CONCERTED ACTION
ENERGY PERFORMANCE OF BUILDINGS

(CT1) New Nearly Zero Energy Buildings (NZEB)

Status in 2022

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1. Introduction

Member States must implement Nearly Zero Energy Building (NZEB) requirements for new construction. The Energy Performance of Buildings Directive (EPBD) sets out that all new public buildings had to be NZEB from the end of 2018 and all other new buildings had to be NZEB from the end of 2020. CA V EPBD Core Team 1 (CT1) on New Nearly Zero Energy Buildings (NZEB) examined both energy efficiency aspects as well as the use of renewable energy in new buildings.

The work focused on large and complex buildings with special attention for public buildings. The work in this team closely coordinated with Core Team 2 – Building Codes and many sessions were developed as common sessions or with shared roles between the two teams.

With implementation of the NZEB standard required for all public and private buildings by the end of 2020, the teams shifted the focus beyond nearly zero energy and considered the gradual shift toward development of the zero energy concept for new buildings. Work on how new buildings will develop towards and go beyond nearly zero paid specific attention to: reviewing the definitions of NZEB and the definition of nearby renewable energy sources, and how cost-optimality is implemented in connection to requirements for new buildings.

Ventilation and indoor air quality are important elements in the work with NZEB. The team looked at an example where one Member State displayed an indoor climate specific indicator on the front page of the Energy Performance Certificate (EPC), showing the risk of overheating during the summer period.

2. Objectives

A key element of the EPBD is the requirement for NZEB. Article 9(1) of the EPBD requires Member States to ensure that:

(a) by 31 December 2020, all new buildings are nearly zero-energy buildings; and

(b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

Member States must further draw up national plans to increase the number of NZEB, which may include targets differentiated according to the category of building.

Article 9(2) provides that Member States must develop policies and take measures such as the setting of targets to stimulate the transformation of buildings that are refurbished into NZEB and provide updates to the European Commission in their national plans.

Article 9(3) states that 'The national plans shall include, inter alia, the following elements:

(a) the Member State's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and including a numerical indicator of primary energy use expressed in kWh/m^2 year

(b) intermediate targets for improving the energy performance of new buildings, by 2015

(c) information on the policies and financial or other measures including details of energy from renewable sources in new buildings and existing buildings undergoing major renovation in the context of Article 13(4) of Directive 2009/28/EC and Articles 6 and 7 of this Directive.'

This Core Team leads work and reports progress on the following articles of the Directive 2010/31/EU:

- *Article 2 – Supporting the national application of the definition of NZEB.*

Article 2 defines a 'nearly zero-energy building' as a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be provided to a very significant extent by energy from renewable sources, including renewable sources produced on-site or nearby.

Examples from Members States of definitions of NZEB facilitate comparison, discussion, and development of national definitions.

- *Article 6 – New Buildings*

Member States present and discuss how Member States plan to implement NZEB requirements in new buildings, covering topics such as envelope U-values, renewable energy sources, primary energy use and the role of Energy Performance Certificates (EPCs).

- *Article 9 – 'Nearly-zero energy buildings*

This includes the application of the definition, the development of National Action Plans, and reporting on progress in increasing the number of NZEB.

CT1 further supports work on the development of the calculation methodology and cost-optimality for new buildings (Article 3, 5 and Annex I and III), electro-mobility (Article 8a), certification of, and finance for new buildings (Article 10 and 11). The team supports all articles and elements relevant for NZEB.

CT1 contributed to sessions of other core teams on these topics:

- Further development of definition of Nearly Zero Energy Buildings
- Nearly Zero Energy public buildings from 2019
- National action plans for NZEB
- Levels of renewable energy, nearby systems
- Reporting on NZEB development
- NZEB development beyond 2021.

3. Analysis of Insights

3.1 NZEB requirements for Renewable Energy Sources (RES)

For newly constructed buildings, the level for NZEB requirements is set by the individual Member State based on cost-efficiency / cost-optimality studies. Comprehensive calculation methodologies are essential to ensure that renewable energy requirements for new buildings are designed and delivered in practice. The EPBD recast Article 9 requires Member States to ensure that new buildings use nearly zero energy, and the very small amount of energy required should be mainly from renewable sources, including from renewable sources produced on-site or nearby.

3.1.1 Renewable Energy Sources (RES)

Because the NZEB requirement applied initially to new public buildings, from 2018, many of the early NZEB examples are public buildings. Public buildings, e.g., hospitals and other complex public buildings, have specific user profiles and needs that generally lead to high energy consumption. The NZEB requirement for any energy to be provided from renewable sources can be challenging in these public buildings for technical, economic, and practical reasons such as space constraints.

Member States may have one or more forms of requirement: energy performance, carbon performance and renewable energy requirements. In NZEB, the renewable energy system must be on-site or nearby and physically connected to the building. RES technologies include heat pumps, solar water heaters, photovoltaics, biomass-burning systems, technologies for electricity production from renewable energy (wind, water turbines, etc.) and free cooling.

If there is a high share of electricity supplied to the building from RES there may be a reduced or no requirement for on-site renewable energy generation. NZEB and RES requirements should also factor in any electricity that is exported to the grid.

In determining the impact on the energy performance of the building, Member States may differentiate between imported and exported electricity produced by on-site RES. For example, Member States might choose to create incentives to export RES to the grid by applying a higher primary energy factor for exported electricity.

Status of selected Member States in 2018

Estonia

An NZEB must be built with best practice energy efficiency and renewable energy solutions in a technically reasonable fashion, and it must achieve the low energy building requirement without on-site electricity generation. There are requirements for non-renewable primary energy, but there are no RES share requirements so lower energy use is always better.

The energy performance requirement for buildings is based on primary energy use only. Energy performance requirements are linked with EPC classes.

The NZEB requirement will be class A. Delivered energy is determined by system efficiencies, and there is also a calculation of how much of the renewable energy generated is used on site versus exported.

After a change in 2018, exported energy no longer reduces the primary energy figures; only renewable energy consumed in the building counts, on an hourly basis.

The EPC will display total renewable energy generated on-site separately from the renewable energy used in the building. By comparison, in other Member States the EPC includes exported renewable energy.

Bulgaria

The definition of NZEB is in two parts: primary energy consumption (including appliances) must be class A; and at least 55% of final energy (excluding appliances) must be covered by RES, which must be sourced within 15 km of the building. The most effective RES technologies for Bulgarian conditions are heat pumps, solar water heaters, photovoltaics, biomass-burning systems, technologies for electricity production from renewable energy (wind, water turbines, etc.) and free cooling.

Passive solar systems and solar cooling are also effective, but these are not widely used. Waste heat and cooling are not regarded as RES.

Ireland

Requirements are set in terms of primary energy, emissions, and the proportion of total primary energy that is from renewable sources (the renewable energy ratio, or RER).

The RER must be at least 20%, or 10% where the primary energy and emissions are 10% lower than minimum requirements.

The RER is calculated in line with ISO 52000 standard and the renewables must be produced on-site or nearby.

The technologies included are photovoltaic, solar heating, wind, heat pump, biomass/biogas, district heating, and combined heat and power.

Heat pumps for cooling do not count towards the renewable energy figure.

Full credit is given for renewable energy exported to the grid, but there is debate as to whether the assessment should differentiate between energy used on-site and exported energy.

The RER requirement is difficult to achieve for energy-intensive buildings such as data centres and hospitals. There are similar challenges with mid-/high-rise office blocks in city-centre locations due to limited roof space and technical building system equipment rooms.

Conclusions from 2022 discussions

The EPBD and the Renewable Energy Directive (Directive 2009/28/EC) are considered complementary and mutually supportive frameworks in relation to renewable energy sources. The revised EPBD makes buildings fit for renewables, whilst the REDII makes renewables fit for buildings.

Some key challenges regarding the requirement for renewable energy from nearby sources might be expected in the future:

- space limitations;
- on-site production could be more expensive;
- impact on scenic views;
- the definition could be limiting;
- building permits could be difficult to obtain.

3.1.2 Primary Energy Factors (PEF) - for renewable and non-renewable sources

The European Committee for Standardisation (CEN) presented a reporting template on Primary Energy Factors (PEFs) for renewable and non-renewable sources. A survey of 25 Member States found that PEFs are not regularly updated. They are typically only reviewed to see if updates are necessary. PEFs vary significantly between Member States.

There are several possible reasons:

- For conventional carriers such as fossil fuels, PEFs do not vary greatly (between 1-1.2) whereas for less established and centralised carriers such as biomass and biofuels much greater variations are observed (between 0.0-1.3).
- Electricity will have great PEF variations (between 0.0-3.0) as renewable energy sources become more prevalent.
- District Heating PEFs vary significantly (0.0-1.6) across Member States as they are influenced by parameters such as cogeneration, type of source (renewable or not), and waste heating.
- 18 of 24 Member States do not use different PEFs for some sectors or technologies, for example for photovoltaic systems.
- 21 of 24 Member States base their PEFs on national standards.
- 14 of 24 Member States use different primary energy factors or weighting factors for individual district systems.

There are aspects of PEFs calculations that will require further discussion, such as improving guidance on policy and transparency behind PEF calculations.

Highlights of 3.1	The renewable energy component of electricity from the grid influences the requirement to install on-site or nearby RES for buildings. NZEB can be defined using primary energy or a combination of primary energy and other factors including minimum on-site renewable energy. The factors applied to the import and export of energy from buildings are important elements of the NZEB requirement for RES.

Main Outcomes of 3.1
The application of the NZEB requirement should be reviewed at the national level, to account for the experience gained from buildings that have already been completed and the evolving electricity generation fuel mix from the grid. It was suggested that while RES is desirable, it should primarily be generated for use in the building.

3.2 NZEB regulations for public buildings

In general, the NZEB definition is the same for public buildings and for other buildings. The EPBD has no specific requirements for the envelope or technical building systems that relate only to public buildings. Some Member States have adopted the same approach but they may, however, choose to set specific requirements for public buildings.

In many Member States, there are separate requirements for residential and non-residential buildings and, often, there are also sub-categories for non-residential buildings. For example, in some countries, sub-categories include schools, offices, hospitals, industrial buildings, retail, hotels and other buildings.

Consideration should be given to whether there should be different treatment for renewable energy used on-site or exported. On the other hand, well-insulated and airtight buildings can have problems with overheating and internal environmental quality. Regulations should ensure that windows and ventilation systems are appropriately sized.

Most Member States base their NZEB requirements on the date when design process begins. It is difficult to base requirements on the completion date because development may have started before the NZEB regulations were in place. Building codes typically include transitional arrangements to account for projects that have begun construction or are at an advanced stage of design.

It is important to make the technical building system operation as simple as possible for building owners to use so that they can understand how their nearly zero energy building is intended to be operated and consequently also the purpose of the technical building system. It was also noted that engagement between the designer, the technical building system installer/commissioner and the building owner is vital.

The main challenges identified at the Concerted Action 2018 meeting were sufficient funding and lack of knowledge. Public budgets often operate under strict rules, and it can be difficult for small public authorities to implement NZEB measures because they often do not have the required resources (knowledge, finances, etc.)

Furthermore, another challenge for renovation to NZEB levels was that existing and historic public buildings tend to be in central areas where measures that can be taken are restricted.

Highlights of 3.2	Most Member States base their NZEB requirements on the date of the start of the design process. It is difficult to base requirements on the completion date because development may have started before the NZEB regulations were in place.

Main Outcomes of 3.2
The major challenges identified were sufficient funding and the lack of knowledge. It was suggested that although RES is desirable, the energy should primarily be generated for use in the building.

3.3 NZEB and major renovation requirements in building codes

The EU energy efficiency policy framework aims to realise the potential of cost-effective energy savings of the building sector by increasing the rate and the depth of renovations and significantly improving the energy performance of buildings.

Improvement in the depth and rate of building renovation will need a better understanding of the effectiveness of policy measures and market support mechanisms. Unfortunately, there is a lack of quality data on the impact of current energy efficiency policies on the building stock across Member States. The current statistical framework for the construction sector does not provide clear information on the renovation of existing buildings or the energy renovations of buildings.

Better instruments for the monitoring and registration of building efficiency / energy performance are essential. Renovation passports, which are proposed in the 2022 EPBD recast, could be the vehicle for registration of improvement / renovation activities to be catalogued and monitored.

Consumers generally associate renovations with maintenance and repair. Building professionals generally have slightly different motivations from owners or residents.

Global warming, environmental impact and health effects seem to be priorities for contractors and designers. Contractors focus on new construction over renovation. Architects put priority on the integration and adoption of renewable energy, especially for non-residential buildings.

Financial, administrative, and technical aspects are the main barriers for consumers. Building owners and tenants tend to see cost and lack of financial support as an obstacle to renovation, more so than landlords. It is important to map these perspectives and to develop incentives to stimulate deeper renovation. Energy bill savings can encourage building owners to invest in major renovation, along with indoor comfort and air quality.

In the renovation or construction process it is vital to involve all professionals and skilled workers early in the design phase and keep them engaged through to the completion of the project so that they are aware of developments and can advise on best practice when needed.

Across Member States, the skill level and number of skilled professionals needs to be increased. NZEB renovation often goes beyond the interest of those directly involved with the building. There will need to be incentives in order for NZEB to be widely adopted. The owners and occupiers require detailed recommendations on the steps to complete an NZEB renovation, and reassurance that the renovated building will achieve the NZEB level of performance. In order to encourage consumers, subsidies, grants, low interest loans or tax rebates for energy renovation are important.

Highlights of 3.3	National administrations play an important role to ensure suitable framework conditions for financing deep renovations. Financing periods should be aligned with the utilisation period (typically at least 30 years) wherever possible.

Main Outcomes of 3.3
In the renovation or construction process it is vital to involve all professionals and skilled workers early in the design phase and keep them engaged through to the completion of the project so that they are aware of developments and can advise on best practice when needed. Advice should be provided to building owners and users so that they can monitor their energy performance to check that consumption meets expectations.

3.4 The role of Energy Performance Certificates (EPCs) in promoting NZEB and energy renovation

Currently, the implementation and content of EPCs varies quite considerably across the Member States. Experience has shown that building owners and users tend to ignore the more detailed advisory report and only read the certificate itself.

For the next generation, it is important to design EPCs to be more accessible and user friendly. Certification data for statistics is extremely valuable. For example, the data can be used in national equivalence reports (for Articles 14 and 15 of the EPBD) and to support national building renovation planning, developing national energy and climate plans, etc. EPC databases can help to assess which regions within Member States require the most support to implement building efficiency improvements.

An example of this is Ireland's Building Energy Rating Database which gathers statistical data on the Irish building stock from EPCs on a quarterly basis. This enables the Sustainable Energy Authority of Ireland to assess trends in both new and existing buildings and log the types of heating systems installed. It also makes it possible to identify areas where renovation should be encouraged.

Discussions at the Concerted Action meeting in 2019 focused on the content included in EPCs, and what should be included in future versions of EPCs. Several Member States have already looked at linking the EPC to a Building Renovation Passport. There is consensus that the Building Renovation Passport should be used as depository of detailed information on the building, with the EPC included alongside other documentation and technical reports. The Smart Readiness Indicator (SRI) could be included in this documentation. With the General Data Protection Regulation (GDPR), there are concerns about what parties can have access to the data. This will need to be addressed as more data are kept in the EPC database.

It was noted that overheating and daylighting do not tend to be featured in current EPCs and were seen as possible additions.

The Flanders EPC directly promotes NZEB: 'Class A' is equivalent to a NZEB, and the EPC advisory report includes recommendations on how to achieve Class A status for buildings that fall short.

In some Member States, work is currently being undertaken to incorporate the Building Renovation Passport with the EPC.

Standardisation across the EU of the energy scale displayed on EPCs would facilitate wider comparison, but would be particularly challenging. In updating methodologies or reclassifying energy scales, countries should be careful to make sure they are transparent across regions. This might require each country to adopt a similar calculation methodology which is currently not the situation.

To improve EPCs and encourage building renovation alongside the development of NZEB, priorities should include:

- accessibility of the EPC certificate and report, so that it is understandable for the average user;
- mandatory reference to NZEB within the EPC and advice on how to achieve a NZEB level;
- establishing a link between the EPC and other tools, such as the Building Renovation Passport and the Smart Readiness Indicator;
- collection and analysis of statistical data via the EPC;
- ensuring quality of the energy performance assessor;
- including indicators of overheating and daylighting;
- including real energy consumption and comfort levels.

Highlights of 3.4	The use of EPC data for statistics is extremely valuable. The data can be used in national building renovation planning and writing national energy and climate plans. EPC databases can also help to assess which regions within the Member States require the most support in implementing building efficiency.

Main Outcomes of 3.4
The top three priorities for EPC development should be: accessibility of the EPC certificate and report, so that it is understandable for the average user, inclusion of a reference to NZEB within the EPC and advice on how NZEB can be achieved, and establishing a link between the EPC and other tools, such as the Building Renovation Passport and the Smart Readiness Indicator.

3.5 Building energy renovation – uptake of NZEB

At the 2019 Concerted Action meeting, most Member States agreed that the methodology being developed on data gathering needed to be very robust in order to support the EU Building Stock Observatory database.

The similarities of thinking between consumers, contractors, installers and architects offered many insights. But it was even more valuable to observe the differences in the views among the renovation and new-build industries. This led to the conclusion that in the renovation or construction process it is vital to involve all professionals and skilled workers early in the design phase and keep them engaged through to the completion of the project so that they are aware of developments and can advise on best practice when needed.

While there are encouraging signs of the uptake in NZEB both in newbuild and renovation, there is still some way to go to make the process market viable and broadly successful.

The groups highlighted that communication with the customer is key. Whether the customer is a housing association, landlord or private tenant, it. Is very important for them to understand what will be done to the building, how that will impact them and their energy bill, as well as where the financing will come from.

The initial modelling and design phases are crucial to credibility and success. The system needs to have been well tested and be proverbially ‘bullet proof’ when it comes to its efficiency. Without a product that will achieve (and has been proven to achieve) what it says, there will be no trust from the clients. Everything depends on the consumer/investor being confident of the entire process.

Financing was highlighted as a common challenge throughout. Access to appropriate financing is essential.

Highlights of 3.5	Communication with the customer is key. Whether the customer is a housing association, landlord or private tenant, the knowledge share of what will be done to the home, how that will impact them and their energy bill, where the financing will come from, etc. is very important. The information needs to be freely accessible to all involved stakeholders.

Main Outcomes of 3.5
Financing is likely to be challenging in all Member States. Access to appropriate financing is essential. Building owners need to be incentivised to invest in a renovation and need to have confidence that the renovation will achieve the expected energy performance and other benefits.

3.6 NZEB in cold climates

The European standard for ventilation of buildings, EN16798-1:2019 divides Europe into four regions: Mediterranean, Oceanic, Continental, and Nordic.

Recommendations are provided for each region because of the differing conditions. For example, in the Nordic region, the net primary energy use ranges from 40-65 kWh/m² year for new residential houses. This is the value that Member States within this region should target. The standard for Nordic countries stipulates that only heating ventilation and air-conditioning should be included as an energy use. Nonetheless, Estonia, Finland and Norway take account of heating ventilation and air-conditioning, appliances and lighting, whilst Sweden takes account of heating ventilation and air-conditioning and facility lighting.

In Denmark, the electricity for appliances is not considered within residential buildings, but the internal heat gains from these appliances are included.

The ‘Nordic-Baltic Project’ on zero energy buildings was established to collect examples of NZEB as well as compare the requirements and performance of the buildings.

The project concluded that:

- Having two sets of requirements, with and without inclusion of renewable production, is helpful for comparison purposes.
- The Oceanic zone EN 16798-1:2019 recommendations for primary energy appeared to require relatively higher energy performance compared to the Nordic zone recommendations.
- Recommendations are typically met with the provision of ground source heat pumps and extensive photovoltaic installation.
- Estonian requirements complied closely with EN Nordic NZEB recommendations.
- Finnish requirements were less strict and did not fulfil the EN Nordic NZEB recommendation.

In accordance with the EN recommendations, Denmark is considered part of the Oceanic region. The other Member States located in the Oceanic region have climatic variations. With Denmark likely to be at the colder end of the range, it would make it harder to fulfil the recommendations outlined by the EN.

From the responses of 23 Member States, 17 stated that no NZEB building example accompanied their national NZEB requirements, whilst six (6) confirmed that they had examples.

Thirteen (13) Member States replied that their national NZEB requirements follow the recommendations in EN16798-1:2019, whilst eight (8) stated that they did not follow the recommendations.

The Horizon 2020 CoNZEBs project identified and evaluated technological solutions that could result in significant reduction of consumption and operational costs, lifecycle costs and lifecycle environmental impacts from new NZEB.

Within the CoNZEB project, a Danish example concluded that it is possible to identify cost savings if there is careful building design and the use of photovoltaic or solar thermal collectors as opposed to extra insulation, will lower the price. Heat recovery from greywater was also an economically viable solution.

Results from examples in Germany, Italy, and Slovenia concluded that, overall, the reduction in investments varies from 1 €/m² (with slightly better energy performance) to 94 €/m², with the largest cost reduction shown in one of the Italian examples.

NZEB in Ireland are controlled through Part L of the building regulations for both domestic and non-domestic buildings, although different requirements are outlined for each. In order to assess whether a building has met the NZEB standard, it is compared to a notional building to determine its level of performance. There are minimum performance levels required in relation to the fabric, thermal bridging and air permeability, with minimum efficiencies for space heating and hot water systems also outlined.

It is difficult to compare the energy performance requirements across Member States. Although it may not yet be possible to compare solutions directly across the climate zones, it is possible to adapt the solutions from other Member States.

Highlights of 3.6	The 'Nordic-Baltic Project' on zero energy buildings was established to collect examples of NZEB, and compare the requirements and performance of the buildings. The CoNZEBs project was carried out to identify and evaluate technological solutions that could result in significant reduction of consumption and operational costs, lifecycle costs and lifecycle environmental impacts from new NZEB.

Main Outcomes of 3.6
Results of the 'Nordic-Baltic project' showed that the Oceanic zone EN recommendations for primary energy appeared to require relatively higher energy performance compared to the Nordic zone recommendations.

3.7 NZEB development beyond 2021 – status in Member States

The progress of NZEB implementation in Member States was reviewed in 2019, focusing on the results and challenges in the implementation of NZEB. There was also discussion on future NZEB requirements and possible priority areas that could be implemented in the review of the EPBD.

The Joint Research Centre (JRC) summarised the results in its report 'Assessing Nearly Zero Energy Buildings (NZEB) development in Europe', published in 2021. The report provided an overview of the implementation of national definitions and energy performance values for new, existing, residential, and non-residential buildings in Member States. It provides a comprehensive analysis of the European NZEB implementation depicting a positive overall progress improvement for NZEB definitions, uptake, technology development, and energy performance levels. Some of the relevant conclusions showed that:

- NZEB requirements are on average 70% better than 2006 national requirements.
- NZEB performance levels appear to be more ambitious than cost-optimal.
- NZEB clearly contribute to meeting climate and energy targets.
- NZEB alleviate environmental, social and ethical discrepancies.
- NZEB fight energy poverty, especially for retrofit.

A Poll Everywhere survey was undertaken to understand the views of Member States on NZEB. It showed that:

- 54% of participants agreed that NZEB have been fully implemented in their own country.
- 11% of participants confirmed that buildings built in 2020 are close to 100% NZEB;
- 30% of participants confirmed that 50% or less of 2020 buildings are NZEB;
- going beyond NZEB, 74% of participants considered that renewable energy should play a bigger role.

Highlights of 3.7	The JRC summarised the results of its 2021 report on the uptake and status of NZEB implementation from 2021. The report provided an overview of the implementation of national definitions and energy performance values for new, existing, residential, and non-residential buildings in Member States.

Main Outcomes of 3.7
A Poll Everywhere survey found that, going beyond NZEB, the majority of participants considered that renewable energy should play a bigger role in future building energy performance requirements.

3.8 NZEB development beyond 2021 – future planning

Concerted Action discussions in 2021 focused on future NZEB requirements and considered possible priority areas for the review of the EPBD. Participants concluded that there is a need for further discussion on fossil fuels, lifecycle emissions, global warming potential, healthy indoor climate conditions, adaptation to climate change, fire and seismic safety and accessibility for persons with disabilities.

Participants highlighted the difficulty of implementing the zero emission principles into buildings higher than five storeys, because of insufficient space for renewables. This problem could be solved by locating renewables off-site where the community has the infrastructure to accommodate this.

Without a direct connection to renewable sources, grid instability problems could arise. These problems could be resolved if grid operators and building designers work together to engineer a solution that would work for the grid and for buildings.

Positive energy neighbourhoods and buildings, as opposed to buildings that are just zero energy and zero emissions, were discussed.

Some Member States expressed concerns about the destabilisation of the grid. On the other hand, positive energy buildings might not damage the grid because they can meet the new growth of demand for energy from buildings that do not currently have on-site renewables, and from electric vehicles that are charged from buildings.

In order to keep the grid balanced and to promote self-consumption and cost-optimality, it should not be necessary for all buildings to produce energy. The Sustainable Plus Energy (SPEN) concept for buildings encourages analysis of the average energy balance of a neighbourhood, rather than individual buildings.

It is thought that not all buildings will need to contribute electricity to the grid in order to be compliant with the next revision of the EPBD. For example, buildings with a small roof area compared to their height or shaded buildings might not be technically and economically suitable for a large amount of solar photovoltaics. Heat pump technology or other renewable technologies might be more suitable in those buildings.

Building designers should have flexibility to choose the renewable technologies that best suit each building in achieving NZEB compliance, considering cost-optimality and self-consumption.

It is important that the EPBD is technology-neutral in order to allow for possible integration of emerging and developing renewable technologies.

The topic of zero emission buildings (ZEB) should be discussed at future plenary meetings in the context of the update to the EPBD in 2021/2022.

In future revisions of the EPBD it will be important to define the calculation methodology for a ZEB.

Highlights of 3.8	Some Member States expressed concerns about the destabilisation of the grid. On the other hand, positive energy buildings might not damage the grid because they can meet the new growth of demand for energy from buildings that do not currently have on-site renewables, and from electric vehicles that are charged from buildings. To keep the grid balanced and to promote self-consumption and cost-optimality, it should not be necessary for all buildings to produce energy. The Sustainable Plus Energy (SPEN) concept for buildings encourages analysis of the average energy balance of a neighbourhood, rather than individual buildings. Further discussions need to be held on a zero energy (ZEB) definition, EPC harmonisation, fossil fuels, lifecycle emissions, global warming potential, healthy indoor climate conditions, adaptation to climate change, fire and seismic safety, and accessibility for persons with disabilities.

Main Outcomes of 3.8
The topic of zero emission buildings (ZEB) should be discussed at future plenary meetings in the context of the update to the EPBD in 2021/2022.

3.9 NZEB – beyond energy performance and energy use

The 2022 Concerted Action meeting shared experience of NZEB implementation. The sessions delved into how various elements affect energy use and explored current and future potential NZEB requirements for EPBD CA VI.

Estonia – new build

In Estonia, NZEB requirements state that an EPC of at least class A must be attained for new buildings and a minimum EPC class C for major renovations. The energy performance values are based on non-renewable primary energy, with the energy performance calculation focused on the energy consumed within the building.

Exported energy is not accounted for within the energy performance calculation. The calculations consider all lighting, appliances, and internal heat gains. Under the requirements of the EPBD, only a small fraction of lighting would be included, and appliances would not be accounted for at all.

In addition to the requirement for an EPC class A for a new NZEB, an EPC class B is required without on-site electricity generation. To attain this B class, the energy efficiency cannot be compensated by on-site renewable energy generation.

Once an EPC class B has been obtained, the next step would be to incorporate the on-site electricity generation to reach class A. There are exceptions to these NZEB requirements if the building is not suitable for photovoltaic installation.

For example, if the building is particularly high, there is limited roof space and where the photovoltaic generation will be below 70% of the optimum. In such cases, the EPC class can remain between A and B.

The Estonian regulation allows for renewable energy generation to be either on-site or nearby. If the RES is nearby, it needs to be directly connected to the building via cable or pipeline. Therefore, it is not possible to transport this energy via a grid or district heating network. This requirement led to the creation of the largest photovoltaic plant in Tallinn -- 24,000 m^2 and producing 1.4 MW. The photovoltaic plant simultaneously services many office buildings within the same area.

Estonian regulations also set out building categories that include four different types of residential buildings, as well as industrial buildings and warehouses. These distinctions of building categories are not required in the EPBD but they were considered advantageous in Estonia.

Figure 1 below displays the building categories and compares the Estonian NZEB requirements with the EPBD.

Building category	A (EST)	A(EPBD)
1) Detached house <120 m^2	145	89.4
2) Detached house 120 - 220 m^2 and row houses	120	73.4
3) Detached house >220 m^2	100	59.5
4) Apartment buildings	105	45.9
5) Office buildings	100	62.1
6) Shopping and terminals	160	154
7) Hotels	145	138
8) Restaurants	130	118
9) Public buildings	135	135
10) Educational buildings (schools)	100	82.6
11) Daycare centers	100	90.0
12) Health care buildings	100	83.7
13) Military barracks	170	85.9
14) Industrial buildings	110	68.7
15) Warehouses	65	65.0

Figure 1. Displays the building categories and compares the Estonian NZEB requirements with the EPBD in kWh/m^2 year.

The differences between the EPBD requirements and Estonian requirements are because the Estonian requirements account for lighting and appliances. This changes the primary energy values. The difference in value can be quite significant, for example in the case of apartment buildings, where the Estonian requirement is 105 kWh/m^2 year whilst the EPBD requirement is 45.9 kWh/m^2 year.

It is important to establish two sets of requirements for NZEB, i.e., requirements including and not including RES generation. This accounts for situations where on-site RES cannot be installed. These exceptions are necessary, otherwise construction could be blocked.

Estonia - major renovation

For major renovations, Estonian regulations require a minimum EPC class C. A building must achieve at least a class C to qualify for the national renovation grant scheme. Other financial support schemes require class B as a minimum.

Various solutions have been developed for renovations in multi-family houses. In one example, a new centralised heat recovery ventilation system was installed in conjunction with additional insulation. Ductwork was installed on the facade at the same time as the additional insulation. In order to minimise the level of disturbance to building occupants, there was no ductwork installed in the apartments.

In another case, a new mechanical ventilation system was installed, whereby heat was collected from the roof and the exhaust air was pumped to the basement to transfer the heat.

A comparison of NZEB requirements between Estonia and other Eastern European countries is summarised in Figure 2.

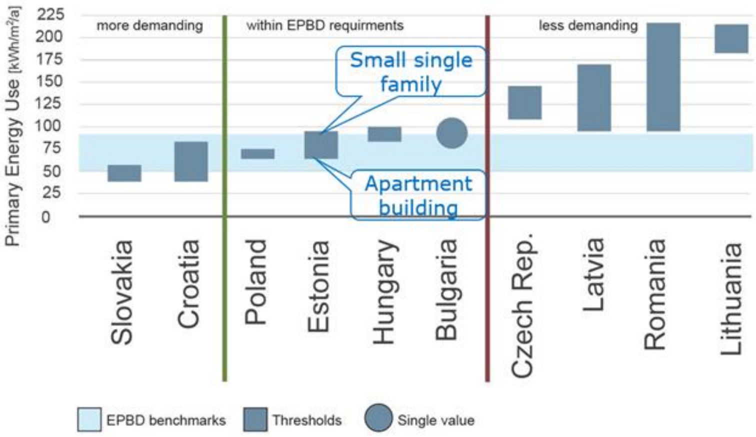

Figure 2. A comparison of NZEB requirements between Estonia and other Eastern European countries.

Estonian buildings perform well, with requirements for small single-family homes and apartment buildings being within the EPBD requirements. Estonian NZEB requirements for apartment buildings are more stringent than for small single-family homes.

A study was undertaken for countries located within the Nordic climate, including Estonia, Finland and Denmark. The results of this study are presented in Figure 3.

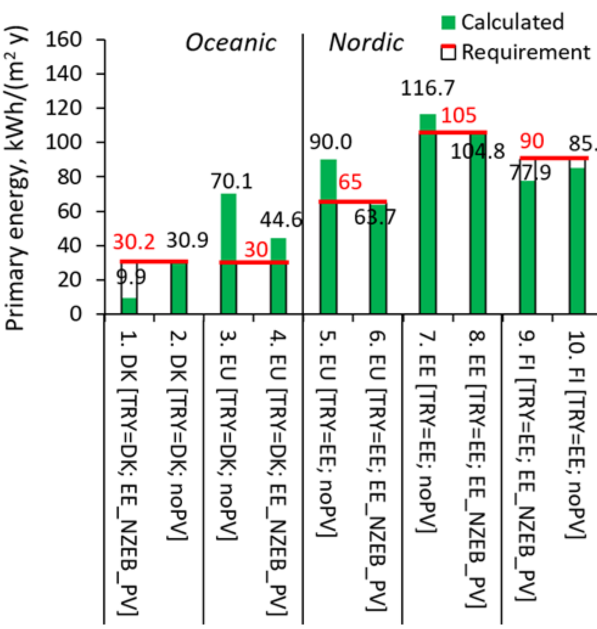

Figure 3. A comparison of NZEB requirements between countries located within the Nordic climate.

A national methodology was used to determine the European input data. This was then compared against the input data from the European Standard for the regulation recommendation. The results of the study found that the Estonian NZEB closely followed the European Commission (EC) Nordic NZEB recommendations.

The Netherlands

While Dutch EPCs do not address indoor climate in much detail, on the front page of the EPC there is an indoor climate specific indicator called the temperature overshoot in July (TO_{July}). This indicator shows whether there is a risk of overheating during the summer period in residential buildings.

Furthermore, the EPCs also look at ventilation, drawing attention to airtightness.

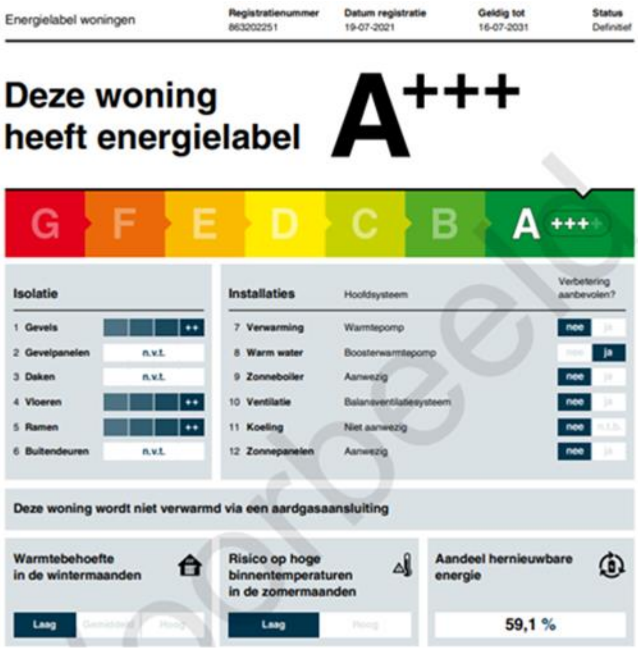

Figure 4. Front page of the Dutch EPC, with overheating risk in the bottom, middle box.

Denmark

Energy performance requirements for new buildings were introduced in stages in 2010, 2015 and 2020. Requirements were more ambitious than those of the EPBD. The requirements were amended following an evaluation of the 2020 requirements undertaken in 2018, when it was found that the energy performance requirements were no longer cost-optimal.

The EC was informed of the change to the definition of NZEB. The more ambitious 2020 requirements were kept as a voluntary building class, which allowed more ambitious projects to pursue them.

The more ambitious requirements associated with the building envelope and ventilation systems were implemented into the building regulations with slight modifications.

As a result of these more ambitious requirements, new buildings are often built to a high standard. The average data for a new building can be found below. Although there are no requirements for heat recovery, this has been adopted by many as an optional measure.

Average data for new buildings:

- Insulation:
  - Wall: 0.15-0.16
  - Roof: 0.08-0.09
  - Slab on ground: 0.08-0.09
  - Windows: 0.8-1.0
- Installations
  - Energy efficient heat supply
  - District heating: 60-75%
  - Heat pump: 20-30%
  - Gas/biomass: 5-10%
  - Photovoltaics: 20-50%

In Denmark, because most recently built buildings include a large share of renewables and have a high energy performance standard, there is more focus on lifecycle assessments and the embodied CO_2 in materials.

Highlights of 3.9	NZEB requirements in Estonia state that an EPC of at least class A must be achieved for new buildings and a minimum EPC class C for major renovations. The energy performance values are based on non-renewable primary energy, with the energy performance calculation focused on the energy consumed within the building. Exported energy is not accounted for within the energy performance calculation. The calculations also consider all lighting, appliances and internal heat gains, whereas EPBD requirements would only include a small fraction of lighting in these calculations, and appliances would not be accounted for at all. Dutch EPCs do not address indoor climate in much detail, however on the front page of the EPC there is an indoor climate specific indicator called the temperature overshoot in July (TO_{July}). This indicator shows whether there is a risk of overheating during the summer period in residential buildings. Energy performance requirements in Denmark, for new buildings were introduced in stages in 2010, 2015 and 2020. Requirements that were in place were more ambitious that those of the EPBD. An evaluation of the 2020 requirements undertaken in 2018 concluded that the energy performance requirements were no longer cost-optimal, and the requirements were amended.

Main Outcomes of 3.9
It is important to set two sets of requirements for NZEB, i.e., requirements including and requirements not including RES generation. This accounts for cases where on-site RES cannot be installed, e.g., for high buildings, or buildings where there is a lot of shading. Such exceptions are necessary to avoid blocking new construction and major renovations. The uptake of major renovations benefits from the provision of financial incentives. Future discussions should address the definition of zero emissions buildings, the use of climate data for the design and construction of buildings, and cost-optimality for renovations vs newly built NZEB.

4. Lessons Learned and Recommendations

During the course of the CA EPBD V, NZEB evolved from theory (a concept in the 2010 EPBD) to reality, with implementation dates starting in 2018 for public buildings and 2020 for all other buildings. Throughout this period, the CA EPBD focused on many aspects that are discussed in this report from CA EPBD Core Team on New Nearly Zero Energy Buildings (CT1).

Challenges, successes and areas for future discussion about NZEB implementation were identified as described below.

Challenges:

- External factors can have an influence on NZEB implementation, e.g., on energy price changes, security of supply issues, inflation, and interest rates.
- Material costs and availability are a major issue. Energy is a significant driver of material costs due to transportation and the energy used in manufacturing. Life cycle analysis will be an important element in future revisions of the EPBD, and therefore proximity of manufacturing to material destination will become increasingly important.
- Aligning EPBD requirements with cost-optimality. The assumptions underlying the EPBD requirements are subject to significant change, e.g., energy price inflation, interest rates, etc. The 5-year cycle of the cost-optimal reports may need to be shortened.
- The lack of skilled construction workers, trades, manufacturing and professionals affects overall implementation. NZEB evolving into future ZEB will require skilled design and construction professionals. Member States should activate plans to ensure availability of sufficient workers.
- The nearby and on-site boundaries for RES. The focus is changing from the individual building to a community focus. For example, better solutions may be available at community level due to economies of scale with shared ownership.
- Finding the optimal balance between energy efficiency and RES supply for NZEB is essential but complex. A minimum level of energy efficiency should be required before RES are considered in the NZEB calculation, with RES also being a requirement.

There are important successes:

- There has been job creation within the construction sector, e.g., energy assessors and auditors, and many more. The creation of the NZEB label facilitated awareness in the construction sector and beyond.
- There are best practice examples of the integration of RES into buildings. NZEB has been one of the drivers for the scaling up of the renewable energy technologies for buildings. NZEB created market demand for low energy buildings and accelerated more ambitious building codes.
- There are encouraging innovative design solutions. NZEB major renovations are being carried out on a large scale in multi-family developments/units.
- Governments have been motivated to invest in the construction sector and in climate action.

Future discussion and analysis are needed on the following topics:

- definition of zero emissions buildings;
- minimum energy performance standards (MEPS) for existing buildings;
- harmonisation of the EPC scale as a means to support EU-wide monitoring and solutions;
- integration of the use of climate data for the design and construction of buildings;
- cost-optimality for renovations versus newly built NZEB;
- Life Cycle Assessments;
- Building Renovation Passports and the path to NZEB for existing buildings to benefit owners and tenants so they can better understand the path to meeting long-term objectives;
- Smart Readiness Indicators as buildings' performance becomes more and more digitalised.

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