A Qualitative Methodology for Identifying Governance Challenges and Solutions in European Positive Energy Labs

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Abstract.
Cities play a significant role in energy-related climate change, yet they also have considerable potential to implement solutions for sustainability challenges. Furthermore, cities and local governance can act as innovation "hubs," driving sustainable urban transitions. Urban Living Labs are becoming essential for achieving sustainability goals in cities, operating at the crossroads of research, innovation, and policy. These labs are designed to create, demonstrate, and evaluate urban interventions in real time. Despite their growing prominence, our understanding of their nature and purpose is still limited, with a lack of critical analyses. This study employed a qualitative methodology to identify critical aspects for deploying Positive Energy District (PED) Labs, structured into three steps: questionnaire distribution, qualitative analysis of responses, and formulation of

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research questions. The questionnaires focused on barriers, drivers, and stakeholders, yielding valuable insights into the factors influencing the implementation of PED Labs. Key findings revealed nine categories of barriers, with social and financial factors emerging as the most significant challenges. In terms of drivers, the necessity for climate change mitigation, strong local networks, and improved political frameworks were identified as essential conditions for fostering PED Lab initiatives. The analysis highlighted seven stakeholder groups involved across six phases of PED Lab deployment, with governments recognized as pivotal actors in the process. To further guide implementation, the study proposes a SWOT matrix to encapsulate resources, capabilities, and requirements necessary for successful operation or replication of PED Labs, emphasizing that while specific conditions may vary, general principles must be considered in all contexts

Keywords: Urban Living Labs, PEDs, online survey, qualitative methodology.

1 Introduction

To address the challenges generated by climate change and the rapid urbanization of inhabited areas, it is necessary to develop an urban framework that allows reversing energy and environmental trends and reducing strong inequalities. Under this context, different governance initiatives are being proposed that are capable of managing several urban flows through climate-friendly models. One of these initiatives focuses on testing solutions under real conditions of use through Urban Living Laboratories [1], a crucial step in learning how to design inclusive, sustainable, and climate-resilient urban environments [2]. These labs embody an experimental governance model that facilitates the evaluation of different solutions and the proposal of enhancements. Ultimately, they are designed to create a collaborative environment where various stakeholders can explore, develop, and experiment with solutions to urban challenges, all while involving local communities [3].

Their innovative approach to urban development and public-private partnerships underscores the need for adaptability, transparency, and informality in their processes. As a result, they generate highly valuable insights that can inform decision-making for city stakeholders. The innovation drivers in these projects stem from agglomeration effects, where innovation activities cluster around urban initiatives. However, these effects are not evenly distributed, nor are they consistently beneficial for all participants [4]. Other authors explore the application of Living Labs to foster gendered energy technology innovation in impoverished urban settings [5]. Additionally, challenges and dilemmas associated with strategic urban experimentation have been assessed through a review of the literature on Socio-Technical Systems, alongside insights from transdisciplinary research on living labs [6].

Several urban strategies tailored to the local context can be assessed, creating a comprehensive map of solutions to tackle the climatic and energy challenges facing cities. Current literature presents various concepts related to climate-friendly neighborhoods,

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including Zero Emission Neighborhood, Zero energy District, Smart Energy Community, Nearly Zero Carbon Neighborhood or Positive Energy District (PED) [7]. The latter concept, introduced by Set Plan Action 3.2 [8], encompasses three topics related to energy: flexibility, efficiency and production [9]. The implementation, analysis and optimization of innovative urban solutions necessitates flexible laboratories that facilitate synergies among different urban factors such as energy, social, economic or governance, and that are equipped to monitor and quantify urban fluxes [10].

Within this study framework, the activities of WG3 of COST-PED-EU-NET CA19126 [11] titled `PED Laboratories, Monitoring and Replication' are encompassed, in particular Task 3.1 aims to review existing concepts, projects and facilities relevant to PED Labs [12]. Under this objective, the activities carried out in this task have tried to position PED Lab concept within the international debate, attempting to formulate and answer some research questions related to the development of PED Lab concept. This paper presents some of the results obtained in this task 3.1.

2 Methodology

A qualitative methodology is employed to identify the main aspects that must be considered in the deployment of PED Labs. The approach consists of three steps: administering questionnaires to focus groups, conducting qualitative analyses of the responses, and proposing research questions. Figure 1 presents a schematic representation of the methodology implemented in this study.

In the first step, appropriate questions are crafted to gather comprehensive information based on existing literature on Smart Cities and Positive Energy Neighborhoods. Three categories of questions are proposed to collect data on barriers, drivers, and main actors. In the second step, a qualitative analysis is performed by processing the answers and discussing the results within several working groups formed by members of WG3 of COST-PED-EU-NET CA19126 [11]. Finally, a series of research questions are formulated to identify the main aspects and gaps to be addressed in the implementation and replication of a PED Lab.

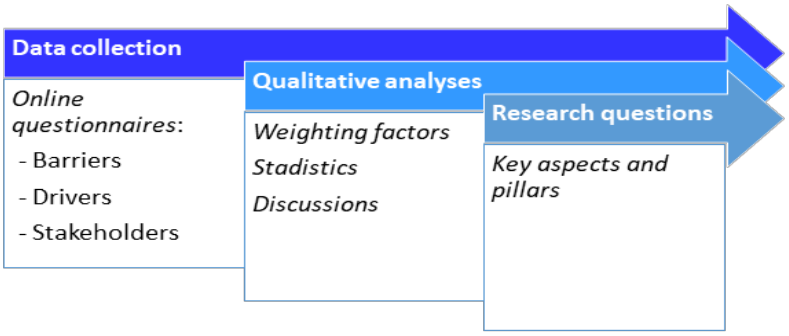

Fig. 1. Diagram of the methodology implemented in this research.

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2.1 Questionnaires

To gather information on real PED and PED lab initiatives from Action Cost WG3 Task 3.1 members, several online discussions were held, averaging participation from 20 experts in the field. This work was structured in two phases: the online completion of questionnaires followed by open discussions to refine the results of the questionnaires and reach a consensus. To obtain weighted responses on these issues, three actions were proposed through online working tools such as MURAL:

- Approve a proposed list of items in each of the three proposed issues, suggesting groupings and modifications where necessary.
- Weigh the importance of each listed item by scoring them on a Likert scale from 1 to 5 where 1 indicates low relevance and 5 indicates high relevance.
- Discuss the questionnaires results collectively to extract some learnings.

Three main topics were addressed in these workshops: barriers, drivers and stakeholders.

Barriers. A series of questions were developed to identify the key aspects that hinder or block the implementation and development of PED Labs. These questions were formulated based on existing bibliography on Smart Energy Cities projects [13, 14, 15, 16, 17], although they were subsequently adapted, updated and ranked based on feedback from a WG3 workshop with 18 experts from COST-PED-EU. In this workshop, a series of questions were formulated based on the premise that the existing barriers to implementing a Smart Energy City are similar and scalable to the PED-LAB concept. Nine types of barriers were suggested to the Workshop participants: policy, administrative, legal and regulatory, financial, market, environmental, technical, social, information and awareness; resulting in a total of 51 questions.

Drivers and unlocking factors. Additional questions aimed to identify the key factors that drive the adoption of initiatives or establish favorable starting conditions for the implementation and development of PED Labs. These questions are derived from the existing literature on Smart Cities and Urban Laboratories [18, 19, 20]. Based on the area of action, these factors are classified into two categories: drivers and unlocking factors. Drivers are the key elements that motivate the initiation and execution of a laboratory, while unlocking factors are those that enhance or improve the initial conditions, thereby facilitating the deployment of these urban laboratories.

Stakeholders and processes. PEDs require collaboration among diverse stakeholders, necessitating engagement methods that systematically identify stakeholder types throughout the development phases. Cheng et al. [21] proposed a stakeholder mapping framework that addresses dynamic roles at the building, district, and city levels, and suggests incorporating managerial tools into the PED development toolbox. Other authors evaluate stakeholders' perceptions of energy vulnerability mitigation through PEDs by conducting interviews, promoting an inclusive transition in urban areas [22]. However, harmonizing design phases, stakeholder interests, and scales can be challenging due to their frequent intersections. In practice, these elements are interconnected by

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critical decision-making moments known as "intervention points," where it is essential to identify the key stakeholders and the tools to be used at each point [23].

Similarly, further questions sought to identify the main actors as well as the processes involved at each stage of deploying PED Labs. In these questionnaires, six phases were identified: vision, decision, planning, execution, evaluation (check/act) and scaling and replication. Seven stakeholder groups were proposed: people, industries and companies, planners and architects, academia, financial institutions, governments and developers. Figure 2 shows an outline of the key aspects considered in these three blocks of questions.

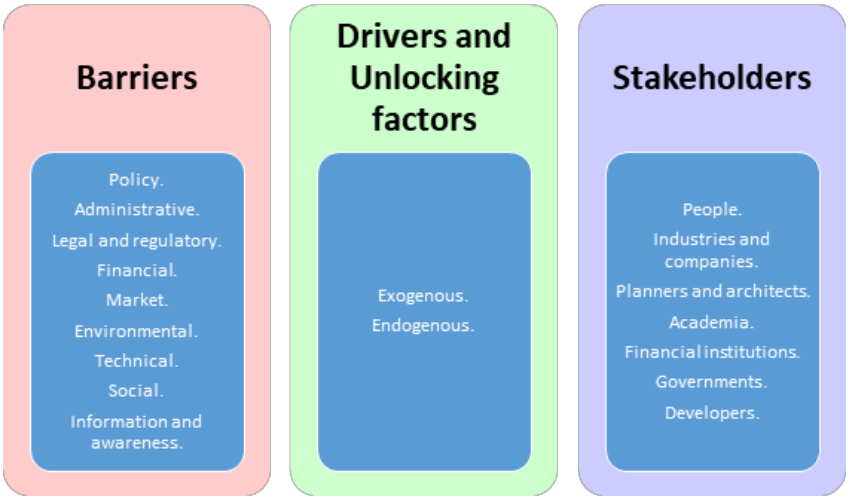

Fig. 2. Scheme of the key aspects considered in the three blocks of questionnaires proposed.

2.2 Qualitative analysis

Once the database is generated from the responses to the questionnaires, a qualitative study is conducted to identify the main challenges faced by the PED Labs. Key aspects of the three proposed blocks - barriers, drivers and stakeholders - are analyzed. This qualitative approach allows for the collection of diverse perspectives from different stakeholders, leading to the formulation of a set of research questions that highlight the main pillars to consider.

2.3 Research questions

Research questions summarize the objectives of our research, identifying the key aspects to consider. To formulate these questions, a series of online discussions and a

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qualitative analysis of the responses are carried out, enabling a focused examination of the main pillars and challenges faced by PED Labs.

3 Results

Once the questionnaires are completed among the participants in WG3 of Action Cost CA19126 regarding the three raised topics, the data were analyzed on a weighted basis. The importance of each aspect was assessed using the Likert scale from 1 to 5, where 1 represents a factor of little relevance and 5 is equivalent to a very relevant factor.

3.1 Barriers

Nine topics are proposed within the group of blocking factors, considering aspects such as:

- *Policy*: energy plans, governance body visions, or political commitment.
- *Administrative*: coordination, public participation, dissemination, ownership or authorization procedures.
- *Legal and regulatory*: regulations, instability, building codes, incentives or privacy protection.
- *Financial*: cost, financial support, access to capital, economic crisis or risks and uncertainty.
- *Market*: split incentives, energy price distortion or energy market actors.
- *Environmental*: lack of information or negative effects on the natural environment.
- *Technical*: tested solutions, technical commitments, qualified personnel, computational scalability, grid instability or accurate urban models.
- *Social*: inertia, interest, acceptance, engagement, rebound effect, attitudes, exclusion or lack of trust.
- *Information and awareness*: insufficient information, awareness, perceptions or information asymmetry.

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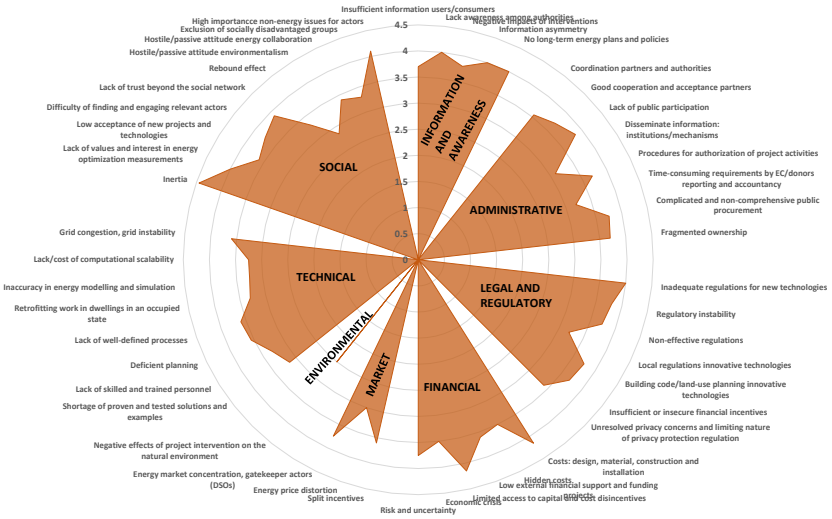

Fig. 3. Radar graph showing the blocking factors weighted from 1 to 5 by the participants of the questionnaires.

Figure 3 shows the results of the questionnaires on this topic. As illustrated in the radar graph, the social aspect of inertia is the most significant barrier to the development of PED Labs, while environmental factors are the least obstructive. Analyzing each topic reveals that administrative, legal, financial and some social factors pose challenges. Conversely, the aspects that least hinder the implementation of these laboratories are environmental along with many technical and market factors.

3.2 Drivers and unlocking factors

Two categories are defined for the group of driver factors, considering aspects such as:

- *Drivers*: climate change, urbanization trends, urban redevelopment, economic growth, market attractiveness, environmental quality or energy autonomy.
- *Unlocking factors*: technological improvements, innovative solutions, prefabricated packages, energy communities, prosumers, storage systems, decreasing cost, benefits, awareness, engagement, social acceptance, policy frameworks, funding or multidisciplinary approaches.

Figure 4 presents the results of the questionnaires regarding driving factors. As illustrated in the radar graph, the factors that most enhance the implementation of a PED Lab, according to respondents, include climate change mitigation, energy autonomy and independence, economic growth, financial mechanisms, strong existing local networks and associations, improved local and national policy frameworks, technological

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improvements for RES production, energy efficiency and prefabricated packages for buildings.

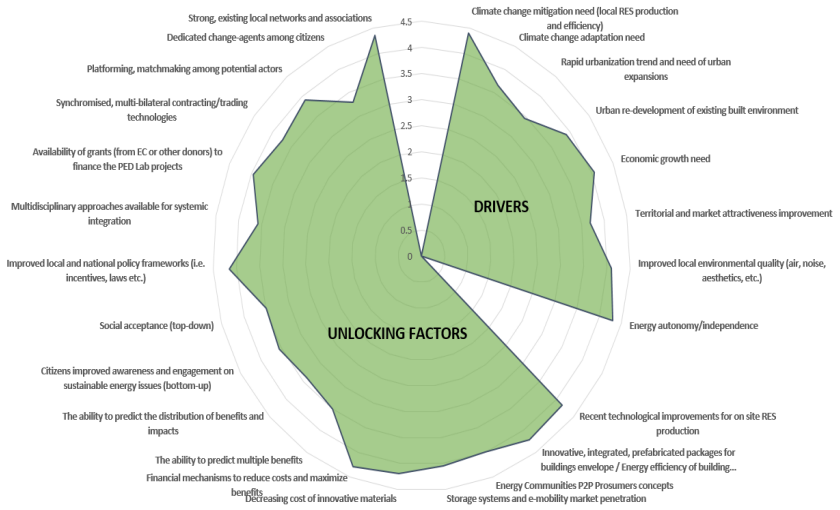

Fig. 4. Radar graph showing the unlocking factors and drivers weighted from 1 to 5 by the participants of the questionnaires.

Conversely, the aspects that contribute least to these urban laboratories involve aspects such as social acceptance, multidisciplinary approaches for systemic integration, matchmaking among actors, urban re-development of existing urban environments, territorial and market attractiveness improvement and the ability to predict benefits and impacts.

3.3 Stakeholders and processes

The correct mapping of stakeholders requires identifying who will participate in each of the processes of these laboratories. Six phases are considered in the life cycle of a PED Lab: vision, decision, planning, implementation, check/act and upscale and replicate. Seven groups of stakeholders are proposed: people, industries and companies, planners and architects, academia, financial institutions, governments and developers.

Figure 5 shows the influence of each stakeholder in the six proposed phases. As shown, the influence of each stakeholder varies throughout the implementation process, and it's important to note that some stakeholders may change their positions or reconsider their participation as they move from one phase to another.

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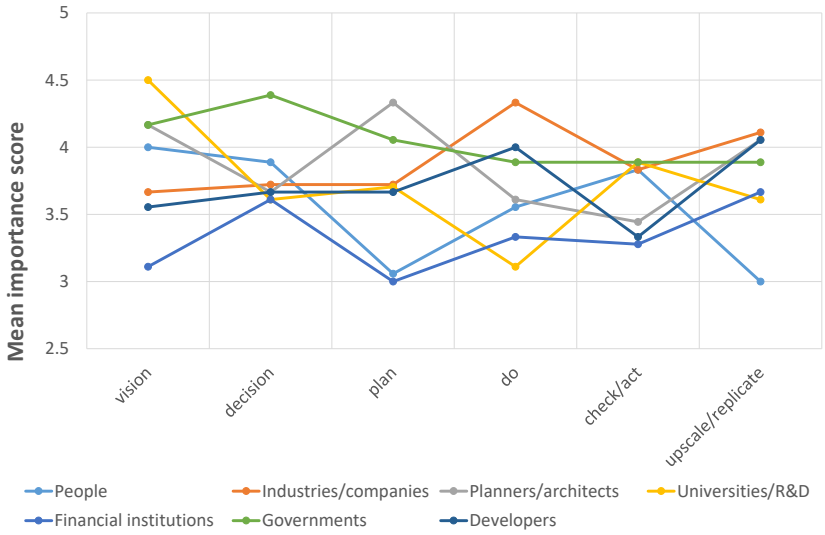

Fig. 5. Line graph showing the stakeholders involved in each of the proposed processes weighted from 1 to 5 by the participants of the questionnaires.

The distribution of stakeholder roles in each phase is as follows:

- *VISION phase:* the participation of universities and the R&D sector is determinant along with that of government and planners. Consulting with citizens is also a high priority.
- *DECISION phase:* the government is the main actor, supported by citizens.
- *PLAN phase:* in this phase, planners manage the process with support from the government, assisted by industry, universities and developers.
- *DO Phase:* industry and developers are the primary actors operating within a framework promoted by the government. The role of financial institutions as investors also becomes prominent.
- *Check/Act Phase:* all stakeholders must be involved in this phase in various capacities.
- *Upscale/replicate phase:* this phase is linked to the do phase and features a similar distribution of roles. Notably, the lack of citizen involvement in this phase is surprising.

3.4 Research questions

The implementation of this methodology leads to the formulation of three research questions that highlight the main aspects to consider in the deployment of a PED Lab. The three proposed questions are:

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What are the current barriers to the implementation of PED-LABS?

This research identifies nine categories of factors that hinder the development of a PED Lab. The qualitative analysis reveals that social and financial factors stand out as the most relevant, followed by administrative, regulatory and legal, and information and awareness aspects.

What are the drivers and incentive factors (unlocking) that determine the "fertility of the soil" for PED-LAB initiatives?

This research formulates forty-two questions related to unlocking and driving factors. The qualitative analysis identifies the need for climate change mitigation measures, the presence of strong local networks, and the improvement of local and national political frameworks as the primary aspects that most encourage the development of a PED lab.

What processes and actors define the steps, power relationships, and subsidiarity in responsibilities and decisions within PED LAB initiatives?

In this work, seven groups of stakeholders have been identified that influence the achievement of urban laboratory objectives across the six proposed phases, depending on the activities required at each phase. Governments stand out as one of the main actors throughout the process.

Once the key aspects and main actors are identified, it is necessary to structure the results to highlight the available resources and necessary requirements for the successful operation or replication of a PED Lab. To this end, the creation of a SWOT matrix is proposed, underlining factors that may constitute barriers (weaknesses, threats) or promote (strengths, opportunities) the deployment of these urban laboratories, as illustrated in Figure 6. Although these factors are highly dependent on the specific characteristics of each laboratory, this matrix will highlight general aspects that must be considered.

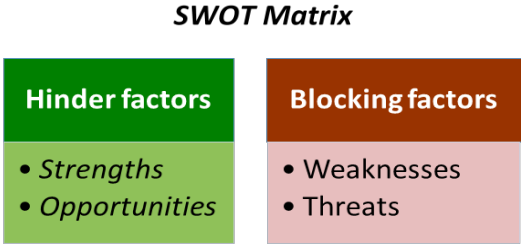

Fig. 6. Swot matrix proposed to underline the main factors that block or hinder the deployment a PED Lab

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4 Discussion and conclusions

When implementing a PED Lab, the first challenge is to establish a clear definition of what this type of urban laboratory entails. The initial concept is rooted in the Smart Energy City, Near Zero Energy Buildings and Urban Living Labs frameworks, with a focus on the district scale and a robust monitoring component within controlled environments. This approach merges the capabilities of a laboratory with sustainability and energy positivity objectives, enabling experiments to be conducted in real urban settings to validate innovative solutions on small and medium scales.

A PED Lab serves as a platform for conducting a variety of experiments, allowing for the analysis and validation of integrated solutions across similar or diverse urban contexts.

To identify key aspects in the implementation, development, and operation of a PED Lab, a methodology was employed based on qualitative analyses of responses gathered from questionnaires and working groups. Three main topics emerged: barriers, drivers, and stakeholders. Responses were quantified to assess the influence of each aspect, revealing nine categories of blocking factors, with social and financial aspects identified as the most significant. Climate change mitigation measures, strong local networks, and improvements in local and national political frameworks were noted as the primary driving factors. The mapping of stakeholders is essential, revealing the dynamic roles of various groups throughout the six phases of a PED Lab's life cycle. The findings underscore the pivotal role of government actors and the importance of citizen involvement, particularly during the vision and decision phases. Based on this analysis, the formulated research questions serve to guide future investigations, focusing on the most relevant aspects for implementing a PED Lab (barriers, drivers, and stakeholder processes), particularly when replicating this model in other contexts.

The research suggests creating a SWOT matrix to identify available resources, capabilities, and requirements for the successful operation or replication of a PED Lab.

The proposed SWOT matrix offers a framework to analyze available resources, capabilities, and requirements for effective operation and replication of PED Labs, emphasizing that while specific challenges may vary, overarching themes remain consistent across different environments.

Finally, this methodology promotes greater stakeholder participation and engagement in the deployment of PED Labs, as it identifies challenges and gaps through qualitative analyses derived from the questionnaires completed by these stakeholders.

The development of PED Labs can be instrumental in generating trust among governments, homeowners, and residents by facilitating the evaluation and experimentation of various technological combinations. This approach promotes proactive innovation while ensuring the solutions remain fit for purpose. Additionally, these initiatives could enhance the ability of governments and decision-makers to swiftly implement effective recovery measures that address immediate needs while also driving systemic change to improve the quality of life for all citizens.

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