi 2749. Ispra 21027. Italy.
E-mail: delia.dagostino@ec.europa.eu
Tel.: +39 0332 78 3512

JRC Science Hub
https://ec.europa.eu/jrc

JRC97408

EUR 27804 EN

PDF	ISBN 978-92-79-57343-9	ISSN 1831-9424	doi: 10.2790/659611	LD-NA-27804-EN-N
Print	ISBN 978-92-79-57344-6	ISSN 1018-5593	doi: 10.2790/012311	LD-NA-27804-EN-C

How to cite: D'Agostino et al., Synthesis Report on the National Plans for NZEBs; EUR 27804 EN; doi 10.2790/659611

Abstract

Buildings are a key element of European energy policies due to the high energy consumption and estimated potential energy savings that are associated with this sector. The recast of the Energy Performance of Building Directive (EPBD) requires Nearly Zero-Energy Buildings (NZEBs) as the building target from 2018 onwards. Member States are required to draw up National Plans towards NZEBs, establishing definitions, intermediate targets, measures and policies to progressively move to NZBEs. This report provides an assessment of the current status towards the implementation of NZEBs in Member States. National Plans and other sources of information have been considered in the analysis with the aim of evaluating the current status of European progress towards NZEBs.

Table of contents

Acknowledgements

This report has been prepared in the framework of the Administrative Agreement "Technical and scientific support on the implementation of the related EPBD provisions", under the supervision of Paolo Bertoldi. The JRC, on behalf of DG ENER, analysed Member States National Plans to assess the progress towards Nearly Zero Energy Buildings (NZEBs). The different aspects of NZEBs definitions have been evaluated and compared among Member States. A particular focus has been given to the study of interim targets for new and existing buildings, and to policies and supporting measures for refurbishing the existing stock to nearly zero energy levels.

Many thanks to Heinz Ossenbrink, Head of Unit of the JRC Renewables and Energy Efficiency Unit, who provided strategic guidance during the work. A thank is also due to Robert Kenny for proof-reading and Luca Castellazzi for editing.

Executive summary

The current energy policy framework foresees a substantial reduction of energy consumption in buildings by 2020. The implementation of nearly zero energy buildings (NZEBs) from 2018 onwards represents one of the biggest opportunities to increase energy savings and reduce greenhouse gas emissions.

The Energy Performance of Building Directive (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. Intermediate targets for improving the energy performance of buildings have to be provided as part of National Plans for increasing the number of NZEBs. Member States also have to develop policies and take measures to stimulate the transformation of refurbished buildings into NZEBs, and inform the Commission thereof.

The progress made by Member States towards the establishment of NZEBs has been evaluated based on the National Plans, templates developed by ENER, information from the EPBD Concerted Action (CA), Energy Efficiency Action Plans (NEEAP), and National Codes. In relation to the definition of NZEBs, many aspects have been 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 have been highlighted, with special focus on high impact policies and measures designed to target residential and non-residential building retrofit to NZEB or deep renovation level. Intermediate targets have been assessed for new buildings and buildings occupied and owned by public authorities. A literature review is also provided in the last part of the report with a special focus on NZEB renovation and NZEB best practices.

This study highlights that progress can be seen in many Member States in comparison with the previous Commission progress report. The current situation towards the establishment of applied national NZEB definitions has improved and consolidated and systematic information has been submitted through National Plans and the ENER templates. At the end of this report, a qualitative evaluation is given of Member States in relation to the status of NZEBs development and compliance with the EPBD requirements. This includes NZEB definitions, RES inclusion, and intermediate targets as well as measures to promote renovation. Even though many Member States have already introduced measures addressed to existing building stock within national renovation strategies, there is still the need to further strengthen these measures to successfully stimulate cost-effective NZEB renovation in a forward-looking perspective.

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.

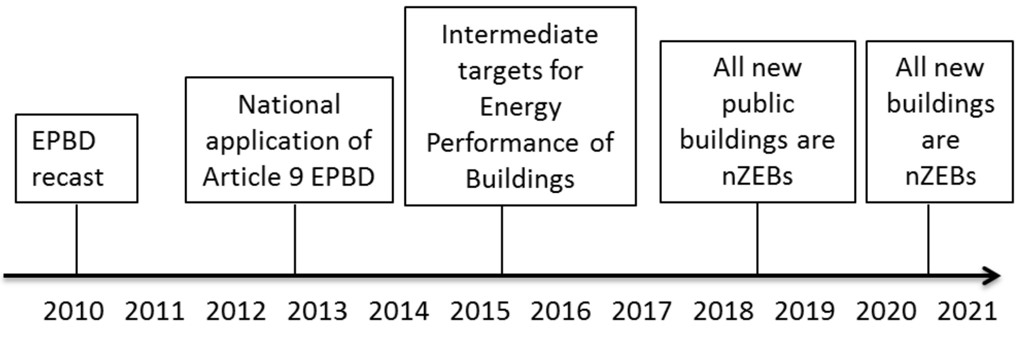


Figure 1 - Timeline for NZEBs implementation according to the EPBD recast.

Article 9 of the EPBD states that Member States shall ensure that new buildings occupied and owned by public authorities are NZEBs after 31 December 2018 and that all new buildings are NZEBs by 31 December 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 $kWh/m^2/y$	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 credits for notary fees, subsidised mortgage interest rates for energy efficient homes and

[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.

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).

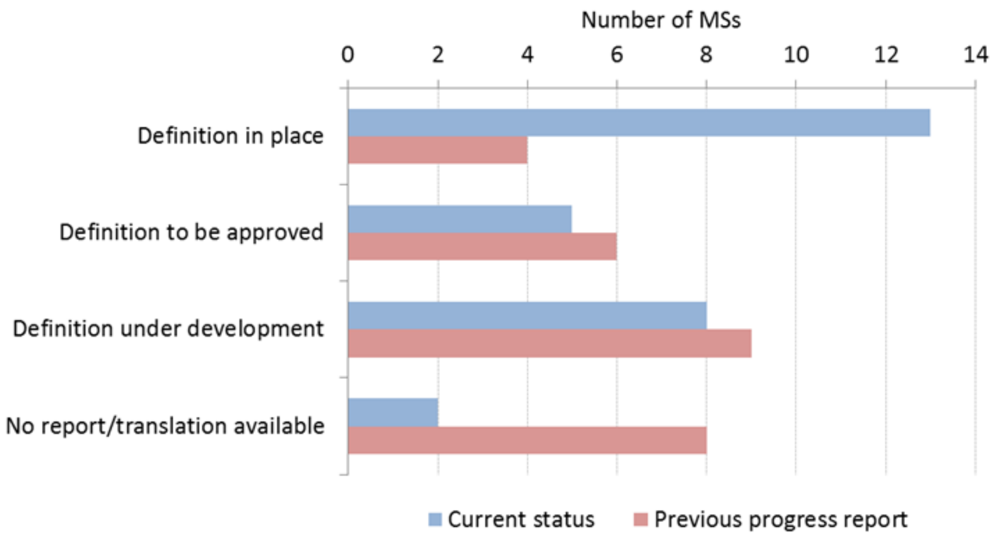


Figure 2 - Status of development of the NZEB definition in EU Member States.

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. Analysis of the NZEB National Plans

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 Table 3.

.

[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		✓	

2.1 Progress of EU Member States towards NZEB 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**Error! Reference source not found.**).

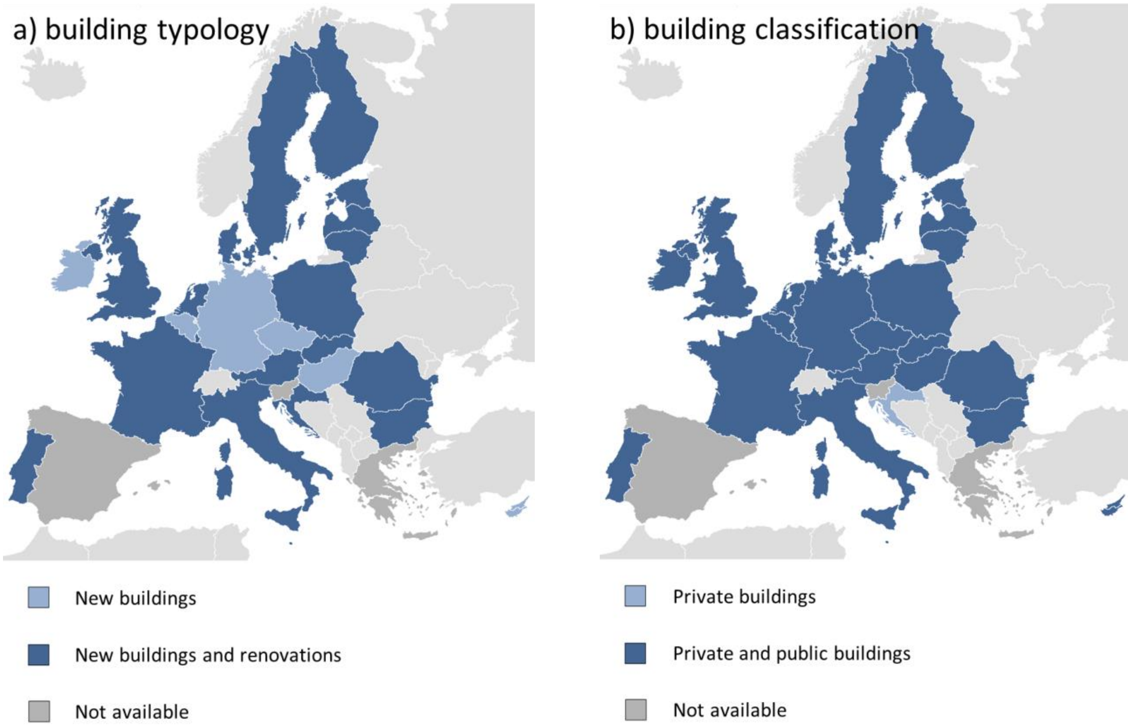
Table 4 - Building subcategory as accounted in NZEBs EU Member States definitions (✓= Included in national definition, - = not defined).

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**Error! Reference source not found.** 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 3 reports building typology (new/retrofit), building classification (public/private), balance type, and physical boundary chosen by EU Member States in their NZEB definitions.



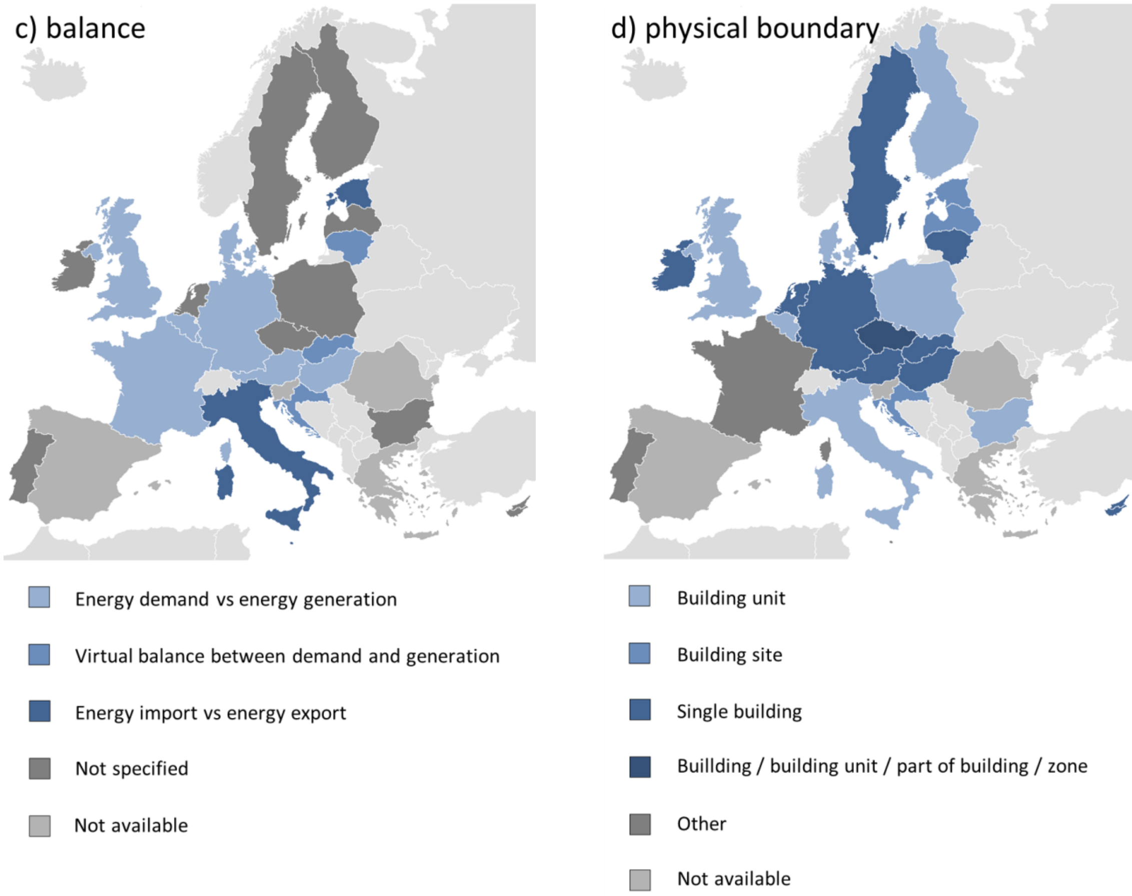


Figure 3 - a) building typology; b) building classification; c) balance; d) physical boundary in NZEBs EU Member States definitions. For explanations on the terms, please go to the guidance on the consolidated template[3].

According to Figure 3a, 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 3b). The graph in Figure 3c 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 3d 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

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

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 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.

[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).

Table 6Table 5 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).

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

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

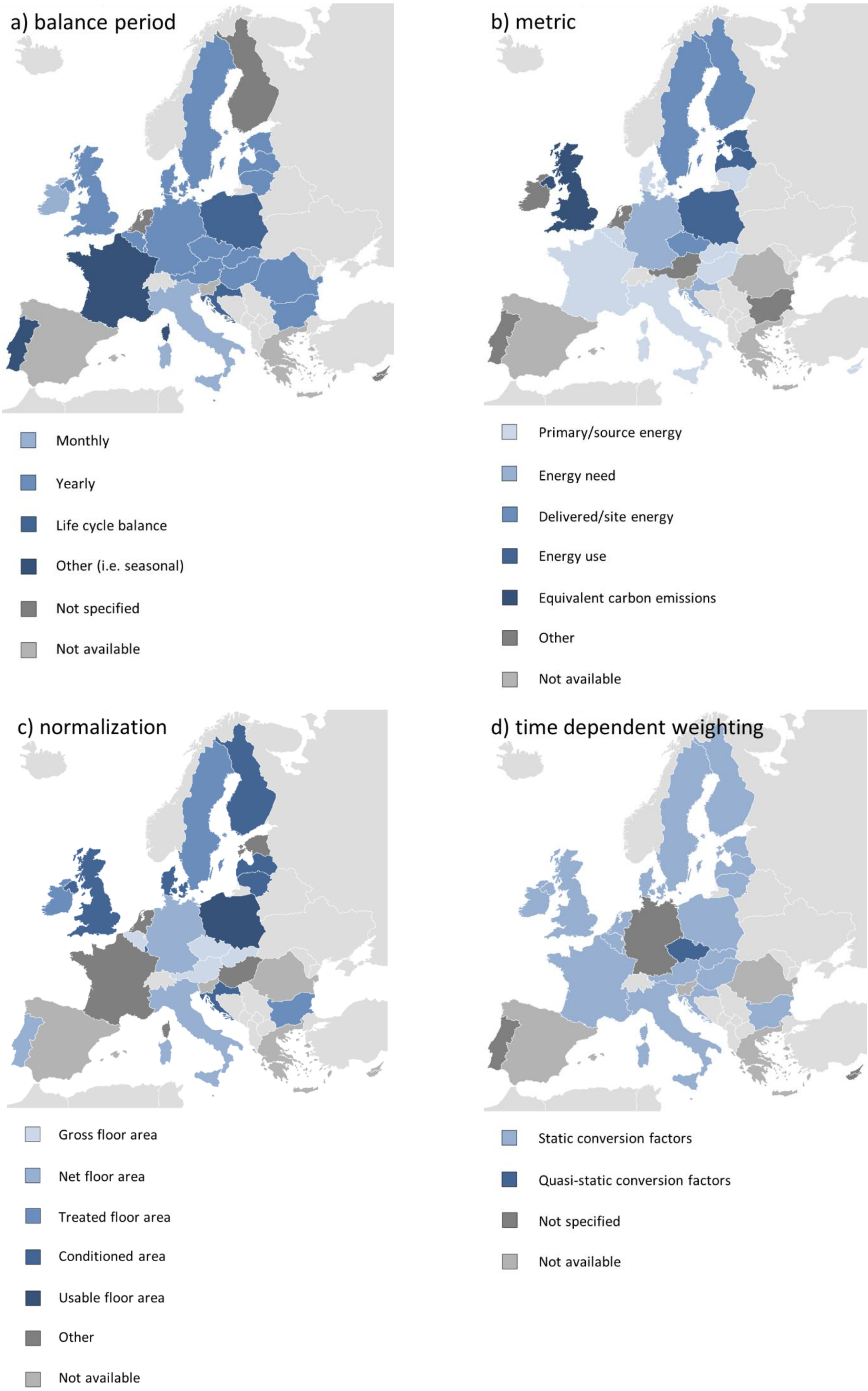


Figure 4 - a) balance period; b) metric; c) normalization; d) time dependent weighting in NZEBs EU Member States definitions.

Most Member States take a year as balance period; only one considers a monthly balance, and two life cycle balance (Figure 4a).

According to Figure 4b, 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 4c 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 4d). 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/m^2y (Brussels region) E 30 (Flemish region) E_w45 and $E_{spec}85$ (equal to 85 $kWh_{EP}/m^2/y$)(Walloon region)	~ 54	95-2.5*C Or (95-2.5*C)+(1.2*(x-15) kWh/m^2y (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.

2.2 Evaluation of the consistency 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 3a and Figure 3b).

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 3c).

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 4a and Figure 4d). 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 3d). 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 4c).

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).

2.3 Front-runner policy frameworks

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. As regards refurbishment, the new EU Member States measures are listed in Table 13. In agreement with the analysis carried out by the ENTRANZE Consortium [19] [37], the EU Member States that have 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) [38]. The 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 [39]. 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/m^2/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 [40][41]. 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 [42]. 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.

2.4 Intermediate targets

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. Table 9 and

Table 10 summarise the intermediate targets as reported by Member States for all new buildings and new buildings occupied and owned by public authorities.

Table 9 – Qualitative and quantitative intermediate targets addressed by Member States for all new buildings.

MS	Qualitative 2015 target	Quantitative 2015 target	Miscellaneous
AT	OIB Guideline 6 prescribes new minimum requirements for 2016, 2018 and 2020 for residential and non-residential buildings, new construction and major renovations.	n/a	Passive buildings cover a growing share of buildings. The AT National Plan is gradually establishing requirements for primary energy demand, CO2 emissions and heating and final energy demand.
BE Brussels	From 1 January 2015, requirement on final/primary energy demand close to Passive House standard (for housing, office, service buildings and schools)	n/a	The target is deeper defined in line with the Passivhaus requirements (e.g. net heating need below 15 kWh/m2/y).
BE Flanders	Requirement on primary energy demand for new and non-residential buildings: 45 KWh/m^2/y	n/a	For residential and office buildings and buildings for education, E-level requirements have to comply with E60 since 2014. U-values have to be tightened. Next tightening is in 2016 (E 50) as follows: residential buildings and office buildings of public organisations: E50. Office buildings and buildings for education: E55.
BE Wallonia	All new buildings have to comply with a "very low energy standard" from 2014 onwards (Ew< 80 and, for residential buildings, Espec130 kWh/m².y, K< 35).	n/a	Next tightening is in 2017 (E65 and, for residential buildings, Espec115).
BG	ZEVI set a 2015 target of at least 15 % of the total amount of heat and cooling energy needed must be produced from renewable sources. The National NZEB Plan will be actualized to set NZEB intermediate targets.	n/a	It is foreseen to revise the national legislation, including building codes, in order to define NZEB requirements (BG161PO001/5-01/2008/076 "Analyses, studies and actualization of legal acts" project).
CY	The targets are finalized.	n/a	The new minimum energy performance requirements will be issued in 2016.
CZ	Depending on size and type, buildings will become NZEB progressively. In 2016 all new buildings larger than 1500 m^2 will be NZEB.	n/a	n/a

MS	Qualitative 2015 target	Quantitative 2015 target	Miscellaneous
DE	By 2016, the Energy Saving Ordinance (EnEV) aims at increasing minimum requirements for new buildings (residential and non-residential) by 25% (12.5% per year).	According to the Federal Government, it is neither possible nor necessary to establish numerical guidelines for intermediate targets as far as the number of NZEB will be achieved in future.	The energetic minimum standards are gradually tighten towards NZEBs (i.e. having the effect of an intermediate target).
DK	Voluntary building class: Low Energy Class 2015, with a reduced energy consumption of 50% in relation to 2006 levels. In particular: 30 kWh/m2/y + 1000 kWh for residential buildings and 41 kWh/m2/y + 1000 kWh for non-residential buildings.	No plans of making specific target of a share of NZEB.	Additional information about the Low Energy Class 2015 is provided.
EE	Energy performance requirements will be updated in 2016.	2015 quantitative targets are not yet established, they are established only for 2030 (energy roadmap ENMAK 2030+, which foresees improvement scenarios by 2030).	Current requirement on primary energy demand are: 50 kWh/m^2/y for small residential buildings; 100 kWh/m^2/y for apartment buildings, office buildings, libraries and research buildings; 130 kWh/m^2/y for business buildings.
EL	n/a	n/a	n/a
ES	n/a	n/a	n/a
FI	n/a	A share of 15 % NZEB single-family houses is expected by 2015.	The Ministry of the Environment will issue technical descriptions of NZEBs as recommendations.
FR	The energy requirement will be lowered from 57.5 to 50 kWh$_{ep/}$m2/y in 2015 for collective housing, 50 kWh/m2/year for individual housing.	n/a	NZEBs are already mandatory for new buildings. Furthermore, all new buildings will be energy positive in 2020.
HR	Intermediate requirements on primary energy demand are given for single family houses (depending on the climate, lowered from 160 kWh/m^2/y to 102 kWh/m^2/y for new constructions, or from 160 kWh/m2/y to 66 kWh/m2/y). 41 kWh/m^2/y (continental Croatia) and 33 kWh/m2/y (litoral Croatia) primary energy consumption is established for new single family houses.	Intermediate targets in the present moment are not likely to be achieved, primarily due to dramatic shrinkage of real estate market. Unrealistic projections were made in strategic documents and plans.	n/a

MS	Qualitative 2015 target	Quantitative 2015 target	Miscellaneous
HU	Requirements will be strengthened in 2016, the targets are under discussion. Also direct requirements on solar systems will be included.	n/a	n/a
IE	The aim is to target 60% improvement by 2019 subject to cost-optimal calculations. An upgraded Energy Performance Standard for existing buildings undergoing renovation is foreseen.	No quantitative targets have been set for dwellings or for non-residential buildings to achieve nearly zero energy prior to 31 December 2020.	The 2011 step change at 60 $kWh/m^2/y$ is the intermediate step to advance towards 2020 performance levels of 45 $kWh/m^2/y$. A draft standard will be produced in 2015 for dwellings; it will be passed into legislation in the timeframe between 2015 and 2020, but may be applied on a voluntary basis once published. An improvement between 40% - 50% over the 2008 standard is proposed as an interim measure to be introduced in early 2015. A further review is expected to achieve an aggregate improvement between 50% - 60% over the 2008 standard, to be completed by 2018.
IT	The maximum U-values required will be lowered by 15% compared to their current value from 1 January 2016. A similar improvement will apply to the minimum performance of heating and conditioning systems. The obligation to include RES in new buildings and major renovations is equal to 20% of total consumption for heating, cooling and hot water. This latter share will be increased to 35% from the beginning of 2014 and to 50% from the beginning of 2017.	New obligations are into force since October 1st, 2015 for new and existing buildings. It is believed that on the basis of the current share of 1.6% of new buildings, 20% of them can be ranked as NZEB.	Verification of the requirements for nearly zero-energy buildings is planned to be applied starting from 2018.

MS	Qualitative 2015 target	Quantitative 2015 target	Miscellaneous
LV	The Cabinet Regulations No.383 of 9th June 2013 gives energy efficiency improvement measures and a breakdown by building classes. For residential buildings: A Class: heating energy efficiency ratio no more than 40 kWh/m2/y; Class B: heating energy efficiency ratio between 40 and 60 kWh/m2/y; Class C: for heating energy efficiency ratio between 60 and 80 kWh/m2/y; Class D: between 80 and 100 kWh/m2/y; Class E: between 100 and 150 kWh/m2/y; Class F: more than 150 kWh/m2/y.	n/a	The amendments adopted on 10 November 2015 entered into force on November 21, 2015 and provide the conditions for which all new buildings must meet NZEB requirements from 2021, public buildings from 2019.
LT	From 2016 new buildings or their parts shall comply with the requirements for class A buildings and from 2018, class A+. In buildings of class A++ (reference after 2021), energy from RES must form the largest part of energy consumed.	The 2013 data are provided: more than 5700 Class B buildings and more than 20 Class A buildings were certified.	Example of requirements on final/primary energy demand.
LU	For new residential buildings, since 1st January 2015 the heating energy class have to be at least B and the primary energy class A. For new non-residential buildings, an improvement from classes D-D to classes C-C was introduced.	n/a (the share of residential buildings which meet the nZEB will rise the forthcoming years)	The government decided to require nZEB-buildings being the standard for new buildings from 1st January 2019 on for public and private buildings.
MT	Minimum requirements to cost-optimal levels are expected to reduce useful energy demand for new residences (having sufficient access to RES) in the range 40-60%. New dwellings are expected to be required to produce a portion of energy through on-site renewable sources. (> 15-25% of the energy demand).	n/a (the number of buildings unable to meet the near zero level as per proposed definition may be significant)	Cost-optimality studies are ongoing. The intermediate targets are expected to be very close to the requirements for NZEB. Financial incentives have been in place for the adoption of key strategies.

MS	Qualitative 2015 target	Quantitative 2015 target	Miscellaneous
NL	The Energy Performance Coefficient of (new) residential buildings will be lowered to 0.4, as per 1 January 2015 (increasing the energy efficiency in new buildings by 50%). The percentage of renewable energy will automatically become increasingly important in order to fulfil the requirement.	60.000 new NZEB dwellings by 2015.	Reference: Spring Agreement on Energy-Efficient New Buildings of 28 June 2012. A feasibility study will be conducted twice a year until 2018/2020 to assess how feasible and cost-effective it would be to introduce a stricter EPC in the interim.
PL	At 1st of January 2017 the technical requirements (U-values) and the requirements on primary energy demand (by building category) will be increased (e.g. to 85-95 kWh/m2/y for residential buildings). Intermediate targets are specified by dates.	n/a	Reference: Ministry of Infrastructure Ordinance of 12 April 2002. It wasn't lead any official register concerning the number of NZEB.
PT	Requirements on U-values of envelope elements, efficiency of generators and lighting power.	n/a	Reference: Decree Law No 118/2013 of 20 August 2013
RO	Intermediate targets (primary energy and CO2 emissions) for residential and non-residential buildings	n/a	depending on building type and climate
SI	Heating energy demand < 25 kWh/m²yr; fraction of RES > 50%.	480 single-family houses, 8 apartment blocks, 26 other non-residential buildings.	
SK	From 1 January 2016 the minimum requirements for new buildings will be Energy Class A1.	n/a	National plan for increase of the number of NZEB: in new buildings, a 12% of energy needs in the housing stock should be covered by RES.
SE	n/a	n/a	The current information basis does not permit the setting of binding quantified target for 2015.
UK	Regulations to force all new UK homes to be 'zero carbon' from 2016 have been dropped by the Government in July 2015.	The UK does not have a formal definition of Nearly Zero Energy Buildings, and so does not have a reference parameter for the proportion of Nearly Zero Energy Buildings.	UK will consider the need for setting further intermediate targets in due course.

Table 10 - Qualitative and quantitative intermediate targets addressed by EU Member States for new building occupied and owned by public authorities.

MS	Qualitative 2015 target	Quantitative 2015 target	Miscellaneous
AT	Qualitative requirements for public buildings from 31.12.2018 are defined in the OIB Guideline 6, with reference to the minimum requirements in the national plan.	n/a	n/a
BE Brussels	Requirement on final/primary energy demand close to Passive House standard (for housing, office, service buildings and schools).	n/a	The target is deeper defined in line with the Passivhaus requirements (e.g. net heating need below 15 $kWh/m^2/y$).
BE Flanders	As other new buildings 2015: K 40, E 60, U-values tightened.	n/a	NZEB U-value requirements are the 2016 requirements. E level is sharpened to E 50 in 2016.
BE Wallonia	As other new buildings	n/a	n/a
BG	As other new buildings	2015 estimated NZEB target: 1÷1.5 % share of the total floor area of new buildings occupied by central and local government	As other new buildings
CY	As other new buildings	n/a	As other new buildings
CZ	As other new buildings	n/a	n/a
DE	As other new buildings	As other new buildings	As other new buildings
DK	As other new buildings. Requirements for "class 2020" will apply for public buildings by the end of 2018.	n/a	As other new buildings
EE	As other new buildings	n/a	Current requirement on primary energy demand are: 120 kWh/m2/y for public building; 90 kWh/m2/y for educational buildings; 100 kWh/m2/y for pre-school institutions for children.
EL	n/a	n/a	n/a
ES	n/a	n/a	n/a
FI	New public buildings for public administration built after 2015 shall follow the "Passive House" standard.	n/a	New public buildings built after 2017 shall be NZEBs.
FR	As other new buildings	n/a	As other new buildings
HR	n/a	n/a	n/a
HU	As other new buildings	n/a	n/a
IE	The approach for buildings in the public sector will be largely similar to that for non-residential buildings. An improvement of between 40% - 50% over the current 2008 standard is proposed as an interim measure to be	No quantitative targets have been set for new public buildings to achieve NZEB prior to 31 December 2018. The Government foresees an energy efficiency	The public sector will lead by example achieving defined nearly NZEB standard two years in advance of the private sector. It is envisaged that new regulations / technical guidance will be finalised

	introduced in early 2015, with a further review to achieve an improvement between 50% - 60% over the 2008 standard by 2018. This will facilitate the public sector in meeting the advanced deadline for NZEB by 31 December 2018.	improvements of 20% by 2020, with the target of 33% set for the public sector.	by in early 2015. An improvement of at least 40% is proposed over the existing 2008 standard (primary energy demand of 67 kWh/m^2/y for a naturally ventilated primary school rising to 220 kWh/m^2/y for an air-conditioned office).
IT	As other new buildings	As other new buildings	n/a
LV	As other new buildings	As other new buildings	n/a
LT	As other new buildings	As other new buildings	As other new buildings
LU	All new public buildings should be at minimum at passive house level	n/a	n/a
MT	Proposed Requirements on primary energy demand: 60 kWh/m^2/year (subject to limitations)	A minimum of 5% of the new buildings occupied and owned by the public authorities will be built according to nZEB.	The major milestone is still the acceptance of the proposed NZEB level.
NL	As other new buildings	n/a	As other new buildings
PL	At 1st of January 2017 the technical requirements (U-values) and the requirements on primary energy demand (by building category) will be increased (e.g. to 60-290 kWh/m^2/y for public buildings)	n/a	As other new buildings
PT	As other new buildings	n/a	n/a
RO	As other new buildings.	n/a	depending on climate
SI	For the public sector, the requirements are tightened by 10%.	41 public buildings.	n/a
SK	As other new buildings	n/a	National plan for increase of the number of NZEB: in new buildings, an 8% of energy needs in the public sector should be covered by RES.
SE	n/a	n/a	n/a
UK	All new build public sector buildings (and refurbishment project valued at over £500k) in England should be built to a BREEAM excellent standard or equivalent. At present in England and Northern Ireland there are no targets for the Fabric Energy Efficiency of non-domestic buildings, but they are subject to the carbon targets in same way as domestic buildings.	As other new buildings	As other new buildings

2.5 Policies designed to target building renovations

Most EU Member States did not describe in a detailed way policies and measures that would lead to the NZEB level in refurbishments. Reported policies appear in line with the EPBD requirements, but rarely do these legislative and normative measures explicitly refer to a clear definition of an NZEB renovation.

In order to summarise recent improvements towards the effective support of deep and NZEB renovations, additional data sources have to be considered. For the present analysis we refer to: i) the ODYSSEE-MURE database[6] includes around 2000 energy efficiency policy measures (including their impact); ii) the GBPN on-line Policy Tool for Renovation[7] which captures the performance of current best practice in some EU Member States and enables their comparison; iii) the third NEEAPs provided by EU Member States in mid-2014 which include descriptions of the new measures adopted; iv) the first renovation strategies in line with Article 4 of the Energy Efficiency Directive which Member States were due to provide by 30th April 2014.

Successful policy measures can be selected from ODYSSEE-MURE, which includes about 225 measures explicitly related to the renovation of the residential and non-residential existing building stocks. Selecting the most recent ones (those adopted in the last 10 years), excluding the legislative-normative ones and focusing on those with a medium or high impact, around 50 interesting ongoing or proposed measures can be recognised. They are listed in Table 11.

Table 11 - Ongoing and proposed policy measures on building renovation with medium or high impact, extracted from the ODYSSEE-MURE database.

MS	Sector	Measure title	Status	Type	Starting Year
AT	Residential	klima:aktiv building - new standards for efficient buildings	Ongoing	Information-Education	2005
BE	Residential and Tertiary	Brussels - Develop and promote exemplary buildings - BATEX (with virtually zero consumption and of high environmental quality)	Finished	Financial	2007
BG	Residential	EU-related: Energy Performance of Buildings EPBD (Directive 2010/31/EU) - National Program for Renovation of Residential Buildings in the Republic of Bulgaria, 2006-2020	Ongoing	Financial	2007
	Residential	Support for energy audits in multifamily buildings at guaranteed implementation of the recommended measures	Ongoing	Financial	2012
	Residential	Support for energy efficiency in multifamily buildings	Ongoing	Financial	2012
	Residential	Energy renovation of Bulgarian residential buildings	Ongoing	Financial	2012

[6] http://www.measures-odyssee-mure.eu/
[7] http://www.gbpn.org/databases-tools/purpose-policy-tool-renovation

MS	Sector	Measure title	Status	Type	Starting Year
	Tertiary	National Strategy for financing the building insulation for energy efficiency 2006-2020 - services	Ongoing	Financial, Legislative-Informative, Legislative-Normative	2006
DE	Residential	Tax incentives for Energy renovations	Ongoing	Financial	2015
	Residential	KfW Programme "Energy-efficient refurbishment" (former CO2 Building Rehabilitation Programme)	Ongoing	Financial	2009
DK	Residential	Strategy for energy renovation	Ongoing	Information-Education, Legislative-Normative	2014
EE	Residential	National Development Plan for Housing Sector 2008-2013	Ongoing	Financial, Information-Education	2008
	Residential	Building design and construction supervision support for apartment associations for making preparations for major renovation	Ongoing	Financial	2010
	Residential	Support scheme for reconstruction of apartment buildings	Ongoing	Financial	2010
	Residential	The programme of renovation loan for apartment buildings (under the Operational Programme for the Development of the Living Environment)	Ongoing	Financial	2009
	Residential	Provision of national guarantees for construction and renovation to achieve energy savings	Proposed	Financial	
	Tertiary	A programme for reconstruction of public sector buildings	Ongoing	Financial	
ES	Residential and Tertiary	State Plan 2013-2016 for Rental Housing, Housing Rehabilitation, and Urban Regeneration and Renewal	Ongoing	Financial	2013
	Tertiary	Action Plan 2008-2012:Energy Saving and Efficiency Plans in Public Administrations	Ongoing	Information-Education-Training, Legislative-Informative	2008
FI	Residential	Window Energy Rating System	Ongoing	Information-Education	2006
	Residential	Coordinated energy advice to the consumers	Ongoing	Information-Education	2010
	Tertiary	Renovation of State Property Stock	Ongoing	Information-Education-Training	2009

MS	Sector	Measure title	Status	Type	Starting Year
FR	Residential	Zero-rated eco-loan	Ongoing	Financial	2009
	Residential	Social housing eco-loan	Ongoing	Financial	2009
	Residential and Tertiary	Energy Savings Certificates (ESC)	Ongoing	Financial	2006
	Tertiary	"Moderning building and cities" programme	Ongoing	Financial, Legislative-Informative	2008
HE	Residential	“Energy Savings in households” Program	Ongoing	Financial, Legislative-Normative	2010
HR	Residential	Plan for Energy renovation of residential buildings	Ongoing	Financial	2011
	Residential	Integral multi-dwelling unit renovation incentives	Ongoing	Financial	2014
	Residential	Energy renovation of public sector buildings programme	Ongoing	Financial	2014
	Tertiary	Energy reconstruction of commercial non-residential buildings	Ongoing	Financial	2011
	Tertiary	Energy renovation of commercial non-residential buildings	Ongoing	Financial	2012
HU	Residential	“Our Home” Renovation Sub-Programme: Mitigation of heat demand of residential buildings (family homes and multi-occupied residential buildings) with individual or central heating	Ongoing	Financial	2008
	Residential	Liveable Panel Dwellings Renovation Sub-Programme: mitigation of district heating demand in residential buildings built by industrialised technologies	Ongoing	Financial	2008
IT	Residential	Fiscal incentives for energy savings in the household sector	Ongoing	Financial	2008
LT	Residential	‘Visagino Enervizija’, Visaginas town Programme for energy efficiency improvement in multi-apartment buildings	Ongoing	Financial	2011
	Residential	Programme for the renovation/upgrading of multi-apartment buildings	Ongoing	Financial	2005
	Tertiary	EU Structural Funds 2007–2013	Ongoing	Financial	2007
	Tertiary	Renovation of State institutions	Unknown	Financial	2014
LV	Residential	Grant scheme for renovation of residential buildings (2013-2016)	Ongoing	Financial	2013
	Residential	Information Campaign "Let's Live Warmer"	Ongoing	Information-Education	2009

MS	Sector	Measure title	Status	Type	Starting Year
	Residential	EU-related: Energy Performance of Buildings EPBD (Directive 2010/31/EU) - Energy Audits and Energy Certification of Residential Buildings	Ongoing	Financial, Legislative-Informative, Legislative-Normative	2009
	Residential	Increasing Heat Energy Efficiency in Multi Apartment Buildings (Measures to Improve the Thermal Stability of Apartment Blocks): EU programming period of 2007-2013	Ongoing	Financial	2009
	Residential	Increasing Energy Efficiency in Multi Apartment Buildings: EU programming period of 2014-2020	Proposed	Financial	2015
	Tertiary	Increasing Energy Efficiency in State (Central Government) Public Buildings: EU Programming Period of 2014-2020	Proposed	Financial	2015
	Tertiary	Increasing Energy Efficiency in Municipal Buildings: EU Programming Period of 2014-2020	Proposed	Financial	2015
NL	Residential	Reduced VAT rate on labour costs for insulation and glass and for maintenance an renovation of residential buildings (Verlaagd BTW tarief)	Ongoing	Financial	2009
SI	Residential	Financial incentives for energy-efficient renovation and sustainable construction of residential buildings	Ongoing	Financial	2008
	Tertiary	Financial incentives for energy-efficient renovation and sustainable construction of buildings in the public sector	Ongoing	Financial	2008

To support NZEB-refurbishments, LU runs since 2008 a financial scheme supporting the renovation of residential buildings. Furthermore, bonuses are paid for deeper renovations (A, B and C standard) since 2012. The GBPN analysis [43], focused on six Countries (DE, DK, FR, NL, SE and UK), identified: i) key themes and elements that support the development of policy packages that drive the existing building stock towards deep renovation; ii) current best practice elements of policy packages for the residential building stock. Each policy package was selected based on two main criteria: a demonstration of their policies including elements that cover energy renovations; and a reduction of residential energy consumption. The main results obtained are shown in Table 12.

Table 12 - Best practice measures selected by GBPN in a selection of European Countries.

Measure type		Measure description	MS
Financial Instruments	Incentive Schemes	The KfWs Energy Efficient Construction and Rehabilitation (EECR) programme for residential properties provides subsidised lending for the renovation of existing building stock. The funding is set according to the level of energy efficiency achieved, KfW can finance up to 100% of the loan. When more than one element is improved, or a combination of measures are undertaken it is possible to receive a bonus. As required by the Government's Energy Concept 2050, from 2009-2012, funding of EUR 500 million was provided for the renovation of existing buildings.	DE
		The Green Deal works hand-in-hand with the UK's Energy Company Obligation and aims to improve the energy efficiency of most of the 26 million homes in the UK. It works within a framework of accredited market participants. Individuals pay a part of the cost of improving their homes by taking a loan that is paid back via the savings they make on their fuel bills. The scheme, established by the Coalition Government through the Energy Bill, is designed to run between 2013-2027 although recently the new UK government has put this under review.	UK
Financial Instruments	Taxation Mechanisms	A fund for energy renovation has been made available in an effort to boost the sector. The renovation fund contains 1.5 billion DKK of subsidizes for private building projects and is supposed to reduce the increasing unemployment rates in the construction sector. An income tax deduction (BoligJob-ordning) has been reintroduced in 2013 and 2014, which is estimated to amount to 1.5 billion DKK annually. The scheme will be unchanged and allows tax deductions for home renovation costs up to DKK 15,000 per person annually for renovation services.	DK
		The 'Haushaltsnahen Dienstleistungen' tax incentive allows for 20% of the labour costs (up to 6000 Euros, tax relief on up to 1,200 Euros) of certain home renovations associated with reducing the energy demand of the building, this tax relief will be available over a period of 10 years.	DE
		A Regulatory Energy Tax (REB) was introduced in 1996 for environmental reasons. Energy Tax is a tax on energy consumption that intends to improve the cost-effectiveness of measures aimed at energy saving and renewable energy. The Energy Tax significantly increases energy prices for small-scale consumers, such as households (up to 5 000 m3 gas and 10 000 kWh) to promote energy efficiency. The energy tax applies to electricity and natural gas and has increased every year.	NL
Economic Instruments	Utility-Funded Energy Efficiency Programmes	In Denmark, since 1990, utilities have been providing their customers with energy saving advice and services. Since 1996 there has been a legal obligation placed on the utilities and the latest 2009 (Utilities' Saving Obligations Agreement requires for utilities to realise 6.1 PJ of saved energy. Each utility is allowed to decide on the way in which it will accumulate these savings, but the most common ways of doing this is through the provision of consumer advice, and financial incentives. Each utility must present documentation to prove that they have realised their targets.	DK

Measure type		Measure description	MS
		The Energy Company Obligation (ECO) was introduced in 2013 legally requiring the six biggest energy suppliers in the UK to deliver energy efficiency measures to the domestic energy users. The financial support provided to households is provided when the energy companies and individuals communicate to identify and apply suitable saving measures. Up to 100% of the cost for improvements will be provided by the energy companies.	UK
Economic Instruments	Market Instruments for Energy Efficient Renovations	The ESCO market is perceived to have grown in 2008 in comparison to the period 2005- 2007, this is due to a policy framework (including incentives) and to demonstration projects. France's National Energy Agency (ADEME) with the Grenelle programme, has been able to create a market for energy renovations in the public sector with PPPs and private investments. There are other programmes available that aim to increase energy efficiency such as the white certificates. The ESCOs market is under further development through a new programme called "Marché Public" that offers smaller amounts (< €5 million) for project financing.	FR
Information and Capacity Building	Training and Education Campaigns	The German Energy Agency (Dena, Deutsche Energieagentur) is a "centre of expertise for energy efficiency, renewable energy sources and intelligent energy systems" (Dena). With regards to energy efficiency in buildings it organises campaigns, distributes information to the public, supports the building sector (architects or craftsmen) to work in line with current standards and regulations and develops standards and labels for efficiency.	DE
		The Swedish Energy Agency supports local authorities by training them to provide energy efficiency measures. A number of policy packages are available for the residential including information tools and economic incentives. An interesting measure is the creation of procurement groups that directly address both property owners and tenants to help them to develop options for improving their energy efficiency.	SE
Information and Capacity Building	One Stop Solution Centre	KfW & Dena both act as one-stop-shops in Germany whereby advice is given on all energy saving activities.	DE
		The agency RVO.nl on behalf of the Dutch government provides market parties with information and tools on energy renovation projects, including deep renovation. RVO.nl also has a helpdesk for entrepreneurs. The program Energy Leap specialises in deep renovation.	NL

About the new policy measures that the EU Member States are implementing (or aim to implement) to reduce the energy consumption of the existing building sector, information can be found in the third NEEAPs, that MSs provided by April 2014. Table 13 lists the main news, distinguished by Member States and typology.

Table 13 - New measures about the building renovations included in the 3rd NEEAPs.

MS	Measure Type	Description
BE	Financial	In the Brussels Capital Region of Belgium, new financial incentives are tested through a "pilot" initiative to building landlords ("Répercussion du coût d'occupation"), providing economic incentives covering part of the implementation costs to stimulate energy savings under this measure, the rental charge and energy bills are merged and a calculation tool is offered to estimate the repercussion on occupation costs of these actions. In Wallonia, a 0% interest loan scheme named Ecopack started in May 2012
	Information-Education	The "Energy House" initiative in the Brussels-Capital Region of Belgium (known as Maison de l'Energie – Energie Huis) has consisted in the creation of an organization that are disseminating information and advice to energy end-users regarding available energy savings. Experts of the "Energy House" go to energy end-users houses, provide advice and perform small regulation and adjustments of energy consuming equipment. The Energy House is active on the territory of the Brussels-Capital Region since 2013. Since November 2015, the different antennas have come together to form a single Energy House. They are now twenty advisers gathered in the heart of the city that can meet personalized support requests.
DE	Financial	Additional funding for energy-related building renovation is secured from 2013 onwards with extra KfW grants of €300 million.
DK	Information-Education	BedreBolig (Better Homes) scheme was introduced on 1 January 2014 to make it easier and clearer for home owners to renovate their homes by offering comprehensive, expert advice as well as by strengthening cooperation between home owners and financial institutions advisers, banks and mortgages institutions to facilitate the interaction between home owners throughout the energy renovation process.
EL	Financial	The Energy Efficiency at Household Buildings Programme will enter its second phase by the end of 2015. Greece also plans to carry out Energy performance improvements of services buildings through ESCOs in the period 2015-2020 where 3000 buildings should be renovated through ESCOs.
ES	Financial	The Aid Programme for the Energy Renovation of Existing Buildings (PAREER) approved in September 2013, aimed at buildings used for housing and in the hotel industry. With a budget of €125 million, it promotes integrated energy efficiency improvement and renewable energy measure in the stock of existing buildings by awarding grants and repayable loans to projects.
FR	Financial	The social housing eco-loan has also been extended to the end of 2020.
	Information-Education	A renovation Information Services based on the concept of one-stop approach is set up in France with the aim of helping owners to make decisions through the implementation for the energy renovation of private dwellings. This is a new local public service with 450 Renovation Information Service Points (PRIS), present on the whole territory and has a mission of guiding property owners based on their profile and their location and suggest local information centres, local counselling centres and provide basic information. A new awareness campaign for the existence of these PRIS was launched in September 2013.
IE	Financial	A National Energy Efficiency Funds (NEEF) has been established in March 2014 (€35 million committed by government) with the objective of directly assisting energy efficiency upgrades in the commercial and public sectors.

MS	Measure Type	Description
IT	Financial	An incentive scheme for the promotion of renewable thermal energy and energy efficient heating (also known as "Conto Termico") started in 2012. This measure partly overlaps with the existing tax credits scheme, meaning that a large series of measures implemented by private actors can be eligible both for tax credits and incentives available under the "Conto Termico".
LV	Financial	An existing public building renovation scheme will be refinanced for a new period (2014-2020). Specifically, a grant scheme, financed through EU structural funds will target renovations of central government buildings and improvements in the energy performance of municipal buildings.
RO	Financial	Ongoing program on energy renovation of apartment blocks, started in 2009
NL	Financial	The government has created a new revolving fund for energy-saving measures in existing buildings, where € 555 million of central government funds are in total made available. Co-financing from banks amounting to € 225 million is also secured for projects specifically targeting owner-occupiers. At the same time, the Dutch central government is providing landlords in the social rental sector with a new subsidy of € 400 million for investments in energy-efficiency in 2014-2017 with the aim of contributing to the objectives of the Energy Saving Agreement for the Rental Sector. Under this agreement, the aim of an average label B (corporations) and a minimum label C (private landlords) for 80% of homes for 2020 is set.

According to the NEEAP Guidance, Member States were requested to provide within their Renovation Strategies an overview of the policies measures to stimulate cost effective deep renovations of buildings, in particular to: i) give an appraisal of existing measures/policies in the Member States; ii) provide an analysis of existing barriers to deep building renovation; iii) give an appraisal of relevance of policies used in other territories; iv) provide a design of new policy landscape that addresses barriers and enables the delivery of the required ramp up in deep renovation activity, with a particular focus on those measures which need to be introduced within the next 3 years.

Overall, Member States addressed quite exhaustively Article 4(c) requirements, providing a comprehensive set of policy designed to address the identified barriers, with 23 strategies that resulted to be fully compliant, 6 partly compliant and only 1 non-compliant (i.e. Belgium Wallonia). As shown in Figure 5 there is a great heterogeneity of policy packages in different Member States, both in terms of absolute number and in terms of policy type, with a predominance of financial/fiscal and regulatory measures.

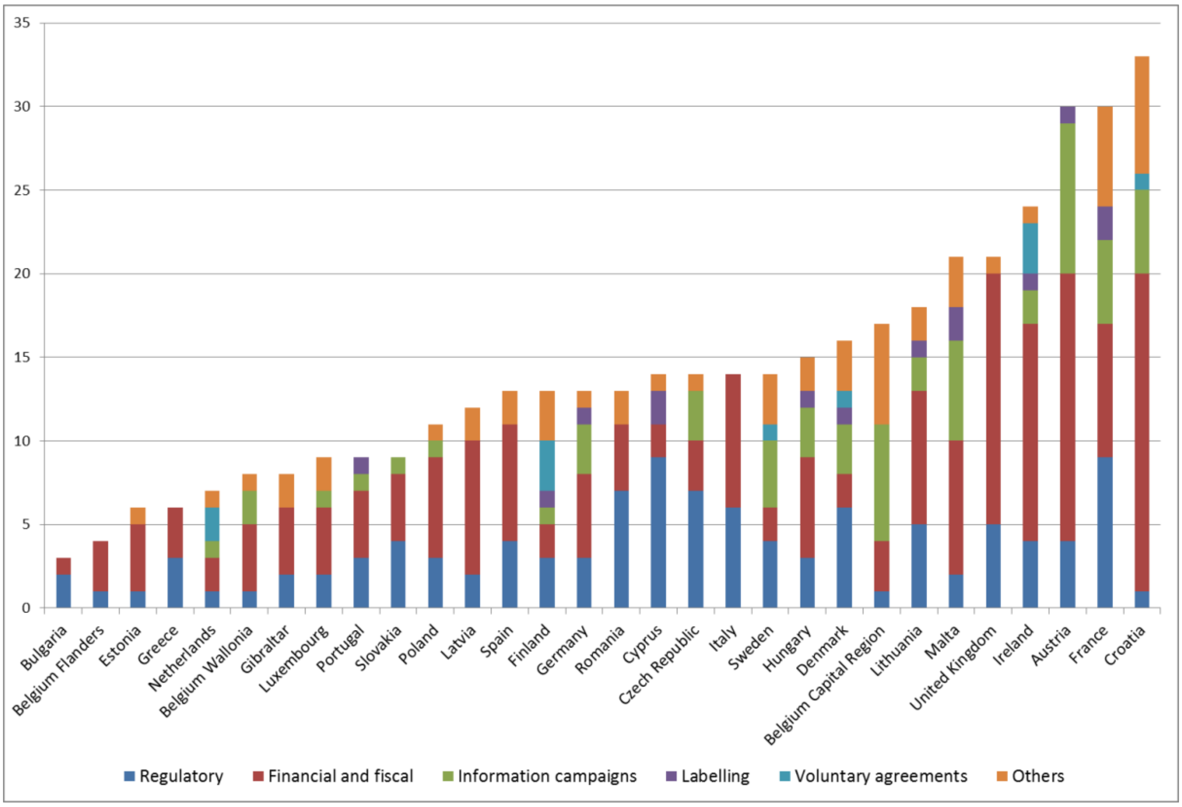


Figure 5 - Number of all the measures in the building sector (implemented and planned) by country and type.

In order to design new effective policies focused on deep renovation of the existing building stock, the following projects could provide valid support to EU Member States in the coming years:

- the ZenN project will develop a holistic approach on optimized near Zero Energy Building renovation actions, including a harmonized concept of NZEB Renovation (the project will establish an agreed framework for the definition of NZEB-R, taking into account area specifics such as climate, construction culture, and others) and demonstrations that the NZEBR vision is technically, economically and socially feasible (work is oriented towards the definition and optimization of highly efficient and cost effective renovation processes under variable scenarios) [44].
- By March 2016, the project "Collaboration for housing nearly zero energy renovation" (COHERENO) will develop proposals and concepts for promising cross-sector and company business models for high efficiency refurbishment of single-family houses to nearly zero-energy housing [45].
- The core objective of the RePublic_ZEB project is to define cost-benefit optimised “packages of measures” based on efficient and quality-guaranteed technologies for the refurbishment of the public building stock towards NZEB that are standardised and adopted by builders and building owners [46].
- The project Nearly zero energy hotels (neZEH), supported by the Intelligent Energy Europe (IEE), aims at accelerating the refurbishment of existing buildings into NZEBs in the hospitality sector, and will provide specific policy recommendations for this rather unique building type that often crosses the boundary between residential and non-residential buildings [47].

- Project EPISCOPE (IEE) aims to track the rates of renovation of housing and model the effects of policy scenarios [48] .

3. Summary and 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.

Table 14 reports a qualitative evaluation of the current status of NZEB development in EU Member States and compliance with the EPBD requirements. It includes the main aspects discussed in this report, such as the NZEB applied definitions, the inclusion of RES in the NZEB concept, intermediate targets (qualitative and quantitative) as well as measures to promote NZEB renovation. For this evaluation three colours have been used: a satisfactory development of the specific NZEB issue has been indicated with green, a partial development with orange and a lack of definition or of clarity with red.

Table 14 - NZEB development evaluation in Member States (green: satisfactory development; orange: partial development; red: not defined/unclear).

MS	NZEB Definition	RES included in the NZEB concept	Qualitative and quantitative intermediate targets	Measures promoting deep or NZEB renovation
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				

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.

Regarding intermediate targets, most EU Member States presented only qualitative targets (related to the "quality" of the NZEB level, expressed in terms of energy demand or energy class or percentage reduction with respect to a reference level) whereas quantitative targets (e.g. the number or share of NZEBs to be reached in the coming years) are almost never defined. Regarding this point some positions to be highlighted are: DE ("it is neither possible nor necessary to establish numerical guidelines for intermediate targets as far as the number of NZEB will be achieved in future") and HR ("intermediate targets in the present moment are not likely to be achieved, primarily due to dramatic shrinkage of real estate market. Unrealistic projections were made in strategic documents and plans"). Moreover, only a few Member States provided information regarding the mechanism that will be used to monitor the future results. BE-Flanders region has recently published an analysis of the foreseen amount of NZEBs.

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 4 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***
  As already stated in several studies [49], 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.

4. ANNEX

4.1 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 [50][51][53][54][55][56] 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" [57] 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 [58].

Three system boundaries can be distinguished in reference to energy need, energy use, imported and exported energy (Figure 6).

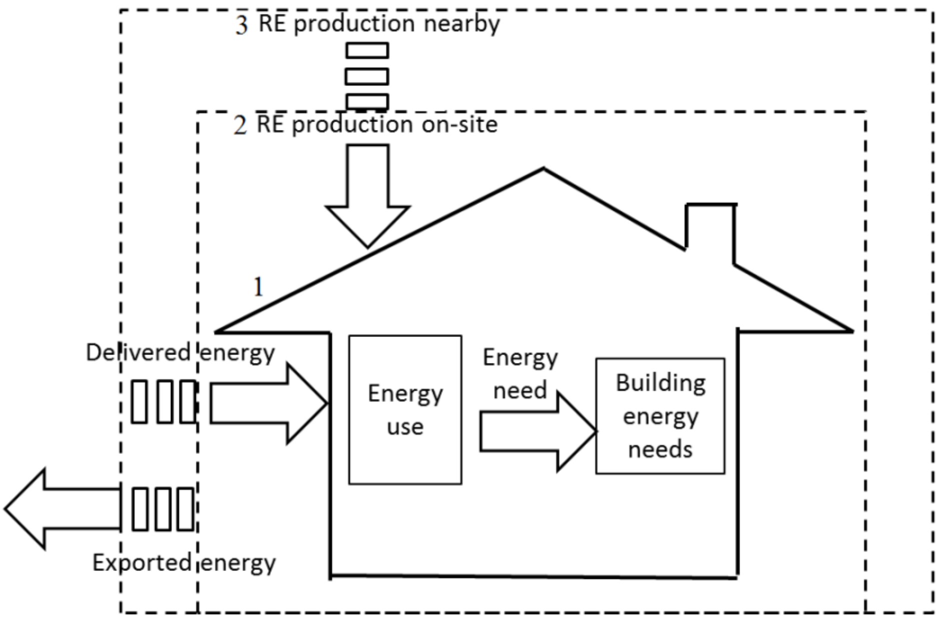


Figure 6 - Possible system boundaries for a building.

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 [59]

The main arguments are schematised in Figure 7 and are related to: physical boundary, period and type of balance, type of energy use, metric, renewable supply options and connection to energy infrastructure.

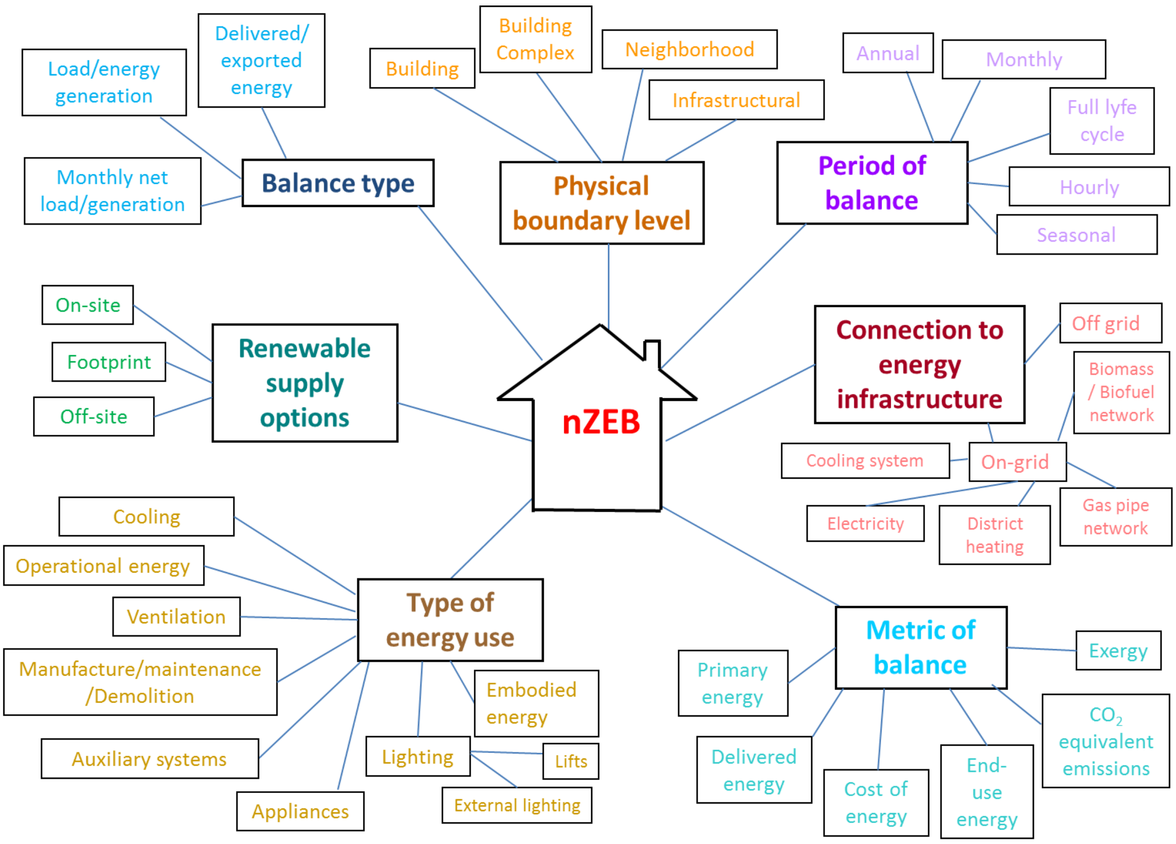


Figure 7 - Main arguments around NZEBs to be established in the definition.

- ***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 [58], 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 [59]. As starting point, 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 8). The different RES options and the fraction of RE production to be included have to be also defined.

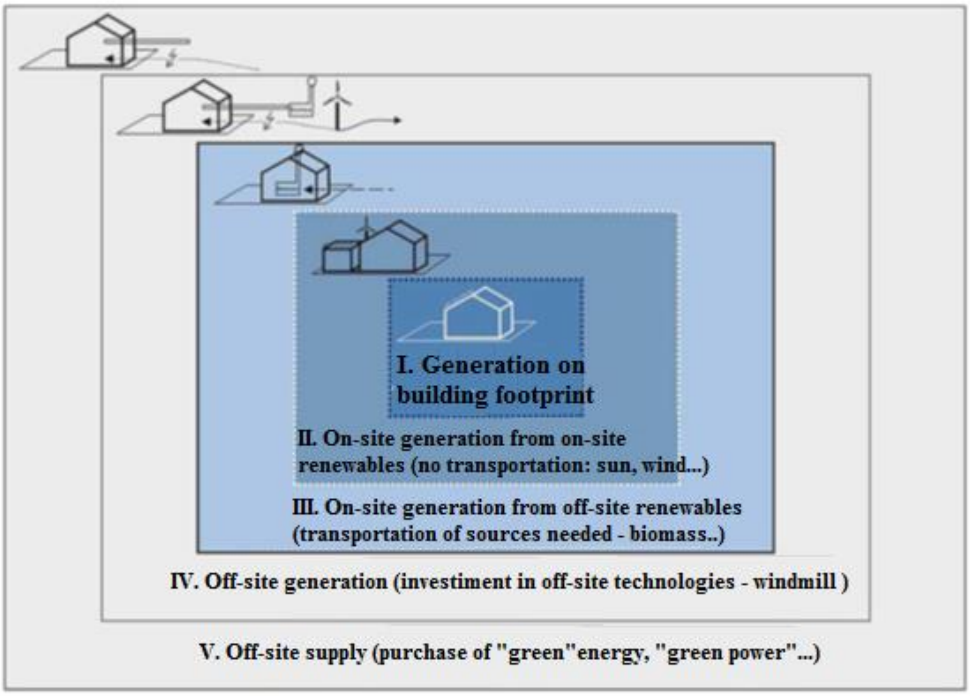


Figure 8 - Overview of possible RES options (Source:[60]).

With regard balance type, the energy use has to be offset by RE generation in off-grid ZEBs [61]. 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.

4.2 Deep and NZEB renovations

In the framework of the EPBD and EED Directives, the European Commission requested that Member States develop and adopt more concrete actions with a view to achieving the great unrealized potential for energy savings in the building sector, to which other key benefits are related: improvement in energy security, job creation, fuel poverty alleviation, improved indoor comfort, increased property values, energy system benefits, etc.

The energy consumption of the existing residential building stock, which has an average age of about 55 years (Figure 9), is one of main challenges that Member States are facing during an economic downturn. As suggested by the evolution of building permits (Figure 10) and of sales of material and equipment related to low-energy buildings (Figure 11), it is plausible to assume that the economic crisis of recent years contributed to curb building renovation activity.

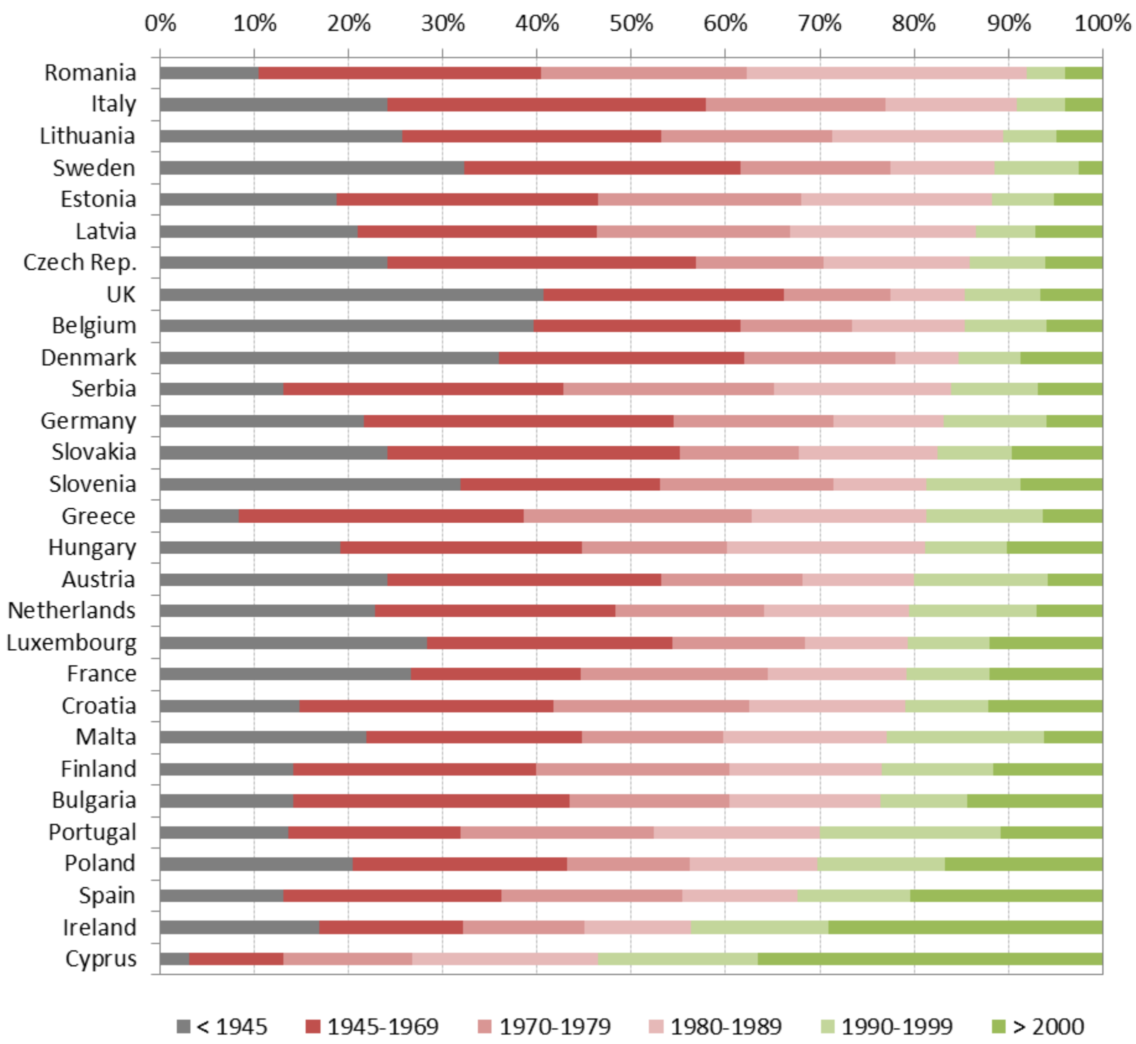


Figure 9 – EU-28 dwellings according to construction date. Source: ENTRANZE (http://www.entranze.enerdata.eu/).

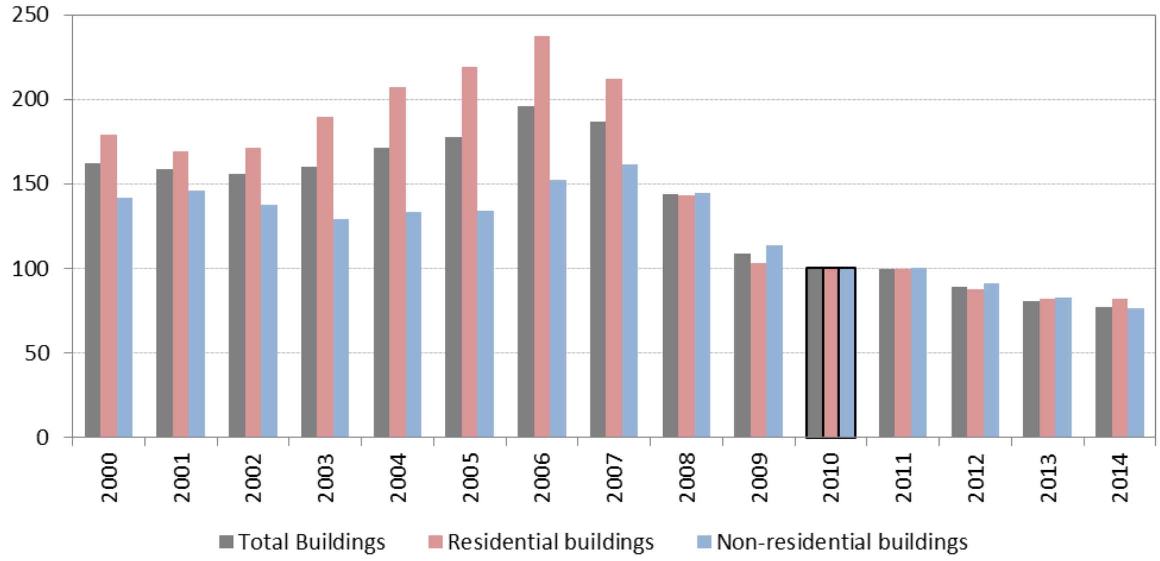


Figure 10– Trend of building permits in EU28 referred to 2010 (2010 = 100). Source: EUROSTAT [sts_cobp_a].

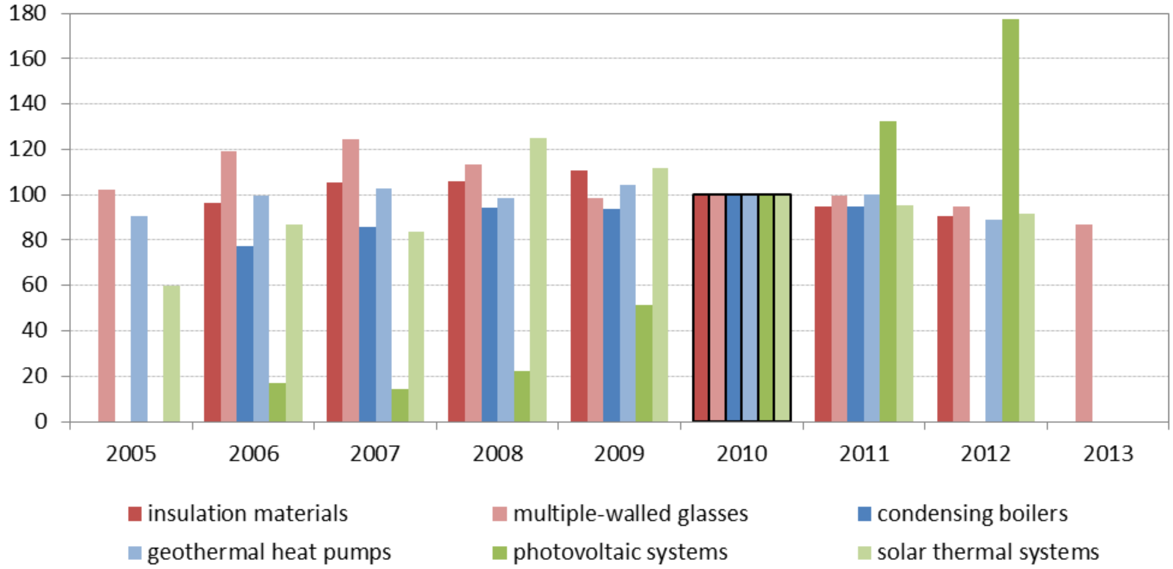


Figure 11– Sales trend of equipment related to low-energy buildings in EU28 (2010 = 100). Source: elaboration from ZEBRA2020 data (http://www.zebra-monitoring.enerdata.eu/).

Unfortunately it is not easy to have a clear picture of the renovations being undertaken: few data are available on their numbers, their depth, or indeed trends in renovation rates. In 2011, BPIE [62] noted that most estimates of renovation rates (other than those relating to single energy saving measures) are mainly between around 0.5% and 2.5% of the building stock per year. The authors have assumed a European renovation rate of 1%, considering that higher rates had reflected the activity of the previous few years which in some cases had linked to special circumstances (e.g. the existence of a renovation programme). This value was in line with the study carried out for the European Commission led by Fraunhofer Institute [63], where refurbishment rates of 1.2%, 0.9% and 0.5% per year were assumed for North-Western Europe, Southern Europe and New Member States respectively.

However the main expectations are focused on the "deep" and "NZEB" renovations. But what is a deep or a NZEB renovation? Firstly it is interesting to observe that the term "renovation" has been used by different experts to describe a wide variety of improvements to an existing building or group of buildings. Qualitatively, it can be seen that the refurbishment of the building façade (i.e. walls and windows) will provide a different level of energy saving than one addressing all of the building envelope and its energy systems (HVAC, lighting, etc.) as well as the installation of renewable technologies.

The EED Directive defines it as: "deep renovations which lead to a refurbishment that reduces both the delivered and the final energy consumption of a building by a significant percentage compared with the pre-renovation levels leading to a very high energy performance". In its report (Amendment 28, Article 2, paragraph 1, point 27.a) of July 2012 [64] the European Parliament proposed this definition: "'deep renovation' means a refurbishment that reduces both the delivered and the final energy consumption of a building by at least 80% compared with the pre-renovation levels". In the SWD (2013)143 final, the Commission services have indicated that Member States should aim to encourage deep renovations of buildings leading to significant (typically more than 60%) efficiency improvements.

Adopting the BPIE setting [62], the energy performance of a building can be improved by the implementation of a single measure, such as a new heating generator or the insulation of the roof. Normally, these types of measures might be called "small retrofit" or "minor renovation". Typically, energy savings of up to 30% might be expected by the application of 1-3 low cost/easy to implement measures. At the other end of the scale, renovation might involve the wholesale replacement or upgrade of all elements which have a bearing on energy use, as well as the installation of renewable energy technologies in order to reduce energy consumption and to close to zero (or to less than zero). The reduction of the primary energy demand towards very low levels (also including RES systems) can lead to the avoidance of a traditional heating/cooling system. This level can be termed nearly Zero Energy renovation, because in line with the EPBD-r definition[8]. In between these two examples are renovations involving a number of upgrades. These can be subdivided into: "moderate", involving improvements (typically more than 3) resulting in energy reductions in the range 30-60%; "deep", related to the integration of high-grade improvements, able to reach energy savings of 60-90%.

The term "deep renovation" has also been used by other references with similar, but not identical meanings:

- The Global Buildings Performance Network (GBPN) [65] equates a deep renovation to a reduction in energy consumption for heating, cooling, ventilation and hot water of 75% or more.
- The ENTRANZE Consortium selected as "deep" the renovation level implementing high-grade refurbishment packages (e.g. 30, 20 and 15 cm of insulation on roof, walls and basement; very efficient heating/cooling generators; heat recovery strategies).
- The ZEBRA2020 project[9] defines it as deep thermal renovation with more than 2 thermal solutions (e.g. heating + insulation of wall/roof, etc.).

[8] "'Nearly zero-energy building' means a building that has a very high energy performance [...]. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby".

[9] http://www.zebra2020.eu/

ZEBRA2020 is also collecting data and evidence for policy evaluation and optimisation (providing a strategy to boost the market uptake of NZEBs). As shown in Figure 12, at the moment deep renovation rates are available only for few Countries and, despite the efforts of EU Member States, they are significantly lower than 1% of the whole building stock renovated each year.

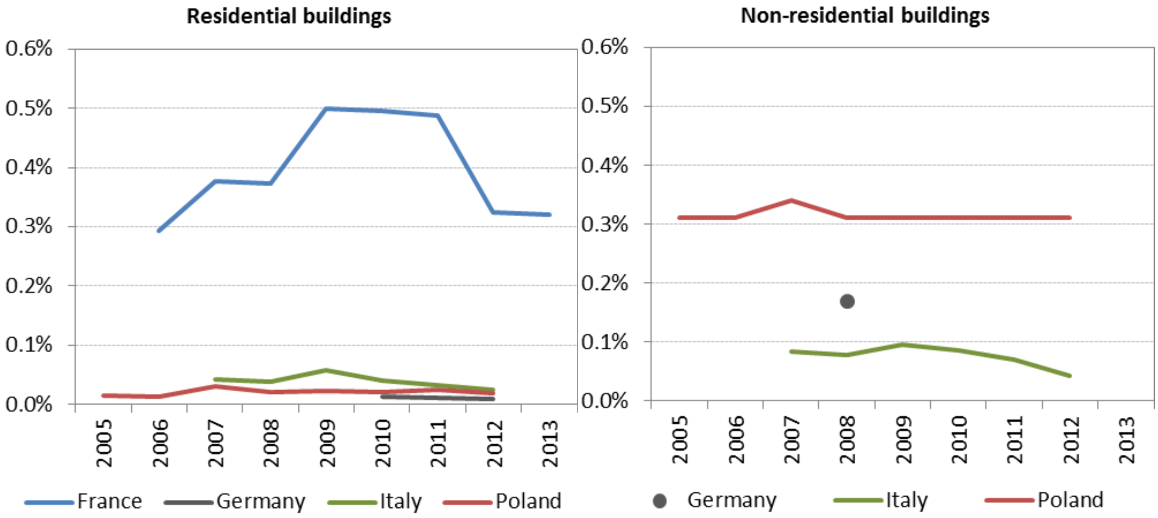


Figure 12– Evolution of deep renovation rates in some European Member States (in terms of % of the whole building stock renovated every year). Here "deep renovation" means deep thermal renovation with more than 2 thermal solutions (e.g. heating + insulation of wall/roof, etc.). Source: ZEBRA2020 (http://www.zebra-monitoring.enerdata.eu/).

Another term used in the reference bibliography (sometimes as synonymous of "deep") is "major renovation". In 2010 it has been officially defined by the EPBD-r Directive (where there are no mentions of the term "deep renovation") as: "the renovation of a building where: (a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25% of the value of the building, excluding the value of the land upon which the building is situated; or (b) more than 25% of the surface of the building envelope undergoes renovation; Member States may choose to apply option (a) or (b)".

As suggested by Shnapp et Al. [66] this definition identifies a window of possibility for a "deep renovation", but probably it is erroneous to associate these two terms. In the spirit of the EPBD-r Directive it was necessary a reference to harmonise a certain level of renovation to the minimum energy requirement of new buildings. In this context an ex-ante reference (economical or geometrical) was considered functional to the administrative management (i.e. building permit, inspections, etc.). The EPBD asked for effective renovations[10] but the message has been emphasized with the EED Directive. The run to establish a long-term strategy (for mobilising investment in the renovation of buildings with a view to improving their energy performances) introduced the need for an ex-post reference: we have to stimulate the renovations able to reach significant energy savings, we need for "deep renovations".

---

[10] "Major renovations of existing buildings, regardless of their size, provide an opportunity to take cost-effective measures to enhance energy performance. For reasons of cost-effectiveness, it should be possible to limit the minimum energy performance requirements to the renovated parts that are most relevant for the energy performance of the building".

Notwithstanding the above, we should avoid to overlap the meaning of "deep renovation" and "major renovation"[11], and talk about "deep or NZEB renovations". About the application of the nearly Zero Energy target to renovations, official definitions are missing, but several references have been proposed in the recent years:

- the COHERENO project [67] developed a set of criteria to identify the different types of NZEB renovation for single-family houses, including holistic renovation, renovations close to NZEB levels and deep renovation of building components (e.g., walls, windows, roofs etc.) that can lead to an entire NZEB house renovation. Criteria are based on national market conditions in four Countries (Austria, Belgium, Germany, Netherlands) using existing instruments, such as Energy Performance Certificates (EPC), to track relevant projects in a practical and simple way. For example in Austria the minimum requirements of the national climate initiative klimaaktiv[12] have been considered and in Germany the methodology used by the KfW Bank [13] for funding programmes (German government-owned development bank) was applied.
- The ZenN Consortium [68] provided an overview of the current status for the European NZEB definition work and presents the definition agreed upon by the ZenN Partners for three Countries (France, Spain, Sweden). For Sweden two references have been chosen: the official building code BBR 20 (with a minimum requirement of primary energy demand of 90 kWh/m^2/a) and the indication of the FEBY (Forum for energy efficient buildings) with an upper limit of 63 kWh/m^2/a. For Spain and France they referred only to the existing national building codes.
- Adopting a different point of view, the ENTRANZE project [69] investigated which performance levels are reachable by 4 building types (single family house, apartment block, office and school) in 10 European contexts adopting typical and deep renovation measures. Focusing on the NZEB target, the consortium recognized as obtainable maximum values[14] of net primary energy of 40, 75 and 100 kWh/m^2/a respectively for the South, Central and North Europe. Moreover they found that often (27 times out of 40) the NZEB levels result economically more advantageous (lower global costs over 30 years) than the Base Renovation Levels[15], especially in the Central-North Europe.

In accordance with the scenario analysis carried out by the ENTRANZE Consortium, the policy measures already in place (BAU scenario) should result in the Deep Renovation of approximately 2.5% of the EU-28 building stock by 2020 and of around 5-

[11] In application of EPBD-r, a "major renovation" has a legal implication in terms of building codes. On the other hand a "deep renovation" does not carry these legal requirements.

[12] Heating demand: 51 kWh/m^2/a for SFH (A/V=0,8); Primary Energy demand: 200 kWh/m^2/a; CO2-Emissions: 32 kg/m^2/a.

[13] Efficiency House 55 or better, which indicates a reduction of 45% of primary energy compared to the requirement for new construction. Houses refurbished before 2009 are considered nZEB if their primary energy demand is below 40 kWh/m^2/a and transmission heat loss is below 0,28 W/m^{2}K.

[14] These maximum values are always associated to the apartment block type that shows a lower energy saving potential due to geometric limits (e.g. lower available roof surface for solar systems).

[15] It represents the lower level of renovation to which compare the more efficient ones (in other word it is not contemplated the possibility of not intervening in any way on a building with an age of at least 40 years) and, avoiding to consider the renovation of building elements without an influence on the thermal energy needs, it includes: the rehabilitation of the building façade and roof (finishing material); the substitution of the old window systems and of the old heating/cooling systems with similar (in terms of technology) components; the installation of an active cooling system (to guarantee similar thermal comfort conditions).

5.5% by 2030. As shown in Figure 13, a moderate additional effort[16] could increase these shares to 3,7% (by 2020) and 8.7% (by 2030) and an ambitious improvement[17] to 5.4% and 14.4%.

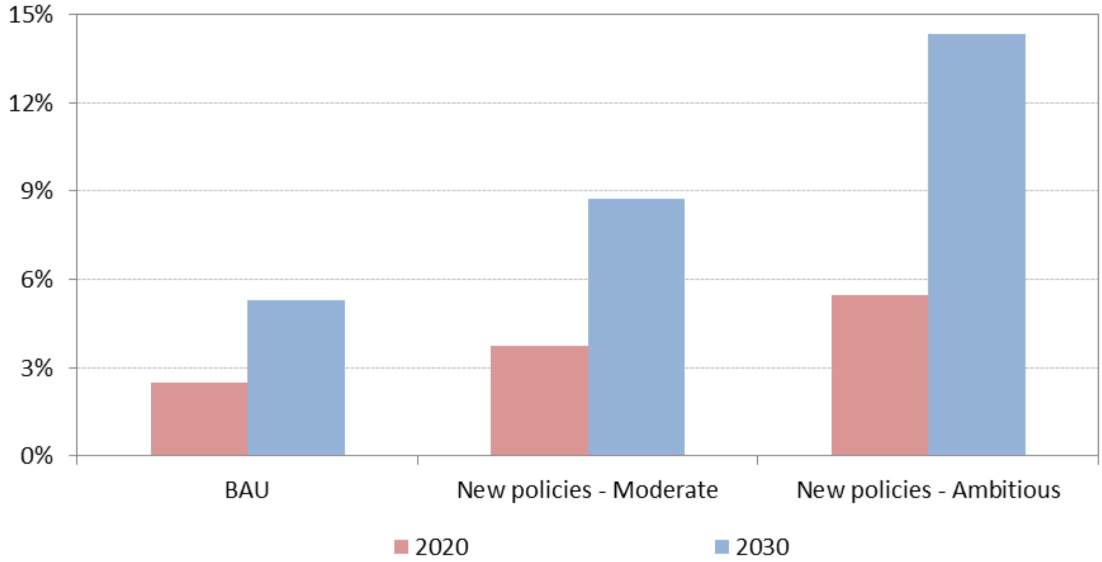


Figure 13– Share of EU28 building stock renovated deeply (or to an NZEB level) by 2020 and 2030, varying the policy scenario. Source: ENTRANZE (http://www.entranze-scenario.enerdata.eu/site/).

Looking forward, a key issue will be therefore the development and the adoption of new national policies, but no less important will be the guidance role of the European Commission. For example the stakeholders are asking for a clear guidance for NZEB renovation, to be possibly followed up in the context of the EPBD review. Moreover several experts point out that the net yearly primary energy indicator is insufficient to characterize NZEBs: for instance Hermelink et Al. [70] proposed to implement several indices for a more complete and correct description and ranking of NZEBs.

4.3 Exemplary NZEBs

A great variety of concepts, models and examples of highly energy-efficient or low energy buildings are available throughout Europe [71]. European policies seem to have motivated the private construction sector to take initiatives and the construction sector appears to moving towards NZEBs. However, the majority of NZEBs are still demonstration projects, indicating that a full implementation of the concept is not yet present.

A database of ZEBs throughout Europe has been created by IEA [49]. The website testifies that ZEBs built examples are diffusing in many Countries, but a considerable

---

[16] Some effort in more innovative and consistent policy packages, however with a moderate ambition. Information, qualification and training are intensified. Regulatory instruments (RES-H obligation) and enforcement of building renovation are implemented. A moderate energy tax is introduced. Budgets for subsidies for building renovation and RES-H are increased moderately.

[17] Strong effort in more innovative and consistent policy packages, with a high policy ambition. Information, qualification and training are intensified, leading to a comprehensive coaching and support of building owners. Split incentive is addressed in the legal framework leading to a reduction of this barrier. Regulatory instruments (RES-H obligation) and enforcement of building renovation are implemented. A high energy tax is introduced and accompanied with social measures to support in particular low-income households. Budgets for subsidies for building renovation and RES-H are increased.

number of projects are located in AT, DE, DK, and SE. However, energy data of available case studies reflect the uncertainty of calculation methodologies and accounted energy flows. Furthermore, measurements should be also required at a built NZEB level during its operation to verify the claimed performance and the effectiveness of the solutions after their implementation.

This chapter presents some examples of refurbished buildings as defined by the designers or indicated as "Nearly Zero-Energy Building", buildings that have a very high energy performance, for which the very low amount of required energy is covered to a very significant extent by renewable energy sources, as indicated in the EPBD - Article 2[18].

The selected examples should reflect as accurately as possible the actual national NZEB refurbished building stock of that country in order to enable repeatability of the results achieved and to transform the lesson learned into a procedure path.

A spreadsheet template analysis has been created in order to evaluate and compare fundamental information about the NZEB refurbished building through EU.

Many different sources have been used in order to obtain an exhaustive overview of the building stock under analysis [72][73][74][75][76][77][78][79][80][81][82][83][84][85][87][88]. The following additional sources have been considered: scientific journals (e.g. Energy, Building an environment, Energy and Buildings, Renewable Energy, Applied Energy); technical reviews (e.g. A+U Architecture & Urbanisme, Domus, Arca International, azero, Journal of GreenBuilding, Lotus International); dedicated portal (e.g. www.buildup.eu, www.worldarchitecture.org); reports of International and recognized Scientific Institutes and Agency (e.g. IEA, BPIE); conference proceedings (e.g. World Sustainable Energy Days 2014 Wels).

The following information has been selected to better describe examples of refurbished NZEBs and inserted in a spread sheet Excel database (Annex 1).

The structure of the table is based on the GreenBuilding Programme (GBP) [19] database structure. Key information for the analysis of the NZEB has been integrated.

General information

This includes:

a) Name of the building; b) Country; c) year of construction and year of refurbishment; d) area in m^2 (area is not a harmonized value, can be the heated area or the net surface or not specified); e) climate conditions.

Building categories

The different types of buildings are listed below as categorized in Annex 1 of

DIRECTIVE 2010/31/EU (EPBD):

(a) single-family houses of different types;

(b) apartment blocks;

[18] Directive 2010/31/EU of The European Parliament and of the Council 0f 12 may 2010 on the energy performance of building (Article 2)

[19] The GBP ran from 2005 to 2014, with more than 1000 buildings subscriptions. was a European Commission voluntary programme for non –residential buildings which undertook significant energy efficiency measures and introduced renewable energy sources. See Bertoldiand Valentova." *The European GreenBuilding Programme 2006-2009. Evaluation. JRC Scientific and Technical Reports*". European Communities 2010

(c) offices;

(d) educational buildings;

(e) hospitals;

(f) hotels and restaurants;

(g) sports facilities;

(h) wholesale and retail trade services buildings;

(i) other types of energy-consuming buildings.

Consumption and savings

The absolute value of energy consumption after the renovation works is collected. The achieved savings are analysed in relative terms (%).

Technical measures

Technical measures were categorized into 8 main areas, as areas of intervention, which are considered a common denominator of NZEB refurbished building: envelope, heating, cooling, ventilation, lighting system, control system, renewable sources (RES).

As part of the envelope and commonly considered as different components of it, basement, roof, external walls and type of windows. Where possible each transmittance values are reported.

Financial parameters

The economic parameters taken into account are two: the investment costs (EUR o EUR/m^2) and the discounted pay-back time period (y). Notes about the financial incentives (if applicable) have been included. Investment costs, as energy measures, are reported in the Annex as indicated in the source. Differences have been kept in order to show were harmonisation has not been yet achieved.

NZEB definition

Other information filed in the table is: if there is a NZEB definition in the EU Member Stateswhere the building is located and the reference value eventually established in Member States and % of energy covered by RES.

From the case studies available in the literature it is difficult to drawn a common picture of the EU state of the art in implementing EPBD requirements on NZEBs: the information is scattered and usually not homogeneous and several important data are still missing. The establishment of an EU database of benchmark refurbished buildings, collected through an harmonized methodology which compares values although respecting differences among EU Member States, could be an important step in future research on NZEBs

4.4 NZEB SPREEDSHEET

Name of the Building	Edificio Residenziale
Country	Italy
Location	(TO) Pont Canavese
Category	single-family house
Year of construction	1980
Year of refurbishment	2013-2014
Area (type)	212 m² (net area)
consumption after renovation (energy measures and type are reported as defined from the source)	4.95 kWh/m^{2}yr (n/a)
percentage saving	65%
type of envelope	EPS insulation + graphite (25cm) ; no thermal bridges; blower test
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	0.11
basement U value [W/m²K]	0.14
windows type or U value [W/m²K]	triple glass
heating technology	pellet boiler (28kW); existing radiators
ventilation technology	CAV with heat recovery
cooling technology	shading devices
lighting system	n/a
control system	BMS (1)
renewable sources /technology	Solar thermal plant; PV
% of RES (energy level)	100% domestic hot water
investment costs euro or euro/m^2 (or as reported from the source)	52.700 (for HVAC systems)
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	Class A+ (Regione Piemonte)
Project/Source	azero- EdicomEdizioni- n14

Name of the Building	Edificio Residenziale
Country	Italy
Location	(TO) Pont Canavese
Category	single-family house
Year of construction	1980
Year of refurbishment	2013-2014
Area (type)	212 m² (net area)
consumption after renovation (energy measures and type are reported as defined from the source)	4.95 kWh/m^{2}yr (n/a)
percentage saving	65%
type of envelope	EPS insulation + graphite (25cm) ; no thermal bridges; blower test
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	0.11
basement U value [W/m²K]	0.14
windows type or U value [W/m²K]	triple glass
heating technology	pellet boiler (28kW); existing radiators
ventilation technology	CAV with heat recovery
cooling technology	shading devices
lighting system	n/a
control system	BMS (1)
renewable sources /technology	Solar thermal plant; PV
% of RES (energy level)	100% domestic hot water
investment costs euro or euro/m^2 (or as reported from the source)	52.700 (for HVAC systems)
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	Class A+ (Regione Piemonte)
Project/Source	azero- EdicomEdizioni- n14

Name of the Building	Boutique Hotel Stadthalle
Country	Austria
Location	Vienna
Category	hotels and restaurants
Year of construction	19th century
Year of refurbishment	2001-2010 (+new expantion)
Area (type)	2,271 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	318 kWh/m^{2}yr (n/a)
percentage saving	n/a
type of envelope	n/a
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	n/a
heating technology	district heating
ventilation technology	heat recovery
cooling technology	n/a
lighting system	LED technology; presence controlled
control system	BMS (1)
renewable sources /technology	Solar thermal plant; PV
% of RES (energy level)	5% (n/a)
investment costs euro or euro/m^2 (or as reported from the source)	5 mio
financial incentive	financed throught a lease-back scheme
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 54 kWh/m2/y for existing buildings
reference value or standards eventually established in the MS	reference value defined by the neZEH project for Western Europe Countries (REHVA Journal)
Project/Source	neZEH- Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Technical University - Sofia, University Research Centre
Country	Bulgaria
Location	Sofia
Category	educational buildings
Year of construction	n/a
Year of refurbishment	n/a
Area (type)	1,630 m² (total gross floor area)
consumption after renovation (energy measures and type are reported as defined from the source)	15.98 kWh/m²yr (+RES 27.40 kWh/m²yr) (n/a)
percentage saving	77.60%
type of envelope	concrete and brick with thermal insulation
roof U value [W/m²K]	0.26
external walls U value [W/m²K]	0.35
basement U value [W/m²K]	0.56
windows type or U value [W/m²K]	n/a
heating technology	ambient-based variable refrigerant flow (VRF) heat pump
ventilation technology	heat recovery unit, with seasonal efficiency of 75% (heating mode)
cooling technology	VRF based system
lighting system	Low-energy lighting system
control system	n/a
renewable sources /technology	Geothermal
% of RES (energy level)	63.2% (of the total final energy)
investment costs euro or euro/m^2 (or as reported from the source)	62,000 (envelope) + 150,000 (HVAC systems, lighting and DHW)
financial incentive	operative program "Regional Development), National Research Found
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 40-60 kWh/m2/y for existing buildings
reference value or standards eventually established in the MS	national requirments defined by Ordinance fro heat retention and energy efficiency in buildings (updated in 2009)
Project/Source	Concerted Action EPB - Selected examples of Nearly Zero-Energy Buildings - Detailed Report, 2014

Name of the Building	Sems Have, Roskilde
Country	Denmark
Location	Roskilde
Category	apartments block
Year of construction	n/a
Year of refurbishment	n/a
Area (type)	3,388 m² (gross floor area after renovation)
consumption after renovation (energy measures and type are reported as defined from the source)	16.17 kWh/m²yr (primary energy use)
percentage saving	70%
type of envelope	pre-fabricated, light weight, with up to 480 mm insulation
roof U value [W/m²K]	0.09
external walls U value [W/m²K]	0.2
basement U value [W/m²K]	1.1
windows type or U value [W/m²K]	1
heating technology	district heating
ventilation technology	Balanced mechanical ventilation system with a Specific Fan Power (SFP) factor of 2 J/m³ + heat recovery efficiency 84%.
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	PV
% of RES (energy level)	16% (of the total final energy)
investment costs euro or euro/m^2 (or as reported from the source)	n/a
financial incentive	The renovation was in the traditional way via loans and funding from the building association
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes: 20 kWh/m2/y
reference value or standards eventually established in the MS	Danish Building class 2020 (NZEB)
Project/Source	Concerted Action EPB - Selected examples of Nearly Zero-Energy Buildings - Detailed Report, 2014

Name of the Building	Hauptschule Schrobenhausen (DENA Efficient)
Country	Germany
Location	Schrobenhausen
Category	educational buildings
Year of construction	1975
Year of refurbishment	2012
Area (type)	7,080 m² (net floor area)
consumption after renovation (energy measures and type are reported as defined from the source)	104.5 kWh/m²yr (primary energy use)
percentage saving	44%
type of envelope	concrete structure with internal brickwork was insulated with 24 cm expanded polystyrene.
roof U value [W/m²K]	0.11
external walls U value [W/m²K]	0.17
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	triple glazing (air-tight fitting).
heating technology	district heating system, based on renewable energy.
ventilation technology	heat recovery
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	PV
% of RES (energy level)	43% (heating energy based on the district heating. RES of the PV system unknown
investment costs euro or euro/m^2 (or as reported from the source)	11.1 million € (all costs incl. VAT)
financial incentive	Efficient house pilot projects2009. Co-financed by the KfW Group and Federeal Ministry of Environment, Nature Conservation, Building and Nuclear Safety (BMVBS)
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 55 % PE for existing buildings
reference value or standards eventually established in the MS	DENA's efficient house pilot project (2009) intended to undershoot the national energy saving ordinance EnEV by at least 15% (primary energy use)
Project/Source	Concerted Action EPB - Selected examples of Nearly Zero-Energy Buildings - Detailed Report, 2014

Name of the Building	Urban semi-detached house
Country	Irland
Location	n/a
Category	single-family house
Year of construction	1950
Year of refurbishment	n/a
Area (type)	160 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	47.1 kWh/m²yr (primary energy use)
percentage saving	90% to achieve an A2 energy rating 56% Compared to the overall primary energy calculation using the maximum permissible U-values
type of envelope	150 mm Platinum EPS insulation and mineral render finish externally
roof U value [W/m²K]	0.13
external walls U value [W/m²K]	0.145 – 0.19
basement U value [W/m²K]	0.11 – 0.14
windows type or U value [W/m²K]	New tripled-glazed windows and doors - 0.9
heating technology	condensing boiler + floor heating
ventilation technology	heat recovery
cooling technology	n/a
lighting system	n/a
control system	Five-zone temperature control and timer
renewable sources /technology	Solar thermal plant
% of RES (energy level)	30% (n/a)
investment costs euro or euro/m² (or as reported from the source)	170,000 € (1,063 €/m²)
financial incentive	client funds with support from Sustainable Energy Authority of Ireland (SEAI)
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes: 45 kWh/m2/y for new buildings
reference value or standards eventually established in the MS	A2 energy rating
Project/Source	Concerted Action EPB - Selected examples of Nearly Zero-Energy Buildings - Detailed Report, 2014

Name of the Building	Mosta House of Character
Country	Malta
Location	Mosta
Category	single-family house
Year of construction	n/a
Year of refurbishment	n/a
Area (type)	209 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	39.47 kWh/m²yr (primary energy use)
percentage saving	50%
type of envelope	The walls are made of stone masonry with a total thickness of 0.5 m (2 limestone walls of 0.22 m and o.o5 air cavity in between
roof U value [W/m²K]	0.25
external walls U value [W/m²K]	1.57
basement U value [W/m²K]	1.9
windows type or U value [W/m²K]	double glazed with an argon-filled gap
heating technology	inverter split-type air-conditioning system
ventilation technology	n/a
cooling technology	inverter split-type air-conditioning system / high thermal mass
lighting system	n/a
control system	n/a
renewable sources /technology	Solar thermal plant
% of RES (energy level)	49% (n/a)
investment costs euro or euro/m^2 (or as reported from the source)	n/a
financial incentive	benefits from schemes available for double glazinf, roof insulation and solar water heaters.
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	national EPC rating system
Project/Source	Concerted Action EPB - Selected examples of Nearly Zero-Energy Buildings - Detailed Report, 2014

Name of the Building	Powerhouse Kjørbo
Country	Norway
Location	Kjorbo
Category	offices
Year of construction	1980
Year of refurbishment	n/a
Area (type)	5,200 m^2 (net floor area)
consumption after renovation (energy measures and type are reported as defined from the source)	28.3 kWh/m²yr (primary energy used)
percentage saving	100% of the total final energy. Surplus of 18.4 kWh/m2yr, with operational energy and embodied energy in materials taken into account
type of envelope	highly insulated timber frame walls and charred wood cladding added to maintain the aesthetics of the old black glass façade
roof U value [W/m²K]	0.08
external walls U value [W/m²K]	0.13
basement U value [W/m²K]	0.14
windows type or U value [W/m²K]	triple glass - 0.80
heating technology	Geothermal heat pumps
ventilation technology	heat recovery
cooling technology	Geothermal heat pumps; Exterior sunscreen automated system
lighting system	demand controlled lighting
control system	n/a
renewable sources /technology	PV; geothermal system
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	14.9 million NOK (1.81 million €) in funding from the national support program for upgrade of existing buildings (ENOVA).
financial incentive	national support programme for upgrade of existing buildings (ENOVA)
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	Fulfil all requirements in the Norwegian passive house standards for non redisential buildings. The project is aiming for a BREEAM-NOR classification
Project/Source	Concerted Action EPB - Selected examples of Nearly Zero-Energy Buildings - Detailed Report, 2014

Name of the Building	Innova
Country	Finland
Location	Riihimäki
Category	apartments block
Year of construction	1975
Year of refurbishment	2011
Area (type)	3771 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	Total: 157.5 kWh/m^2 (n/a) Heating: 92.8 kWh/m^2 (n/a)
percentage saving	30% after one year of measurement
type of envelope	A new façade was retrofitted using prefabricated timber based elements
roof U value [W/m²K]	0.08
external walls U value [W/m²K]	0.08
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	0.66
heating technology	n/a
ventilation technology	heat recovery
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	n/a
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	4.3 M€ (1,510 €/m2)
financial incentive	Own funding with a 4.2 % grant from The Housing Finance and Development Centre of Finland
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	n/a
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Sleephelling
Country	The Netherlands
Location	Rotterdam
Category	apartments block
Year of construction	1903
Year of refurbishment	2009
Area (type)	n/a
consumption after renovation (energy measures and type are reported as defined from the source)	Space heating and cooling: 25 kWh/m^2/year Total: 130 kWh/m^2/yr (primary energy use)
percentage saving	n/a
type of envelope	Inside insulation 300 mm Rockwool; backside insulation 350mm polystyreen + plaster covering
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	double glass, low U and triple glass
heating technology	Individual high efficiency gas boilers
ventilation technology	heat recovery
cooling technology	Sun shades to prevent summer overheating
lighting system	n/a
control system	n/a
renewable sources /technology	Solar hot water boilers
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	n/a
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 60 kWh/m2/y for existing buildings
reference value or standards eventually established in the MS	label A++ (passive house level).
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	District of Mogel
Country	Spain
Location	Eibar
Category	apartments block
Year of construction	1949
Year of refurbishment	2013
Area (type)	9,450 m^2 (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	65.2 kWh/m²/yr (n/a)
percentage saving	n/a
type of envelope	improved insulation
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	Double glazing windows with thermal break frames
heating technology	Solat thermal system provide pre-heated water to heating system
ventilation technology	n/a
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	Solat thermal plant
% of RES (energy level)	30% (n/a)
investment costs euro or euro/m^2 (or as reported from the source)	5.2 M€ - Financing cost: 33,900 €-36,230 €/dwelling. Grant (53-57 %): 14,213 €/dewlling- Basque Government; 850 €/dewlling- council; 4,400 €/dewlling- Zeen project.
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	n/a
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Brogården
Country	Sweden
Location	Alingsås
Category	apartments block
Year of construction	1971-73
Year of refurbishment	2008-2014
Area (type)	19,500 m² (heated area)
consumption after renovation (energy measures and type are reported as defined from the source)	48 kWh/m²/yr (n/a)
percentage saving	60%
type of envelope	Additional insulation 430-480 mm.
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	0.85 W/m2K
heating technology	Building heated by ventilation air (passive house concept)
ventilation technology	Installation of central ESX-ventilation system
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	Solat thermal plant
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	36.5 M€ - Loan and minor contribution from EU (0.68 M€) and about 0.4 M€ from county administrative board.
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 30-105 kWh/m2/y for existing buildings
reference value or standards eventually established in the MS	n/a
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Eberlgasse 3
Country	Austria
Location	Wien
Category	apartments block
Year of construction	1850
Year of refurbishment	2014
Area (type)	828 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	11.11 kWh /m^{2}yr (n/a)
percentage saving	73%
type of envelope	Brick or stone walls, were repaired and insulated.
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	Passive house windows were installed
heating technology	groundwater heat pump
ventilation technology	Controlled ventilation: a central ventilation unit with heat recovery (recovery rate of 82%).
cooling technology	groundwater heat pump
lighting system	from PV
control system	n/a
renewable sources /technology	Pv; georthermal
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	1.6M€ Financing: city of Vienna's grant, 143,000 €; state loan, 292,000 €; ownwer own funding
financial incentive	see W
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 250 kWh/m2/y for existing buildings
reference value or standards eventually established in the MS	category A
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Cotentin Falguière residence
Country	France
Location	Paris
Category	apartments block
Year of construction	1950
Year of refurbishment	2009-2013
Area (type)	n/a
consumption after renovation (energy measures and type are reported as defined from the source)	Heating: 13 kWh/m²/year (gas) Hot water: 28 kWh/m²/year (gas), Ventilation fans (electricity): 2.6 kWh/m²/year Auxiliaries (electricity): 0.5 kWh/m²/year Lighting (electricity): 6 kWh/m²/year
percentage saving	75%
type of envelope	Addition of 20 cm ETICS EPS polystyrene thermal insulation 0.032 W/(m K).
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	New PVC double glazing, U=1.5 W/(m²K).
heating technology	new condensing boilers for heating and warm water.
ventilation technology	new controlled mechanical ventilation.
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	n/a
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	4 M€ (695 €/m2)
financial incentive	Financing: ICF Habitat performed the renovation with its subsidiary for intermediate housing, ICF Habitat Novedis.
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes: 40-65 kWh/m2/y for new buildings
reference value or standards eventually established in the MS	n/a
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	ReBuilt, Oulu
Country	Finland
Location	Oulu
Category	apartments block
Year of construction	1985
Year of refurbishment	2012
Area (type)	575 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	Total: 83 kWh/m^2/yr (n/a) Heating: 40 kWh/m^2/yr (n/a)
percentage saving	46%
type of envelope	The original outer sandwich façade layer was removed, leaving only the inner layer.A new façade based on timber elements was placed (TES Energy Façade).
roof U value [W/m²K]	0.08
external walls U value [W/m²K]	0.11
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	0.8
heating technology	New district heat circuit and domestic water pipes. New thermostatic control radiators.
ventilation technology	n/a
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	Heat recuperation from waste water.
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	1.4 M (2.483 €/m^2)
financial incentive	Financing: Owner own funding and supported by EU FP7 funding
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	No
reference value or standards eventually established in the MS	From energy class C to A.
Project/Source	NeZeR - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Group School Salamanque
Country	France
Location	mediterranean Csa (HDD 994; CDD 403)
Category	educational buildings
Year of construction	1965
Year of refurbishment	2010
Area (type)	2,303 m² (heated floor area)
consumption after renovation (energy measures and type are reported as defined from the source)	99 kWh/m^2/yr (n/a)
percentage saving	n/a
type of envelope	n/a
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	low double glazing
heating technology	2 natural gas boilers
ventilation technology	mechanical ventilation
cooling technology	n/a
lighting system	T5 efficient bulbs
control system	n/a
renewable sources /technology	PV
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	n/a
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes: 40-65 kWh/m2/y for new buildings
reference value or standards eventually established in the MS	n/a
Project/Source	ZEMeds - Co-funded by the intelligent Energy Europe Programme of the EU

Name of the Building	Ludwigshafen „3 Litre House in Stock“
Country	Germany
Location	Ludwigshafen
Category	apartments block
Year of construction	1930
Year of refurbishment	2006
Area (type)	700 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	2.6 litres/m^2 (n/a)
percentage saving	80%
type of envelope	small black beads of polystyrene (EPS) containing particles of graphite and containing blowing agent, which makes it expandable.
roof U value [W/m²K]	n/a
external walls U value [W/m²K]	n/a
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	triple glass 0.8 U value
heating technology	combined heat and power unit consisting of a fuel cell and an auxiliary burner
ventilation technology	heat recovery
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	n/a
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes, 55 % PE for existing buildings
reference value or standards eventually established in the MS	n/a
Project/Source	http://www.werkstatt-stadt.de/en/projects/94/short/

Name of the Building	semi detached house (EnerPHit Retrofit)
Country	Ireland
Location	Dublin
Category	single-family house
Year of construction	1960
Year of refurbishment	2012
Area (type)	146 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	Heating (PHPP): 17 kWh/m²yr Total: 102 kWh/m²/yr (primary energy use)
percentage saving	n/a
type of envelope	insulation: 150mm EPS 0,031 W/(mK) and 38mm PIR 0.025 W/(mK) to inner leaf with skim finish
roof U value [W/m²K]	0.11
external walls U value [W/m²K]	0.13
basement U value [W/m²K]	0.11
windows type or U value [W/m²K]	U_g value: 0.61
heating technology	Post heater battery on MVHR with back up gas-fuelled convector heaters and towel radiators within the building
ventilation technology	Air flow rate of 180 m^3/hr, specific HER 92%
cooling technology	n/a
lighting system	n/a
control system	yes
renewable sources /technology	500 litre, non-electric, gravity-fed rainwater harvesting tank supplying filtered water to all toilets, water conserving taps and toilet
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	n/a
financial incentive	n/a
discounted payback time period [yr]	n/a
NZEB energy performance in the country YES/NO	Yes: 45 kWh/m2/y
reference value or standards eventually established in the MS	certified Passive House
Project/Source	Passive House Database EnerPHit

Name of the Building	Jean-Paul-Platz Nüremberg
Country	Germany
Location	Nüremberg
Category	apartments block
Year of construction	1930
Year of refurbishment	2002
Area (type)	897 m² (n/a)
consumption after renovation (energy measures and type are reported as defined from the source)	49.3 kWh/m²/yr (n/a)
percentage saving	84%
type of envelope	slabs of graphite modified polystyrene
roof U value [W/m²K]	0.12
external walls U value [W/m²K]	0.15
basement U value [W/m²K]	n/a
windows type or U value [W/m²K]	3-pane thermal protection glazing
heating technology	boiler low temperature
ventilation technology	heat recovery
cooling technology	n/a
lighting system	n/a
control system	n/a
renewable sources /technology	Solar thermal plant
% of RES (energy level)	n/a
investment costs euro or euro/m^2 (or as reported from the source)	503 €/m2
financial incentive	n/a
discounted payback time period [yr]	2 years
NZEB energy performance in the country YES/NO	Yes, 55 % PE for existing buildings
reference value or standards eventually established in the MS	compared with the existing datas from the SOLANOVA - Project
Project/Source	TREES - Training for Renovated Energy Efficient Social Housing (Intelligent Energy Europe Programme)

5. References

[1] Eurostat, Final energy consumption by sector, available at: http://ec.europa.eu/eurostat/web/energy/data/main-tables.

[2] GBPN, Global Buildings Performance Network, (2014), Reducing energy demand in buildings: learning from best practices renovation policies, Available at: http://www.gbpn.org/sites/default/files/08.%20Renovation%20Tool%20Report.pdf

[3] EU, Directive 2002/91/EC. European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings, Official Journal of the European Communities (2003): 65-71.

[4] EU, Directive 2010/31/EU. European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings (recast), Official Journal of the European Union (2010): 13-35.

[5] EU, Directive 2012/27/EU. European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

[6] EU, Directive 2009/28/EU. European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

[7] EC, Guidelines accompanying Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements, Official Journal of the European Commission 19/04/2012, available: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52012XC0419(02).

[8] Ecofys, Cost-Effective Climate Protection in the EU Building Stock, Report for EURIMA (2005).

[9] CA EPBD, Concerted Action EPBD: report from Malmo meeting 10th-11th October 2013. Implementing the Energy Performance of Buildings Directive (EPBD). Website with information on the joint initiative of the EU Member States and the European Commission, available at: http://www.epbd-ca.eu/countries/country-information.

[10] BPIE, Buildings Performance Institute Europe. Principles for nearly zero-energy buildings (2011), available: http://bpie.eu/pub_principles_for_n_zeb.html.

[11] Ecofys, Principles for nearly Zero-Energy Buildings, 2012, available at: http://www.ecofys.com/en/publication/principles-for-nearly-zero-energy-buildings/

[12] Ecofys, Towards nearly Zero-Energy Buildings under the EPBD, 2013, available at: http://www.ecofys.com/en/project/towards-nearly-zero-energy-buildings-under-the-epbd/

[13] Ecofys, Improved information on nearly Zero-Energy Buildings in EU Member States, 2015, Available at: http://www.ecofys.com/en/news/improved-information-on-nearly-zero-energy-buildings-in-eu-member-states/

[14] Commission Delegated Regulation No. 244/2012 of 16 January2012. Supplementing Directive 2010/31/EU of the European Parliament and ofthe Council on the Energy Performance of Buildings by Establishing a Comparative Methodology Framework for Calculating Cost-Optimal Levels of MinimumEnergy Performance Requirements for Buildings and Building Elements.2012

[15] Guidelines Accompanying Commission Delegated Regulation (EU) No.244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the Euro-pean Parliament and of the Council, Off. J. Eur. Union; 19 April 2012.

[16] CA EPBD, Concerted Action EPBD: Implementing the Energy Performance of Buildings Directive (EPBD). Information of the joint initiative of EU Member States and the European Commission. Available from: http://www.epbd-ca.eu/themes/cost-optimum

[17] A. Panek., Impact, compliance and control of legislation, In: Papaglastra, M., Wouters, P., Stimulating increased energy efficiency and better building ventilation, INIVE-EEIG, (2010): 1-573, ISBN 2-930471-31-X, available: www.inive.org.

[18] M. Spiekman, N. Heijmans, P. Wouters, S. Caillou, Stimulating innovation with EPBD, what Countries can learn from each other, ASIEPI project (2010), available: http://www.asiepi.eu/asiepi-reports.html.

[19] Entranze, Cross-analysis on Member-States' plans to develop their building regulations towards the NZEB standard (2013), available: http://www.entranze.eu/files/downloads/D5_1_3/ENTRANZE_Integration_of_report_D5.1_D5.2_D5.3_final.pdf, 1-256.

[20] IEE, Intelligence Energy Europe, Project database available at https://ec.europa.eu/energy/intelligent/projects/

[21] Z. Szalay, A. Zöld, Definition of nearly zero-energy building requirements based on a large building sample, Energy policy 2014, http://dx.doi.org/10.1016/j.enpol.2014.07.001i.

[22] M.J. Oliveira Panão, M.P. Rebelo, S.M.L. Camelo, How low should be the energy required by a nearly Zero-Energy Building? The load/generation energy balance of Mediterranean housing, Energy and Buildings 61 (2013): 161–171.

[23] P.C.P. Silva, M. Almeida, L. Braganc, V. Mesquita, Development of prefabricated retrofit module towards Nearly Zero-Energy Buildings, Energy and Buildings 56 (2013): 115–125.

[24] U. Desideri, L. Arcioni, D. Leonardi, L. Cesaretti, P. Perugini, E. Agabitini, N. Evangelisti, Design of a multipurpose "zero energy consumption" building according to European Directive 2010/31/EU: Architectural and technical plants solutions, Energy (58) (2013): 157-167.

[25] M. Ferrara, E. Fabrizio, J. Virgone, , M. Filippi, A simulation based optimization method for cost-optimal analysis, Energy and Buildings (2014), http://dx.doi.org/10.1016/j.enbuild.2014.08.031.

[26] A. Ferrante, M.T. Cascella, Zero energy balance and zero on-site CO2 emission housing development in the Mediterranean climate, Energy and Buildings (43) (2011): 2002–2010.

[27] S. Schimschar, K. Blok, T. Boermans, , A. Hermelink, Germany's path towards nearly zero-energy buildings—Enabling the greenhouse gas mitigation potential in the building stock, Energy Policy 39 (2011): 3346–3360.

[28] EC, European Commission report on progress by Member States towards Nearly Zero-Energy Buildings (2013), available: http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm.

[29] H. Erhorn, The Path towards 2020: Nearly Zero-Energy Buildings (2012), REHVA Journal.

[30] EC, European Commission, National plans for nearly zero-energy buildings (2013), available: http://ec.europa.eu/energy/efficiency/buildings/implementation_en.htm.

[31] Ecofys, Politecnico di Milano / eERG, University of Wuppertal, Towards nearly zero-energy buildings, Definition of common principles under the EPBD, final report 2013, available: http://ec.europa.eu/energy/sites/ener/files/documents/nzeb_full_report.pdf.

[32] EC, Consolidated information from the Member States on Nearly Zero-Energy Buildings, Information from individual countries (2014), available: http://ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings.

[33] EC, Overview of Member States information on NZEBs - Background paper – final report, 2014, available at:

https://ec.europa.eu/energy/sites/ener/files/documents/Background%20paper%20NZEB.pdf

[34] EC, Progress by Member States towards Nearly Zero-Energy Buildings COM/2013/0483 final, 2013, available at: http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=RwlQTpNpmthG6W4Y21G7GpmpbCd7cHTvxyZ9GpBRDlbJDKp1zJCT!-1435825667?uri=CELEX:52013DC0483R(01)

[35] EC, Overview of Member States information on NZEBs, Working version of the progress report - final report, October 2014, Available at: https://ec.europa.eu/energy/sites/ener/files/documents/Updated%20progress%20report%20NZEB.pdf

[36] EPBD CA, Key Implementation Decisions (KIDs) to quantify the status of EPBD implementation in EU countries, http://www.epbd-ca.eu/countries/indicators

[37] BPIE, Building Policies and Programs in the EU-27: EU Overview and Nine Factsheets on ENTRANZE Countries, Buildings Performance Institute Europe, 2013.

[38] Energistyrelsen, BR10 (Danish Building Regulation, only in Danish) including the energy frame for 2020, available: http://www.ebst.dk/bygningsreglementet.dk/br10_02_id5180/0/42.

[39] Moniteur Belge, Moniteur Belge n.264, Sept 14, 2011, available: http://www.ejustice.just.fgov.be/cgi/article.pl?caller=list&numac=2011031430&pub_date=2011-09-14&language=fr&view_ann=1&urlimage=/mopdf/2011/09/14_1.pdf#Page1.

[40] BBSR, Investigations concerning the amendment of the European Directive 2010/31/EU on the energy performance of buildings (EPBD recast), 2012. Federal Institute for Research on Building, Urban Affairs and Spatial Development, BMVBS-Online-Publikation, Nr. 16/2012, available: http://www.bbsr.bund.de/cln_032/nn_340720/BBSR/EN/Publications/BMVBS/Online/2012/ON162012.html.

[41] Fraunhofer IRB, Fraunhofer-Informationszentrum Raum und Bau; Fraunhofer Information Center for Planning and Building, available: http://www.irb.fraunhofer.de/bauforschung/projekte.jsp?local=en&p=20128035721.

[42] BPIE, Buildings Performance Institute Europe, Implementing nearly Zero-Energy Buildings, Towards a national definition and roadmaps, 2011.

[43] GBPN, REDUCING ENERGY DEMAND IN EXISTING BUILDINGS: LEARNING FROM BEST PRACTICE RENOVATION POLICIES, July 2014, available at: http://www.gbpn.org/sites/default/files/08.%20Renovation%20Tool%20Report.pdf

[44] ZenN, available at: http://www.zenn-fp7.eu/download/18.15a855cb14c38029e6415c6/1431008683363/A+common+definition+for+NZEB+renovation_D1.2.pdf

[45] Cohereno, availbale at: http://www.cohereno.eu/fileadmin/media/Dateien/Cohereno_Report_NZEB_Criteria.pdf

[46] RePublicZEB, availbale at: http://www.republiczeb.org/index.jsp

[47] neZEH – Nearly Zero Energy Hotel

[48] EPISCOPE

[49] IEA, SHC Task 40 / Annex 52, towards net zero energy solar buildings, IEA SCH task 40 and ECBCS Annex 52, Available: http://task40.iea-shc.org/.

[50] S. Deng, R.Z. Wang, Y.J. Dai, How to evaluate performance of net zero energy building - A literature research, Energy, 71 (2014): 1-16.

[51] J. Kurnitski, A. Saari, T. Kalamees, M. Vuolle, J. Niemelä, T. Tark, Cost optimal and nearly zero (NZEB) energy performance calculations for residential buildings with REHVA definition for NZEB national implementation, Energy and Buildings, 43 (2011): 3279–3288.

[52] D. D'Agostino, Assessment of the progress towards the establishment of definitions of nearly zero energy buildings (nZEBs) in European Member States, Journal of Building Engineering (2015), http://dx.doi.org/10.1016/j.jobe.2015.01.002[

[53] M.J. Oliveira Panão, M.P. Rebelo, S.M.L. Camelo, How low should be the energy required by a nearly Zero-Energy Building? The load/generation energy balance of Mediterranean housing, Energy and Buildings 61 (2013): 161–171.

[54] C. Baglivo, P.M. Congedo, D. D'Agostino, I. Zacà, Cost-optimal analysis and technical comparison between standard and high efficient mono-residential buildings in a warm climate, Energy (2015), http://dx.doi.org/10.1016/j.energy.2015.02.062

[55] I. Sartori, A. Napolitano, K. Voss, Net zero energy buildings: a consistent definition framework, Energy and Buildings, 48 (2012): 220-232.

[56] H. Lund, A. Marszal, P. Heiselbergb, Zero energy buildings and mismatch compensation factors, Energy and Buildings, 43 (7) (2011): 1646–1654, 10.1016/j.enbuild.2011.03.006.

[57] REHVA, Federation of European Heating, Ventilation and Air Conditioning Associations, Task Force on Technical definition for Nearly Zero-Energy Buildings. Technical definition and system boundaries for Nearly Zero-Energy Buildings, 2013 revision for uniformed national implementation of EPBD recast prepared in cooperation with European standardization organization CEN.

Report n.4 (2013). Available: http://www.rehva.eu/publications-and-resources/hvac-journal/2011/032011/how-to-define-nearly-net-zero-energy-buildings-NZEB/.

[58] EN 15603: Energy performance of buildings – overall energy use and definition of energy rating, 2008.

[59] U. Desideri, L. Arcioni, D. Leonardi, L. Cesaretti, P. Perugini, E. Agabitini, N. Evangelisti, Design of a multipurpose "zero energy consumption" building according to European Directive 2010/31/EU: Architectural and technical plants solutions, Energy (58) (2013): 157-167.

[60] P. Torcellini, S. Pless, M. Deru, D. Crawley, Zero Energy Buildings: A Critical Look at the Definition, National Renewable Energy Laboratory and Department of Energy, US (2006).

[61] A.J. Marszal, P. Heiselberg, J.S. Bourrelle, E. Musall, K. Voss, I. Sartori, A. Napolitano, Zero energy building – a review of definitions and calculation methodologies, Energy and Buildings 4(3) (2011): 971–979.

[62] Buildings Performance Institute Europe (BPIE), Europe's buildings under the microscope - A Country-by-Country review of the energy performance of buildings, October 2011.

[63] Fraunhofer Institute for Systems and Innovation Research ISI, "Study on Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries: Final Report for the European Commission Directorate-General Energy and Transport", 2009.

[64] European Parliament, On the proposal for a directive of the European Parliament and of the Council on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC, 30th of July 2012.

[65] Global Buildings Performance Network (GBPN), WHAT IS A DEEP RENOVATION DEFINITION?, Technical Report, February 2013.

[66] Shnapp et Al., How can we renovate deeply if we don't know what that is?, ECEEE Summer School 2013.

[67] COHERENO, Mapping of frontrunners in NZEB renovation of single-family houses - Executive Summary, 2013.

[68] ZenN, Final report on common definition for NZEB renovation - D.1.2 Report, November 2014.

[69] ENTRANZE, Report on Cost/Energy curves calculation - D3.3. of WP3 of the Entranze Project, September 2013.

[70] Hermelink et Al., Towards nearly zero-energy buildings. Definition of common principles under the EPBD. Final Report, 2013.

[71] COWI, Mapping of strategies for low energy housing in the EU Countries 2011, available: ⟨http://www.byggmaterialindustrierna.se/wp-content/uploads/2011/02/energikrav_i_eu_lande.pdf)

[72] M. Panagiotidou, R. J. Fuller, Progress in ZEBs - A review of definitions, policies and construction activity, Energy Policy 62 (2013): 196-206, http://dx.doi.org/10.1016/j.enpol.2013.06.099i.

[73] ZEMedS – Co-founded by the Intelligent Energy Europe Programme of the European Union

[74] azero EdicomEdizioni – rivista trimestrale

[75] Loga T. Diefenbach N. editors. Use of building Typologies for energy performance assessment and common approach. First TABULA synthesis report. 2010.

[76] Dascalaki E.G. et ali. Building typology as a tool for assessing the energy performance – a case study for the Hellenic building stock. Energy Build. 43.2011

[77] Speikman M. editor. Comparison of energy performance requirements levels: possibilities and impossibilities. Summary report. Report of ASIEPI, 210

[78] Atanasiu B. Boermans T. et alii Priciples of Nearly Zero-Energy Buildings. Paving the way for effective implementation of policy requirements. Bruxelles: Building Performance Institute Europe (BPIE) 2010.

[79] Economidou M. Atanasiu B. Desprect C.et al. Europe's building under microscope. A country reviw of the energy performance of buildings Bruxelles: Building Performance Institute Europe (BPIE) 2011.

[80] Dolmans D. Change is going to come . A new mandate : Nearly Zero-Energy Buildings. Eur HVAC Rehva 2011.

[81] Technology Roadmap – Energy efficient buildings envelopes – OECD/IEA, 2013

[82] What is a deep renovation definition? GBPN "Global Buildings Performance Network" Technical report – February 2013

[83] EnerPHit and EnerPhit +I - Certification Criteria for Energy Retrofits with Passive House Components – technical report 2013 – Passive House Institute

[84] http://www.epbd-ca.eu/themes/nearly-zero-energy

[85] http://www.renovate-europe.eu

[86] http://passiv.de/en/

[87] http://www.worldarchitecture.org/architecture/

[88] http://www.agenziacasaclima.it/it/casaclima/1-0.html

List of figures

List of tables

LD-NA-27804-EN-N

JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

Serving society
Stimulating innovation
Supporting legislation

Publications Office

doi: 10.2790/659611

ISBN 978-92-79-57343-9