PEDvolution

Interoperable solutions to streamline
PED evolution and cross-sectoral integration

Deliverable 4.2

PED Readiness Assessment Policy Strategy Roadmap

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Responsible Author	**Paulina Rodriguez Fiscal (VITO), Katarina Kosutova (VITO)**		
Contributions from	**Ruken Karakus Acipinar (VITO), Natalia Altman (VITO), Matthias Hasse (ZHAW)**		
Reviewed by	**Inger Andresen (NTNU), Reda El Makroum (TUW), Marina Laskari (INLE)**		

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1 According to Project's Quality Assurance Process

Table of Contents

List of Figures

List of Tables

Glossary of terms and abbreviations used

ABBREVIATION / TERM	DESCRIPTION
AFIR	Alternative Fuels Infrastructure Regulation
BREEAM	Building Research Establishment Environmental Assessment Method
CAM	Italian Minimum Environmental Criteria
CASBEE	Communities and Comprehensive Assessment System for Built Environment Efficiency
CEC	Citizen Energy Community
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
COST	European Cooperation in Science and Technology
DBL	Digital Building Logbook
DUT	Driving Urban Transition
EBC	Energy in Buildings and Communities
EC	Energy Community
EDHC	Efficient District Heating and Cooling
EE	Energy Efficiency
EEA	European Energy Association
EED	Energy Efficiency Directive
EMD	Electricity Market Directive
EPB	Energy Performance of Buildings
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
ESTI	European Telecommunications Standards Institute
EU	European Union

EV	Electric Vehicle
GBRS	Green Building Rating Systems
GHG	Green House Gas
H&C	Heating and Cooling
IEA	International Energy Agency
ISO	International Standard Organisation
JPI	Joint Programming Initiative
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
LIFE	Programme for the Environment and Climate Action
MRV	Monitoring, Reporting and Verification
MS	Member State
NBRP	National Building Renovation Plan
NECP	National Energy and Climate Plan
NSA	Neighbourhood Sustainability Assessment
NZEB	Nearly Zero Emission Buildings
PED	Positive Energy Districts
PV	Photovoltaic
RA	Readiness Assessment
RAA	Renewables Acceleration Area
RED	Renewable Energy Directive
SCIS	Smart Cities Information System
SME	Small and Medium-sized Enterprise
SPEN	Sustainable Plus Energy Neighbourhoods

SRI	Smart Readiness Indicator
TSO	Transmission System Operator
ZEB	Zero Emission Buildings

1 EXECUTIVE SUMMARY

This deliverable presents the PED Readiness Assessment (PED RA) Policy Roadmap, developed within the PEDvolution project to support the establishment of a harmonised European framework for assessing the readiness and maturity of Positive Energy Districts (PEDs). As PEDs are increasingly recognised as a cornerstone of Europe's transition towards climate-neutral, energy-efficient, and resilient cities, the lack of a common assessment approach risks fragmentation, limited comparability, and reduced policy and investment impact.

The roadmap responds to this challenge by outlining a strategic and actionable pathway for embedding a harmonised PED Readiness Assessment framework within the European policy landscape. It builds on the technical foundations of the PED RA methodology [1] developed earlier in the project and connects them with relevant EU legislative, regulatory, and strategic instruments, including the Energy Performance of Buildings Directive (EPBD) [2], the Renovation Wave [3], the Energy Efficiency Directive (EED) [4], the Renewable Energy Directive (RED) [5], and the EU Strategy on Energy System Integration [6].

The document sets out three overarching objectives. First, it aims to support technical harmonisation by promoting shared definitions, indicators, data protocols, and assessment procedures that enable transparent and comparable PED evaluations across Member States. Second, it seeks to strengthen policy alignment and legal coherence, ensuring that PED readiness assessment can complement and reinforce existing EU policy instruments and reporting frameworks. Third, it focuses on replicability and scalability, enabling PEDs to transfer and apply PED assessment practices across diverse urban, climatic, and regulatory contexts.

To achieve these objectives, the roadmap analyses the current landscape of PED assessment approaches, identifies gaps and barriers in existing policy frameworks, and explores synergies with European and international initiatives and tools such as the Smart Readiness Indicator (SRI) [7], the Technical Guidelines of the Digital Building Logbooks (DBL) [8], IEA EBC Annex 83 [9], COST Action PED-EU-NET[10] and the DUT PED Framework 3.0. [11]. Based on this analysis, it proposes a phased action plan with short-, medium-, and long-term priority actions, including pilot testing, integration into EU policy processes, data interoperability measures, and capacity-building activities.

Overall, the PED RA Policy Strategy Roadmap serves as a bridge between innovation and implementation. It provides guidance for European institutions, Member States, cities, and stakeholders on how a harmonised PED readiness assessment can support evidence-based policymaking, facilitate access to finance, enhance comparability and transparency, and accelerate the deployment of PEDs as a key enabler of Europe's climate-neutral urban transition.

2 INTRODUCTION

Positive Energy Districts (PEDs) are increasingly positioned at the heart of Europe's strategy to decarbonise the built environment and transform cities into climate-neutral, resilient, and inclusive systems. By shifting the focus from individual buildings to the neighbourhood scale, PEDs enable the integration of energy efficiency, local renewable generation, flexibility, digitalisation, mobility, and social innovation within a coherent urban framework. However, despite growing policy attention and a rising number of pilot projects across Europe, the absence of a harmonised and policy-aligned assessment approach continues to limit the comparability, scalability, and mainstreaming of PEDs.

In this context, the PEDvolution project has developed a PED Readiness Assessment (PED RA) framework to evaluate the maturity and implementation capacity of PEDs across technical, social, market, and interoperability dimensions. While the technical and methodological foundations of the PED RA are addressed in earlier project deliverables, there remains a clear need to define how such an assessment framework can be strategically embedded within the European policy landscape and aligned with existing legislative and governance structures.

This document addresses that need by presenting a policy strategy roadmap for the PED Readiness Assessment. Its purpose is to outline how a harmonised PED RA framework can be progressively established, tested, and mainstreamed at the European level, while ensuring coherence with EU climate, energy, and urban policy objectives. The roadmap translates technical assessment concepts into a policy-relevant narrative, identifies key actors and governance levels, and proposes concrete actions to support uptake, alignment, and long-term sustainability of the framework.

By doing so, the roadmap aims to support policymakers, public authorities, and stakeholders in leveraging PED readiness assessment as a decision-support and coordination tool, enabling more consistent monitoring, informed investment decisions, and accelerated replication of PEDs across Europe.

2.1 Mapping Project's Outputs

The purpose of this section is to map the project's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 1: Adherence to Project's GA Deliverable & Tasks Descriptions.

PROJECT GA COMPONENT TITLE	PROJECT GA COMPONENT OUTLINE	RESPECTIVE DOCUMENT CHAPTER(S)	JUSTIFICATION

DELIVERABLE			
D4.2 PED Readiness Assessment Policy Strategy Roadmap	EU initiatives like the Renovation Wave, trialogue on the revision of the Energy Performance of Buildings Directive, EU strategy on Energy System Integration, JPI Urban Europe, etc. have emphasised the importance of the neighbourhood	Chapter 6 – 7	This chapter outlines the EU policy context at different levels and highlights how PEDs, by integrating energy, mobility, digitalisation, and social innovation at the neighbourhood scale, align with EU initiatives like the Renovation Wave and Energy System Integration Strategy.
TASK(S)			
T4.3 PED Readiness Assessment Policy Strategy Roadmap	This task will conduct a strategic plan that outlines how a European harmonised PED assessment can be achieved.	Chapter 8	This chapter details how the roadmap will be put into practice and continuously evaluated. It defines the governance structure, clarifying roles for the European Commission, Member States, cities, and research actors in coordinating, deploying, and updating the PED Readiness assessment tool.
	The roadmap will include a concrete action plan, identify the priority actions for the European Commission and suggestions for synergies with existing EU and international initiatives (e.g. SRI, IEA Annex 83, Cost Action PED-EU-NET, Digital Building Logbook technical study, Concerted Actions EPBD, etc.)	Chapter 8	This chapter outlines the short-, medium-, and long-term measures the European Commission should take to establish, pilot, and mainstream the PED assessment tool. It highlights concrete steps such as defining the framework, integrating it into EU policies, expanding pilots, and embedding the tool into governance cycles by 2030.

2.2 Deliverable Overview and Report Structure

This deliverable provides the strategic and policy-oriented complement to the technical and methodological work developed across the PEDvolution project. While earlier deliverables define the conceptual foundations, indicators, and calculation logic of the PED Readiness Assessment (PED RA), this report focuses on how a harmonised PED readiness assessment can be embedded, governed, and scaled within the European policy landscape.

The primary objective of D4.2 is to translate the PED RA framework into a coherent policy roadmap that supports European institutions, Member States, cities, and other stakeholders in adopting and operationalising PED readiness assessment in a consistent and comparable manner. The deliverable, therefore, does not replicate technical definitions or calculation methodologies; instead, it positions the PED RA within existing EU strategies, legislative frameworks, and governance processes, and identifies the actions required to enable its long-term uptake and impact.

D4.2 builds on, and is closely connected to, several work packages and deliverables within the PEDvolution project, ensuring continuity from concept development to demonstration and evaluation.

The policy roadmap presented in D4.2 is grounded in the conceptual foundations of the PED Readiness Assessment developed in WP2 (Solution Specification and Concept Design). The definitions of PED readiness, assessment dimensions, system boundaries, and maturity logic were established in WP2, *D2.2 - Understanding the PED Readiness Assessment framework* provides the analytical baseline that this deliverable strategically operationalises at the policy level and D4.2 uses it as a reference to identify policy needs, harmonisation gaps, and governance requirements.

D4.2 complements *D4.1 – PED Readiness Assessment Methodology and Calculation Tool* by addressing the strategic and institutional dimensions of PED readiness assessment. While D4.1 focuses on *how to calculate and score PED readiness*, D4.2 focuses on *how such an assessment can be adopted, governed, and mainstreamed*. Together, the two deliverables form a coherent methodological policy package: D4.1 provides the operational tool, and D4.2 defines the conditions for its effective policy integration.

D4.2 is directly linked to WP9, and in particular to *Task 9.3 - PEDs Performance Assessment, and D9.2. PEDs performance assessment report,* where the PED Readiness Assessment is applied to real demonstration sites. The policy roadmap anticipates this demonstration phase by defining the preliminary governance roles, evaluation logic, and comparability requirements that underpin PED performance assessment in practice. In turn, the outcomes of WP9 provide critical validation and feedback on the feasibility, relevance, and usability of the PED RA framework, informing future policy refinement and scaling pathways identified in this roadmap.

The roadmap also supports cross-cutting objectives related to replication, exploitation, and impact maximisation. By aligning the PED RA with EU initiatives such as the Smart Readiness Indicator, the Digital Building Logbook, IEA Annex 83, and Concerted Actions EPBD, D4.2 creates a foundation for

continued uptake beyond the project's lifetime and supports exploitation activities addressed in later work packages.

The report is structured to progressively move from strategic context to actionable policy guidance:

- **Chapter 3** defines the objectives of the roadmap, including its background, problem statement, and strategic goals.
- **Chapter 4** positions the PED Readiness Assessment as a policy-support instrument and clarifies its role within the overall PEDvolution framework.
- **Chapter 5** explains the need for a harmonised PED readiness assessment, addressing fragmentation in existing approaches and stakeholder perspectives.
- **Chapter 6** explores synergies with European and international initiatives relevant to PED assessment and monitoring.
- **Chapter 7** analyses European policy and legislative frameworks affecting PEDs and identifies gaps relevant to district-scale assessment.
- **Chapter 8** presents the policy roadmap and action plan, including priority actions, governance considerations, and implementation timelines.
- **Chapter 9** concludes the report by synthesising key messages and outlining implications for European policy and practice.

3 ROADMAP'S OBJECTIVES

The complexity of urban sustainability challenges has amplified the need for robust and transparent, grounded assessment tools capable of informing policy and guiding decision-making. While such tools offer significant potential to support evidence-based governance, their effectiveness depends not only on methodological soundness but also on their alignment with institutional frameworks, regulatory requirements, and practical implementation pathways. A policy roadmap provides a strategic framework that connects the technical architecture of an assessment tool with the broader policy environment in which it is expected to operate. The purpose of the Positive Energy Districts Readiness Assessment (RA) roadmap is to provide a strategic, actionable plan outlining how a harmonised PED assessment tool can be achieved. As mentioned in *D2.2. Understanding the PED Readiness Assessment framework*, PED RA should provide standardised performance analysis to facilitate PED monitoring, comparison, and replication across different cities and contexts.

In addition, the roadmap identifies priority actions and outlines opportunities for synergies with existing European and international initiatives. It contributes to a coherent policy landscape that accelerates the uptake of PEDs as key enablers of Europe's climate-neutral and inclusive urban future. The roadmap serves as a policy-support instrument to coordinate European action, ensuring that the PED RA framework is embedded within the wider EU climate and energy policy landscape. By establishing common concepts, indicators, and assessment procedures, it aims to mitigate the risk of methodological fragmentation and provide a clear strategic direction for the implementation and monitoring of PEDs. Ultimately, the policy roadmap serves as a bridge between innovation and implementation. It enables policymakers, practitioners, and researchers to collectively advance the maturation, adoption, and mainstreaming of the assessment tool, thereby enhancing its relevance and impact within ongoing transitions toward climate-neutral and resilient urban systems.

3.1 Background

In Europe, approximately 75% of the population resides in urban areas, making them significant contributors to the EU's overall energy consumption. According to the European Energy Association (EEA) buildings are responsible for 35% of annual greenhouse gas emissions (GHG) and 42% of the EU's annual energy consumption [12] , over 77% of which is used for space heating and cooling [13]. These figures highlight the urgent need for a deep transition of not only the individual buildings but also systemic transformation of urban energy systems and infrastructure. According to DUT PED Framework 3.0, PEDs can be defined as *"**energy-efficient and energy-flexible urban neighbourhoods or areas of connected buildings and facilities, that produce local renewable energy, achieve net zero greenhouse gas emissions, and actively contribute to overall climate neutrality**."* [11]. PEDs shift the focus from individual "net-zero buildings" to a systemic neighbourhood level, where interactions among many buildings, shared infrastructure, local renewables, and energy-system flexibility can result in more efficient energy use and enhanced utilisation of renewable energy sources, leading to significant reductions in GHG emissions compared to renovation of single buildings.

The concept of PEDs emerged in Europe in the mid-2010s as part of a broader shift from building-level energy performance toward **district-scale, system-integrated decarbonisation strategies.** The formalisation of the PED concept occurred around 2017–2018 within the Joint Programming Initiative Urban Europe (JPI Urban Europe) and the European Commission's emerging Climate-Neutral and Smart Cities Mission. In 2018, the SET-Plan Action 3.2 working group defined PEDs, which anchored PEDs as a policy-enabling concept intended to help European cities meet climate goals by turning districts into local energy ecosystems. Europe aims to be a global role model in energy transition and in reducing its carbon footprint. Cities and the building sector play a decisive role in that process. The Programme "Positive Energy Districts and Neighbourhoods for Sustainable Urban Development" (Set-up in SET Plan Action 3.2 on Smart Cities Implementation Plan) aims to implement 100 Positive Energy Neighbourhoods by 2025 [14].

PEDs deliver a wide range of energy, environmental, economic, and social benefits by transforming urban areas into local, renewable-based energy ecosystems. Several recent scientific papers from 2023 to 2025 have been analysing the impact and benefits of PEDs. Based on different study types, Table 2 identifies the main benefits of PEDs.

Table 2: Benefits of PEDs.

Paper	Ref.	Study type	Main benefits highlighted
Ten questions concerning Positive Energy Districts	[15]	Conceptual review	PEDs as key to urban decarbonisation, integration of renewables, storage and flexibility, plus social inclusion and liveability gains.
Positive energy district stakeholder perceptions and measures for energy vulnerability mitigation	[16]	Survey	Identifies perceived benefits: reduced emissions, energy cost savings, improved quality of life, social inclusion and affordability in planned European PEDs.
Values and implications of building envelope retrofitting for residential Positive Energy Districts	[17]	Techno-economic analysis	Deep retrofits enable lower demand, higher self-sufficiency, and emission cuts, making PED targets technically and economically feasible at district scale.
Renovation assessment of building districts: Case studies and implications to the positive energy districts definition	[18]	Case study	Highlighted that the renovation of the district could allow to significantly improve the performances of the district, thus allowing for a large reduction in overall primary energy consumptions.

Comprehensive Technical Analysis of Retrofitting a Danish Residential Area into a PED	[19]	Case study	Shows retrofitting a district to a PED yields significant energy use reductions, CO_2 cuts, better use of district heating & electricity networks, supporting national climate targets.
Ten questions on tools and methods for Positive Energy Districts	[20]	Methods review	Links tools/methods to sustainability, system flexibility, and efficient planning, arguing PEDs help address "multifaceted urban challenges" when properly evaluated.
Positive Energy Districts: Fundamentals, Assessment Methodologies, Modelling and Research Gaps	[21]	Integrative review	Synthesises fundamentals and stresses PED benefits: urban decarbonisation, system integration, improved stakeholders' engagement and sustainability across pillars.
Transition Approaches towards Positive Energy Districts: A Systematic Review	[22]	Systematic review	Reviews "transition approaches" and concludes PEDs can advance energy transitions and enhance city-level liveability when embedded in urban strategies and roadmaps.
Assessing Multiple Benefits of Housing Regeneration and Smart City Development: The European Project SINFONIA	[23]	Case study	Co-benefits emerging alongside the kWh of energy savings or tons of CO_2 avoided must be clearly identified, discussed, described, measured, and estimated, so as to accurately explain the holistic contribution of the project to the city and involved actors

The main conclusions from these findings are:

- **Multidimensional gains** - not just energy savings, but environmental, economic, and social benefits (reduced emissions, lower energy bills, improved living standards).
- **Leveraging local renewable potential** - district-scale planning improves the ability to harness renewables within urban contexts.
- **Flexibility & resilience** - PEDs integrate generation, storage, demand response, and energy-efficient buildings to create flexible and robust urban energy systems.
- **Support for sustainable business models and energy communities** - by bundling services (energy supply, energy management, e-mobility), PEDs can make distributed energy and renewables economically viable for multiple stakeholders.
- **Facilitating the urban-scale energy transition** - PEDs provide a "meso-scale" (district rather than single building) that helps cities more realistically and effectively implement decarbonisation, aligning with broader climate and policy goals.

3.2 Problem Statement

PEDs become central to the decarbonisation of the built environment, and establishing a consistent and transparent assessment approach is crucial to ensure effective policy implementation and market alignment across Europe and to avoid fragmentation [20]. Although several frameworks and tools for PED assessment exist across international initiatives, such as the IEA EBC Annex 83 definition [9] and from several EU-funded projects, none have been formally endorsed by the European Commission or standardised through bodies such as CEN or ISO. Section 5.1 presents a more detailed analysis of PED assessment approaches, which concludes with the following learnings:

- No legally anchored definition or taxonomy for PEDs currently exists at the EU level. While working definitions have been developed through initiatives such as the SET-Plan Action and IEA Annex 83, these remain non-binding and subject to varying interpretations across countries and projects [24], [25].
- Methodological heterogeneity persists across existing PED assessment approaches. Frameworks differ significantly with respect to scope, system boundaries, performance metrics, and underlying modelling assumptions, creating substantial challenges for comparability, reproducibility, and scalability [21], [26].
- The delineation of spatial and functional boundaries -including electricity and thermal systems, mobility, storage, and user behaviour- remains unevenly defined in practice, undermining the coherence of assessments across Member States [21], [26].
- Implicit assumptions regarding local renewable energy supply, flexibility, digitalisation, and socio-technical factors are seldom made explicit, limiting transparency and evidence-based policy evaluation.

Collectively, these issues limit the capacity to evaluate PED performance consistently, monitor progress towards climate-neutrality objectives, and replicate successful configurations. Without a harmonised readiness-assessment framework, fragmentation across Member States risks impeding the contribution of PEDs to broader EU policy goals on decarbonisation, energy-system integration, and resilient urban transformation.

3.3 Strategic Goals

In line with the PEDvolution project's objectives and the progressive consolidation of the PED Readiness Assessment (PED RA) framework across the project lifecycle, this roadmap defines three core strategic goals. The PED RA framework has evolved from its conceptual foundations developed in WP2, D2.2. [1], through methodological operationalisation in WP4. These updates have strengthened the clarity of assessment dimensions, maturity logic, and governance relevance of the PED RA, while highlighting the need for policy alignment, institutional embedding, and scalability beyond project pilots. Against this background, the strategic goals outlined below translate the PED RA framework into a coherent policy vision that supports harmonisation, adoption, and long-term integration of PED readiness assessment across Europe.

1. *Technical Harmonisation across the EU*

Technical harmonisation refers to the development and application of common technical rules, standards, and procedures that mitigate fragmentation in the assessment of the readiness of PEDs across Europe. Its primary purpose is to ensure consistency, transparency, and comparability in how PED readiness and performance are evaluated across different national, climatic, and institutional contexts. This includes:

- Developing shared definitions, minimum indicator sets, data protocols, assessment procedures, and a digital tool to ensure that PED readiness is assessed using a common methodological baseline.

- Ensuring alignment with key EU instruments such as the Energy Performance of Buildings Directive (EPBD), which has successfully raised building performance standards and stimulated market innovation [11]. The EU policy tools, legal and technical frameworks, such as the Digital Building Logbook (DBL) and the Smart Readiness Indicator (SRI), support enabling technical harmonisation within Europe.

- Benchmarking existing PED assessment approaches across the EU and systematically evaluating KPIs, with the aim of converging towards a unified and coherent assessment methodology within the PEDvolution project.

Together, these elements address current methodological fragmentation and form the foundation for robust, transparent, and comparable PED readiness assessments, enabling learning, replication, and evidence-based decision-making across Europe.

2. *Legal Harmonisation and Policy Alignment*

Legal harmonisation focuses on strengthening coherence between EU-level strategies and national legislation, enabling integration of PED RA into planning, regulatory, and reporting systems. Key objectives include:

- Establishing common rules and certification mechanisms, drawing on successful precedents such as the EPBD, which has improved building performance standards and supported market innovation.

- Ensuring interoperability among local, national, and European governance structures.

- Ensuring policy coherence of the PED RA with major EU strategies and directives, including the European Green Deal, European Climate Law, Fit for 55 Package, Renewable Energy Directive (RED), Energy Efficiency Directive (EED), Renovation Wave, the EU Strategy on Energy System Integration, and the Recast EPBD, as reviewed in Section 7 *European Policy and* .

This alignment ensures a level playing field for stakeholders and supports the mainstreaming of PED concepts into regulatory frameworks.

3. Replicability across Member States

Replicability ensures the transferability of PED assessment practices, tools, and maturity-analysis methods across Europe's diverse urban, climatic, and regulatory contexts. Achieving replicability will:

- Enable the broad deployment of PEDs,
- Foster an internal market, innovation, and new business models for PED-related services and technologies,
- Support scalable and comparable PED development pathways.

Through these three dimensions of harmonisation, the roadmap strengthens interoperability across governance levels and reinforces coherence with major EU energy, climate, and digitalisation initiatives.

4 PED Readiness Assessment methodology

This chapter describes the proposed PED RA Assessment Tool and discusses how it supports the policy strategy roadmap D4.2. It outlines the needs and the methodology from *T4.1 PED Readiness Assessment co-development* and the deliverables. *D4.1. PED readiness assessment methodology and calculation tool,* and *the deliverable D2.2. Understanding the PED Readiness Assessment framework.* This PED Readiness Assessment methodology operationalises as the draft Calculation Tool, which will be finalised after the interventions in *WP9. PEDvolution Demonstration and Performance Assessment* and *D9.1: Demonstrator solution testing*, the three PED demonstrators.

4.1 PED Readiness Assessment Framework's objectives and methodology

The PED Readiness Assessment (PED RA) framework aims to provide a harmonised, transparent, and comparable approach for evaluating the maturity and implementation capacity of Positive Energy Districts (PEDs) across Europe. Building on the foundations established in *Deliverable 4.1 PED readiness assessment methodology and calculation tool,* and the conceptual basis defined in *Deliverable 2.2. Understanding the PED Readiness Assessment framework,* the framework supports cities, policymakers, and stakeholders in assessing performance, identifying gaps, and guiding strategic planning toward climate-neutral urban development.

The objectives of the PED RA framework evolve from the initial work in WP2 (Solution specification and concept design) while aligning with the refined direction of WP4 (PED Readiness Assessment):

- **Harmonisation:** Ensuring consistency among existing EU PED assessment tools, schemes, and frameworks by providing shared definitions, standardised indicators, and coherent assessment procedures.

- **Comparability:** Enabling meaningful benchmarking between PEDs within the same Member State or region, supporting replicability and shared learning.

- **Policy compliance:** Ensuring alignment with EU-level legislation and strategies, including the EPBD, the Renovation Wave, the Energy System Integration Strategy, and climate neutrality objectives.

In line with the definition in the PEDvolution report entitled *D2.2. Understanding the PED Readiness Assessment framework*, the framework provides standardised performance analysis that enables rigorous monitoring of PEDs and ensures their measurable contribution to EU goals on energy efficiency, carbon neutrality, and sustainable urban transformation. Standardised indicators and methodologies enhance comparability across diverse PED contexts -different climates, socio-economic conditions, and urban forms- while improving replicability by allowing lessons learned in one context to guide PED development elsewhere.

The PED RA supports robust policy and investment decision-making by generating evidence on the energy, environmental, economic, and social impacts of PEDs. This evidence helps justify public and private investments, informs urban development policies, and strengthens stakeholder engagement. Social metrics -including behavioural aspects, community satisfaction, and quality of life indicators- ensure that PEDs are not only technically sound but also socially integrated and responsive to local needs.

Finally, the framework promotes continuous improvement. By providing a structured feedback mechanism and consistent monitoring over time, the PED RA encourages adaptation, innovation, and the integration of emerging technologies -ensuring the long-term viability and scalability of PEDs.

Methodology

The PED RA methodology, presented in Figure 1, follows a multi-phase process that starts with a review of existing frameworks and progressively defines the analysis through stakeholder input and synthesis of results. As illustrated, the work began with a desktop research phase that collected and examined KPIs, sustainability criteria, and certification schemes relevant to PEDs. This was followed by stakeholder workshops (both ideation and evaluation), where feedback, needs, and practical insights were incorporated. In the final phase, the findings from all stages were consolidated into clear dimensions and an integrated assessment framework.

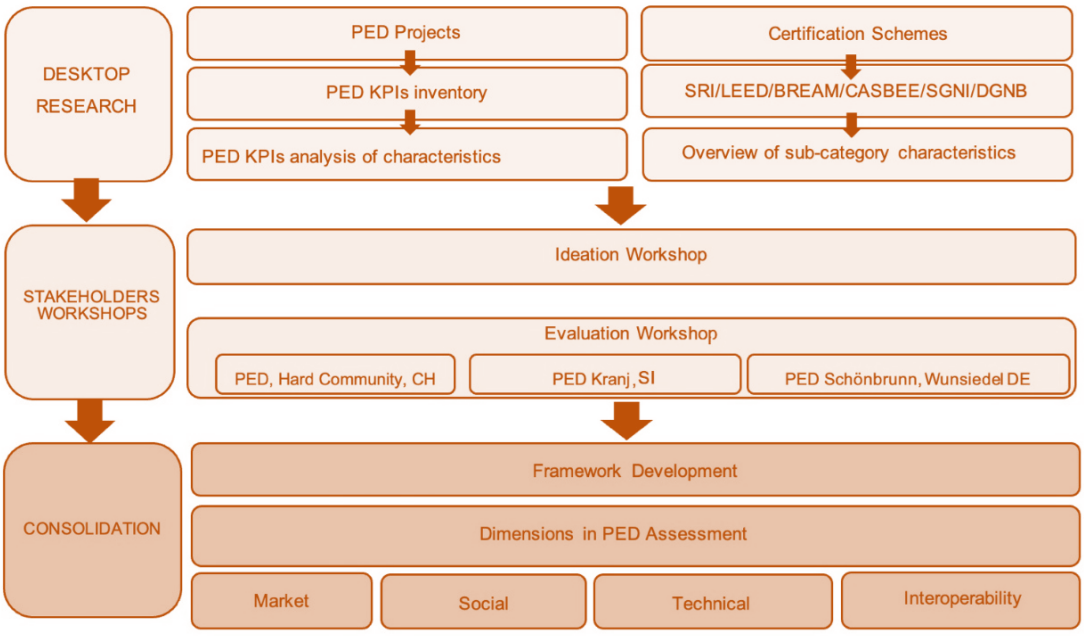

Figure 1: PED RA methodological approach [1].

The PED RA methodology translates these objectives into an operational assessment tool grounded in common indicators, shared data sources, and harmonised evaluation procedures. It incorporates:

- **A structured indicator set** covering PED genotype domains (social, market, technical, and interoperability) and broader performance areas, including energy, environmental impact, mobility, governance, financial viability, and social dimensions.

- **Standardised data sources and protocols** ensuring consistent, transparent, and comparable assessment across sites.

- **Defined target values, weighting systems, and maturity scoring,** enabling both quantitative and qualitative evaluation of PED readiness.

- **Benchmarking mechanisms** aligned with EU climate and energy objectives, and consistent with European and international standardisation frameworks (ISO[27], CEN/CENELEC[28], ETSI[29]).

This methodological structure ensures coherence with EU policy instruments while supporting the broader aims of harmonisation and comparability. The transparent scoring approach allows stakeholders to identify performance gaps, define priorities, and support evidence-based planning.

Overall, the PED RA methodology is designed to be **replicable, scalable, and adaptive**, acting as a decision-support tool for cities, public administrations, PED managers, and industry actors committed to Europe's transition toward climate-neutral, energy-positive urban districts.

5 Background and rationale for establishing a harmonised PED Readiness Assessment framework

5.1 Fragmentation in neighbourhood and PED Assessment Approaches

PEDs are being promoted in Europe as a key instrument for urban decarbonisation. They represent an innovative approach to thinking and designing cities sustainably and holistically. They integrate sectors such as urban planning, energy, and construction to address energy and environmental challenges [30]. Yet no sustainability assessment systems have been developed specifically for PEDs, as they are newly created. As a result, existing districts cannot be systematically compared beyond their basic descriptive characteristics [31].

The landscape of sustainability assessment for districts and Positive Energy Districts (PEDs) encompasses a diverse set of instruments and governance mechanisms, each serving different purposes and levels of formalisation. Understanding the distinctions between assessment tools, national frameworks, certifications, and international standards is essential for selecting the most appropriate approach when evaluating district performance or designing policy-supportive methodologies. While these instruments may overlap in scope and ambition, they differ significantly in their governance structures, enforcement mechanisms, outputs, and degrees of flexibility. Table 3 provides a comparative overview of definitions and assessment tools that clarifies the differences and situates each instrument within the broader ecosystem.

Table 3: Definitions of assessment tools and certifications.

Category	Assessment tools	Certification
Definition	A methodological instrument (software, KPI set, or scoring system) used to measure, evaluate, or model the performance of a neighbourhood, district, or project.	A formal third-party evaluation and label verifying that a project meets a predefined set of criteria.
Purpose	Support quantitative evaluation, modelling, performance benchmarking, and scenario analysis.	Provide market-recognised validation of quality, sustainability, or performance.
Governance	Developed by research institutions, agencies, NGOs, EU projects, or software providers.	Managed by independent certification bodies (e.g., BREEAM, DGNB), often accredited.

Level of enforcement	Voluntary; depends on adoption within projects or research.	Voluntary but often required in procurement or market-driven processes.
Output	Assessment results, dashboards, KPIs, modelling outputs, performance ratings.	Certificate, rating level, audit report.
Validation process	Usually self-assessed or expert-evaluated; no formal external audit required.	Requires third-party auditor verification.
Flexibility	High; tools can be adapted or extended.	Low–medium; strict criteria tied to certification guidelines.
Examples	Siemens City Performance Tool [32], PED KPI sets such as Syn.ikia framework [33], and other tools such as EnergyPLAN [34]	BREEAM Communities [35], LEED for Cities & Communities[36], DGNB Districts[37].

Assessment schemes

The European Union supports a range of initiatives aimed at advancing sustainability across different scales of the built environment and urban systems. Among these, the Smart Cities Information System (SCIS), CIVITAS, and Level(s) play key roles in promoting low-carbon development, resource efficiency, and environmentally responsible practices.

As analysed in *D2.2 Understanding the PED Readiness Assessment framework,* these schemes focus on several domains and scales. Together, these initiatives illustrate the EU's integrated approach to addressing climate and environmental challenges across cities, mobility, and the construction sector. A brief description and comparison of the three PED-related schemes:

- The **Smart Cities Information System** (SCIS) [38] was an EU platform designed to collect, analyse, and disseminate results from smart city and energy-efficiency projects funded under Horizon 2020 and earlier programmes. It focused on sustainable urban energy, mobility, and ICT solutions, providing evidence-based insights and best practices. SCIS supported cities and project developers by offering case studies, monitoring data, and tools to help upscale innovative low-carbon solutions.
- **CIVITAS** is an EU initiative promoting sustainable urban mobility. Since 2002, it has helped cities test and implement cleaner, more efficient transport solutions such as alternative-fuel vehicles, public-transport innovations, mobility management, active travel measures, and low-emission transport planning [39]. It aims to reduce transport-related emissions, improve air quality, and shift mobility habits toward sustainability. CIVITAS operates as a knowledge-sharing network supported by real-world pilot projects.

- **Level(s)** is a voluntary EU sustainable building assessment framework that uses a life-cycle approach to evaluate environmental performance [40]. It focuses on carbon emissions, resource efficiency, circularity, indoor environmental quality, and resilience. Level(s) creates a common language for assessing sustainability in buildings, from design to end of life.

Table 4 provides a comparison of EU-established assessment methodologies.

Table 4: Comparison of EU-established assessment methodologies [1].

Aspect	SCIS Evaluation Methodology	CIVITAS	Level(s)
Goal	Assess and evaluate the performance and impacts of smart city solutions.	To promote sustainable urban mobility and improve transport systems in cities.	Provide a common framework for assessing the environmental performance of buildings in their entire life cycle.
Scope	Focuses on smart city solutions across various domains such as energy efficiency, ICT, transport, and sustainability.	Urban mobility solutions, with focus on clean transport, public transit, walking, and cycling.	Focuses on the environmental performance of buildings, from construction to demolition.
EU Support	Funded and supported by the European Commission.	Funded by the European Commission.	Endorsed by the European Commission.
Target Audience	City authorities, urban planners, and stakeholders involved in smart city development.	Cities, transport authorities, urban mobility planners, and innovators in sustainable transport.	Architects, builders, developers, and building. owners involved in sustainable construction.
Scalability	Promotes replicable solutions across cities.	Encourages scalable transport innovations.	Aims for widespread adoption across buildings.
Methodology	A Standardised framework to evaluate impacts, including performance metrics and impact indicators.	Structured evaluation, with combination of KPIs and stakeholder feedback.	Lifecycle-based evaluation, with set of guidelines and performance indicators.

Categories of indicators	Energy, Environmental, Economic, ICT, Mobility.	Energy, Environmental, Economic, Social, Mobility, Governance.	Environmental, Economic, Social and Adaptability and Resilience.

Certifications

In practice, there are some certification protocols that can represent a valuable starting point for addressing sustainability challenges at the district level. Leadership in Energy and Environmental Design (LEED) [41] for Neighbourhood Development, the Building Research Establishment Environmental Assessment Method (BREEAM) [42] for Communities, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) [43] for cities are the most well-known sustainability protocols for the evaluation of districts. However, these were designed before the PED concept was established and therefore do not explicitly address its distinctive features, even if they are widely used to evaluate districts in general [42]. These certifications often neglect elements like energy surplus, innovative business models, the role of energy communities, and the evaluation of nature-based solutions. Furthermore, Volpatti et al. [31] add that the weighted aggregation and complexity of neighbourhood certification tools make it difficult to interpret what labels and grades actually mean in terms of which sustainability dimensions have been addressed, further complicating comparison between projects.

Ferrante et al [30] further enhances the literature review by adding that PED-oriented frameworks and reviews have underlined the importance of more comprehensive KPI sets. Authors such as Haase & Baer [44] relate the “2000 W Site” and “Zero Emission Neighbourhood” concepts to planetary boundaries and identify key KPIs on construction materials (total and lifecycle GHG emissions, lifecycle neutrality, and circular, Environmental Product Declarations-based material choices) as critical for remaining within climate- and land-use-related limits. Guarino et al. [18] highlight that environmental, social, and economic applications of PED assessment are also highlighted, with particular attention to direct and lifecycle emissions, circular economy strategies, and air-pollution impacts along material supply chains. Embodied emissions are also important to consider in the carbon balances.

Within this landscape, the criteria and indicators used by existing tools are fragmented across scales and schemes. Ferrante et al. show that Neighbourhood Sustainability Assessment tools, when examined through the lens of material-related criteria, tend to focus on reducing the environmental impact of materials in public space design, while the selection of materials at the building scale is effectively delegated to the presence of green-certified buildings, revealing a disconnection between neighbourhood-level and building-level assessments [30].

At the building scale, established Green Building Rating Systems (GBRS) such as LEED [41] and BREEAM [42], together with national schemes like KlimaHaus Nature [45] and overarching reference frameworks like Level(s) [40] and Italian Minimum Environmental Criteria (CAM) [46], provide detailed LCA-based indicators and material-selection requirements (e.g. global warming potential, non-renewable primary energy, durability, sourcing distance, exclusion lists, and third-party eco-labels). They can help reduce

the environmental impact of building interventions, particularly through passive energy efficiency solutions, as well as enhance transparency and traceability of material selection, strengthening social and institutional credibility.

At the same time, a review of LCA methodologies within major European green building rating systems -including schemes such as KlimaHaus Nature alongside other GBRS- reveals substantial differences in how life-cycle assessment is integrated; these differences undermine the comparability of results and are compounded by a lack of standardised data, the complexity of LCA calculations, and the need for specialised training [30]. Moreover, most evaluation tools still concentrate on energy-related aspects, with only a small minority performing a full life-cycle assessment of CO_2-equivalent emissions, and the application of building-scale GBRS at the district level remains limited [30].

However, their systematic application at the district level and their explicit integration into PED certification and benchmarking remain limited [30]. Still, it is advisable for building interventions to follow GBRS criteria in material selection. Certification protocols can play a significant role in energy retrofitting projects by increasing the likelihood of employing sustainable materials. Future PED-specific certification systems should integrate criteria dedicated to material selection.

Even at the core PED level, basic ingredients for consistent assessment are still under discussion. Cellura et al. highlight ongoing debates in the literature around the requirement for a net-positive energy surplus and stress that clear, well-defined district boundaries and a robust quantitative energy balance are essential preconditions for future certification and standardisation of PEDs [47].To coherently channel the positive surplus of PEDs to contribute to sustainability in urban areas, they propose a methodology that links PED energy flows and surplus redistribution to SDG-oriented performance indicators across environmental, economic and social dimensions, thereby extending assessment beyond simple energy balances to consider contributions to SDGs such as affordable and clean energy, sustainable cities, and climate action [47].

5.2 Stakeholder Needs and Perspectives

As the complexity of PED projects grows, managing stakeholders becomes critical. Cheng et al. underline the necessity of systematically mapping stakeholders across different spatial scales (building, district, and city) and across project phases, to account for the shifting roles and levels of influence of various actors [48]. Recent studies emphasise that the social dimension (governance, participation, inclusion) must be treated as a core component - not as an afterthought - alongside technical, economic, and environmental aspects of PEDs [21].

Dourlens-Quaranta et. al. represented the stakeholder ecosystem for PEDs (Figure 2), which is made of four layers regarding the stakeholders active or present in the district, plus some stakeholders not necessarily present or active within the district’s boundaries [49].

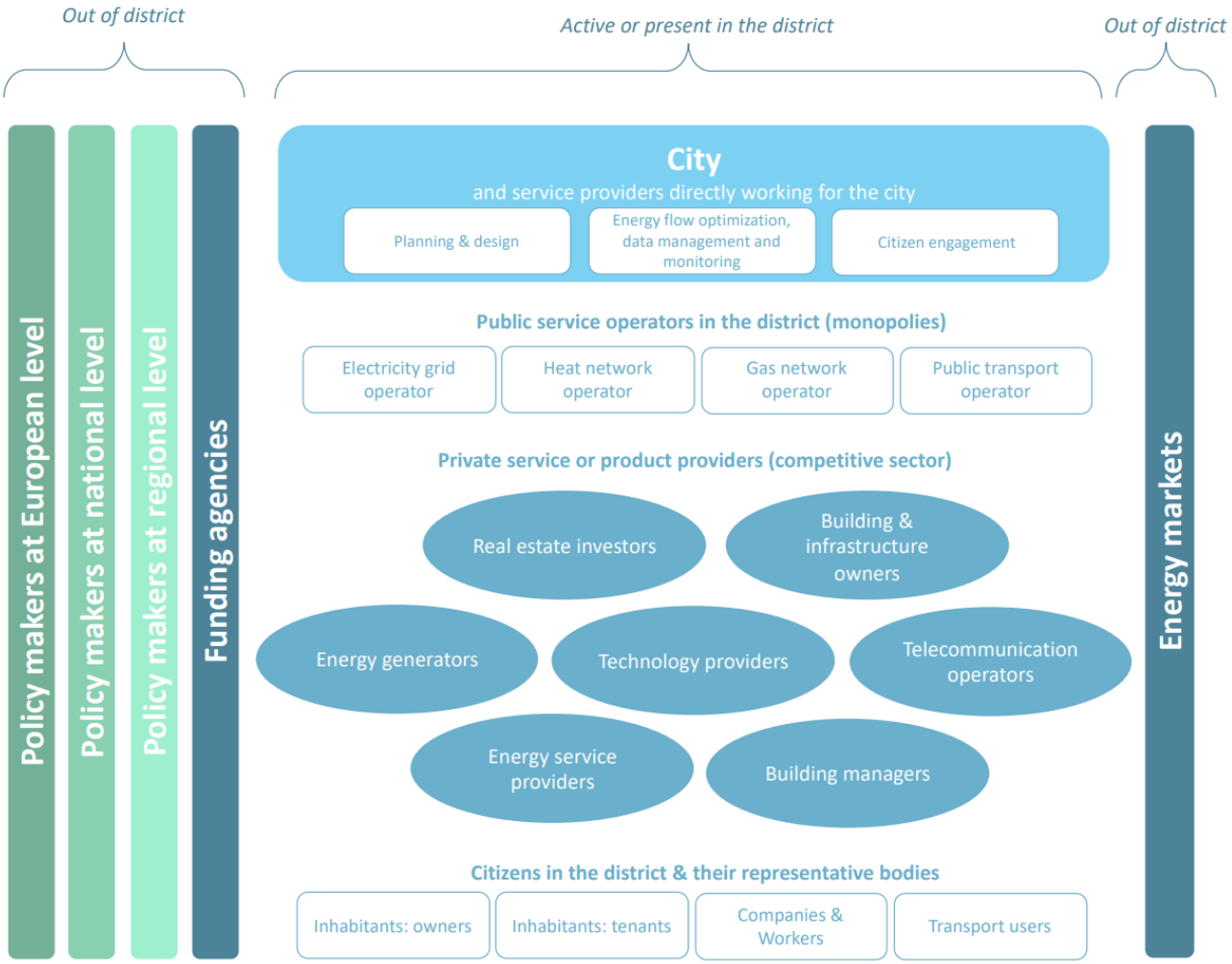

Figure 2: Stakeholder mapping in PEDs [49].

Stakeholders active or present in the district are:

- Layer 1: The city itself is represented at the top of the mapping, as the main body in decision-making and implementation processes of PEDs.
- Layer 2: Public service operators are key players in PEDs. Not necessarily all of them are involved: their participation depends on the technological choices and available energy sources within the PED
- Layer 3: The following service or product providers, in general from the private sector, have a strong role in PED; Real estate investors, Building and infrastructure owners, Building and infrastructure managers, Energy service providers, Energy generators, Technology providers, Telecommunication operators.
- Layer 4: Citizens, either individually or through representative bodies, are players in the PED, being either active or passive.

Stakeholders not necessarily present in the district are:

- Policy makers at European, national, and regional levels: Those policy makers, above the level of the city, might be involved in regulatory or economic incentives for PEDs.
- Funding agencies: They might be involved in finance services for the development of PEDs.
- Energy markets: PEDs generate energy surpluses that can be traded either within the district or exported beyond its boundaries through organised markets (e.g., power exchanges) or bilateral contracts with external stakeholders.

Understanding the differentiated needs of stakeholders is fundamental to the effective planning, implementation, and long-term governance of PEDs. PEDs embody a complex socio-technical transition in which public authorities, utility operators, private-sector actors, civil society, and higher-level policy and financing bodies must coordinate across interdependent energy, mobility, digital, and built-environment systems. As recent literature emphasises, the success of PED initiatives depends not only on technological innovation but also on the capacity of diverse stakeholders to collaborate, align incentives, and navigate regulatory, financial, and social constraints. Table 5 synthesises the latest evidence on the specific needs of each stakeholder category, offering a structured basis for understanding their roles, expectations, and potential contributions within PED development pathways.

Table 5: Main needs for PED stakeholders. (Needs highlighted in bold indicate priority issues with high relevance for policy intervention and cross-stakeholder impact, while non-bold items represent supporting or context-specific requirements).

Stakeholder Category	Key Needs
Layer 1– City (*Municipal government, urban authorities)* **[22], [50], [51]**	• Clear regulatory frameworks enabling PED implementation (zoning, energy regulations, building codes). • **Integrated planning tools supporting cross-sectoral coordination (energy, mobility, buildings, digital infrastructure).** • Mechanisms to align long-term climate-neutrality strategies with district-level interventions. • Access to reliable data for decision-making and monitoring. • Stakeholder coordination platforms to manage public–private–citizen collaboration. • Capacity-building for city staff on systemic energy planning and innovation procurement.
Layer 2 – Public service operators *(transport, water, waste, district heating/cooling, grid operators)* **[51], [52]**	• **Stable regulatory conditions for integrating renewable and distributed energy resources.** • Interoperable ICT systems enabling real-time data exchange for grid balancing and energy optimisation. • Investment certainty for upgrading existing infrastructure (e.g., district heating networks, flexibility services). • Clear delineation of responsibilities regarding energy flows, data governance, and maintenance.

	• Access to risk-sharing mechanisms for innovative PED technologies.
Layer 3 – Private-sector service and product providers *(real estate investors, owners, managers, energy service providers, generators, technology providers, telecom operators)* **[50], [53], [54]**	• Predictable return-on-investment conditions for PED-aligned developments • Clear business models for flexibility services, energy communities, and prosumer arrangements. • Market incentives for high-performance buildings and smart technologies. • **Access to standardised procurement procedures for PED solutions.** • Regulatory clarity on data ownership, cybersecurity, and interoperability standards. • Ability to collaborate early in planning to minimise transaction costs and reduce design uncertainties.
Layer 4 – Citizens *(individuals, communities, association)* **[54], [55], [56]**	• **Transparent information on benefits, costs, and behavioural expectations related to PED participation.** • Opportunities to co-design energy and mobility solutions (participatory governance). • Fair distribution of costs and benefits, avoiding energy poverty. • Protection of privacy, autonomy, and data security. • Access to digital literacy resources that enable active engagement in smart systems. • Trust in institutions and technology providers.
Policy makers (EU, national, regional) **[22], [24], [51]**	• **Evidence-based insights to inform regulatory reforms supporting PED scaling** (energy communities, grid flexibility markets, construction standards). • Alignment of multi-level governance frameworks to avoid regulatory overlaps and contradictions. • **Monitoring tools to track PED contributions to national and European climate targets**. • Input from local authorities and stakeholders to craft realistic policy instruments. • **Mechanisms to harmonise financing schemes and accelerate innovation uptake.**
Funding agencies *(public and private, including development banks, green investors, EU programmes)* **[22], [51], [52]**	• Clear risk assessments and bankable project structures for PED investments. • **Standardised frameworks for evaluating long-term energy, environmental and social returns.** • Transparent governance structures within PED projects to ensure accountability. • Stable regulatory environments that reduce financial uncertainty. • **Demonstrated replicability and scalability of PED models.**

Taken together, these differentiated stakeholder needs illustrate the inherently multi-actor and multi-scalar character of PED development, underscoring that technical performance alone cannot secure successful district-level energy transitions. Instead, coherent governance arrangements, transparent collaboration mechanisms, and supportive regulatory and financial environments must be established to align the diverse interests, capacities, and constraints of the actors involved. By clarifying these needs, the analysis provides a foundation for designing more effective engagement strategies, reducing implementation risks, and fostering the institutional learning required for PEDs to move from isolated demonstrations to **scalable, replicable components of climate-neutral urban development.**

5.3 Exploiting the Benefits of a European Harmonised Framework

Harmonisation enables secondary benefits within the EU ecosystem:

- **Comparability and Benchmarking:** The roadmap further seeks to enable comparability by establishing transparent benchmarking approaches and facilitating knowledge exchange among PED demonstrators across Europe. The identification of core indicators, assessment domains, and consistent data-collection protocols is critical to ensuring that PED performance can be evaluated systematically across projects. Comparable assessment outcomes will support cross-border policy learning, strengthen investor confidence, and enable evidence-based monitoring and evaluation of PED uptake.
- **Maturity Assessment:** The roadmap also serves as a structured maturity-assessment process for evaluating the readiness of districts to become PEDs. This process supports continuous performance monitoring across the planning, implementation, and operational phases. It enables stakeholders -including planners, energy engineers, architects, utilities, community groups, and public administrations- to identify technical, institutional, financial, and governance readiness levels. This approach aims to accelerate PED implementation, highlight structural barriers, and support the replication of successful practices across Member States, which can be operationalised through a dynamic decision-support tool and offered as an open, replicable methodology.
- **Role in multi-level Governance and a strategic planning tool:** Local authorities are critical actors in the operationalisation of PED frameworks. They play a central role in embedding PED principles in spatial planning, facilitating citizen engagement, and integrating decentralised energy systems into urban development strategies. The roadmap emphasises the need for capacity-building and empowerment of municipalities within a coherent multi-level governance architecture, ensuring that EU- and national-level ambitions translate into effective local implementation. Local authorities act as enablers of local energy transition by embedding PED principles into urban planning standards, establishing local one-stop shops, and fostering community engagement in the shift toward decentralised, green energy systems [11].

In summary, the roadmap articulates a clear and actionable policy pathway towards a technical and legally harmonised and scalable PED readiness-assessment framework in Europe. It identifies priority actions for the European Commission, Member States, and local authorities; enhances coherence

across existing initiatives; and supports the acceleration of PED deployment as a core component of Europe’s transition to a climate-neutral, resilient, and inclusive urban future.

6 Synergies with International and EU initiatives

The PED Readiness Assessment (PED RA) Policy Roadmap identifies priority areas for strategic alignment with key European and international initiatives that contribute to the PED RA framework. Establishing these synergies ensures that the PED RA framework builds upon existing scientific, regulatory, and technical foundations, thereby enhancing its legitimacy, applicability, and integration within the wider EU policy landscape. The roadmap builds on the DUT Partnership, PED Framework 3.0. Several initiatives provide critical knowledge, methods, and tools that complement the PED RA framework:

- **Smart Readiness Indicator (SRI)** [7]**:** Is a European Commission's initiative to asses building's ability to use smart technologies. It provides insights into a building's smartness, which then can be leveraged during the planning phase of PED. The SRI's implementation process - characterised by, phased testing and coordinated expert participation across Member States- serves as an instructive example for advancing harmonisation of the PED Readiness Assessment methodology.

- **Digital Building Logbook (DBL) technical study** [8]:The DBL technical framework report provides a European-level standardised framework for DBLs on building data collection and interoperability. Alignment with DBL principles strengthens the data foundations of PED assessment -facilitating consistent data exchange, enhancing transparency, and enabling cross-scale integration between building and district performance records.

- **IEA EBC Annex 83 PED Framework** [9]**:** This working group provides a scientifically grounded international definition and definition of key characteristics, system boundaries, performance domains, indicators, and assessment methodologies for PEDs, supporting policy harmonisation and evidence-based standardisation across Europe. By integrating insights from Annex 83, the roadmap anchors its methodological choices in peer-reviewed international research, ensuring conceptual robustness and alignment with global scientific consensus.

- **COST Action PED-EU-NET** [10]**:** This network provides a collective database of the PEDs within Europe and establishes a European research and policy network that fosters knowledge exchange, methodological alignment, and policy dialogue to accelerate the mainstreaming of PEDs in urban development strategies. Synergies with PED-EU-NET ensure that the PED RA framework incorporates diverse European perspectives and benefits from collective learning, shared case studies, and harmonised terminologies.

- **Concerted Action EPBD (CA-EPBD)** [57]**:** The CA-EPBD facilitates coordinated national implementation of the EPBD. Engagement with CA-EPBD processes provides an opportunity to explore how PED-related concepts could be embedded into Member States' building and renovation policies, supporting long-term legal and regulatory harmonisation.

- **Syn.ikia's Evaluation Framework for Sustainable Plus Energy Neighbourhood** [33]This framework defines the key performance indicators (KPIs) for evaluations of sustainable plus energy neighbourhoods (SPEN) on the neighbourhood and building level. The assessment covers the whole neighbourhood, considering interaction between buildings. Incorporating relevant elements from this framework provides methodological complementarity, particularly regarding KPIs on energy balance, environmental performance, and social sustainability.

- **Making-City PED Readiness Indicator Tool (PEDTool)** [58]**:** This tool offers a practical, only city-level self-assessment instrument to evaluate PED readiness and identify gaps in governance, finance, and technical capacity, thus guiding local policy planning and implementation. Aligning the PED RA framework with this instrument helps ensure that readiness assessment accounts for institutional and organisational dimensions critical to PED implementation.

Together, these initiatives provide essential scientific, regulatory, and technical inputs. By positioning the PED RA framework in close alignment with them, the roadmap ensures complementarity, avoids redundancy, and strengthens the integration of PED assessment within the broader European policy architecture for climate-neutral and energy-efficient urban development. These will be discussed in more detail in the following sections.

6.1 Smart readiness indicator (SRI)

The Smart Readiness Indicator (SRI) is currently in a phase of voluntary testing and preparation for potential future mandatory implementation within the European Union.

Status of Legal Scheme and Policy Act

- **Optional Scheme (Currently):** The SRI, as outlined in the 2024 recast of the Energy Performance of Buildings Directive (EPBD) (Directive (EU) 2024/1275), remains an optional scheme. Member States have the freedom to decide whether to test and/or implement it nationally.

- **Future Mandatory Potential:** The EPBD requires the European Commission (EC) to submit a report by June 30, 2026, on the testing and implementation status. Based on that report, the EC must then adopt a delegated act by June 30, 2027, requiring the application of the SRI to non-residential buildings with an effective rated output for HVAC systems over 290 kW. This indicates a clear path toward a mandatory, albeit limited, scope in the near future.

- **Legal Acts in Place:** The methodology is defined by the Commission Delegated Regulation (EU) 2020/2155 and the technical modalities for implementation are set by the Commission Implementing Regulation (EU) 2020/2156.

Status of Implementation and Testing

The focus across the EU is currently on national test phases to refine the methodology and prepare for market adoption.

- **Active Testing:** The SRI is currently being officially tested in at least 16 EU countries, including Austria, Belgium (Flanders), Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Poland, Portugal, Slovenia, and Spain.

- **Support Projects:** The testing is heavily supported by EU-funded LIFE Clean Energy Transition projects (like SRI2MARKET, easySRI, Smart2, and SRI-ENACT), which develop and provide practical tools, e-learning platforms, and technical assistance to Member States and assessors.

- **National Objectives:** Each national test phase has a specific focus, such as:

    - Training requirements for SRI assessors (e.g., Belgium/Flanders).

    - Integration with existing Energy Performance Certificate (EPC) schemes (e.g., Italy).

    - Benchmarking the methodology against other national methods (e.g., Austria).

The Key Functionalities assessed by the SRI

It is not envisioned that the SRI can be used in the same way as the PED RA, as it is not meant to measure performance. Instead, the SRI rates a building's "smart readiness" based on its ability to use smart-ready technologies, and it can be expressed either as an overall score or as a score for each of the key functionalities.

The methodology is based on modular multi-criteria assessment of the smart ready services present in a building, and it is structured amongst nine technical domains (e.g. heating, cooling), seven impact criteria (e.g. energy efficiency), and three key functionalities (optimising energy efficiency, adapting to the needs of the occupant, and adapting to the signals from the grid).

6.2 Digital Building Logbook

The Digital Building Logbook (DBL) is currently in a critical phase of implementation and standardisation across the European Union, moving from a policy concept to a forthcoming requirement. The DBL is no longer a concept, but an emerging legal requirement that is actively being defined, standardized, and piloted across Europe to digitally transform the building sector.

Policy and Legal Status (European Union)

- **Mandate in the EPBD Recast:** The DBL has been formally included in the revised Energy Performance of Buildings Directive (EPBD) (Directive (EU) 2024/1275). This mandates that EU Member States establish a framework for a DBL, making it a key legislative tool for achieving the EU's climate and renovation goals.

- **Purpose:** The DBL is defined as a common repository for all relevant building data throughout its lifecycle -from construction and renovation to operation and demolition. It's intended to increase transparency, facilitate informed decision-making, and boost renovation rates.

- **Interoperability Requirement:** The DBL must be interoperable and integrated with other EU tools, such as the Energy Performance Certificates (EPCs), the Building Renovation Passports, and the Smart Readiness Indicator (SRI).

Framework and Standardisation

- **EU Framework Developed:** The European Commission has commissioned and published a comprehensive Technical Study and Guidelines for developing an EU framework for DBLs (finalized around 2023). This provides Member States with a reference model for data collection, management, and exchange.

- **Focus on Harmonisation:** The goal is a network of interoperable national DBL platforms connected via a European portal. Standardisation bodies (like CEN/TC 350 Sustainability of construction works[59]) are actively working on developing standardized approaches to ensure consistency and avoid market fragmentation.

- **Key Data Focus:** The DBL is designed to consolidate data related to:

    - Energy performance and consumption.

    - Renovation history and potential.

    - Material composition for circular economy/recycling (Resource Passports).

    - Environmental data (Whole Life Carbon emissions).

Implementation and Challenges

- **Varying National Roll-out:** While the EU has set the legal framework, implementation is left to Member States in their transposition of the EPBD. Some countries (like France and Belgium) have existing "Building Passport" or logbook-like initiatives, while others are still defining their approach.

- **Main Barriers:** The primary challenges facing widespread implementation are:

    - Lack of Data Standardisation: Inconsistent data models across national and regional initiatives make harmonisation difficult.

    - Data Quality and Scarcity: Collecting high-quality, continuous data, especially for existing buildings, is complex.

- Legal and Trust Issues: Questions around data ownership, access rights (e.g., in line with GDPR), and the trustworthiness of the data must be resolved.

- Integration with Existing Systems: Ensuring seamless connection between the DBL and existing public registers (like cadasters and permitting systems) and private industry tools is a major technical hurdle.

6.3 IEA Annex 83

The concept of Positive Energy Districts (PEDs), initiated in 2019 under the special focus of SET Plan 3.2, represents a critical shift in urban planning. The core principle of a PED is to establish a defined urban area capable of generating more energy than it consumes annually.

A PED's ambition goes beyond a simple annual energy surplus. It must also be agile and flexible to manage energy market fluctuations and, crucially, minimise its impact on the centralized energy networks. This is achieved by:

- **Maximizing Onsite Management:** Increasing onsite load-matching and self-consumption.
- **Integrating Storage:** Utilizing short- and long-term storage technologies.
- **Smart Control:** Providing energy flexibility through smart control systems.

PEDs are designed to include all building types within city boundaries and remain connected to the energy grid, positioning them as a rising concept to shape future carbon-neutral communities.

The transition to carbon-neutral urban energy infrastructure inherently involves a multisectoral dimension. This requires the synchronized development of:

1. **Instrumental Technologies:** New technical solutions.
2. **Public Perception:** Acceptance of new building energy technologies.
3. **New Economic Paradigm and Business Models:** Tailored financial approaches.

Cities play a unique and vital role as hosts, facilitators, and incubators of these new technologies and solutions. This is essential for co-creating all-inclusive, citizen-centric, carbon-free energy packages.

Global policy mandates reinforce the necessity of PEDs:

- **Climate Agreements:** The 2015 Paris Agreement emphasizes reducing GHG emissions, where urban areas -responsible for 70% of global emissions- are key players.

- **UN SDGs:** The UN Sustainable Development Goals (SDGs) include sustainable cities and communities, directly supporting the transition to low-carbon urban environments.

- **European Commission (EC):** The EC has proposed regulatory conditions to support the integration of PEDs into a tangible urban concept by 2050.

The international research community is tasked with leading this domain by defining future research streams for PED development and providing accurate information to support decision-making, particularly when faced with potential conflicting policy goals. The Annex 83 is in the reporting phase. The outcome is published in dedicated deliverables. In addition, a PED book is in the publication process.

Guidelines summary

PEDs are a crucial concept in the transition towards sustainable urban energy systems, representing a shift from individual building-centric approaches to a district-scale perspective for integrated, efficient, and sustainable urban development. Positive Energy Districts (PEDs) are a strategic and essential concept for developing sustainable urban energy systems. They mark a transition from focusing solely on individual buildings to adopting an integrated, district-scale approach for greater efficiency and sustainability in urban environments.

The European Commission (EC) has designated PEDs as a priority, supporting their development through funding pilot projects via initiatives like Horizon 2020. The concept builds upon earlier models, such as Net Zero Energy Districts (NZEDs), by prioritizing the systemic integration of renewable energy sources, smart grid technologies, and local energy sharing mechanisms across an entire urban area.

While a single, universally accepted definition for Positive Energy Districts (PEDs) is still lacking, leading to difficulties in comparing projects, various organisations agree on several core attributes:

- **Net-Positive Energy Balance:** A fundamental requirement is achieving a positive annual energy balance by maximizing local renewable energy production and efficiency, typically measured as a net surplus of renewable energy exports over energy imports.

- **Net-Zero Emissions:** PEDs are consistently defined as working towards or achieving net-zero greenhouse gas (GHG) emissions annually.

- **Integration and Flexibility:** Key definitions emphasize that PEDs are energy-efficient and flexible urban areas that strategically integrate energy, mobility, and Information and Communication Technology (ICT).

- **Systemic Management:** PEDs involve multiple buildings that actively manage energy usage and regulate energy exchanges to maintain the positive balance, often integrating with and managing energy flows within the broader regional energy system.

In essence, different definitions focus on the same goal: creating an integrated, efficient, and emissions-free urban area that generates more renewable energy than it consumes over the course of a year.

Key topics that were covered in the Deliverable STD[2] of the IEA Annex 83 include:

1. **Definitions and Frameworks**: PEDs are defined within the context of sustainable urban energy transitions, emphasizing their role in achieving net zero energy imports and CO_2 emissions. Frameworks for holistic energy planning and the systemic integration of renewable energy, smart grids, and energy-sharing mechanisms are discussed.

2. **Energy Balance Methodologies**: Several calculation methods and tools are provided to assess energy production, demand, and balance at the district level. These include dynamic modeling approaches, GIS-based tools, and standardized frameworks like ISO 52000-1.

3. **Technological Solutions**: The document explores energy efficiency technologies, renewable energy production systems, energy flexibility tools, and the integration of ICT solutions, e-mobility, and smart infrastructure. Emphasis is placed on optimised integrated designs and advanced energy systems.

4. **Monitoring and Evaluation**: A systematic approach to monitoring, assessment, certification, and evaluation is outlined, including the use of Key Performance Indicators (KPIs). The importance of data collection, visualisation, and governance frameworks is emphasised.

5. **Social Aspects**: The transformation to PEDs requires stakeholder engagement and inclusive planning. Strategies like urban living labs, co-creation platforms, and justice assessments ensure citizen participation and equitable energy access.

6. **Financial and Business Models**: Financing strategies for PEDs include public-private partnerships, risk mitigation measures and regulatory support. The document highlights innovative funding mechanisms and streamlines regulatory frameworks to overcome financial barriers.

7. **Urban Planning and Integration**: PEDs must be embedded into urban master plans for effective spatial integration. Land use evaluations, regulatory alignment and synergy between energy and urban planning are essential for successful implementation.

8. **Governance and Legal Aspects**: Collaborative governance models, policy frameworks, and systems thinking approaches are critical for overcoming institutional silos and regulatory

[2] The standard deliverable of IEA Annex 83 is still under review and is therefore not yet available for formal referencing.

barriers. Multi-stakeholder coordination and quadruple helix models are recommended to align PEDs with broader urban strategies.

9. **Implementation Processes**: Structured methodologies like the Smart City Guidance Package (SCGP) and PED-LAB model are proposed, focusing on adaptive, step-by-step approaches for PED deployment. Feedback loops and stakeholder-driven processes ensure continuous improvement.

10. **Alignment with Urban Sustainability Initiatives**: PEDs are positioned as integral elements of climate-neutral and smart cities, aligning with initiatives like the European Climate Neutral Cities program, Nearly Zero-Energy Buildings (NZEBs), Nature-Based Solutions (NBS), New European Bauhaus (NEB) and others. Their contribution to achieving EU climate goals is highlighted.

PED Database

The PED EU-NET Database [60] is a joint effort of COST Action 'PED-EU-NET', IEA EBC Annex 83, and JPI Urban Europe (i.e. DUT Partnership) to provide a wealth of information about new and refurbished urban environments aiming to produce more energy than they consume. Civiero et al. [61] reports the realisation of the PED-EU NET Database framework and its online implementation in the form of a web interoperable platform, which has been designed in a modular way, allowing the division of the general survey into smaller and independent sections that facilitate data entry and subsequent processing. The internal peer-review process for the data entry through the editors assures that the data in the database is sourced from reliable and verified information, ensuring its accuracy and reliability.

The development process moves through a database development life cycle (DDLC), starting with the scoping phase of establishing requirements expressed as a statement of requirements, with the aim of creating a framework for data collection from demo cases.

Finally, a testing phase has been initiated, and from this first analysis, it became clear that there is no one-fits-all solution for PED implementation. Overall, PED framework definitions require further detailing in the local context. The database provides an overview of not only different implementation strategies, but also existing different conceptualisations and approaches for the PED concept.

Thanks to contributions, all inputs are collected in the PED-EU NET Database, and the users of the platform can visualise and compare different scenarios of PEDs by customizing their selection. Before exporting, it can be displayed in the user-friendly frontend of the database that covers each KPI resulting from the gathered information by DB editors. Then, the selected comparison can be saved as an output file and can be exported as a .csv format file. In this way, users of the tool can select and work on the information that best meets their expectations and goals, and then build their own further storytelling.

6.4 Cost Action PED-EU-NET

The Cost Action was running from April 2021 until March 2025. In the Cost Action PED-EU-NET deliverable 3.3 "Report on PED Labs characterisation and KPIs," the authors state that Positive Energy

Districts (PEDs) are recognised as a promising approach to achieving energy efficiency and reducing the negative environmental impact of climate change through the surplus of local renewable energy generation. PED Labs, as have been defined by JPI UE in the SET-Plan ACTION n°3.2 Implementation Plan, can serve as «*seeding ground for new ideas, solutions and services, will be developed according to place- based needs and local context baselines. PED Labs will follow an integrative approach including technology, spatial, regulatory, financial, legal, social and economic perspectives*».

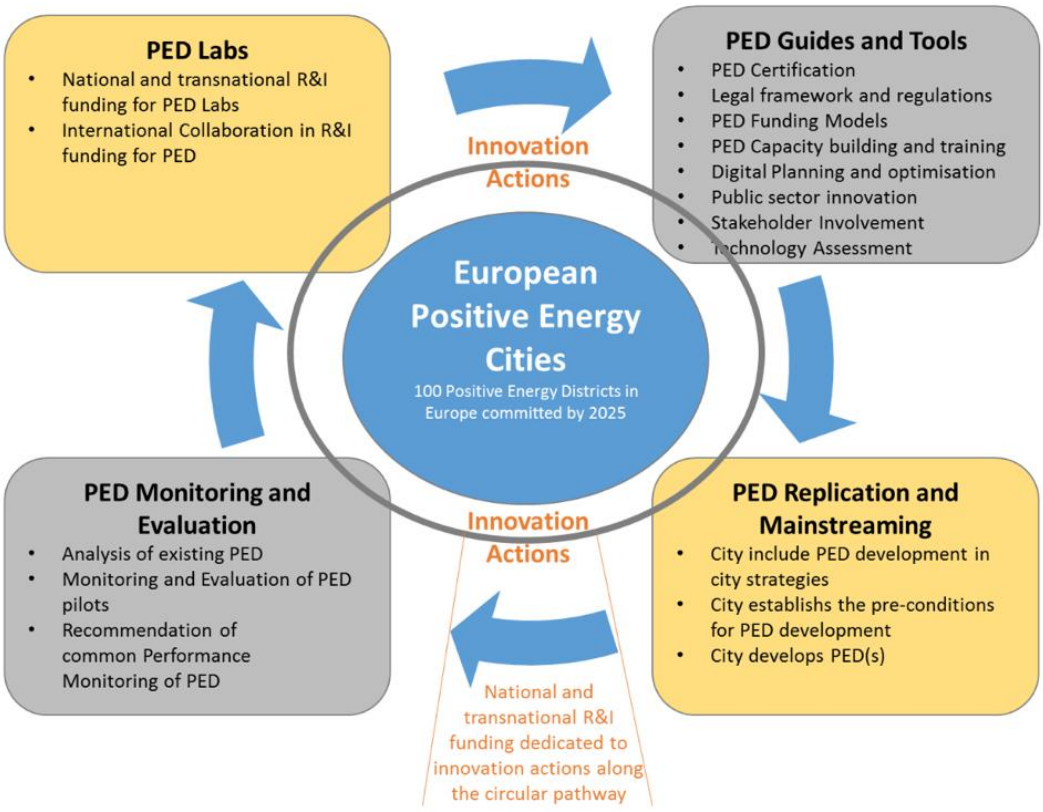

Figure 3: Pathways to Positive Energy Districts in Europe. Source: SET-Plan ACTION n°3.2 [24].

As part of this effort, report D3.3 of Cost Action PED-EU-NET [10] aimed to consolidate the PED Labs definition based on analysis of implemented cases, by identifying the aspects (technical, social, financial, regulatory) and how they influence both implementation and evaluation.

The report presents the analysis of PED Labs and provides guidance on their design and implementation from technological, social, financial, and regulatory perspectives. Leveraging this experience and the involvement in the Action aimed at answering the following research questions:

- Which KPIs are the most relevant for PED Labs implementation?
- How can those aspects be organised to address the appropriate scale and stakeholders?
- Which lessons learned can support the PED Lab implementation, particularly considering existing districts?

The PED Labs provide an opportunity to find ways to address the inherent complexity of the implementation and learn how to overcome the challenges. As part of this effort, this report, D3.3 of Cost Action PED-EU-NET, summarises the existing PED Labs and provides the key success factors for implementation of PED Labs, presents the analysis of PED Labs, and provides guidance on their design and implementation from technological, social, financial, and regulatory perspectives. The authors aimed at answering these three research questions to define the methodology by leveraging this experience and the involvement in the Cost Action PED-EU-NET:

- Review of KPIs for PED Labs and identified the most relevant for PED Labs implementation. As part of this effort, this work summarises the existing PED Labs and provides the key success factors for the implementation of PED Labs.
- Analysis showed that PED Labs provide an opportunity to find ways to address the inherent complexity of the implementation and learn how to overcome the challenges and how those aspects should be organised to address the appropriate scale and stakeholders.
- The lessons learned resulted in some guidelines for PED Labs that show how to support the PED Lab implementation.

They conclude that "*by implementing these PED Lab guidelines within PED Lab framework which provides a relation between the 4 key aspects (Technical, Financial, Regulatory, Social) of PED Labs along the 3 dimensions (stakeholders, scale, lifecycle stages), we can create a more supportive policy and regulatory environment for PED Labs, enabling their widespread adoption and contribution to a sustainable energy future*."

6.5 Concerted Actions EPBD

Full neighbourhood-scale PED assessment goes beyond the current EPB scope. It must recognise multiple owners, public streets, thermal networks, storage, market arrangements, or energy sharing, additional urban-planning, regulatory, financial, and social considerations that are not yet comprehensively covered by the EPBD/EPB framework.

While the assessment in the EPBD focuses on a single building, there is a shift towards a group of buildings (e.g. a block) envisioned. In this context, ISO 52000-1 allows connected buildings on a single site to be assessed together, defining boundaries and interactions for shared systems and delivered energy carriers.

Scaling up Positive Energy District (PED) developments in line with the national implementation of the Energy Performance of Buildings Directive (EPBD) requires strategic alignment across four key domains: Regulatory Framework, Data and Digitalisation, Financial Incentives, and Capacity Building.

Regulatory Alignment and Mandates

National EPBD implementation provides the necessary legislative muscle to transition PEDs from pilot projects to standard practice. Table 6 sums up the role of Minimum Energy Performance Standards

(MEPS), Building Renovation Passport (BRP), Digital Building Logbook (DBL), Smart Readiness Indicator (SRI) in the PED scaling strategy and its benefits for PEDs.

Table 6: PED scaling strategies in relation to EPBD.

EPBD Component	PED Scaling Strategy	Benefit for PEDs
Minimum Energy Performance Standards (MEPS)	Integrate MEPS at the district level, not just the building level. Mandate a collective energy balance across a defined urban area.	Ensures that deep renovations are standard within the district, forming the foundation for energy surplus.
Building Renovation Passport (BRP)	Mandate the BRP to include a "District Renovation Roadmap" component, detailing the building's role in achieving the PED's overall energy goals.	Provides a long-term, coordinated renovation schedule necessary for achieving district-wide energy optimisation.
Digital Building Logbook (DBL)	Require the DBL to be interoperable with the district energy management system. The DBL must record material and energy data relevant for the PED's circular economy and energy balance.	Provides the continuous, standardised data stream needed for smart PED operation and monitoring its positive energy status.
Smart Readiness Indicator (SRI)	Encourage or mandate the SRI assessment for all non-residential and large residential buildings within defined PED areas.	Incentivises the deployment of the smart technologies (sensors, controls, flexibility) that are essential for dynamic energy management in a PED.

Data and Digitalisation Integration

The core of scaling PEDs is managing energy flows, which relies heavily on the data standards pushed by the EPBD in relation to data ecosystem and energy sharing mechanisms:

- **Interoperable Data Ecosystem:** Leverage the DBL framework to create a standardised digital twin of the district. This ensures data from individual buildings (energy consumption, material inventories) can be aggregated and shared securely with the District Energy Management System (DEMS).

- **Energy Sharing Mechanisms:** National EPBD implementation must explicitly address and simplify the regulatory barriers for citizen energy communities and local energy sharing. The

DBL provides the foundation of verified consumption data necessary for transparent billing and management within these communities.

Financial and Investment Incentives

Scaling requires financial and investment incentives. These can help moving from public grant reliance to private investment, using EPBD tools to de-risk projects like:

- **EPC and Financing:** Link improved Energy Performance Certificate (EPC) ratings (achieved through renovation guided by the BRP) directly to financial incentives, lower interest rates on green loans, or preferential taxation within future PED zones.

- **Life Cycle Assessment (LCA):** Integrate mandatory LCA requirements (as foreseen in the EPBD) into the PED planning process. This provides investors with a clear metric (Whole Life Carbon) that showcases the long-term sustainability and value of the district.

- **Green Public Procurement (GPP):** Mandate the use of performance-based GPP criteria for public construction and renovation within identified PED zones, prioritizing solutions that contribute to the district's positive energy goal.

Capacity Building and Urban Planning

PEDs require a new set of skills and a different approach to urban governance:

- **Integrated Spatial Planning:** National planning regulations, when revised to accommodate EPBD, should introduce the concept of "Positive Energy Zones" in local municipal master plans. This integrates energy goals with land use, transport, and social services from the outset.

- **Skill Development:** Establish specialised training programs (for architects, engineers, city officials, and builders) focused on system integration—how to design buildings that function as energy producers and flexible assets within a larger PED framework.

- **Demonstration and Replication:** Use the mandatory nature of EPBD implementation to establish a few large-scale National Reference PEDs. These projects can validate the integrated regulatory, data, and financial models for easy replication across other municipalities.

6.6 Syn.ikia's Evaluation Framework for Sustainable Plus Energy Neighbourhood

The syn.ikia Evaluation Framework for Sustainable Plus Energy Neighbourhoods (SPEN) [33] was developed within the Horizon 2020 syn.ikia project to evaluate the performance of plus energy buildings and neighbourhoods across a broad range of sustainability dimensions. The framework adopts a neighbourhood-scale perspective, explicitly accounting for interactions between buildings, shared energy systems, and local infrastructure.

The primary aim of the framework is to support the assessment of system-integrated energy solutions at district level, moving beyond single-building evaluations to capture collective energy, environmental, and social effects.

Assessment Framework and Key Performance Indicators

The syn.ikia framework defines a comprehensive set of Key Performance Indicators (KPIs) covering:

- Energy balance and renewable energy integration,
- Environmental impacts and emissions,
- Indoor environmental quality and comfort,
- Economic aspects related to energy systems,
- Selected social and well-being indicators.

A central methodological feature of the framework is its emphasis on interactions between buildings and shared infrastructure, such as collective generation, storage, and demand management, which are essential characteristics of plus energy neighbourhoods and PEDs.

Methodological Contribution to PED Readiness Assessment

From the perspective of the PED Readiness Assessment framework, syn.ikia project [33] offers valuable methodological contributions, particularly in relation to neighbourhood-scale performance evaluation. Its KPI structure and system-based approach provide concrete examples of how district-level energy balances and sustainability indicators can be operationalised.

These contributions inform the PED RA policy strategy roadmap by supporting the development of technical harmonisation and coherent KPI structures and by demonstrating how technical, environmental, and social dimensions can be assessed in an integrated manner at the district scale.

Policy Alignment and Transferability

The syn.ikia project`s framework [33] was developed as a project-specific evaluation methodology and is not directly anchored in EU policy, regulatory, or standardisation frameworks. As such, it is not intended to serve as a harmonised European assessment or certification scheme.

However, the lessons learned from syn.ikia are transferable to the development of a European PED readiness assessment framework. In particular, they highlight the importance of clearly defined system boundaries, integrated KPI sets, and neighbourhood-level assessment logic. Within this roadmap, syn.ikia is therefore positioned as a methodological reference that informs, but does not replace, the development of a harmonised, policy-aligned PED RA framework.

6.7 Making-City PED Readiness Indicator Tool (PEDTool)

The MAKING-CITY PED Readiness Indicator Tool (PEDTool) [62] was developed within the Horizon 2020 Making-City project [58] as a city-level self-assessment instrument designed to support municipalities in preparing for the development of Positive Energy Districts. Its primary objective is to assess the readiness conditions required for PED implementation within the cities, rather than to measure quantitative PED performance outcomes.

PEDTool is specifically targeted at the early stages of PED planning, supporting cities in identifying institutional, regulatory, financial, and technical gaps that may hinder the realisation of PED initiatives for cities. The tool adopts a qualitative, questionnaire-based approach that allows municipalities to reflect on their internal capacities and enabling frameworks.

Assessment Approach and Key Dimensions

Based on the Making-City PEDTool documentation and project deliverables [63] it evaluates PED readiness across several qualitative dimensions, including:

- Governance and institutional arrangements,
- Policy and regulatory preparedness,
- Financial and investment frameworks,
- Stakeholder engagement and collaboration,
- Technical knowledge and organisational capacity.

By structuring these dimensions into a systematic self-assessment process, PEDTool enables cities to prioritise actions, allocate resources more effectively, and strengthen coordination among relevant local actors. More practically, the MAKING-CITY PED-readiness indicator tool (PEDTool) [62] allows cities to quickly and simply assess whether they are ready to develop a Positive Energy District (PED), which helps the city to become climate neutral. The evaluation functions in the following steps:

Level 1: Pre-evaluation of cities: Simple indicator at the country and city level to provide a preliminary assessment of the city's readiness for PEDs.

Level 2: Self-evaluation questions: Targeted questions to help refine the level-1 assessment.

Level 3: Tailored workshops to raise awareness on one of the following key success factors: Team motivation alignment, Business ecosystem, Stakeholders' engagement, Energy mapping.

Relevance for the PED Readiness Assessment Framework

From the perspective of the PED Readiness Assessment (PED RA) framework, PEDTool provides important methodological insights into the assessment of non-technical enabling conditions. In particular, it demonstrates the importance of governance capacity, institutional readiness, and policy coherence as prerequisites for successful PED implementation.

These insights are directly relevant for the PED RA policy strategy roadmap, as they support the inclusion of qualitative readiness indicators alongside technical performance metrics; however, differentiates by the scope as PEDTool only aims for cities, not districts. PEDTool thus complements performance-oriented assessment approaches by highlighting the institutional and organisational factors that determine whether PED concepts can be translated into operational projects.

Policy Alignment and Limitations

PEDTool was developed as a project-level instrument and is not designed for harmonised European benchmarking or certification. It is not embedded within EU legislative or standardisation processes. Nevertheless, its experience provides valuable lessons for policy development, particularly with regard to capacity-building for cities and the structuring of early-stage PED readiness diagnostics.

Within this roadmap, PEDTool is therefore referenced as a source of methodological learning and complementarity, rather than as a direct policy instrument. Its contribution reinforces the need for PED readiness assessment frameworks to address governance and institutional aspects in addition to technical performance.

7 European Policy and Strategic Frameworks

7.1 Energy Legislation and Directives Relevant to PEDs

At the policy level, the PED agenda is anchored via the Green Deal, the Climate Law and the Fit for 55 Package. Moreover, the Renovation Wave strategy explicitly champions neighbourhood approaches, placing an *"integrated, participatory and neighbourhood-based approach at the heart of the Renovation Wave"* and noting that *"synergies for renovation become evident when scaled up to district and community approaches… [which] may lead to zero-energy or even positive energy districts."* [64]

Against this backdrop, PEDs represent a cross-sectoral approach to renovations, energy provision and urban planning whose value propositions rest on the synergies between these domains [65]. Because PEDs are impacted by several policy fields, they are not yet explicitly defined or enshrined in a single instrument within EU energy/buildings legislation (including the EPBD, the Renewable Energy Directive (RED), the Energy Efficiency Directive (EED) or the Electricity Market Design and Governance). This sets the stage for mapping indirect anchors across EPBD, RED, EED and the Electricity Market Design and Governance (e.g. provisions that back and hint towards PEDs), identifying provisions that together function as an enabling legislative framework for PEDs (e.g. district-scale approaches, renewable energy communities, zero/positive-emission building concepts, cost-optimality, among others). The next sections unpack these elements and then highlight the remaining gaps.

7.1.1 Provisions in the EPBD

The EPBD does not explicitly mention or encourage PEDs. However, the EPBD has been central, as it paved the way for the reduction in energy demand from buildings across Europe. The following themes reflect the EPBD levers most applicable to PEDs.

(Nearly) Zero-Emission Buildings

In 2010, the EPBD introduced the concept of Zero-Energy Buildings (NZEB) as "*a building that has a very high energy performance* [51]. *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*" (Directive 2018/844/EU, Article 2(2)) [66]. The directive further required that, from 2020, all new buildings deliver high energy performance with very low energy needs, covered largely by on-site or nearby renewable energy sources (supported by 2016 guidelines[3] to help ensure 2020 compliance). In contrast to the 'passive house' concept -focused primarily on space heating and the utilisation of passive solar gains- NZEBs established an integrated approach that combines energy efficiency (EE) and renewable energy sources [51].

With the recast of the EPBD in 2024, the 'nearly-zero' benchmark was elevated to Zero-Emission Buildings (ZEB). Under the recast, all new buildings owned by public bodies must be ZEBs from 1 January 2028, and all other new buildings from 1 January 2030, with targeted exemptions [67]. The Commission's 2025 implementation guidance (part of the official EPBD package) explains how Article

[3] *COMMISSION RECOMMENDATION (EU) 2016/1318. Guidelines for the promotion of nearly zero-energy buildings and best practices.* Link

7 (timeline for the application of ZEBs) and Article 11 (ZEB requirements) work in practice, especially the treatment of "on-site/nearby renewables", efficient district heating/cooling, and "carbon-free sources" [68]. These clarifications matter for PEDs because they define what energy can legally count toward a building's balance.

PEDs build on ZEB by linking low-demand buildings, adding local renewables and district heating/cooling, and enabling energy sharing. Still, both (Near) Zero Energy Buildings (NZEB) and (Near) Zero Energy Districts (NZED) aim to minimise building energy use, but PEDs add key advantages: buildings can share resources and balance each other's demand, jointly managing peak loads for major savings; designs are highly replicable as new buildings can follow proven district examples; the larger scale enables economies of scale in products, systems, services, and technologies; excess or waste energy from one building can be recovered and used by others; and district-level storage boosts resilience, allowing continued operation during power outages [69].

Calculation methodology of the energy performance of buildings

To operationalise these ZEB requirements, the EPBD relies on a common calculation framework based on the EPB standards; the next subsection summarises what that framework covers and where its current district-scale limits lie.

The Commission's 2025 implementation guidance (EPBD package) notes the update of the common general framework for calculating building energy performance [68]. Under the EPBD, Member States must describe their national methods with reference to the EPB standards -principally ISO 52000-1[70] (overarching framework), together with ISO 52003-1[71], ISO 52010-1 [72], ISO 52016-1 [73], ISO 52018-1 [74], ISO 52120-1[75], EN 16798-1 [76], and EN 17423 [77], [78], [79], [80]. ISO 52000-1 provides a systematic, modular structure for assessing new and existing buildings by measurement or calculation, and for expressing performance in primary energy (and other energy-related metrics) [33]. In line with the EPBD and EPB standards, the energy balance includes the main end uses -heating, cooling, ventilation, domestic hot water, and lighting- with additional services (e.g. humidification or lifts) included where relevant[80].

When the assessment moves from a single building to a group of buildings (e.g. a block), ISO 52000-1 allows connected buildings on a single site to be assessed together, defining boundaries and interactions for shared systems and delivered energy carriers [33], [81]. However, full neighbourhood-scale PED assessment extends beyond the current EPB scope: once districts involve multiple owners, public streets, thermal networks, storage, market arrangements, or energy sharing, additional urban-planning, regulatory, financial, and social considerations arise that are not yet comprehensively covered by the EPBD/EPB framework [33].

Cost-optimal levels of energy performance requirements for buildings

Beyond defining ZEB as the new floor and how to calculate energy performance, the EPBD also specifies how that floor must be economically justified and periodically raised through the cost-optimality framework [82]. As the recast from 2024 links energy, emissions, and costs, the EPBD cost-optimality framework for minimum energy-performance requirements becomes an enabler for PEDs: it lowers demand at the asset (building) level as it requires MS to reset performance requirements to the cost-optimal level and can evolve to recognise shared, district-scale solutions.

The cost-optimal methodology framework was first set in 2012, with Delegated Regulation (EU) No 244/2012. The framework requires Member States, since 2013 and every five years, to calculate cost-optimal minimum energy performance levels, compare them to the national minima in force, and adjust those minima where gaps are significant. Member States must report the inputs, assumptions, and results to the Commission. Under the recast EPBD (Annex VII), the framework now enables calculation of energy and emission performance and the economic aspects of related measures, linking them to the 2030 and 2050 goals, including a zero-emission building stock [83].
While official district-level cost-optimal methods are not yet defined, Article 19 of Directive (EU) 2018/844 tasks the Commission (by January 2026) to examine how Member States could apply integrated district or neighbourhood approaches in EU building and energy-efficiency policy, while still ensuring each building meets minimum requirements. This provides a clear policy pathway to recognise PED-relevant, collective assets (shared PV and storage, efficient district heating/cooling, flexibility services) in future iterations [51].

District approach

Building on that mandate in Article 19 of Directive (EU) 2018/844 to examine integrated district or neighbourhood approaches (by January 2026), the recast now brings the district/neighbourhood scale into focus. The district/neighbourhood approach appears in several parts of the recast. First, Article 28 provides that the Commission will review the EPBD by end-2027 and, in that context, examine how Member States could apply integrated district or neighbourhood approaches within Union building and energy-efficiency policy.

Second, Article 17 recognises the neighbourhood/district approach as a cost-efficient way to scale up renovations while taking account of social and environmental aspects [65]. For the first time, the recast explicitly frames renovation not only at the individual-building level but also as part of the wider urban infrastructure [65].
National Building Renovation Plans (NBRPs) reflect this shift. Their objective is a highly energy-efficient, decarbonised stock and the transformation of existing buildings into ZEBs by 2050, and Member States must describe measures and timelines for district and neighbourhood approaches in their plans [65].
In practice, the district approach is most often referenced in relation to heating and cooling. The EPBD recognises the role of Efficient District Heating and Cooling (EDHC) to decarbonise zero-emissions buildings [84]. The Horizon 2020 project oPEN Lab highlights shared heating and cooling systems (in combination with storage and heat pumps) as core neighbourhood-scale solutions -that act as the shared thermal infrastructure for a PED by pooling building loads, integrating on-site/nearby renewables and recoverable waste heat via heat pumps and storage, and delivering flexibility and cost-efficient decarbonisation at district scale [64].

7.1.2 Provisions in the RED

The Renewable Energy Directive (RED II/III) also provides some practical levers that enable PEDs. In particular, RED II/III sets out provisions for renewable self-consumers, jointly acting self-consumers, and renewable energy communities which are detailed below. This matters because PEDs need an enabling framework for collective production, storage and exchange to reach a net district balance [51], [65].

Beyond governance models, RED III also tightens sectoral ambition that matters for PEDs. RED III strengthens sectoral targets that support district-scale decarbonisation, including an indicative target for renewable energy in buildings (often cited at 49% by 2030) [85] and annual increases in the share of renewables and waste heat/cold in district heating and cooling. These signals align with PED logics - lowering fossil heat dependence and making local renewable supply and waste-heat use more attractive at the neighbourhood scale [13].

- Renewables self-consumers (Art. 21 RED II): Self-consumers were first defined in RED II as a final customer […] "*who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity*". For PEDs, renewables self-consumers are the basic building blocks. When organised under community schemes or sharing arrangements, their surplus and flexibility can be pooled to improve the district's annual net balance.
- Jointly acting self-consumers[4]: The directive also refers to jointly acting self-consumers in the same building [5]. This means a group of at least two renewables self-consumers located in the same building or multi-apartment block (or, where permitted, other premises) who can share energy produced on their site(s). PEDs aim to increase energy flexibility by maximizing self-consumption and minimizing peak power demand through the installation of smart (micro) grids, energy management, and battery storage [86]. Where useful, jointly acting self-consumers can serve as a stepping stone toward broader neighbourhood-scale models (e.g., renewable energy communities).
- Renewable energy communities[5]: In this sense, RED III (amending RED II) defines a 'renewable energy community' as a "*legal entity, based on open and voluntary participation, autonomously controlled by shareholders or members in proximity to renewable energy projects, consisting of natural persons, SMEs, or local authorities, with the primary goal of delivering environmental, economic, or social community benefits rather than financial profits*." RECs are limited to renewable energy activities (heat and electricity) and are locally rooted [5].
  Renewable energy communities are often seen as a viable option to achieve the vision formulated by PEDs because energy communities are an essential part of carbon-neutral urban districts capable of producing energy to cover local needs [87]. To this end, it is necessary to create a body of knowledge, tools, and methodologies for a holistic approach to the energy and ecological transition. There are two components: the data dimension and the societal dimension. Data is used to identify solutions to support the community. Knowledge developed in the world of research on smart grids allows for the intelligent management of electrical grids, operating them in an efficient, rational manner while minimising costs and inconveniences. Renewable energy communities are often seen as a viable option to achieve the vision formulated by PEDs because energy communities are an essential part of carbon-neutral urban districts capable of producing energy to cover local needs [87].

[4] REDIII, approved in November 2023, keeps the same definitions for collective self-consumption
[5] REDIII, approved in November 2023, keeps the same definitions for renewable energy communities

7.1.3 Provisions in the EED

Following EPBD and RED, the EED supplies the third pillar for PEDs: it operationalises the Energy Efficiency First principle and sets binding savings/planning duties that lower demand at building and district level -creating the conditions for a positive annual balance [88]. This aligns with the Smart Cities Marketplace view of PEDs resting on four pillars -efficiency, renewables, flexibility and e-mobility [89] and here the focus is on the EED provisions that most directly enable the efficiency pillar at neighbourhood scale.

- Energy Efficiency First principle: The EED establishes the Energy Efficiency First principle and a common EU framework to promote and mandate efficiency improvements in Member States, helping public authorities, businesses, and citizens manage and reduce consumption through binding measures and targets [4]. According to the PED reference framework, among the functions, or dimensions for the realisation of PEDs, energy efficiency should always be the first priority ("energy efficiency first"), as the space needed for the generation of renewable energy will always be limited in an urban environment [25].
- District heating and cooling: As part of the integrated NECPs, Member States must deliver comprehensive heating and cooling (H&C) assessments and planning. In practice, this requires municipalities to prepare H&C plans showing how local systems will shift to renewables and waste heat, and to assess the potential role of energy communities and consumer-led initiatives in local H&C projects [90]. This matters for PEDs because local H&C plans are where cities line up renewable supply, waste-heat sources, thermal storage, and network temperatures -core levers for achieving a net-positive balance at the district scale.
  Moreover, the EED further strengthens the framework for efficient district heating and cooling (DHC) by requiring that final customers are equipped with competitively priced meters; billing and consumption information must be reliable, accurate, based on actual consumption, and accessible to customers [90]. Granular, trusted data lets districts shift demand in time coordinated operation of shared PV/storage/thermal systems, and transparent, fair billing.

7.1.4 Provisions in the Electricity Market Design and Governance Directive and Regulation (EMD)

The EU's electricity market rules were (re)enacted in June 2019 as part of the Clean Energy Package - Directive (EU) 2019/944 (the "Electricity Directive") and Regulation (EU) 2019/943 (the "Electricity Regulation") -and reformed in June 2024 by Directive (EU) 2024/1711 and Regulation (EU) 2024/1747 [88]. Their core aim is to adapt market rules to increase flexibility and enable the large-scale integration of renewables, while safeguarding a consumer-centred, competitive internal market (free supplier choice, fair access, clear consumer rights). For PEDs, these acts supply the operational toolkit to (i) organise collective participation and energy sharing, (ii) act as one flexible resource via aggregation and demand response, and (iii) access the data needed to coordinate and settle sharing.

- Citizen energy communities and energy sharing: The EU electricity rules (Directive (EU) 2019/944, reformed in 2024) introduced energy communities as a cooperation concept in the energy market. Citizen energy communities (CECs) must be enabled to access all electricity markets and are entitled to arrange the sharing of electricity produced by community-owned

units (Art. 16). A PED can rely on an EC for its realisation, but PEDs and ECs are not necessarily equivalent. They may, however, intersect at many points [91].
The 2024 reform adds a new right to energy sharing (Art. 15a), requiring Member States to let households, SMEs and public bodies (and other groups if a Member State decides) participate in shared energy uses within a defined area. At the unit/building level, the active customer definition (Art. 2(8)) explicitly permits self-generation, storage, sale of self-generated electricity and participation in flexibility schemes, individually or jointly [92].

- Demand response and aggregation: Member States must allow and foster participation of demand response through aggregation, letting final customers (including those acting via aggregators) participate alongside producers in all electricity markets on a non-discriminatory basis (Art. 17). This is the legal basis for a PED to shift loads, shave peaks and earn flexibility revenues by coordinating buildings, storage and EVs as a single aggregated resource.
- Data access, smart metering and interoperability: The electricity framework requires smart metering and secure data access/exchange; the 2024 market-design reform adds Article 7b to Regulation (EU) 2019/943 so that Transmission System Operators (TSOs)/Distribution System Operators (DSOs) and market participants (incl. independent aggregators) may -with customer consent- use data from dedicated measurement devices for the observability and settlement of demand-response and flexibility services, with Member States ensuring data validation and interoperability [92], [93]. Similar to the EED, for PEDs, this provides the granular data needed to settle energy sharing, allocate costs/credits fairly, and coordinate shared PV, storage, heat pumps and EV charging at neighbourhood scale.

7.2 Driving Urban Transitions (DUT) Partnership PED Framework 3.0 and Mission 100 Climate-Neutral Cities

The evolution of the Positive Energy District (PED) concept in Europe reflects a transition from exploratory coordination under JPI Urban Europe [94] to a more structured and policy-oriented approach within the Driving Urban Transitions (DUT) Partnership. The initial JPI Urban Europe PED Programme[25] focused on transdisciplinary research and city-led experimentation, developing a shared conceptual foundation while revealing significant variation in governance, assessment methods, and monitoring practices. Building on these insights, the DUT PED Framework 3.0 [11] was introduced as a policy guide to advance PED implementation and harmonisation across Europe. Rather than prescribing a fixed methodology, it offers an adaptive framework that aligns local innovation with European policy objectives, embedding PEDs into the broader context of the European Green Deal [95], the Renovation Wave [3], the Fit for 55 Package [96], and the EU Energy System Integration Strategy [6]. The framework emphasises multi-level governance, financial viability, and the creation of enabling innovation ecosystems, helping cities translate PED ambitions into planning, investment, and monitoring programmes.

Complementing this, the Mission 100 Climate-Neutral and Smart Cities by 2030 [97] provides a practical arena for the real-world application of PED concepts. Through Climate City Contracts [98], the Mission mobilises innovation, governance reform, and financing mechanisms to enable at least 100 European cities to achieve climate neutrality by 2030. PEDs play a central role in this process, serving as district-

scale interventions that demonstrate measurable emission reductions, foster systemic transformation, and enable replication across Europe.

According to the DUT PED Framework 3.0.[11], achieving climate neutrality in PEDs requires leveraging existing projects, engaging diverse stakeholders, and aligning local actions with regional and national policies. Effective PED development depends on multi-level governance to establish policy frameworks and financial instruments that coordinate efforts across government and society. Collaboration among key actors—city authorities, the real estate sector, and energy providers—is essential for informed policy and investment decisions, while empowering local and energy communities fosters innovation, participation, and local economic growth [11]. Sector coupling and cross-sectoral integration enhance PED efficiency and sustainability by connecting diverse energy systems and maximising local renewable resources. Furthermore, improved spatial planning and integration of urban systems create more connected and resilient neighbourhoods, while securing sustainable financing through mechanisms such as the EU Taxonomy [99] ensures the long-term viability and scalability of PED initiatives.

The DUT PED Framework 3.0 [11] and this report -PED RA Tool strategic policy roadmap- share a common, impact-driven vision for the harmonised assessment and deployment of Positive Energy Districts (PEDs) across Europe. Both promote multi-level governance, broad stakeholder engagement, and the alignment of local innovation with EU policy objectives, establishing clear synergies with initiatives such as the EPBD [82], Renovation Wave, 100 Climate-Neutral Cities Mission [97] by scaling building-level metrics to the neighbourhood level, creating a bridge between micro-scale energy performance and macro-scale renovation strategies. It supports the EU Energy System Integration Strategy [6] by operationalising sector coupling and local flexibility, establishing PEDs as active nodes in multi-energy systems. Most importantly, they emphasise the importance of advancing the standardisation of PED boundaries and key performance indicators consistent with international benchmarks like IEA Annex 83 [9, p. 83]. PED RA policy roadmap especially focuses on enhancing data interoperability and continuous monitoring through EU policy tools such as the Smart Readiness Indicator (SRI) [7] and Digital Building Logbook (DBL) [8]. This integrated framework improves transparency, comparability, and policy feedback across governance levels, supporting the integration of PED metrics into planning, reporting, and implementation mechanisms, including National Energy and Climate Plans (NECPs) and Climate City Contracts [98], as well as local and regional level planning. By promoting sector coupling, cross-sectoral integration, and transnational collaboration through the DUT Partnership, Horizon Europe, and networks like IEA Annex 83 [9, p. 83], COST PED-EU-NET [10]; these initiatives collectively foster methodological alignment, digital integration, and knowledge exchange.

The DUT PED Framework 3.0 [11], supported by the 100 Climate-Neutral Cities Mission [97], establishes the analytical and policy foundation for a harmonised European PED assessment, aligning research, policy, and implementation through methodological, digital, and governance synergies that advance a coherent and unified pathway toward Europe’s climate-neutral urban future.

7.2.1 Renovation Wave and EPBD Recast 2024 in more detail

Positive Energy Districts (PEDs) directly reinforce the objectives of the Renovation Wave by demonstrating how renovation efforts can move beyond single buildings toward integrated, district-

scale transformation. The Renovation Wave strategy emphasises neighbourhood-based and participatory approaches, noting that synergies in renovation become far more impactful when aggregated at the district level—where zero-energy or even positive-energy outcomes are achievable [100]. PEDs embody this ambition by treating neighbourhoods as micro-energy hubs that combine deep renovation, renewable energy generation, flexibility measures, and community participation. At the same time, the EPBD recast (Directive (EU) 2024/1275) has entered into force on 28 May 2024 and sets a transposition deadline of 29 May 2026 for Member States [82]. The updated directive introduces strengthened measures for building renovation and decarbonisation—such as minimum energy performance standards for the worst-performing buildings, zero-emission standards for new buildings, and renovation trajectories for residential building stock [101]. While the recast is a major step forward, it still leaves a gap in explicitly mandated district- or neighbourhood-scale renovation programmes. Hence, PEDs need an advocacy to monitor national transposition efforts to ensure that the neighbourhood perspective of the Renovation Wave is meaningfully reflected in national implementation frameworks.

8 PED RA Policy roadmap

8.1 Identified gaps

The EPBD, REDIII, and EED include important provisions to encourage energy storage, smart heating and cooling, and energy management systems. Demand-side flexibility is central to PEDs, which aim to maximise self-consumption at the neighbourhood level and provide flexibility services to the grid. Regulations like the EMD promote demand-side flexibility and smart technologies [65].

Nevertheless, compared with established EU assessment frameworks -such as the Smart Readiness Indicator (SRI) or Energy Performance Certificates (EPCs)- the regulatory framework for PEDs is still weak, causing several challenges. Firstly, there is no explicit EU target or obligation for PEDs, giving governments and local actors little incentive to prioritise them. Secondly, without a common definition and metrics, PEDs can diverge widely across Member States, hampering benchmarking and replication. Lastly, unlike EPC schemes, there are no standardised requirements for assessors, methods or quality control, which undermines reliability and cross-country comparability.

With these obstacles in mind, the next section summarises the key legislative and regulatory gaps and suggests potential avenues for further action. This also builds on the recommendations and key messages coming from other projects.

- **Harmonised definition and framework for PEDs:** Unlike Renewable Energy Communities in RED or NZEB in the EPBD, there is no agreed-upon definition of PEDs in the reviewed legislation. This can lead to variability and problems of comparability across projects, inconsistent measurement, lack of financing options, difficulties in replicating and scaling, among others. The definition should be, on the one hand, flexible enough to allow for local adjustments, depending on limitations such as heritage regulations, renewable energy potential, and electricity grid capacity. On the other hand, there is a need for a common approach and calculation method to allow comparison across projects, Member States (MS), among others [64], [102]. A definition is also key to enable follow-up of the policy goals related to the progress of districts and neighbourhood approaches in the NBRPs.
- **PED boundaries definition:** Not only is a PED definition needed, but also the frontiers or boundaries of a district need to be clarified. This can, for instance, help prevent double-counting of buildings. A district can encompass a mix of existing and new buildings, with some that can be kept as they are, while others need to go through targeted upgrades, major renovations, and have some positive or zero energy new buildings. A key advantage of the PED is to allow for some individual buildings within the community to undergo minor renovations or be left untouched, and hence, individually, they will not necessarily meet the district's energy performance requirements, but overall, the district can still reach a positive energy level. For example, some buildings are far too complicated or not cost-effective to renovate (e.g., heritage buildings) [88].

There is currently no harmonised legal definition of a "district" boundary in EU legislation, nor in the emerging PED policy framework. While individual MS may define districts for planning or statistical reasons, these units differ across countries. Existing PED guidelines explicitly acknowledge that defining the PED boundary is not straightforward and leave substantial discretion to national and local actors [89], suggesting that what is realistic at this stage is not a fixed EU-wide geometry, but potentially a requirement that projects make their district boundaries explicit and transparently justified in relation to existing planning or statistical units and the underlying energy system, as well as an accompanying methodology to do so.

- **Establish financing measures for PEDs:** Because investors need clarity on what qualifies and how performance is measured, the priority at EU level is a harmonised PED framework. With common metrics in place, the Commission can (i) make the definition the reference for eligibility for EU funding (Cohesion Policy, InvestEU, Social Climate Fund, LIFE, Horizon Europe), (ii) align State-aid clearance via the Climate, Energy and Environment Aid Guidelines so national grant/operating-aid schemes for PED-type projects are easier to approve, and (iii) integrate PED criteria in the EU Taxonomy technical screening [102] (so private capital can count PED investments as sustainable). As a result, this would also give signals to MS and eventually lead to subsidies and tax incentives.
- **Identification of renewable energy sites to make PEDs viable:** Current EU legislation does not oblige MS or cities to designate neighbourhoods for PEDs. In contrast, the RED III introduces renewables acceleration areas (RAAs) (article 15c), or the EED requires heating and cooling assessments and local H&C plans, that require the assessment of the role of energy communities and consumer-led initiatives (article 25). These two examples evidence how EU legislation can help pre-identify and reserve urban spaces suited to renewables, storage, and flexibility [102]. To close the gap, the EPBD review by 2028 could clarify how the Commission plans to map the potential of integrated district and neighbourhood approaches [64], and potentially assess whether MS could be required to link H&C plans and RAAs to neighbourhood-scale projects. This would respect national planning competences while creating a consistent EU expectation to earmark suitable areas for PED-type initiatives.
- **Independent experts and certification schemes:** Even though EPCs still suffer from a lack of harmonisation (i.e. discrepancies in assessments, differences in methodology, and evaluative skills) across EU countries, the experience with them offers some good examples to learn from [103]. The EPBD recast requires MS to set up a system for certifying the energy performance of buildings and to use a harmonised A-G scale. Moreover, Member States must ensure EPCs are issued "by independent experts" and shall be certified in accordance with Article 28 of Directive (EU) 2023/1791, taking into account their competence. The EPBD doesn't itself design the certification scheme; instead, it points to the Energy Efficiency Directive (EED), Directive (EU) 2023/1791, Article 28, which creates a horizontal framework for energy-efficiency professions. The recast EPBD also adds a separate article on "Certification of building professionals": Article 26 EPBD obliging Member States to ensure an "appropriate level of competence for building professionals carrying out integrated renovation works" and aligns with Article 28 EED.
- **The EPBD and EED framework can serve as inspiration for PEDs**. For instance, the PED assessment and certification could be done by independent experts who are qualified or certified under national schemes - exactly as for EPCs. PED assessors could be brought under

the same national certification/qualification schemes for energy-efficiency professions, with additional PED-specific modules (district energy, multi-building LCA, governance). Moreover, a PED performance certificate with a harmonised EU template (minimal fields, core KPIs, boundary description, energy/GHG balance, share of renewables, etc.) could be envisaged.

8.2 Priority actions for the EC

By establishing common indicators and assessment procedures, PED RA aims to mitigate the risk of methodological fragmentation and provide a clear strategic direction for the implementation and monitoring of PEDs. Based on the identified gaps listed, a series of priority actions and policy suggestions were formulated, based on research design and data sources, as well as a collection of recommendations identified from sources in Chapter5.

8.2.1 Short-term actions (0–2 years)

Establish a Harmonised PED RA Core Framework

- **Priority: High**
- **Expected impact: High** – early proof of concept, real-world data, and political visibility.
- **Rationale:**
    - Tackles the **lack of harmonised PED definition and framework**, making assessments comparable and "finance-ready". A strategy would be to define it based on the grid configuration (low and medium voltage, within 1 transformer, and the available capacity of the grid). Another strategy is administrative or physical boundaries, based on regulations for energy sharing, e.g. 2 km of CSC in Spain. [104]
    - Ensures PED RA outputs can be directly reused in **National Building Renovation Plans** and other EPBD/EED reporting.

Launch an EU-level pilot programme for the PED Readiness Assessment tool (10–20 cities)

- **Priority: High**
- **Expected impact: High** – early proof of concept, real-world data, and political visibility.
- **Rationale**:
    - Select a representative set of **cities/districts across climates and urban typologies** (Mission Cities, Smart Cities projects, PED lighthouse projects, Cohesion-funded urban

districts). Existing research shows that applying assessment methods to real districts reveals gaps and unrealistic assumptions.

- Provide technical support (via JRC, Horizon Europe projects, or ELENA-type TA) to implement the tool and report:
  - Data availability and quality;
  - Institutional bottlenecks;
  - Needs for simplification or additional modules (e.g. social/affordability indicators).

- **Synergies:**
  - Use **PED-EU-NET**'s city labs and case studies as early adopters.
  - Share results and lessons through **CA EPBD** meetings so Member States see the tool as directly relevant for EPBD implementation, not as a separate "research gadget".

Develop common guidance, templates and training for national and local authorities

- **Priority: Medium**
- **Expected impact: Medium**– enables consistent application and reduces perceived complexity.
- **Rationale**: Literature consistently stresses that the complexity of PED assessments, multi-domain indicators and data requirements are barriers for cities and planners.
  - Prepare:
    - A **practical guidance document** (How-to for cities and Member States).
    - Standardised **data templates** (Excel/CSV schemas) aligned with typical EPBD and energy statistics data.
    - **Training modules/webinars** targeted to:
      - National EPBD contact points (via CA EPBD);
      - City planners and utilities (via PED-EU-NET, JPI Urban Europe and Mission Cities).
- **Synergies:**

- Run joint **CA EPBD–PED-EU-NET training sessions**: Member States see the urban/PED dimension; cities see the EPBD and national policy angle.

Clarify governance, hosting and maintenance of the PED Readiness Assessment tool

- **Priority: High**
- **Expected impact: Medium–High** – ensures continuity and trust among Member States and cities.
- **Rationale**:
  - Decide early whether the tool will be:
    - Hosted and maintained by **JRC** or another EU body;
    - Co-managed by a **European platform** (e.g. JPI Urban Europe / EERA Smart Cities) with formal links to the Commission.
  - Define:
    - Update cycle (e.g. aligned with EPBD revisions and NECP updates);
    - Procedures for feedback from **CA EPBD** and **PED-EU-NET**.

8.2.2 Medium term actions (2-5years)

Integrate PED readiness indicators into EPBD implementation and guidance

- **Priority: High**
- **Expected impact: Very high** - mainstreams district-level thinking within building policy, and anchors PEDs in core legislation.
- **Rationale**: As Member States implement the *recast* EPBD and related initiatives (e.g. long-term renovation strategies, ZEB requirements, building logbooks and digital tools), district-level energy planning and flexibility become increasingly relevant.
  - Use the CA EPBD process to:
    - Recommend **voluntary PED readiness indicators** as part of EPBD reporting (e.g. in country reports or annexes to national plans);

        - Develop **guidance notes** on how PED readiness can complement building-level EPBD requirements (e.g. shared RES systems, district energy, flexibility).

- **Synergies:**
    - **CA EPBD:** official channel for Member State dialogue and Commission guidance on EPBD implementation.
    - **PED-EU-NET:** ensures that technical and social dimensions of PEDs remain visible (not reduced only to an energy balance metric).

Link PED readiness scoring to EU funding and state aid priorities

- **Priority: High**
- **Expected impact: Very high** – creates strong incentives and accelerates district-scale renovation and investments.
- **Rationale**:
    - The SET-Plan and related policy documents emphasise PEDs as a key pathway to climate-neutral cities.
    - Over the medium term, the Commission can:
        - Encourage using **PED readiness scores** as a **selection or weighting criterion** in:
            - Cohesion policy / ERDF programmes,
            - Social Climate Fund operations,
            - Horizon Europe / successor programmes,
            - National climate funds or state-aid schemes.
        - Develop a **simple scoring summary** that managing authorities can apply in calls without needing full technical analysis.
- **Synergies:**
    - **CA EPBD** can ensure consistency with EPBD-related funding measures (e.g. building renovation schemes).
    - **PED-EU-NET** can help define realistic scoring thresholds and prevent “PED-washing”.

Embed the tool in national and local planning routines (urban & energy planning)

- **Priority: Medium–High**
- **Expected impact: High** - moves PEDs from project pilots to mainstream planning practice.
- **Rationale**: Research stresses that PEDs must be embedded in wider **urban planning, mobility planning and socio-economic strategies**, not treated as isolated energy projects.
    - Encourage Member States, via CA EPBD and other Concerted Actions (e.g. CA EED, CA RED), to:
        - Reference **PED readiness assessments** in:
            - spatial/land-use plans,
            - Sustainable Urban Mobility Plans (SUMPs),
            - climate neutrality roadmaps and NECPs;
        - Use the tool systematically when designating **urban regeneration areas** or district-scale renovation zones.
- **Synergies:**
    - **CA EPBD**: links to building stock renovation and national long-term strategies.
    - **PED-EU-NET**: provides models of governance, stakeholder engagement and citizen participation in PED projects.

Develop a data interoperability layer with EPBD and urban data platforms

- **Priority: Medium–High**
- **Expected impact: High** - reduces transaction costs, improves quality and comparability of PED assessments.
- **Rationale:** The literature on PED tools underlines the need for consistent data models and interoperable workflows between building stock data, energy systems and urban models.
- Over 2–5 years:
    - Define a **standard data schema / API** for the PED readiness tool (building on ongoing work on building logbooks, digital product passports, and national EPBD databases).

  - Encourage national EPBD calculation systems and building registries to **export a minimal dataset** that can be ingested by the PED tool.
  - Link with city digital twins and urban data platforms (e.g. developed under Horizon Europe projects).

- **Synergies:**
  - **CA EPBD**: forum to ensure compatibility with national EPBD databases and calculation tools.
  - **PED-EU-NET**: source of use cases where district-scale simulation tools and monitoring systems are already in place.

Establish a long-term European community of practice on PED assessment

- **Priority: Medium**
- **Expected impact: Medium–High** - keeps methodologies evolving, avoids obsolescence, supports continuous capacity-building.
- **Rationale:** After 2025, COST Action **PED-EU-NET** formal funding ends, but the network and knowledge base provide a strong foundation for an ongoing **community of practice**.
- Medium-term actions:
  - Transform the PED-EU-NET network into a **permanent European platform** for PED assessment, supported by the Commission and/or other European partnerships.
  - Use this platform to:
    - Collect case studies and **benchmark PED readiness scores** across Europe;
    - Update and co-develop the tool (new modules, e.g. social equity, affordability, circularity);
    - Maintain a **knowledge hub** of methods, datasets and guidance documents.
- **Synergies:**
  - Continuous links with **CA EPBD** and **JPI Urban Europe** will keep the tool technically robust and politically relevant.

Integrate social, affordability and governance dimensions more deeply into the tool

- **Priority: Medium**
- **Expected impact: Medium–High** - ensures PED deployment is socially acceptable, equitable and politically resilient.
- **Rationale:** Recent policy guides and research emphasise that PEDs must combine **energy performance, affordability and financial sustainability**, and address social innovation, business models and citizen engagement – not only energy balances.
- Use the medium term to:
    - Add/refine **non-technical indicators** (affordability, distributional impacts, governance maturity, participation processes);
    - Pilot these in cities via PED-EU-NET successors and Mission Cities.
- **Synergies:**
    - **PED-EU-NET** and related COST/Horizon projects bring social sciences expertise.
    - **CA EPBD** can ensure that social aspects are aligned with EPBD's affordability and comfort objectives.

8.3 Timeline

There are clear conceptual parallels between the development of Level(s) and the process required to create a PED RA tool in Europe. Both frameworks aim to provide a harmonised European methodology that reduces fragmentation and enables consistent assessment across diverse national and local contexts. Each begins with high-level macro-objectives that establish a strategic direction before translating these into detailed indicators and calculation methods. Crucially, both rely on broad stakeholder co-creation, involving policymakers, researchers, practitioners, industry actors, and civil society to ensure that the tool is scientifically robust, practical to apply, and aligned with real-world needs.

As an exemplary, Level(s) emerged as the European Commission's response to the growing need for a harmonised approach to assessing the sustainability of buildings across Europe. Developed by the Joint Research Centre, the framework was drafted during the mid-2010s and shaped through expert consultation to provide a common set of life-cycle performance indicators for residential and office buildings [105]. Below is a brief timeline of the development of Level(s):

- 2017 -An earlier draft version of what would become Level (s) was prepared by JRC as a "common framework of building indicators."
- 2019 -Launch of the project LIFE Level(s) — supporting alignment and uptake of Level (s)

- 2017- Proposed start of initial testing phase for Level (s). The testing phase was to begin in autumn 2017 and run for two years
- 15-Oct-20- Official launch of Level (s) as the European framework. The framework was formally made available by the EC Version 1.0 of the "User Manual – Introduction to the Level (s) common framework was published.
- 2022- Public statement emphasising its role in upcoming legislation. The framework was described as guiding building-sector professionals, anticipating upcoming regulatory developments such as updates to the EPBD and a new Construction Products Regulation.

Like Level(s), a PED assessment tool would benefit from a progressive, staged application model that accommodates users with varying levels of expertise and supports assessment throughout different phases of planning and implementation. Both frameworks also depend on structured European-wide testing phases, where pilot projects serve to refine methodologies and identify barriers before the tool is formally launched.

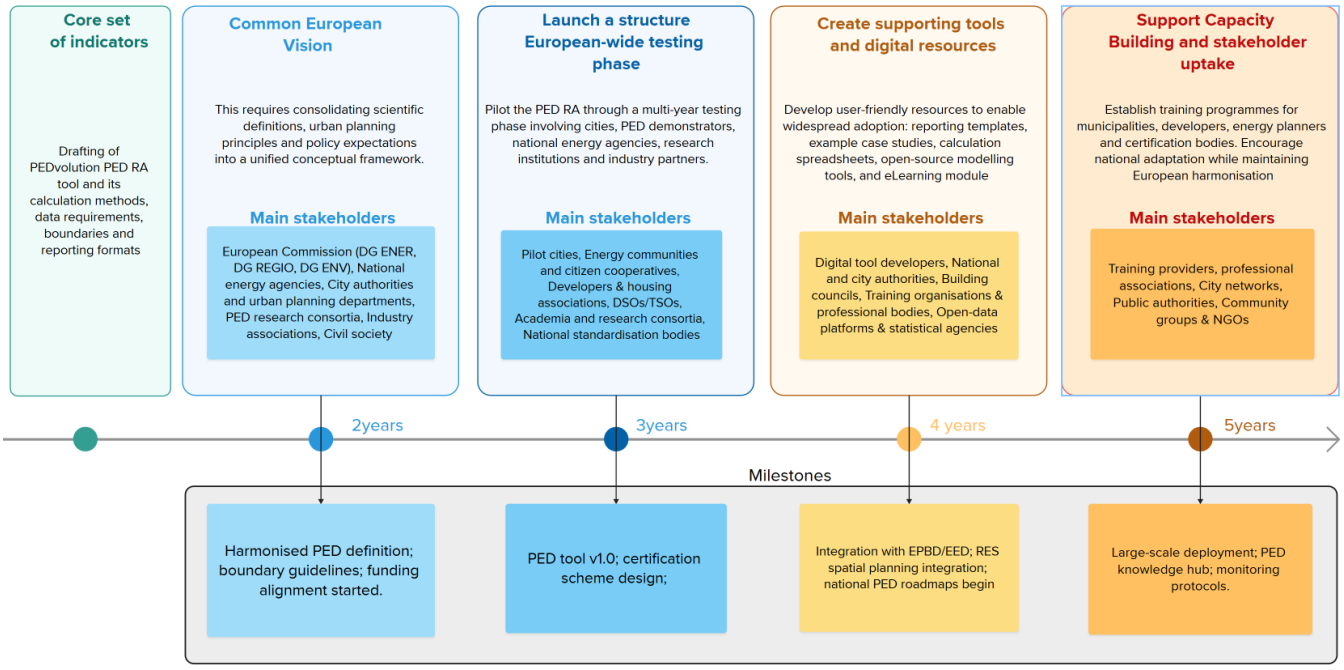

Figure 4: Timeline for PED RA rollout.

Figure 4 presents a visual representation of the priority actions for PED RA as outlined in the section 8.2. It details the five-year timeline for implementing the PED RA rollout. During Task 4, specifically D4.1, the core indicators were initially defined. The anticipated milestones for the first five years are as follows:

- 2nd year: The initial milestone involves establishing harmonised PED definition boundary guidelines. A unified European vision should be developed by aligning scientific research with policy initiatives, engaging key stakeholders such as the European Commission, leading academic institutions, city practitioners, and civil society within short-term actions.

- 3rd year: The next milestone is the legalisation of the PED RA tool Version 1 certification scheme, supported by the introduction of a Europe-wide testing framework.
- 4th year: This phase focuses on integrating PED RA with EU instruments such as EPBD/EED to expedite national PED roadmaps by developing supportive tools and digital resources.
- 5th year: The final milestone encompasses the large-scale deployment of the PED knowledge hub and monitoring protocols to enhance capacity building and promote stakeholder adoption.

The figure is described in detail and broken down into its parts in later subsections.

Common European Vision

This stage aims to consolidate scientific knowledge, urban planning principles, and policy expectations into a unified conceptual framework for PEDs. It involves aligning definitions, boundaries, and governance principles to create a shared European vision of what constitutes a Positive Energy District. The process requires substantial coordination among EU institutions, national authorities, cities, research networks, and civil society. Achieving this consensus supports coherent implementation across Member States and underpins future funding, regulation, and certification pathways.

Launch of European-wide testing phase

This phase represents the transition from conceptual development to practical validation. The PED RA tool is piloted across a variety of contexts -cities, PED demonstrators, national energy agencies, research institutions, and industry partners- through a multi-year testing phase. The objective is to refine the tool through real-world use, gather feedback on feasibility and data requirements, and test the robustness of indicators and methodologies. This structured testing phase is crucial for ensuring the tool is credible, operationally usable, and adaptable to diverse urban and national contexts.

Supporting tools and digital resources

Following the testing phase, user-friendly resources are developed to enable widespread adoption across Europe. These include reporting templates, case studies, calculation spreadsheets, and open-source modelling tools, as well as training materials and e-learning modules. These digital support instruments help standardise the application of the PED RA tool, reduce barriers to implementation, and build the technical capacity of local authorities, developers, and practitioners. The creation of such resources ensures the tool can be used consistently and effectively by a broad range of stakeholders.

- **Peer-learning platforms and case study exchange**

To enable continuous improvement and alignment across the MSs, a structured knowledge sharing, such as a peer-learning cycle, case study exchanges, or twin schemes, should be established. During peer-learning cycles, the cities can present results from their PED RA, exchange implementation challenges and co-develop solutions. Case study exchanges will help to document practical experiences, governance approaches, and lessons learned from the demonstration cities, while twinning schemes connect demonstration and follower cities to accelerate knowledge transfer.

- **Knowledge hub integrating EU project outputs**

This knowledge hub will host all the training materials, guidance documents and templates for PED RA implementation. Furthermore, it will provide access to performance benchmarks and integrate outputs from related EU projects to ensure coherence and to avoid fragmentation.

Capacity building

To motivate the wider use of the PED RA across the MSs, a dedicated set of capacity building and knowledge-sharing initiatives should be established. These will help municipalities, regional authorities, and local stakeholders (such as developers, PED planners) to understand the value of PED RA, integrate it effectively and integrate its outcomes into planning and deployment of PEDs. Capacity building programs should include tailored training programs for different stakeholders (cities, municipalities, PED planners) on data collection, KPIs interpretation, and use of PED RA supported by practical guidance.

Expected Outcomes (2026–2030)

If the actions outlined in the roadmap are progressively implemented by **EU institutions, Member States, cities, and relevant stakeholders**, the following outcomes are expected to materialise between 2026 and 2030. These outcomes build directly on the establishment of a common European vision, the European-wide testing phase of the PED Readiness Assessment (PED RA), and the deployment of supporting tools, digital resources, and capacity-building mechanisms described above.

- **A harmonised European reference framework for defining and assessing PEDs**, supported by coordinated action from the European Commission, national authorities, and research networks, enabling consistent interpretation and application across Member States.

- **Improved access to EU and private financing for PED projects**, facilitated by clearer data structures, transparent assessment results, and more comparable eligibility criteria, supporting investment decisions by funding bodies and financial institutions.

- **Accelerated development and replication of PEDs integrated into local and regional energy systems**, driven by cities, developers, and public service operators using the PED RA to inform planning, implementation, and monitoring.

- **A growing and skilled European community of PED assessors and practitioners**, supported through coordinated training programmes, peer-learning platforms, and knowledge-sharing initiatives.

- **Stronger integration between building data, spatial planning, and energy system planning**, enabled by the use of interoperable tools, shared data frameworks, and alignment with digital initiatives such as the Digital Building Logbook.

- **Increased comparability, transparency, and replicability of PED projects across Europe**, resulting from the consistent application of the PED RA framework and the systematic exchange of lessons learned through European knowledge hubs and peer-learning mechanisms.

Together, these outcomes reflect the added value of a coordinated, multi-level approach to PED readiness assessment and support the transition from isolated PED pilots towards scalable and policy-aligned district-level solutions across Europe.

8.4 Policy Recommendations

The policy recommendations presented in this section synthesise the findings of the preceding chapters, in particular the analysis of European policy and strategic frameworks (Chapter 7), the assessment of synergies with existing EU and international initiatives (Chapter 6), and the roadmap actions defined in Chapters 8.1–8.3. Building on the identified gaps, alignment opportunities, and governance challenges, these findings translate the PED Readiness Assessment (PED RA) policy strategy roadmap into policy recommendations. They are addressed to European institutions, Member States, cities, financial actors, and research bodies, and aim to support the systematic integration, scaling, and long-term uptake of a harmonised PED assessment approach across Europe.

Link District-Level Assessment to EU Climate & Energy Legislation

- Ensure that the PED method aligns explicitly with **EPBD**, **EED**, **RED**, **AFIR** (Alternative Fuels Infrastructure Regulation), and **NECP** (National Energy Climate Platforms) reporting structures.
- Require PED assessments to provide **quantified contributions to NECP targets**, including renewable energy shares, energy-efficiency improvements, and CO_2 reductions.
- For Mission Cities, mandate that the PED assessment feeds into **Climate City Contracts (CCC)** progress monitoring.
- Create an EU indicator on "**District-scale energy-positive transformation**" embedded in DG ENER & DG CLIMA monitoring dashboards.

Improve Bankability and Attract Private Capital

- Introduce an **EU PED Performance Label**, aligned with the EU Taxonomy, to certify compliant projects and reduce investor uncertainty.
- Mandate **transparent MRV (Monitoring, Reporting & Verification)** standards for PED performance, enabling use in sustainable finance instruments (green bonds, sustainability-linked loans).
- Develop an **EU PED Data Template** for financial actors, modelling what banks, ESCOs and investors need (baseline energy use, CAPEX/OPEX, payback, resilience metrics).

- Encourage the EIB and national promotional banks to apply the harmonised method in **project appraisal**.

Improve Quality and Interoperability of PED Tools

- Fund coordinated testbeds (Horizon Europe / DUT Partnership) for **benchmarking tools against identical case studies**.
- Establish a "**PED Test Case Library**" where all tools must demonstrate compliance.

Support Replication and Cross-City Learning

- Require EU-funded PED projects to publish results in a **central EU PED Observatory**, with PED RA harmonised indicators.
- Create an EU "**PED Replicability Score**" based on the common assessment method, helping other cities judge transferability.
- Ensure that Mission Cities and Cohesion Policy programmes apply the harmonised method to all district-scale transformation actions.

Increase Governance Transparency and Citizen Trust

- Require cities to publish **citizen-friendly PED dashboards** using the harmonised indicators.
- Make participatory planning compulsory for large PEDs, including **co-design sessions, citizen juries, and feedback loops**.
- Introduce a requirement for PED assessments to conduct a **distributional impact analysis** (who benefits/pays).
- Encourage local authorities to adopt **participatory investment models** (cooperative solar ownership, shared storage, local green bonds) facilitated by clear and trusted PED indicators.

Align Research, Regulation, and Standardisation

- Require that all Horizon Europe PED projects **report using the same core assessment method**.
- Integrate the method into national **urban planning codes**, linking district-scale energy planning with climate neutrality targets.
- Encourage Member States to include harmonised PED metrics in **building permitting**, district heating/cooling concessions, and municipal climate planning.

- Task the JRC with maintaining and updating the **EU PED Reference Framework**, ensuring alignment between research and policy developments.

9 Conclusions

This deliverable presents the PED Readiness Assessment (PED RA) Policy Roadmap, developed within the PEDvolution project to support the establishment of a harmonised European framework for assessing the readiness and maturity of Positive Energy Districts (PEDs).

The roadmap aims to support technical harmonisation to enable comparable evaluations of PEDs across the Member States. This can be mostly achieved by common definitions, data protocols, and assessment procedures. At the moment, there is no agreed-upon definition of PEDs or PED boundaries

Furthermore, it seeks to strengthen policy alignment by identifying the PED-related policy gaps and strategic frameworks within existing EU energy and buildings legislation. As a result of the analysis, the roadmap highlights the absence of a harmonised PED definition and clear boundary principles, as well as common metrics and assessment procedures to enable comparability, replication, and monitoring across Member States. It also underlines the importance of embedding PEDs in the EU's financing and planning architecture by linking eligibility for EU funds, State-aid clearance, and taxonomy criteria to PED-compliant projects, and by connecting PED deployment to other existing instruments, i.e., renewables acceleration areas and local heating and cooling plans. Finally, it points to the opportunity to build on the EPC/EED model by establishing certified independent PED assessors and, in the longer term, a harmonised PED performance certificate.

It also aims to promote replication and scalability by addressing the persistent methodological heterogeneity that currently limits the comparability and transferability of Positive Energy District (PED) initiatives across Europe. By establishing a harmonised and policy-aligned PED Readiness Assessment framework, the roadmap enables consistent evaluation of PED maturity across diverse urban, climatic, and regulatory contexts, supporting evidence-based replication beyond isolated pilot projects. The proposed approach facilitates cross-city learning through shared indicators, benchmarking mechanisms, and knowledge exchange platforms, while leveraging EU instruments such as the EPBD, Mission Cities, and Cohesion Policy programmes to embed replicability into implementation pathways. In doing so, the roadmap supports the accelerated and scalable deployment of PEDs integrated into local and regional energy systems, strengthening coherence across governance levels and contributing to the mainstreaming of PEDs as a core component of Europe's climate-neutral urban transition.

In the last chapter, the policy actions for the EC are outlined and divided into:

- Short-term actions (0-2 years): Such as establishing a Harmonised PED RA Core Framework, launching an EU-level pilot programme for the PED RA tool, developing common guidance, templates, and training for national and local authorities, and clarifying governance, hosting, and maintenance of the PED RA tool and,
- Medium-term actions (2-5 years): Integrating PED readiness indicators into EPBD implementation and guidance, linking PED readiness scoring to EU funding and state aid priorities, embedding the tool in national and local planning routines (urban & energy planning), developing a data interoperability layer with EPBD and urban data platforms, developing a data interoperability layer with EPBD and urban data platforms, and establish a long-term European community of practice on PED assessment.

Overall, the PED RA Policy Strategy Roadmap serves as a bridge between innovation and implementation. It provides guidance for European institutions, Member States, cities, and stakeholders on how a harmonised PED readiness assessment can support evidence-based policymaking, facilitate access to finance, enhance comparability and transparency, and accelerate the deployment of PEDs as a key enabler of Europe's climate-neutral urban transition.

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