June 2024

EPBD.wise

Bringing European Building Policy to Life

National Building Renovation Plans and Zero-Emission Buildings

Policy needs and best practices

Authors: Ece Özer, Irma Imamovic and Lukas Kranzl (TU Wien); Gabriella Azzolini, Silvia Di Turi, Francesca Hugony and Fabio Zanghirella (ENEA)
Reviewers: Denisa Diaconu, Jules Oriol and Caroline Milne (BPIE); Martin Pehnt (Ifeu); Francesca Conselvan (e-think energy research)

This project has received funding from the European Union's LIFE programme under grant agreement No.101120194.
Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.

Project number	101120194
Start date of the project	October 2023
Duration of the project	33 months
Deliverable number	D2.1
Deliverable leader	TU Wien

About EPBD.wise

EPBD.wise aims to kickstart action to bring to life the recast European Performance of Buildings Directive (EPBD) as part of making EU climate goals a reality. Over the course of three years, project partners worked with public authorities (such as municipalities, energy agencies, etc.) in six European countries: Bulgaria, Greece, Hungary, Poland, Romania and Ukraine. The aim overarching aim was to ensure the design, implementation and evaluation of key provisions to ensure EU buildings align with climate goals. Starting with investigation of needs and good practices in the six focus countries, EPBD.wise builds replicable models to support the widespread implementation of effective measures across Europe.

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Executive summary

National Building Renovation Plans (NBRPs) and zero-emission buildings (ZEBs) are newly introduced policy elements in the recast Energy Performance of Buildings Directive (EPBD 2024/1275). This report analyses policy needs concerning the implementation of NBRPs and ZEBs across focus countries (FCs) in the EPBD.wise project: Bulgaria, Greece, Hungary, Poland, Romania and Ukraine. The Deliverable offers an overview of existing nearly zero-energy building (nZEB) definitions and ZEB concepts, preparatory to the proposal of a ZEB definition, to be elaborated in the subsequent phase of the project. Finally, the report presents various selected best practices regarding the implementation of these new policy instruments.

The Deliverable synthesises findings from comprehensive desk research, stakeholder interviews, and targeted questionnaires to assemble a broad spectrum of policy needs related to NBRP and ZEB implementation. Regarding elaboration of NBRPs, EPBD.wise identified seven main policy needs: 1) better availability and understanding of building stock data particularly for non-residential buildings, which critically impacts strategic planning and implementation of renovation strategies; 2) support in defining policies in line with defined targets, especially for worst-performing buildings (WPBs); 3) identification of investment needs, budgetary resources and how to leverage private investments; 4) how to identify and collect data on the WPBs; 5) setting up measures for public buildings; 6) analyses on wider impacts and addressing energy poverty; and 7) methods for drafting the trajectories.

Regarding ZEB-implementation, EPBD.wise identified five main needs: 1) adoption of technical and economically feasible requirements; 2) involvement and consultation of industry and citizens prior to adoption of a national definition; 3) availability of best practices and examples from other Member States (MS) regarding ZEB concepts or advanced nZEB implementations useful for ZEBs; 4) identification of indicators and metrics to be included in the ZEB definition; and 5) calculation methods and tools for energy and global warming potential (GWP) calculations.

Review of nZEB definitions and of ZEB concepts revealed a set of criteria to be taken into consideration and subsequently assessed for the adoption and implementation of a ZEB definition, to be elaborated in this project. The main criteria are: the ‘energy efficiency first’ principle; renewable energy sources (RES) share and contribution; site boundary; boundaries for renewables; energy balance input; energy efficiency and renewable energy technologies; cost-optimality approach life-cycle assessment (LCA); identification of key indicators; and metrics, calculation methods, source energy calculations and monitoring.

To address the identified policy needs, the Deliverable presents a series of good practice examples from across the European Union (EU), illustrating successful strategies and interventions that can be adapted and replicated in the FCs while elaborating and implementing NBRPs and ZEBs. These examples cover various aspects of building renovation, from public consultation processes to financing models and from data management to the integration of RES.

It should be noted that this Deliverable is not intended to provide recommendations. Rather, it serves to identify and compile the policy needs and good practices upon which tailored recommendations for NPRPs will be developed in later stages of the project. These upcoming recommendations will be adapted to the individual requirements of each FC. For ZEBs, the identified needs will be taken into consideration while developing the proposal of a ZEB definition in the subsequent phase of the project.

In conclusion, this Deliverable represents an essential step in the EPBD.wise project, laying the foundational knowledge and strategic framework necessary for developing tailored and actionable policy recommendations in the next phases of the project.

List of abbreviations

BIM	building information modelling
BRP	building renovation passport
CA EPBD	Concerted Action EPBD
CO_2	carbon dioxide
CPC	carbon performance coefficient
DHW	domestic hot water
EC	European Commission
EMOR	building renovation monitoring system (Hungary)
EPB	energy performance of buildings
EPBD	Energy Performance of Buildings Directive
EPC	energy performance certificate
EU	European Union
FCCP	focus countries contact points
GHG	greenhouse gas
GWP	global warming potential
JRC	Joint Research Centre
LCA	life-cycle assessment
LTRS	Long-Term Renovation Strategy
MEPS	Minimum Energy Performance Standards
MLPDA	Ministry of Public Works, Development and Administration
MPCPC	maximum carbon performance coefficient
MPEPC	maximum permitted energy performance coefficient
MS	Member States
NBRP	National Building Renovation Plan
nZEB	nearly zero-energy buildings
OGHG	operational greenhouse gas
OSS	one-stop shops
PIVERT	Exceptional Investment Plan and the Green Investment Programme
RE	renewable energy
RED	Renewable Energy Directive
RES	renewable energy sources
RP	renovation passport (recast EPBD (2024/1275))
WGBC	World Green Building Council
ZEB	zero-emission buildings

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1 Introduction

1.1 Scope and objectives of the Deliverable

According to Article 3 of the recast EPBD (2024/1275) [1], each Member State (MS) is mandated to establish a National Buildings Renovation Plan (NBRP). This initiative is designed to ensure that, by 2050, all residential and non-residential buildings, both public and private, are transformed into highly energy-efficient and decarbonised structures. The overarching aim is to transition existing buildings into ZEBs. This report outlines the policy needs identified in relation to implementing NBRPs. Regarding ZEB, this Deliverable reports the results of a review of the definitions and concepts of nZEB and ZEB, and outlines needs identified regarding the implementation of a ZEB definition.

Article 11 of the recast EPBD (2024/1275) specifies the criteria for ZEB. It mandates that ZEB should not produce any on-site CO_2 emissions from fossil fuels. These buildings should, where economically and technically feasible, possess the capability to respond to external signals by adjusting their energy use, generation or storage. The directive sets a stringent standard for the energy demand of ZEB, requiring that it be at least 10% lower than the threshold established for nZEB as of May 28, 2024. This provision aims to promote the adoption of advanced energy-efficient technologies and practices, contributing to the broader EU goals of reducing energy consumption and mitigating climate change impacts.

Within the project framework, EPBD.wise focussed on six countries: Bulgaria, Greece, Hungary, Poland, Romania and Ukraine. The report details the specific policy needs identified for each FC concerning implementation of NBRPs, and the needs and features identified as key for implementing a ZEB definition. It also presents best practices, mainly from across the EU-27, providing exemplary models that FCs can emulate. By documenting these policy needs alongside best practice examples, the report aims to facilitate effective transformation of the building stock, ensuring alignment with the EU's long-term renovation objectives.

The primary purpose of this document is to compile the policy issues and needs from which EPBD.wise will derive specific, tailored recommendations for NBRPs. These recommendations will be detailed and customised to meet the unique circumstances of each focus country. This Deliverable does not aim to offer recommendations at this stage. Instead, recommendations will be developed in the subsequent phase of the project. For ZEBs, the purpose of the document is to summarise the existing status quo of nZEB definitions and ZEB concepts, and to identify the needs that will be considered in developing a proposal of a ZEB definition, in the subsequent phase of the project.

1.2 Structure of the Deliverable

The Deliverable covers two elements of EPBD (2024/1275) – ZEBs and NBRPs. Chapter 2 addresses good practice criteria for both NBRPs and ZEB, while Chapters 3 and 4 are devoted to presentation of policy needs. Chapter 5 provides an overview of good practice examples for NBRPs, and Chapter 7 is dedicated to ZEBs, the status quo of nZEB definitions and ZEB concepts. The identified good practices are described in more detail in Annex 3: Template for Good Practice Description NBRP and Annex 5: Template for Good Practice for ZEB. The Deliverable concludes with recommendations for developing guidelines for the efficient and effective implementation of NBRPs and considerations on the status quo of nZEB and ZEB for developing a proposed ZEB definition.

1.3 Relations to other tasks and deliverables

Within the EPBD.wise project, methods and procedures for collecting policy needs and good practice examples have been jointly developed for ZEBs and NBRPs (WP2); minimum energy performance standards (MEPS) (WP3); building renovation passports (BRPs) (WP4); and energy performance certificates (EPCs) (WP5). The interrelationships and, in particular, potential synergies among the individual topics are considered.

2 Methods and procedures

2.1 Challenges and policy needs

The compilation and review of challenges and policy needs are based on the results of other EU and national projects, national contacts with relevant stakeholders, and literature review. Specific attention is paid to the six FCs selected in the EPBD.wise project. However, to replicate results in all EU MS, the compilation and analysis of policy needs should not be limited only to the FCs.

2.2 Survey of policy needs in focus countries

A list of questions was answered by representatives of the FCs. The questions are available in Annex 2: Template of Questionnaire on NBRP for the Focus Countries Contact Points (FCCP) and Annex 4: Template of Questionnaire on ZEB for the Focus Countries Contact Points (FCCP)

2.3 Definition of good practice

The compilation of good practice examples is based on both general criteria and specific criteria that apply particularly to the topics of NBRPs and ZEBs. Criteria were compiled based on the identified challenges and policy needs.

2.3.1 General criteria

In general, good practice examples respond to the general challenges outlined in the Grant Agreement. These challenges are relevant for all WPs 2 through 5 and have been further developed to a set of criteria which is used to define good practice, as shown in Table 1. Good practice examples can provide a solution and/or a response to one or more criteria.

Table 1 Criteria for selection of good practice examples for the NBRP and ZEB

Good governance
Collaboration among regional, federal and municipal levels (vertical and horizontal) to tap the full potential of available data on building stock
Public consultation process for the elaboration and review of NBRPs
Policies and actions to target public buildings
Phasing out inefficient technologies and fossil fuels in heating and cooling
Staff shortages in public administration
Overcoming the lack of staff capacity
Raising awareness of the need for personnel resources
Data availability, accessibility and quality for effective policymaking

Data quality assurance
Data availability and access for understanding potential impacts of policies and different design options
Data availability and access for monitoring progress in the building stock and evaluating policy impacts
Estimation of the impacts, in particular, the broader benefits of energy efficiency
The complex interplay among different instruments, effects and measures is considered for assessing the impacts of policy instruments and addressing the energy performance of the building stock
Other benefits (such as indoor comfort, health and economic implications) are explicitly considered in target-setting and decision-making processes
Construction industry and labour and skill shortages
Overview of national initiatives to promote smart technologies as well as skills and education in the construction and energy efficiency sector
Evaluation of training needs and reduction of them through technology development
Development of training modules and on-site training
Clear presentation of co-benefits
Improved indoor environment and health and better quality of life
Estimation of expected energy savings
Mitigation of energy poverty
Financing
Aggregation of projects
One-stop shops (OSS)
Reduction of the perceived risk for investors
Financing the investment cost of renovation measures
Use of public funds to leverage private sector investment or address specific market failures

In addition to generally relevant challenges, specific aspects are important for the topics of both NBRPs and ZEBs.

2.3.2 Criteria addressing the NBRP scheme

Specific criteria for NBRPs are derived from the elements based on Article 3 and Annex II of EPBD (2024/1275), which outlines the obligations of NBRPs.

The criteria can be distinguished according to those addressing the content on NBPRs (EPBD Article 3.2 and Annex II) and those addressing the framework for NBRPs (EPBD Article 3 all other paragraphs outside of Article 3.2). For a further overview of good practice examples and policy needs they address, refer to Chapter 5 and Table 5.

EPBD Article 3.2:

- building stock overview (residential and non-residential)
- expected energy savings and wider benefits, and
- mechanisms for mobilising investments (e.g. aggregation of projects under single or multiple ownership to make them more attractive to investors; reduction of the perceived risk of energy efficiency financing for investors and

the private sector; use of public funds to leverage private investment; guidance of investments into an energy-efficient public building stock; and provision of better advice in the market, such as OSS).

Annex II:

- roadmap with indicative milestones (e.g. decarbonisation, renovation rate, renovation of building stock, energy savings)
- cost-effective approach to renovation (e.g. identification of trigger points), and
- policies and actions on: deep renovation of buildings, including staged deep renovation and RPs; WPBs and energy poverty; public buildings; an overview of national initiatives to promote smart technologies; skills and education in the construction and energy efficiency sectors).

EPBD Article 3 (paragraphs outside of Article 3.2):

- public consultation, and
- latest Long-Term Renovation Strategy(LTRS) implementation details.

2.3.3 Criteria addressing the ZEB objective

Specific criteria useful for achieving ZEB objectives and identifying good practices are derived from the literature review and the status quo. These criteria are based on Article 11 of the recast EPBD (2024/1275), which defines ZEB. Selected criteria address the following areas:

- existing policies addressing nZEB and the implementation of the ZEB definition,
- specific targets in terms of energy performance of the buildings, RES share and contribution, phasing out fossil fuels and greenhouse gas (GHG) emissions,
- methodology for evaluating energy consumption and GHG emissions and the calculation of cost-optimal levels,
- indicators and metrics derived from the nZEB standard or new and cost-effective approaches,
- financing tools to incentivise construction according to ZEB standards, and
- monitoring of ZEB through databases and collection of good practices (e.g. EU Building Stock Observatory).

All these elements are summarised in

Table 2, wherein specific criteria are detailed and described for each category. Certain parameters are adapted from established nZEB standards (in light grey in the table); others have been defined considering ZEB definitions and concepts and the current background.

Table 2 Specific criteria for ZEB good practices in details: sub-criteria transposed from nZEB (light grey) and new ZEB sub-criteria

Categories	Descriptions
Existing policies (nZEB) and ZEB definition	
Advanced nZEB	Advanced nZEB definition and standard applied in MS
ZEB definition	ZEB definitions
Specific targets	
Energy performance	Very low or zero amount of energy need and very high energy performance (zero energy or net zero energy)

	Demand flexibility management: managed in a cost-effective way
RES share and contribution	Renewable energy (RE) generated on-site or near-by (e.g. solar energy, geothermal, hydroelectric power and biomass, district heating, and cooling based on RES or waste heat; off-grid communities)
Phasing out fossil fuels	Transitioning away from fossil fuels, e.g. by promoting the use of heat pumps and accelerating the phase-in of RE
Low operational greenhouse gas (OGHG) emissions	Low OGHG emissions associated with energy consumption of technical building systems during the use and operation phase of the building
Low on-site carbon emissions from fossil fuels	Achievement of zero or low values of low on-site CO^2 emissions (search of good practices in research programmes or national legal frameworks)
LCA and GWP	Application of LCA to evaluate the overall contribution to emissions that lead to climate change
Methodology	
Calculation method	Calculation methodology for assessing ZEB (e.g. dynamic calculation for energy balance evaluation; yearly, monthly, hourly or sub-hourly time-steps; LCA assessment)
New tools and evaluation methods	Development of new tools and approaches for evaluating ZEB
Indicators and metrics	
nZEB Indicators to be maintained	Existing nZEB indicators and related typology (e.g. energy performance index; total primary energy; non-renewable or RE performance; energy classes)
New ZEB indicators	e.g. operational GHG emissions, total GHG emissions
Cost effectiveness	e.g. application of a cost-optimality approach
Other	e.g. Building Automation and Control Systems (BACS); control devices for the monitoring and regulation of indoor air quality; SRI; heat-recovery; waste-water; system balancing; smart solutions; passive heating and cooling elements; shading; indoor environmental quality; indoor comfort; adequate natural light and design; adaptability to climate change.
RES for other uses	e.g. electric vehicle charging points
Financing	
Public Incentives	Public funding to support renovation and construction towards nZEB or ZEB targets
Other	Other financial initiatives by municipalities, local or national bodies, and research world to support deployment of nZEB or ZEB
Monitoring and data collection	
Databases / Observatory	Existing websites, data collection, or similar about advanced nZEB or ZEB buildings and related initiatives

2.4 Template for good practice description

Based on the definition for good practice provided in the previous section, EPBD.wise developed two templates for documenting good practice examples: one for NBRPs and one for ZEBs. The template for NBRPs is available in Annex 3: Template for Good Practice Description NBRP. The template for ZEBs is available in Annex 5: Template for Good Practice for ZEB. Good practice documentation is also available as separate Annexes to enable flexible use of good practice examples in discussions and for target group-oriented dissemination. The project team members will document most examples, but some examples might also be

elaborated by other organisations interested in using the EPBD.wise good practice examples as dissemination channels. With these purposes in mind, it is easier to work with individual templates per case study than to have one lengthy document. The template was developed such that, depending on the progress of the project and the number and quality of examples of good practice, descriptions could be transferred to a database or documentation could be entered directly into a database. This would make it easier for stakeholders to later find examples relevant for their work.

3 Policy needs regarding implementing NBRP

This section is dedicated to identifying the key policy needs related to the development and implementation of NBRPs. The EBPD.wise approach began with comprehensive desk research, analysing existing projects and related reports to establish a baseline understanding. Subsequently, EPBD.wise facilitated a workshop with representatives from the FCCPs and conducted a detailed questionnaire with its six FCs: Bulgaria, Greece, Hungary, Poland, Romania and Ukraine. This multi-faceted research approach helped pinpoint specific policy needs for each FC, based on combined insights from the desk research, questionnaire responses, and discussions during the workshop. From this analysis, certain countries were prioritised for each policy element based on their unique needs. For NBRPs, priority countries identified were Poland, Romania and Ukraine. EPBD.wise recognises that its findings must not cater only to the immediate needs of these FCs but also are structured to be applicable and replicable for other MS. This broader applicability ensures that the strategies developed can serve as models for building renovation policies across the entire EU, promoting uniformity and effectiveness in addressing building renovation challenges.

3.1 Desk research to identify policy needs

The process of identifying policy needs began during the initial proposal phase of the EPBD.wise project and was further enhanced through comprehensive desk research. This research included a thorough review of European as well as national projects, programmes and initiatives. The aim was to gather a broad spectrum of data and insights, which helped in understanding the current landscape and pinpointing gaps in policies and practices. This foundational work provided a critical baseline from which specific policy needs could be systematically identified and addressed within the project's scope.

Since NBRPs is a rather new provision within the EPBD (2024/1275), few projects related to the topic are available. The desk research thus focuses on relevant studies and reports regarding LTRS, which, according to the EPBD (2024/1275) will be replaced by NBRPs. The most valuable report – and the one used most to examine the current situation in the FCs – is the Joint Research Centre (JRC) assessment of the LTRS [2]. The report evaluates the strategies according to Article 2a of the EPBD (2018/844) recast [3] and assesses the compliance of each strategy. The scores were given on a scale of 0-5[1] for each of the clauses of Article 2a. These include: building stock overview (Art.2a.1a); cost-effective approaches to renovation (Art.2a.1b); policies and actions (Art.2a.1c-f); expected energy savings and wider benefits (Art.2a.1g); roadmaps with indicative milestones (Art.2a.2); mechanisms for mobilising investments (Art.2a.3); public consultations (Art.2a.5); and latest LTRS implementation details (Art.2a.6).

The evaluation template used for the compliance assessment follows the structure indicated in the Commission's recommendation on building renovation. In particular, this recommendation specifies the areas that MS are requested to address under each of EPBD (2018/844) Article 2a requirements and provides guidelines on how to comply with them. All

[1] 0 = MISSING – the item is not covered at all or only described in another source; 1 = UNSATISFACTORY – only the most cursory coverage of the item; 2 = INADEQUATE or PARTIALLY COMPLIANT – item addressed poorly, with insufficient detail, or with important aspects missing; 3 = ADEQUATE – meets the basic minimum requirements; 4 = GOOD – the topic is described in some detail; 5 = EXCELLENT – exemplary coverage of the topic

the strategies have been evaluated against all the EPBD requirements, grouping the clauses into eight different sections that have been scored and assessing the extent to which the clauses have been addressed from a compliance perspective.

Across the six FCs, the following policy needs were identified.

- **Bulgaria:** The systematic approach of the LTRS encompasses a clear vision, specific objectives towards achieving this vision and defined priorities under each objective. These priorities are supported by detailed policies and measures, with indicators established to measure progress. Annex 3 of the LTRS provides comprehensive measures and packages for energy renovation. The LTRS covers details on the following topics: expected energy savings and CO_2 emissions reduction; anticipated share of RE; and investment needed for various building types (e.g. single and multi-family residences, administrative buildings, hospitals, schools and kindergartens). Additional information could be provided on current renovation rates and CO_2 emissions from buildings to quantify relative reductions and overall impacts on the EU 2050 decarbonisation target.

- **Greece:** Strengths and innovative approaches include a detailed list of milestones for 2030, 2040 and 2050, supported by elaborated 2050 scenarios developed using the PRIMES Buildings Model (PRIMES-BuiMo). A comprehensive set of policy measures is given, such as increasing the building coverage ratio in energy-efficient buildings and offsetting arbitrary fines for energy upgrades. Additionally, there is a new focus on financial measures, such as the National Energy Efficiency Fund, the Electra programme, and innovative financial models that blend different funding sources. More details could be provided on RP and measures to address split incentives, support vulnerable groups and tackle energy poverty, as well as innovative financial schemes.

- **Hungary:** Effective use of EU funds is evident in Hungary, such as Cohesion Funds and the ELENA Facility, combining non-reimbursable assistance with loans and green bonds. A strong focus on monitoring the implementation of measures has been put in place, using proper indicators and schemes, and exemplified by the establishment of the building renovation monitoring system (EMOR) and a database on public buildings. A scenario analysis is recommended to explore different policy options and strategic decisions.

- **Poland:** Effective use of grant schemes is seen in Poland, particularly focusing on already secured EU structural funds for financing building renovation projects. Robust scenario analysis helps identify the most efficient renovation roadmap as does a detailed overview of renovation packages for each building type. Wider benefits could be better identified and quantified.

- **Romania:** The institutional framework for public financial mechanisms in Romania has been revised. A notable assessment suggests that apartment owners who refuse renovation proposals may risk losing access to future financial support from public funds. More details could be provided on: the energy-saving impacts and budget for all measures; indicative building renovation milestones for 2030, 2040 and 2050; and how these milestones contribute to achieving EU energy efficiency targets. Other aspects that would be helpful include: information on the non-residential building stock (including hospitals and schools); cost-benefit analysis in terms of jobs, energy cost savings, health and emission reductions; and scenario analysis to investigate different policy or

intervention options. A discussion and justification of the assumptions used in the scenario analysis are recommended.

Another report worth mentioning is BPIE's *A Review of EU Member States' 2020 Long-Term Renovation Strategies*, which assesses the compliance of 14 LTRS [4]. The assessment examines the extent to which the LTRS comply with provisions of Article 2a. The evaluation judges the completeness of the strategy and the quality of details provided. It does not assess, for example, whether the policies, measures, and roadmap suggested are ambitious and credible, and have potential to be well implemented. For each clause, a score is assigned ranging from 0 = not addressed to 5 = exemplary, with 3 being an acceptable submission.

A survey of other relevant studies is available in Annex 1: Survey of Related Projects and Studies.

3.2 Interviews and workshops to identify policy needs

During interactions with the FCs, EPBD.wise organised a series of stakeholder workshops. One workshop focused on RPs and EPCs; another addressed ZEBs, NBRPs and MEPS. These workshops aimed to delve deeper to: understand specific policy needs; discuss potential data gaps; clarify unresolved questions and issues; and explore solutions to overcome these challenges. This subsection concentrates on aspects of the workshop related to NBRPs.

Based on the discussions during the workshop, a lack of building stock data emerged as a common issue across most FCs and among stakeholders. Official data are often missing, and even when an official database exists, it is sometimes outdated. In some cases, these databases do not include information related to the renovation status of buildings. A strong emphasis emerged on the need to share best practices and explore potential methods to address these data gap challenges.

Financing instruments and the challenges of finding and mobilising financing were other common issues identified. Participants expressed a need for support in engaging stakeholders and fulfilling responsibilities to secure funding for renovation plans. Market maturity for actual implementation emerged as another area of uncertainty. Making NBRPs not merely an 'administrative document' but also a practical, applicable plan for all MS is a major concern. In this context, the importance of baseline building stock data and financing cannot be overlooked.

The involvement of social partners and related stakeholders in the development of NBRPs is strategically necessary for operational success and crucial for gaining societal acceptance. Achieving a unified vision and securing political consensus are pivotal, signalling a shift towards a cohesive strategy that gains widespread support. Consequently, renovation plans become more than regulatory obligations; they represent a collective aspiration for sustainable and resilient living environments. This effort is also connected to the need for qualifying the workforce for implementation tasks, as ensuring an adequate and skilled workforce is imperative. The lack of skilled staff presents another significant barrier to achieving renovation targets and making the plans practical.

There is a growing recognition that NBRPs need to evolve beyond their traditional administrative boundaries. The aim is to transform NBRPs into dynamic instruments that not only promote energy efficiency but also drive broader renovation initiatives. These enhanced plans would not only meet basic regulatory requirements but also add significant value by

addressing a wide range of environmental and socioeconomic challenges. This holistic approach to building renovation encompasses several areas; improving building resilience against climate change; enhancing occupant health and comfort; and contributing to economic revitalisation through job creation in the renovation sector. By broadening the scope of renovations to include these aspects, NBRPs can play a crucial role in achieving sustainable urban development and equitable social progress. Such an expansive vision for NBRPs would require robust collaboration among various stakeholders – including government entities, private investors, community groups and environmental organisations – to ensure that the plans align with the broader goals of environmental sustainability and social welfare.

3.3 Questionnaire to focus countries to identify policy needs

In the project, EPBD.wise conducted a survey covering all policy instruments: ZEBs, NBRPs, MEPS, RPs, EPCs. This section specifically focuses on NBRPs based on feedback from representatives of the FCs. After reviewing the survey responses and engaging in discussions with the FCCP, EPBD.wise decided to prioritise Poland, Romania and Ukraine for their national building renovation strategies. Selection of these countries was guided by the goal of ensuring a balanced representation across each policy instrument while also prioritising countries that demonstrated a significant need for support in developing their NBRPs. This section includes a summary table that outlines the key challenges and support needs from all the FCs.

Table 3 Shortened questions and answers for the selected focus countries

Country	Key challenges	Specific support needs
Bulgaria	• Data on building stock are not detailed enough, and technical and accessibility issues with existing data • Limited policy formulation using available data • Non-realistic assumptions in the process of preparing the NECP* • Lack of information about clear engagement and responsibilities to secure funding in the LTRS	• Support for engagement and responsibilities to secure funding for the renovation plans • Policy support based on improved data insights
Greece	• Statistical data available, but challenges in deriving actionable insights • Inconsistent renovation targets and lack of clear policy directives	• Governmental and stakeholder consultation to standardise renovation targets • Development of clear, actionable strategies based on available data • Support on mobilising investments
Hungary	• Lack of data for current status of the building stock • Inadequate baseline data affecting renovation planning • No clear risk/responsibility distribution between public and private stakeholders • Missing clear financial descriptions and tools	• Development of specific tools for better estimation of the renovation needs and rate • Sharing best practice examples for renovation plans and strategy cases for different focus groups

Poland	• Insufficient understanding of the building stock (especially single-family houses) • Delays in adoption of policy documents, affecting implementation timelines	• Tailored support in drafting and operationalising NBRP, with a focus on decarbonisation • Initiatives to promote energy-efficient technologies in residential housing
Romania	• No formal National Buildings Renovation Strategy in place • Severe lack of data on building stock, hindering effective policy development • Lack of relevant financial instruments and funding	• Comprehensive guidance in developing an NBRP aligned with EPBD (2024/1275) • Robust data collection and analysis methodologies to inform policy and planning • Support for identifying appropriate mechanism for fast implementation of the building stock database
Ukraine	• Existence of a strategy, but poor implementation and integration with broader energy policies • Focus on thermal modernisation not comprehensive	• Support in refining and executing building renovation plans • Integration of renovation strategy with national energy and environmental policies

* National Energy and Climate Plan.

For the template of the questionnaire sent to FCs, please refer to Annex 2: Template of Questionnaire on NBRP for the Focus Countries Contact Points (FCCP)).

The remainder of this subsection presents a detailed analysis for each FC, concentrating on the current status of their building stock data, challenges they encountered while preparing the LTRS, and their specific needs for preparing the NBRP.

3.3.1 Bulgaria

Bulgaria faces technical and accessibility issues with its existing data on building stock, which is not detailed enough to support effective policy formulation. The challenges are compounded by limited use of these data in crafting comprehensive renovation strategies. To improve this situation, Bulgaria requires significant enhancements to its EPC database, focusing on improving data quality and accessibility. These improvements would provide policymakers with better tools to formulate policies that are more aligned with actual needs. Additionally, there is a need for policy support that leverages these improved data insights to develop tailored strategies for building renovation, ensuring they meet the specific requirements of the Bulgarian context and comply with EPBD mandates. Bulgaria also needs support for explicit engagement and responsibilities to secure funding.

3.3.2 Greece

In Greece, the availability of statistical data through national agencies provides a foundational layer for understanding the building stock. The main challenge lies in deriving actionable insights that can lead to consistent and effective renovation targets across various sectors. There needs to be more explicit policy directives that can guide these renovation efforts uniformly. To address these issues, Greece needs support in the form of governmental and stakeholder consultations aimed at standardising renovation targets. This would help create clear, actionable strategies informed by the available data. Enhancing capabilities for data

interpretation and usage would empower policymakers to make informed decisions that align with EPBD guidelines and national sustainability goals. In terms of mobilising investments, Greece's bureaucratic operational framework needs support.

3.3.3 Hungary

Hungary presents a unique case with its climatic uniformity but diverse building types, which pose distinct challenges for data collection and analysis. This diversity makes it difficult to collect baseline data that accurately reflect the entire building stock, thereby affecting the planning and implementation of building renovations. Hungary would benefit from the development of specific tools and methodologies tailored to its national conditions. These tools should enhance the accuracy and efficiency of data collection, enabling better estimation of renovation needs. Sharing best practices and methodologies across Europe could provide Hungary with insights into effective building renovation strategies. Such collaborative efforts would help align Hungary's renovation plans with EPBD goals and improve the overall sustainability of its built environment.

3.3.4 Poland

In Poland, the pathway to fully understanding and implementing the NBRP is hampered by a significant building stock data gap, especially concerning single-family houses. This segment represents a significant and crucial part of Poland’s building stock yet lacks comprehensive strategies and coherent policy support and data. Late adoption of relevant policies, with pivotal documents only being authorised in 2022, has delayed essential renovation efforts and complicated the integration of these plans with broader environmental and energy goals. Poland needs tailored support not only in drafting and operationalising these plans but also in fostering sector-specific integration, methods of building stock data collection, ideas on funding and financing mechanisms, and methodology on cost calculations. This should mainly focus on decarbonising the building sector, where targeted initiatives could include incentivising energy-efficient technologies and practices. Enhancing expertise and resources dedicated to these areas would improve Poland’s alignment with EPBD mandates and its overall energy efficiency targets.

3.3.5 Romania

Romania faces foundational challenges in its approach to building renovations, primarily due to the need for a formal national building renovation strategy. This deficiency prevents the establishment of a unified vision and clear objectives, making it exceedingly challenging to direct and measure progress effectively. Coupled with a critical lack of comprehensive data on the existing building stock, Romania needs support in planning and executing effective building renovations. The country requires extensive assistance to develop an NBRP that is comprehensive and also aligns closely with the goals of the EPBD. This entails developing robust methodologies for data collection and analysis, which are essential for identifying priority renovation areas and allocating resources efficiently. Romania would benefit from guidance on integrating these plans with broader economic and environmental policies, thereby ensuring a holistic approach to building renovation that supports sustainable development.

3.3.6 Ukraine

Ukraine's scenario presents a unique set of challenges. While a long-term strategy for building renovation exists, its implementation has been suboptimal, primarily due to poor integration

with broader national policies and a lack of practical guidelines. The focus has predominantly been on thermal modernisation, which, although crucial, only encompasses some aspects of energy efficiency and environmental impact. The strategy's limitations are further deepened by insufficient operational guidelines and ineffective monitoring frameworks, which hinder the assessment of progress and outcomes. Ukraine needs a comprehensive support package that not only aids in the refinement and execution of its existing plans but also ensures that these plans are seamlessly integrated within the larger framework of national energy and environmental policies. Support should include the establishment of clear implementation guidelines, regular monitoring and evaluation mechanisms, and the facilitation of stakeholder engagement to ensure that the strategies are both effective and inclusive.

4 Policy needs regarding implementation of ZEB

This section is dedicated to identifying needs related to the development and implementation of a national ZEB definition, and to identifying the features and aspects considered as key for the ZEB definition. It also considers the experience of the FCs in developing their national nZEB definitions. EPBD.wise facilitated a workshop with representatives from the FCCP and conducted a detailed questionnaire with six FCs: Bulgaria, Greece, Hungary, Poland, Romania and Ukraine. This research approach helped pinpoint needs and key aspects based on the combined insights from the desk research, questionnaire responses and discussions during the workshop. From this analysis for ZEBs, Bulgaria, Hungary and Ukraine were identified as priority countries, based on their unique needs and their interest in the ZEB topic.

4.1 Interviews and workshops to identify policy needs and key aspects for ZEBs

EPBD.wise organised a series of stakeholder workshops, during its interactions with the FCs. One workshop focused on RPs and EPCs; the other addressed ZEBs, NBRPs and MEPS. The purpose of these workshops regarding ZEBs was to: delve deeper into understanding specific needs; discuss potential key features and aspects; discuss main challenges; clarify unresolved questions and issues; and explore solutions to overcome these challenges. This subsection concentrates on aspects of the workshop related to ZEBs.

Based on common points raised during the stakeholder workshop for ZEBs, a nuanced understanding of the multifaceted challenges and strategic considerations has been recognised as vital for the successful implementation of a ZEB definition across MS.

A major challenge is developing a standard that can actually be reached within the specific national contexts of every country. From the nZEB implementation experience, it is clear that setting thresholds and targets without considering the difficulty of reaching them leads people to underestimate or disregard the target or even try to avoid it.

Energy efficiency measures and the ‘energy efficiency first’ principle are considered pivotal elements in implementing a ZEB standard nationwide, especially for existing buildings, in view of the steps planned for decarbonisation by 2050. The most important renovation measures are considered to be those on the building envelope.

On-site energy generation to meet building energy needs and limit use of energy from the grid are considered relevant aspects to be taken into consideration.

During the workshop, concerns emerged about the possible financial sustainability of transitioning the building stock to ZEB standards. A possible price increase in the building market is considered likely and a challenge to be addressed; as such, a financing scheme for the transition to ZEBs is considered necessary.

Involvement and consultation of industry and citizens prior to adopting a national definition and methodology of ZEB are considered necessary, since support of these groups may ensure that the ZEB standard is widely accepted at the time of implementation.

4.2 Questionnaire to focus countries to identify policy needs and key aspects for ZEB

This section focuses exclusively on key aspects and needs referring to ZEBs derived from the survey addressed to the selected FCs as well as additional clarifying calls. Following an analysis of the collected responses and discussions held with representatives of the FCs, EPBD.wise resolved to collaborate with Bulgaria, Hungary and Ukraine in the proposal phase of a ZEB definition, to be elaborated in the project. This selection process was informed by an intent to achieve an equitable distribution of countries across each policy instrument, while simultaneously prioritising those countries that exhibited a pronounced interest in the realm of ZEBs. Nevertheless, ZEBs will not be treated as a 'full' policy instrument. Rather, EPBD.wise will develop a single proposed ZEB definition, the development of which will consider the needs and key features identified for the priority countries (i.e. Bulgaria, Hungary and Ukraine). However, no support or policy recommendations specific to ZEBs will be provided. Answers provided to the shortened survey are summarised in Table 4.

Table 4 Shortened questions and answers for selected focus countries

	nZEB or maximum energy performance level buildings requirements to be maintained for ZEB standard	Most important aspects in the ZEB definition and methodology	Most relevant key features (among system boundary, emission balance boundary, spatial boundary, calculation methods, indicators and metrics) for the ZEB definition	Learned lessons from nZEB standard	Support needs
Bulgaria	nZEB standard was enforced only at the start of 2024; thus, no assessment of nZEB implementation and no ZEB modelling have been done to determine key indicators. The ZEB standard should follow technical and economic feasibility.	Technical and economic feasibility, as well as market readiness in terms of workforce and construction product certification.	No such analyses have been carried out at national level on key features. All proposed key features (system boundary, emission balance boundary, spatial boundary, calculation methods, indicators and metrics) are considered equally relevant.	Technical and financial barriers are expected, especially for renovation of existing buildings. Requirements regarding the connection to district heating systems and the RES share were inapplicable in many situations. Difficulties arose in communicating requirements to different stakeholders and	Technical assistance would be welcome for assessing the nZEB performance, technical and financial/cost-optimality analyses, energy modelling, and definition preparation. Sharing experience and practices from other countries on methodologies for modelling and preliminary analyses are considered important.

				in building the necessary capacity among designers, builders and contractors.	
Hungary	The nZEB requirements to be maintained are: energy consumption performance of the building (0.14 W/m3K), overall energy performance (76 kWh/m2y, or 80% of the reference building) and GHG emissions (20 kg/m2y, or 80% of the reference building).	Both the 'energy efficiency first' principle and the mandatory calculation of life-cycle GWP are considered important.	Life-cycle approach; net-zero emissions; grouping of buildings/districts, with relevant policy role of the local government; both static and dynamic calculation; GHG emissions and GWP should be the main indicators.	The design praxis accommodated for the nZEB requirements for new buildings should be maintained.	Support to adopt a dynamic approach, a district scale system boundary and suggestions for suitable software for calculation are considered useful.
Ukraine	The main nZEB requirements are: specific primary energy consumption of the building and the share of RES. It is currently unclear what requirement should be maintained.	Definition should be based on intermediate goals for improving the energy efficiency of buildings and their monitoring. Lack of capacity of building owners to comply with the requirements is considered an issue; implementing measures to increase such capacity will be focal.	All would be relevant.	Ukraine has a problem of implementing nZEB buildings; not much work is being performed so far on the topic.	Ukraine would need to have best practices examples on both nZEB and ZEB standards from other EU MS, and a pathway of how to implement it.
Greece	Requirements related to the efficiency of the building without RES, and on minimum requirements on IEQ*, would be useful to be examined.	A ZEB should be defined in terms of estimated or measured energy consumption in kWh/m2 (not using EPC energy class, which is currently defined in comparison to a reference building). Primary energy, final energy, CO2 emissions, fuel type analysis and some indications on IEQ are the parameters currently used for evaluating energy	The 'energy efficiency first' principle, and an approach closer to the absolute zero emissions boundary, should be supported. A ZEB standard referred to a group or district level could be problematic. An optional dynamic approach in larger projects would be preferable.	The nZEB definition took many years to be defined by the government. The ZEB definition should be introduced in a very clear and straightforward way.	N/A

		performance of a building and could be used for the ZEB standard.			
Poland	Final (not primary) energy should be taken into account when considering energy efficiency and ZEB requirements.	Final (not primary) energy should be taken into account when considering energy efficiency and ZEB requirements	N/A	Poland has not implemented the nZEB standard.	A proposal for a systemic approach for implementing the ZEB standard could be needed. Ready-made solutions and recommendations / best practices would be helpful and useful.
Romania	Zero or a very low amount of operational GHG emissions requirement should be updated from nZEB to ZEB threshold and the mechanism of verification should be created.	The main aspects to be considered are: a clear mechanism of evaluation and verification; and a clear definition / methodology for the options available to cover the energy needs of a ZEB from renewable sources.	In the first stage of implementing ZEB requirements, less complex features should be in place considering the lack of proper instruments for monitoring and evaluation for a life-cycle approach.	Clear indicators and calculation methods are needed. A clear monitoring and verification process for implementing the standard is important and should be based on both technical documentation and on on-site direct verification of the construction / renovation works. The ZEB implementation policy targets should be accompanied by strong and coherent budget and appropriate incentives.	Support based on other countries best practices would be useful. Specifically, regarding key features such as: operational vs. life-cycle approaches; calculation methods: static vs. dynamic approaches in calculation methods; indicators and metrics (primary energy, final energy, CO2 emissions, GHG emissions, GWP).

* IEQ = indoor environment quality.

The template of the questionnaire sent to FCs is available in Annex 4: Template of Questionnaire on ZEB for the Focus Countries Contact Points (FCCP) .

4.2.1 Bulgaria

The nZEB definition was adopted and enforced in early 2024; it is applicable only to new buildings. The process of integration into national legislation took a long time, mostly because the requirements related to the connection to district heating systems and the share of energy from RES were inapplicable in many situations. There was an obvious gap in terms of a centralised approach for communicating requirements to the different stakeholders, as well as for building the necessary capacity among designers, builders and contractors. Similar concerns are foreseen for the ZEB implementation. Technical assistance for developing a ZEB definition and an operational methodology, as well as good practices from other countries regarding advanced nZEB definitions and ZEB concepts, are considered useful.

4.2.2 Hungary

The nZEB definition was adopted and enforced in late 2023, related only to new buildings. The share of RE is replaced by a life-cycle based CO_2 emission requirement, which is considered important to retain in the ZEB definition. The system boundary for the future ZEB definition is preferred to be at the district/neighbourhood level (rather than at the single building). Support to adopt a dynamic approach, a district-scale system boundary and suggestions for suitable software for energy calculations are considered useful.

4.2.3 Ukraine

The nZEB definition was adopted in late 2018 and corresponds to the 'A' energy class. At present, there are no obligations for new, renovated or existing buildings to meet this requirement. Experiences and best practices from other MS are considered useful.

5 Summary of good practice examples and status quo analysis for NBRPs

This chapter outlines the policy needs of the FCs and provides relevant good practice examples. Status quo analysis and identification of good practice examples include quantitative and qualitative analysis, stakeholder engagement, legal and administrative screening, and evaluation techniques.

Directive (EU) 2018/844 outlines reporting obligations for LTRS, which can be viewed as a predecessor to NBRPs [3]. The JRC report assessing each LTRS evaluates the strategies' compliance with the Directive and checks if all requirements were adequately addressed [2]. Based on this report, good practice examples were identified and compiled (see Annex 3: Template for Good Practice Description NBRP); where required, additional research was done.

ndividual good practice descriptions follow in subsequent Annexes and are summarised in Table 5.

Table 5 Overview of good practice examples and challenges they address

General challenge addressed	Specific challenge addressed	Policy needs (1-7, according to Chapter 6)	Good practice example	Annex
Data availability, accessibility and quality for effective policymaking	Building stock overview (residential and non-residential)	1	Italy	3a
Good governance	Public consultation	-	Slovakia	3j
	Policies and actions on public buildings	2	Wallonia, Belgium	3e
	Implementation details on the latest LTRS	2	Spain	3k
	Policies and actions on deep renovations of buildings, including staged deep renovation and RPs	2, 6	Wallonia, Belgium	3c

	Policies and action on WPBs and energy poverty	2, 4, 6	Spain	3d
Construction industry and labour and skill shortages	An overview of national initiatives to promote smart technologies, as well as skills and education in the construction and energy efficiency sectors	-	Wallonia, Belgium	3f
Clear presentation of co-benefits	Expected energy savings and wider benefits	6, 7	Lithuania	3g
Estimation of the impacts, in particular, the broader benefits of energy efficiency	Roadmap with indicative milestones (decarbonisation, renovation rate, renovation of building stock, energy savings)	7	Finland	3h
	Cost-effective approach to renovation (identification of trigger points)	2, 7	Lithuania	3b
Financing	The mechanisms for mobilising investments (the aggregation of projects under single or multiple ownership to make them more attractive to investors, the reduction of the perceived risk of energy efficiency financing for investors and the private sector, the use of public funds to leverage private investment, the guidance of investments into an energy-efficient public building stock, the provision of better advice in the market, such as OSS).	3	Wallonia, Belgium	3i

* WPB = worst-performing buildings.

In the subsequent subsections, we provide an in-depth examination of the priority countries, outlining key data and insights gathered from the survey results to better understand their specific contexts and challenges.

5.1 Poland

Building stock overview: The Polish LTRS gives a good overview of the residential and non-residential building stock, with indicators relating to building type, age, ownership, energy consumption (including energy carrier), and heating systems. The most common renovation measures are presented (e.g. envelope and windows replacement), as well as the share of renovated residential and public buildings in 2020 by year of construction. It also provides an estimate of the residual potential final energy savings in the residential sector. A definition of and data on WPBs is still missing in the building stock overview and will be important to tackle in the NBRP. As this indicator was not mandatory in the scope of Article 2a.1(a) of EPBD (2018/844), not many countries reported on it. The LRST of Finland stands out as it does

provide information on shares of WPBs, i.e. buildings in energy classes F and G of the building stock in 2020 (6% single-family and semi-detached houses; 4% terraced houses; 10% residential buildings; and 14% non-residential buildings). As it still needs to first define which buildings are WPBs and then present data on this segment in its NBRP, Poland could follow this example.

Evidence-based estimate of expected energy-savings and wider benefits: An estimate of total energy savings and emissions reduction is provided in the Polish LTRS, but wider benefits could be better identified and quantified. The Lithuanian LTRS provides a good practice example for this, where environmental, economic and social benefits are split into monetised and non-monetised, and a quantified estimate is given for each benefit described. The Lithuanian example also outlines the following wider benefits: reduced energy consumption; reduced CO_2 emissions; increase in GDP; improved health and working capacity of the population; growth in the value of residential real estate; impacts of the renovation of the building stock on pollution; and reduced compensation for heating costs of the vulnerable population group. The following non-quantifiable benefits are also discussed: energy independence; utilisation of existing production capacity; increase in the service life of buildings; reduced need for subsidies in the sectors concerned; and strengthening of the sector of manufacturers of construction and building materials.

Implementation details of latest LTRS: The Polish strategy is missing a specific section on the implementation of its 2017 LTRS (including the planned policies and actions). However, it provides a detailed overview of building renovation investments for the period 2014-2019, with the main supporting programmes/measures (e.g. Thermomodernisation and Repair Fund [5], NFOŚiGW[2] programme [6]). According to Article 2a.6 of EPBD (2018/844) and Article 3.8 of EPBD (2024/1275), each MS shall annex details of the implementation of its most recent LTRS to its revised LTRS, including on planned policies and actions. The good practice example for this provision can be found in the Spanish LTRS, in which examples of the reported measures include: regulatory development and administrative measures in favour of energy renovation; renovation of public administration buildings and other exemplary measures; public financing measures; combatting energy poverty; etc.

Measures to improve the energy performance of public buildings: Measures addressing public buildings are included; however, they could have been elaborated in more detail to comply with Article 2a.1e of EPBD (2018/844) [3], Article 6 of Energy Efficiency Directive (2023/1791) [7], and obligations of Article 3 and Annex II of EPBD (2024/1275) [1]. The Wallonian LTRS could provide a good practice example, as it shows the public sector at the forefront of the measures and expected to play an exemplary role through renovations. Specifically, exemplary renovation of public housing will be carried out through the public housing renovation plan to achieve the average decarbonised energy performance of buildings A label by 2040 (~5 000 dwellings/year), complemented by other activities to support the plan above. To do so, the Wallonian government launched two consecutive programmes – the Exceptional Investment Plan and the Green Investment Programme (PIVERT) – that have enabled almost 47 000 public housing units (47% of the stock) to be upgraded to follow energy standards and health and safety requirements. Poland can take this as an example as it currently has the NFOŚiGW grants co-financing for energy renovation investments in public buildings and repayable aid in the housing sector. An NFOŚiGW programme, ‘Clean Air in

[2] National Fund for Environmental Protection and Water Management

Schools' is also to be included among the support programmes for thermal renovation of NFOŚiGW buildings. This programme aims (among other things) to improve air quality and reduce energy consumption of educational establishments. Other public buildings could also be included.

5.2 Romania

Building stock overview: In the Romanian LTRS, the building stock data are sufficiently described, including, according to building types, information about: the number of buildings; the heated surface; the areas built before 2000; the areas renovated by 2020; and not-renovated areas. The building types described are: residential; rural and urban dwellings; multi-family residences; schools; hospitals/healthcare facilities; social housing; offices; warehouses; and hotels/restaurants. The analysis incorporates climatic zones to estimate investment costs, as well as their impacts on energy efficiency and CO_2 emission reduction. The tenure of the building stock is also reported. However, data on non-residential building stock are insufficient. Romania would benefit from creating a database of the national building stock with details covering: building type; renovations and upgrades performed over the useful life of the building; safety and structural integrity; energy consumption, etc. Italy has developed such a database. A national portal on the energy performance of buildings was established in 2020, which collects, in a unique digital public database, all information on the Italian building stock (e.g. size, energy performance, and suggested renovation good practices).

Policies and actions on deep renovations, including RPs: The LTRS describes four different building types: residential buildings, schools, healthcare and social housing. It then suggests an integrated, step-by-step approach (staged renovation) throughout the life of a building to increase energy savings and energy performance, including by defining subsequent renovation phases in order to reach a deep renovation level over time. A number of measures regarding deep renovation are included in the document; however, corresponding policies are not described. So far, Romania is revising building standards to stimulate deep renovations of existing buildings, as well as revising and updating the energy efficiency standards based on the cost-optimal methodology. At the moment, some national programmes promote energy efficiency in buildings. Still, need better awareness-raising campaigns are needed to promote the benefits of deep renovations with relevant guidance on appropriate building strategies to conduct them. Such guidelines should consider good practices and access to public financial instruments. Concerning the RP, Romania's LTRS suggested including them in the technical book of the building (a mandatory document encompassing all information on the building in question). The RP could include other sets of information related to each building, such as: funding options available in the area for renovation projects (e.g. green loans, incentives, tax credits); energy bills; equipment maintenance recommendations; and ownership obligations. It should be available to owners in digital format. A good practice example regarding policies and action on deep renovations of buildings, including staged renovation and RP, comes from Wallonian (Belgium) LTRS. It presents details of individual actions and steps to implement the building passport and related renovation and monitoring of the building stock. The RP and renovation roadmap have been identified as tools to be developed as a priority, to ensure that any renovation project is part of a comprehensive assessment consistent with the long-term vision and targets for building

decarbonisation. As it is one of the pilot countries in the project iBRoad2EPC,[3] Romania could use the tool developed within that project to develop and implement an RP scheme.

Policies and action on public buildings: To tackle this challenge, the Romanian LTRS suggests the development of two dedicated programmes: a long-term national programme for state-owned public buildings; and a long-term national public building programme. The current LTRS identifies renovation trigger points targeting public buildings and pursues deep and nZEB renovation. The project *Romania Eficienta* addresses the issue of deep renovation of public buildings through four main avenues: renovation of several public schools; energy efficiency information campaigns; development of practical guides for renovation works; and specialised energy efficiency training for public administration representatives. It is helpful that such a programme is already established in Romania. National authorities could enhance it by following the example of Wallonia, where two consecutive programmes (PIVERT) enabled the upgrading of almost 47 000 public housing units, following energy standards and health and safety requirements. It is reported that ministries with significant building portfolios (e.g. Ministry of Education; Ministry of Health; local authorities; and other relevant bodies within the other ministries) should prepare priority lists for building renovation as part of their infrastructure and energy efficiency planning by 2030. This should include WPBs along with expected energy savings, investment needs and expected payback periods.

Mechanisms for mobilisation of investments: The mechanisms for mobilising investments were only partially described in Romania's LTRS. Aggregation of projects is not mentioned and the perceived risks for investors are not yet assumed. For public funding, a revision of the institutional framework for public financial mechanisms is in place under the supervision of the Ministry of Public Works, Development and Administration (MLPDA). An investment fund should mobilise funds and manage financial transactions. Under the supervision of the MLPDA, the investment fund would: forecast financial needs; facilitate the acquisition of financing; develop financial instruments; administer; act as a lender or a paying agent for revolving grant schemes/loans; and receive repayments. The co-financing programme will be supported by the introduction of deployment intermediaries such as 'financial intermediaries' (local banks) and 'implementing intermediates' (municipalities, public or private maintenance companies, ESCOs and utility companies). This framework enables building owners to execute investments, oversee contractors, facilitate repayments and amplify the advantages of the programme. A good practice example comes from the Wallonian LTRS, which describes five key mechanisms: 1) aggregation of projects, including by investment platforms or groups and by consortia of small- and medium-sized enterprises (SMEs), to enable investor access as well as packaged solutions for potential clients; 2) reducing the perceived risk of energy efficiency operations for investors and the private sector; 3) using public funding to leverage additional private-sector investment or address specific market failures; 4) guiding investments into an energy-efficient public building stock; and 5) introducing accessible and transparent advisory tools and energy advisory services. For aggregation of projects, Wallonia envisages promotion through investment platforms or groups and consortia of SMEs to allow access to investors and package solutions for potential clients. The Wallonian LTRS has a diversified strategy to reduce the (perceived) risks of renovation by pooling projects (e.g. aggregation measures above; promoting projects by cooperatives; pooling projects for EPCs;

[3] iBRoad2EPC project explores energy performance assessment schemes and certification practices with the aim of promoting and showcasing the integration of Renovation Passport elements into EPC schemes.

establishing a de-risking platform; training for the banking sector; and guaranteeing loans for disadvantaged groups). It will be crucial for Romania to work further on this topic, since EPBD (2024/1275) will require NBRPs to outline: investment needs for implementation; financing sources and measures; and administrative resources for building renovation.

Implementation details of the latest LTRS: Implementation details of Romania's latest LTRS are not provided. A good practice example for this can be found in the Spanish LTRS, which reports the implementation details on measures such as: renovation of public administration buildings; public financing; measures to encourage and mobilise private financing; combatting energy poverty' and others.

5.3 Ukraine

Building stock overview: Statistical data on the national building stock in Ukraine are limited due to changes in the composition and level of detail of statistical indicators regarding the building sector. Currently, there are data on the number of apartments in the residential segment or on the area of buildings put into operation (without dividing them into residential and non-residential areas). Statistics on non-residential buildings contain data on the number of buildings and the number of beneficiaries/users, but have no information on the area of buildings. Also, at the state level, there is no systematic collection of detailed statistical information on the amount of energy consumption in residential and public buildings. The Russian invasion of Ukraine also poses challenges for this problem due to frequent changes in the building stock from destructions. The Ukrainian LTRS reported that the data were collected from different sources and, since those sources are already providing the data, it would be advantageous to collect it in a unique national building stock database (similar to what was done in Italy). One priority goal mentioned in the Ukrainian LTRS is creating an electronic database of buildings and compiling it with operational (technical) characteristics of buildings using a geo-information system (GIS). Authorities would also like the database to be filled with information on the characteristics of completed thermal modernisation projects (energy-efficient measures) in buildings and to ensure the exchange of information between the Building Database and the EU Building Stock Observatory. The Italian example could be a lead in achieving this goal, as besides collecting indicators on the building stock, their database provides an estimate of the current annual renovation rate. The crucial step for the Ukrainian authorities will be updating and maintaining the database.

Worst-performing buildings and energy poverty: The Ukrainian LTRS outlines an approach to energy poverty, including some measures, actions and indicators for overcoming it. However, the strategy lacks data and any measures regarding WPBs. It will be essential to define this segment, as the EPBD (2024/1275) requires identifying and renovating those buildings. As mentioned earlier, this indicator was non-mandatory in the scope of the LTRS, and not many countries reported on it. A good practice example comes from Finland. Following Finland's example, Ukraine could start by defining which buildings would fall under the worst-performing category (e.g. lowest EPC label). Then setting up a building stock database, would make it easier to keep track of information on these buildings.

Roadmap with indicative milestones: Expected energy savings for 2030, 2040 and 2050 are mentioned in Ukraine's LTRS. Other indicators (e.g. targets for annual energy renovation rate and operational GHG emission reductions), however, are not quantified. Again, a good practice example is set by Finland. The Finnish strategy provides a clear roadmap to 2050, with indicative building renovation targets, milestones and measurable progress indicators

determined for 2030, 2040 and 2050. The strategy clearly describes the development of the building stock (residential and non-residential), as well as the estimated change between 2020-2050. Heating primary and final energy consumption for 2020, 2030, 2040 and 2050 are reported. Other progress indicators are also included, such as CO_2 emission reduction and the share of nZEB for each type of building. As it might be hard to report on all these indicators, the roadmap needs to include national targets for 2030, 2040 and 2050 regarding the annual energy renovation rate, primary and final energy consumption of the national building stock, and its operational GHG emissions reduction.

Public consultations: The summary of public consultations should be annexed to the LTRS, which is not the case for Ukraine. As such, it is not possible to analyse whether they were fully inclusive and transparent. Slovakia provides a good practice example for this as it directly involved many stakeholders in the development of its strategy. During the material preparation, the Ministry consulted members of the working party on individual areas, in person or writing, depending on the respective topic and the specific part of the strategy. The renovation strategy also went through an inter-departmental consultation procedure and public consultation via the publicly accessible web portal www.slov-lex.sk. Using an electronic form, any entity, including the public, may provide a comment on any part of the submitted material. The submitting party must evaluate every comment provided. Any accepted comments are incorporated by the submitting party. Results of the consultation are presented in detail in an attached document that includes main points raised by all relevant stakeholders involved (45 entities in the Slovakian case) and how they have been considered. It may be helpful for Ukraine to have the example from Slovakia (a fellow eastern European country) so it would be easier to follow their steps. This is especially important, as the EPBD (2024/1275) poses even stricter obligations on public consultations for future NBRPs.

6 Conclusions for developing policy guidelines for a NBRP

The policy guidelines, to be concluded in the EPBD.wise project by January 2026, will include tailored recommendations for each of the selected FCs on how to deal with identified problems and data gaps. In the following section, identified policy needs that will be addressed in the policy guidelines are structured into seven items.

For all three countries (Poland, Romania and Ukraine), the recommendations will focus on: 1) how to improve building stock data; 2) how to assess policies and measures required to set and achieve specific targets; 3) understanding investment needs and required financing programmes; and 4) how to identify and collect data on the worst-performing buildings.

Stakeholders from Poland and Romania also expressed the need for support in: 5) defining measures to improve energy performance on public buildings; and 6) policies and actions on deep renovations, analyses on wider impacts and measures to address energy poverty.

For all countries assessed (Poland, Romania and Ukraine), the support will also include suggestions regarding: 7) developing a roadmap with indicative milestones, especially decarbonisation targets and renovation rates. This will include discussion regarding evidence-based estimates of expected energy savings and wider benefits, especially how to better identify and quantify them. In particular for Romania, EPBD.wise will put a special focus on mechanisms for mobilising investments. For Ukraine, a special focus will be on organising public consultations.

The policy guidelines to be elaborated separately for each FC will have the following structure:

- Description of the NBRP framework according to EPBD (2024/1275).
- Summary of best practice examples.
- Status quo regarding previous LTRS, scenario development, data availability and processes (stakeholder interaction, main actors etc.) in the country.
- Draft of NBRP document structure, including templates for figures and tables.
- Draft of NBRP scenario analyses, showing ranges of various variables in different scenarios, in particular energy and GHG emission savings and investment needs.
- Recommendations regarding the above-mentioned problems tailored for each focus country

7 Summary of good practice examples and status quo analysis for ZEB definitions

7.1 Status quo of nZEB definitions

The EPBD 2018/844 [3] states that new buildings occupied by public authorities and properties were required to be nZEB by 31 December 2018. For all new buildings, the date was given as 31 December 2020. An nZEB is defined as a building with a very high energy performance, for which the nearly zero or very low amount of energy required should be covered, to a very significant extent, by energy from RES, including RES produced on-site or nearby.

Across the EU, the nZEB standard is defined by different characteristics and parameters. In general, each MS has set specific requirements for the U-value of each part of the building envelope and, in some cases, of the technical building systems. Requirements are also differentiated according to climatic area, shape of the building and use of the building. Primary energy is another major metric within the EPBD Directive 2010/31/EU, but the methodology used to calculate it is left up to each MS. Specifically, both 2010 and 2018 EPBD require that the energy performance of a building include an energy performance indicator [...] based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on-site production [3] [24]. These performance indicators are used to set minimum requirements for new and renovated buildings, and as the basis for informing EPCs that are required whenever a building is constructed, sold or rented.

Calculation of net primary energy is the final result, starting with the calculation of final energy needs for heating and cooling. The ‘direction’ of the calculation goes from the building's needs to the source (i.e. to the primary energy). Energy produced on-site, by RES, reduces the primary energy needs associated with delivered energy.

At present, there is no uniform, mandatory approach for national transposition of the nZEB definition. Many elements depend on national, regional and local conditions, as well as the calculation methodology to define the numerical indicator of primary energy use (kWh/m^2 y).

EPBD (2018/844) established a benchmarking system – the principle of ‘cost-optimality’ – to guide MS in setting energy performance requirements within national or regional building codes and reviewing them constantly (i.e. once every five years). The cost-optimal methodology allows MS to define the range of nZEB requirements in 2020.

JRC researchers working on nZEB policies have published an analysis [8] assessing MS methodologies, comparing them with benchmarks and recommendations published by the European Commission (EC) [9] to promote nZEB and best practices to ensure that, by 2020, all new buildings are nZEB. Assessment has been conducted for different parameters, with some analysed here to give an overview of their application in Europe. The following parameters are analysed in particular: a distinction between residential and non-residential; primary energy indicators; and RES contribution requirements.

The report reveals that all MS have adopted nZEB regulations defining energy indicators for new residential and non-residential buildings. For existing buildings, some MS still have not adopted any energy requirements.

Each MS can define the primary energy indicator it will use to determine nZEB energy performance, with a specific calculation balance period. Most MS indicate a balance of one year (for others, the calculation period is monthly), considering primary and/or source energy (the share of RES is not included), and delivered or on-site energy. A few countries refer to energy need or energy use; only one refers to equivalent CO_2 emissions. Even the normalisation procedure differs among MS; it can be based, for example, on gross floor area or net floor area.

The contribution of RES provided to the building to meet its energy demand is another parameter that should characterise the nZEB. At present, 7 MS do not include this aspect in their nZEB definitions and/or methodologies, while 18 countries adopt an energy label equivalent for nZEB (see Figure 1).

Figure 1 nZEB parameters definition in MS

Table 1
NZEB definitions summary.

	Definition/ requirements	Energy Class/label equivalent	U-VALUES	Energy Indicator (residential)	Energy Indicator (non-residential)	Energy Indicator (existing buildings)	Renewable share
AT	✓	X	✓	✓	✓	→	X
BE-BRU	≡	✓	X	✓	✓	✓	≡
BE-WA	✓	✓	✓	✓	✓	X	≡
BE-FLA	✓	X	✓	✓	✓	✓	✓
BG	✓	✓	X	✓	✓	✓	✓
HR	✓	✓	X	✓	✓	✓	✓
CY	✓	✓	✓	✓	✓	✓	✓
CZ	≡	X	✓	✓	✓	X	≡
DK	✓	✓	X	✓	✓	X	≡
EE	✓	✓	✓	✓	✓	✓	≡
FI	✓	✓	±	✓	✓	✓	≡
FR	✓	X	X	✓	✓	→	X
DE	✓	X	X	→	→	→	X
EL	✓	✓	X	✓	✓	✓	✓
HU	≡	✓	✓	✓	✓	✓	✓
IE	✓	✓	✓	✓	✓	✓	✓
IT	✓	X	✓	✓	✓	✓	✓
LV	✓	✓	X	✓	✓	✓	X
LT	✓	✓	✓	→	→	X	X
LU	±	✓	X	✓	→	✓	X
MT	✓	X	X	✓	✓	✓	→
NL	✓	X	X	✓	✓	X	✓
PL	✓	X	✓	✓	✓	✓	
PT	✓	✓	✓	→	→	→	✓
RO	✓	X	X	✓	✓	✓	✓
SK	✓	✓	✓	✓	✓	✓	≡
SI	✓	✓	±	✓	✓	✓	✓
ES	±	X	X	→	→	X	X
SE	✓	✓	X	✓	✓	X	X
UK	≡	X	X	→	→	X	X

±	under development	under development	draft				under development
→				calculated/assumed	calculated/assumed	calculated/assumed	calculated
X		no	not available	No/not available	No/not available	No/not available	not available
✓	yes/provided/to be approved	yes	yes	yes/provided (value or formula)	yes/provided (value or formula)	yes/provided (value or formula)	yes/provided
≡	under revision						not quantified/non obligatory

Source: JRC Report [8].

Another overview of different energy indicators used by MSs for defining nZEB is offered in *National applications of the nZEB definition: The complete overview'* [10], publicly available on the website of the Concerted Action EPBD (CA EPBD). Data were updated in 2018 and report on information was given by national contact points of the CA EPBD. While most MSs use primary energy indicators to define the energy performance of nZEB, four also indicate final energy benchmarks (Austria, Czech Republic, Poland and Slovak Republic). Ireland is the only MS to include a threshold for CO_2 emissions in its nZEB definition.[4]

A more recent study, *Nearly Zero: A Review of EU Member State Implementation of New Build Requirements* [11], carried out by BPIE with data updated by January 2021, compares the transposition of nZEB policies in terms of:

- Dates when nZEB is required for new buildings (1 January 2019 for all new publicly owned and occupied buildings, 1 January 2021 for all).
- Presence of a numerical indicator of primary energy use for nZEB definition. [11]
- Clear specification of RES requirements.

The figure below summarises findings from the BPIE study:

[4] A brief explanation of the used parameters is reported in section 7.2

Figure 2 January 2021 situation of nZEB regulation transposition in MS

Country/Region	Was nZEB legislation in place for public buildings by January 2019?	Was nZEB legislation in place for all buildings by January 2021?	Is there a numerical indicator of primary energy use expressed in kWh/m² per year?	Are renewable energy requirements clearly specified?
Austria	✓	✓	✗	✓
BE - Brussels	✓	✓	✓	✗
BE - Flanders	✓	✓	✗	✓
BE - Wallonia	✓	✓	✓	✗
Bulgaria	✓	✗	✓	✓
Croatia	✓	✓	✓	✓
Cyprus	✓	✓	✓	✗
Czechia	✓	✓	✓	✗
Denmark	✓	✓	✓	✓
Estonia	✓	✓	✓	✗
Finland	✓	✓	✓	✗
France	✓	✓	✓	✓
Germany	✗	✓	✗	✓
Greece	✗	✗	✓	✓
Hungary	✗	✗	✓	✓
Ireland	✓	✓	✓	✓
Italy	✓	✓	✗	✓
Latvia	✓	✓	✓	✗
Lithuania	✓	✓	✓	✓
Luxembourg	✓	✓	✗	✗
Malta	✓	✓	✓	✗
Netherlands	✓	✓	✓	✓
Poland	✓	✓	✓	✗
Portugal	✓	✓	✗	✓
Romania	✓	✓	✓	✓
Slovakia	✓	✓	✓	✗
Slovenia	✓	✓	✓	✓
Spain	✗	✓	✓	✓
Sweden	✓	✓	✓	✗

Source: BPIE report [11].

7.2 nZEB definitions in selected MS

This section provides specific information on nZEB definitions in Ireland, Germany and France. These schemes include parameters related to the building's operational CO_2 emissions and can be of inspiration for FCs developing a national ZEB definition.

Ireland is the only MS to introduce thresholds for GHG emissions within its nZEB definition. This may inspire other MS in elaborating a future definition of ZEB and in establishing new indicators to measure building CO_2 equivalent emissions.

Germany recently published a revision of its building energy law (*Gebäudeenergiegesetz*) with relevant amendments concerning decarbonisation of the building stock, focusing on technical building systems.

In France, the 2020 building regulation (*Réglementation environnementale* [RE2020]) for new buildings (for now only for residential buildings, offices and schools) set thresholds on CO_2 emissions linked to energy consumption, based on a life-cycle analysis for all energy carriers.

The Irish building regulation [12] [13] includes a benchmark for operational CO_2 emissions to ensure that buildings comply with the nZEB definition. It is the only MS to do so. Ireland introduced two parameters in its nZEB definition, the latter of which is related to CO_2 emissions. The maximum permitted energy performance coefficient (MPEPC) and the maximum carbon performance coefficient (MPCPC) are defined as the ratios of calculated primary energy consumption and corresponding CO_2 emissions for the proposed building, relative to a reference building.

a. The calculated energy performance coefficient of the dwelling being assessed should be no greater than the MPEPC. The MPEPC for a nZEB is 0.30 [12].
b. The calculated carbon performance coefficient (CPC) of the dwelling being assessed should be no greater than the MPCPC. The MPCPC for a nZEB is 0.35 for dwellings and is 1.15 for non-residential buildings [12] [13].

The main energy indicator is primary energy, calculated from the delivered energy, with an allowance for any energy exported from the site, using conversion factors. The minimum contribution from RES is 20% for residential and non-residential buildings. For non-residential, if the calculated energy performance coefficient=0.9 and CPC=1.04 is achieved, then the RES ratio can be 10%. The regulation provides for a comparison analysis between cost-optimal and nZEB levels. The German case [14] is interesting in that the country recently approved and published a revision of its building energy Law (in force from 1 January 2024), with relevant amendments concerning decarbonisation of the building stock, starting from technical building systems. According to the new law, every newly installed heating system in a new development area must be powered by 65% RES. For cities and municipalities with more than 100 000 inhabitants, installation of heating systems with 65% RES will be mandatory from 1 July 2026 at the latest. For cities and municipalities having fewer than 100 000 inhabitants, the new law comes into force from 1 July 2028. The changes will be accompanied by a revision of the Federal Funding Guidelines for Efficient Buildings. The main energy indicators are non-renewable primary energy demand and specific transmission losses. The minimum contribution from RES is different for the various technologies. The regulation provides for a comparison analysis between cost-optimal and nZEB levels.

In France [15], the 2020 building regulation RE2020 establishes a new regulatory framework for energy consumption to improve the environmental performance and comfort of buildings. Specific requirements are based on a whole life-cycle approach, as they establish emissions and energy consumption limits that must not be exceeded throughout the building's life. The energy indicator used for the nZEB definition is the total primary energy consumption (which includes heating, cooling, domestic hot water [DHW], lighting and electrical appliances). Additionally, the RE2020 introduced new indicators and benchmarks for new buildings: 1) 'Ic_{energy}', captures the impacts of energy consumption on climate change, during building life cycle; and 2) '$Ic_{construction}$', captures the climate change impacts of materials and equipment used for building construction, including the impacts of the construction phase. Thresholds, in kg CO_2/year, are calculated for these carbon performance indicators.

7.3 Status quo of ZEB definitions

Buildings play a significant role in GHG emissions. Accounting for 40% of final energy consumption in the EU and 36% of energy-related GHG emissions, they contribute to adverse environmental effects and climate change. Adoption of a ZEB standard represents a crucial step in mitigating these impacts, ZEBs are designed to effectively reduce GHG emissions.

The concept of ZEB has been developed over the last two decades and is perceived as a concrete way to decarbonise the buildings sector. Since 2006, research on ZEBs has increased gradually [16]. Relevant works can be a useful introduction, such as Torcellini et al. [17] and Marszal et al. [18].

The revision of the EPBD (2024/1275) [1] introduces the concept of ZEB, which represents the future building standard as of 2028, and the target that each MS must achieve to completely decarbonise its building stock by 2050. Article 2 of the Directive provides the following definition for the ZEB standard: "'ZEB' means a building with a very high energy performance, as determined in accordance with Annex I, requiring zero or a very low amount of energy, producing zero on-site carbon emissions from fossil fuels and producing zero or a very low amount of operational GHG emissions, in accordance with Article 11" [1]. Where it is technically or economically feasible, the total annual primary energy use of a ZEB must be covered by: on-site energy or nearby renewables, fulfilling the criteria from Article 7 of Directive (EU) 2018/2001 Renewable Energy Directive (RED); energy from renewable energy communities, within the meaning of Article 22 of Directive (EU) 2018/2001 (RED); energy from efficient district heating and cooling in accordance with Article 26(1) of Directive (EU) 2023/1791 (EED); or energy from carbon-free sources. MS must set maximum thresholds for the energy demand (with a view to achieving at least the cost-optimal levels and at least 10% lower than the threshold for total primary energy use for nZEB) and for operational GHG emissions. Where economically and technically feasible, the ZEB shall offer the capacity to react to external signals and adapt its energy use, generation or storage.

To achieve the target of carbon neutrality by 2050, MS need to transition from nZEB to ZEB. While nZEBs remain the current building standard (since 2021) for new buildings, ZEBs are set as the future building target as of 2028/2030.

Figure 3 Definitions for buildings with zero or very low emissions [19]

Name and source	Definition
Zero Emission by The Norwegian Research Centre on Zero Emission Buildings (ZEB, 2022)	A zero emission building produces enough renewable energy to compensate for the building's GHG emissions over its life span. The ZEB research centre has defined different levels of zero emission buildings depending on how many phases of a building's lifespan that are counted in. The 5 most important definitions, in rising ambition level, are: ZEB – O: The building's renewable energy production compensate for greenhouse gas emissions from operation of the building. ZEB – O + EQ: The building's renewable energy production compensate for greenhouse gas emissions from operation of the building minus the energy use for equipment (plug loads). ZEB – OM: The building's renewable energy production compensate for greenhouse gas emissions from operation and production of its building materials. ZEB – COM: The building's renewable energy production compensate for greenhouse gas emissions from construction, operation and production of building materials ZEB – COMPLETE: The building's renewable energy production compensate for greenhouse gas emissions from the entire lifespan of the building. Building materials – construction – operation and demolition/recycling.
Zero-Carbon-Ready by International Energy Agency (International Energy Agency, 2021a)	A zero-carbon-ready building is highly energy efficient and uses either renewable energy directly or from an energy supply that will be fully decarbonised by 2050 such as electricity or district heat. This means that a zero-carbon-ready building will become a zero-carbon building by 2050, without any further changes to the building or its equipment.
Net Zero Emission by (Good et al., 2015)	In a net zero emission building, all operational and embodied emissions from materials are offset by on-site renewable energy generation. The word "net" indicates that energy can be exported from and imported to the building, and the net energy or emission balance is calculated over a specific period of time, usually a year. In practice, this usually means that the building is connected to the energy grid.
Zero Emission by (Brozovsky et al., 2019)	Zero emission buildings focus on the reduction of GHG emissions and are not targeting energy use as a criterion, at least not primarily. Such building aims to produce enough renewable energy to compensate for the GHG emissions over its life span.
Zero Emission by (Søgnen et al., 2016)	Zero emission buildings should replace fossil fuels with renewable clean energy so that the saved emissions equals the emissions caused by the building's construction, operation and materials.
Zero Emission by (Skaar et al., 2018)	A zero emission building is an energy-efficient building with on-site renewable energy generation that can export enough energy to compensate for the carbon footprint of the building's own energy and material consumption in a life-cycle perspective.
Net Zero Emission by (Ruparathna et al., 2017)	Net zero emission buildings use emission-free energy and supply the energy demand through on-site renewable energy generation.

Net Zero Emission by (Torcellini et al., 2006)	A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources.
Zero carbon by (Riedy et al., 2011)	A zero carbon building has no net annual Scope 1 and 2 emissions from operation of building-incorporated services. Scope 1 emissions are direct GHG emissions from sources owned or controlled by the occupant. Scope 2 emissions are those from generation of electricity used in the building. Building-incorporated services include all energy demands or sources that are part of the building fabric at the time of delivery, such as the thermal envelope (and associated heating and cooling demand), water heater, built-in cooking appliances, fixed lighting, shared infrastructure and installed renewable energy generation.
Zero Emission by Australian Government (Pipkorn et al., 2013)	A zero emission house is a detached residential building that does not produce or release any CO_2 or other GHG to the atmosphere as a direct or indirect result of the consumption and utilisation of energy in the house or on the site.
Net Zero Carbon by UK government (UK gov, 2022)	For new buildings and renovation: The amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy. For all buildings in operation: The amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.

The literature has many examples of definitions of zero carbon/emission or zero energy buildings: defining what is meant by these terms is often seen as complex and challenging. Ambiguities arise from conflicting definitions and diverse calculation methods endorsed by global organisations, making it challenging to precisely define a ZEB project. Despite this abundance, there is a scarcity of universally acknowledged definitions. A general consensus is that a ZEB is a highly energy efficient building that produces enough RE to compensate for its GHG emissions. At present, only a few definitions are given in national legislation; the majority are concepts developed and studied at a theoretical level.

Figure 3 [19] summarises the main definitions for buildings with zero or very low emissions identified in the literature.

7.3.1 Criteria for ZEB

A set of criteria must be assessed to establish a strong definition of a ZEB. These differ both in their ideology and their methodology and use a variety of metrics for verification. Certain aspects of these standards may already be addressed in existing national building energy codes. Many standards are interrelated; as such, decisions made on one criterion may impact or potentially force decisions on another. The main criteria identified from the literature to define a ZEB are the following.

'Energy efficiency first' principle: In ZEBs, to avoid unnecessary energy generation, it is crucial to implement strategies that minimise energy needs, through cost-effective efficiency measures. One possible method for formulating a ZEB definition involves minimising energy needs as broadly as possible by incorporating energy-efficient measures, starting with passive design measures prior to adopting renewable energy technologies.

RES share and contribution: ZEBs include RE systems that produce enough energy to cover the remaining energy needs. Any remaining GHG emissions linked to the low amount

of energy the building requires can be compensated via the surplus RE generated by the building, i.e. generation that exceeds its own demand.

Site boundary: The definition of a ZEB should include a defined site boundary, i.e. a geometrical concept representing a boundary that is functionally integrated into the building. In the case of a single building on a single property, the site boundary generally coincides with the property boundary. The site boundary should encompass the utility interface point. If the on-site RE is located within the building footprint, the site boundary may encircle the building footprint. If some of the on-site RE is on-site but not within the building footprint, the site boundary may be around the building site. Energy delivered to and exported from the site is measured at the site boundary [20].

Boundaries for renewables: Various options exist concerning RE supply, including on-site RE generation, off-site RE-purchase or off-site RE generation.

On-site generation refers to the option to generate energy from RES installed on the building (e.g. PV and solar thermal installed on rooftops or facades) or to use RES available at the site (e.g. PV on parking lots). On-site generation is preferable to off-site options because it increases the total installed capacity of clean RE within a city or a district. It also helps to enhance the building's energy security and energy resilience in case of disruptions to the grid.

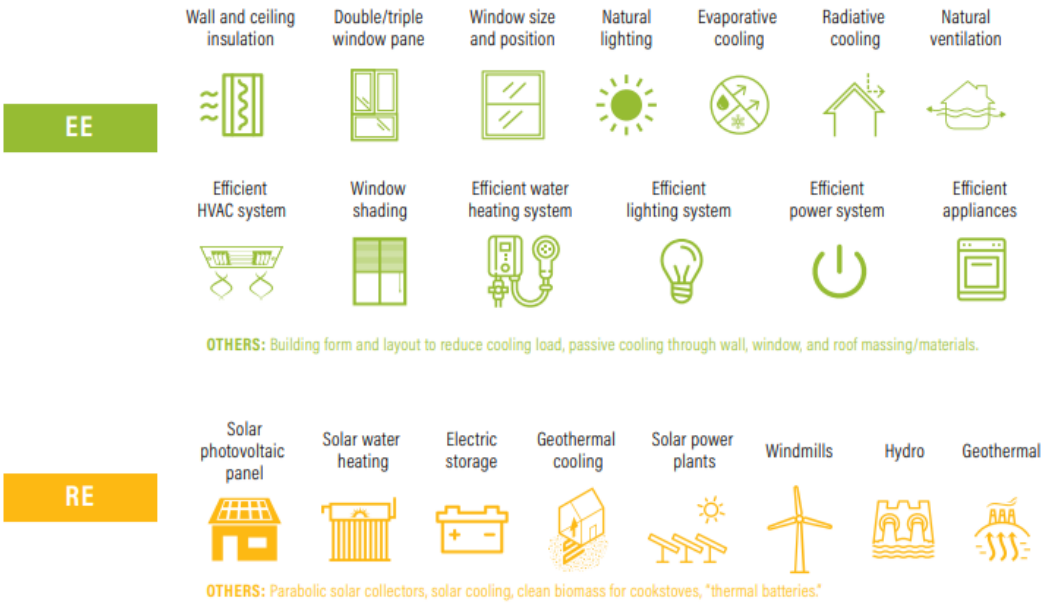
Where on-site generation for individual buildings faces technical, financial and/or legislative barriers, alternative off-site energy solutions can be considered. It may be possible to purchase RE locally. If not, interested parties can explore the possibility of generating RE at the district level to serve a cluster of buildings within an area. Distributed generation models help enhance local energy security and resilience during grid power interruptions. High-density urban areas, however, may lack sufficient suitable space for on-site or local off-site generation and may have to rely on clean energy generated beyond the district or even city boundaries.

Energy accounting (balance input): A ZEB is commonly a very energy-efficient building that generates energy and is connected to the grid. The fundamental idea is that a ZEB uses the electric grid (or other energy networks) to redistribute to other consumers any excess on-site RE. Energy accounting for ZEBs would encompass energy consumption for heating, cooling, ventilation, DHW, indoor and outdoor lighting, and plug loads. On-site RE can also be distributed through transmission methods other than the electricity grid, such as charging electric vehicles used outside the building.

Energy delivered to the building can encompass grid electricity, district heating and cooling, as well as renewable and non-renewable fuels. A ZEB balances its energy consumption annually, ensuring that energy exported to the grid (or other energy networks) matches or surpasses the energy delivered to the building. A ZEB may only use on-site RE (i.e. energy produced from RES within the site perimeter) to offset the delivered energy. Renewable fuels transported to the site boundary are not included, as they are considered part of the delivered energy. Energy accounting for ZEBs does not allow the use of non-renewable energy exported from the site boundary to offset delivered energy.

Energy efficiency and renewable energy technologies: The ZEB concept promotes buildings that use the grid as the virtual energy storage medium. They exchange a large amount of energy with the grid and rely heavily on these energy exchanges to fulfil their yearly zero balance. Large-scale application of ZEBs in the building stock can only be realised with the implementation of well-designed energy solutions [18] [21].

Figure 4 Available energy efficiency and renewable energy technologies that support a ZEB [22]



Energy efficient solutions for a ZEB aim to reduce energy consumption while maintaining or improving indoor comfort and functionality. Priority should be given to energy efficiency measures before installing renewable energy systems, in order to maximise their effectiveness and minimise any energy waste.

Cost-optimality approach: In the context of the EPBD, MS are required to determine cost-optimal levels of minimum energy performance for new and existing buildings using a comparative methodology provided by the EC. Studies show that this cost-optimal methodology has been used to define nZEB levels across MS.

A comparison between cost-optimal and nZEB levels reveals that nZEB requirements are typically around 50% lower than cost-optimal references, which, in turn, are about 70% lower than the national minimum energy performance requirements set in 2006 (D'Agostino et al., 2021) [8]. MS have progressively enhanced these requirements over the last 15 years through legislative steps.

In the cost-optimal approach, the macro-economic perspective includes assessing the cost of GHG emissions, represented as the monetary value of environmental damage caused by CO_2 emissions related to building energy consumption. Almost all MS have performed macro-economic calculations, although with varying approaches. However, when MS focus solely on financial perspectives, CO_2 emissions are often overlooked.

Some MS incorporate CO_2 emissions indicators (in addition to primary energy) in their nZEB definitions. The embodied energy in low-energy buildings such as nZEBs is becoming increasingly significant in their life cycle, highlighting the importance of assessing life-cycle GHG emissions. Several countries have established threshold values for CO_2 emissions in nZEBs, based on building types and climatic zones.

To effectively decarbonise the building stock by 2050 through the introduction of ZEB buildings, it is necessary to revise current energy performance requirements, which do not automatically lead to carbon-neutral buildings. Building on progress made with the cost-optimal methodology and nZEB definitions, introducing GHG emissions requirements for buildings, starting with nZEB definition, can encourage MS to continue upgrading energy efficiency requirements, thereby adhering to the 'energy efficiency first' principle.

Life-cycle assessment (LCA) approach: Determining GHG emissions associated with a building's life cycle usually includes two aspects: operational emissions and embodied emissions. The whole life cycle of a building includes construction, maintenance and repair, renovation and retrofit, and eventually demolition. All of these stages produce CO_2 emissions from materials, machinery and fuel, which are known as 'embodied carbon'.

The modular framework of LCA approach is based on the building standard EN 15978:2011 for the sustainability of construction works and maps the environmental information based on the building's value chain stages.

Increasingly, governments are likely to encourage the inclusion of embodied carbon in ZEB approaches to account for all CO_2 emissions across the building's full life cycle.

The new EPBD requires that "the whole life cycle emissions of buildings should therefore progressively be taken into account (...) not only in new construction but also in renovations through the inclusion of policies for the reduction of whole life cycle GHG emissions in MS building renovation plans." [3].

The performance of new buildings and buildings renovated in class A+ should also be calculated using the life cycle GWP. GWP with a 100-year time horizon (GWP 100) is now widely recognized as a key indicator in the construction sector. It is often quantified as a 'carbon footprint' to effectively describe and communicate the carbon performance of a building.

A growing volume of literature acknowledges the importance of assessing the energy and emissions performance buildings from a life-cycle perspective. Few studies, however, focus on achieving net-zero life-cycle primary energy or GHG emissions, as calculating the embodied emissions is a complex process. In the case of existing buildings, data on materials used may be lacking, making a thorough evaluation of embodied emissions challenging.

Indicators and metrics: Despite the importance of embodied carbon, current ZEB approaches most commonly have indicators based on an operational approach.

The operational part of an LCA calculates the final energy demand for the operation of the building, generally including heating, cooling, hot water supply, ventilation or air conditioning, auxiliary energy for pumps, and fixed lighting. It sometimes also covers occupants' use of plug-in appliances (so-called 'plug loads'). The EPBD defines primary energy as energy from renewable and non-renewable sources that has not undergone conversion. In the past, the primary metric for assessing building performance was non-renewable primary energy consumption. Due to increasing concerns about climate change, GHG emissions are now considered the primary indicator. Primary energy factors (PEF) describe the efficiency of converting energy from primary sources, like fossil fuels, to secondary energy carriers (e.g. electricity) [23] that provide the services delivered for EPB-related uses (e.g. for heating, cooling, ventilating, etc). PEFs are used to calculate the energy performance of buildings, which is expressed in terms of primary energy, while emissions factors convert final energy

demand into GHG emissions. While energy demand is often used as a proxy for CO_2 emissions, the relationship is complex.

The standard on the EPB EN ISO 52000-1:2017 categorizes PEFs as follows [23]:

- **non-renewable PEF,** considering only non-renewable energy overheads of delivery to the point of use, excluding RE overheads and primary energy components;
- **renewable PEF** considering only RE overheads of delivery to the point of use, excluding non-renewable energy overheads and primary energy components;
- **total PEF,** which represents the sum of the non-renewable and renewable PEFs.

A strong link exists between PEF and carbon emissions coefficients, and carbon emissions coefficients are strongly linked to PEFs for non-renewable sources such as fossil fuels (but less so for other sources such as renewables, biomass, and nuclear energy). To date, there is no consensus on these sources. The standard prEN 17423 provides a framework for determining PEFs and carbon emission coefficients.

For existing buildings, standards such as the Carbon Metric of an Existing Building during Use Stage offer methods to calculate, communicate, and verify carbon metrics for GHG emissions during building activity. This metric is the sum of annual GHG emissions and removals associated with the building's use stage, expressed as CO_2 equivalents.

Calculation method: Evaluation of a building's operational energy balance and associated emissions commonly employs two calculation methods: steady-state and dynamic. Steady-state methods provide calculations in a stationary manner, they ignore the building's true dynamic behaviour, using fixed lengths for heating and cooling seasons. Dynamic methods consider actual dynamic parameters such as: environmental behaviour, heat gain variability, ventilation, infiltration rates and building mass capacity. Although dynamic approaches are more time-consuming and costlier due to additional digitalisation, when reliable input data are available, they offer a more accurate representation of a building's behaviour.

Dynamic approaches are especially important when considering the carbon intensity of the energy mix, which can change over time. Using GHG emissions factors with a detailed time scale allows for a more precise accounting of GHG emissions, capturing variations in the energy mix over time. Decreasing the GHG intensity of electricity grids can complicate efforts to displace initial embodied GHG emissions of buildings, particularly in fully decarbonised energy grids. Sensitivity analyses are needed to accurately simulate changes in the electricity mix, especially for renovation scenarios involving electricity-based heating systems.

The GHG emission intensity of the electricity mix can be considered on various time scales, including annual, seasonal, monthly, daily or hourly. Hourly and regionally specific (marginal) GHG emissions factors are crucial for accurately assessing the benefits of GHG emission reduction strategies, such as on-site renewable energy systems.

Source energy calculations: Building managers commonly rely upon on-site energy metrics, which use utility meters to measure energy consumed by a building. While useful for understanding the building and system performance, site energy alone does not capture the full impact of resource consumption and emissions associated with energy use. This is especially true for buildings with different energy mixes or on-site generation, such as PV systems or cogeneration units. To compare efficiencies across buildings with different fuel types, it is necessary to convert energy types into equivalent units of raw fuel consumed on-site, a process known as source energy conversion. Source energy accounts for the

extraction, processing and transport of primary fuels, as well as losses in generation, transmission and distribution. The ZEB definition uses national average ratios to ensure fairness in assessing energy efficiency. Source energy is calculated from delivered and exported energy for each type, using conversion factors from ASHRAE Standard 105. On-site RE, while carbon-free and having zero energy loss when exported to the grid, displaces grid electricity. In ZEB accounting, it is therefore recognised with the same source energy factor as delivered electricity.

Monitoring: Monitoring a ZEB is crucial to ensure that it continues to operate efficiently, maintains its zero-emission status and achieves its sustainability goals over time. By implementing comprehensive monitoring strategies and leveraging advanced technologies, ZEB owners, operators and stakeholders can maximise energy efficiency, environmental performance, and occupant satisfaction throughout the life cycle of the building. Regular monitoring, analysis, and optimisation are essential for achieving and maintaining the zero-emission status of ZEBs and advancing sustainability goals in the built environment.

7.4 Difference analysis between nZEBs and ZEBs

Table 6 compares the main indicators extracted from the definitions of nZEB and ZEB, according to descriptions contained, respectively, in Directive 2010/31/EU [24] and Directive 2024/1275/EU [1]. The table refers to the two documents mentioned previously as EPBD 2010 (Directive 2010/31/EU) and EPBD 2024 (Directive 2024/1275/EU).

Table 6 Differences between nZEBs and ZEBs

Indicator	nZEB	ZEB	
Energy efficiency principle	Yes, for new and existing buildings	Yes, for new and existing buildings	The 'energy efficiency first' principle is an overarching principle that should be considered across all sectors, going beyond the energy system, at all levels. New buildings shall meet the minimum energy performance requirements, which are more energy efficient than cost-optimal energy efficiency levels. For existing buildings, Art. 2 (20) in EPBD 2024, 'deep renovation' means a renovation that is in line with the energy efficiency first principle, which focuses on essential building elements, and transforms a building or building unit: (a) before 1 January 2030, into a nZEB; (b) from 1 January 2030, into a ZEB.
RES share and contribution	Yes	Yes	EPBD 2018, Art. 2: "Nearly zero-emission building (…) 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." EPBD 2024, Art. 11: "MS shall ensure that the total annual primary energy use of a new or renovated ZEB is covered by: (a) energy from renewable sources generated on-site or nearby (…) (b) energy from renewable sources provided from a renewable energy community within the meaning of Article 22 of Directive (EU) 2018/2001."

Indicator	nZEB	ZEB	
Energy class Label	No	Yes	Not requested for nZEB. EPBD 2024, Art. 19-2. “The letter A shall correspond to zero-emission buildings.”
Phasing out fossil fuels	No	Yes	Not defined for nZEB. ZEB: EPBD 2024, Art. 2: ZEB means “a building... producing zero on-site carbon emissions from fossil fuels..., in accordance with Article 11.”
Operational GHG emissions $kgCO_2eq/(m^2y)$	No	Yes	Not defined for nZEB. ZEB: EPBD 2024, Art. 2: ZEB means “a building ... producing zero or a very low amount of operational GHG emissions, in accordance with Article 11.”
On-site/nearby RE production	Yes	Yes	nZEB: EPBD 2024, Art. 2: (3) “The nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced onsite or energy from renewable sources produced nearby.” ZEB: EPBD 2024, Art.11, p.7: “MS shall ensure that the total annual primary energy use of a new or renovated ZEB is covered by: (a) energy from renewable sources generated on-site or nearby, fulfilling the criteria laid down in Article 7 of Directive (EU) 2018/2001.”
On-site/nearby carbon emissions from fossil fuels	No	Yes	Nothing in the nZEB definition. ZEB: EPBD 2024 Art. 2: “ZEB means a building ... producing zero on-site carbon emissions from fossil fuels ... in accordance with Article 11.”
Life-cycle approach/ global warming potential (GWP)	No	Yes, for new buildings	Nothing in the nZEB definition. ZEB: EPBD 2024, Art. 7 - New buildings: “MS shall ensure that the life cycle GWP is calculated in accordance with Annex III and disclosed in the EPC of the building.”
Reference period for energy balance	Yes	Yes	nZEB: EPBD 2018, Annex I, 1: “The energy performance of a building shall be determined on the basis of calculated or actual energy use and shall reflect typical energy use for space heating, space cooling, DHW, ventilation, built-in lighting and other technical building systems.” ZEB: EPBD 2024, Annex I: “The energy performance of a building shall be determined on the basis of calculated or metered energy use and shall reflect typical energy use for space heating, space cooling, DHW, ventilation, built-in lighting and other technical building systems. (…). Metered energy use for the purpose of calculating the EPB shall require readings of at least monthly intervals and must differentiate between energy carriers.”

Indicator	nZEB	ZEB	
Timelines (to come into effect)	Yes	Yes	EPBD 2018, Art. 9: "MS shall 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." EPBD 2024, Art. 7: "MS shall ensure that new buildings are ZEB in accordance with Article 11: (a) from 1 January 2028, new buildings owned by public bodies; and (b) from 1 January 2030, all new buildings."
Primary energy	Yes	Yes	EPBD 2018 for nZEB, Art. 2: 'Primary energy' means energy from renewable and non-renewable sources which has not undergone any conversion or transformation process." Art. 9: "The national plans shall include the MS's detailed application in practice of the definition of nearly zero-energy buildings, (…) including a numerical indicator of primary energy use expressed in kWh/m2 per year." EPBD 2024, Art. 2: 'Primary energy' means energy from renewable and non-renewable sources which has not undergone any conversion or transformation process."
Energy demand	No	Yes	Nothing in the nZEB definition. EPBD 2024, Art.11: "MS shall take the necessary measures to ensure that the energy demand of a ZEB complies with a maximum threshold."
Emission factors (PEF)	Yes	Yes	EPBD 2018, Annex I, 2: "The calculation of primary energy shall be based on PEF or weighting factors per energy carrier, which may be based on national, regional or local annual, and possibly also seasonal or monthly, weighted averages or on more specific information made available for individual district system." EPBD 2024, Annex I, 2: "The calculation of primary energy shall be based on regularly updated and forward-looking PEF (distinguishing non-renewable, renewable, and total) or weighting factors per energy carrier, which have to be recognised by the national authorities and considering the expected energy mix on the basis of its national energy and climate plan. Those PEF or weighting factors may be based on national, regional, or local information. PEF or weighting factors may be set on an annual, seasonal, monthly, daily or hourly basis or on more specific information made available for individual district systems."
Cost-optimality approach	Yes	Yes	EPBD 2024, Art. 2: "'Nearly zero-energy building' means a building with a very high energy performance, as determined in accordance with Annex I, which is no worse than the 2023 cost-optimal level reported by MS pursuant to Article 6(2) and where the nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources,

Indicator	nZEB	ZEB	
			including energy from renewable sources produced on-site or energy from renewable sources produced nearby." EPBD 2024, Art. 5: "MS shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to at least achieving cost-optimal levels and, where relevant, more stringent reference values such as nearly zero-energy building requirements and ZEB requirements."

A nZEB is a building that generates as much energy as it consumes over the course of a year. nZEBs focus primarily on energy usage and production and incorporate RES to generate the energy needed for operating the building. nZEBs are typically connected to the grid and may draw energy from it when demand exceeds on-site generation. They can also feed surplus energy into the grid when production exceeds demand. The primary aim of nZEBs is to achieve a balance between energy consumption and energy production, with a focus on minimising energy use through energy efficiency measures and maximising RE generation.

A ZEB is a building that eliminates GHG emissions associated with its energy consumption and operation. ZEBs focus on reducing or eliminating emissions (particularly CO_2 emissions) through various means such as energy efficiency measures, on-site RE generation and carbon offsetting. While ZEBs often incorporate RES (as do nZEBs), the emphasis is on minimising or completely eliminating emissions associated with energy use, rather than achieving a specific energy balance. ZEBs may or may not be connected to the grid, depending on their design and location. Off-grid ZEBs rely entirely on on-site RE generation and energy storage systems. ZEBs address broader environmental impacts beyond just energy, aiming to reduce or eliminate emissions from all sources associated with building operation. EPBD (2024/1275) requires a calculation of GWP throughout a building's life cycle.

In summary, while both nZEBs and ZEBs aim to reduce environmental impacts, they differ in their primary focus and scope. nZEBS aim to achieve a balance between energy consumption and production over time; ZEBs focus on eliminating GHG emissions associated with building operation, encompassing broader environmental considerations beyond just energy use.

7.5 Good practice examples for ZEB

Since ZEB is a new concept in the EPBD Directive, it encompasses several aspects that have not yet been implemented by MS. The challenge of providing a definition and a methodology at national levels can be addressed by drawing upon the best practices of nZEBs, for which MS have already integrated relevant energy policies. Referring to new research and practical case studies in Europe and beyond can help MS better understand how to implement the new ZEB standard.

The choice of the good practice examples for ZEB was conducted according to the general criteria and specific criteria defined in Sections 2.3.1 and 2.3.3. Those selected (summarised in Table 7) manage to address most of these criteria simultaneously. The good practice examples were selected from a wide field of applications (e.g. new or existing buildings; residential or non-residential; and building, neighbourhood or district approaches).

Table 7 Good practices selected in accordance with specific criteria for ZEB and related Annex reference

Categories	Good Practices	Annex
Existing policies and ZEB definitions		
Advanced nZEB	nZEB in Ireland	5a
	nZEB in Germany	5b
	nZEB in France	5c
ZEB definition	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	Norwegian Research ZEN	5f
	World Green Building Council (WGBC) case study library	5g
Specific targets		
Energy efficiency	nZEB in Ireland	5a
	nZEB in Germany	5b
	nZEB in France	5c
	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	WGBC case study library	5g
RES share and contribution	nZEB in Ireland	5a
	nZEB in Germany	5b
	nZEB in France	5c
	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	WGBC case study library	5g
Phasing out fossil fuels	nZEB in Germany	5b
	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	WGBC case study library	5g
Low OGHG emissions	nZEB in Ireland	5a
	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	Norwegian Research ZEN	5f
	WGBC case study library	5g
Low on-site carbon emissions from fossil fuels	nZEB in Ireland	5a
	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	Norwegian Research ZEN	5f
	WGBC case study library	5g
LCA and GWP	nZEB in France	5c
	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	Norwegian Research ZEN	5f
	WGBC Advancing Net Zero – Case study library	5g
Methodology		
Calculation method	Co-inventing Doria	5d
	Norwegian Research ZEB	5e
	Norwegian Research ZEN	5f
New tools and evaluation methods	nZEB in Ireland	5a
	nZEB in Germany	5b
	Co-inventing Doria	5d

Categories	Good Practices	Annex
	Norwegian Research ZEN	5f
Indicators and metrics		
nZEB Indicators to be maintained	nZEB in Ireland	5a
	nZEB in Germany	5b
	nZEB in France	5c
New ZEB indicators	Co-inventing Doria	5d
	Norwegian Research ZEN	5f
	WGBC case study library	5g
Cost effectiveness	nZEB in Ireland	5a
Other	nZEB in Ireland	5a
RES for other uses	nZEB in Ireland	5a
Financing		
Public Incentives	nZEB in Germany	5b
	nZEB in France	5c
Other	Co-inventing Doria	5d
Monitoring		
Databases / Observatory	WGBC case study library	5g

* WGBC = World Green Building Council.

As stated in Section 7.2, Ireland, Germany and France have implemented advanced nZEB levels in their national regulatory frameworks, considering consolidated indicators while also introducing new technical goals and new indicators and metrics.

In summary, Ireland (Annex 5a) has established criteria for the RES ratio, CO_2 emissions and the cost-optimal level to define nZEB. These aspects are crucial for shaping the future definition of ZEB and establishing new indicators to measure building energy performance and CO_2 equivalent emissions. Germany (Annex 5b) led the way in shaping the concept of nZEBs and in establishing goals for highly energy-efficient buildings and implementing RES. In addition to the recent implementation of renewable heating laws and accompanying subsidies, Germany is making significant strides towards diminishing its reliance on fossil fuels. By focusing on investing in clean, sustainable technologies – and reinforcing them through strategic policy measures such as the Building Energy Act – Germany is actively facilitating this transition. The energy regulation in France RE2020 (Annex 5c) was one of the pioneering initiatives globally, aimed at integrating environmental performance into new construction projects through life-cycle analysis.

Other reported ZEB good practices are based on significant research programmes or case studies that could be examples for realising the new ZEB standard. As a case study of an advance ZEB, Co-Inventing Doria (Annex 5d) was selected as an inspiring project of a hostel and the wider adjacent area, combining high performance and carbon neutrality.

As for research programmes, those conducted by the Norwegian Centres for Environment-friendly Energy Research on ZEB (Annex 5e) and Neighbourhoods (ZEN – Annex 5f) were considered noteworthy because of the development of competitive solutions towards the zero-emission objective in different building types (residential and non-residential) and in different district areas. The Research Centre on ZEB provided five levels of ZEB, depending on the RES production and the compensation of GHG emissions in the lifespan of the buildings, which could serve for future implementation of the ZEB definition. The research programme on ZEB developed instructions on how to document and realise zero-emission pilot buildings. The ZEB goal at different levels was defined at an early stage of designing the pilot cases,

involving key stakeholders and researchers to ensure cooperation and multidisciplinary skills. Advanced building envelope and mechanical solutions were used in the buildings while solar energy use was ensured to provide the necessary RES production. Low GHG emissions were reached in all pilot cases, adopting LCA and BIM tools. Extending the approach to the neighbourhood scale, the Research Centre on ZEN considered nine pilot areas spread across Norway, developing technologies and solutions for the design and operation of energy-flexible districts with cost-effective and energy efficient buildings. They adopted low-carbon technologies and construction systems based on life-cycle design strategies, which could serve as a guide for implementing zero-energy districts. Key performance indicators – e.g. GHG emissions, energy, power, mobility, spatial qualities, economy, and innovation – were considered to evaluate the quality of the projects.

The project Advancing Net Zero, from the Case Study Library of the World Green Building Council (WGBC), was cited as good practice (Annex 5g). It features an extensive collection of high-energy-efficient and low- or zero-energy buildings worldwide that could be a source of inspiration for pilot projects of ZEB and to create databases on ZEBs realized in the future by each country. Among the collected case studies, it gathers (from various locations across the globe) 67 operational net-zero carbon buildings and one building with net-zero whole-life carbon emissions. The WGBC has disseminated well-established strategies aimed at boosting energy efficiency, promoting adaptation and resilience, reducing embodied carbon emissions, and seamlessly integrating with nature-focused solutions. Each case study aligns with at least one of WGBC's three key impact areas: net-zero operational carbon/climate action; health, equity, and resilience; and resources and circularity.

8 Conclusions on the status quo of ZEB definitions and for developing a proposed ZEB definition

The EPBD.wise project will develop a single proposed ZEB definition by January 2026, taking account of the needs and key features identified for the priority countries (Bulgaria, Hungary and Ukraine). However, no support or policy recommendation will be specifically provided about ZEBs.

The concept of ZEB follows that of nZEB. While both nZEBs and ZEBs aim to reduce the environmental impact of the building stock, they differ in their primary focus and scope. nZEBs aim to achieve a balance between energy consumption and production over time. ZEBs focus on eliminating GHG emissions associated with building operation, encompassing broader environmental considerations beyond energy use.

The review of ZEB definitions available in the literature and of advanced nZEB definitions adopted by selected MS showed a set of criteria to be taken into consideration and subsequently assessed for the adoption and implementation of a ZEB definition. Twelve main criteria include; the ‘energy efficiency first’ principle; RES share and contribution; site boundary; boundaries for renewables; energy balance input; energy efficiency and renewable energy technologies; cost-optimality approach; LCA; identification of key indicators and metrics; calculation methods; source energy calculations; and monitoring.

References

[1] European Commission (2024), *Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)*, Official Journal of the European Union, Luxembourg. Available : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275

[2] Joint Research Centre (European Commission) (2022), *Assessment of the first long-term renovation strategies under the Energy Performance of Building Directive (Art. 2a),* Publications Office of the European Union, Italy. Available: https://data.europa.eu/doi/10.2760/535845.

[3] European Commission (2018), *Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency*, Official Journal of the European Union, Luxembourg. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0075.01.ENG

[4] D. Staniaszek, J. Kockat, and A. Vitali Roscini (2020), *A Review of EU Member States' 2020 Long-Term Renovation Strategies*, Buildings Performance Institute Europe, Brussels. Available: https://www.bpie.eu/wp-content/uploads/2020/09/LTRS-Assessment_Final.pdf

[5] BGK, *TERMO Programme*, Website of the Bank Gospodarstwa Krajowego. Available : https://www.en.bgk.pl/programmes/termo-programme/.

[6] Republic of Poland, *National Fund for Environmental Protection and Water Management*, Website of the Republic of Poland. Available : https://www.gov.pl/web/nfosigw-en/priority-programmes84.

[7] European Commission (2023), *Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast)*, Official Journal of the European Union, Luxembourg. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_231_R_0001&qid=1695186598766

[8] D. D'Agostino, S. T. Tzeiranaki et al. (2021), "Assessing nearly zero energy buildings (NZEBs) development in Europe", *Energy Strategy Reviews,* vol. 36, p. 100680, Elsevier, Italy, doi: 10.1016/j.esr.2021.100680

[9] European Commission (2016), *Commission Recommendation (EU) 2016/1318 of 29 July 2016 on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings*, Official Journal of the European Union, Luxembourg. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016H1318

[10] H. Erhorn-Kluttig and H. Erhorn (2018), *National applications of the NZEB definition – The complete overview*, Concerted Action Energy Performance of Buildings, Germany. Available : https://www.ca-epbd.eu/Media/638373627030751512/CT1-Factsheet-National_applications_of_nZEB_definition.pdf

[11] D. Staniaszek, A. Mayer, I. Jankovic et al. (2021), *Nearly Zero: A Review of EU Member State Implementation of New Build Requirements*. Buildings Performance Institute Europe, Brussels. Available: https://www.bpie.eu/publication/nearly-zero-a-review-of-eu-member-state-implementation-of-new-build-requirements/#

[12] E. Bourdin (2019), *EPBD and Part L 2019 nZEB Dwellings and Major Renovations*, Government of Ireland, Dublin. Available: https://www.seai.ie/publications/TGD-L-2019-Dwellings_Energy-Show-2019-Presentation.pdf

[13] E. Murray (2019), *Part L and EPBD*, presented at the SEAI Energy Show, Department of Housing, Planning and Local Government, Ireland. Available : https://www.seai.ie/publications/NZEB-in-Non-Domestic-Buildings.pdf

[14] OID (2023), *nZEB - The EU Energy Building Standard Building on a New Reference*, European Sustainable Real Estate Initiative by Observatoire de l'Immobilier Durable, France. Available: https://globalabc.org/resources/publications/nzeb-eu-energy-building-standard-building-new-reference

[15] *Réglementation environnementale des bâtiments neufs (RE2020)* [RE2020 environmental regulations], Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement (Cerema) Ministère de la Transition écologique (MTE).
[16] E. Ohene, A. P. C. Chan et al. (2023), "Navigating toward net zero by 2050: drivers, barriers, and strategies for net zero carbon buildings in an emerging market", *Building and Environment, vol. 242, p. 110472*, Elsevier. doi: 10.1016/j.buildenv.2023.110472
[17] P. Torcellini, S. Pless, and M. Leach (2015), "A pathway for net-zero energy buildings: creating a case for zero cost increase," *Building Research and Information*, vol. 43, no. 1, pp. 25–33, The Alliance for Sustainable Energy, doi: 10.1080/09613218.2014.960783
[18] A. J. Marszal et al. (2011), "Zero energy building – A review of definitions and calculation methodologies," *Energy and Buildings*, vol. 43, issue 4, pp. 971–979, Elsevier. doi: 10.1016/j.enbuild.2010.12.022
[19] Joint Research Centre (European Commission) (2023), *Defining zero-emission buildings: support for the revision of the Energy Performance of Buildings Directive.* Publication Office of the European Union, Italy. Available: https://data.europa.eu/doi/10.2760/107493.
[20] K. Peterson, P. Torcellini, and R. Grant (2015), A Common Definition for Zero Energy Buildings, U.S. Department of Energy, Washington, DC. Available: https://www.energy.gov/sites/prod/files/2015/09/f26/A%20Common%20Definition%20for%20Zero%20Energy%20Buildings_0.pdf
[21] U. I. Dar, I. Sartori, et al. (2014), "Advanced control of heat pumps for improved flexibility of Net-ZEB towards the grid," *Energy and Buildings*, vol. 69, Elsevier. doi: https://doi.org/10.1016/j.enbuild.2013.10.019.
[22] R. Becqué, D. Weyl, et al. (2019), *Accelerating Building Decarbonization: Eight Attainable Policy Pathways to Net Zero Carbon Buildings for All*, World Resources Institute, Washington DC. Available: https://www.wri.org/research/accelerating-building-decarbonization-eight-attainable-policy-pathways-net-zero-carbon
[23] J. Hogeling (2018), "New standardization project on Primary energy factors and Greenhouse gas emission factors," *REHVA Journal*, pp. 57-58, Available: https://www.rehva.eu/fileadmin/REHVA_Journal/REHVA_Journal_2018/RJ1/RJ.57-58/57-58_RJ1801.pdf
[24] European Commission (2010), *Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast).* Available : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02010L0031-20181224

Annex 1: Survey of Related Projects and Studies

EU projects relevant to the NBRP

Name of the Project: Support to monitor the implementation of the national long-term renovation strategies and the renovation component of the national recovery and resilience plans

Objectives:

- Assessing the impacts and monitoring the progress in the achievement of the national goals and indicative milestones of the LTRSs and the renovation component of the RRP (Recovery and Resilience Plans)
- Elaborating a methodology for (a) the evaluation of the LTRSs and RRPs and (b) the continuous monitoring of the renovation activity in all EU Member States and the EU as a whole
- Evaluating the implementation of the LTRSs and RRPs and their impact against the energy and environmental targets and assessing the renovation activity in the MSs and in the EU as a whole

Elements of NBRPs: Analysis of the latest round of LTRS submitted by Member States while trying to make data collection framework and evaluation methodology future proof for NBRPs.

Reports/studies/papers relevant to the NBRP

A Review of EU Member States' 2020 Long-Term Renovation Strategies

Year: September, 2020

Institution: BPIE

MS Covered: Austria, Belgium (Brussels Capital Region and Flanders), Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Luxembourg, The Netherlands, Spain, Sweden

Assessment methodology: The assessments examine to what extent the LTRS comply with the provisions of Article 2a. The evaluation judges the completeness of the strategy and the quality of details provided. It does not assess, for example, whether the policies, measures, and roadmap suggested are ambitious, credible, or have the potential to be well implemented. For each clause, EPBD.wise has assigned a score ranging from 0 = not addressed to 5 = exemplary, with 3 being an acceptable submission.

Clause of Article 2a requirements in focus: All

Link: https://www.bpie.eu/publication/a-review-of-eu-member-states-2020-long-term-renovation-strategies/

Are National Long-Term Renovation Strategies Fit For 2050?

Year: March, 2021

Institution: BPIE

MS Covered: Belgium (Flanders), Czechia, Estonia, Finland, France, Germany, The Netherlands, Spain

Assessment methodology: The primary aim was to examine the 2050 objective set within each strategy, both in terms of the decarbonisation goal and the transformation to a highly energy-efficient building stock. We also sought to determine whether the long-term objectives were underpinned by clear policies and financing mechanisms, though none of the strategies provided a detailed roadmap spanning the whole period to 2050 to enable firm conclusions to be drawn.

Clause of Article 2a requirements in focus: Clause 1(g), 2, and 3

Link: https://www.bpie.eu/publication/the-road-to-climate-neutrality-are-national-long-term-renovation-strategies-fit-for-2050/

Long-term renovation strategies as key instruments to guide local renovation - Lessons learned from good practices across Europe: Financing, data collection, and tailored approaches

Year: February, 2021

Institution: BPIE

MS Covered: Belgium (Flanders), Denmark, France, Ireland, Latvia, Luxembourg, Netherlands, Spain, Sweden

Assessment methodology: This report focuses on three overarching challenges faced by public authorities and summarises best-practice examples that help to overcome them:

(1) describes new European funding opportunities related to the Renovation Wave, assesses in what way national LTRS already include innovative financing schemes targeting the local level, and presents good-practice examples illustrating different financial approaches local authorities can consider;

(2) indicates if national LTRS already include relevant data collection initiatives for local authorities and describes good-practice examples related to data collection, digital storage, and next-generation EPCs;

(3) assesses to what extent national LTRS mention integrated planning procedures and approaches tailored to specific building segments, types of residents, or added value besides energy savings;

Clause of Article 2a requirements in focus: Clause 1(d) and 3

Link: https://www.bpie.eu/publication/our-buildings-ltrs-as-key-instruments-to-guide-local-renovation/

Towards climate neutrality within the European Union: Assessment of the Energy Performance of Buildings Directive implementation in Member States

Year: November, 2023

Institution: JRC

MS Covered: All

Assessment methodology: The assessment of the LTRS requirement focuses on the energy and emission reduction impact by climatic zone. Furthermore, the assessment at the EU level

is performed by compiling the indicative milestone reported by each country in the 2020 LTRS. The scope of this assessment is to provide an overall EU ambition based on the LTRS roadmaps rather than to set milestones for individual countries.

Clause of Article 2a requirements in focus: Clause 1(g) and 2

Link: https://publications.jrc.ec.europa.eu/repository/handle/JRC134673

Report on renovation of the national stock of residential and non-residential buildings and on nearly zero-energy buildings ANNEX to the Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions State of the Energy Union Report 2023 (pursuant to Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action)

Year: October, 2023

Institution: EC

MS Covered: All

Assessment methodology: The report, starting from the assessment of data coming from the first NECPR exercise by the JRC and other available sources, fulfils the obligation, introduced in Article 35 of the Governance Regulation 2018/1999, for the Commission to submit to the European Parliament and the Council, as part of the State of the Energy Union Report, the following, biennially, an overall progress report on the renovation of the national stock of residential and non-residential buildings, both public and private, in line with the roadmaps set out in the long-term renovation strategies that each Member State shall establish in accordance with Article 2a of Directive 2010/31/EU.

Clause of Article 2a requirements in focus: Clause 1(d), 1(g), and 2

Link: https://energy.ec.europa.eu/publications/report-renovation-national-stock-residential-and-non-residential-buildings_en

Assessment of the first long-term renovation strategies under the Energy Performance of Building Directive (Art. 2a)

Year: 2022

Institution: JRC

MS Covered: All

Assessment methodology: The report focuses on compliance aspects: evaluating how the 2020 strategies comply with the provisions of EPBD Article 2a. The evaluation template used for the compliance assessment follows the structure indicated in the Commission's recommendation on building renovation. In particular, this recommendation specifies the areas that Member States are requested to address under each of EPBD Article 2a requirements and provides guidelines on how to comply with them. All the strategies have been evaluated against all the EPBD requirements, grouping the clauses into eight different sections that have been scored and assessing to which extent the clauses have been addressed from a compliance perspective.

Clause of Article 2a requirements in focus: All

Link: https://publications.jrc.ec.europa.eu/repository/handle/JRC128067

Analysis of the national long-term renovation strategies

Year: November, 2022

Institution: EC

MS Covered: All

Assessment methodology: The present staff working document contains (i) a general part that provides an overall assessment of the long-term renovation strategies (including a summary table with the main numeric pledges available, the investments needs and the corresponding budget allocation for each Member State), (ii) a second part that lists existing and planned measures proposed by the Member States and highlights good practices and (iii) a third part with an analysis of each Member State's long-term renovation strategy based on a standardised template.

Clause of Article 2a requirements in focus: All

Link: https://energy.ec.europa.eu/system/files/2022-12/SWD-Analysis-of-2020-LTRS.PDF

Annex 2: Template of Questionnaire on NBRP for the Focus Countries Contact Points (FCCP)

Questions for all focus countries

National Building Renovation Plan (NBRP)
Specific questions relevant to the focus countries
Is there a full understanding of the building stock in your country (building typologies, construction styles, age, climatic zones, occupancy and ownership patterns)? In which area can you identify data gaps?
What were the most difficult issues in your country regarding drafting the Long-Term Renovation Strategy (LTRS)?
Please assess the need for support that is required when drafting the NBRP (high/medium/low): • *Describing the status of the building stock, its energy use and GHG-emissions.* • *Describing the recent dynamics in the building stock (renovation rate, new buildings construction, demolition practices etc.).* • *Deriving consistent targets for renovation rates, primary and final energy savings as well as related GHG-emission reductions for 2030, 2040, 2050.* • *Expected wider benefits.* • *Expected impact of policies.* *Investment needs and budgetary sources.*
If EPBD.wise would develop a template for NBRPs, which elements would be most relevant and helpful for you (and representatives in your country responsible for NBRP development)?
Which support would you and representatives in your country responsible for NBRP development like to receive from the EPBD.wise project in terms of NBRP development?

Extended questionnaire for the selected focus countries interested in NBRP topic

National Building Renovation Plan (NBRP)
How can NBRPs be framed to harmonise the planning and reporting further and to ensure comparability, as well as, a higher level of aggregation?
Implementation and policy framework
What are the institutional processes to set up NBRP? What is the main stakeholders' involvement in each policy instrument's design process (ZEB, MEPS, BRPs and EPCs)?[5] *Is there a long-term vision for the decarbonisation of buildings in your country? Does this vision link strategic measures together with an appropriate investment plan?* *What are the most difficult barriers you envision for your country to the elaboration of NBRPs?* *Are there any restrictive practices concerning the local deployment of low/zero carbon technologies in buildings?*
Monitoring
Are there any monitoring tools overseeing the progress achieved so far through the LTRS? *What monitoring tools would need to be expanded or developed for a better implementation of the NBRPs?*
Questions related to Art 9(2) (national trajectory for the progressive renovation of residential buildings)

[5] What EPBD.wise are trying to get from this question is a description of the main steps as well as the leading stakeholders involved in the elaboration of the NBRP (e.g. who is responsible for drafting the NBRP, how do they gather the data, is there a specific focus on any of the elements addressed by the EPBD.wise: ZEB, MEPS, BRPs and EPCs?).

Do you consider the currently existing and/or planned policy instruments sufficient to provide compliance with the national trajectory for residential buildings (according to Art 9(2) of the draft recast EPBD)? *What policies do you think would be required for the implementation of the national trajectory?* *Which legal framework in your country might hamper the implementation of MEPS for residential buildings? (e.g. legal framework for protecting property rights of building owners)* *What type of assistance would your country need for the elaboration of a methodology for the national trajectory?*
Other
If EPBD.wise would develop a template for NBRPs, which elements would be most relevant and helpful for you (and representatives in your country responsible for NBRP development)?
Which support would you and representatives in your country responsible for NBRP development like to receive from the EPBD.wise project in terms of NBRP development?

Annex 3: Template for Good Practice Description NBRP

EPBD.wise	Good Practice #
Author: Name and organisation	Date: Month yyyy
Contributors: Name and organisation, Name and organisation, Name and organisation, Name and organisation	
Source:	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed			Specific challenges addressed: NBRP	
Good governance	☐		Building stock overview	☐
Staff shortage in public administration	☐		Cost-effective approach to renovation	☐
Data availability for effective policies	☐		Policies and actions	☐
Data accessibility for effective policies	☐		Expected energy savings and wider benefits	☐
Data quality for effective policies	☐		Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☐		Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐		Public consultation	☐
Clear presentation of co-benefits	☐		Latest LTRS implementation details	☐
Financing	☐			

Legend: Tick the appropriate box

Short description of good practice – summary	
Text Text Text Text Text Text	Image / Figure

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	
Societal	
Economic	

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☐	☐
Non-residential buildings	☐	☐
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☐
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☐		Federal administration	☐
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice	
Description of elements that work well Text Text	Image / Figure
Description of the enabling environment Text Text	Image / Figure
Description of success factors	Image / Figure

Text Text	
Lessons learnt and recommendations Text Text	Image / Figure

Annex 3a: Good Practice #1

EPBD.wise	Italy
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/49a04289-fd3e-4b4f-a398-644101813e6a_en?filename=2020_ltrs_italy_-_en.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☐	Building stock overview	☒
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☒	Policies and actions	☐
Data accessibility for effective policies	☒	Expected energy savings and wider benefits	☐
Data quality for effective policies	☒	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☐	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☐	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
The Italian strategy can be considered a best practice in this section as it provides a detailed overview of the Italian building stock. The building stock is presented by climatic zones, size, age, energy consumption, and conservation status with a very good level of detail both for the residential and non-residential sectors. Thermal and electricity energy consumption indicators are also provided for all the building categories, together with the main findings from the digital EPC database and the State Property Agency database.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	Set up of a building stock database
Societal	
Economic	

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☐		Scientists	☒
Property managers	☐		Professional associations	☒
Energy companies	☒		Municipal administration	☐
Architects, engineers	☐		Regional administration	☒
Consultants	☐		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well The building stock is presented by climatic zones, size, age, energy consumption, and conservation status with a high level of detail, both for the residential and non-residential sectors. The non-residential building stock is also broken down into schools, offices, hotels, commercial buildings, hospital/healthcare facilities, penitentiaries, and barracks.
Description of the enabling environment for the development/establishment A national portal on the EPB was established in 2020, collecting, in a unique digital public database, all the information on the Italian building stock (e.g. size, energy performance, suggested renovation good practices etc.).
Description of success factors for continuing operation An estimate of the current annual renovation rate is also provided. For this, a 'virtual deep renovation rate' indicator has been developed, considering all the renovation interventions (including minor interventions) and, from the energy-saving obtained, calculating the virtual equivalent deep renovations needed to obtain these savings.

Annex 3b: Good Practice #2

EPBD.wise	Lithuania
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/73b6debd-95d7-4754-abf5-7f77c45f7d4e_en?filename=lt_2020_ltrs_en.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☐	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☒
Data availability for effective policies	☐	Policies and actions	☐
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☒	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☐	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
Chapter 2 of the Lithuanian strategy includes a comprehensive methodology to identify the most cost-effective renovation approach. Energy efficiency measures and renewable energy measures grouped into 33 renovation packages to achieve energy classes from C to A++ (nZEB level) are analysed.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	
Societal	
Economic	Cost-effective renovation approach

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☒		Professional associations	☒
Energy companies	☐		Municipal administration	☐
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice

Description of the elements which work well

Considering the type of building, period of construction and the energy classes, 816 different combinations resulted. The strategy reported the following steps:

- Calculation of key indicators for each combination (investment costs, projected energy-savings, economic benefits, the expected financial and economic return);
- The saving of 1 kWh in terms of financial and economic returns are calculated for each simulated combination;
- All combinations are ranked in terms of return (€/kWh), with the highest grade assigned to the packages of renovation with maximum economic benefit;
- Setting the primary energy-saving target at the building stock level in GWh or %;
- A list of combinations that satisfies the primary energy target is selected;
- Renovation investments and an energy-saving curve are obtained by changing the energy-saving target.

Description of the enabling environment for the development/establishment

The EPBD defines trigger points as a moment in the life cycle of a building for carrying out energy efficiency renovations. Lithuanian strategy identifies the following trigger points:

- for single-family houses: change of ownership;
- for apartment buildings: district renovation is seen as a key measure to initiate and accelerate energy renovation;
- for industrial buildings: generally, owners invest in the modernisation of the buildings to reduce maintenance costs. EPCs are required when renting or selling industrial buildings;

• for other non-residential buildings: many of them are commercial buildings, rented. When renewing the rental contract, the owners are required to provide the EPC, modernise the technical systems, and introduce renewable energy.
Description of success factors for continuing operation It is concluded that even a conservative estimation of economic benefits outweighs the investment costs. The maximum economic return at the building stock level is between 45% and 55% (16-20 GWh/year) of energy savings. This corresponds to renovation to class B with RES measures or a smaller part to class B and A.

Annex 3c: Good Practice #3

EPBD.wise	Belgium, Wallonia
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/12b25ff3-655b-4572-9bfb-de3c6e682fbf_en?filename=be_wal_2020_ltrs_annexs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☐	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☒	Policies and actions	☒
Data accessibility for effective policies	☒	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☐	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☐	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
Belgium Wallonia represents a good practice example regarding policies and action on deep renovations of buildings, including staged renovation and renovation passports. Renovation passports play an important role in raising awareness and informing the renovation strategy. Specifically, core measure 15 details the individual actions and steps to implementing the building passport and related renovation and monitoring of the building stock. The main actions include the renovation roadmap tool, developing the energy part of the building passport, and implementation of the other parts.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	Building renovation passports
Societal	

Economic	

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☐	☐
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☒		Professional associations	☒
Energy companies	☐		Municipal administration	☐
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well The building passport brings together and centralises all the information available for a building, organised under various topics: energy (EPB certificate, applications for incentives, housing audit), technical (plans, structural surveys, HVAC, soil and water tests, etc.) and administrative (location, type of housing, permissions, etc.). The passport is interactive and evolving, accompanying the building throughout its life and being transferred with each change of ownership. The information recorded in the Government databases will automatically feed into the building passport. Different types of access to the tool can be created for different user groups. Hard copies of all documents can also be sent free of charge for inclusion in the building passport. Likewise, anyone with access to a particular passport can receive a free hard copy.
Description of the enabling environment for the development/establishment The building passport and renovation roadmap have been identified as the tools to develop as a priority to ensure that any renovation project can form part of a comprehensive assessment consistent with the long-term targets for energy performance. The housing audit provides a solid basis on which the renovation roadmap has been developed, taking care to incorporate lessons learned from the use of the audit over recent years.
Description of success factors for continuing operation The building passport gives citizens a clearer view of a building's history (roadmap, energy audits, energy-saving works and/or restoration works), enables citizens to initiate a global renovation approach in an informed manner and simplifies the contact between citizens and local authorities.

For public authorities, the tool will facilitate the process of premium requests, increase dialogue between the different administrations and gather data to give policymakers a clearer idea of the Walloon building stock. For professionals, the tool will give access to historical information about a building without them having to gather all the different documents or other information.

Annex 3d: Good Practice #4

EPBD.wise	Spain
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/35ac6823-6ce8-47db-a796-6be8f9b81146_en?filename=es_2020_ltrs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☒
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☒	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
Spanish LTRS provides an excellent overview of the strategy and actions to mitigate energy poverty. Analysis of energy poverty, its social implications and linkages with economic vulnerability. A specific focus on interventions and renovation approaches dedicated to buildings occupied by vulnerable citizens (concerning energy poverty) is detailed. Technical details are provided in Annex A.5. The four points are addressed in a structured and articulated strategy with clear objectives and milestones.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	
Societal	Mitigation of energy poverty
Economic	

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☐	☐
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☒
Architects, engineers	☐		Regional administration	☒
Consultants	☐		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well One of the most relevant new measures in the LTRS strategy is the National Strategy Against Energy Poverty (NSEP), a coherent and structured set of measures targeted at the worst-performing buildings and the most vulnerable households. A set of clear targets is indicated. The strategy's four-point approach includes: (i) improving knowledge, (ii) improving the response to the current situation, (iii) structural changes to reduce energy poverty, and (iv) measures to protect consumers and raise social awareness. The main building-related actions include: (i) agile and low-cost refurbishments for vulnerable households, (ii) an increase in the number of social housing renovations through public intervention, and (iii) specific provisions for vulnerable households in terms of grant allocation for building renovations.
Description of the enabling environment for the development/establishment Spain is in an intermediate situation regarding energy poverty indicators compared to other EU Member States. According to the 2018 data from the EU Statistics on Income and Living Conditions, 9.1% of people in Spain live in a household which is unable to keep its home adequately warm (EU-28 average: 7.6%) and 7.2% live in a household unable to pay utility bills on time (heating, electricity, gas, water…) (EU-28 average: 6.8%). However, Spain suffers from low levels of energy efficiency, especially in the homes of the most vulnerable people.
Description of success factors for continuing operation The NSEP is based on a governance model that involves social, economic and institutional actors with an interest in the objectives of the strategy. It has been the subject of prior consultation and has been drawn up by an inter-ministerial working group, which also included experts and NGOs working in the field of energy poverty and environmental protection.

The strengths of the NSEP include greater visibility for the problem of energy poverty, the commitment to approve a minimum vital supply and the structuring of measures that connect a reduction of energy poverty with greater access to housing. The governance model, with broad stakeholder participation, has made it possible to adopt a broadly consensual strategy.
Lessons learnt and key recommendations Some of the weaknesses of the operational development of the strategy are difficulties in coordinating regional and local administration in terms of management and financing and lack of basic budgetary commitments.

Annex 3e: Good Practice #5

EPBD.wise	Belgium, Wallonia
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/12b25ff3-655b-4572-9bfb-de3c6e682fbf_en?filename=be_wal_2020_ltrs_annexs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☒	Policies and actions	☒
Data accessibility for effective policies	☒	Expected energy savings and wider benefits	☐
Data quality for effective policies	☒	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☐	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☐	Latest LTRS implementation details	☐
Financing	☒		

Legend: Tick the appropriate box

Short description of good practice – summary
In Wallonian LTRS, the public sector is at the forefront of the measures and expected to play an exemplary role through exemplary renovations and others. Specifically, exemplary renovation of public housing will be carried out through the Public housing renovation plan (Measure 6) to achieve the average decarbonised EPB A label by 2040 (~5,000 dwellings/year), complemented by further activities to support the plan above. In addition, the exemplary role of public buildings (Measure 7) will be strengthened through many activities, including coordinated service in the form of OSS, strengthening the role of internal energy managers, and facilitating financing. The LTRS also aims at incorporating social, ethical, and environmental clauses into the public works contracts, thus going beyond the pure energy efficiency targets in the renovation strategy.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	

Administrative	Measures related to public buildings
Societal	
Economic	

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☐	☐
Non-residential buildings	☐	☐
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)	Public buildings	

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☒
Energy companies	☐		Municipal administration	☒
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice

Description of the elements which work well

The creation of cadastres for public housing and public tertiary buildings will make it possible to identify the worst-performing buildings to be targeted (renovated) as a matter of priority.

Public-private partnerships are specifically promoted through structuring and disseminating communication to local authorities on existing PPP solutions, organising standard documents to facilitate the use of innovation partnerships and organising a programme to support the use of innovation partnerships.

Other measures include encouraging municipalities to put in place an energy and climate policy on their territory, increasing the efficiency of subsidies for the renovation of public tertiary buildings, ensuring revolving funding to allow the financing of longer-term investments, strengthening preferential loans and other credit arrangements for deep renovation, ensure coherence of regional budgets with the long-term objectives of the renovation strategy.

Description of the enabling environment for the development/establishment

Two consecutive programmes have enabled almost 47,000 public housing units, or 47% of the stock, to be upgraded following energy standards and health and safety requirements:

- the Exceptional Investment Plan approved in 2003 and completed in 2007 and 2009;

- the Green Investment Programme (PIVERT), the first phase of which was approved in 2012 and the second in 2014.

Annex 3f: Good Practice #6

EPBD.wise	Belgium, Wallonia
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/12b25ff3-655b-4572-9bfb-de3c6e682fbf_en?filename=be_wal_2020_ltrs_annexs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☐	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☒
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☐	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
In Belgian (Wallonia) LTRS, increasing skills in the construction sector is covered in detail by two measures (Measures 18 and 19). The LTRS also focuses on promoting and educating about better materials, i.e., again going beyond 'pure' energy efficiency. Annex 6 gives an overview of initiatives to promote smart technologies and skills.

Characteristics and detailed description of the solution

Context addressed	
Technical	Smart technologies
Legal	
Administrative	
Societal	Increasing skills in the construction sector
Economic	

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply

Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☐	☐
Non-residential buildings	☐	☐
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☐		Scientists	☒
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☒		Regional administration	☐
Consultants	☒		Federal administration	☐
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well Increasing skills in the construction sector include training needs evaluation, development of training modules, on-site training, capacity building in the renovation sector through an Employment and Renovation Alliance, and promoting and educating about better materials. Good practices in construction and sustainable renovation are included in the competence centres of FOREM and IFAPME (including ConstruForm Hainaut and Liège). Since 2014, the Sustainable Construction Portal has provided professionals (entrepreneurs, architects, consultancy firms, 103 producers and traders) with an internet tool that gathers validated information on innovative and sustainable techniques, materials and products and links with the Energy Portal.
Description of the enabling environment for the development/establishment To give consumers confidence and to guarantee the quality of their installations, Wallonia has decided to support and promote businesses installing renewable systems that commit to a 'quality' process. The quality label for businesses has been designed for this purpose. Initially intended to cover many areas of construction (insulation work, technical installation, structural work), the first label introduced is for installers of renewable energy systems. This NRQual label has three components: NRQual PAC (heat pumps), NRQual PV (photovoltaics) and NRQual SOL (solar thermal).

Annex 3g: Good Practice #7

EPBD.wise	Lithuania
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/73b6debd-95d7-4754-abf5-7f77c45f7d4e_en?filename=lt_2020_ltrs_en.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☐
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☒
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☒	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☒	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☒		

Legend: Tick the appropriate box

Short description of good practice – summary
The Lithuanian LTRS outlines the following wider benefits: reduction of energy consumption, reduced CO_2 emissions, increase in GDP, improved health and working capacity of the population, growth in the value of residential real estate, impact of the renovation of the building stock on pollution, and reduced compensation for heating costs of the vulnerable population group. In addition to the mentioned benefits, the following non-quantifiable benefits are also discussed, such as energy independence, utilisation of existing production capacity, increase in the service life of buildings, reduction in the need for subsidies in the sectors concerned, strengthening of the sector of manufacturers of construction and building materials.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	

Societal	Reduction of energy poverty, improved quality of life, etc.
Economic	GDP growth, increase in the value of buildings, improvement in the technical condition of buildings, increased productivity in individual sectors, etc.

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☒		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice

Description of the elements which work well

Environmental, economic and social benefits split into monetised and non-monetised are discussed in the Lithuanian LTRS. The total value of the monetised benefits is estimated at around € 75.4 billion over 2021 and 2050. The investment of each € 1 million is expected to create between 19 and 37 jobs per year. The investment of each € 1 is estimated to increase the country's GDP by € 0.5. To estimate the health benefits, for each invested € 1 a benefit of € 0.325 was considered. Currently, in Lithuania, the vulnerable people are receiving heating and DHW aid by being reimbursed the heating costs that exceed 10% of the difference between the family income and the state-supported income. It is expected that by 2050, the need for heating aid will decrease by 80%, thus saving an average of € 0.58 million per year. The LTRS addressed the following non-monetised benefits: increasing energy independence, lowering the investments in the production capacity of energy, increasing the life of the buildings, reducing fossil fuel and RES subsidies and redirecting the funds to clean technologies and finally, the growth of other sector and new business in the construction and energy sectors.

Description of the enabling environment for the development/establishment

Introduction of a pollution tax for energy inefficient/polluting buildings, e.g. by introducing an additional tax if the energy consumption of a building exceeds 150 kWh/m^2 and/or CO_2 emissions. This would consider not only energy efficiency but also the fuel source (to move away from fossil

fuels). Other alternatives to the implementation of this tax could include a differentiation of the property tax according to energy consumption/CO_2 emissions and an additional levy on non-managed buildings.
Description of success factors for continuing operation • A significant share of the benefits is transferred to the period after the renovation implementation (after 2050), e.g. a building renovated in 2050 will save energy at least until 2079 • Even over the implementation period of the renovation strategy (2021-2050), the additional benefits outweigh the investments, i.e. the investments pay off • The wider benefits are significantly higher than the direct benefits of renovation in terms of energy savings and CO_2 emissions over all periods assessed • Reducing primary energy consumption by ~60% is expected to reduce CO_2 emissions by 3.8 million tonnes, or ~70% per year • It is estimated that at least EUR 4.5 billion in benefits would accrue over the lifetime of the LTRS because of reduced CO_2 emissions • It is estimated that an investment of EUR 1 in renovation will increase the country's GDP by EUR 0.5 • It is estimated that the social benefits from improved health and work capacity of the population will amount to EUR 19.5 billion throughout 2021–2050 • It is estimated that over the LTRS implementation period, residential property value growth would generate at least EUR 4 529 in benefits in the five largest Lithuanian cities alone • It is estimated that EUR 1.201 billion in air pollution will be prevented over the lifetime of the LTRS

Annex 3h: Good Practice #8

EPBD.wise	Finland
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/58721db6-4127-4a14-9d59-b6ea055a58db_en?filename=fi_2020_ltrs_en.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☐
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☒
Estimation of impacts (broader benefits)	☒	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
The Finnish strategy provides a clear roadmap to 2050, with indicative building renovation targets, milestones, and measurable progress indicators determined for 2030, 2040, and 2050. The development of the building stock (residential and non-residential), as well as the estimated change between 2020-2050, are clearly described. Heating primary and final energy consumption for 2020-2030-2040-2050 are reported. Other progress indicators, such as CO_2 emission reduction and the share of nZEB for each type of building, are also included.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	
Societal	CO_2 emission reduction, reduction in energy consumption
Economic	

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☒		Professional associations	☒
Energy companies	☒		Municipal administration	☒
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well • 2030: 55.5 TWh Consumption of heating energy (gross) for residential and service buildings • 2040: 45.1 TWh Consumption of heating energy (gross) for residential and service buildings • 2050: 36.4 TWh Consumption of heating energy (gross) for residential and service buildings; the goal is for all buildings (residential and non-residential) to have an energy class of C or above by 2050; removing all vacant buildings from the building stock (by 2050, only 70% of the Finnish building stock will remain); CO_2 emissions reduced by 90% by 2050
Description of the enabling environment for the development/establishment • Central government and municipalities will stop using oil heating by 2024 • Energy subsidy for renovating buildings in energy classes F and G. A renovation subsidy can also be applied for if the housing unit/residential building has humidity/microbial damage or indoor air problems
Description of success factors for continuing operation • Renovation projects are expected to cut the energy consumption of residential and non-residential buildings by half by 2050 compared to heating energy consumption in 2005 • By the currently valid binding legislation, CO2 emissions of the building stock will be reduced by 90% by 2050

- Objective of having all buildings (residential and not residential) with an energy class C or above by 2050
- Good maintenance ensures the correct functioning of the building and promotes the energy efficiency and indoor conditions of the property

Annex 3i: Good Practice #9

EPBD.wise	Belgium, Wallonia
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/12b25ff3-655b-4572-9bfb-de3c6e682fbf_en?filename=be_wal_2020_ltrs_annexs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☐
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☒	Mechanism for mobilising investments	☒
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
In Wallonia's strategy, the following mechanisms have been developed to cover the various aspects under Article 2a(3) of the EPBD and thus promote: • the aggregation of projects, including by investment platforms or groups and by consortia of small- and medium-sized enterprises, to enable investor access as well as packaged solutions for potential clients; • the reduction of the perceived risk of energy efficiency operations for investors and the private sector; • the use of public funding to leverage additional private-sector investment or address specific market failures; • guiding investments into an energy-efficient public building stock; • the introduction of accessible and transparent advisory tools and energy advisory services.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	
Societal	
Economic	Mobilisation of investments

Legend: Allocate a topic
Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☐
Property managers	☒		Professional associations	☐
Energy companies	☐		Municipal administration	☒
Architects, engineers	☐		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well Aggregation: Generally, the LTRS envisages that aggregation of projects will be promoted through investment platforms or groups and consortia of small and medium-sized enterprises to allow access to the investor and package solutions for potential clients. Specifically, Measure 29 encourages and facilitates group renovation approaches by tools and interlocutors by promoting insurance schemes for collective loans, establishing a working group with liquidators/trade union representatives, etc. In the mid-term, the support should be integrated into OSSs. Measure 7.16 on strengthening the exemplary role of public buildings also aims to 'facilitate the financing of projects by structuring mechanisms for mobilising complementary funding (PPP, citizen funding, other), in particular by aggregating projects and reducing (perceived) risks'. Measure 44 aims to stimulate and support the development of cooperatives active in energy renovation. The LTRS has a diversified strategy to reduce the (perceived) risks of renovation by pooling projects (aggregation measures above, promoting projects by cooperatives, pooling projects for EPC,

establishing a de-risking platform and training for the banking sector, guaranteeing loans for the disadvantaged groups, etc).

Support to EPC projects and third-party financing is explored in detail in the LTRS, including the development and standardisation of tools and documents, training in the banking sector, facilitating access to capital for smaller ESCOs, developing pilot projects, monitoring of the EPC and ESCO market, etc.

Public-private partnerships are specifically promoted by measure 36 through structuring and disseminating communication to local authorities on existing PPP solutions, organising standard documents to facilitate the use of innovation partnerships and organising a programme to support the use of innovation partnerships: appoint a team of legal, financial and technical experts to assist (public authorities wishing to launch an innovation partnership project) in structuring and implementing innovation partnership contracts.

Comprehensive support for households in the form of an OSS is one of the key elements of the LTRS. The main actions include coordination of sustainable housing information advisers, financial support to one-stop shop pilot projects, developing tools and guides to facilitate the promotion of renovation, integrating social aspects in the advisory service, etc.

Description of the enabling environment for the development/establishment

The Wallonian strategy envisages that aggregation of projects will be promoted through investment platforms or groups, and consortia of small and medium-sized enterprises, to allow access to the investor and package solutions for potential clients. The strategy has a diversified strategy to reduce the (perceived) risks of renovation by pooling projects (aggregation), promoting projects by cooperatives, pooling projects for Energy Performance Contracting, establishing a de-risking platform and training for the banking sector, guaranteeing loans for the disadvantaged groups, etc.). Support to Energy Performance Contracting projects and third-party financing is explored, including the development and standardisation of tools and documents, training in the banking sector, facilitating access to capital for smaller ESCOs, developing pilot projects, monitoring of the market, etc.

Comprehensive support for households in the form of an OSS is one of the key elements of the strategy. The main actions include coordination of sustainable housing information advisers, financial support to OSS pilot projects, development of tools and guides to facilitate the promotion of renovation, integration of social aspects in the advisory service, etc.

Description of success factors for continuing operation

The following success factors have to be met: ensure the availability of the financial resources needed to make long-term investments in the renovation of buildings and guarantee access to these financial resources via mechanisms tailored to the different customer segments.

Lessons learnt and key recommendations

It is common for energy renovation projects to encounter a problem with scale: the projects are too small, and the individual management costs are too high. One solution to this would be to group separate projects to achieve critical mass. Joint ownerships can lead by example, such as a residential tower (or block), but also individual houses or small joint ownerships of a few homes forming a cooperative to negotiate conditions for credit and working as a group.

Annex 3j: Good Practice #10

EPBD.wise	Slovakia
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/52d79c38-a80d-4766-8c51-8f041e1e0f93_en?filename=sk_2020_ltrs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☐
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☒	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☒
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☐
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
In the development of the Slovakian strategy, many stakeholders have been directly involved. The renovation strategy also went through an interdepartmental and interdepartmental consultation procedure and public consultation via the publicly accessible web portal www.slov-lex.sk. The results of the consultation are presented in detail in an attached document that includes the main points raised by all the relevant stakeholders involved (45 entities) and how they have been considered.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	Organisation of public consultations
Societal	
Economic	

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☒		Professional associations	☒
Energy companies	☒		Municipal administration	☒
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice
Description of the elements which work well To develop a long-term renovation strategy and to involve as many stakeholders as possible in its preparation, the Ministry of Transport and Construction of the Slovak Republic (the party responsible for the long-term renovation strategy for buildings) set up a working party consisting of representatives of the individual government departments, civic associations active in the field of buildings (renovation or development), representatives of research and professional associations and organisations, representatives of Slovak towns and municipalities, 32 entities in total. During the material preparation, the Ministry consulted the members of the working party on the individual areas, in person or writing, depending on the respective topic and the specific part of the strategy.
Description of the enabling environment for the development/establishment Within the standardised procedure concerning the materials submitted to the Government for discussion, the renovation strategy was subject to ministerial and inter-ministerial consultation. Following the rules for preparing and submitting materials to the Slovak Government for discussion, the material was also subject to a public consultation exercise via the publicly accessible web portal at www.slov-lex.sk; the procedure has a standardised form as well as a standardised process for evaluating comments.
Description of success factors for continuing operation Any entity, including the public, may provide a comment on any part of the submitted material using an electronic form, and the submitting party must evaluate every comment provided. Any accepted comments are incorporated by the submitting party.

Annex 3k: Good Practice #11

EPBD.wise	Spain
Author: Irma Imamovic – TU Wien	Date: 02.2024
Contributors: Ece Özer – TU Wien, Lukas Kranzl – TU Wien	
Source: https://energy.ec.europa.eu/document/download/35ac6823-6ce8-47db-a796-6be8f9b81146_en?filename=es_2020_ltrs_en_version.pdf	

Aspects addressed	
ZEB – Zero-Emission Building	☐
MEPS – Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☒
BRP – Building Renovation Passport	☐
EPC – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: NBRP	
Good governance	☒	Building stock overview	☐
Staff shortage in public administration	☐	Cost-effective approach to renovation	☐
Data availability for effective policies	☐	Policies and actions	☐
Data accessibility for effective policies	☐	Expected energy savings and wider benefits	☐
Data quality for effective policies	☐	Roadmap with indicative milestones	☐
Estimation of impacts (broader benefits)	☒	Mechanism for mobilising investments	☐
Industry and labour and skill shortages	☐	Public consultation	☐
Clear presentation of co-benefits	☒	Latest LTRS implementation details	☒
Financing	☐		

Legend: Tick the appropriate box

Short description of good practice – summary
All implementation measures (articulated in 9 main areas) are reported in Chapter 10 of Spanish LTRS. They are mainly in the planning phase. A catalogue and following-up of existing measures are instead indicated in Chapter 4.

Characteristics and detailed description of the solution

Context addressed	
Technical	
Legal	
Administrative	Elaboration on the implementation of the measures
Societal	
Economic	

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply

Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation

Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Built environment addressed		
	Small	Large
Residential buildings	☒	☒
Non-residential buildings	☒	☒
Office	☒	☒
Educational	☒	☒
Health	☒	☒
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add an explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☒		Professional associations	☒
Energy companies	☒		Municipal administration	☒
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☒
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add an explanation

Detailed description of good practice

Description of the elements which work well

The following implementation measures are reported:

- Structuring area: promoting sectoral, vertical, and horizontal coordination:
- Regulatory development and administrative measures in favour of energy renovation;
- Renovation of public administration buildings and other exemplary measures;
- Public financing measures;
- Measures to encourage and mobilise private financing;
- Combatting energy poverty;
- Measures for the deployment of a new energy model in the construction sector;
- Measures for activation and aggregation of demand;
- Supply-side measures: professionalisation, modernisation of the renovation sector, training and qualifications;
- Information and society area: citizen-centred;
- Cross-cutting area: development of statistics, indicators and monitoring.

Description of the enabling environment for the development/establishment

An organisational model is proposed for the construction and renovation sector based on the tools included in the new version of the EPBD. The proposal aims at two clear objectives: first, the gradual improvement of the quantity and quality of the information on the existing residential stock and second, its availability so that the different actors in the sector can adopt strategic decisions in an informed and coordinated manner.

Lessons learnt and key recommendations

A key recommendation is to improve the quantification of the impacts of individual policies and measures.

Annex 4: Template of Questionnaire on ZEB for the Focus Countries Contact Points (FCCP)

Questions for all focus countries

Zero-Emission Building (ZEB)
Which requirements should be maintained or deleted for the ZEB standard with respect to your current regulation on nZEB requirements or on maximum energy performance level buildings?
What would be the most important aspects to be considered in the new ZEB (zero-emissions building) definition and methodology?
Considering the following key features[6], what are the most relevant aspects for the ZEB definition? *• System boundary (operational vs. life cycle approach).* *• Emission balance boundary (net zero vs. absolute zero emissions).* *• Spatial boundary (e.g. single building, group of buildings, district).* *• Calculation methods (static vs. dynamic approach).* *• Indicators and metrics (e.g. primary energy, final energy, CO_2 emissions, GHG emissions, GWP100).*
What are the lessons learned (from nZEB or the maximum energy performance level building standard) to consider for the future implementation of ZEB standard?
What kind of support would you and representatives in your Country, responsible for the elaboration and implementation of the ZEB standards, like to receive from the EPBD.wise project in terms of implementation of ZEB.

Extended questionnaire for the selected focus countries interested in ZEB topic

Zero-Emission Building (ZEB)
Definitions
Does the definition of ZEB exist in your country? If yes, could you provide it?
Is the nZEB standard implemented in your country (for both new and existing buildings)?
In case the ZEB and/or nZEB definition does not exist in your country, what is the definition of maximum energy performance level building required by your current regulation?
Regulation requirements – regarding ZEB/nZEB or maximum energy performance level building
What are the minimum energy performance requirements in your country?
Is there a distinction between new and existing buildings in the requirements? If yes, could you provide more details?
Are there any thresholds in terms of energy performance indicators or energy classes? If yes, could you provide more details?
Is there a minimum requirement for on-site renewable energy production? If yes, could you provide more details?
Is there a maximum threshold for operational greenhouse gas emissions? If yes, could you provide more details?
Which requirements should be maintained or deleted for the ZEB standard with respect to your current regulation on nZEB requirements or on maximum energy performance level buildings?
Calculation methodology
What should be the methodological approach to develop the ZEB standard?

[6] Maduta, C., Melica, G., D'agostino, D., Bertoldi, P., Defining Zero-Emission Buildings. Support for the revision of the Energy Performance of Buildings Directive, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/107493, JRC129612.

What would be the most important aspects to be considered in the new ZEB (zero emissions building) definition and methodology?
Considering the following key features[1], what are the most relevant aspects for the ZEB definition? *• System boundary (operational vs. life cycle approach).* *• Emission balance boundary (net zero vs. absolute zero emissions).* *• Spatial boundary (e.g. single building, group of buildings, district).* *• Calculation methods (static vs. dynamic approach).* *• Indicators and metrics (e.g. primary energy, final energy, CO_2 emissions, GHG emissions, GWP100).*
What were the most difficult issues in your country regarding the elaboration of the national calculation methodology for nZEB (or of the maximum energy performance level building, in case an nZEB standard does not exist)?
What are the lessons learned (from the nZEB standard, or the maximum energy performance level building, in case an nZEB standard does not exist) to consider for the future elaboration of ZEB standard?
What do you think would be the most difficult issues and challenges in your country regarding the elaboration of the national calculation methodology for ZEB?
Implementation and policy framework
What were/are the most difficult issues in your country regarding implementing the nZEB standard (or the maximum energy performance level building, in case a nZEB standard does not exist)?
What are the learned lessons (from nZEB standard, or the maximum energy performance level building) to consider for the future implementation of ZEB standard?
What do you think would be the most difficult issues and challenges in your country for implementing the ZEB standard?
Is it necessary to have a distinction between new and existing buildings in the new ZEB definition? Which aspects do you think need to differ in the two cases?
Does your country have an observatory or database of high-energy performance buildings as a starting point for the implementation of ZEB and as a monitoring tool?
Moving on to zero-emission buildings, the assessment of the embodied GHG emissions will become mandatory as well. Does your country have the necessary policy tools to target the reduction of embodied carbon (e.g. data reliability, market readiness, etc.)? What do you think needs improvement?
Examples of best practices
Are there good practice examples of ZEB or nZEB or maximum energy performance level buildings in your country? If yes, could you give more information about them (dedicated websites, descriptions of the buildings, etc.)
Is there any financial mechanism to support the achievement of ZEB/nZEB/maximum energy performance level building in your country? If yes, could you provide more details?
Other
What kind of support would you and representatives in your country, responsible for the elaboration and implementation of the ZEB standards, like to receive from the EPBD.wise project in terms of the implementation of ZEB.

Annex 5: Template for Good Practice for ZEB

Name of the Good Practice	Good Practice #
Authors: Name and organisation	Date: Month yyyy
Contributors: Name and organisation, Name and organisation, Name and organisation, Name and organisation	
Authors of the source material underlying the good practice: Name and organisation, Name and organisation, Name and organisation	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed	
Good governance	☐
Staff shortage in public administration	☐
Data availability for effective policies	☐
Data accessibility for effective policies	☐
Data quality for effective policies	☐
Estimation of impacts (broader benefits)	☐
Industry and labour and skill shortages	☐
Clear presentation of co-benefits	☐
Financing	☐

Specific challenges addressed: ZEB	
Existing policies and definitions	☐
Advanced nZEB	☐
ZEB definition	☐
Specific targets	☐
Energy Efficiency	☐
RES share and contribution	☐
Phasing out fossil fuels	☐
Low OGHG emissions	☐
Low On-site carbon emissions from fossil fuels	☐
LCA and global warming potential	☐
Methodology	☐
Calculation method	☐
New tools and evaluation methods	☐
Indicators and metrics	☐
nZEB indicators to be maintained	☐
New ZEB indicators	☐
Cost effectiveness	☐
Other	☐
RES for other uses	☐
Financing	☐
Public incentives	☐
Other	☐

			Monitoring / Data collection	☐
			Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary	
Text Text Text Text Text Text	Image / Figure

Characteristics and detailed description of solution

Context addressed	
Technical	
Legal	
Administrative	
Societal	
Economic	

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☐
Existing	☐

Built environment addressed		
	Small	Large
Residential	☐	☐
Non-residential	☐	☐
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☐
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add explanation

Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☐		Federal administration	☐
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add explanation

Detailed description of good practice	
Description of the elements which work well Text Text	Image / Figure
Description of the enabling environment for the development / establishment Text Text	Image / Figure
Description of success factors for continuing operation Text Text	Image / Figure
Lessons learnt and key recommendations Text	
Main references: Text with the main bibliographic information. Where deemed appropriate, the sources and references are cited in the boxes of the template as follows: ([reference number])	

Annex 5a: Good Practice #1

Nearly-zero energy Building Standard in Ireland	Good Practice #1
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: Ireland Government, Sustainable Energy Authority of Ireland	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed			Specific challenges addressed: ZEB	
Good governance	☒		**Existing policies and definitions**	☒
Staff shortage in public administration	☐		Advanced nZEB	☒
Data availability for effective policies	☐		ZEB definition	☐
Data accessibility for effective policies	☐		**Specific targets**	☒
Data quality for effective policies	☐		Energy Efficiency	☒
Estimation of impacts (broader benefits)	☐		RES share and contribution	☒
Industry and labour and skill shortages	☐		Phasing out fossil fuels	☐
Clear presentation of co-benefits	☐		Low OGHG emissions	☒
Financing	☐		Low On-site carbon emissions from fossil fuels	☒
			LCA and global warming potential	☐
			Methodology	☐
			Calculation method	☐
			New tools and evaluation methods	☒
			Indicators and metrics	☒
			nZEB indicators to be maintained	☒
			New ZEB indicators	☐
			Cost effectiveness	☒
			Other	☒
			RES for other uses	☒
			Financing	☐
			Public incentives	☐
			Other	☐
			Monitoring / Data collection	☐
			Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary
In line with the EPBD directive, Ireland provided the nZEB definition for both new construction and major renovation, and for domestic and not domestic buildings. It introduced thresholds for GHG emissions and carried out a cost optimal analysis to define nZEB requirements. Part L of the Building Regulations defines the requirements in legislation.

Characteristics and detailed description of solution

Context addressed	
Technical	nZEB standard
Legal	/
Administrative	/
Societal	/
Economic	/

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☒

Built environment addressed		
	Small	Large
Residential	☒	☒
Non-residential	☒	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add explanation

Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☐		Federal administration	☐
Other: All the stakeholders				

Legend: Tick the appropriate box or add explanation

Detailed description of good practice
Description of the elements which work well. – **Existing policies**

- The nZEB standard is applied to all new buildings of Public Sector bodies since 31st December 2018 and to all new buildings since 31st December 2020.
- Ireland included the nZEB definition of the EPBD in its regulation in force since 2019 and posed an interesting attention to the cost-optimal analysis to define nZEB requirements.
- The regulation includes both domestic and non-domestic buildings, new builds and major renovations (more than 25% of the surface area of the building envelope undergoing renovation)

– **Specific targets**

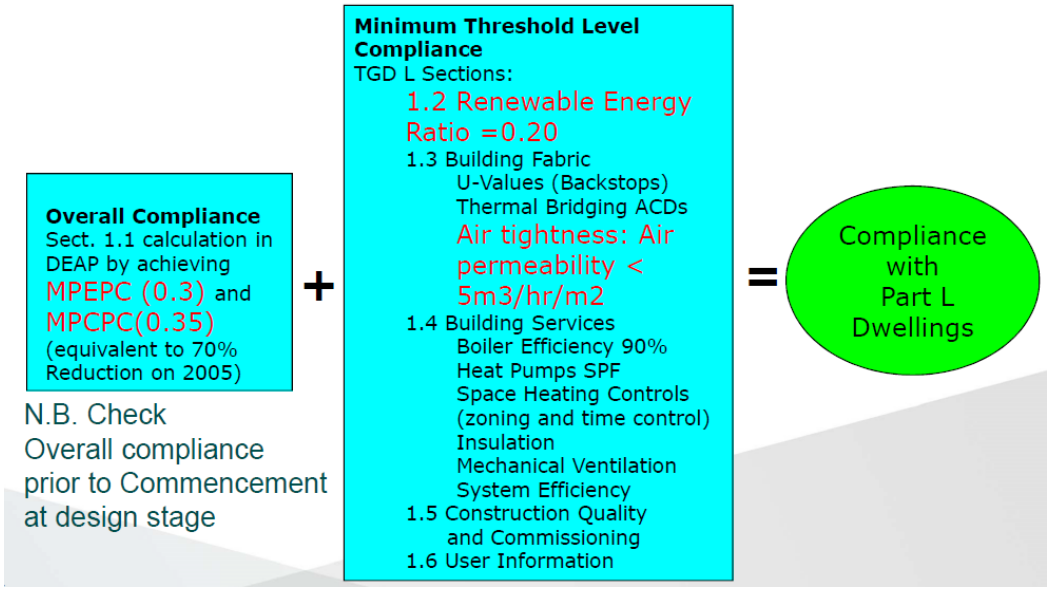
- For new non-domestic buildings:
  - ✓ 60% improvement in energy performance required respect to the 2008 Building Regulations. Consequently, the high energy performance for the fabric, services and lighting specification is achieved.
  - ✓ A Maximum Energy Performance Coefficient (MPEPC) of 1.0.
  - ✓ A Maximum Carbon Performance Coefficient (MPCPC) of 1.15.
  - ✓ Mandatory requirement for renewable sources that must in general provide 20% of the primary energy use. However, there is flexibility where the building is more energy efficient than the regulations. This typically corresponds to an A3 Building Energy Rating.
- For major renovation - non-domestic buildings:
  - ✓ The building is brought up to cost optimal level, i.e. upgrade of heating, cooling, ventilation systems and lighting more than 15 years old.
- For new domestic buildings:
  - ✓ 25% improvement in energy performance is required respect to the 2011 Building Regulations.
  - ✓ Maximum Permitted Energy Performance Coefficient of 0.3
  - ✓ Maximum Permitted Carbon Performance of 0.35
  - ✓ Mandatory requirement for renewable sources with a renewable Energy Ratio of 20%.
- For major renovation - domestic buildings:
  - ✓ The work affects greater than 25% surface area of the existing dwelling including external wall renovation, external or internal insulation; external wall & window renovation; external wall & roof renovation; external wall & floor renovation; new extension.
  - ✓ The cost-optimal level is a primary energy performance of less than 125 kWh/m^2/yr (B2 according to the Building Energy Rating - BER) when calculated using the Dwelling Energy Assessment Procedure (DEAP) or it is the upgrade of ceiling insulation and heating system.

– **Indicators and metrics**

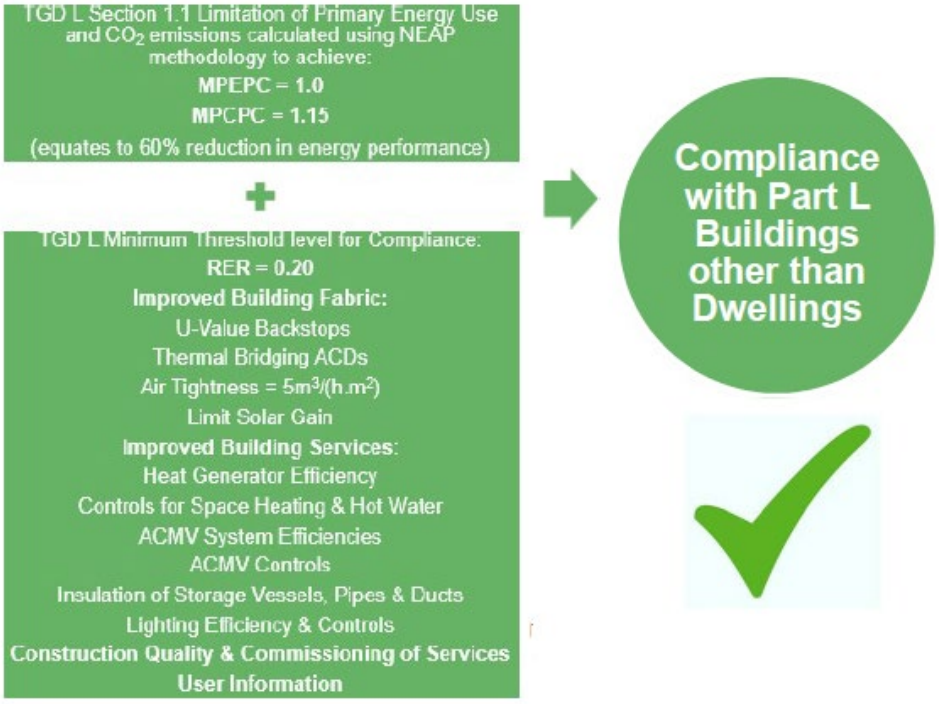
- Maximum Energy Performance Coefficient
- Maximum Carbon Performance
- Primary Energy Consumption (kWh/m^2/year)
- Renewable Energy Ratio (%)
- Cost Optimal Level
- Carbon dioxide emissions (kgCO_2/m^2/y)

– **Methodology**

- The Non-Domestic Energy Assessment Procedure (NEAP) is the methodology to calculate a Building Energy Rating (BER) for non-domestic buildings. It is used to assess energy consumption and carbon dioxide emissions of a building, including space heating and cooling, water heating, ventilation and lighting services.
- The Dwelling Energy Assessment Procedure (DEAP) consists of the compliance tool specified in the Irish Building Regulation. It is used to calculate the energy performance and carbon dioxide emissions of space heating, water heating, ventilation and lighting in dwellings. It is useful to obtain Building Energy Rating Certificates.



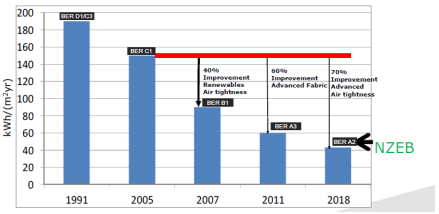
Achieving compliance with Technical Guidance Document L Dwellings 2019 ([3])

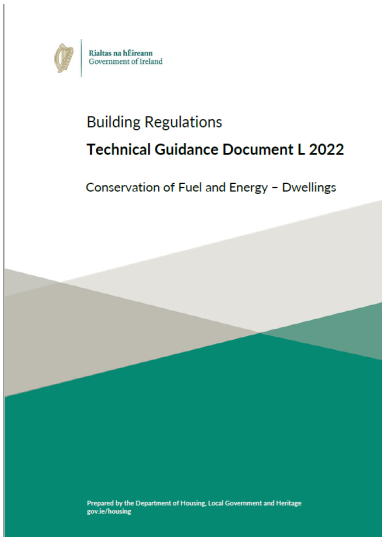
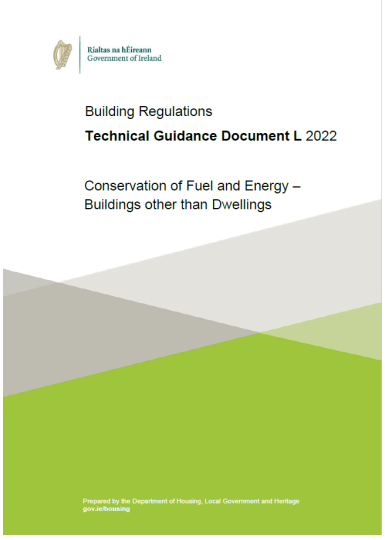


Achieving compliance with Technical Guidance Document L Buildings other than Dwellings 2017 ([3])

Description of the enabling environment for the development / establishment

In the last decades Ireland conducted a substantial development in Building Regulations requirements, obtaining an improvement in energy performance level of buildings and fixing the objective of nZEB since 2020 for all the buildings.



	Building Regulations requirements for new residential buildings over time ([3])
Description of success factors for continuing operation • Introduction of nZEB and MPEPC and MPCPC • Introduction of Major Renovations to a cost optimal level where technically, economically, and functionally feasible • Introduction of a Renewable Energy Ratio (RER). • Reduction of air permeability backstop • Improvement of building fabric by reduction of wall and floor backstop U-Value and of window backstop U-Value • Inclusion of guidance to avoid overheating. • Introduction of cost-optimal approach • For buildings other than dwelling: considering electric vehicle charging for new buildings and application of BACS	  Building Regulations ([3])
Lessons learnt and key recommendations Ireland has introduced thresholds for Renewable Energy Sources Ratio, Carbon dioxide emissions and cost-optimal level for nZEB definition. These elements are fundamental for the future definition of ZEB and the set-up of new indicators measuring EPB and CO_2 equivalent emissions.	
Main references: 1. Department of Housing, Local Government and Heritage, “Building Regulations: Technical Guidance Document L - Conservation of Fuel and Energy – Dwellings (2022)”. Available at: https://www.gov.ie/en/publication/d82ea-technical-guidance-document-l-conservation-of-fuel-and-energy-dwellings/ (Accessed on 27th March 2024) 2. Government of Ireland, Department of Housing, Local Government and Heritage, “Buildings Regulations: Technical Guidance Document L 2022 - Conservation of Fuel and Energy - Buildings other than Dwellings”. Available at: https://www.gov.ie/en/publication/80125-technical-guidance-document-l-conservation-of-fuel-and-energy-buildings-other-than-dwellings/ (Accessed on 27th March 2024) 3. Sustainable Energy Authority of Ireland, “Nearly Zero Energy Building Standard”, available at: https://www.seai.ie/business-and-public-sector/standards/nearly-zero-energy-building-standard/ (Accessed on 27th March 2024).	

Annex 5b: Good Practice #2

Nearly-zero energy Building Standard in Germany	Good Practice #2
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: Ministry of the environment, Climate Protection and the Energy Sector Baden-Württemberg.	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed			Specific challenges addressed: ZEB	
Good governance	☒		**Existing policies and definitions**	☒
Staff shortage in public administration	☐		Advanced nZEB	☒
Data availability for effective policies	☐		ZEB definition	☐
Data accessibility for effective policies	☐		**Specific targets**	☒
Data quality for effective policies	☐		Energy Efficiency	☒
Estimation of impacts (broader benefits)	☐		RES share and contribution	☒
Industry and labour and skill shortages	☐		Phasing out fossil fuels	☒
Clear presentation of co-benefits	☐		Low OGHG emissions	☐
Financing	☐		Low On-site carbon emissions from fossil fuels	☐
			LCA and global warming potential	☐
			Methodology	☐
			Calculation method	☐
			New tools and evaluation methods	☐
			Indicators and metrics	☒
			nZEB indicators to be maintained	☒
			New ZEB indicators	☐
			Cost effectiveness	☐
			Other	☐
			RES for other uses	☐
			Financing	☒
			Public incentives	☒
			Other	☐
			Monitoring / Data collection	☐
			Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary
Germany is one of the frontrunners of the targets and the definition of nZEB concept. It is implemented in a consistent national framework and energy policy that is constantly updated. The Gebäudeenergiegesetz (GEG) delineates Germany's execution of the EPBD, encompassing its array of environmental protection measures.

Characteristics and detailed description of solution

Context addressed	
Technical	nZEB standard
Legal	/
Administrative	/
Societal	/
Economic	/

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☒

Built environment addressed		
	Small	Large
Residential	☒	☒
Non-residential	☒	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add explanation

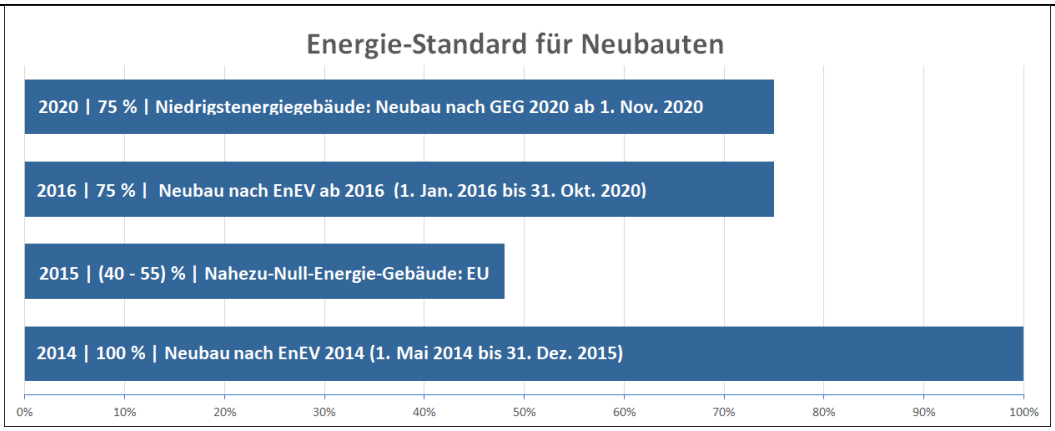
Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☐		Federal administration	☐
Other: All the stakeholders				

Legend: Tick the appropriate box or add explanation

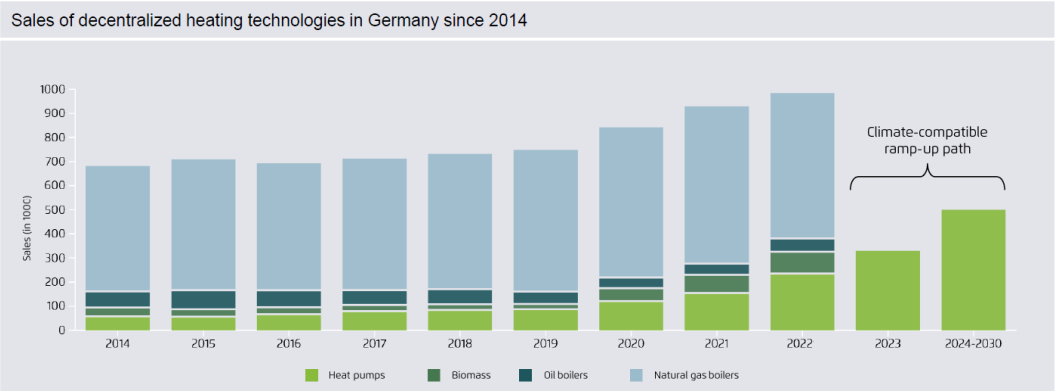
Detailed description of good practice	
Description of the elements which work well. – **Existing policies** • The Gebäudeenergiegesetz (GEG) stands as the principal legislative document on buildings energy efficiency standards in Germany in line with the EPBD. Enacted since	

November 2020, this law consolidates prior regulations concerning energy efficiency and renewable heating into a unified law.

- **Specific targets**
  - For new buildings, the maximum primary energy consumption for heating, cooling, ventilation, and DHW in new buildings must be no more than 75% of the primary energy consumed by the corresponding reference building.
  - To fulfil the requirement of coverage of energy demand from renewable sources. nZEB building can cover 15% of its energy requirements by utilising solar collectors or 50% of its demand through geothermal heat pumps.
  - As of January 1, 2024, Germany implemented the new heating regulation, which mandates that all heating systems installed in newly constructed buildings must derive at least 65% of their energy from renewable sources. For existing buildings, there are extended timeframes and a range of technologies available to transition to renewable heating systems.
- **Indicators and metrics**
  - Primary Energy Consumption (PEC; kWh/m^2/year)
  - Variable Ranges of RES coverage (from 15% to 50%)
- **Methodology**
  - The requirements for new constructions are determined respect to a ‘reference building’ with identical geometry. The reference building utilises standard envelope properties (defined U-values), and standard installation engineering in its calculations. The primary energy consumption of the building must be lower than or equal to that of the reference building. Additionally, a limit is set for specific transmission heat loss, and a minimum portion of heat from renewable sources must be met.
  - The approach for non-residential buildings incorporates energy consumption for space cooling and lighting into the overall building energy balance. In contrast, residential buildings primarily consider space heating, DHW, and ventilation. The detailed nZEB report includes a method for accounting for the energy generated by photovoltaic (PV) systems onsite in the building's energy balance.
- **Financing**
  - The Kreditanstalt für Wiederaufbau (KfW) offers financing initiatives targeting both new constructions and existing buildings aiming at enhanced energy efficiency. Building energy performance undergoes assessment according to GEG standards. The loan amount correlates directly with the degree of energy efficiency enhancement achieved by the building in comparison to the baseline established by GEG.
  - Among the others, since 2023 KfW promotes the initiative Climate-friendly new construction – residential building pointing out:
    - ✓ energy efficiency house level 40;
    - ✓ low CO_2 emissions in building life cycle, meeting the requirements of the “Sustainable Building Plus Quality Seal”;
    - ✓ phasing out of fossil duels.



German energy standard evolution for new buildings ([2])



Increasing numbers of heat pumps sales in Germany([3])

Description of the enabling environment for the development / establishment

Germany was at the forefront in setting targets and defining the concept of Nearly-zero energy Building (nZEB). The passive house concept originated in Germany and was integrated within a comprehensive national framework and constantly evolving energy policy.

Description of success factors for continuing operation

Alongside the recent enactment of the renewable heating legislation and associated subsidies, Germany is effectively advancing towards the reduction of fossil fuel dependency. By prioritising investment in clean, sustainable technologies and bolstering them through strategic policy initiatives such as the Building Energy Act, the nation is steering in the direction for fostering this transition.

Lessons learnt and key recommendations

Key policy strategies:

- Energy efficiency standards outlined in regulatory building codes and labeling schemes.
- Low-interest loans and rebates for energy-efficient renovations and new constructions, contingent upon meeting specified energy standards.
- Grants for existing buildings and mandates for the integration of Renewable Energy Sources for Heating (RES-H) in new constructions.
- Promotion of heat pumps as the key to climate neutrality in buildings.
- Diverse strategies for dissemination of information, incentives, and supply-side measures aimed at promoting energy efficiency.

Main references:

1. Government of Germany, Gebäudeenergiegesetz (GEG). Available at: https://www.gesetze-im-internet.de/geg/ (Accessed on 28th March 2024).

2. Institute for Energy-Efficient Architecture with Internet Media Melita Tuschinski, Near-zero energy buildings and lowest energy buildings (in German: Nahezu-Null-Energie-Gebäude und Niedrigst-Energie-Gebäude). Alaible at: https://geg-info.de/geg_praxishilfen/200813_vergleich_energie_standard_neubau_enev_geg.htm (Accessed on 28th March 2024)
3. Fraunhofer ISE, Oko-Institut e.V., Agora Energiewende, Heat pumps are the key to climate neutrality in buildings. Insights from Germany, July 2023, Berlin. Available at: https://static.agora-energiewende.de/fileadmin/Projekte/2022/2022-04_DE_Scaling_up_heat_pumps/2022_Scaling_up_heat_pumps_in_Germany.pdf (accessed on 17th April 2024)

Annex 5c: Good Practice #3

Nearly-zero energy Building Standard in France	Good Practice #3
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: French Ministry of Ecological Transition	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed			Specific challenges addressed: ZEB	
Good governance	☒		**Existing policies and definitions**	☒
Staff shortage in public administration	☐		Advanced nZEB	☒
Data availability for effective policies	☐		ZEB definition	☐
Data accessibility for effective policies	☐		**Specific targets**	☒
Data quality for effective policies	☐		Energy Efficiency	☒
Estimation of impacts (broader benefits)	☒		RES share and contribution	☒
Industry and labour and skill shortages	☐		Phasing out fossil fuels	☐
Clear presentation of co-benefits	☒		Low OGHG emissions	☐
Financing	☐		Low On-site carbon emissions from fossil fuels	☐
			LCA and global warming potential	☒
			Methodology	☐
			Calculation method	☐
			New tools and evaluation methods	☒
			Indicators and metrics	☒
			nZEB indicators to be maintained	☒
			New ZEB indicators	☐
			Cost effectiveness	☐
			Other	☐
			RES for other uses	☐
			Financing	☐
			Public incentives	☐
			Other	☐
			Monitoring / Data collection	☐
			Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary
The *Réglementation environnementale* 2020 (RE2020) provided new energy and environmental indicators for the nZEB standard and was one of the first to introduce a new methodology including the LCA.

Characteristics and detailed description of solution

Context addressed	
Technical	nZEB standard
Legal	/
Administrative	/
Societal	/
Economic	/

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☒

Built environment addressed		
	Small	Large
Residential	☒	☒
Non-residential	☒	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add explanation

Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☐		Federal administration	☐
Other: All the stakeholders				

Legend: Tick the appropriate box or add explanation

Detailed description of good practice
Description of the elements which work well. – **Existing policies** • The French key regulation for nZEB was the *Réglementation thermique 2012* (RT2012).

- The *Réglementation environnementale* 2020 (RE2020) fixes the updated standards for new constructions and is endorsed by the French Ministry of Ecological Transition as aligning with nZEB standards.

– **Specific targets**

The three major objectives outlined by the French government are:

- Energy efficiency and decarbonisation of buildings;
- Reduction in carbon footprint;
- Guarantee of comfort during periods of high heat.

– **Indicators and metrics**

- Building Envelope Performance (Bbio; points)
- Primary Energy Consumption (Cep; kWh/m^2/year)
- Not renewable Primary Energy Consumption (Cep, nr en; kWh/m^2/year)
- Summer comfort indicator (DH; °C.h)
- Air Permeability (Q_{4Pa_surf}; m^3/(h.m²)
- Impact on climate change of energy consumption during the building's lifespan (Ic_{energy}; kg_{eq} CO_2/year)
- Impact on climate change of construction products, equipment, and their implementation ($Ic_{construction}$; kg_{eq} CO_2/year)
- Impact on climate change of building, including components, energy, construction site and water ($Ic_{building}$; kg_{eq} CO_2/year)
- Stored biogenic carbon (StockC; kg C/m^2)
- Impact of default environmental data used in the assessment of buildings, excluding roads and infrastructure (Icded; kg_{eq} CO_2/year)

– **Methodology**

- The energy consumption indicator (Cep) counts the quantity of energy necessary to cover the needs of the building.
- RE 2020 requires reducing the consumption of non-renewable energies as a priority: a new indicator, the Cep,nr (consumption of non-renewable primary energy) does not count the consumption of renewable or recovered energies. This new feature encourages designers to reduce the use of non-renewable energies (fossils, electricity) and to use more renewable energies.
- The regulation set a maximum threshold for greenhouse gas emissions from energy consumption. The Ic_{energy} indicator assesses the impact on climate change of energy consumption during the use of the building over its entire lifespan, i.e. 50 years (impact measured in kg of CO_2 equivalent emitted into the environment per m²).
- A new calculation method is used, based on conventional environmental data on energy impacts and on the principles of life cycle analysis (LCA).
- The RE 2020 introduces a new requirement on discomfort degree hours (DH), with a new calculation method which considers the effects of climate change on buildings: the evolution of future temperatures, and in particular heat waves which will become more frequent, more intense and longer.

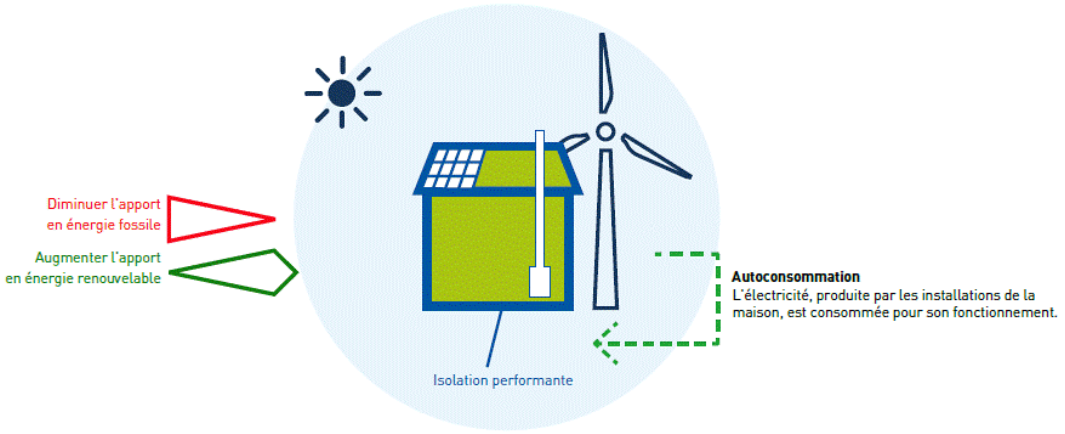


Diagram of the principles taken into account for energy performance in RE 2020 ([2])

LCA phases analysed ([2])

Calculation of the impact of building indicator ([2])

Description of the enabling environment for the development / establishment

In France, the primary rule governing the adoption of nZEB (Nearly-zero energy Building) standards was the *Réglementation thermique 2012*, commonly known as RT2012. This law set out the standards for new constructions, effective from January 1, 2021, applicable to all structures. The newly introduced *Réglementation environnementale 2020* revises the standards for new constructions and gives the occasion to upgrade nZEB standard with more ambitious requirements.

Description of success factors for continuing operation

French national government, together with all the stakeholders involved, have collectively decided to act to reduce building emissions. RE2020 is the first French regulation, and one of the first worldwide, to introduce environmental performance in new construction through life cycle analysis. Utilising a dynamic LCA provides the chance to explore alternative, more sustainable materials.

Lessons learnt and key recommendations

Key objectives and strategies:

- Decrease the climate impact of new buildings:
  - ✓ Consideration of the building's carbon emissions throughout its life cycle.
  - ✓ Encouragement of using construction methods with low carbon emissions or that allow carbon storage.
  - ✓ Prioritisation of the least carbon-intensive energies and phasing out fossil fuels.

- Improve energy performance and reduce consumption:
  - ✓ The RE2020 surpasses the requirements of the RT2012.
  - ✓ Strengthen energy efficiency through Bbio (building envelope performance).
  - ✓ Systematise the use of renewable heat.
- Build housing adapted to future climate conditions:
  - ✓ Objective of summer comfort.
  - ✓ Consideration of heatwave episodes (e.g. Encouraging the adoption of renewable energy sources, such as installing photovoltaic systems to offset excessive air-conditioning usage during heatwaves.
- Ensure good indoor air quality in housing.
- Promote reuse of materials and products.

Main references:

1. Ministères transition écologique cohésion des territoires MER, RT-RE Batiment, RE2020. Available at: https://rt-re-batiment.developpement-durable.gouv.fr/re2020-r320.html?lang=fr (Accessed on 28th March 2024).
2. Ministères transition écologique, Guide RE2020. Réglementation Environnementale. Éco-construire puor le confort de tous, Januay 2024. Available at: *https://www.ecologie.gouv.fr/sites/default/files/guide_re2020_version_janvier_2024.pdf* (Accessed on 28th March 2024).

Annex 5d: Good Practice #4

Co-inventing Doria	Good Practice #4
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: Team representative: RETE FRA INPRESE “B SMART” Architect(s): AMBROGIO RISARI - DRM ARCHITETTURA, EMANUELA SARA CIDRI, 16BIS STUDIO Environmental Expert(s): POLITECNICO DI MILANO, DIPARTIMENTO DI ENERGIA - PROF. FRANCESCO CAUSONE Owner: Municipality of Milan (Italy)	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed	
Good governance	☐
Staff shortage in public administration	☐
Data availability for effective policies	☐
Data accessibility for effective policies	☐
Data quality for effective policies	☐
Estimation of impacts (broader benefits)	☒
Industry and labour and skill shortages	☐
Clear presentation of co-benefits	☒
Financing	☒

Specific challenges addressed: ZEB	
Existing policies and definitions	☒
Advanced nZEB	☐
ZEB definition	☒
Specific targets	☒
Energy Efficiency	☒
RES share and contribution	☒
Phasing out fossil fuels	☒
Low OGHG emissions	☒
Low On-site carbon emissions from fossil fuels	☒
LCA and global warming potential	☒
Methodology	☒
Calculation method	☒
New tools and evaluation methods	☒
Indicators and metrics	☒
nZEB indicators to be maintained	☐
New ZEB indicators	☒
Cost effectiveness	☐
Other	☐
RES for other uses	☐
Financing	☒
Public incentives	☐

		Other	☒
		Monitoring / Data collection	☐
		Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary	
The project Co-inventing Doria won the international competition 'Reinventing Cities' started by the C40 to inspire ambitious carbon-neutral developments across the globe and to transform underutilised sites into examples of sustainability and resilience. The project includes a carbon-neutral hostel and the new green Viale Doria for the renovation of a 610 m^2 empty plot currently used as car park. The site is located on one of the most dense and vibrant neighbourhood of the city of Milan (Italy). The project combines high performances and consistent solutions on all key environmental challenges. The building was designed according to an operational definition for Carbon Neutral Building (CNB).	 (2)

Characteristics and detailed description of solution

Context addressed	
Technical	Eight-storey hostel building + new green street
Legal	Compliant with the Italian nZEB standard (D.M. 26/06/2015)
Administrative	Viale Doria, Municipality of Milan
Societal	Creating a friendly, resilient and sustainable environment for citizens and visitors
Economic	Eventual social housing and energy efficiency incentives

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☐

Built environment addressed		
	Small	Large
Residential	☐	☐
Non-residential	☐	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐

Scale addressed	
Building	☐
Neighbourhood	☐
District	☒

		Other (explain)	Hostel		

Legend: Tick the appropriate box or add explanation

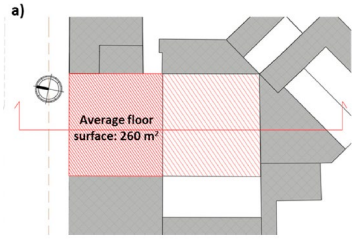
Target group(s) addressed				
Building owners	☐		Scientists	☒
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☒
Architects, engineers	☒		Regional administration	☐
Consultants	☐		Federal administration	☐
Other (explain)			Other (explain)	

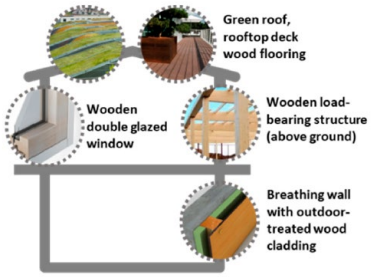
Legend: Tick the appropriate box or add explanation

Detailed description of good practice

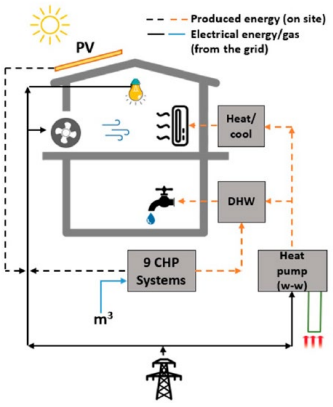
Description of the elements which work well.

- **ZEB definition**
  - Achievement of Carbon Neutral Building (CNB): Net amount of CO_2 or CO_2-eq emissions equal to zero through energy efficiency strategies, on-site/off-site renewables, other certified offset solutions for tackling the remaining emissions.
  - Guaranteeing and overgoing of the Italian nZEB requirements.
  - Carbon neutrality according to EN15804+A1:2019 and EN15978:2011
- **Specific targets**
  - Application of a photovoltaic rooftop of 22kW and a water-to-water heat pump of 300 kW to reach a high level of clean energy.
  - Use of advanced and innovative 'breathing wall' that recover energy and filter air.
  - Low carbon and greenhouse gases emissions
  - Zero on-site emissions
  - Whole LCA assessment
- **Methodology**
  - Integration of the LCA in the methodological approach to define the CNB.
  - Dynamic simulations
- **Indicators and metrics**
  - Operational Carbon emissions
  - Operational energy use
- **Financing**
  - Project to be realised by Municipality of Milan, eventually with social housing and energy efficiency incentives





([4])



([4])

Description of the enabling environment for the development / establishment

The Municipality of Milan decided to develop the 610 m^2 empty plot 'Doria', located in a dense, commercial and busy area of the city. Currently used as car park, the area has a strategic position and is an enabling environment for new construction, to improve high quality of life and adjacent public space. The site has the potential to become an attractive area for citizens and is an opportunity to renovate a void public space.

([3])

([2])

Description of success factors for continuing operation

- Renovation of empty district areas.
- Achievement of low carbon district area.
- Modularity and flexibility of spaces.
- Minimised building energy use in its whole life cycle.
- Wide exploitation of renewable energy sources on site, increasing the overall building performance.
- Promotion of solutions to foster low-carbon buildings and existing district areas.
- Use of bio sourced materials (wood, natural fibres) to promote the sustainability of the whole life cycle.
- Extended positive impact and broader benefits (improvement of social cohesion and green lifestyle; increasing in green; smart parking; proactive sustainable behaviour)

([2])

Lessons learnt and key recommendations.

- A common and shared definition of CNB is needed, specifying what emissions should be considered (operational or on the whole life cycle).
- Calculation method of energy performance should be integrated with the whole-building LCA.
- To achieve CNB buildings it is necessary a reduction of the energy use consumption combined with the selections of sustainable materials with high performance in the whole life cycle.
- A change in the design perspective is needed by the main actors (architect, engineer, municipalities, homeowners, and construction industries).
- The carbon neutrality depends further on occupants' behaviour and systems management and construction site management.
- A great effort by the market is required to afford the increasing initial investment cost for design, materials, and construction.
- The carbon neutrality objective in buildings can be more easily reached enlarging the site boundaries (e.g. involving municipalities for green and vegetation plans or sustainable transportation plans).

Main references:

1. C40, Reinventing cities. Available online at: https://www.c40reinventingcities.org (accessed on 10th January 2024).
2. Infobuildenergia, “Co-inventing Doria, un ostello innovativo con funzioni pubbliche”. Available online at: https://www.infobuildenergia.it/progetti/co-inventing-doria-un-ostello-innovativo-con-funzioni-pubbliche/ (accessed on 09th April 2024)
3. C40, Reinventing cities. Winning projects Co-inventing Doria. Available online athttps://www.c40reinventingcities.org/en/professionals/winning-projects/doria-1270.html (accessed on 10th January 2024)
4. Causone, F.; Tatti, A.; Alongi, A. From Nearly Zero Energy to Carbon-Neutral: Case Study of a Hospitality Building. Appl. Sci. 2021, 11, 10148. https://doi.org/10.3390/app112110148

Annex 5e: Good Practice #5

The Research Centre on Zero-emission buildings (ZEB)	Good Practice #5
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: Norwegian Centres for Environment-friendly Energy Research (FME) ZEB, Norwegian University of Science and Technology (NTNU), SINTEF Community and SINTEF Energy	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		**Specific challenges addressed: ZEB**	
Good governance	☐	**Existing policies and definitions**	☒
Staff shortage in public administration	☐	Advanced nZEB	☐
Data availability for effective policies	☒	ZEB definition	☒
Data accessibility for effective policies	☒	**Specific targets**	☒
Data quality for effective policies	☐	Energy Efficiency	☒
Estimation of impacts (broader benefits)	☒	RES share and contribution	☒
Industry and labour and skill shortages	☒	Phasing out fossil fuels	☒
Clear presentation of co-benefits	☐	Low OGHG emissions	☒
Financing	☐	Low On-site carbon emissions from fossil fuels	☒
		LCA and global warming potential	☒
		Methodology	☒
		Calculation method	☒
		New tools and evaluation methods	☐
		Indicators and metrics	☐
		nZEB indicators to be maintained	☐
		New ZEB indicators	☐
		Cost effectiveness	☐
		Other	☐
		RES for other uses	☐
		Financing	☐
		Public incentives	☐
		Other	☐
		Monitoring / Data collection	☐
		Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary	
The main objective of the research Centre on Zero-emission buildings (ZEB; 2009-2017) was to promote the market penetration of zero emissions buildings through the development of competitive solutions for existing and new residential, commercial and public buildings.	ZEB The Research Centre on Zero Emission Buildings ([1])

Characteristics and detailed description of solution

Context addressed	
Technical	Pilot projects of Zero-emission buildings
Legal	/
Administrative	Norwegian Centres for Environment-friendly Energy Research (FME)
Societal	Contribute to the transition to a low carbon society
Economic	Established by Research Council of Norway

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☒

Built environment addressed		
	Small	Large
Residential	☐	☒
Non-residential	☐	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add explanation

Target group(s) addressed				
Building owners	☐		Scientists	☒
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☒
Architects, engineers	☒		Regional administration	☐
Consultants	☐		Federal administration	☐
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add explanation

Detailed description of good practice

Description of the elements which work well.

- **ZEB definition**
  - The Research centre ZEB provided different levels of **Zero-emission building** intended as a building that "produces enough renewable energy to compensate for the building's greenhouse gas emissions over its life span" ([1]):

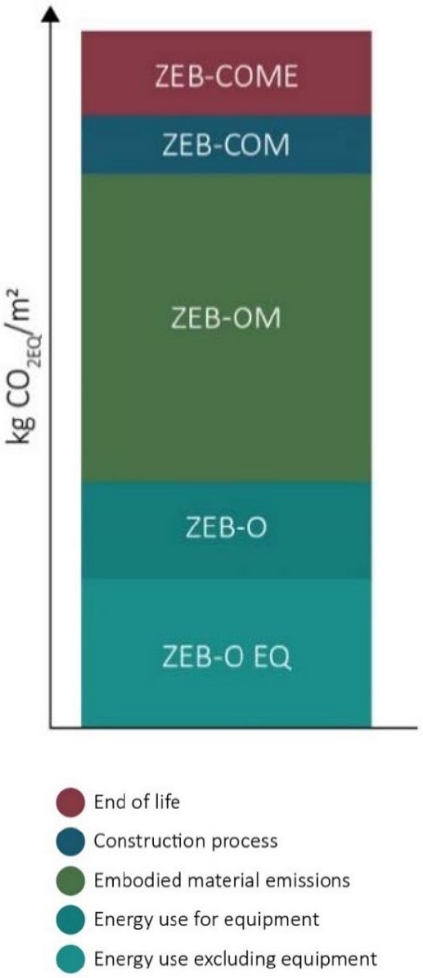
    ZEB – O: RES production compensates for operational GHG emissions.

    ZEB – O ÷ EQ: RES production compensates for operational GHG emissions minus the energy use for equipment (plug loads).

    ZEB – OM: RES production compensates for GHG emissions from operation and production of its building materials.

    ZEB – COM: RES production compensates for GHG emissions from construction, operation and production of building materials.

    ZEB – COMPLETE: RES production compensates for GHG emissions from the entire lifespan of the building (building materials, construction, operation and demolition/recycling).
- **Specific targets**
  - FME ZEB developed guidelines/instructions on how to document zero-emission buildings, useful for future regulations and applied to pilot buildings ([3]).
  - All the pilot cases aim to reach the ZEB at different levels.
  - In some of the projects, LCA was a tool to evaluate the GHG emissions.
  - Low GHG emissions were reached in all pilot cases.
  - The use of solar cells and photovoltaic elements ensures the necessary RES production (e.g. in ZEB Skarpnes, ZEB-house Multikomfort and Visund Haakonsvern).
  - All the architectural and mechanical solutions were studied to reach the ZEB objective (e.g. combined heat and power (CHP) unit, fueled by locally produced biogas in Heimdal VGS).
  - Advanced building envelope and sustainable technologies were used (e.g. double passive house wall in ZEB-house Multikomfort, re-use of grey water in ZEB-house Multikomfort and Skarpnes residential development, etc.).
  - The materials were chosen in the perspective of the reduction of carbon footprint.



ZEB levels ([2])

ZEB Skarpnes residential development ZEB-0 ([1])

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– **Methodology**

ZEB centre developed an excel-based GHG emission calculation tool to calculate CO_2eq emissions from the operational energy use and embodied materials emissions such as in the case of Multikomfort house and Heimdal VGS.
BIM tools were frequently used as powerful support in the design (e.g. in Multikomfort house, Heimdal VGS, Visund, Haakonsvern).

– **Other (addressing general challenges)**

The involved partners gained new knowledge regarding carbon footprint, material usage and technical solutions for isolation and air resistance.
Some shortage of knowledge at the beginning was compensate by the multidisciplinary skills and approaches resulting in an extended expertise.
Good indoor environment and high-living quality were some of the co-benefits of projects

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ZEB House Multikomfort Larvik

ZEB-0M ([1])

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Description of the enabling environment for the development / establishment

The Norwegian authorities have been intensifying their efforts by implementing new regulations and legislation aimed at enhancing energy efficiency. Simultaneously, media attention has heightened on climate issues and the potential ramifications of careless energy usage. This could explain why establishing legitimacy and fostering a common understanding of the ZEB's objectives in pilot projects has proven relatively straightforward. Clients appear driven by either altruistic motives or economic incentives, or a combination of both.

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Visund, Haakonsvern, Bergen

ZEB-0÷EQ ([1])

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Description of success factors for continuing operation

The ZEB goal was defined at the early stage of the design of the pilot cases. In such way the ZEB objective was perceived as integrated part of the process.
Key stakeholders and ZEB centre researchers were involved from the beginning to explain clearly the peoples' needs and to ensure cooperation and different skills contribution.
A collaborative culture emerged during the design processes.

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Heimdal VGS

ZEB-OM* (20% of M) ([1])

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Lessons learnt and key recommendations

The pilot projects led to some reflections that could be driving forces towards ZEB:

To guarantee the success of the projects, all the involved stakeholders have to share the common purpose to achieve the ZEB goal. They must be highly committed and motivated.

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- It is fundamental to reveal and enhance consequences, benefits and challenges given by the zero-emission goal among all the actors from early to advanced stage of the building process.
- The design and innovation process imply that at the beginning it is not everything known, and it is necessary to find new unexperienced solutions. This leads to:
  - Positive results that could also influence the building market, such as new knowledge and improvement of skills by the involved actors; a proactive competition among them; an extensive learning process.
  - Negative impacts such as high costs of investment, time consuming and expensive failures and changes. Extra resources for the project (compared to a traditional building), such as money and time must be predicted and made available in advance.
- The building design is a compromise and requires a balance among goals of energy efficiency, functionality, comfort, and costs. It needs an interdisciplinary good collaboration and well-working teams.
- The economical support from municipality or external promoter is a key element to realise ZEB and to face with unexpected issues and unknown solutions to be applied.
- Calculation of carbon footprint and financial costs, the selection of the most effective energy supply and clear economic boundaries are central elements for the evaluation of the project's feasibility as well as careful planning, management and follow-up.

Main references:

1. FME, The Research Centre on Zero-emission buildings. Available online at: http://www.zeb.no/index.php/en/
2. A. Nocente et al 2021. The ZEB Laboratory: the development of a research tool for future climate adapted zero emission buildings J. Phys.: Conf. Ser. 2069 012109.
3. Anita Moum, Åshild Lappegard Hauge and Judith Thomsen. Four Norwegian Zero Emission Pilot Buildings – Building Process and User Evaluation. ZEB Project report 30 – 2017. FME ZEB. SINTEF Academic Press and Norwegian University of Science and Technology 2017.

Annex 5f: Good Practice #6

The Research Centre on Zero Emission Neighbourhoods (ZEN) in Smart Cities	Good Practice #6
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: Norwegian Centres for Environment-friendly Energy Research (FME) ZEN, Norwegian University of Science and Technology (NTNU), SINTEF Community and SINTEF Energy	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed		Specific challenges addressed: ZEB	
Good governance	☐	**Existing policies and definitions**	☒
Staff shortage in public administration	☐	Advanced nZEB	☐
Data availability for effective policies	☒	ZEB definition	☒
Data accessibility for effective policies	☒	**Specific targets**	☒
Data quality for effective policies	☐	Energy Efficiency	☐
Estimation of impacts (broader benefits)	☐	RES share and contribution	☐
Industry and labour and skill shortages	☒	Phasing out fossil fuels	☐
Clear presentation of co-benefits	☐	Low OGHG emissions	☒
Financing	☒	Low On-site carbon emissions from fossil fuels	☒
		LCA and global warming potential	☒
		Methodology	☒
		Calculation method	☒
		New tools and evaluation methods	☒
		Indicators and metrics	☒
		nZEB indicators to be maintained	☐
		New ZEB indicators	☒
		Cost effectiveness	☐
		Other	☐
		RES for other uses	☐
		Financing	☐
		Public incentives	☐
		Other	☐
		Monitoring / Data collection	☐

		Databases / Observatory	☐

Legend: Tick the appropriate box

Short description of good practice – summary	
The Research Centre on Zero Emission Neighbourhoods (ZEN) in Smart Cities aims to create solutions for the zero-emission buildings and neighbourhoods of the future to achieve a low carbon society.	Research Centre on ZERO EMISSION NEIGHBOURHOODS IN SMART CITIES (1)

Characteristics and detailed description of solution

Context addressed	
Technical	Pilot projects of ZEB and sustainable neighbourhoods with zero GHG emissions
Legal	/
Administrative	Norwegian Centres for Environment-friendly Energy Research (FME)
Societal	Contribute to the transition to a low carbon society
Economic	Established by Research Council of Norway

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☒

Built environment addressed		
	Small	Large
Residential	☐	☒
Non-residential	☐	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☐
Neighbourhood	☒
District	☐

Legend: Tick the appropriate box or add explanation

Target group(s) addressed				
Building owners	☒		Scientists	☒
Property managers	☐		Professional associations	☒
Energy companies	☒		Municipal administration	☒
Architects, engineers	☒		Regional administration	☒
Consultants	☒		Federal administration	☐
Other (explain)			Other (explain)	

Legend: Tick the appropriate box or add explanation

Detailed description of good practice

Description of the elements which work well.

- **Policies and definitions**
  - They provide analytical framework for ZEN design and planning.
  - They deep into policy measure, innovation, and business models.
  - They wish to create new business models, roles, and services to improve the flexibility of markets, extend the public use and develop innovations.
- **Specific targets**
  - FME ZEN (together with public and industry partners) is developing 9 pilot projects in test areas spread all over Norway ([1]). The main goals are ([2]):
    - ✓ "Integrate science-based knowledge on GHG emissions for the development of neighbourhood design and planning instruments.
    - ✓ Create cost effective and energy efficient buildings by developing low carbon technologies and construction systems based on life cycle design strategies.
    - ✓ Develop technologies and solutions for the design and operation of energy flexible neighbourhoods.
    - ✓ Develop a decision-support tool for optimising local energy systems and their interaction with the larger system".
    - ✓ Responsive and energy efficient buildings
    - ✓ Energy-flexible neighbourhoods
- **Methodology**
  - LCA is the main methodology in FME ZEN used to calculate greenhouse gas emissions from a ZEN project ([5]).
- **Indicators and metrics**
  - Key Performance Indicators (KPI) and their calculation are under development. Generally, they are divided into: GHG Emissions, Energy, Power, Mobility, Spatial qualities, Economy and Innovation ([5]).
- **Other (addressing general challenges)**
  - A series of neighbourhood-scale living labs are created with the aim to act as innovation hubs and to test the solutions developed in the ZEN Research Centre([5]).
  - In the ZEN design process, the final aim is the rise of the quality of life of inhabitants to develop a citizen-centred neighbourhood.

ZEN - 9 pilot areas ([1])

ZEN KPI ([1])

Ydalir, Elverum municipality ([6])

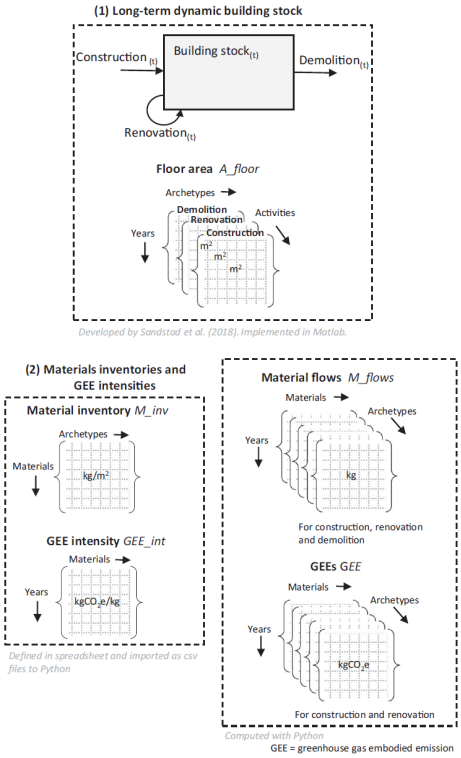
Description of the enabling environment for the development / establishment

Scientists, local governments, businesses, and governmental bodies collaborate with the ZEN Research Centre to design, construct, and manage communities aiming for zero greenhouse gases emissions. The ZEN Centre oversees nine experimental initiatives located throughout Norway, covering an area exceeding 1 million square meters and accommodating over 30,000 residents in total. The pilot projects are Furuset in Oslo, Fornebu in Bærum, Sluppen and Campus NTNU in Trondheim, Campus Mære in Steinkjer, Ydalir in Elverum, Campus Evenstad, NyBy Bodø, and Zero Village Bergen.

Zero Village, Bergen - Snøhetta ([7])

Description of success factors for continuing operation

- A LCA model for neighbourhoods was developed focusing on GHG emissions based on five modules: buildings, mobility, open spaces, networks, and on-site energy infrastructure (e.g. in the Zero Village Bergen). The total emissions associated to these physical elements and to the life cycle stages were accounted ([3]).
- A Dynamic model ([4]) to quantify greenhouse gas embodied emissions (GEEs) was implemented. It calculates the buildings materials flows and related GEE using LCA combined with Dynamic Material Flow Analysis (DMFA) (applied to the ZEN Ydalir Project).
- The main results indicate that decreasing electricity consumption in Norwegian buildings can enhance the contribution of Norwegian hydropower within Europe. Moreover, ZEN initiatives have the potential to lower the costs associated with transitioning to a fossil-free energy system ([5]).
- The projects are developing new knowledge among the actors, stimulating innovation and new market solutions.



LCA-DMFA model ([4])

Lessons learnt and key recommendations

- The general conclusions suggest that attaining net zero greenhouse gas (GHG) emissions at the neighbourhood scale is difficult under current project designs. There is a necessity for strategies to reduce emissions associated with materials, generate excess renewable

energy to offset fossil fuel emissions elsewhere, and significantly decrease emissions from transportation compared to current regulations ([5]).

- It is necessary to consider all the physical elements concurring to the total emissions of a neighbourhood ([3]).
- In the LCA assessment of neighbourhoods it is fundamental understand which physical elements and life cycle stages have been considering moving from the single buildings to the district level ([3]).
- In the planning of ZEN, the definition of emission intensity of electricity is becoming relevant. Predicting the future composition of electricity sources is challenging. Additionally, the electricity grid is a complex system where energy exchanges among countries vary depending on factors such as seasons, accessibility, and transmission capabilities. Given the significant responsiveness of electricity emission intensity, it is crucial to establish a realistic trajectory for emission intensity evolution over time or determine an average value across the analysis period. This ensures better facilitation of decision-making and the selection of energy solutions for a ZEN (Zero Energy Neighbourhood) project during its initial planning phases ([3]).
- The utilisation of LCA modelling holds considerable promise for aiding decision-making during the initial phases of planning ZEN projects. It furnishes insights into pivotal elements and life cycle stages while its modular framework ensures comparability, transparency, and adaptability. However, inherent uncertainties and simplifications within the LCA model, and consequently its outcomes, are evident, especially concerning the potential long-term changes in technologies, user behaviour, and climate. Addressing these uncertainties necessitates further research, particularly in forecasting emission intensities, emissions linked to material and vehicle production in the future and assessing the implications of assuming symmetric weighting for emissions associated with electricity exchanges between the power grid and the neighbourhood ([3]).
- To develop a ZEN project aiming to minimise greenhouse gas embodied emissions (GEEs), it is essential to comprehend the factors driving emissions for every aspect of the neighbourhood as time progresses. Additionally, estimating the energy requirements and on-site energy production would provide insights into the extent to which GEEs could be offset by earning emission credits through surplus on-site energy exported to external grids ([4]).

Main references:

1. FME, Zero Emission Neighbourhoods in smart cities. Available online at: https://fmezen.com/
2. L.A. Bø, E. Junker, M. Askeland 2020. ZEN OG LOVVERKET Muligheter og begrensninger i dagens lovverk ved utvikling av et ZEN område. FME ZEN, NTNU, SINTEF, ZEN MEMO n. 26 – 2020.
3. Carine Lausselet, Vilde Borgnes, Helge Brattebø, LCA modelling for Zero Emission Neighbourhoods in early stage planning, Building and Environment, Volume 149, 2019, Pages 379-389, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2018.12.034.
4. Carine Lausselet, Johana Paola Forero Urrego, Eirik Resch, Helge Brattebø, Temporal analysis of thematerial flows and embodied greenhouse gas emissions of a neighborhood building stock, Journal of Industrial Ecology 2021;25:419–434. DOI: 10.1111/jiec.13049
5. Brynjar Fredus Svarva, Arild Gustavsen, Ann Kristin Kvellheim, Sunniva Moum Danielsen, Annual Report 2021. ZEN REPORT No. 37. ISBN 978-82-536-1739-8.
6. FME, ZEN. Ydalir, Elverum. Available online at: https://fmezen.com/ydalir-elverum/
7. FME, ZEN. Zero Village Bergen. Available online at:https://fmezen.com/zero-village-bergen/

Annex 5g: Good Practice #7

Advancing Net Zero – Case Study Library	Good Practice #7
Authors: Silvia Di Turi - ENEA	Date: 02.2024
Contributors: Gabriella Azzolini, Francesca Hugony, Fabio Zanghirella - ENEA	
Authors of the source material underlying the good practice: World Green Building Council (WGBC)	

Aspects addressed	
ZEB – Zero-Emission Building	☒
MEPS - Minimum Energy Performance Standards	☐
NBRP – National Building Renovation Plan	☐
BRP – Building Renovation Passport	☐
EPCs – Energy Performance Certificates	☐

Legend: Tick the appropriate box

General challenges addressed			Specific challenges addressed: ZEB	
Good governance	☐		**Existing policies and definitions**	☒
Staff shortage in public administration	☐		Advanced nZEB	☐
Data availability for effective policies	☒		ZEB definition	☒
Data accessibility for effective policies	☒		**Specific targets**	☒
Data quality for effective policies	☐		Energy Efficiency	☒
Estimation of impacts (broader benefits)	☒		RES share and contribution	☒
Industry and labour and skill shortages	☒		Phasing out fossil fuels	☒
Clear presentation of co-benefits	☒		Low OGHG emissions	☒
Financing	☒		Low On-site carbon emissions from fossil fuels	☒
			LCA and global warming potential	☒
			Methodology	☐
			Calculation method	☐
			New tools and evaluation methods	☐
			Indicators and metrics	☒
			nZEB indicators to be maintained	☐
			New ZEB indicators	☒
			Cost effectiveness	☐
			Other	☐
			RES for other uses	☐
			Financing	☐
			Public incentives	☐
			Other	☐
			Monitoring / Data collection	☒
			Databases / Observatory	☒

Legend: Tick the appropriate box

Short description of good practice – summary	
The World Green Building Council's Advancing Net Zero initiative is a global programme aimed at achieving complete decarbonisation by 2050. Collaborating with Green Building Councils worldwide, the programme focuses on creating tools, initiatives, and materials to underline the necessity and feasibility of constructing net zero carbon buildings, while also enhancing the industry's capabilities to accomplish this goal.	ADVANCING NET ZERO ([1])

Characteristics and detailed description of solution

Context addressed	
Technical	Net Zero Carbon Buildings around the world
Legal	/
Administrative	/
Societal	Creating a sustainable low-carbon society
Economic	/

Legend: Allocate a topic

Technical: e.g. construction types, materials, heating and cooling systems, electricity supply
Legal: e.g. federal or regional/municipal responsibility; relation with building regulation, energy audit, RES legislation
Administrative: e.g. is the unique definition of building address and unit address available or not; databases, tools
Societal: e.g. how is energy poverty dealt with
Economic: e.g. which subsidy schemes exist on what basis

Building type	
New	☒
Existing	☒

Built environment addressed		
	Small	Large
Residential	☐	☒
Non-residential	☐	☒
Office	☐	☐
Educational	☐	☐
Health	☐	☐
Other (explain)		

Scale addressed	
Building	☒
Neighbourhood	☐
District	☐

Legend: Tick the appropriate box or add explanation

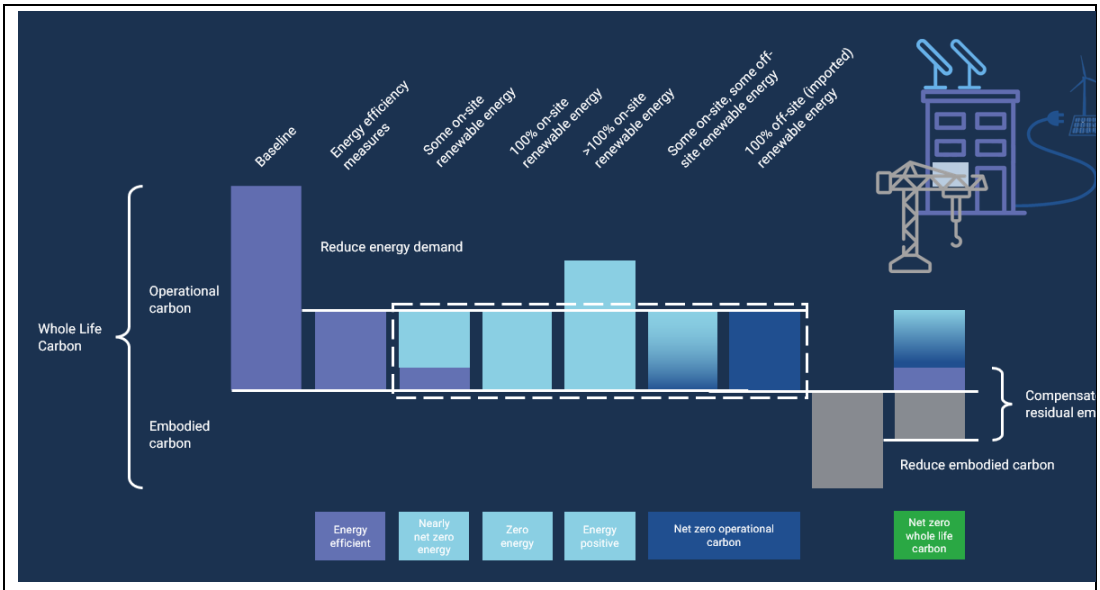
Target group(s) addressed				
Building owners	☐		Scientists	☐
Property managers	☐		Professional associations	☐
Energy companies	☐		Municipal administration	☐
Architects, engineers	☐		Regional administration	☐
Consultants	☐		Federal administration	☐
Other: All the stakeholders are involved depending on the project				

Legend: Tick the appropriate box or add explanation

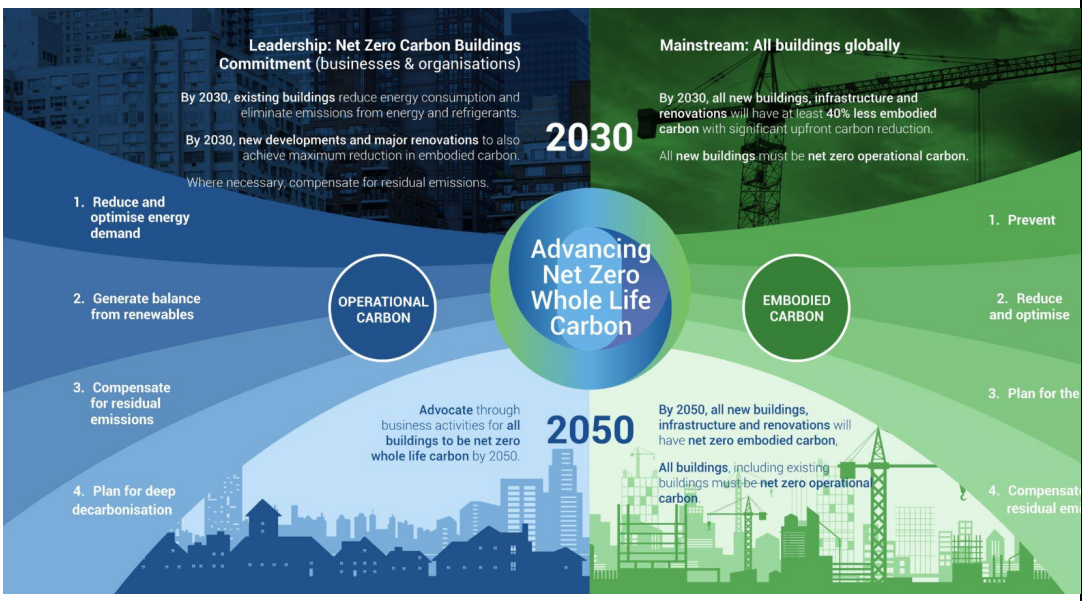
Detailed description of good practice

Description of the elements which work well.

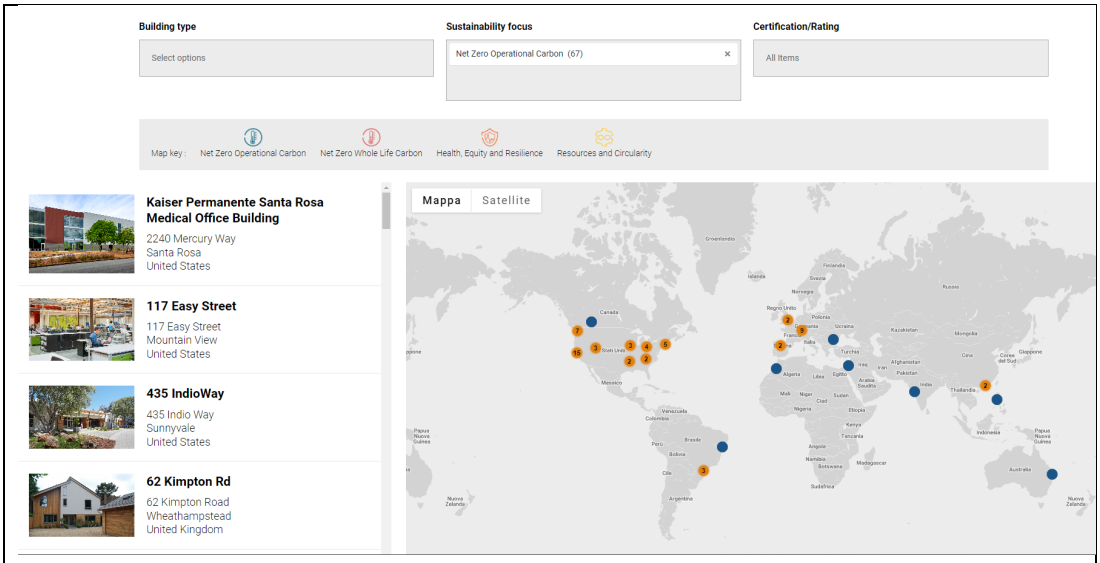
- **Policies and definition**
  - Achievement of Carbon Neutral Buildings. The involved Green Building Councils (GBCs) are actively introducing net zero initiatives and resources to their respective local industries. Additionally, they are supporting policy frameworks to reduce carbon emissions within the built environment. GBCs are also integrating the Whole Life Carbon concept into national-level resources, guidance, and educational initiatives.
  - Plan for deep decarbonisation. The Whole Life Carbon Vision established by WorldGBC aims to the complete decarbonisation of the sector. It includes essential milestones, definitions for net zero operational carbon and net zero whole life carbon buildings, and fundamental principles to guarantee the adoption of optimal methods in reaching these objectives.
- **Specific targets**
  - Reduce and optimise energy demand.
    - ✓ The high energy performance of the buildings is the priority.
    - ✓ Actions for the reduction of energy demand are the basis to ensure high energy efficient buildings.
  - Generate balance from renewables.
  - Compensate for residual emissions.
    - ✓ Efforts are made to reduce emissions from both operational and embodied carbon, while any remaining emissions are offset through compensatory measures during the transition toward achieving net zero emissions.
- **Indicators and metrics** ([1])
  - Carbon offset credit: “A tradable, non-tangible instrument representing a unit of carbon dioxide-equivalent (CO_2e) – typically one tonne – that is reduced, avoided or sequestered by a project and is certified/verified to an internationally recognised carbon accounting standard” ([1,2]).
  - Carbon removal offset: “A type of offset that takes CO_2 out of the air and permanently stores it. For all forms of carbon removal, whether nature-based solutions or technologically mediated processes, carbon must be stored ([1,3]).
  - Embodied Carbon in the whole life of the building.
  - Greenhouse Gases (GHGs).
  - Operational Carbon emissions.
  - Residual Carbon emissions.
- **Data collection**
  - WGBC’s Case Study Library collects examples of 67 net zero operational carbon and 1 net zero whole life carbon building around the world ([4]).



Definitions of Net Zero Carbon Buildings ([1])



Net Zero Whole Life Carbon Vision ([1])



WGBC's Case Study Library: net zero operational carbon buildings around the World ([4])

Description of the enabling environment for the development / establishment

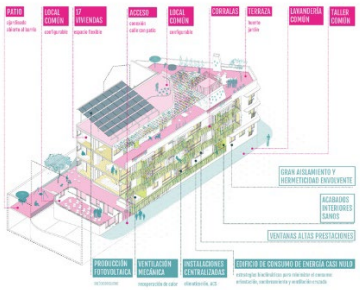
The involved Green Building Councils (GBCs) are actively engaged in introducing initiatives and resources aimed at achieving net zero emissions within their respective regions. Additionally, they are striving to promote policy strategies to reduce carbon footprints in the built environment. GBCs are integrating the fundamental concepts of the Whole Life Carbon approach into various national-level resources, including tools, guidance, and educational initiatives.

Zero Carbon Commitment Signatories in Europe ([6])

Description of success factors for continuing operation

- GBC disseminated established strategies aimed at enhancing energy efficiency, fostering adaptation and resilience, minimising embodied carbon emissions, and integrating seamlessly with nature-oriented solutions.
- The Case Study Library serves as a repository for exemplary case studies in sustainable construction, featuring some of the most innovative and advanced environmentally friendly buildings worldwide. Each case study showcases the exceptional performance of a functioning building that aligns with at least one of WorldGBC's three key impact areas: Net Zero operational carbon - Climate Action; Health, Equity & Resilience; and Resources & Circularity. Whether it is promoting health advantages, revitalising natural ecosystems, or attaining net zero carbon emissions, WorldGBC acknowledges these case studies as worldwide frontrunners in sustainable construction. Each case study

Examples of case studies:



Entrepatios Las Carolinas, Madrid ([4,7])

has undergone validation through recognised certification programmes, rating systems, or third-party authentication processes. Case Study Library is continuously expanding to showcase top-tier buildings that demonstrate excellence in critical sustainability aspects. This evolution aims to meet the increasing market demand for buildings that are low carbon, promote health, equity, and circularity. ([4])

Energy + Home 1.0, Germany ([4])

Lessons learnt and key recommendations

- It is necessary to establish which means a net zero objective (net zero energy building, net zero operational carbon, net zero whole life carbon).
- Increase of renewable energy production is possible promoting on-site and off-site renewable energy and phasing out fossil fuels.
- Reducing operational energy use and embodied emissions means at the same time optimising energy efficiency and reducing embodied carbon.
- Immediate reductions in embodied carbon emissions are achievable through existing resources and technologies. However, there is no one-size-fits-all solution. Business executives must scrutinise every decision through the lens of halving emissions, making informed choices that lead to substantial, comprehensive reductions in whole-life carbon emissions ([5]).
- Offsetting residual emissions is critical to attain sector decarbonisation goals.

Minimal consumption and using less energy must be the priority. In line with this, transitioning to a circular economy will undoubtedly contribute to reducing carbon emissions in future construction endeavours. Striving for maximum reuse value in everything, from entire buildings to their systems and components, will be essential in minimising resource usage, preventing waste, and mitigating the continuous expenditure of embodied carbon over the buildings' life cycles.

Main references:

1. World Green Building Council (WGBC), Advancing Net Zero. Available online at: https://worldgbc.org/advancing-net-zero/
2. ICROA, 'Code of Best Practice for Carbon Management Services' (2020). https://icroa.org/icroa-code-of-best-practice/
3. University of Oxford, 'The Oxford Principles for Net Zero Aligned Carbon Offsetting' (2020). Available online at: https://www.smithschool.ox.ac.uk/sites/default/files/2022-01/Oxford-Offsetting-Principles-2020.pdf
4. World Green Building Council (WGBC), Case Study Library. Available online at: https://worldgbc.org/case-study-library/
5. WGBSD-ARUP. Net-zero buildings Halving construction emissions today. January 2023. https://www.wbcsd.org/contentwbc/download/15653/227132/1
6. World Green Building Council (WGBC), The Net Zero Carbon Buildings Commitment. Available online at: https://worldgbc.org/thecommitment/?_sfm_regions=europe
7. Cohousing ecológico Entrepatios – Las Carolinas. Available online at: https://satt.es/portfolio_page/cohousing-entrepatios/