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ZEBRA 2020 - NEARLY ZERO-ENERGY BUILDING STRATEGY 2020

Deliverable D2.1: Definition of nearly zero-energy buildings as used for market tracking

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	EEG	Energy Economics Group Institute of Power Systems and Energy Economics Vienna University of Technology
	CIMME	International Centre for Numerical Methods in Engineering, Building Energy and Environment
	Ecofys	Ecofys Germany GmbH
	EURAC	EURAC research Institute for Renewable Energy
	NAPE	National Energy Conservation Agency
	SINTEF	The foundation SINTEF
	BPIE	Buildings Performance Institute Europe
	Enerdata	Enerdata SAS

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Table of Contents

About ZEBRA 2020

Nearly Zero-Energy Building Strategy 2020

Sustainability of the European society and economy will be based on renewable energy and high resource efficiency. For the building sector, this implies the large scale deployment of low-energy buildings (so called nearly Zero-Energy Buildings or nZEBs). ZEBRA2020 aims at creating an observatory for nZEBs based on market studies and various data tools and thereby generates data and evidence for policy evaluation and optimisation. European legislation (Energy Performance of Buildings Directive) makes nZEBs a standard by 2020. Therefore, the key objective of ZEBRA2020 is to monitor the market uptake of nZEBs across Europe and provide data as well as recommendations on how to reach the nZEB standard.

ZEBRA2020 covers 17 European countries and about 89% of the European building stock and population. Thus, it is actively contributing to meeting the ambitious target of 100%- share of nZEBs for new buildings from 2020 and a substantial increase of deep nZEB renovations.

Learn more at www.zebra2020.eu

1. INTRODUCTION

European legislation (Energy Performance of Buildings Directive) makes nZEBs a standard by 2020. The technology is already available and proven; however, the large-scale uptake of nZEB construction and renovation will be a big challenge for all market actors and stakeholders involved. A substantial gap in reliable data on current market activities makes it difficult for policy-makers to evaluate the success of their policies and measures. Therefore, the key objective of ZEBRA2020 is to monitor the market uptake of nZEBs across Europe and provide data and input on how to reach the nZEB standard.

As building standards, climate, calculation methodologies and building traditions vary significantly between European Member States, it is a challenging task to find a common denominator for defining a nearly zero-energy building (nZEB) on a European scale. However, within the scope of this project it is necessary to define how to deal with the various numbers of national nZEB definitions that are already in place or that will still be defined by MS and that have not not officially published a definition yet. As the ZEBRA2020 project also aims to monitor the entire nearly zero energy market, the market uptake of nZEB in the renovation market is an important factor as well. Therefore this report aims to define a clear methodology for how nearly zero-energy buildings are defined in the context of market tracking in the cases of new constructions and (deep) renovations.

The report starts with an overview of existing nZEB definitions in EU Member States also identifying main issues around developing a common European definition or comparing different approaches (chapter 2). Chapter 3 describes the project specific approach for tracking the European nZEB market before summarising the outcomes and pointing out conclusions in chapter 4.

2. EXISTING NATIONAL NZEB DEFINITIONS AND THOUGHTS ABOUT A COMMON EUROPEAN DEFINITION

According to EPBD Article 9 Paragraph 3(a) the "national plans shall include (…) the Member State's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and including a numerical indicator of primary energy use expressed in kWh/m² per year. Primary energy factors used for the determination of the primary energy use may be based on national or regional yearly average values and may take into account relevant European standards." Specifically, the following EPBD requirements have to be addressed:

- The building needs to have a very high energy performance:
  - The amount of energy required should be nearly zero or very low
  - The energy required should be covered to a very significant extent by energy from renewable sources
- Inclusion of a numerical indicator of primary energy use expressed in kWh/m² per year
- Primary energy use may be based on national or regional yearly average values and may take into account relevant European standards

As concrete numeric thresholds or ranges are not defined in the EPBD, these requirements let a lot of space for own interpretation and thus allow MS to define their nZEB in a very flexible way taking into account their country specific climate conditions, primary energy factors, ambition levels, calculation methodologies and building traditions. This is also the main reason why existing nZEB definitions (see below) differ significantly from country to country.

For conducting the tasks it is however necessary to find a suitable approach for how to deal with the variety of definitions and approaches. The question arises if it is possible or even necessary that this approach is more specific than the nearly zero-energy building definition given by the EPBD. It has to be kept in mind that the major target of ZEBRA is to illustrate collected data about the way of MS and Europe towards nZEB. Some research projects already tried to specify the EPBD's global definition and to define suitable levels for nZEBs in Europe, as described below. Moreover, 8 countries (status 11 June 2014) already published their national official definition of nZEB. Table 1 shows how diverse the different requirements are.

Table 1: Official national nZEB definitions currently in place (September 2014)

	Primary energy demand [kWh/m²a]		Energy need [kWh/m²a]		Reference
	Single family houses	non-residential	Residential	Non-residential	
Belgium - BXL	45	90	Net heating need: 15	Net heating need: 15 Net cooling need: 15	Ordonnance portant le Code bruxellois de l'Air, du Climat et de la Maîtrise de l'Energie
Belgium - Flemish	60				Energiebesluit van 19 november 2010
Denmark	20	25			Bygningsreglementet 01.01.2014
Estonia			Small Residential: 50 Apartment: 100	Office: 100 Business: 130 Public 120 Commerce: 130 Education: 90 pre-school: 100 Healthcare: 270	RT I, 05.09.2012, 4: Energiatõhususe miinimumnõuded
Latvia	95		"final energy for heating use": 30	"final energy for heating use": 30	OP 2012/201.1 Ēku energoefektivitātes likums
Slovakia	32-54	34-60			Act No 300/2012 amending Act No 555/2005 on the energy performance of buildings, STN 73 0540-2: 2012 Thermal protection of buildings
Croatia	33-41	33-41			Croatian ational plan for increasing the number of nZEB
France	50	70-110			IRéglementation thermique 2012
Ireland	new dwellings: 45				Action Plan for the Implementation in Ireland of 2010/31/EU

It can be seen that the primary energy requirements vary between 20 and 95 kWh/m²a for residential buildings and 25 to 110 kWh/m²a for non-residential buildings. Even bigger bandwidths can be expected for the time when all MS will have their specific nZEB definition in place. In some of the countries, these requirements are furthermore combined with specific requirements on energy needs and minimum shares of renewable energy.

The table clearly highlights that performance standards on MS level differ from country to country and differences in the national framework conditions, methodology, benchmarks for primary energy, energy need and renewable share do not allow for a uniform practical and equitable European benchmark.

Apart from these official definitions mainly aiming at setting the direction for new buildings, other approaches have been suggested by various initiatives and groups to establish a consistent and comparable nZEB definition not only for new constructions but also for (deep) renovations.

In the field of nZEB renovation, Atanasiu et al. in the context of the COHERENO project proposed an approach to identify criteria for nZEB renovations in different countries in order to track market activities. COHERENO amongst others investigates implemented nZEB definitions of selected

Member States and other nZEB definition approaches by several guidance studies and initiatives. Based on this evaluation, characteristics of a "potential definition of nZEB renovation of a house" are described as follows:

1) *"The energy performance of the building after renovation fulfils the nZEB requirements for new buildings as they are defined at level of the EU MS and regions or/and*
2) *The primary energy consumption of the building after renovation is reduced by 75% as comparing to the pre-renovation status or/and*
3) *Potentially an additional primary energy minimum requirement of not more than 50-60kWh/m2/yr energy consumption (GBPN, 2013) for heating/cooling, domestic hot water, ventilation energy consumption of auxiliary building's systems and*
4) *Potentially an additional minimum requirement for renewable energy share (proposed to be at least 50% of the remaining energy demand of the building as it is suggested in (BPIE, 2011) taking into account the nZEB definition from EPBD and*
5) *Potentially an additional minimum CO2 requirement of no more than 3kg CO2/m2/yr as it is suggested in (BPIE, 2011) based on the needs to meet the long-term decarbonisation goals for residential and services sectors as resulted from the EU 2050 Roadmap for a low-carbon economy."*

A specific, technical approach had been made by the REHVA association. They proposed a detailed definition of nZEB for a consistent national implementation of EPBD recast (Kurnitski et al., 2013). REHVA believes that there is the need for such a specific definition because Member States may need more guidance in order to set comparable nZEB values with equal ambition levels.

Recommendations from the EC project "Towards nZEB under the EPBD - Definition of common principles under the EPBD" (Hermelink et al., 2013) also highlight that setting a suitable European definition for nZEB is a challenging task. The project revealed a wealth of (non-official) definitions and schemes related to nearly zero-energy buildings in Europe and beyond. Most definitions have in common the objective to achieve a more or less equalised annual energy balance between consumption and on-site generation, i.e. a net-energy-balance of or close to zero. Nevertheless, calculation procedures differ significantly and are not necessarily in line with CEN standards underpinning the EPBD[1]. Therefore, comparing the energy performance inherent to these schemes and standards turns out to be very difficult.

[1] Member States are not obliged to use CEN standards for determining the "numeric indicator of primary energy use" as required by Annex 1 of the EPBD and even the application of CEN standards leaves quite some flexibility, for example as to the time step used in calculations. For more information on EPBD related CEN standards, see http://www.rehva.eu/fileadmin/EU_regulations/Standards_and_standardization/EPBD_standards/List_of_cen_standards_to_support_the_epbd.pdf

Having done the analysis of many definitions for (nearly) zero-energy buildings, there is a good understanding about why there is such a big bandwidth, especially on primary energy, as shown in Table 1. Member States are not obliged to use CEN standards for determining such numeric indicator, even if they apply CEN standards, these leave quite some flexibility, for example as to the time step used in calculations or as to primary energy factors, which may be determined by political considerations rather than technical reality. Moreover some of these factors are not constant but variable. Primary energy factors usually change over time, and this will hold especially for electricity when the share and efficiency of renewable energies increase.

An additional explanation why primary energy factors differ so much between countries is as follows: The energy need is the starting point for any energy performance calculation. Primary energy is calculated via the additional steps of energy use and delivered energy. In each of these steps additional parameters are included which make the result of the calculation less transparent and increase the bandwidth of potential results for the same building. This means that cross-country comparisons are easiest on the level of energy needs, and least meaningful on the level of primary energy.

As a conclusion, primary energy is quite well suited to make comparisons of building energy efficiency standards within a country, but not meaningful for a cross-country comparison without a very clear, transparent and harmonised methodology which currently is not applied.

3. THE “NZEB RADAR” – VISUALISATION OF SHARE AND AMBITION OF BUILDINGS TOWARDS NZEB IN EUROPEAN MEMBER STATES

The reasoning presented in chapter 2 leads to the insight that qualitative and quantitative components need to be used for comparing building energy efficiency standards and that a different approach should be used for cross-country comparisons than for intra-country comparisons. While for intra-country comparisons it is analysed how a regulation and calculation methodology changed over time perhaps even on local level, for cross-country comparisons it is important to use a simple and transparent approach using clear indicators.

Our main approach for measuring and monitoring the ambition level of newly constructed and renovated buildings in different MS in Europe is the nearly zero-energy building radar which is an evolution of the one developed in the project “COHERENO” (Atanasiu et al., 2013). The nZEB radar allows combining a qualitative and quantitative analysis of building standards in a specific region. It therefore perfectly fits to the requirements of this task. A general illustration of the radar is presented in Figure 1.

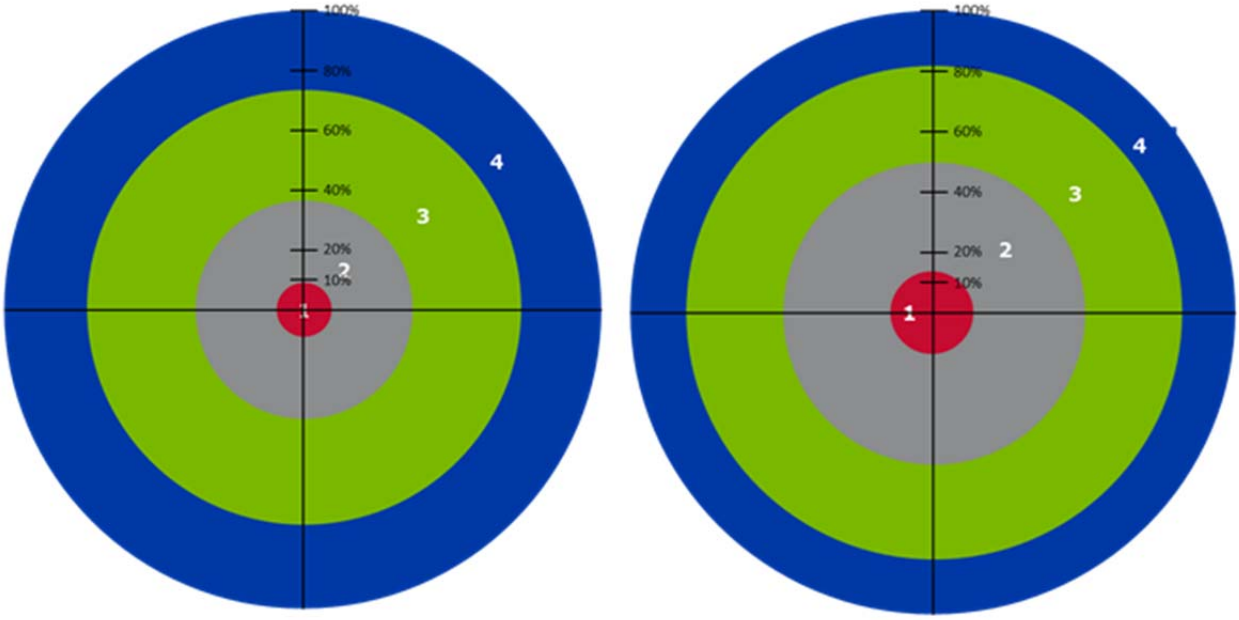

Figure 1: General illustration of the nZEB country radar. Left: Year 1; Right: Year 2 (source: own illustration)

The circles 1-4 represent different relevant energy performance standards of buildings. The inner circle (1) represents the most efficient building standard, the outer circle (4) the least efficient

standard. The share of the total circle **radius** represents the relative share of all annually newly constructed or renovated buildings respectively.

While being visually attractive showing the dynamics/evolution in time, i.e. how the inner circle becomes bigger there is a chance of misinterpretation. Even if outer and inner circles take the same share of the radius, outer circles may appear to indicate larger shares due to their larger areas compared to inner circles. Therefore, for individual country analyses, a simple stacked column chart will be used in addition as especially for visualizing progress throughout a number of years, this chart type provides an easy to understand overview (see example in Figure 2).

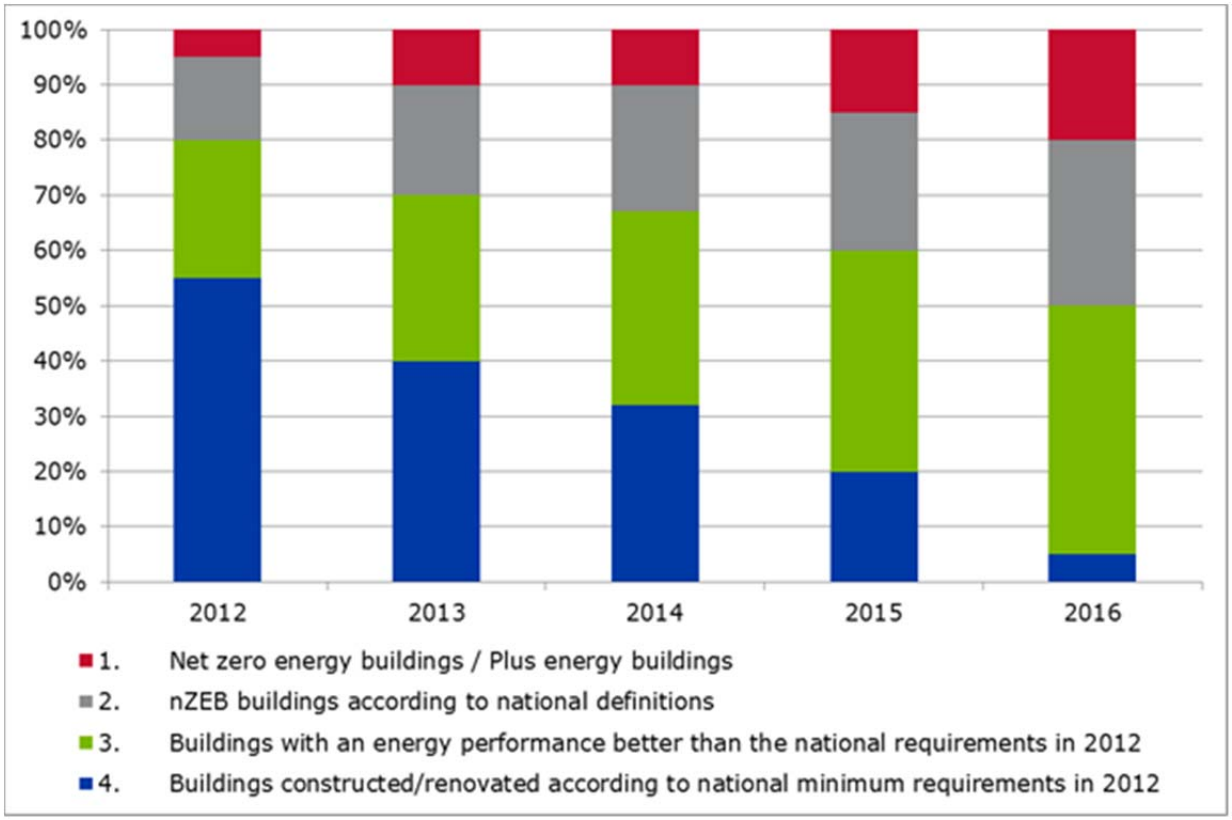

Figure 2: Example for a simple stacked column chart using to present the evalution of building category allocation in a specific country over a number of years

The nZEB radar clusters energy efficiency qualities in 4 different categories. After intense discussions with a number of experts, for the purpose of the project a relative differentiation between the following general building standards on national and European level seems to be most suitable (from most efficient to least efficient category):

1. Net zero energy buildings / Plus energy buildings
2. nZEB buildings according to national definitions
3. Buildings with an energy performance better than the national requirements in 2012
4. Buildings constructed/renovated according to national minimum requirements in 2012

This allows clustering national buildings relative to the national building code and the official national definition for nearly zero energy buildings. Example: If the total number of newly constructed buildings in a year is 100,000, 80,000 buildings constructed according to the national minimum building code requirements in 2012 would lead to a share of 80% of this category in the nZEB radar.. It was decided to use the minimum energy performance requirements in 2012 as the basis for the analysis. This way it is possible to monitor a continuous process towards nZEB in a country. In the case that a country is strengthening its performance requirements, this would lead to the fact that in the following year the building category “Buildings constructed/renovated according to national minimum requirements in 2012” would completely disappear from the radar while the share of the category “Buildings with an energy performance better than the national requirements in 2012” would increase accordingly.

By establishing these qualitative categories combined with absolute quantitative yearly values, we create the basis for subsequent qualitative cross-county comparisons. This is a simple and most equitable approach for tracking not only the nZEB but also the overall building market on MS and on European level.
Gathering these numbers, each year will additionally allow monitoring the process towards more efficient standards in a country/region and on the European level.

Starting points are country specific analyses regarding existing standards (official and “unofficial”) and the respective number of buildings that are constructed/renovated according to these standards. Unofficial standards comprise standards not directly defined in the national building code but by other parties for example the passive house standard or in Germany the promoted “efficient house” standards of the national KfW Development Bank. In this context, all necessary details of these standards will be described. In case that multiple standards in a country match the category “Buildings with an energy performance better than the national requirements in 2012”, ZEBRA’s country sheets will allow adding more information. Numbers and information will be collected for residential as well as for non-residential buildings. Eventually they both will appear in the radar together, i.e. no separate radars will be created for residential and non-residential buildings.

The base year for data collection is 2012. The update cycle is to be one year, as soon as new data is available.

The question arises how to determine the share of buildings in categories 1) or 2) when there is no "official" nzeb definition. In such cases, the national experts need to decide where a clear (but perhaps still not official) "direction" is known and can be taken as an nZEB proxy. As an example, Germany's national application of the nZEB definition will most probably end up with a concept being close to the KfW "Efficiency House 40" (Effizienzhaus 40). When there is no clear possibility to judge about a non-officially defined category, categories simply may be merged, e.g. categories 1), 2) and 3) as one category "Buildings with an energy performance better than the national requirements in 2012", when only the share of 4) is known and the rest must be better. In this way, countries having a definition will have an advantage in the visualization as they explicitly and immediately can be detected as having categories 1) or 2).
Therefore, no country will be disadvantaged and simultaneously those countries will be rewarded which already published a definition. For countries having an "unofficial" definition, a disclaimer will be added.

The visualisation of this approach for one country is shown in Figure 3 (afterwards also presented on the respective country page). A possible further development could be to additionally add bubbles in the different layers (circles) naming the specific national official or unofficial building categories falling into the respective layer.
The national approach as described above also enables to have a cross-country comparison as shown in the "nZEB Europe radar" (Figure 3). It presents the information for each MS in one illustration and thus makes country results comparable.

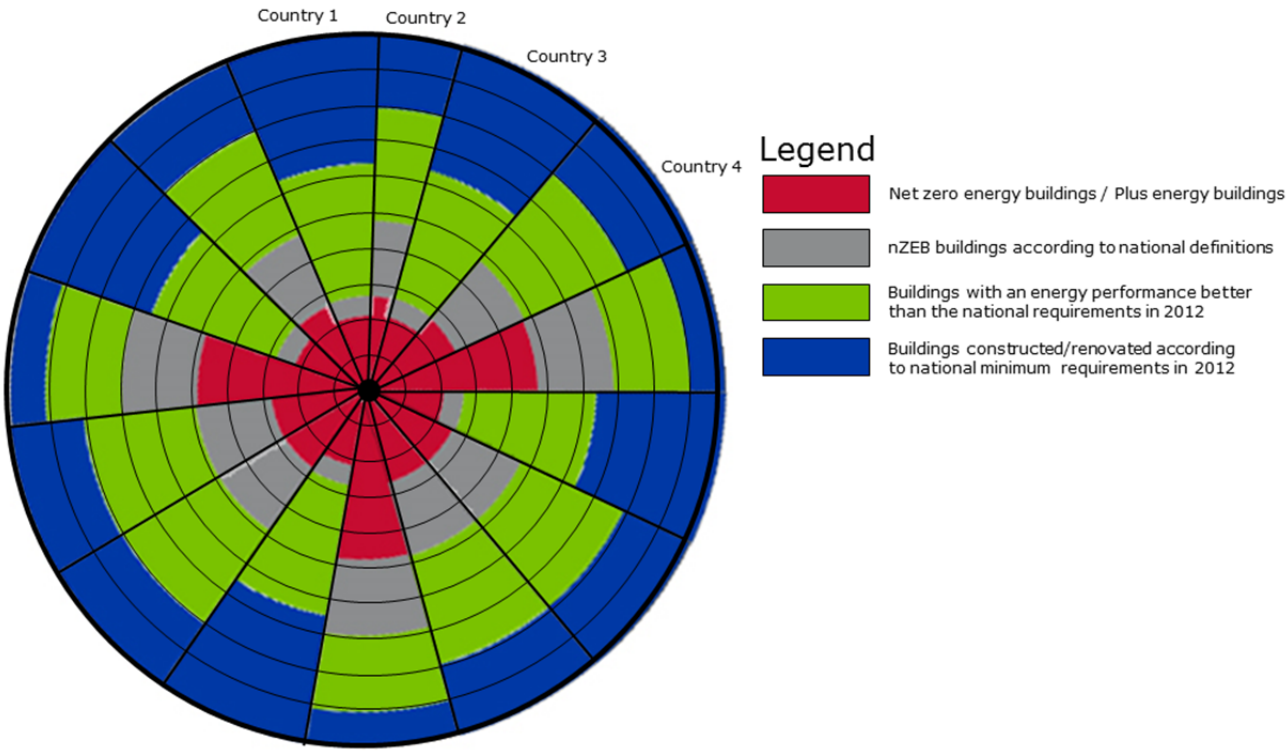

Figure 3: Illustration of the nZEB Europe radar.

Based on all individual national results, an EU radar will be presented. It adds the relative shares of each building category and country "total number of yearly constructed or renovated buildings"- and thus allows comparing of all included MS but also generation of a weighted EU average. The following table gives a fictional example.

Table 2: Example for calculating building category shares for a European nZEB radar (new constructions)

	Total number of constructed buildings in 2012	Net zero energy buildings / Plus energy buildings	nZEB buildings according to national definitions	Buildings with an energy performance better than the national requirements in 2012	Buildings constructed according to national minimum requirements in 2012
Country 1	100.000	0%	2%	18%	80%
Country 2	10.000	0%	0%	30%	70%
Country 3	30.000	1%	5%	21%	73%
Country 4	200.000	1%	3%	9%	87%
Country 5	70.000	0%	0%	7%	93%
EU (weighted)	410,000	1%	2%	12%	85%

Renovations

As mentioned above, it is also planned to collect statistics on major building renovations in the countries. Like for new constructions, also for renovations the same building categories are used. However, by experience it is uncertain whether data availability and quality will allow the same level of reliability for energy related major renovations like for new constructions. Therefore, in case of insufficient useful data, a decision could be made to not set up a separate nZEB renovation radar for a specific country in the course of the project. In those cases a possible revision might focus on achieved energy savings instead. Whether relative to the performance before renovation or relative to the national requirements for major renovations or relative to cost optimality still needs to be discussed after the quality and depth of available information will be known.

Interpretation of results

Further qualitative hints on how to interpret the different shares of nZEB in a country may be added in the country sheets as far as easily available in order to allow the reader to adequately judge the aspiration level. As mentioned above due to potentially very different assumptions and calculation procedures between countries a share of e.g. 30% nZEB buildings in country X may not be comparable at all to a 30% share in country Y. However, the radar is planned to give an easily understandable overview about the implementation status of the EPBD requirements on nZEB. It presents the annual share of buildings that are newly constructed and renovated according to a country specific performance level. Therefore, it allows a cross-country comparison of the nZEB definition implementation without taking into account any conclusions about the ambition level of the respective nZEB definition that is however in line with EPBD requirements.

4. SUMMARY

National nearly zero-energy building (nZEB) definitions differ significantly from country to country and therefore it is necessary to find a useful approach for how to define nZEB in the framework of the ZEBRA project. Considering the variety of country specific climate conditions, ambition levels, calculation methodologies and building traditions in EU Member States (MS), the question arises if it is possible and even necessary that this approach is more specific than the nearly zero-energy building definition given by the Energy Performance of Buildings Directive (EPBD). Besides different official definitions mainly aiming to set the direction for new buildings, other approaches by initiatives and groups have been made trying to establish a consistent and comparable nZEB definition not only for new constructions but also for renovations. However, approaches differ significantly and it is up to each MS to develop more precise definitions than already defined in the EPBD recast. Therefore the project consortium agreed to respect the variety of existing approaches and definitions that are present in MS and for the monitoring of the nZEB market use existent national nZEB definitions.

Our main approach for measuring and monitoring the ambition level and quantity of newly constructed and renovated buildings in EU-MS is the nearly zero-energy building radar which has first been developed in the project “COHERENO”. The nZEB radar clusters all buildings in the following four building energy performance categories:

1. Net zero energy buildings / Plus energy buildings
2. nZEB buildings according to national definitions
3. Buildings with an energy performance better than the national requirements in 2012
4. Buildings constructed/renovated according to national minimum requirements in 2012

This allows clustering national buildings relative to the national building code and nZEB definition. By establishing these qualitative categories combined with quantitative yearly construction values, the basis for a later qualitative cross-county building market comparison will be established. Gathering numbers each year will additionally allow monitoring the evolution towards more efficient standards over time. Based on all individual national results, finally an EU radar will be developed bringing together all national data in a comparable way.

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