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Positive Energy Districts European Network

Deliverable 3.4

Develop common protocols for testing, monitoring, evaluation and replication of PEDs and PED Lab

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Executive Summary

The present report summarizes the activities done in task 3.4 concerning the development of common protocols for testing, monitoring, evaluation, and replication of PEDs and PED Labs

Context and Objectives

Positive Energy Districts (PEDs) represent a cornerstone of the European strategy for climate-neutral and sustainable cities, aiming to integrate renewable energy production, efficient storage, and flexible consumption within urban ecosystems. However, the deployment of PEDs faces persistent challenges, including technological, governance, financial, and regulatory barriers.
To address these challenges, Task 3.4 of the PED-EU-NET project has focused on the development of standardized protocols for testing, monitoring, evaluation, and replication of PEDs and PED Labs.

Key Findings

PED Labs as Innovation Hubs: PED Labs serve as real-world testing environments where urban stakeholders co-develop and validate PED solutions. They function as Knowledge Hubs, facilitating the exchange of best practices and innovative methodologies. PED Labs align with major EU initiatives such as the Climate Neutral Cities Mission and the New European Bauhaus (NEB).
Developing a Robust PED Evaluation Framework: a set of Key Performance Indicators (KPIs) has been proposed to assess PED Lab effectiveness across energy, economic, governance, and social dimensions. A methodology has been developed to integrate PED KPIs into existing certification protocols (LEED-ND, BREEAM-CM, CASBEE-UD), ensuring that PEDs are assessed at the district scale rather than only at the building level.
Pathways for PED Replication and Scalability: the research highlights the need for a scalable PED certification system, facilitating policy alignment and investment attraction. PED Labs should be

integrated into urban policy frameworks, ensuring their role as enablers of long-term sustainability strategies.

Policy and Research Recommendations

- Develop a unified PED certification protocol integrating energy, social, and economic KPIs. (Standardization of PED Assessment)
- Foster co-creation methodologies that empower communities in PED design and governance (Enhancing Stakeholder Engagement)
- Expand knowledge-sharing networks among PED initiatives across Europe (Facilitating Cross-Border Cooperation).

Conclusion

The findings of Task 3.4 highlight the urgent need to establish common evaluation frameworks that can enhance PED scalability, ensure policy alignment, and drive real-world impact. By embedding PED Labs into the European urban transition agenda, cities can accelerate their path toward climate neutrality, energy resilience, and inclusive urban regeneration.

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1. Introduction

Positive Energy Districts (PEDs) are emerging as a key element in the transition toward sustainable urban development, offering a promising approach to enhancing energy efficiency and mitigating the environmental impacts of climate change through surplus locally generated renewable energy [1]. Unlike traditional energy-efficient buildings, PEDs function as urban energy ecosystems, integrating renewable energy production, storage, distribution, and consumption at the district level.

At their core, PEDs are designed to generate more energy than they consume, creating self-sufficient urban areas capable of adapting to fluctuations in the energy market [2]. However, PEDs should not be defined solely by their annual net energy surplus; their success depends on their ability to dynamically integrate multiple stakeholders and respond to evolving technological, regulatory, and socio-economic conditions [3]. As their name suggests, PEDs are characterized by surplus renewable energy generation. Yet, recent advancements in urban environmental science highlight the need for a holistic, integrated approach that aligns with the key performance indicators (KPIs) of the UN's 17 Sustainable Development Goals (SDGs) [4]. This necessitates PED designs that go beyond energy efficiency, incorporating social, economic, and environmental dimensions to ensure their long-term viability and replicability.[3]. As their name suggests, PEDs are characterized by surplus renewable energy generation [5]. Yet, recent advancements in urban environmental science highlight the need for a holistic, integrated approach that aligns with the key performance indicators (KPIs) of the UN's 17 Sustainable Development Goals (SDGs) [6]. This necessitates PED designs that go beyond energy efficiency, incorporating social, economic, and environmental dimensions to ensure their long-term viability and replicability [7] [6]. This necessitates PED designs that go beyond energy efficiency, incorporating social, economic, and environmental dimensions to ensure their long-term viability and replicability [7].

Despite their transformative potential, the implementation of PEDs faces several recurring challenges, such as inadequate governance, lack of incentives, poor social acceptance, missing market structures, technological barriers, and contextual constraints [8]. Addressing these challenges requires innovative frameworks that can validate, refine, and scale up PED solutions in real-world conditions [9]. In this regard, PED Labs—as defined by JPI Urban Europe under the SET-Plan Action 3.2 Implementation Plan—play a fundamental role. These labs serve as seeding grounds for new ideas, solutions, and services, developed according to place-based needs and local contextual baselines [10]. PED Labs follow an integrative approach, encompassing technological, spatial, regulatory, financial, legal, social, and economic perspectives [5], [11], [12], [13]. They provide a structured yet adaptable framework for tackling the complexity inherent in PED implementation, fostering collaborative experimentation, cross-sectoral learning, and iterative innovation cycles.

The PED Lab concept encompasses multiple layers of experimentation and knowledge sharing. For example, it can involve a controlled environment for small- or medium-scale experimentation or a networked ecosystem of prototypal PED experiments [14], [15], [16]. PED Labs enable controlled testing of new technologies, business models, and governance frameworks within real urban contexts [17]. These controlled-risk environments reduce uncertainties, allowing for the validation of innovative solutions before large-scale deployment. Moreover, thanks to supporting international projects and research actions, PED Labs do not operate in isolation[14]. Instead, they form an extended laboratory network where cities, researchers, and practitioners can share both successes and failures, creating a repository of best practices, lessons learned, and validated methodologies.

As defined by the Strategic Energy Technology Plan (SET-Plan Action 3.2), PED Labs serve as pilot actions that facilitate planning, deployment, and iterative learning in the transition toward PEDs. They function as dynamic testing environments where regulatory frameworks, financial incentives, digital infrastructure, and social dynamics can be assessed in an integrated, real-world setting. By fostering cross-disciplinary collaboration and systemic innovation, PED Labs play a critical role in scaling up PED implementation across Europe [10].

However, despite advancements in the conceptualization and implementation of PEDs and PED Labs, several critical questions remain regarding their evaluation, monitoring, and replication [18]. The complexity of PEDs requires multidimensional assessment frameworks that go beyond traditional energy performance indicators to incorporate environmental, social, economic, and governance factors. While PED Labs provide a valuable platform for experimentation, their effectiveness in driving real change and influencing urban energy transitions still needs to be systematically assessed. To address these gaps, this research raises key questions that should guide the development of standardized evaluation methodologies for PEDs and PED Labs.

1.1 Objective of the Task 3.4

The implementation of Positive Energy Districts (PEDs) requires structured methodologies to assess their performance, ensure their feasibility, and support their replication across diverse urban environments. Given the complexity of PED deployment (encompassing technological, social, economic, and regulatory dimensions) Task 3.4 is dedicated to developing common protocols for testing, monitoring, evaluating, and replicating PEDs and PED Labs.

Building on the previous work conducted in WG3, this task also aligns with the broader European agenda on sustainable urban development, particularly in connection with two pivotal initiatives:

- The Climate Neutral Cities Mission, which accelerates the transition toward 100 climate-neutral and smart cities by 2030 [1], [2], [3], [4].
- The New European Bauhaus (NEB), which fosters a human-centered, aesthetic, and inclusive approach to sustainability [1], [2], [3].

Within this context, PED Labs act as Testing Platforms that drive Positive-Energy Living Laboratories, enabling cities to learn from real-world implementations and refine PED strategies for scalability and replication. However, to fully leverage PED Labs as innovation enablers, standardized frameworks are needed to evaluate their effectiveness, measure their impact, and ensure knowledge transfer across different regions.

To address these needs, Task 3.4 has been structured to answer the following key questions:

- What is the current gap between existing certification schemes and the needs of PED initiatives?
- How can we move beyond traditional building-level energy performance assessments by introducing district-scale sustainability criteria and contributing to the development of a PED certification system?
- What benefits do stakeholders expect from PEDs and PED Labs?

Through these research questions, Task 3.4 aims to provide actionable insights for cities and stakeholders to integrate PED strategies into urban development policies and investment plans, ultimately bridging the gap between experimental PED pilots and large-scale deployment. The goal is to ensure that PEDs evolve into replicable, adaptable, and impactful solutions, supporting the transition toward climate-neutral and sustainable urban development.

2. Activities

The activities developed within Task 3.4 have been designed to ensure a comprehensive and interdisciplinary approach, drawing on diverse sources of knowledge, collaboration, and real-world experiences. The key components that have informed the task's development include:

- Literature review: a thorough analysis of scientific literature and policy documents related to Positive Energy Districts (PEDs), focusing on best practices, existing frameworks, and key challenges in their implementation, monitoring, and replication. This review has provided a solid theoretical foundation and identified gaps that Task 3.4 aims to address.
- Consultation and interaction with other tasks of WG3 and other WGs of the COST Action: regular exchanges with other tasks within Working Group 3 (WG3) have ensured alignment and knowledge-sharing, enhancing the coherence of the research outcomes. Collaboration with Working Group 4 (WG4) has been particularly important for organizing events, workshops, and co-creation sessions aimed at gathering input from stakeholders and fostering cross-disciplinary dialogue.
- Consultation and interaction with other relevant initiatives: engagement with external initiatives has broadened the scope of Task 3.4, facilitating the exchange of best practices and innovative approaches. In particular, collaboration with the International Energy Agency's Energy in Buildings and Communities Programme (IEA-EBC) Annex 83 on Positive Energy Districts has provided insights into cutting-edge research, performance metrics, and international benchmarks for PED development.
- Practical Case Studies from the PED Database (https://pedeu.net/map/) and other EU projects: the analysis of practical case studies has been essential in grounding the research in real-world experiences. These case studies, sourced from the PED Database classification and other relevant European projects (such as those funded under Horizon Europe and DUT initiatives), have illustrated the diversity of PED implementations across different contexts. By examining the successes, challenges, and lessons learned from

these examples, Task 3.4 has identified replicable models and contextual factors that influence PED performance and scalability.

3. PED Certification protocols

Climate change and the EU's carbon neutrality target for 2050 present significant challenges, prompting the scientific community to develop innovative solutions [19]. One key initiative is the renovation of buildings across Europe, evolving from a focus on reducing greenhouse gas emissions to achieving climate neutrality [20]. Positive Energy Districts (PEDs) aim to place energy consumption and production at the forefront, demonstrating their benefits for society, the environment, and the economy while supporting new models of territorial governance [21].Climate change and the EU's carbon neutrality target for 2050 present significant challenges, prompting the scientific community to develop innovative solutions [19]. One key initiative is the renovation of buildings across Europe, evolving from a focus on reducing greenhouse gas emissions to achieving climate neutrality [20]. Positive Energy Districts (PEDs) aim to place energy consumption and production at the forefront, demonstrating their benefits for society, the environment, and the economy while supporting new models of territorial governance [21].Climate change and the EU's carbon neutrality target for 2050 present significant challenges, prompting the scientific community to develop innovative solutions [19]. One key initiative is the renovation of buildings across Europe, evolving from a focus on reducing greenhouse gas emissions to achieving climate neutrality[20]. Positive Energy Districts (PEDs) aim to place energy consumption and production at the forefront, demonstrating their benefits for society, the environment, and the economy while supporting new models of territorial governance [21].

However, despite their transformative potential, no comprehensive evaluation models currently exist to assess this revolutionary concept at the urban district level [22]. Globally recognized certification protocols (such as LEED-ND, BREEAM Communities, and CASBEE) serve as quality and comfort certification systems that assess key environmental and social aspects of buildings and districts [23]. These protocols help decision-makers objectively evaluate building performance, ensuring compliance with sustainability standards and enhancing market value [24]. In the real estate sector, such certifications are highly regarded, offering investors a reliable guarantee of long-term performance and sustainability, thanks to their globally recognized ratings[25]. However, despite their transformative potential, no comprehensive evaluation models currently exist to assess this revolutionary concept at the urban district level [22]. Globally recognized certification protocols (such as LEED-ND, BREEAM Communities, and CASBEE) serve as quality and comfort certification systems that assess key environmental and social aspects of buildings and districts [23]. These protocols help decision-makers objectively evaluate building performance, ensuring compliance with sustainability standards and enhancing market value [24]. In the real estate sector, such certifications are highly regarded, offering investors a reliable guarantee of long-term performance and sustainability, thanks to their globally recognized ratings [25].However, despite their transformative potential, no comprehensive evaluation models currently exist to assess this revolutionary concept at the urban district level [22]. Globally recognized certification protocols (such as LEED-ND, BREEAM Communities, and CASBEE) serve as quality and comfort certification systems that assess key environmental and social aspects of buildings and districts [23]. These protocols help decision-makers objectively evaluate building performance, ensuring compliance with sustainability standards and enhancing market value [24]. In the real estate sector, such certifications are highly regarded, offering investors a reliable guarantee of long-term performance and sustainability, thanks to their globally recognized ratings [25].

Despite these benefits, current certification systems are not fully equipped to evaluate PEDs or energy communities at the district scale. Existing protocols have not yet integrated the latest advancements in energy management, making it essential to identify the unique characteristics that differentiate PEDs from traditional developments [9], [26]. In other words, what are the limitations of existing evaluation frameworks when applied to PEDs? While current protocols do not yet account for PED-specific features, they still cover many essential aspects of sustainability. This provides an opportunity to update and expand existing systems by introducing new evaluation criteria and reformulating scoring methods to better assess the performance and impact of Positive Energy Districts [9], [23].Despite these benefits, current certification systems are not fully equipped to evaluate PEDs or energy communities at the district scale. Existing protocols have not yet integrated the latest advancements in energy management, making it essential to identify the unique characteristics that differentiate PEDs from traditional developments [9], [26]. In other words, what are the limitations of existing evaluation frameworks when applied to PEDs? While current protocols do not yet account for PED-specific features, they still cover many essential aspects of sustainability. This provides an opportunity to update and expand existing systems by introducing new evaluation criteria and reformulating scoring methods to better assess the performance and impact of Positive Energy Districts [9], [23].Despite these benefits, current certification systems are not fully equipped to evaluate PEDs or energy communities at the district scale. Existing protocols have not yet integrated the latest advancements in energy management, making it essential to identify the unique characteristics that differentiate PEDs from traditional developments[9], [26]. In other words, what are the limitations of existing evaluation frameworks when applied to PEDs? While current protocols do not yet account for PED-specific features, they still cover many essential aspects of sustainability. This provides an opportunity to update and expand existing systems by introducing new evaluation criteria and reformulating scoring methods to better assess the performance and impact of Positive Energy Districts [9], [23].

As shown in picture below, Task 3.4 has tackled this issue through the following three steps:

1. Identification of Relevant Certification Protocols [9]: The first step involved identifying the main certification protocols that could serve as reference points for compiling a list of qualities and characteristics already recognized within existing sustainability frameworks. The key outcome was a redistribution of the weight assigned to both PED-specific and non-PED criteria, along with the inclusion of new PED-specific criteria within the rating system.
2. Review of Significant PED Case Studies [23]: This step focused on analyzing prominent PED case studies and exploring the applicability of existing sustainability protocols. The objective was to assess how PED projects can both benefit from and contribute to the improvement of current evaluation systems through innovative interventions not previously considered. Three of the world's best-known certification systems—LEED-ND, BREEAM-CM, and CASBEE-UD—were applied to two completed PED case studies in Tampere, Finland, and Salzburg, Austria, to identify gaps and overlooked characteristics.

Review and Refinement of District-Level Certification Protocols: The final step involved a comprehensive literature review and a focus group with PED experts to examine existing district-level certification protocols. The insights gained contributed to the development of a preliminary PED certification framework, including clearly defined criteria, measurable parameters, and scoring systems designed to support PED design and implementation.

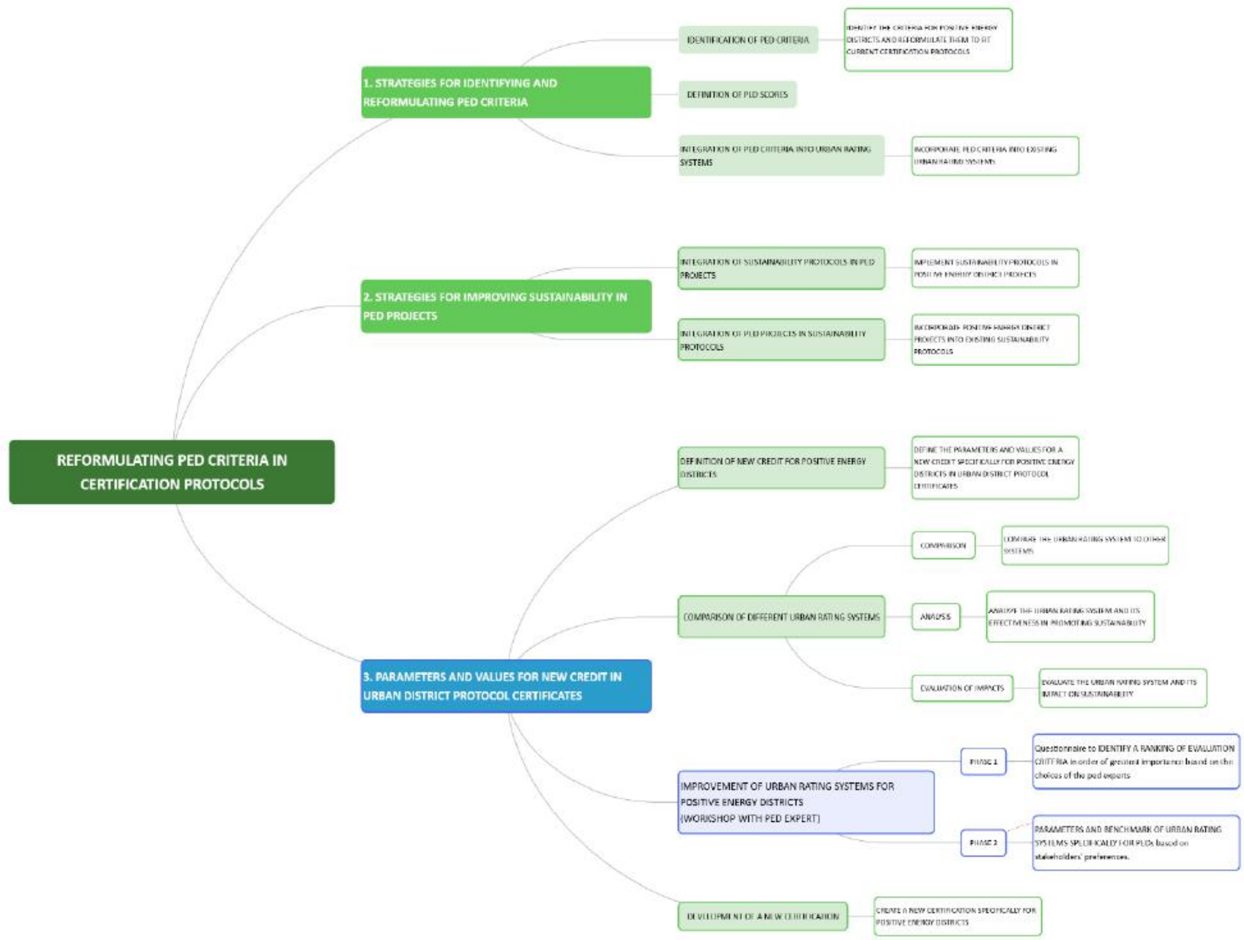

Figure 1 Conceptual approach to the identification of innovative criteria to be included in a PED certification protocol

2.1 Identification of PED criteria, and reformulation of them into current certification protocols

Objectives:

The literature review analyses existing district-level certification protocols, focusing on current evaluation frameworks' criteria and scoring methods. The insights gained contribute to the development of a dedicated PED certification protocol, featuring clear, effective criteria and scoring systems designed to support the design and implementation of Positive Energy Districts (PEDs) [9], [23], [24].

Methodology

The methodology to introduce and weight new criteria is developed in five stages:

1. Analysis of current certification protocols to identify existing PED strategies and assess their alignment with PED-specific requirements
2. Develop a new criterion to be included within the protocol based on the previously identified strategies. This criterion is designed to meet the diverse requirements of different protocols, considering the varying internal strategies of each system.
3. Definition of the internal scores within each protocol, categorizing them into two groups: PED scores (p_PED) and non-PED scores (p_nPED). This classification facilitates the differentiation between PED-specific and general sustainability criteria.
4. Introduction of a new credit score, referred to as P_nc, using one of the following methods to maintain balance within the protocol's evaluation system:
   - 4.1. Decrease the p_PED score by a fixed percentage (%nc) to maintain proportionality within the overall scoring system. The %nc varies for each protocol, depending on the total number of credits (p_tot) and the p_PED score. The following formula is used to determine the reduction:

$$P_{nc} = p_{PED} \times \%_{nc}$$

   - 4.2. Decrease the p_nPED score by a fixed percentage (%nc) to increase the relative value of the PED score within the new protocol. The following formula is used:

$$P_{nc} = p_{nPED} \times \%_{nc}$$

5. Recalculate the scores of the other internal criterion (P_{ic}) using the formulas below to ensure that the newly introduced criterion does not change the overall score of the entire protocol:

$$P_{ic} = p_{iPED} \times (1 - \%_{nc})$$

$$P_{ic} = p_{inPED} \times (1 - \%_{nc})$$

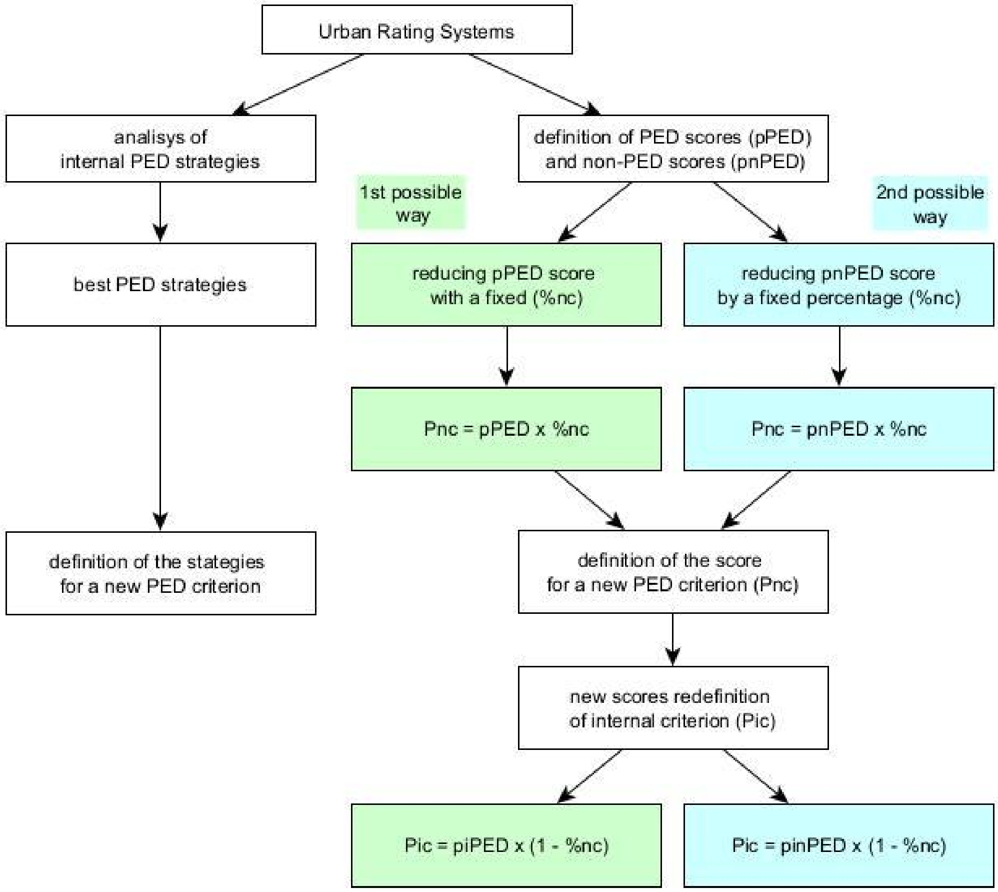

Figure 2 Methodological scheme. Two possible ways are considered to adjust the score of the internal criterion in order to keep the overall protocol consistent. Source: [9]

Then, the methodology is applied to 3 well-known certification protocols: LEED v4 for Neighborhood Development Plan, BREEAMS Communities, and CASBEE Urban District, to test in practice the possible introduction of new criteria and their weighing.

Results and Future Developments

New criteria suggested are:

- Energy surplus and flexibility
- New business model for PED, citizen energy communities (CEC) and renewable energy communities (REC)
- Resilience and security of energy supply
- Quality of life
- Technological system for energy production (for CASBEE Urban District only)

After the introduction of new criteria needed to frame the particular energy characteristics of PED in comparison to general sustainability assessment of original protocols, the importance of PED scores (p_PED) and non-PED scores (p_nPED) takes these numbers:

Table 1 Distribution of PED scores (p_PED) and non-PED scores in three different certification protocols. Source: [9]

	LEED for Neighborhood Development Plan	BREEAM Communities	CASBEE Urban District
p_PED	80	82.1	74.78
p_nPED	20	18.2	25.24
p_Tot	100	100.3	100.02

On the basis of the results obtained in this phase, it was decided to combine PED case studies in order to test and validate the analysis process identified and at the same time to verify with the case studies that the characteristics of the criteria identified for evaluating PEDs were confirmed and possible modifications for both the PED sustainability protocols and the case studies were highlighted.

3.2 Application of modified sustainability protocols in existing PED projects to inspire overall improvement

Objective:

Existing certification protocols were developed before the emergence of Positive Energy Districts (PEDs) and, as a result, do not explicitly account for PED-specific characteristics. However, they incorporate several overlapping sustainability principles that can be leveraged to assess PED performance.

This research explores how the integration of sustainability protocols into existing PED projects can enhance their overall sustainability while also examining how PED initiatives, in turn, can contribute to improving evaluation frameworks through previously unconsidered interventions.

To test a methodology that could be applied to future case studies, three of the world's most widely recognized certification systems—LEED-ND[27], [28], [29], BREEAM-CM[27], [30], [31], [32], and CASBEE-UD[33]—were analyzed in relation to two completed PED case studies: Tampere (Finland) and Salzburg (Austria) [23].To test a methodology that could be applied to future case studies, three of the world's most widely recognized certification systems—LEED-ND [27], [28], [29], BREEAM-CM [27], [30], [31], [32], and CASBEE-UD [33]—were analyzed in relation to two completed PED case studies: Tampere (Finland) and Salzburg (Austria) [23].

Methodology

Figure 1 presents a dual approach for analysing the alignment between sustainability certification protocols and the characteristics of Positive Energy Districts (PEDs). This involves:

- Assessing protocol criteria (i.e., identifying all the criteria within existing certification protocols that correspond to PED characteristics);
- Comparing protocols with real-world PED projects. This is done by evaluating how well these certification schemes reflect the features and requirements of implemented PEDs.

The two case studies were selected based on their status as completed and fully operational PED projects. This allows for a comprehensive evaluation of both the strengths and limitations of the analysed certification protocols and the PED implementations themselves. To facilitate comparison, key parameters and characteristics were extracted from the PED-EU-NET portal, as outlined below.

The first case study examines the Salzburg Gnigl district, located in Salzburg, Austria. This PED consists of a small group of residential buildings designed with a dynamic district and building-scale energy modeling approach. The project's key strategies include microclimate modeling, integration into the Klimaaktiv certification system, the establishment of an energy community, and shared heating and electricity systems to enhance flexibility and efficiency.

The second case study focuses on the Ilokkaanpuisto district in Tampere, Finland. This PED project prioritizes energy efficiency, featuring A-class buildings, geothermal heat pumps, and photovoltaic installations. Additionally, the project incorporates smart digital technologies for HVAC control and indoor climate monitoring, while promoting e-mobility through the installation of EV charging stations.

Much of the information used in this analysis was obtained from the PED-EU-NET database, which serves as a reference for assessing the sustainability performance and replicability of Positive Energy Districts.

From this comparison, three distinct scenarios emerge:

1 The certification protocol already includes PED-relevant aspects (e.g. photovoltaic integration, community involvement) at comparable quantitative levels (Alignment Scenario). In this case no additional changes are required

2 The certification framework demonstrates more advanced sustainability features than the analysed PED projects (Protocol Enhancement Scenario): existing projects or new projects can be improved by adopting best practices from the certification schemes.

3 The PED case studies outperform the existing certification protocols in specific areas, such as energy surplus generation or innovative governance models (PED Contribution Scenario). These insights can inform potential updates to the certification criteria to better capture PED-specific contributions.

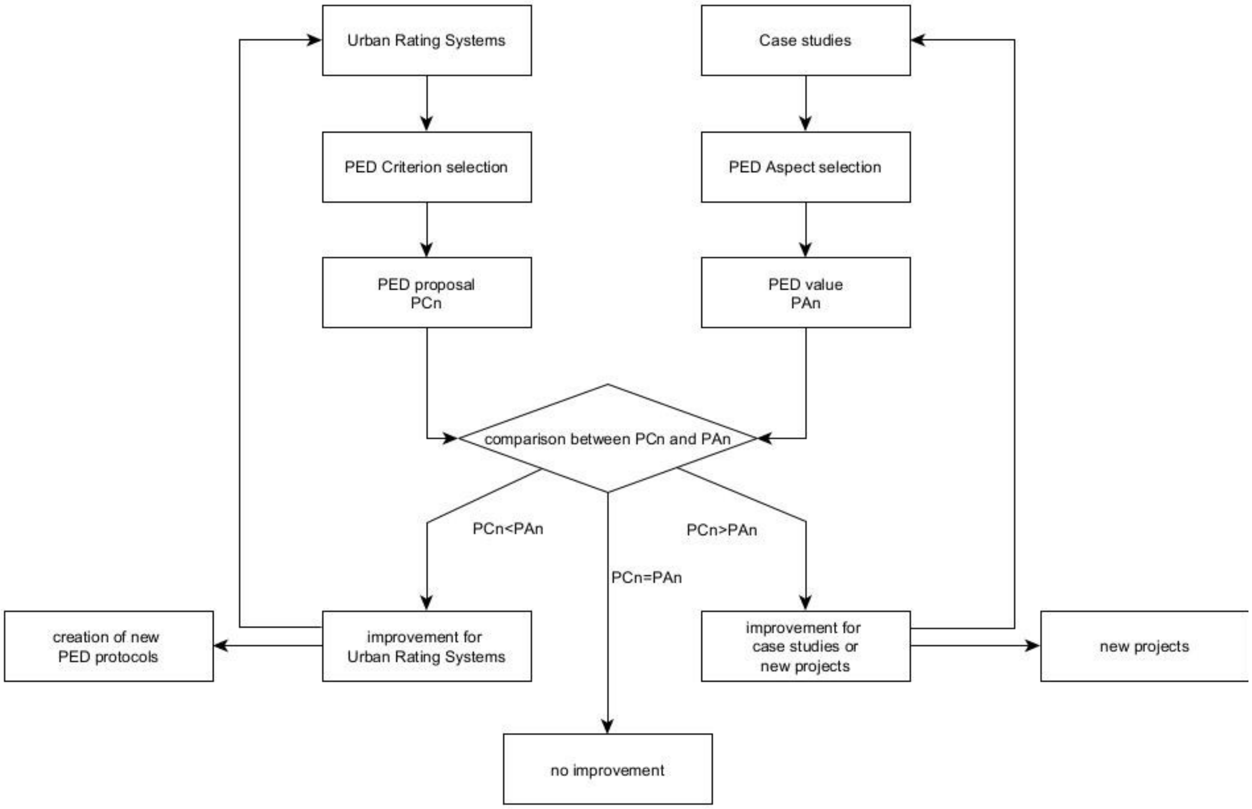

Figure 3 Flowchart of the methodology used, where PCn is the n-th PED criterion selected in an urban rating system and PAn is the n-th PED aspect selected from a case study. Source: [23].

Results

It was observed that certain criteria, such as for LEED-ND access to quality transit, local food production, and wastewater management, are highly valued within the certification framework but were not actively addressed in the analyzed PED case studies.

These aspects can play a crucial role in enhancing the long-term sustainability and resilience of Positive Energy Districts. Access to quality transit promotes low-carbon mobility solutions, reducing reliance on private vehicles and contributing to the overall reduction of greenhouse gas emissions. Local food production fosters community engagement, increases urban resilience, and minimizes the carbon footprint associated with food transportation. Wastewater management, when properly integrated, supports resource efficiency by enabling water reuse, reducing pollution, and contributing to circularity principles.

The fact that these elements were not emphasized in the analyzed PEDs suggests opportunities for future improvements. By incorporating these additional sustainability criteria into PED design and planning, future projects could enhance their environmental, social, and economic performance, further aligning with the broader objectives of sustainable urban development and climate neutrality.

Conversely, LEED-ND does not account for energy surplus—the ability to generate more energy than is consumed—nor does it consider emerging business models and the evolving role of City Energy Communities (CECs) and Renewable Energy Communities (RECs) in relation to both case studies. Additionally, the certification framework does not incorporate nature-based solutions (NBSs), which are particularly relevant to the Tampere case study.

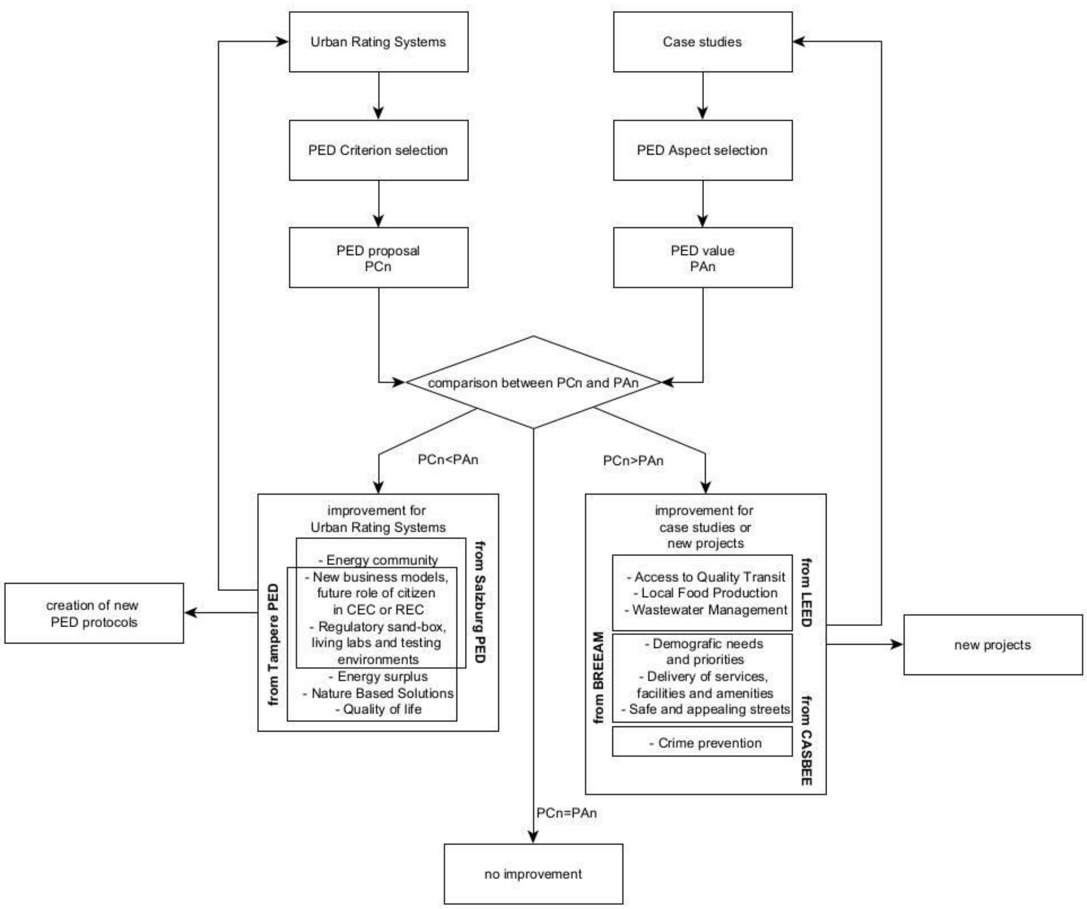

Figure 4 Flowchart of the methodology and key results used. Improvements for the case studies on the right and improvements for the certification protocols on the left. Source:[23].

Possible future developments, based on the methodology outlined, could concern the following aspects:

- The use of the same methodology to evaluate and integrate other protocol systems;
- The implementation of a new PED protocol based on the integration of existing ones.

3.3 Workshop for the inclusion of PED characteristics in urban/district protocols

Given the significance of this research and the relevance of the topic, it was deemed essential to share the progress with the wider COST ACTION community and PED experts. This ensures broader awareness of the positive outcomes achieved thus far while fostering knowledge exchange within the field. Additionally, the research has reached a critical stage where it is necessary to define the indicators, parameters, and threshold values that will be used to evaluate the PED criterion within certification protocols. The need for a dedicated PED evaluation framework stems from the growing number of diverse sustainable urban neighborhoods emerging from European projects and the lack of urban-district-scale certification protocols capable of adequately addressing the unique and innovative characteristics of PEDs. Therefore, within task 3.4 activities, a dedicated workshop with experts has been held on 10-12 June 2024 at the H-Farm Campus in Italy.

Overview and objective of the Workshop

The workshop aimed to present ongoing research on the development of a dedicated certification protocol for Positive Energy Districts (PEDs). It provided a platform to showcase validated strategies and development models while fostering collaborative discussion among experts. Participants were invited to identify key contributions and overlooked aspects that should be incorporated into the assessment of PED sustainability.

Designed for PED professionals and researchers, the workshop not only informed attendees about the research progress but also sought their expert insights to refine the certification framework. The ultimate goal was to define new evaluation criteria that highlight the distinctive added value of PEDs compared to other sustainable urban districts, ensuring the protocol serves as a modern and contextually relevant tool for the ongoing energy transition.

Discussions focused on sustainability protocols at the urban scale, emphasizing the need for innovation in certification methodologies tailored specifically to PEDs.

As illustrated in Figure 5, the process of identifying new criteria that effectively enhance the evaluation of Positive Energy Districts (PEDs) requires a comprehensive reassessment of all existing internal criteria. In particular, the evaluation model must be strategically aligned with the distinctive energy characteristics of PEDs, while maintaining a holistic perspective that extends beyond purely technological and sectoral performance metrics. This approach must also integrate governance structures, business models, and a multi-stakeholder perspective, ensuring that PED assessment reflects the full complexity of their urban, economic, and social dimensions.

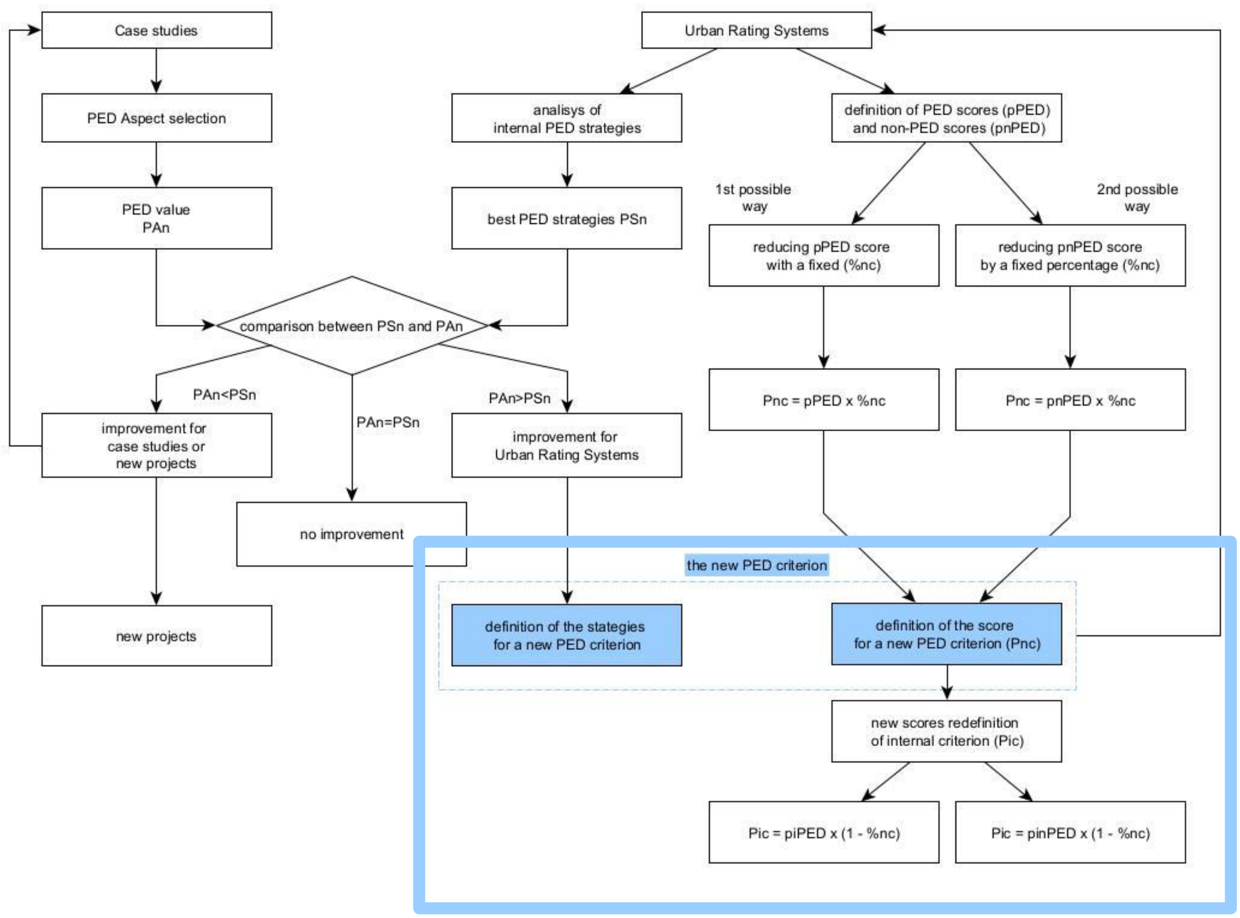

Figure 5 Flowchart of the methodology with a focus on the definition and scoring of a new PED criterion

A key aspect of the workshop was, therefore, to provide a structured division of evaluation criteria into the four fundamental pillars of sustainability: social, economic, environmental, and governance. As part of the ongoing research, participants contributed their expertise to help define new assessment methodologies that accurately reflect the unique characteristics of PEDs. Their input will play a crucial role in shaping a comprehensive and adaptable certification framework for future PED implementation.

Methodology

The workshop was structured into three key parts, each designed to facilitate discussion, collaboration, and the advancement of research on PED certification protocols.

1 The first part set the stage by explaining the necessity of the workshop, introducing both online and in-person participants to the topic of certification protocols and PEDs. This session presented the validated research findings as well as the ongoing research challenges that had yet to be resolved. Additionally, the importance of engaging a specialized scientific committee on PEDs was highlighted, emphasizing the critical role of expert input in validating and refining the proposed certification model.

2 In the second part, active participant engagement was essential in addressing the missing operational components of the research. Participants completed two structured questionnaires:

- The first questionnaire assessed the relative importance of PED characteristics, helping to identify key prerequisites.
- The second questionnaire focused on defining the parameters for the pre-identified evaluation criteria.

While designing this part of the exercise, several key questions emerged:

- How could a hierarchical order of PED indicators be established to effectively highlight their role in sustainability assessments?
- What methodology would ensure a scientifically validated prioritization process?

To address these challenges, we applied a Best-Worst Scaling (BWS) questionnaire tailored for PED experts. The methodology presented respondents with a list of indicators, requiring them to repeatedly select the most and least important ones. To ensure statistical reliability, each indicator appeared at least three times, a threshold scientifically validated for obtaining consistent and accurate results[1].

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[1] Best-Worst scaling method is presented more in detail in section “Multiple benefits and PED Labs Analysis”

3. The final session presented the results of the workshop, analyzing their impact on ongoing scientific research. A summary of key findings was provided, along with conclusions on how the workshop's outcomes contributed to the advancement of PED certification methodologies.

Workshop development – Interactive session

In the inception (initial phase), participants are introduced to the suggested new criteria, then these are analysed to determine their contribution to the overall scoring system (second phase). The criteria embrace all areas of the sustainable development concept and are grouped according to this classification:

- Energy:
  - Energy efficiency
  - Energy flexibility
  - Energy surplus
  - Nearly-Zero Energy Buildings and Net-Zero Energy Districts
  - Renewable Energy production
  - Energy community
- Urban and local development, real estate
  - Technological solutions
  - Sector coupling and cross-sectorial integration
  - New business models, future role of „citizen energy communities“ (CEC) and „renewable energy communities“ (REC)
  - Active involvement of problem owners and citizens
  - Urban areas or groups of connected buildings
  - Existing building stock
  - Resilience and security of energy supply
- Infrastructure
  - Green and blue infrastructures
  - Mobility system in the PED

- People
  - Inclusiveness, tackling affordability of housing and fighting energy poverty as main aspects of inclusiveness
  - Quality of life
  - Regulatory sandboxes, living labs and testing environments

First, the criteria are grouped into categories and assigned a preliminary score based on their relevance. This score is then adjusted using a weighting factor, which determines how much each criterion contributes to defining the unique characteristics of a Positive Energy District (PED).
To ensure the methodology is applied effectively, it is crucial to prioritize the identified criteria according to their alignment with PED-specific features. Establishing this hierarchy of importance helps create a scoring system that accurately reflects the distinctive attributes of PEDs, differentiating them from other types of sustainable urban developments.

Workshop results: relative importance of PED characteristics (1° questionnaire)

Figure 6 presents the results of the first questionnaire, where the identified characteristics have been ranked by the software based on participant responses (15 respondents).

The method used for this questionnaire was the Best Worst Scaling method, a scientific method which, by combining all the characteristics we have placed in a random order, proposes and re-proposes to the user a random combination of the different items, allowing them to choose the best and the worst. This allows the software to produce a ranking based on the answers it receives. This method is widely used in statistics as it allows very accurate results to be obtained, breaking the typical barrier that prevents questionnaires from being objective.

The analysis highlights that many of the most frequently selected characteristics belong to the environmental domain, as expected, given their strong connection to energy-related aspects. Respondents also emphasized the incentivizing role that should be attributed to the presence of existing buildings, provided they are appropriately retrofitted and adapted to contribute to achieving PED status and, more broadly, to urban energy and climate transition goals.

Another notable insight concerns the integration of mobility systems within the PED concept, not only from an energy efficiency perspective but also in terms of urban accessibility and connectivity. Finally, respondents expressed interest in including an indicator related to overall quality of life, reinforcing the idea that a PED should be a livable and attractive environment for residents and users, rather than merely a technological infrastructure or an engineering exercise.

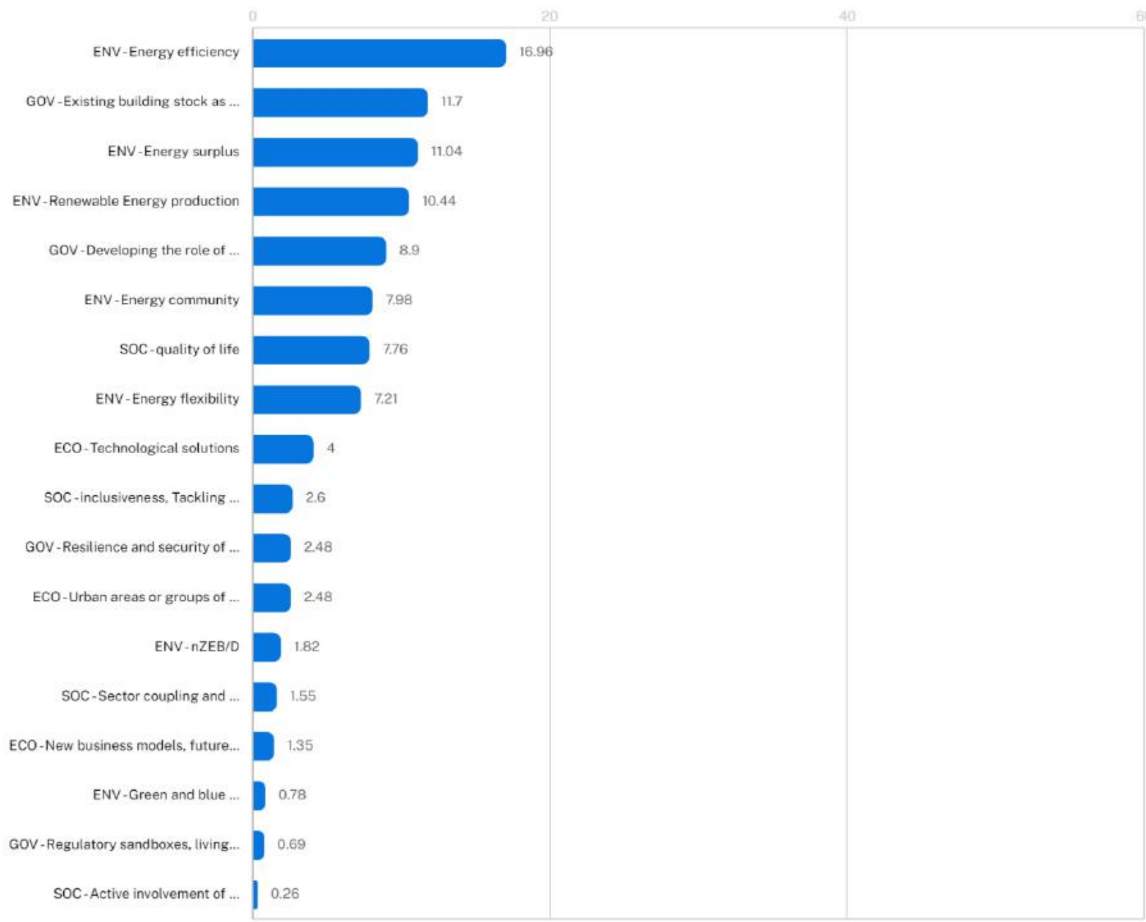

Figure 6 results of the first questionnaire

Workshop results: preferred indexes (2° questionnaire)

Based on the ranking that emerged from the first exercise, the main criteria to be included in the PED strategy were identified. From the initial set of 18 criteria, only 8 were retained, proportionally to the consistency of each of the four thematic areas, i.e., multiplying the number of criteria by the percentage of presence and rounding to the unit figure.

Accordingly, the following are considered:

- 3criteria for the environmental area;
- 1 criterion for the economic area;
- 2 criteria for the social and governance area.

Table 2 Resizing of overall criteria by percentage of presence

	N° of criteria	% of presence	N° of criteria selected/% of presence
ENV	7	39%	3
ECO	3	17%	1
SOC	4	22%	2
GOV	4	22%	2
SUM	18	100%	8

At this point, three different parameter options (indices) were provided to the workshop participants for each characteristic for their objectification (see ANNEX 1). The option that received the most votes was the one highlighted in green, while the one highlighted in yellow received an intermediate vote and the one highlighted in red received the least number of votes. The results are shown in the table below.

Table 3 Ranking preferences expressed by respondents during the PED workshop

SDGs	PED characteristic	Indexes and values
Category	Energy	
ENV	Energy efficiency	The District Energy Efficiency Ratio (DEER) measures how efficiently a Positive Energy District (PED) performs compared to the average energy efficiency of individual buildings within the district.

		DEER= Average Energy Consumption per Building (kWh/m²) / Average Energy Consumption of the PED (kWh/m²)
		Coefficient of Performance (COP) for a PED measures the efficiency of the energy system by evaluating how much useful energy output (electricity, heating, cooling, etc.) is delivered relative to the total energy input, including primary energy consumption from on-site renewable sources and external energy imports. COP PED = Total Useful Energy Delivered (kWh) / Total Energy Input (kWh)
		Optimized use of energy resources within the district to minimize energy consumption while maximizing the utilization of locally generated renewable energy. Energy Efficiency Index = Total Energy Demand in the PED (kWh)/ Locally Generated Renewable Energy (kWh)
ENV	Energy surplus	The Energy Surplus Ratio (ESR) quantifies the ability of a Positive Energy District (PED) to generate more renewable energy than its total energy demand. It provides a measure of PED self-sufficiency and its contribution to the broader energy system by assessing how much excess energy is available for redistribution, storage, or grid injection. Different classes may be possible with regard to surplus basis (sub-hourly, hourly, monthly, annual) ESR= Total Renewable Energy Generation (kWh)/ Total Energy Demand (kWh) /
		The Net Energy Balance (NEB) index measures the energy surplus of a PED by comparing total renewable energy generation to total energy demand, considering energy imports and exports. It provides a comprehensive assessment of whether a PED operates as a net energy producer, consumer, or neutral entity over a defined period (hourly, daily, monthly, or annually). NEBI= (Total Renewable Energy Generation − Total Energy Demand) / Total Energy Demand *100

		The Smart Energy Surplus Utilization (SESU) index measures how efficiently a Positive Energy District (PED) manages and distributes its energy surplus through intelligent power management systems. It evaluates the extent to which surplus energy is stored, shared, or redistributed within the PED or to the grid, instead of being wasted or curtailed. SESU= Effectively utilized surplus energy (kWh) / total surplus energy (kWh) *100
ENV	Renewable Energy production	The Local Renewable Energy Production (LREP) index measures the proportion of a Positive Energy District's (PED) total energy consumption that is covered by locally generated renewable energy sources. It provides a clear assessment of the district's reliance on on-site renewable energy. LREP = Total renewable Energy Generation on site (kWh) / Total energy demand (kWh) * 100
		The PED Renewable Energy Compliance (PREC) index compares the local renewable energy production within a Positive Energy District (PED) to the minimum renewable energy production requirements per building set by the Energy Performance of Buildings Directive (EPBD). This KPI evaluates whether the PED outperforms, matches, or falls short of the required renewable energy standards applied to individual buildings PREC= Total local renewable energy production per mq (kWh/mq) / EPBD minimum renewable energy production per mq (kWh/mq)
		The Renewable Energy Diversity (RED) index measures the variety and balance of local renewable energy sources within a Positive Energy District (PED). It evaluates how well the PED integrates multiple renewable energy technologies (e.g., solar, wind, geothermal, biomass) and avoids over-reliance on a single source. RED = (Σ (RE * W) / Total renewable energy production) * 1000

		Where RE is the energy produced by each different source and W a weighting factor based on the number of sources, promoting diversity
	Urban and local development, real estate	
ECO	Technological solutions	The AI-Based Embodied Carbon Footprint (AECF) index measures the total embodied carbon emissions associated with the construction, materials, and infrastructure of a Positive Energy District (PED) using AI-driven lifecycle assessment (LCA) models. This KPI leverages artificial intelligence to predict, monitor, and optimize the embodied carbon footprint of materials and construction activities across the entire district. AECF = Σ (EC * Q* C) / Total built area (mq) Where EC = embodied carbon per unit of material Q = quantity of material used in the PED C = correction factor for material based on AI-optimized efficiency improvement
		The AI-Based Emission Abatement Forecasting (AEAF) index evaluates the effectiveness of a Positive Energy District (PED) in reducing its carbon emissions over time using artificial intelligence-driven simulations. This KPI predicts future emission reduction trajectories by integrating real-time data, historical trends, and AI-based scenario modeling, helping policymakers and urban planners optimize decarbonization strategies dynamically. AEAF = Predicted CO_2eq reduction by AI (ton CO_2eq) / Baseline CO_2eq * 100
		The Carbon Offsetting Effectiveness (COE) index measures how effectively a Positive Energy District (PED) neutralizes its residual carbon emissions through carbon offset mechanisms such as reforestation, carbon capture, nature-based solutions, etc. It quantifies the proportion of total emissions that are offset and assesses the efficiency and reliability of the offset strategies implemented. COE = Total carbon offset (ton CO_2eq) / Residual Carbon Emissions (t CO_2eq) * 100
GOV	Existing building stock (reuse and adaptation)	The Existing Building Integration and Rehabilitation (EBIR) index measures the effectiveness of a Positive Energy District (PED) in rehabilitating, retrofitting, and integrating existing buildings into its sustainable energy framework. This KPI compares the energy performance improvements of rehabilitated buildings within the PED to the surrounding built environment, assessing the PED's ability to drive urban regeneration

		EBIR = (∑ (E_before – E_after)/buildings inside PED) / ∑ (E_baseline – E_current)/ Buildings outside PED Where E_before = Energy consumption of existing buildings in PED before rehabilitation E_after = Energy consumption of rehabilitated buildings after integration into the PED E_baseline = Energy consumption of existing buildings surrounding the PED E_current = Energy consumption of rehabilitated buildings surrounding the PED after typical renovation practices
		The Adaptive Reuse Business Model (ARBM) index measures the extent to which a Positive Energy District (PED) successfully integrates existing buildings into its energy and sustainability framework through a structured business model for PED management. ARBM = (W1 * adaptive reuse share) + (W2 * business model maturity score) / W1 + W2 Adaptive Reuse Share (%) = The proportion of total PED floor area that consists of repurposed and rehabilitated existing buildings, rather than new construction. Business Model Maturity Score (0-100) = A qualitative assessment of the existence, implementation, and effectiveness of a business model for PED operation, based on predefined criteria (e.g., governance structure, financing mechanisms, stakeholder involvement). W1 and W2 Weighting factors prioritizing physical reuse (W1) and business model effectiveness (W2) based on PED objectives
		The Urban Structure Reuse Masterplan (USRM) index measures the extent to which a Positive Energy District (PED) integrates existing urban structures (e.g., buildings, roads, infrastructure) into its development strategy, based on the existence and implementation of a dedicated reuse masterplan. This KPI evaluates whether urban regeneration efforts are systematically planned and executed, reducing demolition, preserving embodied carbon, and ensuring sustainable land use. URSM = (W1 * Urban structure reuse share) + (W2 masterplan implementation score) / W1 + W2
GOV	Role of mobility in the PED	The Mobility Energy Impact (MEI) index measures the share of transportation-related energy consumption within the overall energy balance of a Positive Energy District (PED). This KPI quantifies how mobility systems affect the district's energy

		efficiency, renewable integration, and carbon footprint, highlighting the relevance of sustainable transportation strategies in PED design. MEI = total mobility energy consumption (kWh) / total PED energy demand (kWh) * 100
		The Sustainable Mobility Infrastructure Development (SMID) index measures the extent to which a Positive Energy District (PED) integrates new dedicated mobility infrastructures (e.g., cycling lanes, pedestrian areas, electric vehicle charging stations, smart mobility hubs) into its urban planning. This KPI evaluates the proportion of newly developed or upgraded mobility infrastructure relative to the total urban area, highlighting the PED's commitment to sustainable and low-energy transport solutions. SMID = total dedicated mobility infrastructure area (mq) / total PED area (mq)* 100
		The Electric Mobility Flexibility Contribution (EMFC) index measures the extent to which electric mobility systems (e.g., electric vehicles, e-buses, e-bikes) contribute to local energy storage and grid flexibility within a Positive Energy District (PED). This KPI evaluates how well Vehicle-to-Grid (V2G), Vehicle-to-Building (V2B), and smart charging strategies support energy management, ensuring that mobility acts as an active component of the PED's energy balance rather than just a consumer. EMFC = Total energy supplied to the grid from EVs (kWh) / Total local energy storage capacity (kWh) * 100
	People	
SOC	Inclusiveness and tackling affordability of housing and fighting energy poverty	Social Housing Inclusiveness (SHI) index measures the extent to which a Positive Energy District (PED) integrates affordable and social housing through dedicated urban planning instruments and policies. This KPI evaluates the share of total residential units allocated to social housing, ensuring that the PED remains socially inclusive and accessible to diverse income groups SHI = 100 * (social housing units in PED / total residential units in PED) * (urban policy implementation score / maximum policy implementation score
		The Inclusive Energy Contract (IEC) index measures the extent to which a Positive Energy District (PED) provides diverse and accessible energy contract options, ensuring that all socio-economic groups—including low-income households, renters, and small businesses—have equitable access to affordable and flexible energy services. This KPI evaluates the distribution of contract types within the PED,

		emphasizing social tariffs, community-based energy programs, and flexible pricing models that enhance affordability and inclusiveness. ICE = 100* (%subsidized energy contracts + % flexible contracts + % participation in REC / total of energy contracts in PED
		The Inclusive and Affordable Energy Access (IAEA) index measures the extent to which a Positive Energy District (PED) ensures affordable, equitable, and inclusive access to clean energy and sustainable urban services. This KPI evaluates the economic accessibility of energy and mobility services, ensuring that the PED benefits all socio-economic groups, including low-income households and vulnerable populations. 100 – (W1*(Average Household Energy Cost / median income)) + (W2*(1-(%Subsidized or Social Energy Access/N Households in PED)))+W3*(1-(%Affordable Mobility Services/total mobility options) Where W1, W2 and W3 are weighting factors prioritizing energy affordability, subsidized access, and inclusive mobility, based on PED policy goals The IAEA index increases when the PED offers more economically and socially accessible energy and mobility. A value close to 100 indicates a highly inclusive and accessible district, while a low value signals equity problems in access to energy and mobility.
SOC	Quality of life	The Quality of Life (QL) index measures the overall well-being and livability of a Positive Energy District (PED) by integrating key dimensions from the OECD Better Life Index. This KPI assesses how the PED enhances housing conditions, environmental quality, accessibility, safety, and social inclusivity, ensuring that urban transformation leads to a high standard of living for all residents. QL = 100*Σ (W*S)/N Where W is a weighting factor for each quality of life dimension based on its relative importance S is a normalized score for each dimension, ranging from 0 to 1, where 1 represents the highest performance.

		N the total number of dimensions evaluated Suggested Key Quality of Life Dimensions (Based on OECD Indicators): Housing Quality – Availability of adequate, energy-efficient, and affordable housing. Air Quality – Average PM2.5 concentration and green space per capita. Accessibility – Proximity to public transport, healthcare, education, and essential services. Safety – Crime rates and perceived safety in public spaces. Social Inclusivity – Integration of diverse social groups, gender equity, and community participation in decision-making.
		The Urban Planning Quality of Life (UP-QL) index evaluates how well urban planning instruments and strategies contribute to quality of life in a Positive Energy District (PED). This KPI assesses whether urban plans effectively integrate key livability factors, such as green spaces, mobility infrastructure, housing policies, public services, and social inclusivity, to create a sustainable and people-centered urban environment. $UP\text{-}QL = 100 * \Sigma (W * P) / N$ Where: W is the weighting factor for each urban planning dimension based on its relative importance. P is the normalized score for each dimension, ranging from 0 to 1, where 1 represents full integration in urban planning. N is the total number of urban planning dimensions evaluated. Suggested Key Urban Planning Dimensions: Green Space Allocation – Percentage of public parks, urban forests, and green corridors relative to the total PED area. Accessibility to Services – Proximity of residents to healthcare, education, and essential public services. Social Infrastructure – Availability of cultural, recreational, and community spaces. Housing Inclusivity – Share of affordable and social housing planned in the PED. Sustainable Mobility – Integration of pedestrian-friendly streets, cycling networks, and public transport infrastructure in urban planning.

		The Policy Action Plan Quality of Life (PAP-QL) index measures the effectiveness of political action plans and policy frameworks in enhancing quality of life within a Positive Energy District (PED). This KPI evaluates whether the policy agenda and implemented actions address key livability factors such as housing, mobility, public services, environmental quality, and social inclusivity, ensuring that the PED fosters a sustainable and equitable urban environment. PAP-QL = 100 * Σ (W * P) /N Where: W is the weighting factor for each policy dimension based on its relative importance. P is the normalized score for each dimension, ranging from 0 to 1, where 1 represents full integration in urban planning. N is the total number of policy dimensions evaluated. Suggested Policy Action Plan Dimensions: Affordable and Inclusive Housing Policy – Integration of social housing, rent control, and community-driven housing initiatives. Sustainable Mobility Policy – Development of low-carbon transport solutions, pedestrian and cycling infrastructure, and public transit improvements. Environmental and Climate Action Policy – Implementation of carbon reduction strategies, air quality improvements, and urban greening projects. Social Equity and Community Engagement Policy – Policies ensuring citizen participation, social inclusion, and equitable access to urban resources. Public Services and Infrastructure Policy – Investments in healthcare, education, digital connectivity, and cultural amenities within the PED.

The index options selected by the majority of the experts involved in the workshop can at this point become the basis of discussion for the elaboration of additional elements to be included in a new formulation of existing certification protocols, in order to make them more adherent to the characteristics of PED, both in terms of the purely energy-environmental aspects and in terms of the relationship these have with aspects related to the innovative governance modes or business models that the PED must activate.

4. Multiple benefits and PED Labs Analysis

Positive Energy Districts represent a transformative approach to urban planning, aiming not just to minimize environmental impact but to actively contribute to energy production and sustainability. However, the concept of PEDs goes beyond energy production [34]. It encompasses sustainable architecture, green building materials, efficient public transportation systems, and the promotion of eco-friendly lifestyles among residents. Buildings within these districts are often designed with high energy efficiency standards, incorporating features like passive solar design, green roofs, advanced insulation, and energy-efficient appliances. Public spaces are designed to enhance biodiversity, promote active transportation, and create healthier living environments. Moreover, Positive Energy Districts encourage community involvement and local governance. By engaging residents in energy-saving practices and decision-making processes, PEDs may foster a sense of ownership and responsibility towards sustainability goals. This participatory approach not only enhances the effectiveness of energy strategies but also strengthens social cohesion and resilience within the community.

The multiple benefits analysis aims to answer the research question: “What benefits do stakeholders expect from PEDs and PED Labs?”. It seeks to understand how PED can bring a broader range of positive impacts that are not part of the primary goal. This stakeholder-centred methodological approach emphasizes the importance of considering diverse perspectives to capture the full spectrum of direct and indirect impacts associated with urban energy initiatives. The concept of multiple benefits is central to understanding the value of urban and energy regeneration projects. It is rooted in two fundamental concepts:

- Primary Goal(s): They are the expected outcomes from the conception of the project [6]. It represents the primary motivation behind decision-making and is often aligned with key performance indicators that measure success. Primary objectives are explicitly defined, supported by dedicated resources and serve as the focal point for planning and execution.
- Co-benefits: They refer to the additional positive outcomes that arise alongside the achievement of a primary goal [35]. These benefits are often unintended or secondary

but can significantly enhance the overall value of an intervention. Co-benefits manifest in various dimensions: social, economic, environmental, and health-related, also depending on the nature of the primary goal.

The concept of multiple benefits combines these two fundamental components in order to ensure a holistic approach [36], in which there is no hierarchy between the positive impacts arising, in this case, from a PED project. This concept started to be developed by the International Energy Agency (IEA) in 2014 in order to fully exploit the potential for investment in building energy efficiency [37]. Co-benefits are, therefore, considered as a fundamental part of the whole, as important as the objectives defined upstream of the project. Recognising and incorporating co-benefits into policy and strategic planning has several advantages. First, it improves cost-effectiveness by ensuring that a single intervention produces multiple positive outcomes. This approach optimises resource allocation, as it eliminates the need for separate initiatives to achieve related benefits. For example, urban green spaces not only promote biodiversity, but also contribute to mental well-being, reduce urban heat islands and increase property values.

Second, considering multiple benefits increases stakeholder support [35]. Policies that offer benefits in several areas are more likely to gain political and public approval. For example, renewable energy investments that generate job opportunities can attract support from both environmentalists and economic policy makers, fostering cross-sectoral collaboration.

Third, a multiple benefits approach increases resilience. By diversifying the range of positive outcomes, initiatives become less vulnerable to blockages in a specific area. If one objective encounters difficulty, the other benefits continue to provide value, ensuring stability and sustained progress.

One approach to exploring the multiple benefits of a PED project is to position PED Labs at the centre, as the core of a PED project [3]. This approach emphasizes the importance of engaging stakeholders in meaningful discussions to better understand their priorities, ensuring that the potential positive impacts of the project are maximized. By actively involving all relevant parties, the project can align its objectives with the specific needs and expectations of the community, fostering more effective and sustainable outcomes. This approach has been partially implemented on two European projects: ARV and ProLight.

This comprehensive framework is developed through four interconnected phases, each of which is designed to build on the insights of the previous phase, ensuring a robust and holistic assessment of urban sustainability initiatives.

4.1 State of the art in multiple benefits research

Objective

Conducting an extensive literature review serves as the basis for the theoretical and empirical foundations of the study. The purpose is to understand which are the most common multiple benefits in PED (and similar) projects reported by scientific literature and reports.

Methodology

The review includes analysis of scientific publications and EU-funded projects regarding PEDs and examines their benefits associated with urban regeneration. Multiple benefits are deduced by carefully analysing documents and looking for related elements in explicit form, implicit form, and in the form of Key Performance Indicators (KPIs). Through this rigorous examination, the study identifies recurring themes and common benefits that underlie successful examples of urban sustainability.

Results

The outcome of this phase is a comprehensive list of multiple benefits identified through the extensive review of scientific literature, relevant publications, and previous projects that share similarities with the one under analysis. These benefits may encompass social, economic, environmental, and governance-related aspects, providing a well-rounded understanding of the project's potential impact. The benefits collected not only highlight the expected positive results, but also help to identify patterns, best practices and key success factors observed in similar initiatives.

4.2 Phase 2: Project partner's consultation

Objective

In the second phase, the emphasis shifts to the active involvement of other project partners, a key step in validating and expanding the insights collected from the literature review. By incorporating different perspectives and expertise, this collaborative process ensures a more comprehensive understanding of the topic. This step plays a key role in refining and consolidating the identified benefits associated with the project, ensuring that they are well-founded and applicable. It also facilitates the contextualization of these benefits within each specific case study included in the project, increasing their relevance and practical impact. Benefit recognition occurs on two levels in the case of a project with multiple case studies: the project level and the case study or detail level. In the first case, all partners involved are asked to collaborate in brainstorming, regardless of their role in the project, as long as they are informed about the necessary actions. In the second case, meetings are held with the partners of each case study, who reflect on the positive repercussions that the implemented actions will have at the local level. These two levels are not disconnected, but rather, the list of multiple benefits at the project level is also fed and consolidated through the detailed brainstorming done for each case study. The actors vary in relation to the project partners involved but can be, for instance, members of universities, municipality, local businesses, research centres, etc. All those who have an active decision-making role in the project at the consortium level.

Methodology

These collaborative ideation sessions can be structured in various ways, depending on the specific goals and constraints of the project. When conducted in an online environment, the use of digital tools can significantly improve both the efficiency and consistency of discussions. A particularly effective platform for this purpose is Miro (https://miro.com/), a web-based collaborative tool designed to facilitate real-time interaction, idea generation, and visual mapping. By providing an interactive workspace, Miro allows participants to contribute asynchronously or synchronously, ensuring that discussions remain structured, inclusive and productive.

Stakeholders are encouraged to share their experiences, priorities, and perceptions of urban regeneration benefits, fostering a participatory environment that captures a wide spectrum of viewpoints. This engagement ensures the methodology reflects the nuanced realities of different communities, enhancing the relevance and applicability of the findings.

Results

As a result, a Miro tab has been prepared, displaying a Venn diagram designed to categorize and analyse the various benefits associated with a project (see figure 7). This diagram consists of multiple clusters, each of which represents a distinct category into which specific benefits can be placed. The selection of categories is flexible and must be tailored to the specific needs and objectives of the project in question. An example of a categorization framework is provided by Bertolami et al., 2024, which includes four key dimensions: social, economic, environmental and governance. These categories help structure the analysis by highlighting different aspects of the project's potential impact.

- Social benefits may include improvements in community well-being, accessibility, education or public health.
- Economic benefits may include job creation, increased investment, cost savings or increased market opportunities.
- Environmental benefits may relate to pollution reduction, conservation efforts, or the promotion of sustainable practices.
- Governance benefits refer to improved decision-making, regulatory compliance, stakeholder collaboration and institutional transparency.

The main purpose of using this Venn diagram is to gain a holistic understanding of project impacts from the planning stage. By visualizing how each identified benefit fits into one or more categories, stakeholders can assess the extent to which the project addresses different priorities. It emphasizes how each benefit can make a positive impact on the territory on multiple aspects.

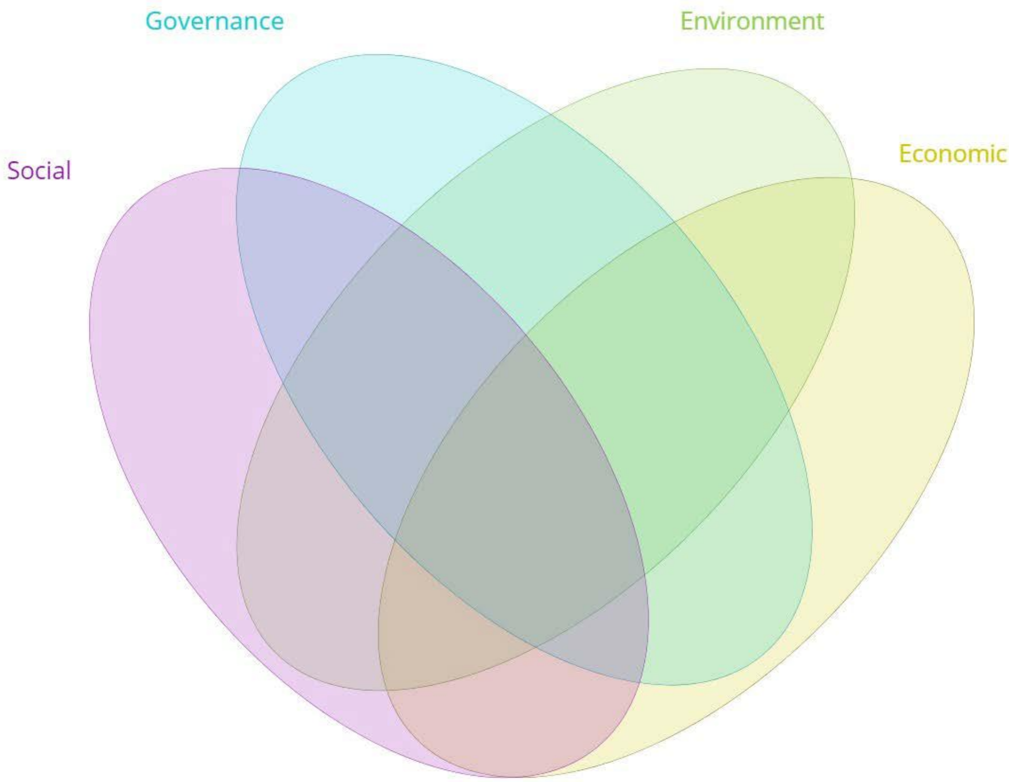

Figure 7 Diagram utilised for brainstorming on multiple benefits

4.3 Cooperation with PED Labs

Objective

The third phase constitutes the core of the methodological framework, centring on a rigorous and systematic evaluation of stakeholder preferences. At this stage, a questionnaire addressed to stakeholders is released to assess the perceived value of the benefits identified in the preceding phases. The primary objective is to determine whether distinct groups of stakeholders exhibit shared priorities or whether significant variations exist across different stakeholder categories. By analysing these preferences, it becomes possible to identify correlations between stakeholder groups, providing insight into potential patterns of alignment or divergence in their valuation of project benefits.

This analytical process plays a crucial role in refining communication strategies and optimizing project implementation. Understanding the hierarchy of stakeholder priorities enables strategic emphasis on the benefits most valued by a wide range of stakeholders. For example, if a particular benefit is consistently prioritized, project managers could allocate additional resources to enhance its impact, ensuring that stakeholder expectations are effectively met. In addition, if discrepancies in priorities are identified, tailored communication approaches can be developed to address the concerns of different stakeholder groups, thereby fostering greater engagement and support for the project. Moreover, this phase ensures that stakeholder insights are systematically incorporated into decision-making processes, improving responsiveness and the overall effectiveness of the initiative.

Methodology

To facilitate a robust and quantitative analysis, the Best-Worst Scaling (BWS) survey method is employed. According to this method, respondents are required to select the most and least important items from a series of sets, each containing a subset of elements. This process is repeated with different randomly presented sets, ensuring that each item is evaluated multiple times in varying contexts. By the end of the exercise, all elements will have been assessed an equal number of times relative to others, allowing for a comprehensive comparison.

This approach enhances the accuracy of preference measurement by asking participants to identify the most and least important benefits within carefully designed sets, thereby providing more nuanced insights than traditional rating or ranking methods. By minimizing cognitive overload, the BWS technique promotes clearer, more consistent responses, ultimately improving the validity and reliability of the data collected for informed decision-making. One of the key advantages of BWS is its ability to mitigate common biases associated with traditional survey methods, such as central tendency bias, where respondents hesitate to rate items at the extremes, and scale-use heterogeneity, where different individuals interpret rating scales differently. By structuring the assessment around comparative judgments rather than absolute ratings, BWS minimizes these distortions, resulting in cleaner and more interpretable data. Furthermore, because participants focus on a limited number of items at a time, cognitive overload is reduced, ensuring more deliberate and consistent responses.

To begin this process effectively, the first crucial step is to identify the key stakeholders. This involves determining the individuals or groups who will be directly or indirectly impacted by the outcomes of the study. These stakeholders may include customers, employees, policymakers, investors, or other relevant entities whose perspectives are essential for a well-rounded analysis.

Results

The result of this phase is a questionnaire addressed to stakeholders of each demo case of the project. A separate questionnaire is developed for each case study, ensuring that it is in line with the specific benefits that the project is expected to bring in that specific context, as defined in the previous steps. These questionnaires serve to assess and validate the expected benefits, while capturing the perspectives of the stakeholders involved in the project.

Each questionnaire also includes a dedicated section where respondents are asked to assess the relative importance of the four key spheres: social, economic, environmental and governance, highlighting how they perceive their importance in relation to each other. In addition, the questionnaire collects key demographic information, including the respondent's role in the project, their gender and age. These data help contextualise the responses, allowing for a more detailed analysis of the perspectives of different stakeholder groups and roles.

4.4 Elaboration and dissemination of the results

Objective:

The primary goal of dissemination is to effectively communicate the project’s results and ensure a comprehensive analysis of the multiple benefits contributing to its success. By sharing findings with diverse audiences, the project aims to promote broader understanding, encourage stakeholder engagement, and maximize its overall impact.

Methodology

Dissemination can be carried out through multiple channels, including published articles in academic journals, project reports, and the organization of local public events. These events provide an interactive platform for presenting key outcomes, fostering discussions, and engaging with the community. By adopting a transparent and proactive approach, the project ensures that its results and benefits are widely accessible, strengthening its influence and long-term success.

Practical implementation and key results

The methodology described above is currently being tested within the framework of two European projects, ProLight (https://www.prolight-project.eu/) and ARV (https://greendeal-arv.eu/). Both apply PED principles to develop sustainable urban areas. By combining energy-efficient renovations, smart technologies, and circular solutions, these projects emphasize energy efficiency, digitalization, and sustainability, creating scalable models for climate-positive districts across Europe. Both projects have applied the methodology in six case studies across different European countries. For both projects, the same methodology was implemented.

The project-level benefits were identified through an online brainstorming session using the Miro platform, allowing project partners to collaboratively map key advantages. This method proved highly efficient, enabling more than twenty participants per project to contribute their insights within just over half an hour. The list of benefits gathered from the literature review served as a reference, helping to identify similar benefits within the projects under study. Figure 8 illustrates the completed diagram for the ProLight project, showcasing the collective input gathered through this process.

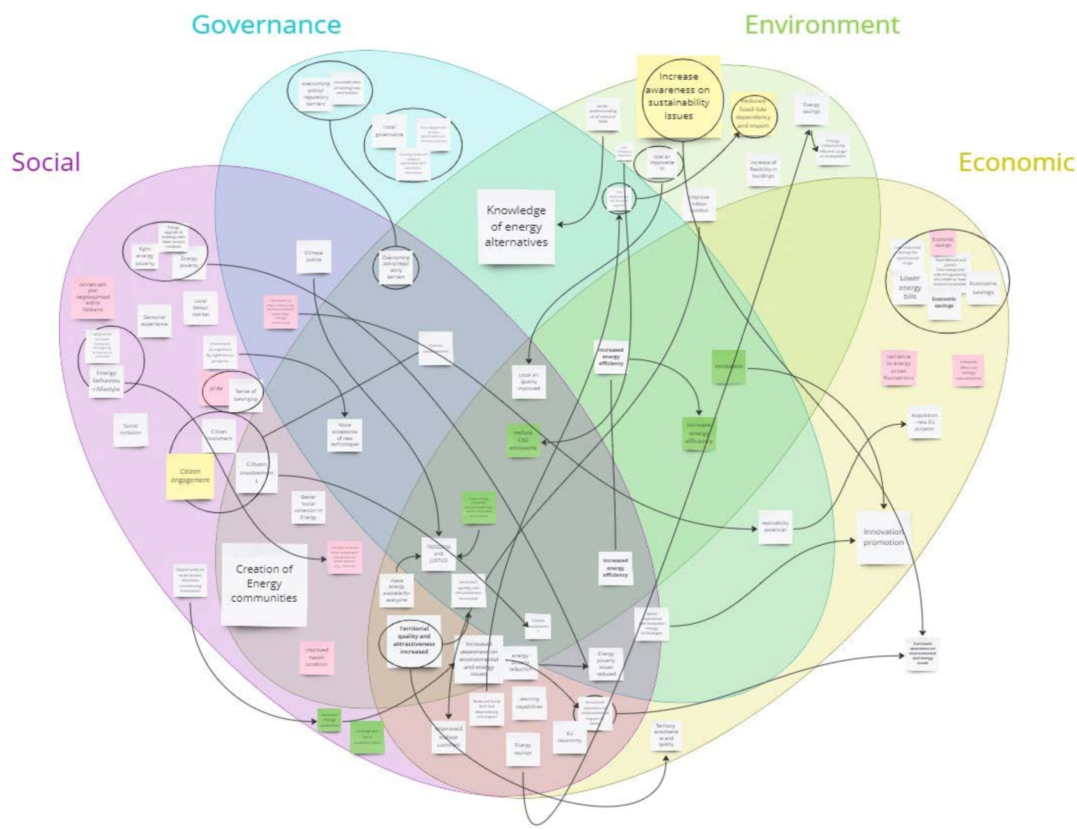

Figure 8 Visual outcome of brainstorming on the most relevant benefits of the ProLight project. Source: (Bertolami et al., 2023)

At the case study level, the approach differed due to the smaller number of experts involved. The sessions were structured as open interviews and free discussions while still conducted online given the partners' geographical spread across Europe. This approach led to the identification of 18 distinct benefits per case study. The number of benefits was carefully selected to be suitable for the BWS method in the questionnaire, ensuring a diverse range of benefits while maintaining focus and avoiding an overly extensive list.

Figure 9 presents a collection of the most commonly identified benefits, as determined through both the literature review and the brainstorming sessions conducted for the ProLight and ARV projects. These benefits were selected based on their frequent occurrence across the collected literature and their relevance to the findings from the collaborative discussions with project partners. The diagram highlights the key advantages that emerged as central to the success and impact of the projects.

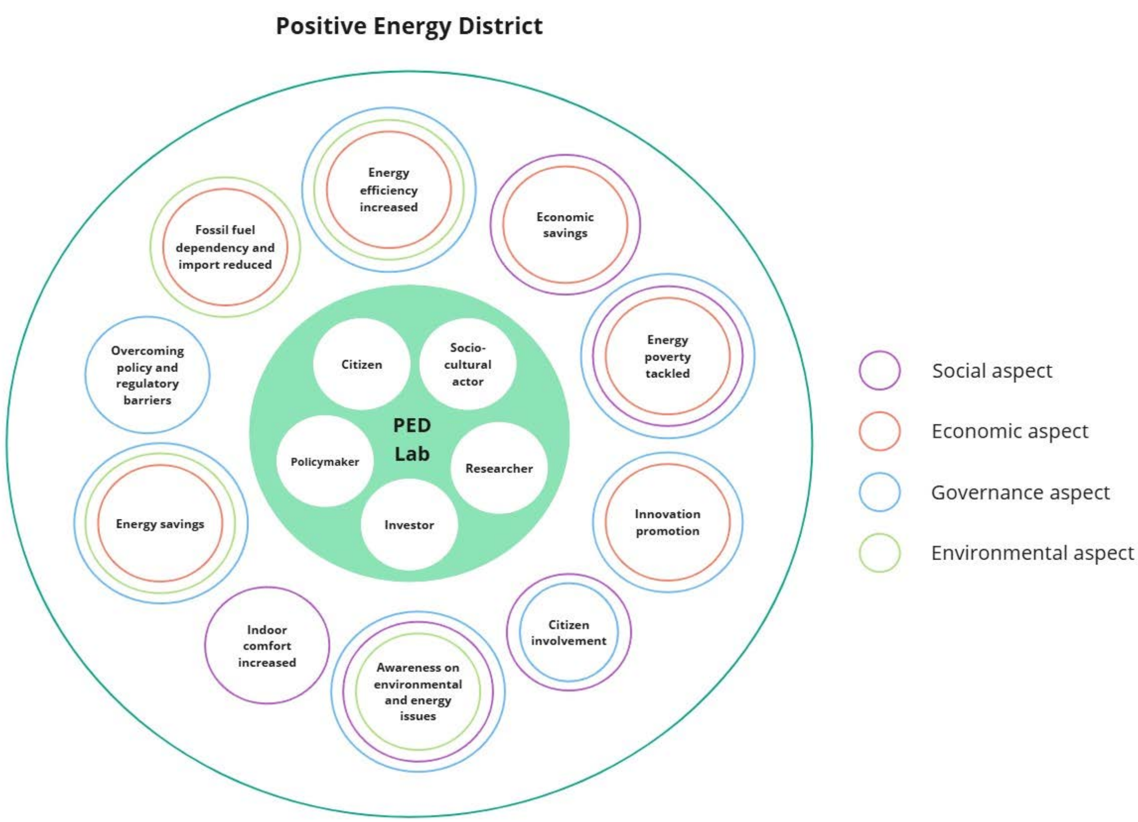

Figure 9 Relevant multiple benefits in a PED

Conclusion

What needs to be kept in mind in multiple benefit analyses is indicated in the centre of figure 9: PED Labs. Stakeholders are not simply passive participants but are fundamental to every stage of a Positive Energy District (PED), from its initial conception to its implementation, and crucially, its long-term maintenance. For a PED system to be successful, it must be designed and built with these stakeholders at its core. The system should primarily aim to deliver benefits to them, reflecting their needs and expectations.

Given this, it is essential that stakeholders fully understand the potential of a PED. This understanding can only be achieved through an ongoing process of engagement, where stakeholders are made aware of how a PED can create value for them, not just in terms of energy savings, but also in the broader social, economic, and environmental benefits. This is where the role of multiple benefit analysis becomes pivotal. It offers a structured approach to identifying and evaluating the diverse benefits that the DPE could bring to different stakeholders.

Moreover, the analysis should be tailored to capture the unique priorities of each individual stakeholder, whether they are local residents, businesses, city planners, or energy providers. By considering these diverse perspectives, a more nuanced understanding of the stakeholders' needs can be developed, ensuring that the PED is designed to meet these needs effectively. Through this iterative process, stakeholders will become more informed and empowered, which not only enhances the adoption of the PED but also strengthens its long-term sustainability. A stakeholder-centered approach ensures that the PED continues to deliver value well into the future, benefiting everyone involved and contributing to the overall success of the project.

5. Conclusions: towards new urban/district rating system?

The transition towards Positive Energy Districts (PEDs) represents a paradigm shift in urban sustainability, requiring a district-scale evaluation framework that goes beyond traditional building certification systems. Current urban sustainability rating protocols (such as LEED-ND, BREEAM-CM, and CASBEE-UD) offer valuable assessment tools, but they were not designed to fully capture the unique characteristics of PEDs, particularly in terms of energy surplus, flexibility, and integrated governance models.

Key Findings and Challenges

The research conducted in Task 3.4 highlights the limitations of existing certification protocols in assessing PEDs and proposes a structured approach to integrate PED-specific criteria into sustainability rating systems. The main findings include:

- energy surplus and flexibility as core PED features, as existing protocols do not fully account for PEDs' ability to generate more energy than they consume or their role in balancing urban energy demand and supply;
- integration of Citizen Energy Communities (CECs) and Renewable Energy Communities (RECs) must be ensured as PEDs promote new governance and business models that require specific evaluation parameters within certification frameworks;
- the PED Lab methodology emphasizes that PED performance should be measured across environmental, social, economic, and governance dimensions, ensuring broader stakeholder engagement, therefore a multi-stakeholder, multi-benefit approach is needed.

A revised urban/district rating system for PEDs should:

- incorporate PED-specific criteria, by introducing indicators for energy surplus, flexibility, resilience, and integration of CECs/RECs into certification schemes;
- adapt existing protocols, rather than replacing current rating systems, updating them and expanding their evaluation criteria to reflect PED characteristics.
- enhance policy and financial integration by aligning certification standards with EU climate policies to attract investment and support large-scale PED deployment.

Future Directions

The findings of this research suggest that the development of a PED-specific certification protocol is a crucial step in supporting scalable, adaptable, and replicable PED solutions across European cities. Moving forward, collaboration between municipalities, certification bodies, energy providers, and research institutions will be essential to define a standardized and widely recognized PED assessment framework.

By addressing these challenges and opportunities, a new urban/district rating system can serve as a catalyst for climate-neutral urban transformation, ensuring that PEDs become a cornerstone of Europe's energy transition strategy.

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ANNEX 1: PED Workshop – List of characteristics

SDGs	PED characteristic	Indexes and values
Category	**Energy**	
ENV	Energy efficiency	The District Energy Efficiency Ratio (DEER) measures how efficiently a Positive Energy District (PED) performs compared to the average energy efficiency of individual buildings within the district. DEER= Average Energy Consumption per Building (kWh/m²) / Average Energy Consumption of the PED (kWh/m²)
		Coefficient of Performance (COP) for a PED measures the efficiency of the energy system by evaluating how much useful energy output (electricity, heating, cooling, etc.) is delivered relative to the total energy input, including primary energy consumption from on-site renewable sources and external energy imports. COP PED = Total Useful Energy Delivered (kWh) / Total Energy Input (kWh)
		Optimized use of energy resources within the district to minimize energy consumption while maximizing the utilization of locally generated renewable energy. Energy Efficiency Index = Total Energy Demand in the PED (kWh)/ Locally Generated Renewable Energy (kWh)
ENV	Energy surplus	The Energy Surplus Ratio (ESR) quantifies the ability of a Positive Energy District (PED) to generate more renewable energy than its total energy demand. It provides a measure of PED self-sufficiency and its contribution to the broader energy system by assessing how much excess energy is available for redistribution, storage, or grid injection. Different classes may be possible with regard to surplus basis (sub-hourly, hourly, monthly, annual) ESR= Total Renewable Energy Generation (kWh)/ Total Energy Demand (kWh) /
		The Net Energy Balance (NEB) index measures the energy surplus of a PED by comparing total renewable energy generation to total energy demand,

		considering energy imports and exports. It provides a comprehensive assessment of whether a PED operates as a net energy producer, consumer, or neutral entity over a defined period (hourly, daily, monthly, or annually). NEB = (Total Renewable Energy Generation − Total Energy Demand) / Total Energy Demand *100
		The Smart Energy Surplus Utilization (SESU) index measures how efficiently a Positive Energy District (PED) manages and distributes its energy surplus through intelligent power management systems. It evaluates the extent to which surplus energy is stored, shared, or redistributed within the PED or to the grid, instead of being wasted or curtailed. SESU= Effectively utilized surplus energy (kWh) / total surplus energy (kWh) *100
ENV	Renewable Energy production	The Local Renewable Energy Production (LREP) index measures the proportion of a Positive Energy District's (PED) total energy consumption that is covered by locally generated renewable energy sources. It provides a clear assessment of the district's reliance on on-site renewable energy. LREP = Total renewable Energy Generation on site (kWh) / Total energy demand (kWh) * 100
		The PED Renewable Energy Compliance (PREC) index compares the local renewable energy production within a Positive Energy District (PED) to the minimum renewable energy production requirements per building set by the Energy Performance of Buildings Directive (EPBD). This KPI evaluates whether the PED outperforms, matches, or falls short of the required renewable energy standards applied to individual buildings PREC= Total local renewable energy production per mq (kWh/mq) / EPBD minimum renewable energy production per mq (kWh/mq)
		The Renewable Energy Diversity (RED) index measures the variety and balance of local renewable energy sources within a Positive Energy District (PED). It evaluates how well the PED integrates multiple renewable energy technologies

		(e.g., solar, wind, geothermal, biomass) and avoids over-reliance on a single source. RED = (Σ (RE * W) / Total renewable energy production) * 1000 Where RE is the energy produced by each different source and W a weighting factor based on the number of sources, promoting diversity
	Urban and local development, real estate	
ECO	Technological solutions	The AI-Based Embodied Carbon Footprint (AECF) index measures the total embodied carbon emissions associated with the construction, materials, and infrastructure of a Positive Energy District (PED) using AI-driven lifecycle assessment (LCA) models. This KPI leverages artificial intelligence to predict, monitor, and optimize the embodied carbon footprint of materials and construction activities across the entire district. AECF = Σ (EC * Q* C) / Total built area (mq) Where EC = embodied carbon per unit of material Q = quantity of material used in the PED C = correction factor for material based on AI-optimized efficiency improvement
		The AI-Based Emission Abatement Forecasting (AEAF) index evaluates the effectiveness of a Positive Energy District (PED) in reducing its carbon emissions over time using artificial intelligence-driven simulations. This KPI predicts future emission reduction trajectories by integrating real-time data, historical trends, and AI-based scenario modeling, helping policymakers and urban planners optimize decarbonization strategies dynamically. AEAF = Predicted CO_2eq reduction by AI (ton CO_2eq) / Baseline CO_2eq * 100
		The Carbon Offsetting Effectiveness (COE) index measures how effectively a Positive Energy District (PED) neutralizes its residual carbon emissions through carbon offset mechanisms such as reforestation, carbon capture, nature-based solutions, etc. It quantifies the proportion of total emissions that are offset and assesses the efficiency and reliability of the offset strategies implemented. COE = Total carbon offset (ton CO_2eq) / Residual Carbon Emissions (t CO_2eq) * 100
GOV	Existing building stock (reuse and adaptation)	The Existing Building Integration and Rehabilitation (EBIR) index measures the effectiveness of a Positive Energy District (PED) in rehabilitating, retrofitting, and integrating existing buildings into its sustainable energy framework. This KPI compares the energy performance improvements of rehabilitated buildings within the PED to the surrounding built environment, assessing the PED's ability to drive urban regeneration

		EBIR = (∑ (E_before – E_after)/buildings inside PED) / ∑ (E_baseline – E_current)/ Buildings outside PED Where E_before = Energy consumption of existing buildings in PED before rehabilitation E_after = Energy consumption of rehabilitated buildings after integration into the PED E_baseline = Energy consumption of existing buildings surrounding the PED E_current = Energy consumption of rehabilitated buildings surrounding the PED after typical renovation practices
		The Adaptive Reuse Business Model (ARBM) index measures the extent to which a Positive Energy District (PED) successfully integrates existing buildings into its energy and sustainability framework through a structured business model for PED management. ARBM = (W1 * adaptive reuse share) + (W2 * business model maturity score) / W1 + W2 Adaptive Reuse Share (%) = The proportion of total PED floor area that consists of repurposed and rehabilitated existing buildings, rather than new construction. Business Model Maturity Score (0-100) = A qualitative assessment of the existence, implementation, and effectiveness of a business model for PED operation, based on predefined criteria (e.g., governance structure, financing mechanisms, stakeholder involvement). W1 and W2 Weighting factors prioritizing physical reuse (W1) and business model effectiveness (W2) based on PED objectives
		The Urban Structure Reuse Masterplan (USRM) index measures the extent to which a Positive Energy District (PED) integrates existing urban structures (e.g., buildings, roads, infrastructure) into its development strategy, based on the existence and implementation of a dedicated reuse masterplan. This KPI evaluates whether urban regeneration efforts are systematically planned and executed, reducing demolition, preserving embodied carbon, and ensuring sustainable land use. URSM = (W1 * Urban structure reuse share) + (W2 masterplan implementation score) / W1 + W2
GOV	Role of mobility in the PED	The Mobility Energy Impact (MEI) index measures the share of transportation-related energy consumption within the overall energy balance of a Positive Energy District (PED). This KPI quantifies how mobility systems affect the district's

		energy efficiency, renewable integration, and carbon footprint, highlighting the relevance of sustainable transportation strategies in PED design. MEI = total mobility energy consumption (kWh) / total PED energy demand (kWh) * 100
		The Sustainable Mobility Infrastructure Development (SMID) index measures the extent to which a Positive Energy District (PED) integrates new dedicated mobility infrastructures (e.g., cycling lanes, pedestrian areas, electric vehicle charging stations, smart mobility hubs) into its urban planning. This KPI evaluates the proportion of newly developed or upgraded mobility infrastructure relative to the total urban area, highlighting the PED's commitment to sustainable and low-energy transport solutions. SMID = total dedicated mobility infrastructure area (mq) / total PED area (mq)* 100
		The Electric Mobility Flexibility Contribution (EMFC) index measures the extent to which electric mobility systems (e.g., electric vehicles, e-buses, e-bikes) contribute to local energy storage and grid flexibility within a Positive Energy District (PED). This KPI evaluates how well Vehicle-to-Grid (V2G), Vehicle-to-Building (V2B), and smart charging strategies support energy management, ensuring that mobility acts as an active component of the PED's energy balance rather than just a consumer. EMFC = Total energy supplied to the grid from EVs (kWh) / Total local energy storage capacity (kWh) * 100
	People	
SOC	Inclusiveness and tackling affordability of housing and fighting energy poverty	Social Housing Inclusiveness (SHI) index measures the extent to which a Positive Energy District (PED) integrates affordable and social housing through dedicated urban planning instruments and policies. This KPI evaluates the share of total residential units allocated to social housing, ensuring that the PED remains socially inclusive and accessible to diverse income groups SHI = 100 * (social housing units in PED / total residential units in PED) * (urban policy implementation score / maximum policy implementation score
		The Inclusive Energy Contract (IEC) index measures the extent to which a Positive Energy District (PED) provides diverse and accessible energy contract options, ensuring that all socio-economic groups—including low-income households, renters, and small businesses—have equitable access to affordable and flexible energy services. This KPI evaluates the distribution of contract types within the

		PED, emphasizing social tariffs, community-based energy programs, and flexible pricing models that enhance affordability and inclusiveness. ICE = 100* (%subsidized energy contracts + % flexible contracts + % participation in REC / total of energy contracts in PED
		The Inclusive and Affordable Energy Access (IAEA) index measures the extent to which a Positive Energy District (PED) ensures affordable, equitable, and inclusive access to clean energy and sustainable urban services. This KPI evaluates the economic accessibility of energy and mobility services, ensuring that the PED benefits all socio-economic groups, including low-income households and vulnerable populations. 100 – (W1*(Average Household Energy Cost / median income)) + (W2*(1-(%Subsidized or Social Energy Access/N Households in PED)))+W3*(1-(%Affordable Mobility Services/total mobility options) Where W1, W2 and W3 are weighting factors prioritizing energy affordability, subsidized access, and inclusive mobility, based on PED policy goals The IAEA index increases when the PED offers more economically and socially accessible energy and mobility. A value close to 100 indicates a highly inclusive and accessible district, while a low value signals equity problems in access to energy and mobility.
SOC	Quality of life	The Quality of Life (QL) index measures the overall well-being and livability of a Positive Energy District (PED) by integrating key dimensions from the OECD Better Life Index. This KPI assesses how the PED enhances housing conditions, environmental quality, accessibility, safety, and social inclusivity, ensuring that urban transformation leads to a high standard of living for all residents. QL = 100*Σ (W*S)/N Where W is a weighting factor for each quality of life dimension based on its relative importance S is a normalized score for each dimension, ranging from 0 to 1, where 1 represents the highest performance. N the total number of dimensions evaluated Suggested Key Quality of Life Dimensions (Based on OECD Indicators):

		Housing Quality – Availability of adequate, energy-efficient, and affordable housing. Air Quality – Average PM2.5 concentration and green space per capita. Accessibility – Proximity to public transport, healthcare, education, and essential services. Safety – Crime rates and perceived safety in public spaces. Social Inclusivity – Integration of diverse social groups, gender equity, and community participation in decision-making.
		The Urban Planning Quality of Life (UP-QL) index evaluates how well urban planning instruments and strategies contribute to quality of life in a Positive Energy District (PED). This KPI assesses whether urban plans effectively integrate key livability factors, such as green spaces, mobility infrastructure, housing policies, public services, and social inclusivity, to create a sustainable and people-centered urban environment. $UP\text{-}QL = 100 * \Sigma (W * P) / N$ Where: W is the weighting factor for each urban planning dimension based on its relative importance. P is the normalized score for each dimension, ranging from 0 to 1, where 1 represents full integration in urban planning. N is the total number of urban planning dimensions evaluated. Suggested Key Urban Planning Dimensions: Green Space Allocation – Percentage of public parks, urban forests, and green corridors relative to the total PED area. Accessibility to Services – Proximity of residents to healthcare, education, and essential public services. Social Infrastructure – Availability of cultural, recreational, and community spaces. Housing Inclusivity – Share of affordable and social housing planned in the PED. Sustainable Mobility – Integration of pedestrian-friendly streets, cycling networks, and public transport infrastructure in urban planning.
		The Policy Action Plan Quality of Life (PAP-QL) index measures the effectiveness of political action plans and policy frameworks in enhancing quality of life within a Positive Energy District (PED). This KPI evaluates whether the policy agenda and implemented actions address key livability factors such as housing, mobility,

		public services, environmental quality, and social inclusivity, ensuring that the PED fosters a sustainable and equitable urban environment. PAP-QL = 100 * Σ (W * P) /N Where: W is the weighting factor for each policy dimension based on its relative importance. P is the normalized score for each dimension, ranging from 0 to 1, where 1 represents full integration in urban planning. N is the total number of policy dimensions evaluated. Suggested Policy Action Plan Dimensions: Affordable and Inclusive Housing Policy – Integration of social housing, rent control, and community-driven housing initiatives. Sustainable Mobility Policy – Development of low-carbon transport solutions, pedestrian and cycling infrastructure, and public transit improvements. Environmental and Climate Action Policy – Implementation of carbon reduction strategies, air quality improvements, and urban greening projects. Social Equity and Community Engagement Policy – Policies ensuring citizen participation, social inclusion, and equitable access to urban resources. Public Services and Infrastructure Policy – Investments in healthcare, education, digital connectivity, and cultural amenities within the PED.