COHERENO
Collaboration for housing nZEB renovation

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Collaboration for housing nearly zero-energy renovation

nZEB criteria for typical single-family home renovations in various countries

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1 Introduction

This report proposes a set of criteria to track nearly zero-energy buildings (nZEB[1]) renovation in order to identify market actors that implement nZEB renovation for housing sector in five target countries. The report is established as part of an Intelligent Energy Europe project, entitled COHERENO-"Collaboration for housing nearly zero-energy renovation" (www.cohereno.eu).

The main objective of this project is to strengthen the collaboration of enterprises in innovative business schemes for realizing nearly Zero Energy Building (nZEB) renovation in owner occupied houses.

Nearly-zero energy building has been introduced by the recast Energy Performance of Buildings Directive - EPBD (recast EPBD, 2010), which has set a very general framework and asked the Member States (MS) to elaborate their national approaches and implementation plans. The wide variety of these national approaches makes impossible their aggregation in a unique nZEB definition. Therefore, nZEB is a very flexible policy requirement and there is not a single and harmonised nZEB definition across Europe. In addition, the nZEB requirement addresses, so far, only new buildings that will be constructed from 2020 onwards and no clear plans or mandatory requirements have been introduced for nZEB renovations.

Hence, the COHERENO project focuses on eliminating barriers for collaboration, providing enterprise with guidance on how to collaborate and developing service for the different customer segments, towards nZEB renovation. Examples of nZEB single family houses renovations in five partner countries (Austria, Belgium, Germany, the Netherlands and Norway) will be used to identify experienced actors.

A methodology is needed to identify nZEB renovations in the market segment of owner-occupied houses. Defining nZEB renovations will lead to identify market actors providing nZEB house renovations in order to:

- map the "front-runners"(i.e. experienced supply-side actors), and
- create a recognized list of these actors.

Hence, in order to identify actors and map the "front-runners" in nZEB house renovations it is necessary to develop a set of harmonised criteria, able to deal with all national approaches and existing definitions and to provide a consistent evaluation framework. Following these criteria, project partners will compile a list of existing nZEB single family house renovations, using national approaches and based on existing market instruments and standards. Moreover, the selected nZEB renovation criteria should not be "too ambitious" and strictly

[1] For making the distinction between nearly Zero-Energy Buildings and Net Zero-Energy Buildings, BPIE suggested in 2011 study Principles for nearly Zero-Energy Buildings (available at www.bpie.eu) to use nZEB for the first as making the distinction from the second which has an already widely accepted acronym, i.e. NZEB.

represent the forthcoming national nZEB definitions, since those will be for new buildings, and since the project purpose is to identify already implemented deep/nZEB renovation[2]. Therefore the set of criteria should act as 'radar' and to be able to identify a wide range of activities, clearly identifying what is likely to be accepted as a holistic nZEB renovation but also revealing renovation activities near nZEB levels as well as partial deep renovation of building components (i.e. walls, windows, roofs etc.) that can lead later on into a whole nZEB renovation of the house by enhancing the cooperation between market actors undertaking these works nowadays.

At the same time, the set of criteria should be based on existing instruments to track in a practical and simple way the renovation towards nZEB level. Therefore, these criteria will have to be based on specific market conditions and existing instruments at national levels for each target country of the project. Consequently, in order to develop appropriate criteria, a closer look at the legislative background and national nZEB approaches which are already in place for new construction is necessary. A toolbox of instruments for identifying nZEB housing renovation will be further defined and detailed for each target country through a dialogue between project partners and national stakeholders.

The report gives an overview of the status quo of nZEB definitions in EU as well as existing buildings standards and ratings that may identify nZEB renovation. The existing definitions and approaches for identifying nZEB renovation are also analysed. Furthermore, the criteria for identifying nZEB renovation are elaborated and a 'nZEB radar' is proposed to track market actors implementing nZEB housing renovations. Based on specific market conditions as they were provided by project partners through a questionnaire-based survey, the criteria for identifying nZEB housing renovations are developed for each of the five COHERENO countries.

2 EU policies for enhancing the energy performance of existing building stock

The building sector is the largest consumer of energy in Europe, accounting for nearly 40% of the total consumption and 36% of the greenhouse gas emissions (EC, 2013).

While new buildings can be constructed with high energy performance levels, the existing stock is predominantly of poor energy performance and consequently in need of renovation work. With their potential to deliver high energy and CO_2 savings, energy efficient buildings can play a pivotal role in a sustainable, low carbon future.

At the same time, building renovation provides a number of societal benefits, including fuel poverty alleviation, health benefits, increased energy security, increased employment, higher

[2] Deep renovation or deep retrofit is a common name for buildings' renovation that delivers a significant amount of energy and carbon savings. At the moment there is not a common understanding concerning how much have to be these savings for considering a renovation activity to be 'deep'. This issue will be analysed in chapter 5 of this report. nZEB renovation is a term suggesting that the energy performance of the building after the renovation reach (or arrive very close to) the nZEB levels. nZEB renovation is largely introduced only at the EU level, in direct relation with the EPBD requirement for new buildings. The term 'nZEB renovation' is also generic and relative as time as each EU country will have its own nZEB approach and possibly different for each building type. Consequently, given the similarity between the two terms but also the wider understanding of 'deep renovation', this report analyses and uses both of them.

rental and resale values and air quality improvement. The EU policies and strategies acknowledge the importance of building renovation as a key element in reaching the long-term energy and climate goals, as well as having a positive economic impact.

Therefore, the building sector is considered in all EU's energy, climate and resource efficiency related strategies by 2050:

- In order to reach the long-term decarbonisation goals, the EU Roadmap for moving to a competitive low carbon economy in 2050 (COM, 2011a) identified the need of reducing carbon emissions in residential and services sectors by 88-91% by 2050 compared to 1990 levels.
- In addition, the Energy Roadmap 2050 (COM, 2011b) concludes that 'higher energy efficiency potential in new and existing buildings is key' in reaching a sustainable energy future in the EU, contributing significantly to the reduction of energy demand, the security of energy supply and the increase of competitiveness.
- Furthermore, the Roadmap for a Resource Efficient Europe (COM, 2011c) identified buildings among the three key sectors responsible for 70-80% of all environmental impacts.

Therefore, better construction and use of buildings in the EU would influence 42% of the final energy consumption, about 35% of the carbon emissions, more than 50% of all extracted materials and could save up to 30% of water consumption.

The Energy Performance of Buildings Directive (EPBD, 2002 & EPBD, 2010) introduced in 2002 and reinforced by the 2010 recast, has introduced the requirement of implementing energy efficiency measures in case of major renovation of a building[1] and all EU Member States (MS) transposed it into national legislation. This is an important step towards boosting building renovation activities, even if the implementation is not yet vigorous in all EU MS and still has to be significantly improved by adding secondary supporting legislation. At the same time, the EPBD asked EU Member States (EU MS) to introduce cost-optimal energy performance requirements for renovation activities as well as to eliminate the market barriers and to introduce economic support instruments to stimulate the renovation of the existing building stock. While the EPBD requirement for moving to nearly zero-energy buildings by 2020 addresses new buildings, this may trigger a strengthening of energy regulations for renovation activities aiming to the same low-energy consumption levels. Therefore, there are increasing initiatives aiming to so-called nZEB renovation with the Intelligent Energy Europe Programme as one of the drivers.

Moreover, the more recent Energy Efficiency Directive (2012) (which replaces the Energy Services and Co-generation Directives) requires EU MS to establish by April 2014 a long-term strategy to mobilise investment in the renovation of national building stocks. The existence of a long-term renovation framework will provide on the one hand the necessary investment predictability for building owners and investors and will increase on the other hand the macro-economic benefits and, eventually, lead to the transformation into a sustainable building sector.

3 Implementation of nZEB in the EU MS

According to the recast Energy Performance of Buildings Directive, a *'nearly zero-energy building'* is *'a building that has a very high energy performance'* and *'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'* (recast EPBD, 2010).

The recast EPBD requires EU MS that all new buildings have to be nearly zero-energy buildings (nZEB) from 2021 onwards (and from 2019 onwards for public buildings). Acknowledging the diversity of the European buildings sector, EPBD requires MS to draw up specifically national nZEB approaches and national plans reflecting national, regional or local conditions. These plans must translate the nZEB requirements into practical and applicable measures and definitions to steadily increase the number of nZEB.

In order to prepare the first progress report as requested by the EPBD, the EU Commission asked the EU MS in autumn 2012 to show the status of the nZEB implementation.

So far, 14 MS reported to the European Commission their plans towards implementing nZEB (NPNZEB, 2013), but only few of them presenting an officially assumed national nZEB approach for 2020. The other MS which didn't report yet are in different stages of the elaboration of nZEB preparatory studies or didn't arrive yet at an official agreement. A summary of the already reported national nZEB approaches is presented in the followings. Although the COHERENO project focuses exclusively on renovation projects in few European countries, the existing plans and nZEB approaches in the EU provide an indication on how ambitious MS are going to be and what are the expected nZEB minimum requirements.

3.1 Belgium

In Belgium, the implementation of the EPBD differs in the various regions (Brussels Region, Flemish Region, and Walloon Region).

Brussels Region

The final decision of the Brussels Capital Region (21 February 2013) was published 26 March 2013 as an amendment to the regional implementation of the Energy Performance of Buildings Directive. As such it also addresses renovations that require a building permit.

In the meanwhile, Brussels Region amended in 2011 the Energy Performance of Buildings Ordinance (MB, 2011) stipulating that from January 2015 onwards, all new public and residential buildings have to fulfil a heating need at level of Passive House standard[3].

The requirements are different for residential and non-residential buildings:

[3] Passive House (Passivhaus) is a well-established voluntary standard for ultra-low energy buildings, requiring a small amount of energy for space heating and cooling (PH, 2013). A more extensive description of this standard can be found on chapter 4.1 of this report.

Residential buildings

- a primary energy consumption for heating, domestic hot water and auxiliary energy below or equal to 45 kWh per m^2 per year;
- a net heating need below or equal to 15 kWh per m² per year;

Office and Education buildings

- a total primary energy consumption below or equal to (95-2.5*C) kWh per m² per year, with C defined as the compactness, that is the ratio between the volume enclosed and the area (maximum C is 4);
- a net heating need below or equal to 15 kWh per m² per year;
- a net cooling need below or equal to 15 kWh per m² per year;

Some exceptions exist when, due to a bad configuration or a bad orientation of a building, the energy demand can't be reached. In those cases, the standard is recalculated accepting renewable energy sources and possible difficulties when a very high density urban area does not allow a systematic extensive renewable energy production on site.

Refurbishment of existing buildings

The legislation in the Brussels Region makes a distinction between major and small renovations. A renovation is considered to be major whenever the renovation activities cover at least 75% of the heat loss surface area and the HVAC system. Major renovations are considered to be almost new construction, so the same requirements apply, but all limits for requirements are multiplied with a factor 1.2, except for indoor temperature overrun. Small renovations only have to fulfil requirements on thermal insulation (U-values and risk assessment of thermal bridges) and ventilation.

It is important to note that from 1 January 2015 each submission of a building permit can follow two directions: either complying with the 'passive house' concept or complying with an alternative solution taking account of specific urban characteristics such as a poor compactness and/or less solar gains. As such, the legislation avoids that 'unfortunate' buildings require excessive investment. The alternative route requires thermal insulation (U-) values of the building skin (average U-value 0.85 W/m^2K for transparent parts; average U-value 0.12 W/m^2K for non-transparent parts).

Walloon region

Tenders for a public service contract were called for by the Walloon Region at the end of 2011 to conduct a study (Co-ZEB Study). The study has not yet determined the nZEB reference level in kWh/m² per year. However, the study qualifies any nZEB by a level of energy performance of the building's envelope close or equivalent to the passive standard. Nevertheless, an nZEB does not necessarily have to comply with all of the criteria set by the passive standard given the highly constraining nature of these criteria for certain types of building and/or in certain locations (in particular the criterion regarding the airtightness of the building envelope, which imposes a specific level of performance that is often difficult to achieve in construction terms).

Hence, in the Walloon region, regarding new buildings, all construction will comply with the 'very low energy' standard from 2014 onwards. Construction will also comply with the 'passive' standard or equivalent from 2017. From 2019 onwards, all new buildings – in addition to the passive standard – will be required to comply as a minimum with the 'net zero' standard and tend towards positive-energy buildings (i.e. buildings where the production of renewable energy is equal to or greater than the consumption of non-renewable primary energy on an annual basis).

In order to set an example, from 2012 onwards the Walloon Region will apply these standards for all public buildings, as well as for granting subsidies, making donations or any other form of aid for property investments that the Region grants to other public or associated bodies.

In the same context, any new building will tend towards the 'very low energy' standard from 2014 onwards, while complying as a minimum with requirements regarding a dimensionless energy performance value (Ew ≤ 60) and regarding the thermal insulation and compactness of the building (K ≤ 35) (NPNZEB_BE, 2012).

Flemish region

The nZEB has not yet been defined in the Flanders Region. A dimensionless primary energy demand calculation for nZEBs will include heating, cooling, ventilation, domestic hot water and auxiliary energy (monthly balancing period). The Flanders Region nZEB development relies on gradual tightening. It is reasonable to assume that the Flanders Region will consider that an nZEB must at minimum satisfy the cost-optimal level with a minimum level of renewable energy as regards energy performance requirements. In single-family houses, at least one of the following arrangements will be necessary from 1 January 2014: thermal solar, photovoltaic panels, a bio-mass heating boiler, a heat pump, connection to a district heating or to participate in a local renewable energy-project. Additional criteria are specified for the chosen arrangements (VEA, 2012). If these arrangements are not made, the overall energy performance needs to be 10% lower than the requirements.

Beyond the Flanders Region process of defining nZEB approaches, Antwerp province announced in June 2013 to apply the Passive House standard in all public new buildings and complete renovations. This decision supports the ambitious province's climate plan to reach carbon neutrality by 2020.

Overall, all Belgian regions have provided detailed lists of actions on the policy, innovation, communication and financial framework, as roadmaps towards nZEB buildings (NPNZEB_BE, 2012).

3.2 Bulgaria

In Bulgaria, the definition for nearly zero-energy buildings is structured as defined in a 2011 BPIE's study (BPIE, 2011), i.e. on three minimum requirements for primary energy

consumption, for a renewable energy share in buildings' energy balance and for the electricity consumption of buildings' equipment and appliances.

The requirements for an nZEB are sorted in three categories, according to the building's floor area (NPNZEB_BU, 2012):

1. **Buildings surface <500 m^2**

- A nZEB must have an energy performance (primary energy) corresponding to the class A in Bulgarian energy performance certificates and
- At least 50 % of the energy needed for heating, hot water, ventilation and cooling has to be supplied from renewables.

2. **500 m^2<Buildings surface <7000 m^2**

- A nZEB must have an energy performance (primary energy) corresponding to the class A in Bulgarian energy performance certificates and
- At least 30 % of the energy needed for heating, hot water, ventilation and cooling is from renewables and
- The share of electricity in the building's annual primary energy consumption balance is no more than 30 % (including electricity for appliances, ICTs, heating, hot water, ventilation and cooling systems).

3. **Buildings surface >7000 m^2**

- A nZEB must have an energy performance (primary energy) corresponding to the class A in Bulgarian energy performance certificates and
- At least 20 % of the energy needed for heating, hot water, ventilation and cooling is from renewables and
- The share of electricity in the building's annual primary energy consumption balance is no more than 40 % (including electricity for appliances, ICTs, heating, hot water, ventilation and cooling systems).

3.3 Cyprus

In the report of Cyprus to the EU Commission (NPNZEB_CY, 2012) nearly zero-energy buildings in Cyprus are defined as follows:

Residential Buildings:

- Primary Energy Use[4] < 180kWh/m^2/yr and
- At least 25% of the 180kWh/m^2/yr of the Primary Energy must be covered by RES.

For non-Residential Buildings (mainly offices):

- Primary Energy Use4< 210kWh/m^2/yr and
- At least 25% of the 210kWh/m^2/yr of the Primary Energy must be covered by RES.

[4] Primary energy use for heating, cooling, lighting and domestic hot water.

In addition, for each building category and climate zone are indicated specific technical characteristics such as maximum U-values for building components, solar thermal for water heating, air permeability, natural ventilation and solar protection for windows.

3.4 Denmark

Denmark is one of the first EU countries that have already set-up their national nZEB definition and roadmap to 2020. The Danish nZEB definition, also known as Building Class 2020, has already been introduced in the current building regulation, BR10, as a voluntary building class until it is introduced as a legal requirement.

Building Class 2020, which reduces the energy consumption of the building by 75 % in relation to the 2006 level, is introduced as a voluntary building class at a relatively early stage in the Building Regulations, considering that the requirements for nearly zero-energy buildings in the Building Directive regarding publicly occupied and owned buildings and private buildings respectively, will not come into force until 31 December 2018 and 31 December 2020 respectively. The intention of this early introduction is to send a definitive signal to players in the building industry with regard to the coming requirements. The intention is also to give a positive assurance to the sector of the development of energy requirements and to create a healthy basis for the development and sale of building materials, building technology, consultancy, etc., that complies with the strict energy requirements. (NPNZEB_DK, 2012).

The minimum energy performance requirements from set buildings regulations will gradually become stricter, starting from the actual standard, BR10, with an interim milestone in 2015 and a final target in 2020 (**Table 1**).

The minimum requirements are different for residential buildings (and other non-residential buildings with similar type of use such as hotels) and non-residential buildings. The energy scope is aligned to EPBD requirements and includes the energy need for heating, ventilation, cooling, domestic hot water and auxiliary equipment. For non-residential buildings, the energy for lighting is also included within the regulated energy.

The improvement of the energy performance is basically done by increasing the requirements for buildings insulation. In addition, the primary energy factors for electricity and district heating have to be improved by 2020 and the renewable energy supply from nearby and onsite will have to grow.

Table 1: Evolution of the primary energy performance requirements towards nZEB levels in Denmark

		BR10	2015	2020
Minimum requirement	**Residential buildings (housing sector and hotels)**	52.5 + 1650/A* kWh/m^2/yr	30 + 1000/A kWh/m^2/yr	20 kWh/m^2/yr
	Non-residential buildings (offices, schools, hospitals, others)	71.3 + 1650/A kWh/m^2/yr	41 + 1000/A kWh/m^2/yr	25 kWh/m^2/yr

Conversion factors	**Electricity**	2.5	2.5	1.8
	District heating	1.0	0.8	0.6

**Note: A=the heated gross floor area*

It is not yet thought to be viable from a total economical (cost optimum) viewpoint to build in accordance with Building Class 2020, however, it is thought that Building Class 2020 will be economically viable when a minimum requirement is introduced into the Building Regulations. Introducing Building Class 2020 as a development class also allows for the development of new building technologies or methods that will change the basis for the total economy of the building industry.

3.5 France

In France,'Grenelle de l'Environnement' (the Environmental Round Table) recommended the adoption of more ambitious requirements for all new constructions, i.e. at the same levels as BBC-effinergie (BBC= Bâtiment Basse Consommation), the voluntary low-energy standard in France. Consequently, low energy requirements were adopted in the recast of the French thermal regulation, RT 2012, which is already applied for new non-residential buildings and since January 2013 also for new residential buildings. The requirement addresses the building's primary energy need for space heating, domestic hot water, cooling, lighting and auxiliary energy (e.g. for fans and pumps) (NPNZEB_FR, 2013).

RT 2012 set the minimum performance requirements for:

- New construction

New residential buildings should be designed and built to consume **less than 50 kWh/m²/year primary energy**, including the energy required for heating, cooling, domestic hot water, lighting and auxiliary systems. To be characterised as BBC, a dwelling must cover part of its energy demand by renewable energy sources (flexible choice between different alternatives)(NPNZEB_FR, 2013).By using renewable energy sources, new constructions are allowed to consume additional 12kWh/m²a.

- Renovated buildings

In order to be characterised as BBC, residential buildings undergoing renovation should consume **less than 80 kWh/m²/year primary energy**, including the energy required heating, cooling, production of domestic hot water, lighting and auxiliary systems.

For office buildings, the target is to achieve **at least 40% reduction of energy consumption**, compared to the buildings equipped with reference insulation materials and energy systems (NPNZEB_FR, 2013).

The requirements for BBC buildings vary depending on geographic zones and altitude.

By 2020, the "Grenelle - 1" Law requires that all new building have to be energy positive, i.e. to produce more renewable energy than the building's need (NPNZEB_FR, 2013).

3.6 Germany

In Germany there is currently no precise energy requirement officially associated to nZEB. The draft of the new Energy Saving Ordinance (EnEV) adheres closely to the EPBD definition and leaves room for a more precise definition at a later stage when more reliable data about the economic reasonability of 2020s construction will be available. In 2011, the government initiated a market analysis to identify common practice in terms of building performance levels and market barriers and to define a political strategy for 2020. The project report mentions that the current method of requiring energy performance standards for new buildings as indicated by the Energy Savings Ordinance 2009 is generally suitable to define also nearly zero-energy buildings, as it asks for maximum primary energy demand, maximum transmission heat loss, minimum share of renewables related to the heat demand and good summer comfort. According to the project consortium, a wider range of calculation boundaries - for example including not only the renewable electricity generated and consumed on site - should be considered for the future.

Moreover, due to the continuous implementation of innovations in the building sector during the last 30 years and under the current economic conditions, a constant reduction of buildings' energy demand took place. Assuming logically that this trend will continue for the next years, it can be derived that new buildings in 2020 will have an energy performance of 50% better than the performance of current buildings. This corresponds to a KfW Efficiency House[5] 40 level in the residential sector. The main criteria for a KfW Efficiency House 40 are a maximum primary energy demand of 40% and a maximum transmission heat loss of 55% relating to the EnEV 2009 standard. Therefore, the study consortium advises to communicate this level as target for the nearly zero-energy buildings, so that the market development can refer to it. It should be noted that this label does not prejudge future regulatory requirements. To this extent, the above description can only serve as an estimate of what may be considered to be generally as economical (cost-efficient) in 2019 or 2021 following the transposition of the requirement of Article 2(2) of the EPBD (NPNZEB_DE, 2013).

The present revision of the Energy Saving Ordinance aims to take first steps on the road to a nearly zero-energy building standard. It is envisaged to tighten the energetic minimum standards for new buildings in two phases (in 2014 and 2016) by an average of 12.5 % each and by 10% regarding the thermal quality of the envelope (transmission heat loss). In this way, the energetic minimum standards are gradually brought in line with the nearly zero-energy standard.

Therefore, the German government decided to keep the renovation requirements stable, and encourage instead deep renovation with support programs. The German government has adopted a mix of instruments in order to significantly increase the number of nearly zero-energy buildings by 2020. Key measures include: the KfW support programmes for energy efficient construction and refurbishment (CO_2 building refurbishment programme), the KfW programme 'Energetic urban renewal' as well as the market incentive programme for the

[5] 'Efficiency House' is a quality seal that was developed by the Federal Government in conjunction with KfW and with the German energy agency, Deutsche Energie Agentur GmbH (dena).

promotion of systems for the use of renewable energies. Moreover, Energy advisory programmes, competitions, pilot projects, roadmap studies, information material and other awareness-raising measures complete the image (NPNZEB_DE, 2013).

Integration of Renewables:

For new buildings and existing public buildings -undergoing major renovations- , additional requirements have to be complied from the Renewable Energies Heat Act (EEWärmeG) since 1 January 2009 (EEWärmeG, 2008). The EEWärmeG stipulates the obligation of using a minimum share of renewable heating or cooling. The obligation can be met when at least a specified percentage of the heating and cooling demand such as in the followings:

- 15% solar energy or
- 30% gaseous biomass or
- 50% liquid or solid biomass or
- 50% geothermal energy and ambient heat

If the above mentioned renewable energy shares cannot be fulfilled due to varied reasons, then, as an alternative, at least a specified percentage of the heat and cold demand have to be covered by use of:

- 50% waste heat or
- 50% combined heat and power (CHP)
- district heating or cooling with a significant share of renewable energy, or at least 50% of the energy consumption generated from waste heat, CHP installations or combination of these

If none of the above mentioned alternatives are possible, the thermal insulation requirements stipulated by the EnEV have to be surpassed by at least 15%.

3.7 Ireland

In Ireland, all new residential buildings, by 2020, will have stricter Energy Performance Coefficient (EPC) and Carbon Performance Coefficient (CPC)[6] (see table 2) .This takes account of the energy load for space heating, water heating, fixed lighting and ventilation. For a typical dwelling this will equate to 45 kWh/m^2/year with a very significant proportion of which will be covered from renewable energy sources produced on-site or nearby (NPNZEB_IR, 2012).

Table 2: Main nZEB requirements for a new residential building in Ireland by 2020

Low Energy Dwelling with Solar Thermal DWH	
Primary Energy (kWh/m^2/yr)	45

[6] The calculated primary energy consumption of the proposed building is divided by that of the reference building, the result being the energy performance coefficient (EPC) of the proposed building. To demonstrate that an acceptable Primary Energy consumption rate has been achieved, the calculated EPC of the building being assessed should be no greater than the Maximum Permitted Energy Performance Coefficient (MPEPC). The MPEPC is 1. The calculated carbon dioxide emission rate of the proposed building is divided by that of the reference building, the result being the carbon performance coefficient (CPC) of the proposed building. To demonstrate that an acceptable Carbon Dioxide emission rate has been achieved, the calculated CPC of the building being assessed should be no greater than the Maximum Permitted Carbon Performance Coefficient (MPCPC). The MPCPC is 1.

CO_2 Emissions (kg/m^2/yr)	10
EPC	0.302
CPC	0.305

Non-residential buildings

By 2020, subject to cost-optimal calculations, it is proposed that all new buildings other than dwellings in Ireland will achieve a 50% to 60% aggregate improvement in terms of energy efficiency and reduction in CO_2 emissions. The energy metrics to be considered will be as described in Annex I of Directive 2010/31/EU on the energy performance of buildings (recast) which includes the energy load for space heating, water heating, cooling, fixed lighting and ventilation(NPNZEB_IR, 2012).

In accordance with the definition for nearly zero-energy buildings as provided for under Article 2 of Directive 2010/31/EU of the energy performance of buildings (recast), it is envisaged that a very significant proportion the building energy demand will be covered from renewable energy sources including energy from renewable sources produced on-site or nearby (NPNZEB_IR, 2012).

3.8 Lithuania

In Lithuania, nearly zero-energy buildings are those that comply with the requirements of Construction Technical Regulation for buildings of class A++ energy performance, i.e. buildings of very high energy performance with nearly zero-energy or very low energy consumption; most of the energy consumed is renewable energy, including renewable energy produced locally or nearby.

According to the established indicators, a building of class A++ must comply with the applicable parameters:

1. values C1[7] and C2[8] of energy efficiency indicators of the building must comply with the requirements of the Regulation, i.e. C1<0.25 and C2≤0.70;
2. calculated specific heat losses of building envelopes must not exceed the normative heat losses;
3. air-tightness of the building must comply with the requirements of the Regulation, i.e. in case of pressure difference of 50 Pa between the inside and outside of the building, air circulation must not exceed 0.6 times per hour;
4. if a building is equipped with a mechanical ventilation system with recuperation, the recuperator performance ratio shall be at least 0.90, and the amount of energy used by a recuperator ventilator must not exceed 0.45 Wh/m^3;

[7]C1 indicator value of energy efficiency of the building: characterises primary non-renewable energy efficiency for heating, ventilation, cooling and lighting

[8]C2 indicator value of energy efficiency of the building, characterising primary non-renewable energy efficiency for preparing domestic hot water

5. a part of energy from renewable resources consumed in the building shall comply with the requirements of the Regulation, i.e. in buildings of class A++, energy from renewable resources must form the largest part of energy consumed. The part of renewable energy consumed in the building should be calculated via a mathematical formula (further details can be found in on the relevant national plan of Lithuania (NPNZEB_LI, 2012)

3.9 Slovak Republic

Slovak Republic proposed, in the draft of their national plan for nZEB implementation, a gradual tightening of energy performance requirements along with prescriptive requirements for main building components. The exact values can be seen in **Table 2** (NPNZEB_SK, n.a).

Table 2: Gradual tightening of energy performance requirements and prescriptive requirements for building components in Slovak Republic

Type of construction	Heat consumption for heating depending on the heat shape function (kWh/m^{2}a)	Heat transfer coefficient (W/m^{2}K)		
		External envelope	Roof cladding	Vent construction
Energy-saving buildings minimum requirements Current situation	≤100	0.46	0.30	1.5
Low-energy buildings standardised requirements Required from 1.1.2013	≤100	0.32	0.22	1.5
Ultra-low-energy buildings recommended requirements Required from 31.12.2015	≤50	0.22	0.10	0.9
Nearly zero-energy buildings recommended requirements Required from 31.12.2018/20	≤25	0.15	0.10	0.6

3.10 The Netherlands

In October 2012, the Netherlands sent its first version of the National Plan Nearly Zero-Energy Buildings ('Nationaal Plan Bijna Energieneutrale Gebouwen', in short 'BENG') to the European Commission and to its national 'Tweede Kamer' (IEB, 2013).The plan sketches a strategy on how to achieve nearly zero-energy buildings at the end of 2018 (public buildings) and 2020 (other new buildings) respectively.

In the Netherlands, a non-dimensional number is used as an indicator of the building's energy performance, depending on how the building is used: the Energy Performance Coefficient, EPC.

A completely zero-energy building will have an EPC = 0. Therefore, the aim in the Netherlands is to institute a requirement close to EPC = 0 by 2018 for government buildings and by 2020 for other buildings. The BENG describes the definition of an 'energy neutral' building as a building with an energy performance coefficient equal to zero (EPC=0). The EPC is determined by the use of the norm NEN 7120: Energy Performance of buildings – Determination method ('Energieprestatie van gebouwen – Bepalingsmethode', in short EPG), which also allows using the prenorm NVN 7125 Energy Performance Standard Measures at District Level ('Energieprestatienorm Maatregelen op Gebiedsniveau', in short EMG).

The determination method has the following characteristics:

- The energy use is determined for standard use and climate conditions;
- Only the building related energy use is valued in the energy performance;
- If applicable, district related energy use can be valued with the EMG;
- The production of energy can take place inside or outside the building;
- Renewable energy sources are valued;
- The net energy use is determined on a yearly basis;

The policy goal is to include a requirement in the Building Decree ('Bouwbesluit') which states that EPC should be close to zero from the end of 2018 for government buildings and from the end of 2020 for other buildings. This level is defined as 'nearly energy neutral' ('bijna-energieneutraal'), but the exact value is still unknown.

Regarding renewable energy sources, the principle is that builders are free to choose measures that reduce the demand for energy, use energy from renewable sources, and make effective use of fossil fuels, in order to achieve the required EPC. As the requirements for the EPC become stricter and stricter, the percentage of renewable energy will automatically become increasingly important in order to fulfil the requirement. Even so, it will still be compulsory to fulfil the requirements for thermal insulation of the building envelope of new buildings, as stipulated in the Building Decree (Rc at least 3.5 m^2K/W for closed building envelope, U value currently at most 2.2, but dropping to 1.65 W/m^2K for windows, doors, etc. in the beginning of 2013).

In 2013, the requirement for new houses and major renovations is EPC≤0.6. In 2015, a strengthening of the requirement to EPC≤0.4 is planned. For utility buildings a similar strengthening is foreseen. Policy will demand studies (cost effectiveness, quality of the

indoor environment, market penetration of technologies) to provide guidance for strengthening.

3.11 United Kingdom

The British Government has already set a target for all new homes in England to be 'zero carbon' (rather than zero-energy) from 2016 and an ambition for all new non-domestic buildings in England to be zero carbon from 2019 (2018 for new public sector buildings).

The process of nZEB definition has been finished and built on the voluntary certification system "Code for Sustainable Homes (CSH)", where the 2016/2019 standard is equivalent to step 5 of CSH. Step 5 means carbon neutrality for heating, ventilation, DHW, cooling and lighting. For 2013 changes in the regulation towards close to Passive House levels have been foreseen to act as an interim step on the trajectory towards achieving zero carbon standards from 2016/19. From 2016 the carbon compliance limits for the building performance should be

- 10 kg CO_2 (eq)/m²/year for detached houses or ~46 kWh/m^2/year
- 11 kg CO_2 (eq)/m²/year for attached houses or ~46 kWh/m^2/year
- 14 kg CO_2 (eq)/m²/year for low rise apartment blocks (four storeys and below) or ~39 kWh/m^2/year.

In contrast to most other countries, apart from taking into consideration onsite renewable generation, in UK it is also discussed how investments in off-site renewable energy ('allowable solutions') can be taken into account in the nZEB balance.

Northern Ireland proposes to apply the same standards as England by 2017 for all new homes and all new non-domestic buildings in England to be zero carbon from 2020 (NPNZEB_UK, 2012).

The Scottish Government share the ambition for zero carbon buildings and work is underway to investigate and discuss the challenges presented by further advancing the zero carbon agenda. At present, the focus is on delivery of revised energy standards within the 2010 Scottish building regulations which reduce CO_2 emissions from new buildings by 30% compared to 2007 Standards. In keeping with the recommendations in the Sullivan Report, *A Low Carbon Building Standards Strategy for Scotland* (SBSA, 2007), the Scottish Government has given a commitment to further reviews of energy standards for 2013 and 2016 (NPNZEB_UK, 2012).

In Wales, the new regulations that took place in October 2010 introduced a 25% improvement on 2006 carbon emissions standards for new buildings. Current consulation proposals are aimed at delivering a 20% improvement in non-domestic building performance and a 40% improvement in new housing (NPNZEB_UK, 2012).

Further review of energy standards within building regulations is being progressed separately in Wales, Northern Ireland and Scotland.

4 Other nZEB/NZEB[9] definitions, standards and initiatives

In parallel to the regulatory and legislative process, there are several initiatives, voluntary standards and guidance studies on how to reach nearly or net zero-energy buildings.

There is a global working group at the International Energy Agency aiming to provide a harmonised approach for implementing net zero-energy buildings (NZEB). Indeed, as also shown in the previous section, there is no global definition for low-energy buildings, but it is widely recognised that a low-energy building must have a high energy performance, achieved by high levels of insulation and energy efficient windows, by high air tightness and by using heat recovery and on-site renewable energy generation for covering partially, entirely or more than the energy demand of the building.

At the moment, there are many terms defining low-energy buildings. For instance, a survey carried out by the Concerted Action supporting EPBD (Erhorn & Erhorn-Kluttig,2011) identified 23 different terms in use to describe such buildings used across Europe, among which the terms low energy house, high-performance house, passive house/Passivhaus, zero carbon house, zero energy house, energy savings house, energy positive house, 3-litre house etc. In the relevant literature additional terms such as ultra-low energy house can be found. Finally, concepts that take into account more parameters than energy demand again use special terms such as eco-building or green building. Among all these, Passive House voluntary standard is probably the best-defined low-energy building concept and already accepted in various countries and regions as being synergistic with the NZEB concept and in line with the nZEB requirement from EPBD. Nowadays there are tens of thousands buildings constructed or renovated according to the passive house standard, mainly in Europe but also worldwide to a limited extend.

Moreover, there are some relevant initiatives and studies to support the implementation of nZEB requirement from the recast EPBD.

All these will be briefly described in the following sub-chapters.

4.1 Passive House

Passive House (Passivhaus) (PH, 2013) is a well-established voluntary standard for ultra-low energy buildings, requiring a small amount of energy for space heating and cooling. The Passive House standard is developed for both residential and non-residential buildings (i.e office buildings, schools etc) and it is applied for both new buildings and refurbishment of existing ones. Passive Houses allow for energy savings of up to 90% compared with typical Central European building stock and over 75% compared to average new builds. A building is a Passive House if it meets the following three criteria (PH, 2013):

- The annual space heating demand may not exceed 15 kWh/m²/yr, in accordance with the Passive House Planning Package (PHPP). This criterion originates from the scientific

[9] For making the distinction between nearly Zero-Energy Buildings and Net Zero-Energy Buildings, BPIE suggested in 2011 study Principles for nearly Zero-Energy Buildings (available at www.bpie.eu) to use nZEB for the first as making the distinction from the second (NZEB, already used as acronym).

observation that under these conditions a comfortable indoor climate can be achieved without the need for a separate heating system next to a balanced ventilation system[10].

- The criteria for thermal comfort must be met for all living areas during winter as well as in summer. Depending on local conditions this may result in recommendations such as:
  - U-values of opaque exterior components must be less than 0.15 W/m²K.
  - U-values of windows and other translucent building components must be less than 0.8 W/(m²K).
  - Consistently uniform flow of air through all areas and into all rooms must be ensured (ventilation efficiency). Noise emission from the ventilation system must be minimal (≤ 25 dBA).
  - Summer overheating should be avoided by using air flow strategies and solar protection.
- The specific primary energy demand for all domestic applications (heating, hot water and domestic electricity) must not exceed 120 kWh/m²/yr in total.

Nowadays there are more than 25000 certified Passive Houses in Europe, most of them being in Central Europe, Belgium and Nordic countries. Passive house networks and criteria are available in all partner countries.

However, when renovating a building towards passive house standards, practice has shown that is sometimes difficult to reach the requirement for space heating demand ≤ 15kWh/m^2/yr (Mlecnik, 2013). In practice many buildings that have undergone large-scale renovation using passive house recommendations can end up with a space heating demand of about 25-30 kWh/m^2/yr. The Passive House Institute itself suggested an 'EnerPHit' standard for renovations[11] requiring a space heating demand ≤ 25 kWh/m^2/yr, but it remains unclear whether this requirement fits all types of existing houses. For example, building regulations might restrict the renovation of building components and listed architecture and sometimes existing thermal bridges are difficult to solve in a cost-effective manner.

4.2 Other considerations and initiatives around zero energy buildings

4.2.1 IEA Task 40 Annex 52 for Net Zero Energy Buildings

The objective of the IEA Task 40 Annex 52 (http://task40.iea-shc.org/) is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. A primary means of achieving this objective is to document and propose practical NZEB demonstration projects, with convincing architectural quality. These exemplars and the supporting sourcebook, guidelines and tools are viewed as keys to industry adoption. The scope includes major building types (residential and non-residential), new and existing, for the climatic zones represented by the participating countries. A goal of the Task is to

[10] When the ventilation system is dimensioned primarily for air hygiene, the 15 kWh criterion ensures that a post-heater in the ventilation system can cover the necessary space heating demand without burning dust the air. In practice, the post-heating in the ventilation system is not required, and separate heaters may be used.

[11] See also the IEE project "Improving the energy performance of step-by-step refurbishment and integration of renewable energies (EUROPHIT)":

advance the NZEB concept from an idea into practical reality in the marketplace. The Task source book and the datasets will provide realistic case studies of how NZEBs can be achieved.

In 2012 was elaborated the NZEB evaluation tool is an excel-based tool that enables energy balance, operating cost and load match index calculation for predefined selected definitions. It aims at evaluating solutions adopted in building design with respect to different NZEB definitions (for building designers), assessing the balance in monitored buildings (for energy managers), and assisting the upcoming implementation process of NZEBs within the national normative framework (for decision makers).

4.2.2 nZEB Principles for nearly Zero-Energy Buildings – BPIE study

In 2011, BPIE elaborated together with Ecofys GmbH Germany and Danish Buildings Research Institute (SBi) a study proposing general common principles for being taken into account by MS for implementing the EPBD requirement on nearly Zero-Energy Buildings (BPIE, 2011).

Briefly, the study proposed three general principles for nZEB claiming that should be clearly defined boundaries in building's energy flow which properly defines the quality of the energy, as well as for measuring and/or calculating renewable energy share, primary energy and associated CO_2 emissions (the last one not being a specific EPBD requirement but representing an alignment to long-term carbon goals). If over a balance period more renewable energy than energy need is produced, should be introduced clear rules on how to account the net export. In addition, the study proposed thresholds for primary delivered energy, renewable energy share and CO_2 emissions such as in the followings:

A minimum primary energy requirement which should be between identified cost-optimal levels and levels defined by BAT:

- A minimum renewable energy share >50%
- A minimum CO_2 requirement of 3kg $CO_2/m^2/yr$
- A potential indication on the other electricity consumption in the building, likely to be subject of a further limitation in order to minimise the all energy consumption of building

4.2.3 REHVA Task Force on nZEB

The REHVA Task Force proposes a technical definition for nearly zero energy buildings required in the implementation of the Energy performance of buildings directive recast. Energy calculation framework and system boundaries associated with the definition are provided to specify which energy flows in which way are taken into account in the energy performance assessment. The intention of the Task Force is to help the experts in the Member States in defining the nearly zero energy buildings in a uniform way. Based on the directive's definition, nearly zero energy building is technically defined through the net zero energy building, which is a building using 0 kWh/(m²a) primary energy. Therefore, the REHVA Task Force proposed that a nearly net zero-energy building should be defined by a primary energy use bigger than 0 kWh/m²/yr and which is technically reasonable achievable at national level by implementing best practice energy efficiency measures and renewable energy technologies which may or may not be cost optimal.

Into support of the above nZEB definition, REHVA Task Force proposes a methodology on which energy flows shall be included in energy performance assessment and how the primary energy factors should be used for primary energy indicator calculation. For the uniform methodology, a general system boundary definition was established with inclusion of active solar and wind energy, as well as the guidance for technical meaning of “nearby” in the directive[12].

5 Existing definitions for nZEB/deep renovation of buildings

The recast EPBD has been identified as one of the most ambitious policies globally in terms of renovation of buildings. However, the EPBD does not require specific requirements as concerning the depth of renovation, i.e. the amount of savings (energy or/and carbon) to be delivered through renovation of the building. The recast EPBD lays down the application of minimum requirements to the energy performance of existing buildings; building units and building element that are subject to major renovation. A ‘major renovation’ in the EPBD means the renovation of a building where total costs related to the renovation of the building envelope or technical building systems is higher than 25% of building’s value or more than 25% of building’s envelope area undergoes renovation.

In order to identify existing definitions for deep renovation, Global Buildings Performance Network (GBPN, 2013) conducted in 2013 a study on current state of the play and looked at existing approaches worldwide. The main part of the experience was found in European Union (EU) and the United States (US).

This definition identifies a ‘window of possibility’ for a ‘deep renovation’. The minimum energy requirement will be set by the individual MS; however, this must be based on the EPBD Article 4 that states a minimum energy performance requirements ‘are set for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels’. This does not prescribe deep renovation but provides an opportunity to renovate with energy performance as a priority, including for building envelope elements that are retrofitted or replaced.

Deep/nZEB Renovation is, however, mentioned in the Article 5 of the Energy Efficiency Directive (EED, 2012). The EED obliges MS to renovate 3% of the total floor area of public buildings. These renovations must meet at least the minimum energy performance requirements that it has set in application of Article 4 of the EPBD (stated above). This applies to all buildings over 250 m^2. Article 4 in the EED requires member states to establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. This strategy must encompass ‘policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations’.

[12] How to define nearly net zero energy buildings nZEB – REHVA proposal for uniformed national implementation of EPBD recast (REHVA Task Force, 2011.).

On the 30th of July 2012, the European Parliament published a report on the proposal for an energy efficiency directive (EUP, 2012) where deep renovation is defined as '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'.

Through an extensive survey all around the world, GBPN study (GBPN, 2013) coagulated several more widespread definitions for deep/nZEB renovation such as in the followings:

- **Deep Renovation** or **Deep Energy Renovation** is a term for a renovation that captures the full economic energy efficiency potential of improvement works, with a main focus on the building shell, of existing buildings that leads to a very high-energy performance. The renovated buildings energy reductions are 75% or more compared to the status of the existing building/s before the renovation. The primary energy consumption after renovation, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting after the deep renovation of an existing building is less than 60 kWh/m^2/yr (GBPN / definition often used in Europe).
- **Deep Retrofit** or **Deep Energy Retrofit** implies replacing existing systems in a building with similar ones that are of higher quality and performance, which leads to a better energy performance of an existing building. The primary energy consumption includes energy used for heating, cooling, ventilation, hot water, lighting, installed equipment and appliances. After the deep retrofit the buildings energy reduction is 50% or more compared to the status of the existing building/s the retrofit (GBPN / definition mainly used in US).
- **Deep Reduction** or **Deep Energy Reduction** is a term used in US for a deep renovation or a deep refurbishment, which aims at more than 75% reduction in energy use in comparison with that prior to the improvement.
- **Zero-Carbon-Renovation:** A deep renovation with large-energy consumption reductions, where the energy needed to supply the resisting need is carbon neutral
- **Zero-Energy-Renovation:** A deep renovation with large-energy consumption reductions, where the energy needed to supply the resisting need is supplied as renewable energy on site.
- Some definitions based on relative targets can support the clarification of deep renovation projects and can help to separate the level of ambition in deep renovation projects.
    - **Factor 2 Renovation**: A renovation with energy consumption reductions of 50% compared to pre-renovation performance.
    - **Factor 4 Renovation**: A deep renovation with energy consumption reductions of 75% compared to pre-renovation performance.
    - **Factor 6 Renovation**: A deep renovation with energy consumption reductions of 84% compared to pre-renovation performance (GBPN, 2013).
    - **Factor 10 Renovation:** A deep renovation with energy consumption reductions of 90% compared to pre-renovation performance

6 Towards a potential definition for nZEB renovation

Based on the findings from Chapters 3-5 of this report and on EPBD requirements, a ***potential definition of nZEB renovation of a house*** seems to be defined as having one or more of the following characteristics:

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/m^2/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 CO_2 requirement of no more than 3kg CO_2/m^2/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.***

However, the above tentative definition for nZEB renovation seems to be more ambitious than many declared national nZEB approaches for new buildings as presented in Chapter 3 of this report. In addition, while primary energy consumption of a building is the obvious indicator for defining nZEB, the differences between countries methodologies for evaluating the energy performance make all efforts for having a widely accepted nZEB definition almost impossible.

7 The nZEB Radar: tracking nZEB in housing renovation

Ideally, the nZEB renovation should have a unique definitions and likely following the requirements proposed in the above. However, it is too restrictive to use very high standards to track current market activities. Other well established means such as existing ambitious standards, EPC classes and other implemented measures should be used instead. Besides, a unique EU definition for nZEB renovation seems not to be feasible at the moment. Therefore, it appears to be more suitable and consistent to elaborate a common set of criteria, applicable in all national contexts that can be used to properly spot nZEB renovations in a coherent and understandable way for each national or local market. At the same time, these criteria have to be linked to a set of instruments for identifying nZEB renovations in a practical way.

Furthermore, one of the main objectives of COHERENO project is to identify actors undertaking nZEB renovation in order to enhance their cooperation and to increase the number of nZEB renovations on the markets. Hence, in order to increase the market impact

of project's activities, it is necessary not only to consider the contractors already providing nZEB renovation but also contractors that provide 'nearly nZEB renovation', who could improve their practice, through the project activities and contacts with top-runners.

All things considered, it becomes evident that for the purpose of COHERENO project and generally in order to track nZEB renovations and relative developments on a given market, it is suitable to work with a 'nZEB radar'. The 'nZEB radar' will allow to cover a broader range of standards, which are all close to nZEB but do not necessarily rely on absolute values. The "nZEB radar" will be accompanied by already existing tracking instruments on a national market, which are suitable to track best practice examples. Among these instruments, the most common are Energy Performance Certificates, nZEB demonstration projects, award winning refurbishments, government funded projects or high performance projects that have obtained a certificate (e.g. passive house), net zero energy buildings etc. In that way, it can be ensured that 'marketable nZEBs' will be identified.

To this end, we created and defined the 'nZEB radar', as presented on the diagram in Figure 1. The 'nZEB radar' depicts different methodologies to define nearly Zero-Energy Buildings. The circles define the ambition of tracking nZEB activities. The radar can be used with flexibility depending on the number of available projects for each circle in each country. A general rule applies: the closer to zero energy, the better.

The concentric circles of the proposed 'nZEB radar' provide the opportunity to identify several levels of nZEB and 'nearly nZEB' renovations, taking at the same time into consideration the credibility and accuracy of the instruments used for spotting these.

Without being an ultimate definition, but an evolving concept to be adjusted during project's implementation, we propose a generic "nZEB radar" defined by 4 circles[13] such as in the following:

① **Circle 1 (very dark green):** This circle depicts the highest performance level of building renovation, i.e. very ambitious, exemplary renovations meeting at least the (assumed) requirements for new nZEB in a specific country and reaching almost zero-energy and/or zero-carbon levels after renovation. Moreover, the circle includes nZEB renovations that reach the highest available EPC class (above energy class A or energy class A with a primary energy consumption near to zero), energy positive buildings[14] standards, net zero energy (or carbon) buildings standards or similar.

② **Circle 2 (dark green):** This circle includes still a very ambitious level for renovation, which does not necessarily fulfil all the principles presented on BPIE's nZEB study, but reaches very low primary energy consumption after renovation. This category includes renovations at passive house levels (around 25kWh/m^2/yr) or similar standards, certified as

[13] The generic circles of the nZEB radar don't have clear borderlines. The definition of the nZEB circles is only indicative at the general level offering flexibility for specific definition for each national context. Therefore, the circles of the nZEB radar may even take a form of a cloud if the market context requested a non-uniform border.
[14] Building which generates more renewable energy than the energy consumed for covering the building's energy needs.

energy class A after renovation but still with a specific primary energy consumption at around 50-60kWh/m^2/yr

③ **Circle 3 (light green):** This circle allows collecting examples of a wider range of projects, such as national data bases, awardees or similar, as well as buildings that reached an A or even B EPC class after renovation, but with higher primary energy consumption than in circles 1 and 2, i.e. with a specific primary energy consumption below 90-100kWh/m^2/yr.

④ **Circle 4 (very light green):** This circle includes projects that are on a good way to nZEB renovation, with at least 3-4 measures such as in the following list:

- deep envelope insulation, U-value ≤ 0.24 W/m^{2}K
- deep roof insulation, U-value ≤ 0.24 W/m^{2}K
- triple glazed windows, U-value ≤ 0.80 W/m^{2}K
- Update of an old heating system (including boiler, pumps, etc.)
- Integration of RES, min. cover 50% of heat demand
- Correct ventilation for securing the air comfort inside building

Finally, for framing the nZEB radar into the nZEB national roadmaps towards 2020, a dot line ‘star’ (see **Figure 1**) is additionally introduced reflecting the interim nZEB definitions adopted or still under debate at the country level. Where there is no nZEB commitment, then the ‘star’ may reflect the anticipated upcoming buildings regulations in the country or at least the actual energy performance requirement for new buildings. According to the specific country context, the dot line star may reflect the 2020 nZEB definition. Alternatively and when possible, two dot line stars may be included in the radar, reflecting both 2015 and 2020 nZEB requirements for houses.

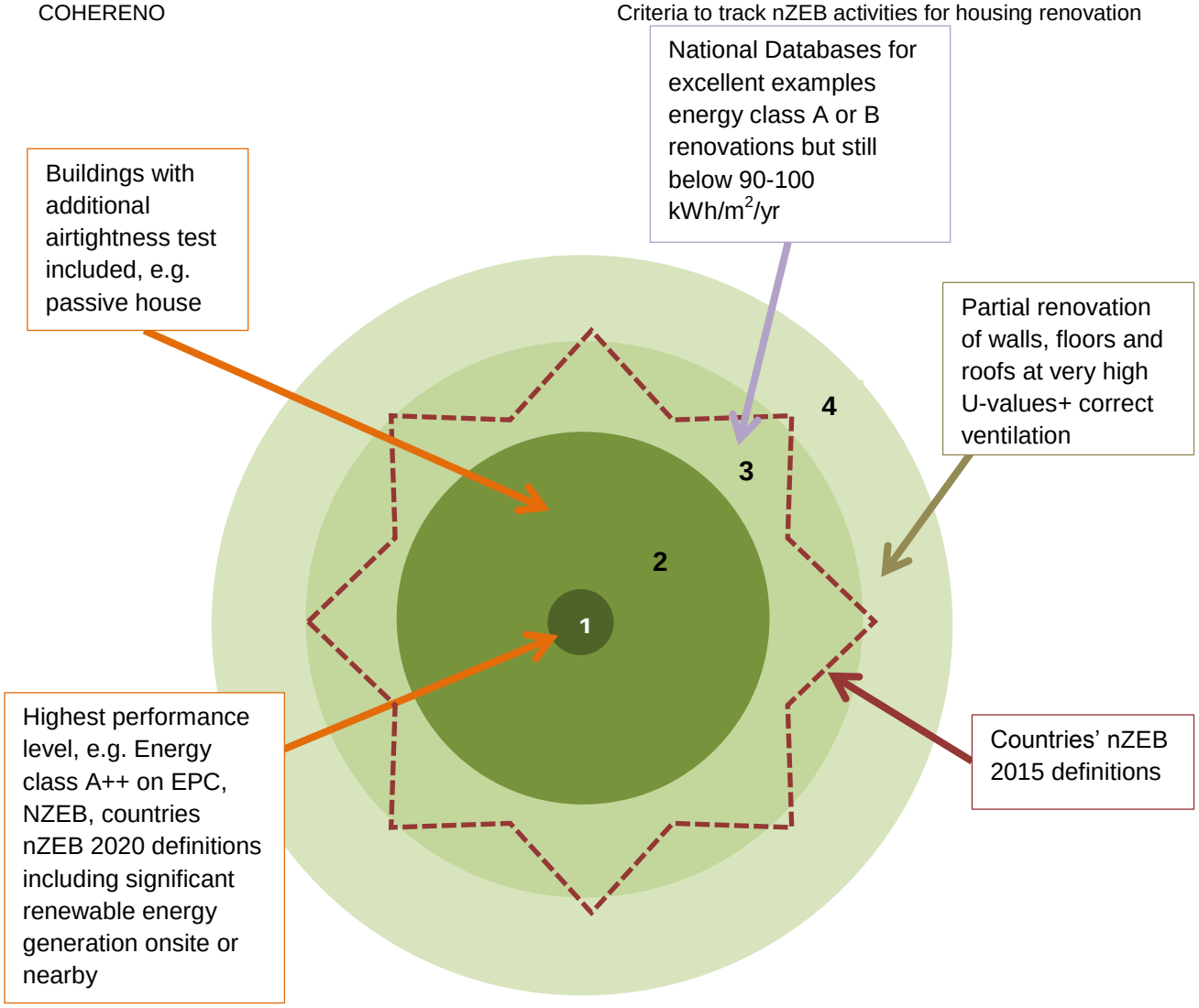


Figure 1: Example of nZEB target which was created to depict different methodologies and standards for defining nZEB buildings.

Table 3 gives an overview of the possible instruments (left column) that should be used to track nZEB housing renovation -in a practical way- in each of the target countries of COHERENO project.

Table 3: A 'toolbox' of instruments to identify nZEB renovation

Instruments/where to search	AT	BE	DE	NL	NO
Adopted future requirements for new or existing buildings	x	x		x	x
Passive House	x	x	x	x	x
Energy performance certificates	x	x		x	x
Governmental support schemes - **Sanierungscheck (AT)** - **BatEx (BE)** - **KfW55 standard (DE)** - **Energiesprong (NL)**	x	x	x	x	
Combination of measures from the pre-defined list (at least 3, see chapter 7)	x	x	x	x	x
Existing projects or lists where relevant market actors can be identified	x	x	x	x	x
Other existing databases with exemplary renovation	x	x	x	x	x

Legend: X= the instrument exists in the given country

8 Proposals for national nZEB renovation radars

This chapter describes national criteria to track nZEB renovation individually for each of the project countries. The choice of the radar has been done pragmatically and in cooperation with the national experts of the project consortium to ensure a sufficient number of identifiable projects. Future policy plans and available long-term requirements have been taken into account when available. Other selected criteria reflect the national circumstances, such as governmental support schemes with clear benchmarks or ambitious EPC classes.

8.1 Austria

Current and future requirements as criteria to track nZEB renovation:

Up to now, Austrian Federal States have agreed on a draft of the national plan according to article 9 (3) of 2010/31/EU. The draft contains a definition of nZEB and interim targets for heating energy demand, final energy demand, total efficiency factor, primary energy demand and CO_2-emissions for the years 2014, 2016, 2018 and 2020. The draft considers both new buildings and the major renovation of buildings. The following table gives the minimum

requirements for major renovation. For the purpose of this project the most ambitious requirement for the year 2020 should be part of the Austrian radar.

Table 4: Minimum requirements of energy efficiency for major renovation of residential buildings (2014-2020)[15]

	HWB_{max}	EEB_{max}	$F_{GEE,max}$	PEB_{max}	$CO_{2\ max}$
	[kWh/m²a]	[kWh/m²a]	[-]	[kWh/m²a]	[kg/m²a]
2014	23 x (1+2.5/lc)	Using $HTEB_{Ref}$	1.10	230	38
2016	25 x (1+2.5/lc)	Using $HTEB_{Ref}$		220	36
		or			
	21 x (1+2.5/lc)		1.05		
2018	19 x (1+2.5/lc)	Using $HTEB_{Ref}$		210	34
		or			
	25 x (1+2.5/lc)		1.00		
2020	17 x (1+2.5/lc)	Using $HTEB_{Ref}$		200	32
		or			
	25 x (1+2.5/lc)		0.95		

Note: The energy demand for electricity has to be considered (domestic/household electricity for residential buildings).

Support programs as a source:

The housing subsidies system of the Austrian provinces, "**österreichische Wohnbauförderung"** is complex but performs highly on an international level. Each Federal State has a different funding scheme including different civil regulations .The minimum requirements for the thermal heating demand are defined in an agreement between the state and the provinces (WBF-15a-B-VG, 2008):

[15] HWB = Heizwärmebedarf (heating energy demand)
EEB = Endenergiebedarf (final energy demand)
f_{GEE} = Gesamtenergieeffizienzfaktor (total efficiency factor)
PEB = Primärenergiebedarf (primary energy demand)
HTEB = Heiztechnikenergiebedarf (energy demand for technical appliances used for heating systems)
lc = characteristic length: a measure for the geometry of a building; gross volume/heat exchanging surface (the inverse of Surface/Volume)

Table 5: Minimum requirements for subsidised major renovations[16]

Surface/Volume	≥ 0,8 (very small SFH)	≤ 0,2
thermal heating demand (WBF-15a-B-VG, as of 1.1.2010)	75 kWh/m²a	35 kWh/m²a

The so called **"Sanierungsscheck"** is a time-limited funding instrument for the thermal renovation of existing private residential buildings. The programme is sponsored by the Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Federal Ministry of Economy, Family and Youth. The aspects eligible for funding are the thermal renovation of external walls and floors, the replacement of windows and external doors as well as the conversion of the heating system for buildings older than 20 years.

The funding amounts to 20 % of the eligible costs or a maximum of 5,000 EUR for the thermal renovation and a maximum of 2,000 EUR for the conversion of the heating system. An additional grant of 500 EUR is also available for renewable, ecologically friendly construction materials or certified windows. If the measures are installed within a certain time period, the funding will be increased by up to 30 % or up to a maximum of 9,000 EUR. The programme supports both major and partial renovation and has following requirements:

Table 6: Sanierungsscheck 2013 - requirements of thermal renovation (source: bmwfj and lebensministerium)

Measure	Extent of renovation	Requirements
Major renovation	Overall reduction of heating energy demand	▪ thermal heating demand 75 kWh/m² (Surface/Volume > 0,8) ▪ S/V ≤ 0,8 [17] ▪ Energy performance certificate (EPC) of existing building and additional EPC including the planned measures
Part renovation 30 %	Reduction of heating energy demand by 30 %	▪ EPC of existing building and additional EPC including planned measures
Part renovation 20 %	Reduction of heating energy demand by 20 %	
Single measure floor/roof	Thermal insulation of the complete floor/roof area	▪ minimum size 16cm (representing a U-value of 0,20 W/m²K) ▪ EPC of existing building
Single measure window/external door	Renovation/exchange of at least 80 % of existing windows	▪ maximum U-value of 1,35 W/m²K ▪ EPC of existing building

[16] major renovation = Renovation, in which more than 25% of the surface of the building envelope are changed unless the total cost of the renovation of the building envelope and building systems are less than 25% of the building value (the value of the land on which the building was built, is not counted)

[17] http://www.publicconsulting.at/uploads/hwb_grenzwerttabelle.pdf

For the purpose of this project the “Sanierungscheck” definition of “major renovation” should be part of the Austrian radar.

The **klima:aktiv climate protection initiative** by the Federal Ministry of Agriculture, Forestry, Environment and Water Management targets to launch climate-friendly technologies and services in the market and to encourage their rapid proliferation. The klima:aktiv's building standard provides a practical guidance for energy-efficient construction and high-quality renovation, e.g.: criteria and requirements for energy efficiency, building materials and construction, user comfort and air quality indoors as well as quality of planning and implementation (klimaaktiv, 2013).

Table 6: klima:aktiv Basis: A selection of criteria and minimum requirements in 2013 for renovation

Energy Efficiency	
Heating demand (without warm water)	HWBBGF,WG,Ref ≤ 50 kWh/m²a (A/V ≥ 0,8) HWBBGF,WG,Ref ≤ 30 kWh/m²a (A/V ≤ 0,2)
Primary energy demand	≤ 200 kWh/ m²a
Renewable Sources	
CO_2-Emissions	≤ 32 kg/m^2a
Quality of the Construction Work	
Blower-Door / airtightness	n50 ≤ 2,0 h-1

Energy Performance Certificate as a source:

The energy certificate is based on calculated values only and assigns an energy performance label to residential and non-residential buildings or building units. The energy label classifies the buildings on a scale ranging from A^{++} (high energy efficiency) to G (poor efficiency). The first page contains general data of the building, of the qualified expert and the heat demand in kWh/m^2a as a key factor. The recast 2011 also provides the primary energy demand, the CO_2-emissions and the final energy efficiency factor f_{GEE}.

Although not explicitly mentioned, the nZEB level is indirectly considered in the Austrian EPC. The targets set to achieve the highest category A^{++} inevitably require an integral strategy concept, including maximum thermal insulation, highly efficient equipment to reduce energy consumption and energy supply from renewable energy sources (e.g. photovoltaic or solar thermal system).

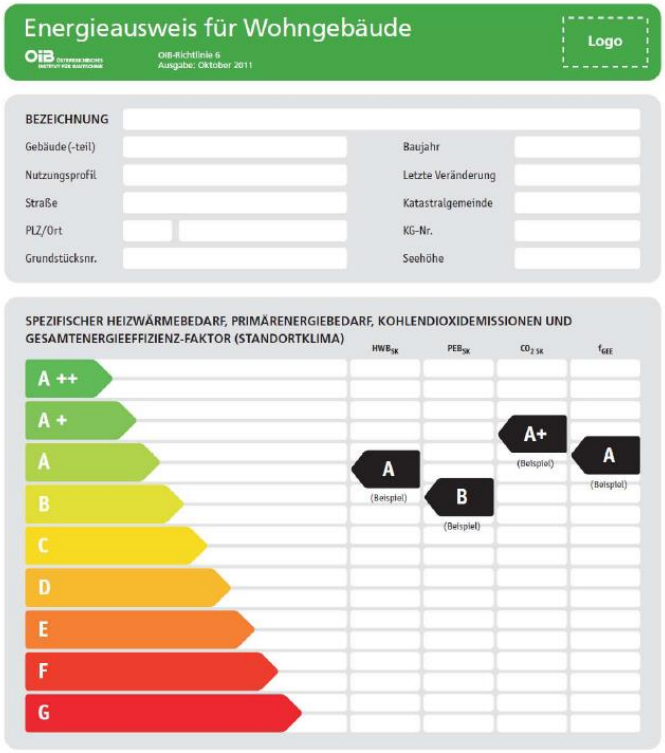


Figure 2: Cover page of the Austrian EPC

The second page provides detailed information concerning the final energy demand of the envelope as well as of the HVAC system, based on the specific climate data of the site. The EPC is valid for 10 years. The next 30 to 40 pages contain information of the building geometry including relevant features concerning the ecological aspects of the materials used. When preparing an EPC for a major renovation, recommendations have to be made by qualified experts. They should include a detailed description, estimates of costs, savings and paybacks as well as the impact on the energy rating if all measures are implemented.

Table 7: Energy classes within the Austrian EPC. Marked with red are the classes selected for the Austrian radar

	OIB Guideline 6, version October 2011			
Class	**heating energy demand** [kWh/m²a]	**primary energy demand** [kWh/m²a]	**CO_2-emissions** [kg/m²a]	**final energy efficiency factor** [-]
Klasse A⁺⁺	$HWB_{BGF,Ref}$ ≤ 10	$PEB_{BGF,SK}$ ≤ 60	$CO_{2BGF,SK}$ ≤ 8	f_{GEE} ≤ 0.55
Klasse A⁺	$HWB_{BGF,Ref}$ ≤ 15	$PEB_{BGF,SK}$ ≤ 70	$CO_{2BGF,SK}$ ≤ 10	f_{GEE} ≤ 0.70
Klasse A	$HWB_{BGF,Ref}$ ≤ 25	$PEB_{BGF,SK}$ ≤ 80	$CO_{2BGF,SK}$ ≤ 15	f_{GEE} ≤ 0.85
Klasse B	$HWB_{BGF,Ref}$ ≤ 50	$PEB_{BGF,SK}$ ≤ 160	$CO_{2BGF,SK}$ ≤ 30	f_{GEE} ≤ 1.00
Klasse C	$HWB_{BGF,Ref}$ ≤ 100	$PEB_{BGF,SK}$ ≤ 220	$CO_{2BGF,SK}$ ≤ 40	f_{GEE} ≤ 1.75
Klasse D	$HWB_{BGF,Ref}$ ≤ 150	$PEB_{BGF,SK}$ ≤ 280	$CO_{2BGF,SK}$ ≤ 50	f_{GEE} ≤ 2.50
Klasse E	$HWB_{BGF,Ref}$ ≤ 200	$PEB_{BGF,SK}$ ≤ 340	$CO_{2BGF,SK}$ ≤ 60	f_{GEE} ≤ 3.25
Klasse F	$HWB_{BGF,Ref}$ ≤ 250	$PEB_{BGF,SK}$ ≤ 400	$CO_{2BGF,SK}$ ≤ 70	f_{GEE} ≤ 4.00

Klasse G	$HWB_{BGF,Ref}$ > 250	$PEB_{BGF,SK}$> 400	$CO_{2BGF,SK}$> 70	f_{GEE}> 4.00

For the purpose of this project the ambitious Energy Performance classes A, A+ and A++ should be part of the Austrian radar.

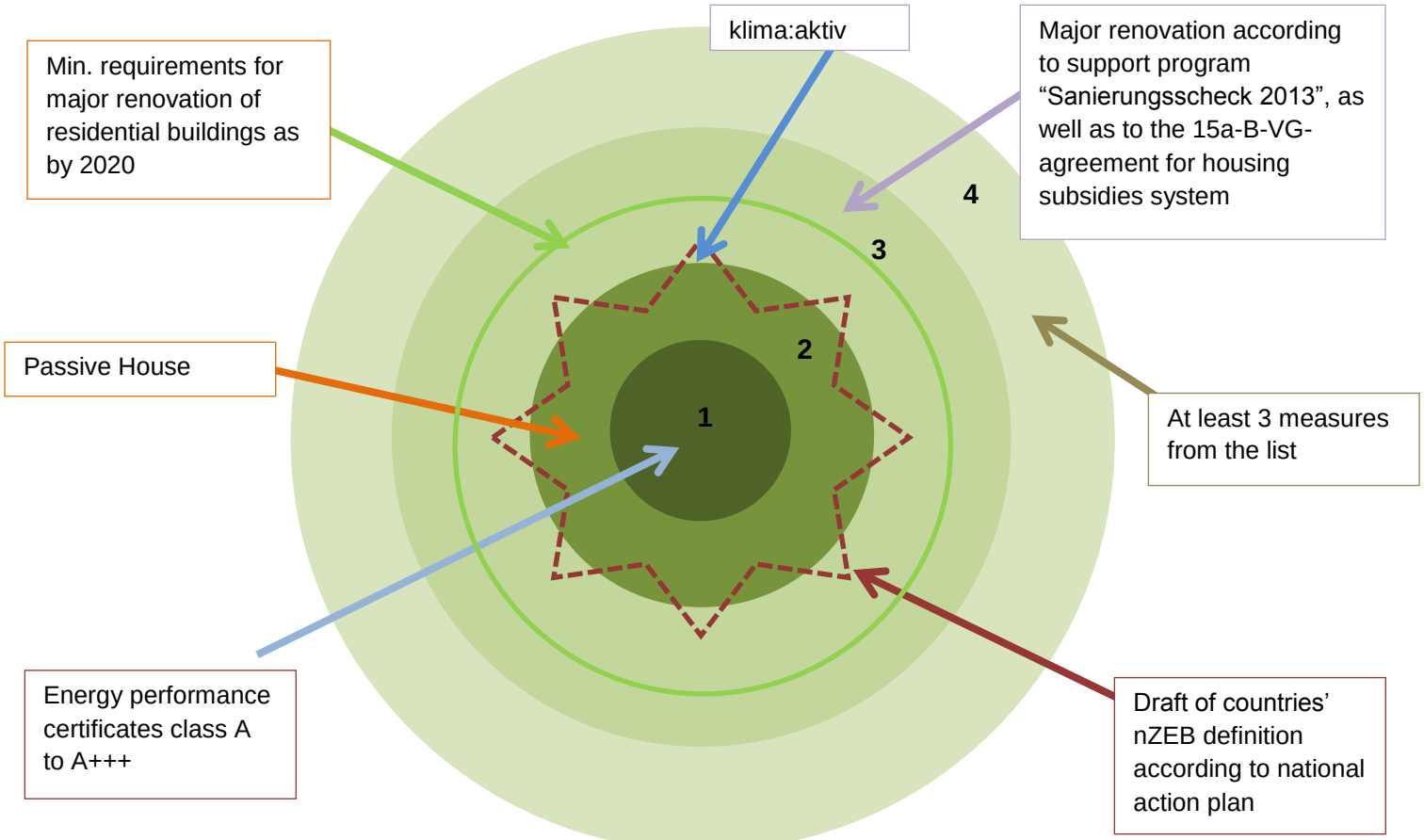
Other sources to identify market actors:

One major source of information is the project **Profis** of the programme **klima:aktiv** which is sponsored by the Federal Ministry of Agriculture, Forestry, Environment and Water Management. The online-based database offers a nationwide list of market players such as architects, planners, builders or traders and craftsmen in the areas of energy efficient buildings, HVAC systems or renewable energy sources. Membership of the "klima:aktiv centre of excellence" (Kompetenzzentrum) is granted on an individual basis and lasts for three years, following which requalification is necessary (klimaaktiv_database, 2013).

The **contracting association DECA** represents a number of members and offers an up-to-date list of the current members which can be found on the relevant website (only in German) (DECA, 2013).

The association **"IG Passivhaus"** also lists a variety of nationwide members corresponding to areas such as the planning and the construction of passive houses, passive house components, quality management as well as research institutions and training facilities. (IG Passivhaus, 2013).

Proposal for the Austrian nZEB Renovation radar:



8.2 Belgium (Brussels and Flemish region)

Current and future requirements as criteria to track nZEB renovation:

The final decision of the Brussels Capital Region (21 February 2013) was published 26 March 2013 as an amendment to the regional implementation of the Energy Performance of Buildings Directive. As such it also addresses renovations that require a building permit.

For all new residential construction the requirement from 2015 onwards is as in follows:

- Primary energy consumption ≤ 45kWh/m^2/year (including heating, domestic hot water and auxiliary energy) and
- Heating need ≤ 15kWh/m^2/year (equivalent to one of the passive house requirements for new built construction)

Furthermore, it will not be permitted to have indoor temperatures above 25°C during more than 5% of the year. A gradual enforcement of building air tightness levels is scheduled towards $n_{50} \leq 0.6\ h^{-1}$.

Some exceptions exist when, due to a bad configuration or a bad orientation of a building, the energy demand can't be reached. In those cases, the standard is recalculated accepting renewable energy sources and possible difficulties when a very high density urban area does not allow a systematic extensive renewable energy production on site.

The requirements also apply on major renovations whenever the renovation activities cover at least 75% of the heat loss surface area and the HVAC system. In such cases all limits for requirements are multiplied with a factor 1.2, except for indoor temperate overrun.

It is important to note that from 1 January 2015 each submission of a building permit can follow two directions: either complying with the 'passive house' concept or complying with an alternative solution taking account of specific urban characteristics such as a poor compactness and/or less solar gains. As such, the legislation avoids that 'unfortunate' buildings require excessive investment. The alternative route requires U-values of the building skin (average value 0.85 W/m^{2}K for transparent parts; average value 0.12 W/m^{2}K for non-transparent parts).

As Brussels is a European frontrunner region in implementing nearly zero-energy housing, the ambitious requirement for the year 2015 for new residential buildings should be a leading option of the Brussels radar to track nZEB renovation.

The nZEB-level has not yet been defined in the Flanders Region. A dimensionless primary energy demand calculation for nZEBs will include heating, cooling, ventilation, domestic hot water and auxiliary energy (monthly balancing period). The Flanders Region nZEB development relies on gradual tightening. The scope towards nZEB is not yet defined, but leans towards a global energy performance level of E ≤30. The energy auditor currently has the opportunity to submit a renovation as new built construction, thus resulting in an E-level.

However, for renovations, it is possible to avoid an E-level calculation, if min. U-/Rc-values for construction parts and ventilation requirements are considered. It is the intention of the Flemish Energy Agency to prepare an E-level procedure for renovation and to define deep energy renovation ('ingrijpende energetische renovaties'). It is reasonable to assume that the Flanders Region will consider that an nZEB must at minimum satisfy the cost-optimal level with a minimum level of renewable energy as regards energy performance requirements. In single-family houses, at least one of the following arrangements will be necessary from 1 January 2014: thermal solar, photovoltaic panels, a bio-mass heating boiler, a heat pump, connection to a district heating or to participate in a renewable energy-project. Additional criteria are specified for the chosen arrangements[18]. If these arrangements are not made, the overall energy performance needs to be 10% lower than the requirements.

As only major renovations (≥75% renovated) with a building permit have an E-level, alternatives should be considered to define renovations according to other criteria. Alternatively, the Flemish Renovation Programme 2020 relies on three criteria: the insulation of all roofs, the replacement of all single glazing and the exchange of old heating systems. Thus, it makes sense to withhold objective performance requirements related to these issues as alternative selection criteria. In relation to the Brussels development it would make sense to require similar U-values of the building skin (average value 0.85 W/m^{2}K for transparent parts; average value 0.12 W/m^{2}K for non-transparent parts).

The current requirements only allow tracking house locations and energy auditors who filled in the declaration.

Support programs as a source:

The "Exemplary Buildings" program (Bâtiments Exemplaires, or BatEx) is the main financial incentive instrument of the Brussels regional government to encourage demand for very high energy and environment efficiency construction based on a yearly call for proposals since 2007 (except in 2010). The planned duration of the program is May 2007-December 2014, with a total budget of 45 million Euros for financial, technical and promotional support. The information on demonstration buildings gathered in the "BatEx programme" can be an important source for collecting examples for the COHERENO project. The awarded projects not only receive grants for the architect and for the owner, but also the information about the projects is widely promoted by the Brussels Region via books, databases, conferences, site visits and so on.

In the Flemish Region, grants are provided by energy distribution net managers (e.g. eandis) according to E-levels. These classifications (41 ≤ E ≤ 60; E ≤ 40) can serve as a basis: E equal to or below 40 is considered an ambitious energy performance level.

Alternatively, grants from distribution net managers also cover thermal insulation measures such as:

- roof insulation, e.g. for an Rd-value ≥ 3.5 m^{2}K/W
- replacement of glazing, e.g. for U-values ≤ 1.1 or 0.8 W/m^{2}K

[18] http://www2.vlaanderen.be/economie/energiesparen/epb/nb1211/annex201211.pdf

- façade insulation, e.g. for an Rd-value ≥ 2 m^2K/W
- floor or cellar insulation, e.g. for an Rd-value ≥ 1.2 m^2K/W
- placement of a condensing boiler

Extra grants are available from these actors for solar thermal panels, heat pumps, and so on. The Flemish Region also supports a green electricity certificate scheme for other renewable energy sources like photovoltaic panels.

Energy Performance Certificate as a source:

Brussels EPC scheme is based on the principle of energy classes A to G. The classes A to E have three sublevels (e.g. A+, A, A-). The associated unit is calculated primary energy use in kWh per square meter per year. Furthermore, the EPC scheme mentions CO_2 emission and recommendations for renovation and rational energy use. In theory, it could be a useful instrument to identify nZEB renovation projects for COHERENO. However, in practice the data from the BatEx programme are considered more reliable, since monitoring and compliance to legislation and calculation procedures is more often checked.

Table 8: Energy classes for EPC in Brussels Capital Region according to kWh primary energy (ejustice, 2011)

	Dwellings			
Energy classes	**Consumption range [kWh primary energy/ m^2/year]**			
A^+			to	0
A	from	1	to	17
A^-	from	18	to	34
B^+	from	35	to	52
B	from	53	to	69
B^-	from	70	to	87
C^+	from	88	to	104
C	from	105	to	122
C^-	from	123	to	139
D^+	from	140	to	156
D	from	157	to	174
D^-	from	175	to	191
E^+	from	192	to	208
E	from	209	to	226
E^-	from	227	to	243
F	from	244	to	295
G	from	295	to	

In the **Flemish EPC scheme**, there is currently no specific energy classes included. The Flemish EPC expresses an energy score in kWh primary energy per gross floor area per year on a continuous green to red scale (0 to > 700). Similarly the average U-value, the installation efficiency and the CO_2 emissions are also expressed on a green to red scale. It further includes recommendations to reduce energy use.

Since there is no definition of an ambitious EPC-value, a 'frontrunner' selection could be made based on a selection on the low value side (e.g. based on a percentage that includes the best values). However, an EPC does not give information if and how a house has been renovated. The buildings with an EPC date from before 2006, so some of them can also be relatively newly-built constructions. Note that generally in Belgium, actors involved in renovation often also engage in newly-built construction.

Other sources to identify market actors:

A Belgian passive house certificate is supported by two organisations: Passiefhuis-Platform vzw (PHP) and Plate-forme Maison Passive asbl (PMP). The passive house certificate expresses space heat demand either as ≤ 15 kWh/m^2/year (procedure for newly-built construction) or ≤ 25 kWh/m^2/year. Additionally, it includes quality assurance criteria such as a limitation of summertime overheating ≤ 5%. Various additional requirements are expressed in a vademecum. Both organisations hold project databases or realized passive house projects and renovations.

PHP, in collaboration with the Belgian Building Research Institute (BBRI) and the Felmish Construction Federation (VCB), also established a list of experts active in integrated energy efficient house renovations in Flanders and Brussels. This list contains data of companies who are based in Flanders or Brussels and who contributed to approved Flemish and Brussels demonstration projects of housing renovation. This public list is based on the information provided to PHP on 27.06.2012 of:

1. Demonstration projects in the Brussels Capital region[19]
2. Certified Passive house projects (category housing renovation)[20]
3. Demonstration projects from the federal research project 'Low Energy Housing Retrofit – LEHR'[21]
4. Example projects Ecobouwers (Ecobuilders) [22].

The list is available on the one stop shop database (One stop shop, 2012). Furthermore the website www.ecobouwers.be allows searching for practitioners.[23]

The Flemish initiative Ecobouwers[22] is being further developed in an IEE project entitled NZEB2021 and might provide a useful source to identify market actors. The web site of Ecobouwers contains a database of projects of mainly owner-occupied houses (newly-built and renovation) which is regularly updated on the occasion of yearly open house days where owner-occupants exchange experiences. Renovation projects are listed according to the following requirements[24] :

- A global thermal insulation level of K ≤ 30 or
- A maximum energy use for space heating ≤ 60 kWh/m^2/year.

[19] http://app.leefmilieubrussel.be/batex_search/SearchEngineResults.aspx?language=NL
[20] Data from PHP and PMP
[21] www.lehr.be
[22] www.ecobouwers.be
[23] http://ecobouwers.be/professionals
[24] http://www.ecobouwers.be/ecobouwers-opendeur-inschrijvingen

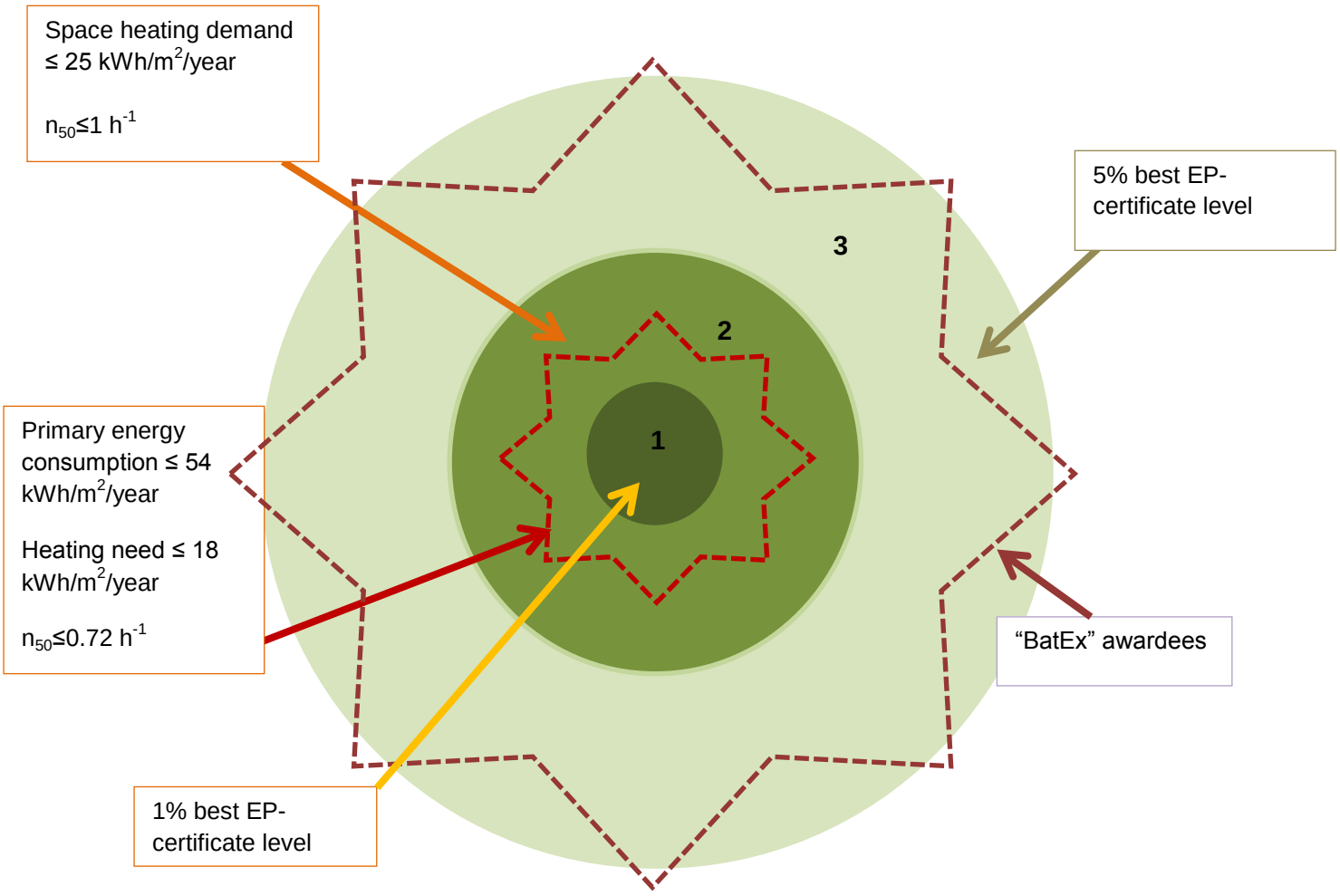
Alternatively, when this data is not available a combination of requirements applies:

- U-value of the roof ≤ 0.2 W/m^{2}K.
- If possible: U-value of the outside walls ≤ 0.3 W/m^{2}K.
- U-value of outside glazing ≤ 1.1 W/m^{2}K.

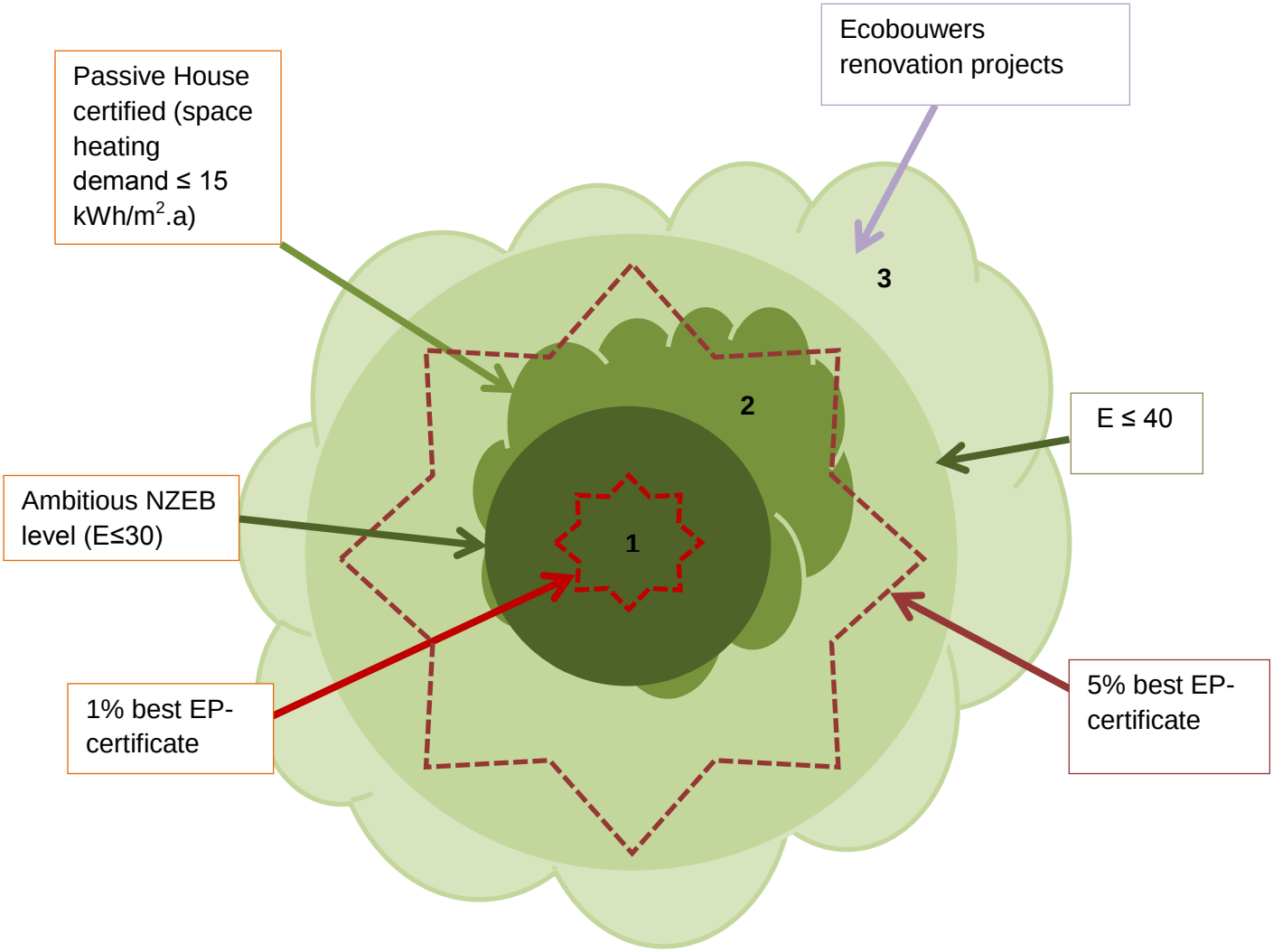
Ecobouwers also list the professionals involved in these renovation projects according to name, type, municipality, membership of PHP, star rating according to VIBE (Flemish Institute for Bio-ecological Construction), and number of projects listed.

The previous discussion shows that the situation is different in the Brussels Capital Region and in the Flemish Region. In the Brussels Capital Region, the main data source is the BatEx programme and the legal nZEB definition, as well as passive house certified projects. In the Flemish Region the nZEB still has to be defined and the major sources for finding actors are passive house certificates, Ecobouwers listing and energy performance certificates or building declarations showing an ambitious energy performance.

Proposal for the Belgian nZEB Renovation radar (Brussels region):



Proposal for the Belgian nZEB Renovation radar (Flemish region):



Criteria	Class 4 Ref. nZEB2015	Inter-mediate Class 3 (proposed)	Inter-mediate Class 2 (proposed)	Class 1 Ref. nZEB2020
Individual selection criteria for actor listing				
E-level (Flemish Region)	≤ 40			≤ 30
K-level **(kWh/m^2/year)**	≤ 30			
EPC **(kWh/m^2/year)**	within 5% of the best values (t.b.c.)			within 1% of the best values (t.b.c.)
Primary energy consumption (including heating, domestic hot water and auxiliary energy) **(kWh/m^2/year)**				≤ 54
Space heating demand (kWh/m^2/year)				≤ 18
Project label	Ecobouwers	EnerPHit	Passive House	
Inter-dependent selection criteria for actor listing				
U-value roof (W/m^{2}K)	≤ 0.2	≤ 0.15	≤ 0.12	
U-value facades (W/m^{2}K)	≤ 0.3	≤ 0.15	≤ 0.12	
U-value floors/ cellars (W/m^{2}K)		≤ 0.15	≤ 0.12	
U-value glazing (W/m^{2}K)	≤ 1.1	≤ 1.1	≤ 0.85	
U-value doors/windows (W/m^{2}K)		≤ 1.1	≤ 0.85	
Recommended quality assurance criteria for project references				
Ψ thermal bridges (W/mK)		Risk evaluation	≤ 0.01	t.b.c.
Building airtightness level (n_{50})		≤ 1	≤ 0.72	≤ 0.72
Ventilation requirements	Yes	η_{HR} ≥ 80 %	η_{HR} ≥ 90 %	η_{HR} ≥ 90 %

Renewable energy installed	Yes			Yes
Summertime overheating requirements		$n_{hours \geq 25°C} \leq$ 10%	$n_{hours \geq 25°C} \leq$ 5%	$n_{hours \geq 25°C} \leq$ 5%

8.3 Germany

Current and future requirements as criteria to track nZEB renovation:

In Germany there no currently no precise energy requirement officially associated to nZEB. The draft Energy Saving Act adheres closely to the EPBD definition and leaves room for a more precise definition at a later stage when more reliable data about the economic reasonability of 2020s construction will be available. In 2011, the government initiated a market analysis[25] to identify common practice in terms of building performance levels and market barriers and to define a political strategy for 2020. The project report mentions that the current method of requiring energy performance standards for new buildings ("EnEV 2009") is generally suitable to define also nearly zero-energy buildings, as it asks for maximum primary energy demand, maximum heat transmission loss, and minimum share of renewables related to the heat demand and good summer comfort. According to the project consortium, a wider range of calculation boundaries- for example including not only the renewable electricity generated and consumed on side-should be considered for the future.

Moreover, due to the continuous implementation of innovations in the building sector during the last 30 years and under the current economic conditions, a constant reduction of buildings' energy demand took place. Assuming logically that this trend will continue for the next years, it can be derived that new buildings in 2020 will have an energy performance of 50% better than the performance of current buildings. This corresponds to a KfW Efficiency House 40 level in the residential sector (the Effficiency House level 40 only exists in the promotional program for construction). Therefore, the study consortium advises to communicate this level as target for new nZEB buildings. For the purpose of this project it seems to be suitable to also refer to KfW level, but specified for existing buildings. See the following chapter about support programs.

Support programs as a source:

The promotional funding program "Energy-efficient Refurbishment" from the KfW Bank promotes refurbishments of houses if afterwards specific energy requirements are not exceeded. The KfW has defined five levels of support for a "KfW Efficiency House". The highest standard, the **KfW Efficiency House 55** (primary energy demand roughly 40 kWh/m²a) comes close to nZEB building criteria. For the purpose of this project, KfW 55 certified projects can be valuable examples for ambitious nZEB renovation in Germany.

The CO_2 building refurbishment programme of the KfW is part of the German climate protection programme. The programme promotes measures for saving energy and reducing CO_2-emissions in residential building by financing corresponding measures.

The five levels of support for energy-efficient refurbishments:

- KfW Efficiency House 55

[25] http://www.bbsr.bund.de/cln_032/nn_340720/BBSR/EN/Publications/BMVBS/Online/2012/ON162012.html; http://www.irb.fraunhofer.de/bauforschung/projekte.jsp?local=en&p=20128035721

- KfW Efficiency House 70
- KfW Efficiency House 85
- KfW Efficiency House 100
- KfW Efficiency House 115
- KfW Efficiency House Monument

The figures indicate the demand of the maximum primary energy requirement of the home specified by the Energy Saving Ordinance (EnEV). The best standard (55) receives the highest support. The standard Efficiency House 55 means the primary energy demand of the building is 55% lower than required for a new building, calculated regarding EnEV. The EnEV standard for a deep refurbished building is 140% in relation of a new building.

There are either grants or loan as promotional funds available. Financing is available for the following measures

- Thermal insulation of walls, roof and floor space
- Renewal of windows and exterior doors
- Installation/renewal of a ventilation system
- Renewal of the heating system
- Optimisation of heat distribution for existing heating systems.

Furthermore it is possible to implement only individual measures and for construction supervision.

In Germany many more promotional programs exist on the one hand in several federal states and at federal banks and on the other hand at private banks and in local authorities.

Energy Performance Certificate as a source:

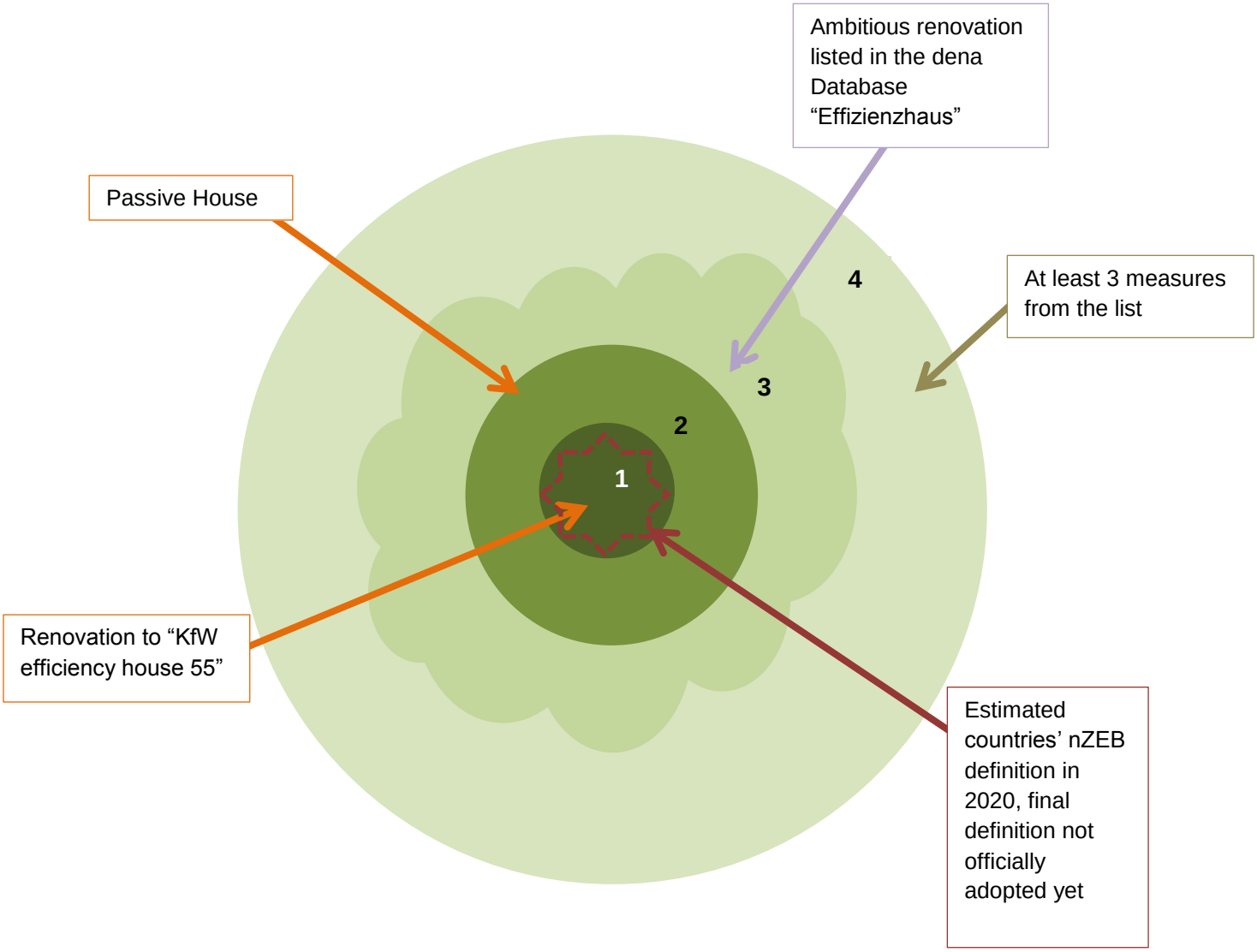
The German Energy Performance Certificate is based on a continuous scale indicating primary energy and final energy in colours from green to red. For residential buildings, the new scale, which will be introduced with the next amendment of the ordinance, ends at 250kWh/m^{2}yr. As there are no performance classes in place and EPCs are not publicly available in a database, the EPC won't be a suitable tool to identify deep renovation in Germany.

Other sources to identify market actors:

The German Energy Agency (dena) provides a best-practise database of energy efficient homes (effizienzhaus datenbank) and a database of energy efficiency experts (experten datenbank) (Effizienhaus datenbank, 2013 & Experten datenbank, 2013)

Both databases can be valuable to identify market actors or refurbishment projects for the COHERENO project.

Proposal for the German ZEB Renovation radar:



8.4 The Netherlands

Introduction

Within the project IEE COHERENO we will have to establish a method to track owner-occupied nearly zero-energy home renovations, in order to list actors involved in such projects on a public list. It is important for the project that the national advisory board reflects on this method, since this method influences the establishment of a public actor list.

This chapter describes the criteria that will be used to track nZEB renovations for the Netherlands. Future policy plans and available long term requirements have been taken into account wherever available. Other selected criteria reflect the national circumstances, such as governmental support schemes with clear benchmarks or ambitious energy performance classes.

Current and future requirements as criteria to track nZEB renovation

Now (**2013**) the EPC requirement[26] for **new houses is EPC ≤0,6**. In **2015** a strengthening of the requirement is planned to **EPC ≤0,4**.

In October 2012 the Netherlands has sent its first version of the National Plan Nearly Zero-Energy Buildings ('Nationaal Plan Bijna Energieneutrale Gebouwen', in short 'BENG') to the European Commission (NPNZEB, 2013) and to its national 'Tweede Kamer'[27] (IEB, 2013). The BENG describes the definition of an **'energy neutral' building** as a building with an energy performance coefficient equal to zero **(EPC=0)**. The policy goal is to include a requirement in the Building Decree ('Bouwbesluit') which states that EPC should be close to zero from the end of 2018 for government buildings and from the end of 2020 for other buildings. This level is defined as 'nearly energy neutral' ('bijna-energieneutraal'). The exact value is unknown and Dutch policy intends to perform at least two studies to understand the feasibility and cost effectiveness of tightening the EPC.

For the purpose of this project, the Energy Performance Coefficient of ≤0,4 can be used to identify still very ambitious renovation activities.

However, EPC values are attributed to major renovations requiring a building permit and therefore not often available for renovations. Therefore, as an alternative selection requirement, it makes sense to use a combination of objective requirements, such as: thermal insulation of roofs, walls, floors/cellars, glazing, thermal bridges; space heating demand; ventilation heat recovery efficiency, and so on. Typically, for EPC-values ranging from 0,4 to 0, the following values are taken as a reference:

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[26] The EPC is determined by the use of the norm NEN 7120: Energy Performance of buildings – Determination method ('Energieprestatie van gebouwen – Bepalingsmethode', in short EPG), which also allows to use the prenorm NVN 7125 Energy Performance Standard Measures at District Level ('Energieprestatienorm Maatregelen op Gebiedsniveau', in short EMG).

[27] Source: Infoblad energieneutraal bouwen – definitie en ambities (april 2013), http://www.agentschapnl.nl/sites/default/files/Infoblad%20Energieneutraal%20bouwen%20Definitie%20en%20ambitie%20april%202013.pdf

- Maximum installed heating power 60 to 15 W/m^2;
- alternatively space heating demand 60 to 15 kWh/m^{2}a

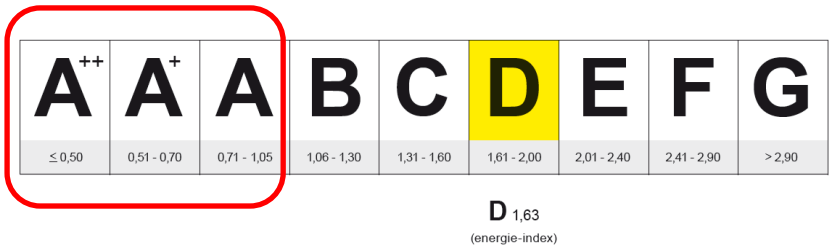
Alternatively, combining various thermal insulation requirements:

- Rc-value roofs minimum 5 to 7 m^{2}K/W
- Rc-value facades minimum 3.5 to 7 m^{2}K/W
- Rc-value floors and cellars minimum 3.5 to 5 m^{2}K/W
- Outdoor glazing minimum HR++/triple glazing.

Renewable energy systems will play a more important role when Rc-values are lower. Alongside these criteria, it is necessary to strengthen comfort requirements for high performance buildings. For example, thermal insulation should not be applied without providing adequate controlled ventilation (either natural or mechanical).

Energy performance certification as a source

The nZEB level is not specifically defined as such in the national labelling scheme related to the energy performance (EP) certification. While the front page of the EP-certificate classifies buildings according to label A to G, the third page of the EP-certificate provides further information about the energy label class and the energy index. Energy indexes are coupled to label classes as expressed in the following figure (source: Agentschap.nl).



The energy index is a calculated number that represents the energy quality of the building and is related to a label A+ (0.51-0.70) or A++ (≤ 0.5) for highly energy-efficient buildings. The range for a label A is 0.71 to 1.05 and for a label B 1.06 to 1.30.
For the moment mostly housing associations regard a renovation to a certain label as a corporate strategy. These associations consider an improvement of two label steps or a renovation to label B already as ambitious, although frontrunners demonstrated the feasibility of renovating towards label A+ or A++.

Depending on the size of the samples and a possible strategy for gradual reinforcement, it would be interesting to collect examples of nZEB renovations with labels A, A+ or A++.

The labels are usually only established when houses are meant for rent or sales. Therefore, it can not be expected that many owner-occupied renovations will have a label.

Supported programs as a source

Further policy is being developed for the transformation of the existing building stock. Some specific initiatives provide experimental space. Financed by the Innovation Agenda Energy

the organization Platform31 carries out a policy programme entitled Energy Leap ('EnergieSprong')[28] for the built environment. This programme addresses frontrunners with the development of experiments and deals, and can be an interesting source of renovation projects. More specifically, the Energy Leap action 'House full of Energy' ('Huis Vol Energie') provides a portal for owner-occupants to exchange information about ambitious home renovation.
The associated web site (www.huisvolenergie.nl) lists dozens of performed and on-going nZEB home renovation projects. This policy related initiative explicitly does not use a strict requirement regarding the nZEB definition, since the main objective of this initiative is to create a growing community.
Also, the Energy Leap programme is on the verge of launching a 'concept and project' database, destined to serve as a file manager for listing suppliers of possible renovation concepts and associated requirements. As a long-term objective, the Energy Leap programme prefers to use the **'energy bill = 0'** requirement instead of 'EPC = 0'.
Within the Energy Leap programme the Platform31 Action 'Locally all lights on Green' (Lokaal Alle Lichten Op Groen) stimulates six municipalities to make at least 20 existing houses energy neutral. This is expected to lead to events and deals with local suppliers and owner-occupants in order to renovate a larger amount of homes: htpp://www.lokaalallelichtenopgroen.nl.

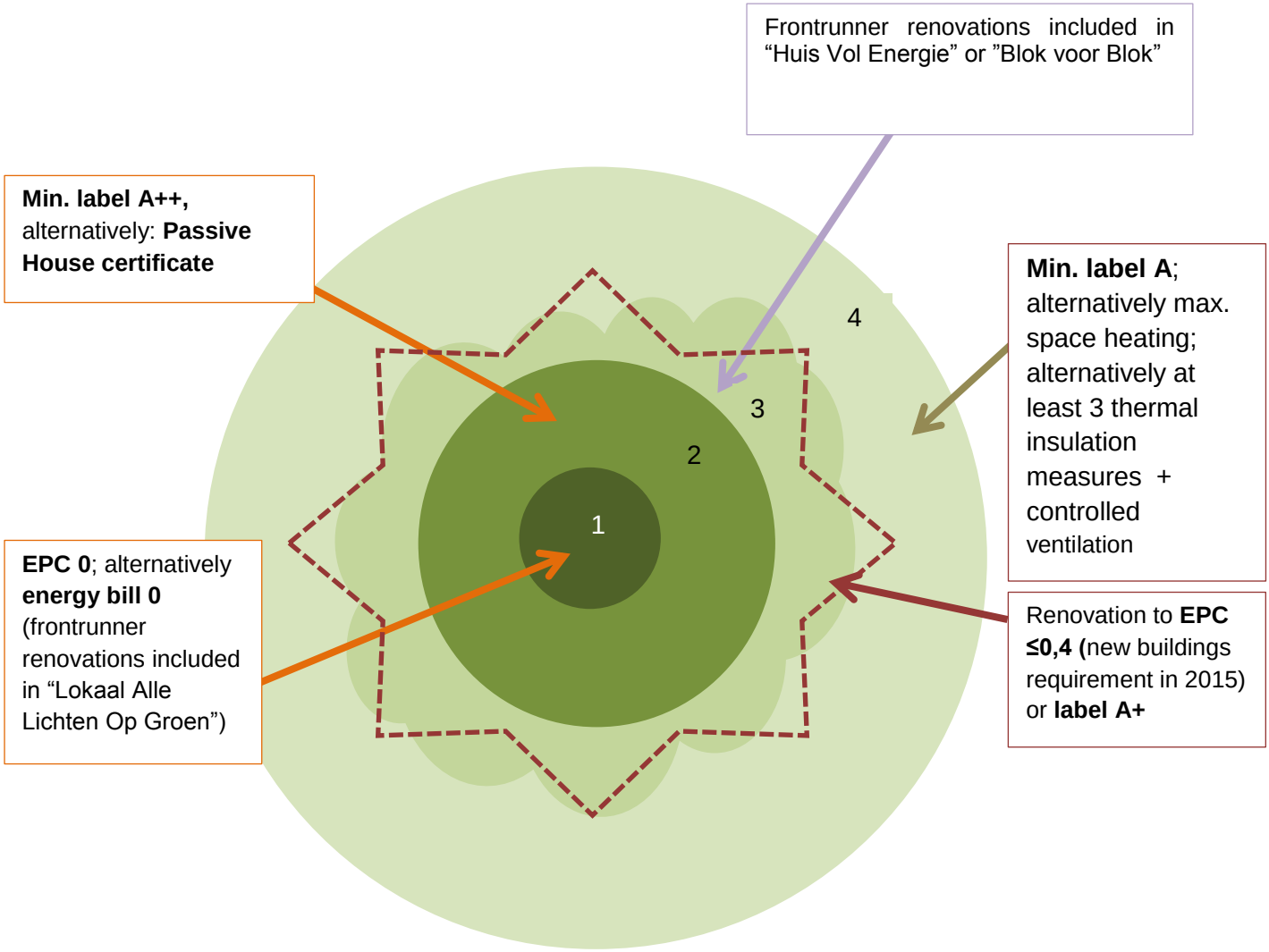
Other sources to identify market actors

Within the programme 'Block by Block' ('Blok voor Blok') there is a list of actors that were involved in consortia for realizing demonstration projects of highly energy-efficient large-scale refurbishments: http://www.agentschapnl.nl/programmas-regelingen/blok-voor-blok-projecten.
The non-profit organization Stichting passiefbouwen.nl also issues **passive house certificates** for renovations towards the passive house standard. All certified projects are listed on www.passiefbouwen.nl. It can be remarked that for passive houses also additional quality assurance requirements such as building airtightness, efficiency for heat recovery of ventilation and the avoidance of summertime overheating (solutions for awning) play a role. For passive house renovations, the space heating demand has to be limited to ≤ 25 kWh/m^2.a.

Proposal for the Dutch nZEB Renovation radar

The choice of establishing a radar has been done pragmatically and in cooperation with the national experts of the project consortium to ensure a sufficient number of identifiable projects. The Dutch radar looks is established as follows.

[28] http://energiesprong.nl/


Frontrunner renovations included in "Huis Vol Energie" or "Blok voor Blok"
Min. label A++, alternatively: Passive House certificate
Min. label A; alternatively max. space heating; alternatively at least 3 thermal insulation measures + controlled ventilation
EPC 0; alternatively energy bill 0 (frontrunner renovations included in "Lokaal Alle Lichten Op Groen")
Renovation to EPC ≤0,4 (new buildings requirement in 2015) or label A+
4
3
2
1

8.5 Norway

Current and future requirements as benchmarks:

Norway has no official nZEB definition yet. The nZEB standard is likely to be close to the existing voluntary Passive house standard (NS 3700:2013[29] for residential buildings), but slightly more ambitious (i.e. bigger share of renewable energy produced on site/building, more efficient technical systems -like ventilation, heat recovery, heating system-, even better building envelope/building components and more focus on environmentally friendly materials).

Moreover, there are plans for gradual tightening of the energy performance standards of new buildings, from passive house level by 2015 to nZEB level by 2020. Requirements for renovation of existing buildings will be put into force towards 2015.

Support programs as a source:

In Norway, the state owned company 'ENOVA'[30] stimulates a more sustainable energy use and production of more renewable energy through a range of support programmes. A new programme for retrofitting of existing single family houses and row houses was launched in September 2013. The programme supports energy consulting/planning as well as the actual building renovation works (75-90 EUR[31] per heated gross area). The support programme has two ambition levels and three criteria have to be eligible support from the programme:

1) Heat loss number

The heat loss number of the housing unit has to be reduced by at least 30% and not exceed the values presented in the table below.

	Heat loss number for transmission- and infiltration heat losses, $H''_{tr,inf}$ W/(m²·K)		
	Houses were A_{fl} < 100 m²	Houses were 100 m² ≤ A_{fl} < 250 m²	Houses were A_{fl} ≥ 250 m²
Upgrading level 1	0,66	0,60	0,54
Upgrading level 2	0,87	0,81	0,69

Note: A_{fl} heated gross area

$H''_{tr,inf}$ heat loss number for transmission- and infiltration heat losses

W/(m²·K) watt per square meter kelvin

[29] http://www.standard.no/passivhus
[30] http://www.enova.no/about-enova/about-enova/259/0/
[31] 1NOK = 7,87EUR per 13.09.2013

2) Requirement on net energy need

The net energy need for the housing unit cannot exceed the values in the table under:

	Yearly net total energy need kWh/m^2
Upgrading level 1	100 + 1600/A_{fl}
Upgrading level 2	125 + 1600/A_{fl}

Note: A_{fl} is heated gross area,the energy needis calculated per m^2 A_{fl}.

3) Requirement to energy supplies

The heating character have to be better than red (see explanations and scale in Figure 3). This is to avoid heating concepts that solely rely on electricity or fossil fuels.

The database that will be built up by projects receiving support can be used to track nZEB building renovation cases.

The Norwegian State Housing Bank[32] provides beneficial loans for energy renovation of homes. This database can also be used to track ambitious renovation projects of single family houses.

Energy Performance Certificate as a source:

The nZEB level is so far not specifically included in the Norwegian *Energy Performance Certificate (EPC)*, nor is Passive house. The Norwegian EPC consists of an energy grade and a heating grade[33]. The energy grade ranges from A to G and are based on calculated delivered energy. The following figure shows the different energy classes for single family houses of various sizes.

[32] http://husbanken.no/english/
[33] http://www.energimerking.no/no/Energimerking-Bygg/Energimerking-av-bolig/Om-energiattesten/Energimerkeskalaen/

Småhus	Levert energi pr m^2 oppvarmet BRA (kWh/m^2)						
	A	B	C	D	E	F	G
Oppvarmet BRA (m^2)	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Ingen grense
50	101,00	147,00	195,00	257,00	321,00	410,00	> F
75	95,67	136,33	178,33	229,67	282,33	356,67	> F
100	93,00	131,00	170,00	216,00	263,00	330,00	> F
125	91,40	127,80	165,00	207,80	251,40	314,00	> F
150	90,33	125,67	161,67	202,33	243,67	303,33	> F
200	89,00	123,00	157,50	195,50	234,00	290,00	> F
300	87,67	120,33	153,33	188,67	224,33	276,67	> F
400	87,00	119,00	151,25	185,25	219,50	270,00	> F
500	86,60	118,20	150,00	183,20	216,60	266,00	> F

Figure 3: Energy classes of Norwegian EPC for single-family houses of different sizes per 01.07.2013

The heating grade is given by a five-divided colour code ranging from red (fossil fuels and electricity) to green (renewables) and ranges the building by which heating system that are installed in it. The share of electricity and fossil fuels must be below the indicated percentage values indicated to achieve that colour.

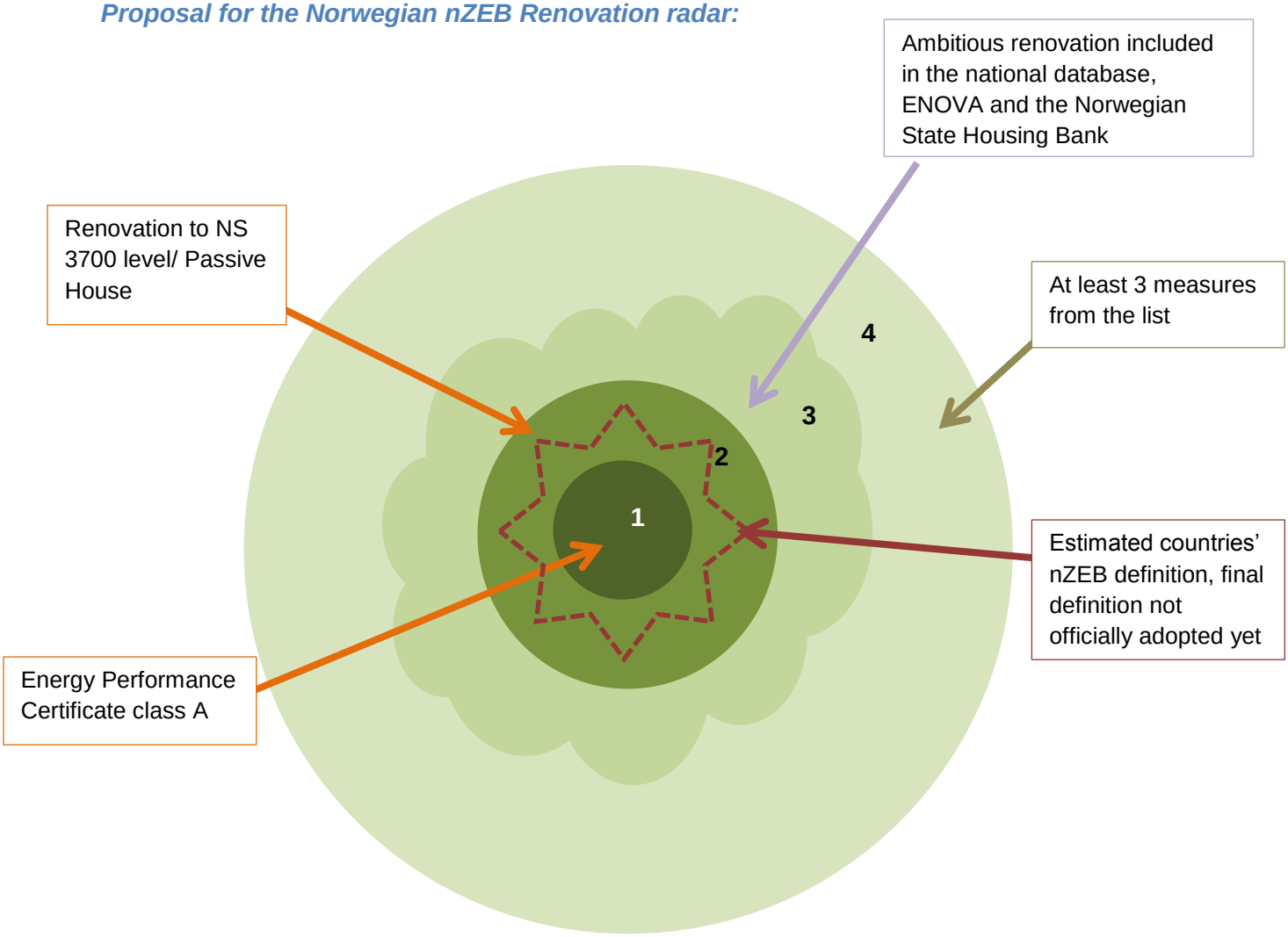
Heating grade ▼				
30,0 %	47,5 %	65,0 %	82,5 %	100,0 %

National database as a source:

Norway has a national database with best practice building examples on a range of issues (energy performance, indoor environment, universal design, etc.) where you can choose your own selection criteria (filter), like for instance passive house + single family home. The Norwegian Architects Association provides a portal to the database.[34]

[34] http://www.arkitektur.no/utvalgt-arkitektur

Proposal for the Norwegian nZEB Renovation radar:



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