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RESEARCH ARTICLE

Citizen-centric pathways to Positive Energy Districts: Lessons from European PED projects

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Abstract

Positive Energy Districts (PEDs) represent a pivotal evolution in urban energy performance, expanding the ambition from individual buildings to entire neighborhoods and wider urban systems. While much attention has been devoted to their technological dimensions, successful PED development equally depends on sustained citizen engagement, inclusive governance and community-driven co-creation. This study brings together nine EU-funded projects — InterPED, TIPS4PED, ARV, COMMUNITAS, PEDvolution, Citizen-led Renovation, NEUTRALPATH, ASCEND, and LEGOFIT — to present and compare their approaches to citizen and stakeholder engagement in PED planning, design, and implementation. Drawing on contributions prepared for a dedicated workshop at the Sustainable Places 2025 Conference, this paper identifies five cross-cutting themes: partnership-based engagement models, digital tools and platforms for co-creation, energy communities as governance frameworks, participatory monitoring and living lab methodologies, and gamification and innovative facilitation. The projects collectively demonstrate that the energy transition is not merely a technical

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challenge but a fundamentally societal one, and that citizens can play an active role as co-creators in PED development processes. The findings highlight the importance of inclusivity, adaptive engagement frameworks, energy literacy, and long-term governance structures in enabling PEDs that are equitable, resilient, and scalable across diverse European urban contexts.

Keywords
Positive Energy Districts; citizen engagement; co-creation; energy communities; digital twins; participatory design; urban energy transition



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Introduction

The concept of Positive Energy Districts (PEDs) has emerged as a cornerstone of the European Union's strategy for climate-neutral urban development. Defined as urban areas that generate more annual renewable energy than they consume, PEDs integrate energy production, distribution, flexibility, and efficiency at the district level, moving decisively beyond the limitations of building-scale interventions.[1,2] As part of the EU Mission for 112 Climate-Neutral and Smart Cities, PED development has received substantial momentum through Horizon Europe and predecessor programmes such as H2020, catalysing a new generation of research and innovation projects across the continent.[3]

Despite significant progress in the technical dimensions of PED development (including renewable energy integration, demand-response mechanisms, digital twins, and data-driven urban planning), a growing body of evidence indicates that technological solutions alone are insufficient to achieve a just and durable energy transition.[1,4] Citizens, as the ultimate inhabitants and users of urban energy systems, must be engaged not merely as consumers or passive beneficiaries but as active co-creators and co-owners of the transition. This shift from top-down governance to participatory, community-centered approaches is increasingly recognized as a prerequisite for the social acceptance, long-term resilience, and replication potential of PEDs.[5]

Energy Communities, as defined under the EU Clean Energy for All Europeans Package (2019), offer a legally recognized and socially innovative framework for this transition, enabling citizens, municipalities, and businesses to collectively produce, consume, share, and trade renewable energy.[6] Combined with advances in digital participation tools, gamification, living lab methodologies, and co-design platforms, Energy Communities have the potential to lower barriers to participation and strengthen the governance of community-driven energy initiatives.

This study contributes to this evolving field by bringing together nine EU-funded PED projects, each at different stages of planning, design, or implementation, and each developing distinctive approaches to citizen and stakeholder engagement. The projects were convened in a dedicated workshop at the Sustainable Places 2025 Conference to share insights, compare methodologies and identify transferable lessons. This paper synthesizes their contributions into a comparative analysis structured around five cross-cutting themes identified across the portfolios. While previous PED literature has extensively explored technological integration, energy optimization, and district-scale decarbonization strategies, comparatively less attention has been devoted to synthesizing citizen-engagement methodologies across multiple PED initiatives.[7,8] This study contributes to the field by providing a comparative cross-project analysis of participatory approaches developed within nine EU-funded PED projects, identifying transferable practices, governance patterns, and emerging methodologies for citizen-centric PED development across diverse European urban contexts. Section 2 describes the methodology; Section 3 presents each project's contribution; Section 4 provides a cross-cutting thematic discussion; and Section 5 presents the conclusions and recommendations.

Methodology

This study adopts an exploratory qualitative synthesis approach, drawing on structured contributions from nine EU-funded projects on citizen engagement and Positive Energy District (PED) development. This paper was developed through a collaborative process facilitated within the framework of the Sustainable Places 2025 Conference (SP2025), held in September 2025. SP2025 serves as an annual European forum that brings together researchers, practitioners, policymakers, and innovation actors working on sustainable and positive energy districts. A dedicated workshop focused on citizen and stakeholder engagement in PEDs brought together representatives from nine Horizon Europe and European Commission-funded projects.

The participating projects were selected based on their direct involvement in the workshop and collectively represent a diverse portfolio of approaches, geographical contexts, technological maturity levels, and participatory methodologies. The projects include initiatives focusing on district-scale governance, Energy Communities, digital twins, participatory monitoring, gamification, user-centered digital design, and climate-neutral district implementation.

To support comparability across contributions, all participating projects prepared structured, written inputs following a common analytical template. The template covered four core dimensions: (i) project context and objectives, (ii) citizen engagement rationale and governance approach, (iii) participatory tools, methods, and frameworks applied, and (iv) preliminary findings, observations, or lessons learned.

Project contributions were first presented and discussed during the workshop, enabling cross-project dialogue, peer exchange, and reflection on common challenges and factors that enable them. Following the workshop, the editorial team conducted an iterative qualitative thematic synthesis of the submitted materials and workshop discussions.

This study has several limitations. First, the study relies primarily on project-reported experiences and does not apply a fully standardized evaluation framework across all cases. Second, the participating projects are currently at different implementation stages, limiting the direct comparability of outcomes and impacts. Third, the findings reflect the European policy and innovation context within which the projects operate and may require adaptation for transferability to other governance settings in other countries. Finally, this paper aims to synthesize emerging practices and methodological insights.

Project contributions

Citizen-led renovation: Scaling methodologies from energy communities to positive energy districts

Citizen-led Renovation (CLR) addresses one of the most persistent barriers in the European building sector: the limited capacity of local actors to organize, finance, and deliver deep renovations at scale. While energy communities have proven effective in mobilizing citizens around shared renewable energy production and local governance, their activities have typically remained confined to single buildings or small clusters. CLR responds by developing methodologies that enable the progressive upscaling of community-led action from the building to the district level, thereby supporting the emergence of PEDs from the ground up.

CLR treats renovation not as a discrete technical intervention but as a socio-technical transformation embedded in local governance and collective decision making. Communities are positioned as intermediaries between individual building owners, municipal authorities, technical experts, and financial actors, a role that is critical for overcoming fragmented ownership, misaligned incentives, limited technical literacy, and high transaction costs. The CLR methodological framework rests on five interlinked pillars: community-based aggregation and governance, integrated renovation planning and sequencing, capacity building and knowledge co-production, financial and regulatory alignment, and technical and digital foundations. This last pillar integrates Building Renovation Passports, interoperable digital tools, and district-level digital twins, which are used not only as expert instruments but also as co-creation and communication tools that build trust in multi-actor PED planning processes.

The scaling pathway from energy communities to PEDs is understood as a gradual expansion across three axes: spatial scale (building to district), system integration (isolated measures to multivector optimization), and governance complexity (cooperative arrangements to multi-actor configurations involving municipalities, grid operators, and financial institutions). CLR demonstrates that Positive Energy Districts can be developed not only through top-down technical planning but also through socially anchored, bottom-up methodologies capable of sustaining long-term engagement across the full lifecycle of urban energy transformation.

InterPED: Not patronising, but partnering

The Clean Energy for All Europeans Package (2019) promotes Renewable Energy Communities (RECs) and Citizen Energy Communities (CECs) as vehicles for local energy action. In practice, establishing and managing these communities frequently involves substantial technical expertise, regulatory complexity, and context-specific adaptation, which are barriers that limit accessibility for communities without prior experience. InterPED responds by developing engagement strategies that do not require specialized knowledge, are implementable across diverse demographic and geographic contexts, and work equally well in emerging and established energy communities.

The project's engagement philosophy is grounded in partnership rather than paternalism: citizens are recognized as active collaborators in shaping energy systems, not as recipients of information or decisions. Engagement frameworks are longitudinal and iterative, acknowledging that meaningful participation and capacity building unfold over extended periods. Central to this approach is the development of energy literacy, which enables informed decision-making and sustained involvement. InterPED also orients engagement towards the co-creation of shared imaginaries — collective visions of sustainable energy futures that emerge from community dialogue and reflect local aspirations. This positions citizens as empowered partners in transitions that are just, inclusive and socially durable.

TIPS4PED: Digital twins for citizen-centric PED planning

TIPS4PED supports municipalities and local stakeholders in planning and managing Positive Energy Districts through an integrated assessment platform that combines real-time data, advanced simulation tools, and evidence-based Key Performance Indicators. A defining feature is its citizen-centric design: rather than treating citizens as passive recipients of top-down planning, the project integrates community feedback, preferences, and local knowledge from the earliest stages of PED development through co-design workshops, participatory sessions and gamification-based tools.

The platform functions as a dynamic digital twin of the district, making complex energy trade-offs visible and navigable for non-expert users to understand. By visualizing alternative pathways and their socio-economic implications,

municipalities can communicate decisions and build a shared understanding between public authorities and communities. Thus, the digital twin is both a technical instrument and a medium for dialogue. TIPS4PED also emphasizes capacity building: equipping communities with knowledge of energy systems, financial frameworks, and regulatory constraints reduces resistance to change and supports more-informed participation. This project highlights the importance of aligning technological innovation, governance approaches, and citizen engagement within urban decarbonization processes.

ARV: Participatory monitoring in a climate positive circular community

ARV (from the Norwegian for 'heritage') is an H2020 initiative that brings together 35 partners from nine countries to deploy Climate Positive Circular Communities (CPCCs) across six pilots in Trento, Sønderborg, Karviná, Palma, Utrecht, and Oslo, representing over 130,000 m^2 of renovation. All pilots adopted Living Lab methodologies and tailored engagement strategies to ensure that residents remained central actors throughout. The Trento case study focuses on the Povo neighborhood, where an innovative timber-based prefabricated façade system (Renew Wall) was installed in 2023 alongside a conventional ETICS solution for comparative assessment.

The residents participated in two participatory monitoring campaigns. First, during the 2023 renovation, perceptions of dust and noise from six homeowners were gathered: 60% found the prefabricated system noisier than ETICS, while all noted lower dust levels, prompting a deeper quantitative investigation. The second, conducted in September 2025, assessed post-occupancy Indoor Environmental Quality via questionnaires, finding improved perceived thermal comfort across all respondents. Both campaigns highlighted the importance of adapting communication for the building's predominantly elderly residents (avoiding jargon and providing concrete examples) as a precondition for meaningful engagement and for reliable data collection.

COMMUNITAS: UX/UI co-design for energy community digital tools

Energy Communities depend not only on sound technical architectures but also on digital platforms that citizens can use. COMMUNITAS was developed on the premise that if platforms are complex or unintuitive, people disengage regardless of the quality of the underlying technology, a 'last mile' failure that undermines the entire community energy model. The project builds a suite of interoperable tools, including a demand response tool, investment advisor, knowledge base, and optimization engine (OPTIMEMS), designed to help communities manage their energy assets effectively while remaining accessible to users with widely varying technical backgrounds.

COMMUNITAS embeds this as a continuous co-creation and risk management process. A hybrid research methodology (combining live user tests, System Usability Scale (SUS) surveys, and eye-tracking) distinguishes between what users report and what they actually do, revealing 'silent friction' moments that are invisible to conventional surveys. Pilots conducted in Crevillente (Spain), Groningen (Netherlands), Poland, and Italy have already produced evidence-based design changes, shifting the project from assumptions to data-driven development. The broader lesson is clear: to be scaled up, Energy Communities must pair the scaling of technology with the scaling of usability and trust.

PEDvolution: A structured methodology for social innovation in PEDs

PEDvolution has developed seven interoperable solutions for PED planning, operation, and monitoring, embedding social innovation as a core enabler of technical adoption. The project introduces a structured four-step stakeholder engagement methodology: PED Scoping (mapping actors and understanding local social realities), Analysis (developing community profiles and stakeholder matrices), Action Plan (co-developing targeted engagement strategies with local partners), and Assess and Evolve (continuous feedback and adaptive learning over the PED lifecycle). This methodology is designed to be replicable across diverse urban contexts, while remaining responsive to local conditions.

The approach was validated across three co-developer sites: Schönbrunn village in Wunsiedel (Germany), Planina neighborhood in Kranj (Slovenia), and Gemeinschaft Hard community in Winterthur (Switzerland). Each site has a long-term development history, providing the institutional maturity required to scale ambitions. A key insight from PEDvolution is that the best entry point for PED development is wherever a community currently stands; the methodology supports continuous evolution regardless of the starting point, turning existing community investment into a foundation rather than a precondition.

NEUTRALPATH: Co-creation for PCEDs through climate-neutral labs

NEUTRALPATH addresses a critical gap in PCED implementation: the difficulty in translating abstract energy and climate strategies into district visions that citizens understand and actively support. Conventional top-down engagement (information campaigns, isolated consultations) fails to build energy literacy at the district scale or sustain participation beyond single events, particularly among tenants, vulnerable groups, and residents without a technical background. NEUTRALPATH's response is the establishment of Climate-Neutral Labs (CN-Labs) across five cities (Dresden,

Zaragoza, Istanbul, Vantaa, and Ghent) as open, place-based innovation ecosystems integrating community engagement, co-design, and social acceptance monitoring into the technical PCED process.

CN-Labs simultaneously serve as community engagement hubs (Open Days, world cafés, thematic workshops), user-centered design engines (co-design of PCED scenarios and governance options, with targeted inclusion of vulnerable groups), and social acceptance observatories (recurring surveys tracking perceptions across project phases). A dedicated toolkit (including the Energize board game and interactive digital totems with 3D PCED visualizations) lowers participation barriers and generates real-time feedback. Early results from Zaragoza (approximately 150 participants at a single Open Day) show that iterative lab engagement builds ownership, reframing PCEDs from city projects into shared neighborhood endeavors, a crucial foundation for the implementation phases ahead.

ASCEND: Designing PCEDs for scale with the business model assembler

ASCEND's central diagnosis is that PCED scaling fails not because of a shortage of technical solutions but because of fragmented governance, financing, and citizen participation strategies designed in isolation. The project addresses this through the PCED Business Model Assembler (a physical card game and complementary digital tool co-developed with the University of St. Gallen) that transforms PCED design into a collaborative, evidence-based process. Workshop participants explore the interdependencies between governance, value creation, financing, and citizen roles in a risk-free sandbox before political and financial commitments are made.

Three rounds of workshops across seven European cities tested the approach in contrasting urban contexts. Lyon and Porto explored community energy schemes linking local production with social benefits. Munich and Stockholm examined citizen engagement as a driver of district resilience. Prague and Budapest centered affordability and equity as design parameters. Charleroi applied the Assembler to the Porte Ouest district's renewable thermal network. ASCEND's core lesson is that scaling is a design challenge as much as a technical one: when cities prototype governance, participation, and financing alongside technology, ambition becomes an actionable goal. There is no single transferable PCED model, but a scalable process for designing one exists.

LEGOFIT: Resident acceptance of energy management in energy-positive homes

LEGOFIT developed a scalable method for energy-positive homes (EPH) (homes producing more energy than they consume) demonstrated across five pilot sites in Spain, Turkey, Hungary, Luxembourg, and the Netherlands. The LEGOFIT Platform integrates passive and active technologies, BIM, and smart building management systems (BMS) to achieve climate-neutral residential performance. Structured interviews with seven households in the Dutch pilot project in Nuenen West (17 units equipped with PV, battery storage, ground-source heat pumps, and EV chargers) revealed consistent patterns in residents' attitudes towards energy management systems (EMS).

A majority (57%) prioritized simplicity over control, preferring systems that 'just work. Furthermore, 29% accepted automation with override options, while only 14% sought maximum control. All households accepted EMS automation when comfort was unaffected, and 71% welcomed live energy monitoring. Cost savings are the primary motivation for EMS adoption (57%), followed by sustainability (29%) and grid support (14%). Regarding flexibility, residents are most accepting of heat pump pauses and battery reserves during grid congestion and are more cautious about EV charging restrictions. These findings directly inform platform design: user-friendliness, automation, and transparent visibility are critical enablers of broader acceptance. Roundtable workshops and open-day events across all five pilots will extend this engagement to local stakeholders and civil society.

The projects presented above illustrate the broad range of citizen engagement approaches currently emerging within the European PED landscape. While each initiative operates under different technological, governance, and geographical conditions, several recurring patterns can be identified across the portfolios. To support the comparative discussion that follows, Table 1 summarizes the main citizen engagement characteristics, participatory methodologies, governance approaches, digital components, and key contributions of the nine projects.

Discussion

Five cross-cutting themes emerge from the nine project contributions, together characterising the current state of practice in citizen engagement for Positive Energy Districts.

Partnership-based engagement models

InterPED's distinction between partnership and paternalism resonates across the portfolio. CLR, PEDvolution, ARV, and NEUTRALPATH each operationalise this principle in different ways — through intermediary community organisations, structured four-step methodologies, participatory monitoring campaigns, and place-based labs respectively. Across these

Table 1. Comparative overview of citizen engagement approaches across the nine PED projects.

Project	Main PED focus	Engagement model	Main participatory tools	Citizen role	Governance approach	Digital components	Key contribution
Citizen-led Renovation (CLR)	Scaling community-led renovation towards PEDs	Community-centred governance and aggregation	Building Renovation Passports, co-creation processes, capacity-building activities	Co-creators and intermediaries	Multi-actor coordination involving municipalities, communities, and financial actors	Digital twins, interoperable renovation tools	Methodology for scaling Energy Communities from building to district level
InterPED	Renewable and Citizen Energy Communities in PEDs	Partnership-based engagement	Longitudinal engagement and co-creation approaches	Active partners and decision-makers	Community-centred governance	Interoperable cloud-based PED planning solutions	Development of inclusive and non-paternalistic engagement methodologies
TIPS4PED	Citizen-centric PED planning and management	Participatory planning and co-design	Co-design workshops, gamification tools, participatory sessions	Contributors to planning and decision-making	Municipality-community collaboration	Integrated Assessment Platform and digital twins	Making PED planning accessible through participatory digital twins
ARV	Climate Positive Circular Communities	Living Lab and participatory monitoring	Monitoring campaigns, questionnaires, participatory IEQ assessment	Active participants in monitoring and feedback	Local pilot-based governance	Monitoring and assessment tools	Integration of participatory monitoring into PED implementation
COMMUNITAS	Energy Community usability and optimisation	User-centred co-design	UX/UI testing, eye-tracking, SUS surveys	End-users and co-designers	Community-oriented energy governance	OPTIMEMS platform, Demand Response Tool	Demonstration of usability as a core enabler of Energy Communities
PEDvolution	Social innovation for PED evolution	Structured stakeholder engagement methodology	Stakeholder mapping, action plans, adaptive feedback mechanisms	Stakeholders throughout the PED lifecycle	Replicable local governance frameworks	Interoperable PED solutions	Four-step social innovation methodology for PED implementation
NEUTRALPATH	Positive Clean Energy Districts (PCEDs)	Climate-Neutral Labs and co-creation	Open Days, world cafés, co-design workshops, surveys	Co-designers and local participants	Place-based innovation ecosystems	Interactive totems, 3D visualisations, digital engagement tools	Institutionalisation of citizen engagement through CN-Labs

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Table 1. *Continued*

Project	Main PED focus	Engagement model	Main participatory tools	Citizen role	Governance approach	Digital components	Key contribution
ASCEND	Scaling PCEDs through collaborative business models	Collaborative prototyping and governance co-design	Business Model Assembler workshops and card-based facilitation	Contributors to governance and financing design	Multi-stakeholder district governance	Digital Business Model Assembler	Co-design of governance and financing mechanisms for PCED scaling
LEGOFIT	Energy-positive homes and EMS acceptance	Resident-centred behavioural engagement	Structured interviews, workshops, open-day events	Users and feedback providers	Residential pilot governance	Smart BMS and EMS platforms	Insights into resident acceptance of automation and flexibility

approaches, common enablers emerge: longitudinal engagement that builds trust and literacy incrementally; communication adapted to specific demographic realities (as demonstrated by ARV's work with elderly residents); and governance structures that distribute agency. CLR's intermediary model is particularly instructive in showing how community organisations can aggregate demand, coordinate investment, and reduce transaction costs in ways that individual or household-level engagement cannot.

Digital tools and platforms as mediators of participation

TIPS4PED, COMMUNITAS, ASCEND, and NEUTRALPATH each deploy digital tools as mediators between technical complexity and citizen agency. The range spans from district-scale simulation platforms (TIPS4PED) to community energy management interfaces (COMMUNITAS) to co-design card games (ASCEND) to interactive visualisation totems (NEUTRALPATH). A consistent finding across these projects is that tools must be designed with rather than merely for citizens. COMMUNITAS's UX/UI methodology is the most rigorous example: by combining eye-tracking with usability surveys, the project distinguishes between perceived and actual usability, revealing invisible barriers that conventional feedback methods miss. CLR's use of Building Renovation Passports and digital twins as co-creation instruments demonstrates how technical artefacts can be reoriented to serve participatory ends.

Energy communities as governance frameworks

The EU Energy Community framework structures the governance ambitions of several contributing projects. CLR most explicitly addresses the scaling challenge, articulating a pathway from single-community arrangements to multi-actor district configurations across three axes of expansion: spatial, technical, and institutional. InterPED similarly develops community models designed for replication across diverse national regulatory contexts. A shared observation is that the gap between EU regulatory frameworks and local implementation realities is a persistent barrier: Energy Community models require adaptation to national legal contexts that vary considerably across Member States. Sustainable scaling requires investment in legal and financial capacity-building alongside social and technical engagement. In addition, several projects highlighted the administrative and organisational burden associated with sustaining long-term participation processes, particularly in contexts with limited municipal capacity or fragmented governance structures.

Participatory monitoring and living labs

ARV's Povo case study exemplifies a broader trend: treating monitoring as a participatory activity that builds citizen agency. By combining resident perceptions with quantitative IEQ measurements, ARV generates insights neither source would yield alone, including non-intuitive findings (e.g., the noise profile of prefabricated installation) that prompted deeper technical investigation. PEDvolution's 'Assess and Evolve' step embeds comparable iterative feedback logic at the methodology level. NEUTRALPATH extends this further, establishing CN-Labs as permanent engagement infrastructure capable of outlasting individual project cycles, a model for institutionalising participatory practice within municipal structures.

Gamification and innovative facilitation

ASCEND, NEUTRALPATH, TIPS4PED, and LEGOFIT each incorporate gamification elements that lower participation thresholds and improve the quality of engagement with technically complex material. ASCEND's Business Model Assembler creates a productive space for exploring governance and financing trade-offs before commitments are made. NEUTRALPATH's Energize board game and digital totems demonstrate that accessible physical and digital artefacts consistently outperform conventional presentations in engaging non-expert audiences. LEGOFIT's interview findings confirm that citizens are open to sophisticated energy concepts (including V2G and demand flexibility) when the supporting interface is appropriately designed. Taken together, these projects make a strong case for treating accessible facilitation as a design requirement in PED development, not an optional supplement.

Conclusions

This study has presented and compared citizen engagement approaches across nine EU-funded PED projects, demonstrating the breadth and maturity of methods being deployed across Europe. The five themes identified (partnership models, digital tools, energy community governance, participatory monitoring, and gamification) together constitute an evidence-based toolkit for inclusive PED development that is both technically rigorous and socially grounded.

Several cross-cutting lessons stand out. Engagement must be longitudinal: one-off consultations do not build the trust, literacy, and ownership that durable PEDs require. Tools must be designed with citizens, not merely validated by them. The diversity of European contexts demands local adaptation even when drawing on transferable models. And digital innovation must advance alongside social innovation, the most sophisticated platforms fail without meaningful human relationships and governance structures to embed them. The intermediary function (communities and organisations

bridging technical, financial, and social dimensions of PED development) emerges as a critical but underexplored enabler across the portfolio.

The findings presented in this paper should also be interpreted within the context of several limitations. The projects analysed operate under different regulatory, institutional, and socio-economic conditions and are currently at different stages of implementation, limiting direct comparability of outcomes. Furthermore, the paper primarily reflects project-reported experiences and emerging practices. Future research could therefore focus on developing more standardised assessment frameworks for citizen engagement in PEDs, including indicators related to inclusiveness, governance effectiveness, behavioural change, and long-term participation.

Together, the nine projects represent a growing pan-European community of practice on citizen engagement in PEDs. Their collective experience highlights the importance of trust, long-term participation, and collaborative governance in supporting inclusive and socially grounded energy transitions.

Ethics and consent

Ethical approval and consent were not required.

Data availability

ZENODO: Empowering Cities Through Positive Energy Districts: Strategies and Implementations from PED Projects of EU Climate Neutral and Smart Cities: https://doi.org/10.5281/zenodo.17497627 (Alpagut *et al.*, 2025).

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Underlying data

This project contains the following underlying data:

- Table 1: Comparative Overview of Citizen Engagement Approaches Across the Nine PED Projects.

Data is available under the terms of the Creative Commons Attribution 4.0 International.

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Summary
This manuscript addresses a highly relevant aspect of Positive Energy District development by focusing on citizen engagement, co-creation, and community participation. The paper brings together experiences from nine EU-funded projects and provides a valuable overview of the approaches currently being tested across Europe. It is well structured, clearly written, and easy to follow. The comparative perspective is particularly useful, as it highlights common themes and lessons that can support future PED initiatives.

Overall Assessment
I found the paper interesting and relevant. It clearly shows that the transition towards Positive Energy Districts is as much a social and governance challenge as it is a technical one. The synthesis of experiences from nine EU-funded projects provides useful insights for researchers, municipalities, and practitioners, and the identified themes are generally well supported by the evidence presented. The overall approach is appropriate for a synthesis paper, and the discussion is one of the manuscript's strengths. However, the methodology section would benefit from additional detail on how the thematic analysis was conducted, how the five themes were derived, and how consistency was ensured throughout the analysis. Providing this information would improve transparency and strengthen the scientific rigor of the study. Given that the projects are at different stages of implementation, the authors should more clearly distinguish between demonstrated results, preliminary observations, and anticipated impacts. This would provide greater clarity and avoid any perception of overstating project achievements. The availability of supporting material through Zenodo is appreciated and contributes to openness. However, the authors should clarify whether the underlying project contributions and workshop materials used in the synthesis are accessible. A brief discussion on the transferability of the identified approaches beyond the European context would also further strengthen the manuscript and broaden its relevance.

Suggested Revisions for the Authors
- Provide a more detailed description of the methodology, particularly how the thematic

synthesis was conducted and how the five cross-cutting themes were identified.
- Clarify the project selection process and discuss potential selection bias arising from including only projects represented at the Sustainable Places 2025 workshop.
- Strengthen the comparative analysis by discussing common barriers, challenges, and success factors observed across the projects, rather than focusing primarily on project descriptions.
- Clarify whether the project submissions and workshop materials that informed the synthesis are publicly available in addition to the data deposited in Zenodo.
- Expand the discussion on the transferability of the findings beyond the European context and discuss how different governance and regulatory settings may influence implementation.
- Further elaborate on future research directions, particularly regarding the development of standardized frameworks and indicators for evaluating citizen engagement, inclusiveness, governance effectiveness, and long-term participation in PEDs.
- Consider adding a brief summary table or discussion highlighting the most important lessons learned, common enablers, and recurring challenges across the nine projects.

Recommendation
This manuscript provides a timely and valuable synthesis of citizen engagement approaches across nine EU-funded PED projects. The paper is well written, relevant, and offers useful insights into the social and governance dimensions of PED development. However, the authors should provide additional detail on the thematic analysis methodology, clarify the distinction between demonstrated results and anticipated impacts, and further discuss data availability and the transferability of the findings beyond the European context. These are relatively minor issues that, once addressed, will further strengthen the manuscript.

Is the work clearly and accurately presented and does it engage with the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

Are all the source data and materials underlying the results available?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Positive Energy Districts, Energy Communities, Urban Energy Systems, Sustainable Buildings, Building Energy Performance, Energy Transition, Smart Cities, Digital Twins

for Energy Systems.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 12 August 2026

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The manuscript addresses a relevant topic, namely citizen engagement in the development of Positive Energy Districts (PEDs), and brings together experiences from several EU-funded projects. However, in its current form, the paper presents substantial methodological and evidentiary limitations that make it difficult to assess the robustness of the analysis and, in particular, to support some of the claims made in the Discussion and Conclusions.

1. References and conceptual framing

Some of the references used to substantiate the conceptual and policy background should be reconsidered.

Citation 2 does not appear sufficiently appropriate to substantiate the concept to which it is linked and should either be replaced with a more authoritative and directly relevant source or its use should be better justified.

Similarly, Citation 3 does not appear to provide adequate support for the statement concerning PEDs. In particular, the framework of the 112 cities participating in the EU Mission “100 Climate-Neutral and Smart Cities by 2030” should not be used as direct evidence of PED development unless a specific connection between the Mission framework and PEDs is explicitly demonstrated.

Citation 5 should also be updated. The cited reference dates from 2020, whereas the PED conceptual framework has subsequently evolved. The authors should refer to the more recent PED Framework 3.0 developed within the Driving Urban Transitions (DUT) Partnership, which continues and further develops the work initiated under JPI Urban Europe. Using the most recent conceptual framework is particularly important for a paper that aims to discuss current PED practices and methodologies.

2. Methodological robustness

The Introduction appropriately acknowledges several important limitations of the study, including the reliance on project-reported experiences, the absence of a fully standardised evaluation framework across cases, the different implementation stages of the participating projects, and the specific European policy and innovation context.

These limitations, however, are not merely secondary constraints; they substantially affect the type of scientific claims that can be derived from the study.

As currently presented, the manuscript appears primarily to report and synthesise an exercise developed in the context of a workshop involving a selected group of projects. Although the authors introduce a common analytical approach, the study does not yet demonstrate the level of methodological standardisation, independent assessment, or systematic comparative analysis that would normally be required to establish an analytical proof of concept.

The manuscript would therefore benefit from a clearer positioning of its methodological contribution. It may more appropriately be presented as an exploratory synthesis, structured cross-project reflection, or methodological learning exercise rather than as an analytical validation of a framework.

3. Analytical template

The Introduction states that the participating projects provided “written inputs following a common analytical template” covering four dimensions:
(i) project context and objectives;
(ii) citizen engagement rationale and governance approach;
(iii) participatory tools, methods, and frameworks applied; and
(iv) preliminary findings, observations, or lessons learned.
However, the actual analytical template is not presented in the manuscript.

This is a significant omission. The section on “Project Contributions” provides a narrative synthesis of each project, but the reader cannot verify how these summaries relate to the stated analytical framework or whether the same criteria were consistently applied across all projects.

The analytical template should therefore be included, preferably as a table, figure, or supplementary material. This would considerably strengthen the transparency and reproducibility of the study and allow readers to understand how the individual project descriptions were translated into the subsequent cross-project findings.
It would also be useful to explain who completed the template, whether the responses were subsequently reviewed or coded by the authors, and how differences in interpretation across projects were handled.

4. selection of the 9 projects

The manuscript refers to “nine EU-funded projects on citizen engagement and Positive Energy District (PED) development”. However, insufficient information is provided to substantiate and characterise this sample.
For each project, the manuscript should report at least:

- the official project acronym and full title;
- the grant agreement or project identification number;
- the relevant EU funding programme or partnership;
- the call and/or funding year;
- the project implementation period;
- the explicit relationship of the project to PED development; and
- the criteria according to which the project was included in this study.

This information is essential to understand the analytical basis of the paper and to assess whether the nine projects constitute a coherent sample.
At present, it remains unclear whether the projects were selected because they explicitly addressed PEDs, because they participated in the workshop, because they included citizen-engagement activities, or through some other selection criterion.

The selection procedure should therefore be made explicit. Otherwise, there is a risk that the resulting themes reflect the composition of the workshop participants rather than a systematic representation of citizen-engagement approaches in European PED projects.

5. Discussion

Following the individual project summaries, the Discussion presents a number of cross-cutting findings and themes. However, the analytical procedure through which these themes were derived is not sufficiently explained.
The manuscript should describe, for example, whether the themes emerged through:

- qualitative coding of the project templates;
- thematic analysis;
- clustering of recurring approaches;
- structured comparison across predefined analytical dimensions; or
- expert interpretation by the authors.

The reader currently moves directly from project narratives to aggregated findings without being able to reconstruct the analytical steps connecting the two.
A table mapping each project against the identified themes would significantly improve the manuscript. It could show which projects provide evidence for partnership models, digital tools, energy-community governance, participatory monitoring, gamification, or other identified approaches. Such a table would make the cross-project synthesis much more transparent and analytically defensible.

6. Conclusion

The strongest concern relates to the level of evidence supporting some of the conclusions.

The manuscript states that the results demonstrate “the breadth and maturity of methods being deployed across Europe” and that the five identified themes — partnership models, digital tools, energy community governance, participatory monitoring, and gamification — “together constitute an evidence-based toolkit for inclusive PED development that is both technically rigorous and socially grounded”.

These statements appear stronger than the evidence presented in the manuscript currently allows.

The analysis demonstrates that these approaches are present within the nine projects considered, but it does not provide sufficient evidence to establish their overall maturity across Europe, their effectiveness, their technical robustness, or their transferability as an evidence-based toolkit.

In particular, identifying the occurrence of a methodology within a project is not equivalent to demonstrating its effectiveness. To substantiate such conclusions, the manuscript would need more systematic information on implementation results, performance indicators, engagement outcomes, comparative effectiveness, or other forms of empirical validation.

The Conclusions should therefore be substantially moderated and aligned with the exploratory nature of the study. The five themes could more appropriately be described as “recurring approaches identified across the participating projects”, “emerging methodological patterns”, or “candidate components of a future toolkit”, rather than as an already validated evidence-based toolkit.

Overall assessment

The manuscript has the potential to provide a useful synthesis of emerging citizen-engagement practices within PED-related European projects. Its main value lies in bringing together experiences from different initiatives and identifying recurring methodological approaches.

However, the paper currently lacks sufficient methodological transparency to support the transition from project descriptions to generalised findings. The analytical template, project-selection criteria, project metadata, and procedure used to derive the cross-cutting themes should be made explicit. In addition, several conclusions should be recalibrated to reflect the exploratory and project-reported nature of the evidence.

Addressing these issues would considerably strengthen the scientific credibility of the manuscript and clarify its contribution as a structured comparative learning exercise rather than an empirically validated assessment of citizen-engagement methodologies for PED development.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
No

Are sufficient details of methods and analysis provided to allow replication by others?
No

Are all the source data and materials underlying the results available?
No

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are the conclusions drawn adequately supported by the results?
No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: PED expert

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.