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Report on the roadmap for PED implementation

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1 Introduction

The Positive Energy District (PED) concept is increasingly gaining recognition within academic and research circles, yet there remains a significant gap in practical strategies for its effective implementation. This study is framed within Task 1.5 of the COST Action 'Positive Energy Districts European Network,' offers a comprehensive and systematic review of the existing roadmaps, pathways, and guidelines—collectively referred to as 'PED-Transition Approaches'—aimed at facilitating the development of innovative models at the district scale [1]. The overarching goal of these efforts is to advance energy transitions and enhance urban livability, thereby contributing to more sustainable and resilient communities.

The "PED Pathway," as articulated within the Driving Urban Transition (DUT) Partnership [2], underscores the urgent need for a more precise definition of the PED concept, which is vital for its effective application in urban environments. The concept of PED is evolving, increasingly embracing a holistic approach that integrates a variety of direct and cross-cutting activities. Concurrently, the definition of PED is being refined to ensure it aligns with community policies and overarching frameworks, including the Strategic Energy Technology (SET) Plan [3], the EU Cities Mission [4], and the forthcoming 10th Framework Programme (FP10) [5].

This report serves as a key resource, encapsulating the context and definitions pertinent to the PED Roadmap. By conducting a thorough review of existing roadmaps and transition pathways, it identifies essential characteristics and key stakeholders that are critical for effective mapping during the implementation process.
In analyzing stakeholder relationships and developing tailored roadmaps, this study aims to deepen the understanding of how to effectively implement PEDs. It highlights the necessity of adopting a multi-level perspective that fosters collaboration among diverse stakeholders, thereby ensuring that the complexities associated with transitioning neighbourhoods to PEDs are addressed in an inclusive, feasible, equitable, and contextually adaptable manner.

The research employs a mixed-methods approach that integrates theoretical frameworks, literature reviews, and stakeholder analyses to capture the intricacies involved in the energy transition. This study is grounded in state-of-the-art, holistic, and inclusive methods and theories, including the PED Matrix and a variety of energy transition pathways that take into account different drivers and contextual factors.

Utilizing insights drawn from the PED Database and the Memorandum of Understanding (MoU) [6], the Working Group n.1 "PED Mapping, Characterization, and Learning" is focused on mapping and analyzing the primary roadmaps, pathways, and guidelines—collectively referred to as 'PED-Transition Approaches (PED-TAs)'—that are currently available for establishing PEDs in real-world settings. The study prioritizes three key objectives: (1) emphasizing the critical need for PED-TA within the current research landscape, (2) providing a comprehensive overview of existing PED-TAs, and (3) proposing future research directions for practical and multi-layered workflows for PED-TAs, including the development of robust PED-Roadmaps. Ultimately, this work aspires to catalyze the transition towards more sustainable urban environments by establishing clear, actionable strategies for the implementation of Positive Energy Districts.

2 Background on the roadmapping concept

The transition to climate-neutral cities is a complex endeavour requiring a nuanced approach that integrates economic, environmental, social, and legislative factors. Effective management of this process can benefit from a multi-level governance approach, emphasizing collaboration and adaptability among various stakeholders.

The Theory of Change (ToC) emerges as a valuable framework in this context [7-11]. It serves as a systematic tool for planning and implementing the necessary steps to achieve long-term goals related to climate neutrality. By defining a sharp vision of the desired change, the ToC allows stakeholders to work backward, identifying each action required to reach that vision. This structured process not only enhances clarity but also fosters a shared understanding among team members regarding the decision-making pathway toward sustainable solutions. Key components of the ToC include:

- Long-term Goal: A well-defined and realistic final objective that provides direction.
- Intermediate Outcomes: Short-term objectives that act as milestones on the way to the long-term goal. These outcomes help to break the larger goal into manageable steps.
- Planned Activities: Specific actions designed to influence the intermediate outcomes directly. These activities should be strategically aligned with the desired changes.
- Enablers: Identification of conditions—both internal and external—that are necessary to facilitate the transition. This may involve resources, policies, or supportive community dynamics.
- Evidence and Assumptions: Incorporating existing data and acknowledging assumptions is crucial for grounding the ToC in reality.

Furthermore, a data-driven approach is essential for the ToC's effectiveness. Conducting thorough situational analyses allows stakeholders to understand the unique context of their locality, including stakeholder dynamics, challenges, and existing systems. This understanding informs the development of a monitoring framework that identifies key indicators for tracking progress towards the intermediate outcomes.
In summary, a well-structured Theory of Change, supported by comprehensive situational analysis and data-driven decision-making, can significantly enhance the process of transitioning toward climate-neutral cities. This framework not only clarifies the path forward but also enables effective communication and collaboration among diverse stakeholders involved in the transition process.

Multiple studies and research underscore the necessity for comprehensive operational strategies to effectively implement innovative interventions at the district scale. In this context, structured pathways, roadmaps, and guidelines, which are designed as step-by-step workflows, emerge as vital instruments within urban strategies. These tools empower cities and their local communities to adopt systemic approaches that facilitate both holistic planning and design, as well as the scalability and replicability of interventions based on the PED concept.
Focusing specifically on transition management in urban environments, Roorda et al. (2014) [12] emphasize that the transformation process within urban settings around three interconnected macro-objectives: (1) cultivating a 'sense of direction' that provides a strategic vision for the future, (2) generating momentum for change that is informed by context-specific needs and ongoing initiatives aligned with the envisioned strategic direction,

and (3) empowering and engaging stakeholders in the co-creation of this vision to ensure their active involvement in the transition process. Building on these objectives, the guidance structures the transition journey into three sequential phases:

- **Orienting**: establishing the groundwork for transition management by examining local dynamics, framing transition challenges, and envisioning a sustainable urban future.
- **Engaging**: bridging short-term and long-term goals through the active involvement of key stakeholders and establishing strong connections within the community.
- **Activating**: implementing actions that involve preliminary experimental transformations, paving the way for broader change.

The approaches analysed above, and the relevant literature consistently highlight road-mapping as a pivotal method for strategic and operational decision-making, particularly in the context of city energy and climate-adaptive master planning. Jeffrey et al. (2013) [13] assert that road-mapping—which encompasses the processes of implementing, monitoring, and updating a roadmap—can be understood as an open and non-linear framework aimed at charting a meaningful path. This involves addressing three fundamental categories of questions:

- **Scoping Stage**: What direction should we pursue? What objectives does the roadmap seek to accomplish? What are the anticipated timelines?
- **Current State Identification**: What is the current situation? Is there an active market for us to engage with? Are there existing policies or initiatives that could facilitate the transition?
- **Action Plans**: How can we realize our vision for the short, medium, and long term? What strategies and actions need to be implemented to achieve these goals?

The third category of questions – *i.e.,* Action Plans - can be encapsulated within the roadmap framework, typically organized along two dimensions: a temporal axis divided into short, medium, and long-term segments, and various thematic layers that are crucial for achieving the overarching goals or ambitions. This roadmap functions as a strategic tool that not only outlines specific milestones and timelines but also identifies the central themes, practical actions, and key stakeholders required at each stage of the process. It provides a visual and structured approach to guide decision-making and prioritize efforts, ensuring that all actions remain aligned with the overarching objectives throughout the entire implementation journey.

3 Stakeholders targeted approach

Successful PEDs require the integration of technological, spatial, financial, legal, and social dimensions, supported by strong collaboration among cities, industry, researchers, investors, and citizens.

Key lessons learned from existing PED projects suggest a) the high importance of early and continuous stakeholder engagement, b) the need for flexible and adaptive governance structures, and c) the value of addressing the different challenges/opportunity of the transition process (i.e. technical, social, economic, legal) simultaneously.
Therefore, any energy transition roadmap hinges on the creation of a supportive framework that integrates environmental, social, and economic sustainability and develops those aspects along with the energy project. This framework must be built on secure and safe pillars, ensuring reliability to avoid project risks.

To address these challenges, the literature highlights the need for structured roadmaps and methodologies that emphasize stakeholder collaboration, context-specific planning, and iterative testing through pilot projects. A tailored approach to stakeholder engagement is also essential to identify weaknesses, foster collaboration, address specific objectives and strengthen the project's impact.

The role of stakeholders in PED development may differ from case to case. The alignment of stakeholder activities and their involvement needs to be integrated into a robust governance structure. To see the differences among the roadmaps, we need a closer look at the main actors (drivers) pathway and introduce the concept of targeted roadmaps tailored to different stakeholder personas and project phases.

Multi-level governance needs to be effective. The governance structure requires collaboration across multiple levels. The project needs to be aligned with broader policy and is dependent on resource allocation. The governance system needs to be adaptive. Given the dynamic nature of PED projects, governance structures must be adaptive, allowing for flexibility in response to emerging challenges and opportunities. This includes continuous monitoring, evaluation, and stakeholder feedback.

Stakeholders in development projects are commonly grouped into four categories as mentioned in the quadruple helix model, to ensure the diversity of expertise and interests in the process.
Public Sector: Governments and municipalities, often the primary promoters or initiators of PEDs.
Public Sector Persona: Focuses on policy alignment and public funding.
Private Sector: Industry players, including energy providers, construction companies, and technology firms.
Private Sector Persona: Emphasizes innovation, investment, and business models.
Civic Sector: Citizens and community organizations, whose participation ensures social sustainability and local relevance.
Civic Sector Persona: Prioritizes community engagement and social equity.
Academic Sector: Researchers and educational institutions, providing expertise and innovation.
Academic Sector Persona: Provides research, expertise, and technological solutions.

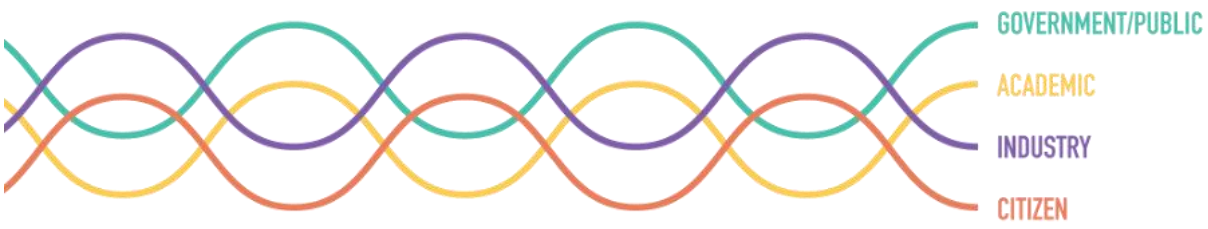

Figure 1: organically evolving collaboration between stakeholder © wonderland

To achieve a holistic approach governance, PED projects must address eight key aspects as outlined in the following PED Matrix [Figure 2]:
Technical: Planning and implementation of energy systems and infrastructure.
Social: Community engagement and empowerment
Managerial: Managing the operational phase and team management.
Financial: Funding models and economic feasibility.
Legal: Regulatory compliance and governance structures.
Environmental: Ecological impact and resource optimization.
Cultural: Preservation of local heritage and identity.
Process: Integration of innovative technologies and practices in a complex process.

Figure 2: PED Matrix © wonderland/Batuhan Akkaya

These “PED aspects” [Figure 3] may gain or lose importance across different stages of the project but must be addressed to ensure sustainability to the process and can be considered as the essence of the transition approach.

3.1 Stakeholder tasks

The PED Matrix [14] (PED Manifesto 2024) is based on cross analysis of urban transformation projects and specifically on dozens of PED projects. Based on the PED Matrix [15], the “PED core aspects” are identified which stakeholder tasks play a significant role in the development of PEDs.

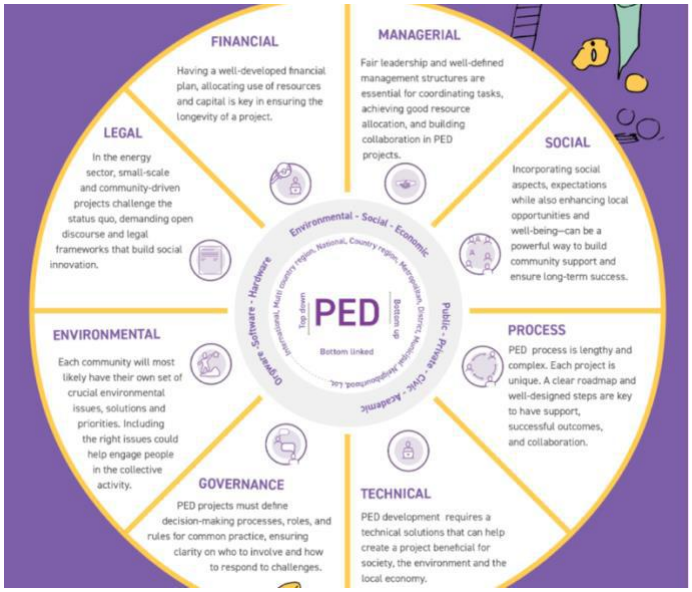

Figure 3: PED core aspects © wonderland/Batuhan Akkaya

3.1.1 Social aspects

A PED project is a transition project, it requires that we use only renewable energy, that we consume as much as we produce, requires that we change our buildings and invest in new projects, impacts how we move around and perhaps coordinate the energy production with the consumption. In this regard, the change into one's life is huge. A project of such dimension has to at least deliver a true involvement scheme. The people affected need to be a part of this change. The process needs to allow them to create the solution which fits THEM. The tasks of involvement and empowerment have to be tackled in the social aspects of the project. The aim is to achieve with early involvement of stakeholders the sense of ownership which unfolds taking care of the developed solution and maintaining the implemented solution properly. Early may mean different things in different projects. In a new development area, where future residents are not clear yet, the inclusion may start much later. In a brownfield redevelopment area as well, the future users may not be clear yet, therefore the social aspects can be developed later in the process. Where else developing a PED out of an energy community may have the social aspects developed fully in the beginning of the process. Such a roadmap for bottom up developed PED's is described in the subchapter "the bottom-up" roadmap. Citizen's inclusion in the process is also particularly important in refurbishment or renewal projects. In any case, at a point, the project needs to aim to create a community around the developed solution, which lives the change and develops it further. The inclusion of social aspects can help to limit the risk of eroding trust or overcome the lack of trust. Social aspects can be pinned best around or based on shared values and can lead to social consent. E.g. the project can have the aim to combat energy poverty and accompanying rules on how to distribute and share the locally produced energy can make the impact for low-income households' tangible and win them over for the project.

3.1.2 Process aspects

Depending on the size of the area of transition and the readiness of the built environment and envisioned transition the process can be lengthy, sometimes requires extensive expertise and the roadmap may be full of uncertainties. Required expertise can cover in

some cases dealing with mistakes, revitalisation of neighbourhoods, dealing with technical shortcomings, juggling with legal or heritage challenges, and handling risks. Many aspects of the PED process can be similar, but they always require particular or individual insights and skills stemming from the context and/or history of the place. Such processes need to be envisioned with the eventualities and altering solutions and scenarios can enable the project developer to react to surprising challenges. The process aspect is potentially prioritised for projects which are developed top-down, especially in new development areas or in the implementation of urban policies and strategies. Uncertainty in the process is a major risk and needs in some cases even external support. Some processes are led by decision makers, administrations, investors, or the citizens. The set of knowledge and skills will always require getting support in the fields which are not covered and a good knowledge about the process and its potential problems. The coordinator of the PED process, with good leadership skills and process knowledge can get accurate support on time (knowledge about needed expertise) and finally lead to success. While process interruptions may lead to loss of time, money, and worst of all trust. Synergic collaborations can also only happen with a well-developed process open to receiving support.

3.1.3 Technical aspects

Expertise about the built environment, systems, energy, material, sustainability, building stock, infrastructure and digitalisation are particularly important to develop a PED project. Technical development of an energy project depends on expertise in various fields and needs in most cases external technical support for particularities, e.g., technical details of buildings, heritage requirements, local context... Specific details of the building, site or neighbourhood or the occupation of the building may need serious alteration of the PED concept. At the same time the environmental aspects allow different renewable energy productions. A very good overview of needs and options can create a balanced technical model. PED is a powerful concept to change district by district the way we produce and consume energy. At the same time, it is decisive to work with skilled and experienced people, to avoid technical shortcomings. The project always will need a certain degree of innovation, as well as acceptance from local users, so the project needs to be developed in the light of matchmaking, matching the local potentials and needs in a meaningful way. How to develop a project from the technical standing point is described in the subchapter “the technical roadmap.”

3.1.4 Governance aspects

Clarity on when to involve whom, how decisions are made and who can step up when matters get too risky can be defined in the governance scheme of the PED. Rule of common practice and decision making, power division in extraordinary situations, common values and defining the purpose of the projects and describing the managerial tasks are some of the topics to be clarified from the beginning. Over long-term people, stakeholders, members, and advisors can be only committed and willing to co-create when their roles are defined, and they know how to contribute. The governance model should respond to the expectations and define where the power in each situation lays. If in a PED project the governance is built by citizens and public authority, this sends a clear message on power distribution. If the governance scheme foresees that the residents of the PED area decide on pricing and investments, this is a clear message on whose interests are respected. Additionally, to ensure resilience in challenging situations, the governance model can include next to multilevel governance model, also that the governance is building on the different expertise in the group, defining procedures and reoccurring moments for stability and

envisioning the future. Finally, a governance model can aim to implement a culture of collaboration in a respectful manner, with a supportive ecosystem from authorities, experts, technicians, and researchers. The governance models in most PED projects are not elaborated yet but could be growing with the process of the PED development and pillars could be developed with the local community and stakeholders collaboratively. Especially top-down developed PEDs described in subchapter “top-down roadmap” need to aim to hand over the project to local actors at a point and for this the governance aspects have to be fortified and co-developed.

3.1.5 Environmental aspects

There are many rules, guidelines and laws which need to be respected in each project. E.g., solar panels or wind turbines may interfere with the local heritage laws, but the location might be good for such energy production. From the local priority to regional and national and continental priorities, there are many nuances. Having the right environmental topic for the PED project can help engage people in collective activities. PED also means some changes in one's own life, like reducing consumption and investing in local production, becoming a member of an energy project etc. Resistance in environmental agenda or legal problems in terms of environmental regulations can jeopardise the project’s success. Such projects also may interfere with individual freedom or rights. Additionally, a well organised energy project can contribute to the overall environmental ambitions with e.g., protection of species or re-naturalising areas. However, the overall aim of environmental aspects is that we optimise the consumption in such a way that the demand can be locally met. Next for energy consumption, also other resources can be brought into the matchmaking with employing Nature Based Solutions, Circular Economy Models, and similar. Typically, environmental aspects have to be clarified in the beginning of an energy project and can be causing further adjustments in the PED process.

3.1.6 Legal aspects

There are many legal loopholes which are challenging for PED projects. In the energy sector the small-scale projects and people driven energy projects are challenging the energy sectors set up significantly. Such projects are transforming the sector and often need an open discourse to innovate in legal terms. Projects need to acknowledge that they need to act in a legal framework. The legal aspects will tremendously identify and classify the project in terms of governance model, the regulations under which they need to operate, how agreements have to be created, how security is assured, etc. But also, simple regulations in terms of GDPR and privacy can significantly challenge how an energy project is set up and works, includes citizens, how it’s financed etc. In legal terms an energy project has to fulfil needs for stability and safety. However, for a sector in transition, this is difficult to establish. For instance, the energy communities are exposed to changing laws in the last years, which also affect PED projects, e.g., the rules and terms of energy sharing. Some envisioned legal changes simply are not possible, or others change their action field significantly. Having a basic legal understanding in the team and perhaps connecting with others to advocate for legal needs are important tips for energy projects. In any case, PED projects need to prevent instability and legal loopholes which can put them in precarious positions. For advancements in the legal framework the development has to be community centred and benefit the communities and not selected corporations. Therefore, the legal framework has to be assessed in the beginning of the project development and needs constant observation and adaptation, with the process of the project.

3.1.7 Financial aspects

The energy transition is a European priority to carbon neutrality and therefore there is a great need for research and many products, applications and methods are in development. These projects are often funded and subsidised. To be impactful those projects should be developed with the local problem owners and especially with people who will be living in the transformed context. Next to who is benefitting from financial resources, it is also crucial to have a well-developed financial plan. Where does the money for investment and maintenance come from, which business model is employed and how to deal with resources…. Financial stability and independence are an important aspect for energy projects. Also, clarity on how different scenarios can impact their operation and empower them is the basis for informed decision making, to have clarity in social, governance and managerial aspects. They need to avoid surprising costs and risks, which will make participants of such projects open for professional consultation and collaboration in research projects, where they can get grounded information to steer their projects effectively. An important aspect is also being clear on future maintenance and reinvestment costs, to be included in the financial plan. An urban energy common will have a different business plan, then an investor driven PED project. Either Way, being clear on which business plan is targeted should be defined in the beginning of a project and therefore will significantly influence the process, social, governance and managerial aspects.

3.1.8 Managerial aspects

PED projects need to be managed somehow, as they need to establish a dialogue on production and consumption, as well as maintenance and adaptations. Currently the PED concepts are not including a managerial organisation, but they would be extremely useful. In settlements, this can be handled for instance by the resident's association, or the residents can form an energy community and include their social aspects with the governance aspects. Typically, the managerial aspects come into force, when the projects are implemented, but the core elements are often defined in the development process. Expertise about the built environment, systems, energy, material, sustainability, digitalisation are important parts of the managerial aspects. When the team cannot cover these, they need to have trustworthy external support.

3.2 Stakeholder mapping

The stakeholder mapping framework helps to identify the roles, responsibilities, and influence of different stakeholders. This framework can be used to tailor roadmaps to specific stakeholder groups, ensuring their effective involvement throughout the project lifecycle. Different stakeholder personas may activate and drive PED projects, each with unique priorities and contributions (persona-based roadmap). Sector-oriented-roadmaps can be developed for each persona, aligning their tasks and "action" with the phases of its development and according to the Theory of Change.
As outlined above, the roles and tasks of stakeholders vary depending on the context, project type, skills, experience, and phase of the PED process, emphasizing the importance of addressing shifting priorities, and fostering long-lasting collaboration. By understanding the unique contributions and needs of each stakeholder type, PED projects can navigate challenges, build consensus, and ensure the successful implementation of sustainable urban solutions. The type of PED project significantly influences stakeholder roles and priorities. For example, a refurbishment project requires collaboration with heritage experts, historic building specialists, and local communities to preserve cultural identity while integrating

modern energy solutions. New construction sites on the other hand often involve real estate developers, urban planners, and technology providers to design and implement innovative energy systems and there are often no citizens involved, as they are not known yet. An energy infrastructure focused on grid or mobility as a service (MAAS) may have the goal to significantly upgrade or adapt existing energy systems towards electricity. In existing neighbourhoods this may disrupt daily life, necessitating close collaboration with citizens to minimize resistance and ensure acceptance.

Stakeholder mapping should be related to a detailed analysis of the PED phases and associated tasks. This process involves:

- Identifying the key activities and deliverables for each phase.
- Determining the stakeholders responsible for or affected by these activities.
- Mapping the relationships and interdependencies between stakeholders.

Clear definition of roles is essential to ensure that each stakeholder group understands its responsibilities and contributions. In this context the role of a Municipality could be to provide regulatory support, funding, and, or policy alignment. Where else a real estate developer might be the driving force for investment and, or they could be overseeing construction. Citizen's role could be to offer local insights, ensure social acceptance, and participate in decision-making, or financing. Synergistically a research institute could provide technical expertise and facilitate innovation.
That means that multiple roadmaps can be designed accordingly: a pathway for innovation where the private sector and the academic sector are steering the PED process. A decision-makers pathway with a top-down approach, driven by the public sector. Finally, a bottom-up approach where the main actors are citizens or citizen groups.

Table 1: Key Stakeholder Groups in PED Development

1. Municipalities	As primary promoters of PEDs, municipalities play a crucial role in setting policy frameworks, securing funding, and coordinating stakeholder efforts.
2. Real Estate Developers and Building Owners	These stakeholders drive the financial and technical aspects of PED projects, ensuring that designs are feasible and aligned with market demands.
3. Energy Providers and Mobility Providers	Energy providers are responsible for integrating renewable energy systems, while mobility providers contribute to sustainable transportation solutions.
4. Research Institutes and Universities	Academic institutions provide expertise, innovation, and evidence-based solutions to address technical and social challenges.
5. Citizens and NGOs	Citizens and non-governmental organizations (NGOs) ensure that PED projects are socially inclusive, equitable, and aligned with community needs.
6. SMEs and ICT Companies	Small and medium-sized enterprises (SMEs) and information and communication technology (ICT) companies contribute to technological innovation and business model development.
7. Politicians	Politicians provide political support, advocate for policy changes, and ensure alignment with broader sustainability goals.

As outlined, the role and tasks of stakeholders will be differing from context to context. Additionally, the needs of and from the stakeholders may differ from stage to stage in the PED development process. The systematic approach stakeholder mapping builds on a comprehensive elaboration of the PED phases and tasks. With the mapping of the actors a definition of roles for each stakeholder (group) is urgently important to allow the impairment with the proper actions and communication tools among them. The success of the PED solution depends next to technical solutions also on social, political, and business commitments. Having a complete roadmap in mind, the PED process needs to ensure a long-lasting collaboration and coordination between the different actors. The stakeholders may have different names and entities in different contexts but consists of municipalities, real estate developers, building owners, tenants, energy providers, research institutes and universities, mobility providers, ICT companies, SMEs, NGOs, politicians, and finally citizens. Depending on the starting point and the objectives of the project different paths can be relevant for the project. An energy project which aims to install a new energy ecosystem may need to employ the pathway of ToC and therefore will need to identify the right stakeholders and their roles for all 8 stages. Common urban planning project which addresses mainly the 5th and 6th stage of the ToC pathway will be needing different focus on stakeholders and the tasks will be for those 2 stages much more detailed. The 7 phases-PED-process correlates similarly with the ToC spectrum, but details further the Urban Planning process for energy transition, e.g., by adding energy planning as an essential dimension to the process.

4 PED Transition Approach: review of existing roadmaps, pathways, and guidelines

4.1 Methodological approach

The review that supports the recognition of the available Transition Approaches towards Positive Energy Districts (PEDs) was conducted in accordance with the PRISMA 2020 guidelines (available at: https://www.prisma-statement.org/prisma-2020-statement) and utilized a two-step approach:

- Document Search and Screening: this initial phase involved a comprehensive exploration of existing projects, initiatives, and research. The primary objective was to gather relevant approaches and methodologies designed to assist stakeholders in the transition towards Positive Energy Districts (PEDs).
- Document Categorization and Analysis: In this subsequent phase, the gathered documents were systematically categorized for two key purposes: (a) to ascertain the necessity for Transition Approaches to PEDs (PED-TAs) and (b) to identify practical methodologies and case studies that employ PED road-mapping. An analysis matrix was created to facilitate a thorough examination and comparison of the essential features and contents of the various transition approaches.

A detailed overview of the methodology employed in this review is visually summarized in Figure 4.

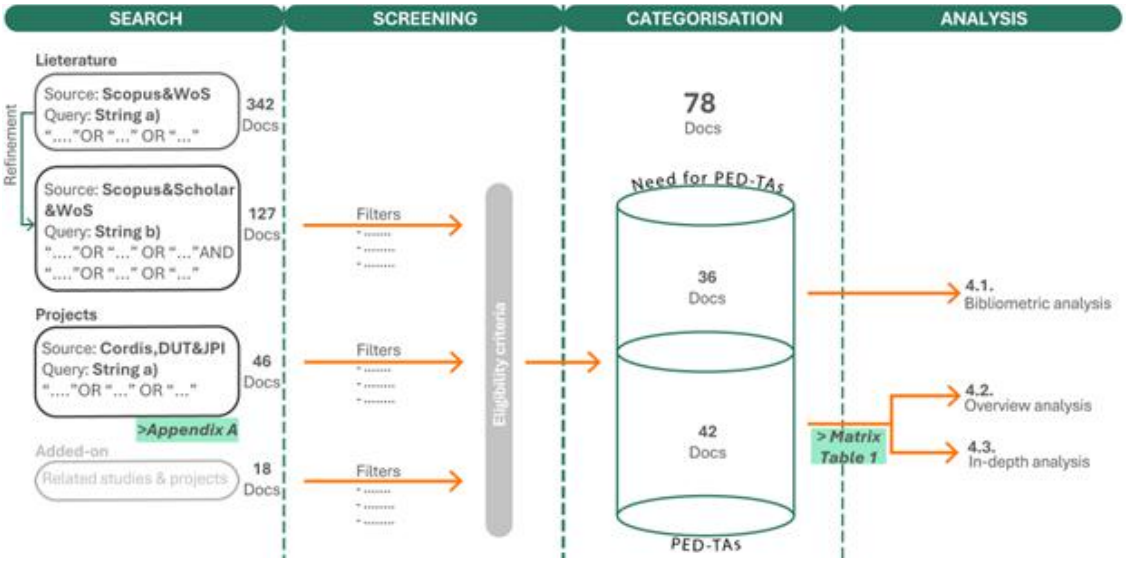

Figure 4: Flowchart: methodological approach for the review (Turci *et al.*, 2024).

The documents that highlight the necessity for PED TAs were utilized to conduct a Bibliometric Analysis of the authors' keywords through VOSviewer software (accessible online at: https://www.vosviewer.com/.) This analysis aimed to show research trends related to PEDs, as well as to explore the background and interconnections among various thematic areas and sectors, such as sustainability, technological innovation, and urban planning.
Specifically, Figure 5 presents a comprehensive overview of the co-occurrence of authors' keywords within the scientific literature, while Figure 6 offers a detailed examination of the temporal distribution of these relevant co-occurrences in the body of research.

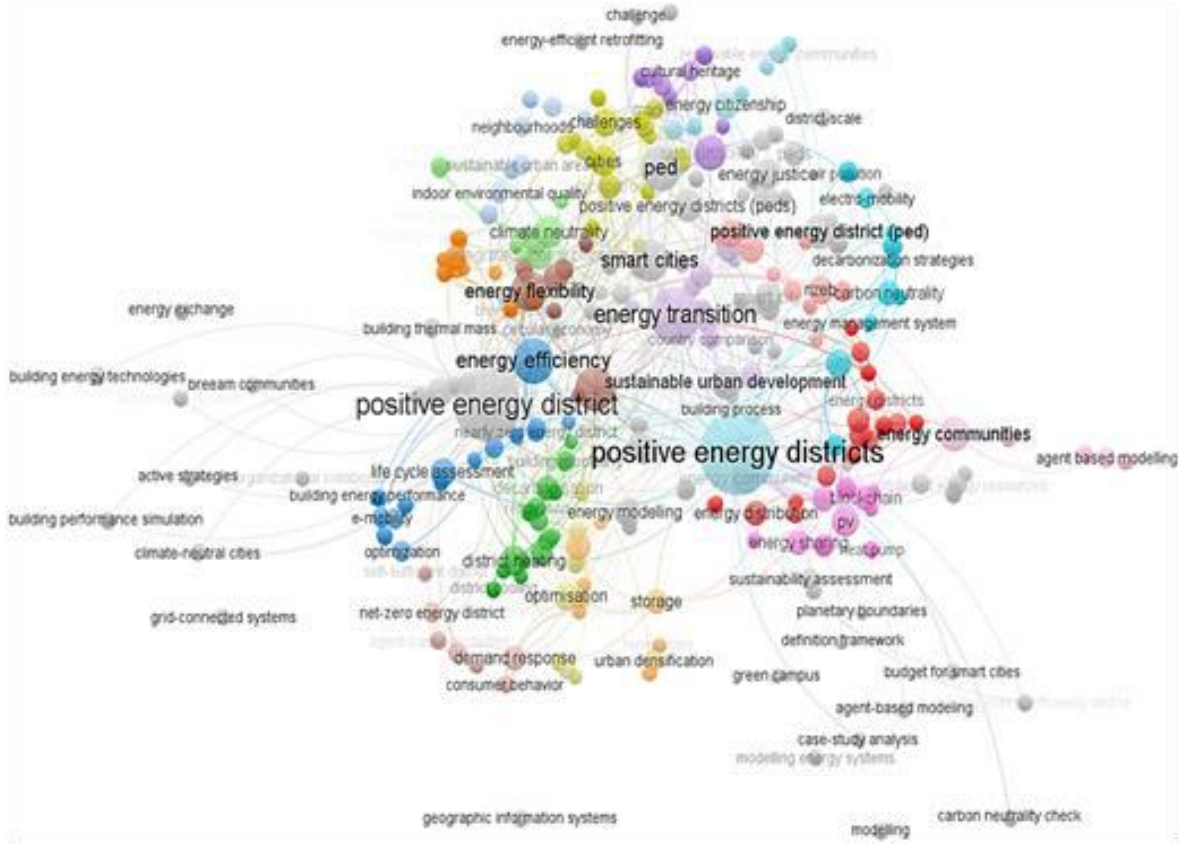

Figure 5: Main overview of authors' keywords co-occurrence of scientific literature (Turci *et al.*, 2024).

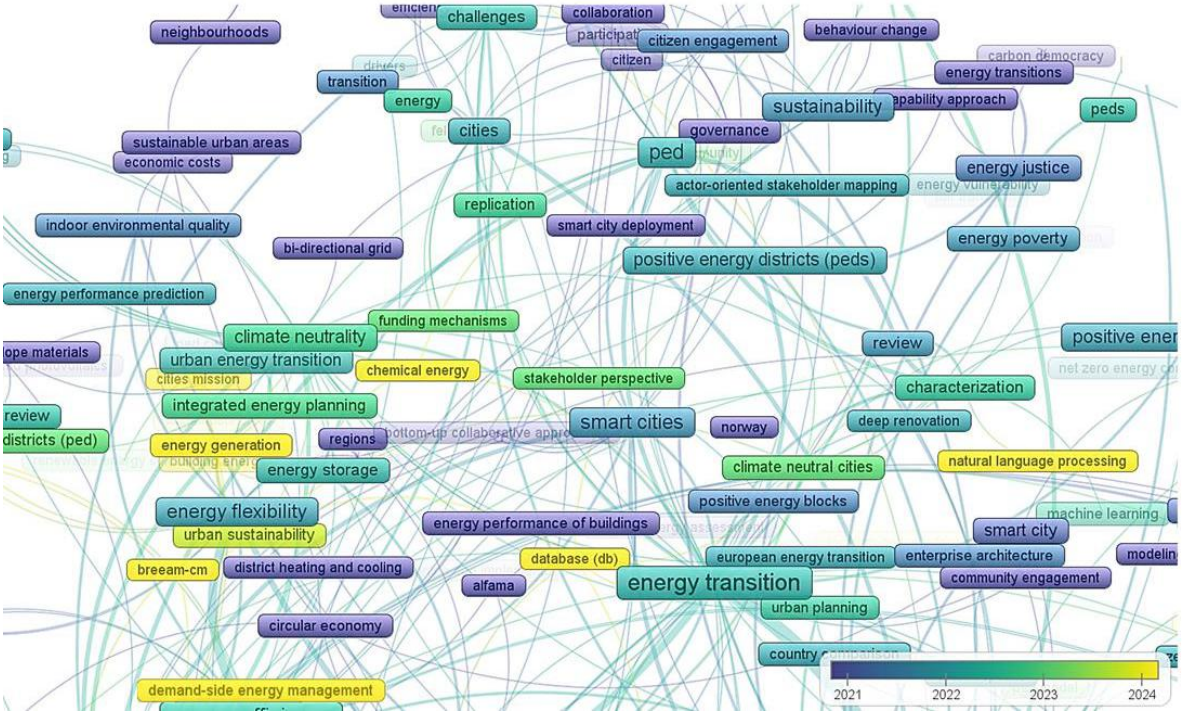

Figure 6: Temporal distribution of the co-occurrence of relevant authors' keywords within the scientific literature (Turci *et al.*, 2024).

4.2 Overview analysis

The global need to move towards climate neutrality demands innovative strategies in urban planning and development. Positive Energy Districts (PEDs) strive to facilitate sustainable urban transformation by integrating energy efficiency, renewable energy systems, and collaboration across various sectors. However, the intricate nature of PED development necessitates a structured and methodical approach to ensure enduring success.
From this standpoint, implementing systematic roadmaps can enhance the spread of PEDs by assisting municipalities during the planning phase and promoting collaboration among corporate stakeholders, citizens, and interdisciplinary research teams. Additionally, establishing a systematic planning approach is crucial for achieving long-term sustainability goals and for encouraging the replicability of PEDs. Nonetheless, many researchers emphasize the necessity for further studies to discover comprehensive solutions and customized roadmaps. A collection of publications categorized as PED-TAs was gathered and thoroughly examined based on the matrix presented in Table 2 which includes the scale of application (4.2.1), scopes (action areas) (4.2.2), key features (4.2.3), target stakeholders (4.2.4), and phases of application (4.2.5).

Table 2: Content framework for the analysis matrix of the PED-Tas (Turci et al., 2024).

Basic info				**PED-TAs analysis**						
Title, Source, Keywords	**Type of document**	**Focus PED**	**EU projects funded**	**Scale**	**Scopes (Action Areas)**	**Key Features**	**Target Users**	**Phases**	**Brief**	**Graph**
[txt]	[single choice]	[single choice]	[single choice]	[single choice]	[single choice]	[multiple choice]	[multiple choice]	[multiple choice]	[txt]	[img]
/	- Journal article; - Conference paper; - Project deliverable; -Book chapter; - Website	- Yes; - No.	- Yes; - No; if Yes, specify	- City; - District; - Buildings block.	- Orienting - Engaging - Activating	- Step-by-step approach; - Focus on renovation; - KPIs calculation; - Scenario simulation; - Digitalisation; - Context-based; - Stakeholders participation; - Customer oriented.	- Public Sector; - Private Sector; - Research Sector; - Citizens and civil society.	- Planning; - Design; - Construction; - Operation.	/	/

Figure 7 demonstrates the steady rise in this category of publications in recent years. It's important to mention that the data for 2024 only includes publications up to June, which is when the literature search was carried out. The emphasis on methodologies and applied cases stems from their notable increase, underscoring their growing significance and relevance within the field.

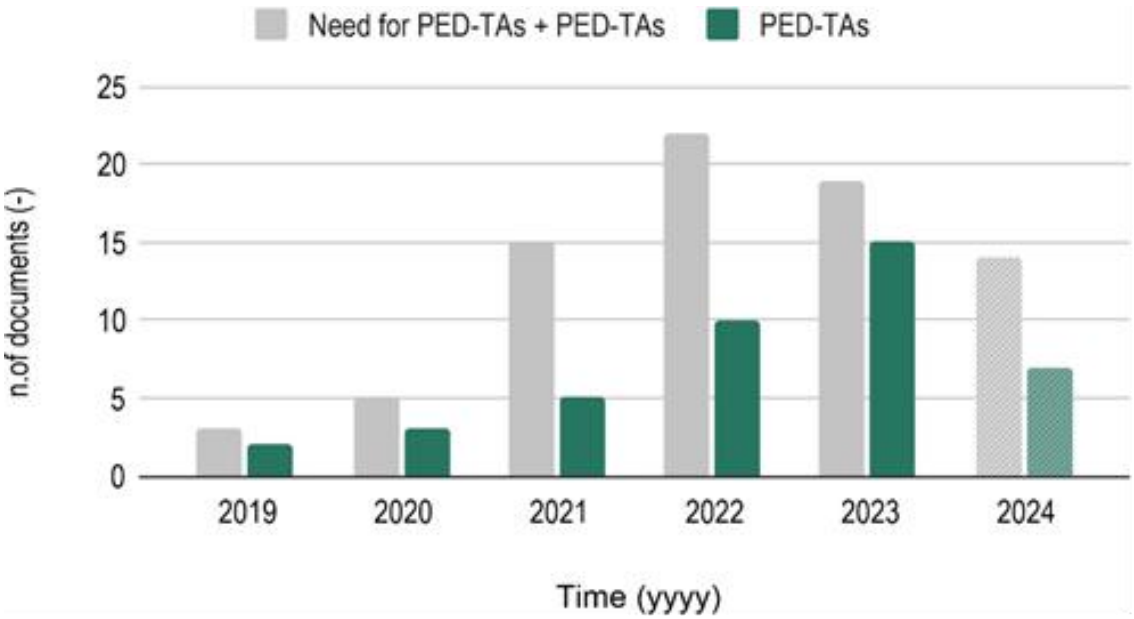

Figure 7: Trend in PED-TAs publications (Turci *et al.*, 2024).

In a comprehensive analysis of the methodologies and practical applications associated with the PED concept, a total of 42 relevant documents have been meticulously identified and examined through a thorough literature review. Out of these, 26 documents specifically concentrate on the core principles and strategies related to the PED concept, as referenced in sources [e.g., 16-18]. The remaining 16 documents explore various assets that share similarities with PEDs, highlighting a broader spectrum of sustainable energy initiatives. These include energy communities, which are collaborative networks aimed at optimizing energy use [19-23], climate-positive communities that strive to reduce their carbon footprint and promote environmental sustainability [24, 25], as well as green and solar neighborhoods or cities that emphasize the integration of renewable energy solutions [26, 27]. Additionally, the review encompasses district-scale renewal projects focused on revitalizing urban areas with sustainable practices and initiatives aimed at achieving net-zero energy and carbon districts, which aim to balance energy consumption with renewable energy generation. This multifaceted analysis not only sheds light on the diverse interpretations of the PED concept but also underscores the interconnectedness of various sustainable energy frameworks and their applicability in fostering energy-efficient communities.

4.2.1 Scale of Application

A significant portion of the analyzed documents, amounting to 64.3%, is dedicated to exploring the district scale, primarily through the lens of the PED concept [28, 29] and associated themes [30, 31]. This strong emphasis on the district level underscores the PED's objective of enhancing energy efficiency across various buildings and public spaces within a specified urban area. By concentrating efforts at this scale, the PED approach offers a practical and impactful framework for driving energy transformation initiatives, facilitating coordinated improvements in energy use and sustainability.

In contrast, the remaining documents delve into methodologies applicable at both broader and narrower scales. Specifically, 26.2% of the studies concentrate on the city scale, which encompasses related concepts such as smart cities, carbon-neutral cities , and climate-positive cities. Furthermore, 9.5% of the papers focus on the building block scale [32], addressing themes like energy communities [19] and building renovation [33]. This exploration of city and building scales complements the predominant district-level analysis, illustrating that while the principles of PEDs are primarily applied within a district framework, they can also be effectively adapted to larger urban environments and individual building contexts (Figure 8).

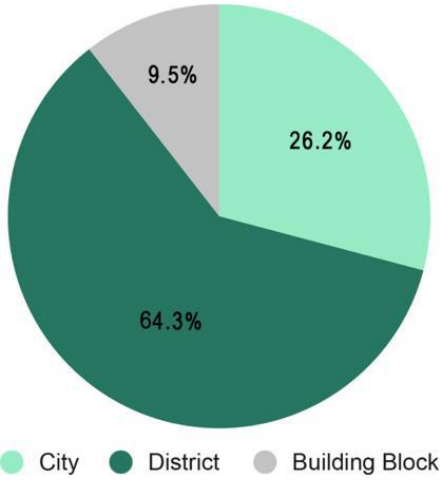

Figure 8: PED-TAs Scale of application (Turci *et al.*, 2024).

4.2.2 Scopes (Action Areas)

According to the transition management methodology proposed by Roorda et al. (2014) [12], the PED-TAs have been systematically analysed by categorizing various cases based on their specific scope or area of action (Figure 9).

Among the diverse cases examined, a significant portion—42.9%—focuses primarily on activating. This emphasis on activating highlights the critical importance of establishing pilot projects aimed at identifying optimal solutions for a range of intervention scenarios [27, 33]. The activating approach is crucial not only for the practical testing and demonstration of PED concepts but also for fostering innovation. By implementing pilot projects, stakeholders can engage in hands-on experimentation, allowing to refine cities' strategies based on real-world applications and outcomes. This process helps to bridge the gap between theoretical concepts and practical implementation, ultimately enhancing the effectiveness of PED initiatives.

In addition to activating, a substantial 40.5% of the cases concentrate on orientation, utilizing strategic tools designed to enhance decision-making processes by assessing specific local challenges from a medium- to long-term perspective [25]. These orienting tools are instrumental in facilitating the PEDs planning with a long-term vision. By addressing immediate needs while simultaneously considering future implications, these tools ensure that urban transformation efforts are sustainable and aligned with broader environmental and social objectives. This foresight is vital for creating resilient urban landscapes that can adapt to evolving challenges over time.

The remaining 16.7% of the cases emphasize engaging, highlighting the crucial role of stakeholder participation throughout all stages of the PED process [34, 26]. Although this focus on engagement is less prevalent compared to activating and orienting, it underscores the necessity of involving local communities, businesses, and other key stakeholders from the very beginning. This inclusive approach is essential for ensuring that the PED is not only technically feasible but also socially accepted and tailored to meet the specific needs of those it impacts. Engaging stakeholders fosters a sense of ownership and commitment to the project, significantly enhancing the likelihood of its success. Notably, some transition activities, even those with a stronger emphasis on activating or orienting, incorporate engagement components into their proposed workflows [26]. This integration reflects an understanding that successful PED initiatives require a holistic approach, combining technical innovation with community involvement to create sustainable and impactful urban transformations.

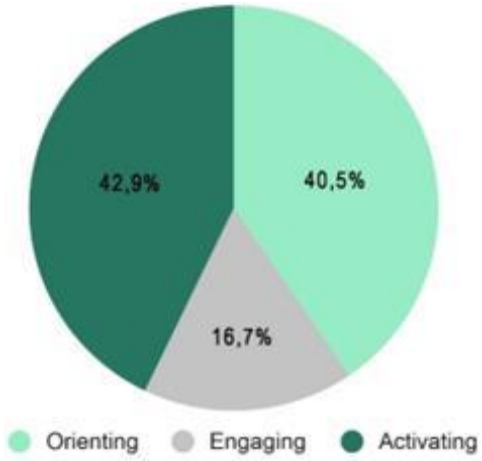

Figure 9: PED-TAs Scopes (Turci *et al.*, 2024).

4.2.3 Key Features

By closely analyzing the content of various documents, several key features have been pinpointed as essential for the development of a comprehensive PED-TA) roadmap, as depicted in Figure 10. These features include a step-by-step approach (SSA) [36], a strong emphasis on renovation (R) [29], the calculation and monitoring of key performance indicators (KPIs) [18], scenario simulations (SS) [28], digitalization (D) [37], context-based strategies (CB) [17], stakeholder participation (SP) [38], and a customer-oriented mindset (CO) [39].

Notably, each of these elements is referenced in at least 15 different documents, highlighting their significance across the literature. Context-based strategies stand out with mentions in 38 documents, while the step-by-step approach is cited in 35, emphasizing the importance of customizing PED strategies to address the unique socio-economic, environmental, and geographical characteristics of each district. This is crucial, as one-size-fits-all solutions typically do not meet the specific needs and challenges faced by different areas.

Moreover, the prominence of the step-by-step approach (SSA) in a substantial number of documents (35) underscores the necessity for a structured and phased methodology when implementing PEDs. This systematic approach not only facilitates incremental progress but

also ensures that each stage of development builds logically upon the previous one. By adopting this method, stakeholders can better manage the complexities associated with transitioning to PEDs, allowing for adaptive learning and adjustments throughout the process.

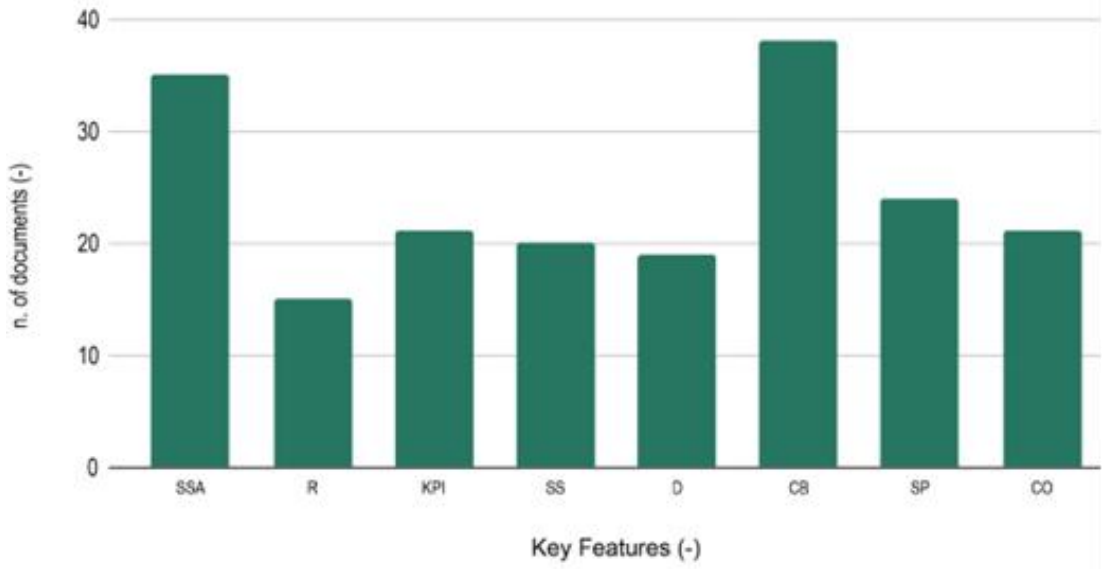

Figure 10: PED-TAs Key features (Turci *et al.*, 2024).

4.2.4 Target Stakeholders

Figure 11 provides a comprehensive overview of the four distinct types of stakeholders involved in the development and promotion of Positive Energy Districts (PEDs). Among these, the public sector is frequently recognized as the leading promoter or initiator [25, 39, 40]. This prominence can be attributed to several critical roles that the public sector plays in the establishment of PEDs.

Firstly, the public sector is essential in establishing regulatory frameworks that set the standards and guidelines for PED development. These regulations ensure that projects align with broader environmental goals and sustainability standards, thereby promoting a more cohesive and effective approach to energy management at the district level. Additionally, the public sector often provides crucial funding mechanisms that enable the initiation and scaling of PED projects. This financial support can come in various forms, including grants, subsidies, and public-private partnerships that lower the financial barrier for innovative energy solutions.

Moreover, policy support from the public sector is fundamental to the successful integration of PEDs into existing urban infrastructures. This support not only helps to streamline the permitting processes but also encourages the adoption of best practices in energy efficiency, renewable energy use, and community engagement. By fostering an environment conducive to innovation, the public sector can catalyze the development of cutting-edge technologies and practices that contribute to the goals of PEDs.

In addition to these foundational roles, public sector initiatives often facilitate collaboration among a diverse array of stakeholders, including private enterprises, research institutions, citizens, and non-profit organizations. This collaborative approach is vital for leveraging the unique capabilities and resources of each stakeholder group, thereby enhancing the overall effectiveness of PED initiatives. For example, private enterprises can bring expertise in technology and commercial viability, research institutions can contribute valuable insights

and data, and citizens can provide essential feedback and support for projects that directly impact their communities.

The involvement of these groups adds depth and diversity to the stakeholder landscape, ensuring that a wide range of perspectives and interests are taken into account. For instance, private sector stakeholders can drive innovation and investment, while academic institutions can contribute research and analysis that inform best practices. Citizens, on the other hand, are crucial for fostering community buy-in and ensuring that the needs and preferences of local populations are met. This collaborative framework not only supports the development of PEDs but also fosters a sense of community ownership and engagement, which are essential for the long-term viability of these initiatives.

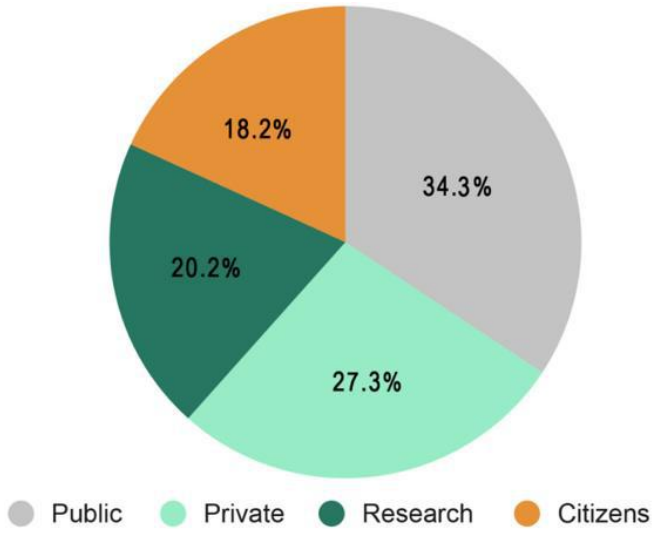

Figure 11: PED-TAs Target Stakeholders (Turci *et al.*, 2024).

4.2.5 Phases of application

In relation to the phases identified through the classification of the PED Database, a significant observation is that the majority of documents focus on the pre-implementation stages. Specifically, 36 publications delve into the planning phase, which is critical for the successful execution of PED initiatives (Figure 12). This group of works includes notable contributions such as [16, 34], which explore various methodologies and best practices for effective project planning. Furthermore, 25 publications concentrate on the design and demand aggregation phase [29, 32], highlighting the importance of aligning project designs with the needs of stakeholders and the community.

This trend emphasizes a prevailing focus within the PED research community on establishing a robust groundwork for projects prior to advancing to the more complex stages of construction and operation. Effective planning is essential for establishing clear objectives, which serve as a guiding framework for the project. It involves thorough analysis and consideration of various factors, including energy demand projections, resource availability, and technological requirements. Additionally, ensuring stakeholder engagement during these early stages is paramount. Engaging with stakeholders—including local communities, policymakers, and industry experts—fosters collaboration and can lead to more innovative solutions that meet the diverse needs of all parties involved.

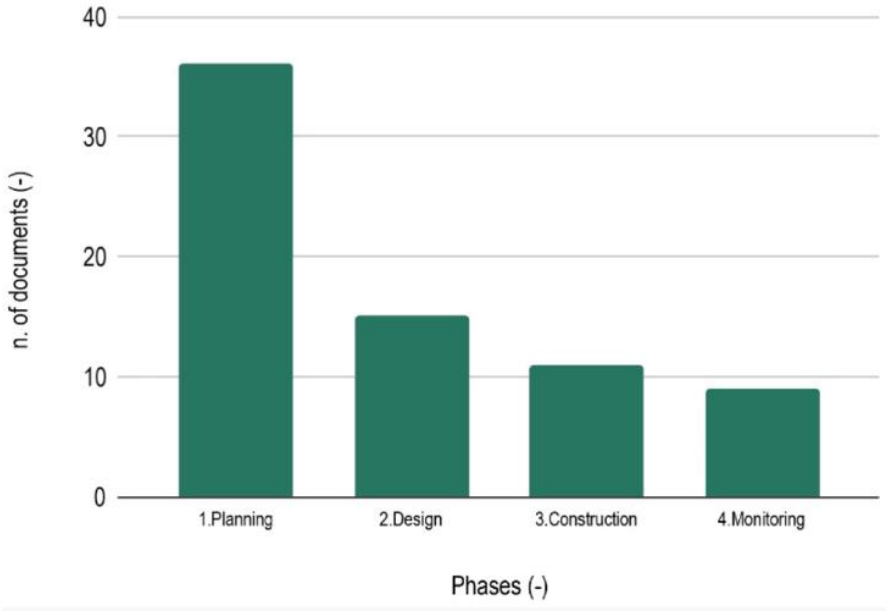

Figure 12: PED-TAs Phase of Application (Turci *et al.*, 2024).

4.3 Gap analyses

To support the implementation of PEDs, practical strategies are primarily developed within research projects, framing PEDs as a circular process characterized by a sequential and incremental workflow. This methodology necessitates specific guidelines for each phase of the PED process, with a particular focus on the planning stage. A comprehensive list of actions and stakeholder engagement throughout the process can enhance each iterative phase. However, the primary challenges faced by public administrations are data availability and capacity building, which must be addressed to ensure social and economic feasibility during the transition.
In this sense, key priorities include: (1) adopting a user-centric approach that considers the roadmap users and their roles at each stage of implementation; (2) defining actions aligned with the goals of Orienting, Engaging, and Activating [12], and sequencing them for effective PED implementation; (3) engaging the entire "PED Community" in the implementation process; (4) customizing the roadmap to fit the intervention context, whether it involves new construction or renovation, while also accounting for regional differences (e.g., northern countries versus Mediterranean areas); and (5) integrating a multi-layered system that encompasses buildings, the environment, people, and other relevant components.
In the short term, the PED roadmap serves as a robust tool to assist municipalities and private investors in planning and designing PED implementations in urban settings. Looking to the mid- to long-term future, this roadmap has the potential to be integrated into city planning instruments, thus facilitating the transition toward climate neutrality targets.

The Theory of Change (ToC) provides a robust framework that can guide actors in the process of transition, by enabling stakeholders to navigate the multi-level, dynamic, and collaborative processes inherent in PED development and beyond. An actor-centric approach will ensure that the roadmap is tailored to the needs and roles of its intended users, stakeholders, and collaborators, including policymakers, urban planners, industry stakeholders, and community members. By considering the perspectives of these actors, the roadmap can address specific challenges and opportunities at each phase of the PED implementation process. In this perspective, the Theory of Change (ToC) [7-11] may be

adopted as a methodological approach to outline a step-by-step pathway helping cities in achieving the long-term goals through a series of interconnected actions and outcomes. In the context of PED development, ToC can serve as a strategic tool to align diverse stakeholders, integrate multi-sectoral perspectives, and ensure the implementation of systematic sustainable solutions. The alignment of the ToC process in PED development can help to focus on a systemic change in all levels, including targeting the social behaviours of all actors. The Theory of Change can create a valuable framework to guide the development of Positive Energy Districts and similar sustainable urban initiatives. By emphasizing structured processes, stakeholder collaboration, and adaptive management, navigating the complexities of climate-neutral urban transformation can be more comprehensive. Aligning the PED roadmap with the ToC, as a complementary tool, offers a visual and actionable pathway for achieving long-term goals. This connection and alignment of the processes represent a critical step toward creating resilient, sustainable, and inclusive collaborations. By breaking down of multiple approaches into manageable phases, as shown in Figure 8, roadmaps facilitate collaborative decision-making and ensure the integration of energy-efficient design, innovative business models, and optimized energy systems, in a participative manner. The development of PEDs can be divided into several phases, each requiring specific actions and collaborations.

The comparison between the phases used in projects development shows significant overlaps but also highlights the differences in the focus.

ToC phases *(1) create a sense of urgency, (2) build a guiding coalition, (3) form a strategic vision, (4) communicate the vision broadly, (5) enable action by removing barriers, (6) generate short-term wins, (7) sustain acceleration, and (8) institute change.*

Urban planning phases *(1) planning, (2) design, (3) construction, (4) operation*

PED as a process *(1) Master planning (2) energy planning (Mobility, Renewables, Flexibility) (3) construction or refurbishment planning, (4) implementation, (5) operation, (6) monitoring, (7) post occupancy evaluation.*

PED phases to align with ToC *(1) adopting a user-centric approach (2) defining actions and their sequential execution for PED implementation; (3) involving the entire 'PED community' in the implementation process; (4) customising the roadmap considering the intervention context, (5) incorporating a multi-layered system.*

Climate transition phase to be aligned in the process of energy transition *(1) analyse and mobilise the ecosystem, (2) build a shared vision, (3) cultivate and nurture collaboration, (4) build capabilities in the ecosystem to act, (5) steward the shared vision*

Figure 13: Breaking down the process into manageable phases

4.4 Future research and recommendation

The concept of PEDs is evolving towards a comprehensive approach that integrates both direct and cross-cutting activities to prepare energy systems for a climate-neutral transition. This holistic perspective underscores the importance of developing technologies, products, processes, infrastructure, and production systems. The focus on energy is intricately linked to integrated urban planning, governance structures, and citizen engagement, all aimed at facilitating the replication and mainstreaming of initiatives that influence urban transitions. While the general definition of PED is currently under review within the PED Programme [41], it is evident that tailored guidelines are essential, with specifications and implementation occurring at local and regional levels. Nevertheless, there is a shared overarching vision that targets climate neutrality by prioritizing energy efficiency, flexibility, sustainability, and renewable energy generation. In this context, PEDs should be framed within the broader energy system, taking into account various perspectives and roles of different stakeholders.
PED projects necessitate a matrix approach that integrates thematic areas such as social, economic, legal, technological, political, and spatial dimensions, alongside specific enablers like markets, funding, feasibility, business models, and information transfer. This structure helps mainstream actions, ensuring that project outcomes yield tangible impacts while remaining closely aligned with the PED vision [42].
To effectively mainstream the results of PED initiatives, it is crucial to identify strategies that integrate project outcomes into the wider context of climate-neutral urban environments [43]. This entails **breaking down siloed structures in energy transition issues**, through clearly identifying project results, engaging stakeholders, and fostering shared communication. Achieving long-term impact requires positioning projects and specific deliverables to facilitate their integration into urban settings. Given the complexity and variety of factors involved in developing PED-TA (Positive Energy District-Transition Areas), it is beneficial to **designate a single stakeholder as the process initiator**. The analysis of target stakeholders reveals that local public administrations often take on this leading role. However, as the initiator, public administrations must understand which stakeholders will participate throughout the entire process of forming the PED and how to effectively engage them. Among the reviewed key features, **a context-based approach emerges as the most prominent aspect**. The complexity of establishing a PED-TA stems from the diverse characteristics that districts may exhibit, including urban planning, renewable resource availability, socio-economic factors, and stakeholder dynamics. Another significant feature identified is the **importance of a step-by-step approach** and **stakeholder involvement**. To facilitate PED implementation, a roadmap should be developed that outlines a phased series of actions, enabling the initiator to systematically plan activities. Additionally, it is vital to identify the stakeholders involved in each action and clarify their respective roles.

Thus, a roadmap can serve as an effective tool that provides common guidelines to promote PEDs and ensure their replicability, while also allowing for flexibility to adapt to the specific context of each district and the iterative nature of the process.
In light of these considerations and based on the analysis conducted, a possible structure for the roadmap includes the following elements:

- first, a **process diagram should be established** to outline the various phases of PED implementation, incorporating specific barriers and drivers associated with each phase. While common **barriers and drivers can be identified**, attention should also be given to **local-specific and district-based factors**.

- next, the **primary categories of actions** should be defined, ranging from goal setting to monitoring and evaluation, including communication and digitalization.
- finally, the action categories may manifest through **more specific actions** across phases, such as establishing **Key Performance Indicators (KPIs)** or assessing the potential for renewable energy integration and flexibility. These actions should encompass a comprehensive system that addresses socio-economic benefits, social engagement, environmental sustainability, integrated governance, digitalization, and technological innovations.

However, delineating these phases and actions is just one part of the process. It should also be explicitly stated whether the nature of these actions involving stakeholders is informative, consultative, collaborative, or co-creative. Figure 14 provides a summary of the key categories to be included in the PED Roadmaps.

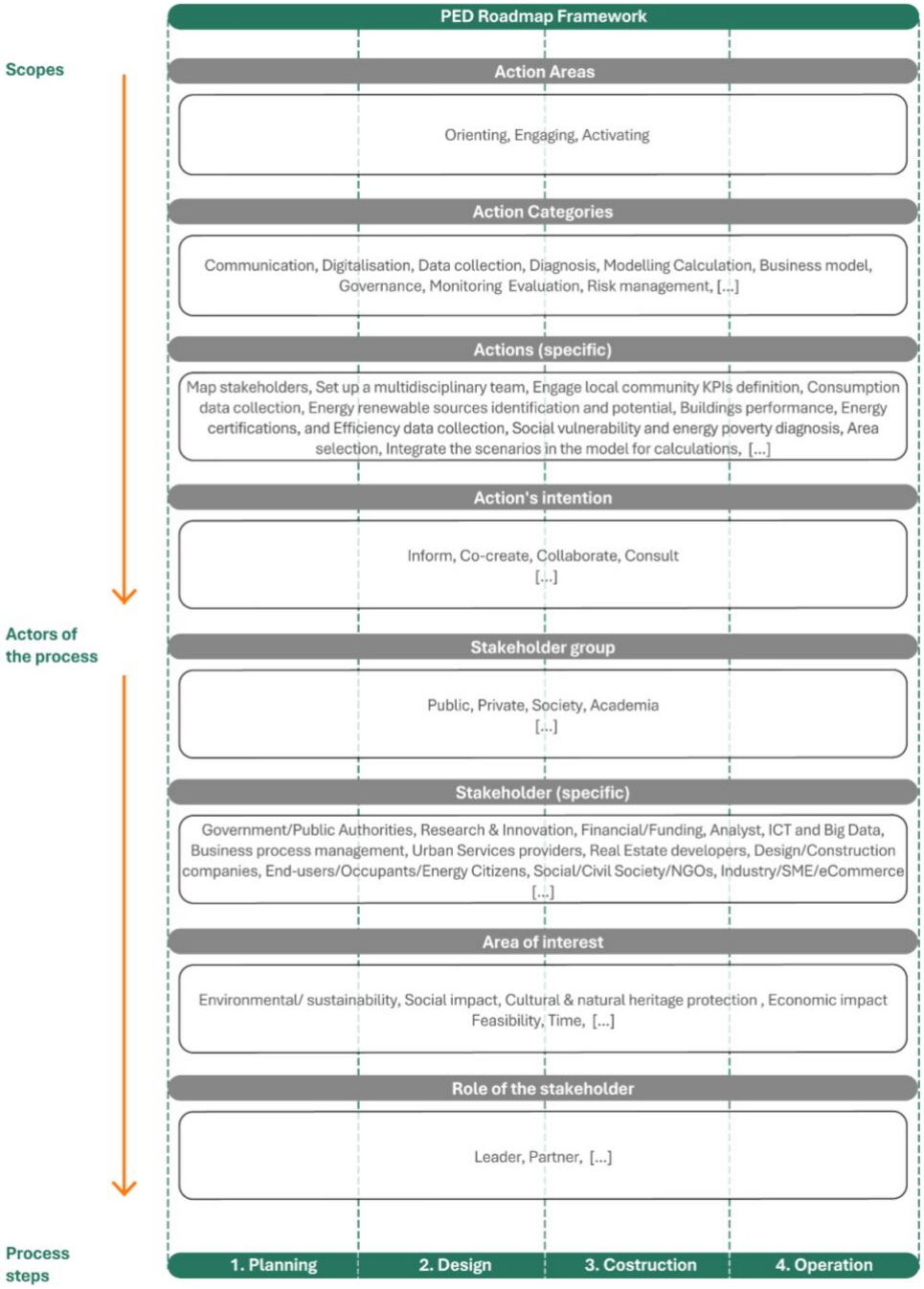

Figure 14: PED roadmap tentative categories.

5 Conclusion

The development of a context framework for the definition of PED roadmaps, guided by the CA 'PED-EU-NET' Memorandum of Understanding, aims to contribute to the following overarching objectives: (1) Share progress in PED research across diverse stakeholders - such as academia, cities, and communities - and across various domains - including technological, social, economic, financial, legal, and regulatory sectors; (2) Develop tools that optimize the PEDs planning and design; (3) support activities and develop operational tools that bridge the gap between science, policy makers, and society by aligning the interests and needs of multiple stakeholders.

The literature review provided a comprehensive overview of the PED-TAs - including roadmaps, pathways, guidelines towards PED/PED similar experiences development.

In addition, the literature review and the results emerging from the literature review analysis offer new impetus to the work developed so far in the CA PED Database, reiterating its strategic role for the mapping, implementation, storytelling and mainstream of PEDs.

Indeed, much of the information collected in Table 2 and Figure 14 Figure 1is the result of what was in depth-analysed in the literature review, nevertheless this information is also available and can be easily extracted from the case studies collected in the PED Database (https://pedeu.net/map/).

The analysis with the PED Matrix and the application of ToC and roadmapping in PED development presents several opportunities, and other gaps which relate the energy transition project to the stakeholder work, namely the need for enhanced collaboration. Structured processes foster collaboration among stakeholders, ensuring the integration of diverse perspectives. An adaptive management and governance of the process, with continuous monitoring, interchange and evaluation enables stakeholders to adapt strategies and address emerging challenges. Therefore, the principles and practices developed for energy transition projects can be scaled and adapted to other sustainable urban development initiatives.

By developing targeted roadmaps, tailored to different stakeholder, and integrating the eight key aspects of sustainability, as shown in the PED Manifesto [14] into a robust governance structure, PED projects can achieve their goals of creating climate-neutral, resilient, and inclusive urban environments.

By adopting a user-centric approach, defining clear actions, involving the entire PED community, customizing the roadmap to context, and incorporating a multi-layered system, stakeholders can create a robust framework for PED implementation. Aligning urban planning processes with the Theory of Change ensures that PED solutions are socially accepted and contribute to broader societal transformation. Tailoring engagement strategies to the specific context and phase of the project ensures that all stakeholders contribute effectively and that the project remains socially, politically, and economically viable.

Stakeholder engagement is a cornerstone of successful PED development that needs a systematic mapping of them, defining roles, and fostering long-lasting collaboration.

Defining stakeholder relationships and aligning roles with project pathways are essential for the successful development of PEDs. By understanding the aims, objectives, and expectations of each stakeholder group, PED projects can foster collaboration, address challenges, and achieve their sustainability goals. Following different motives in the fields of innovation, climate strategies and citizens ambition PED roadmaps are valid pathways for energy transition. Each of these pathways need support and collaboration in different ways and create supporting mechanisms.

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ANNEXES

Annex A. Co-creation session during the Task 1.5 lifetime

Figure 15: Results of the co-creation session on 26th 01/2024_during the T1.5 Kick off meeting

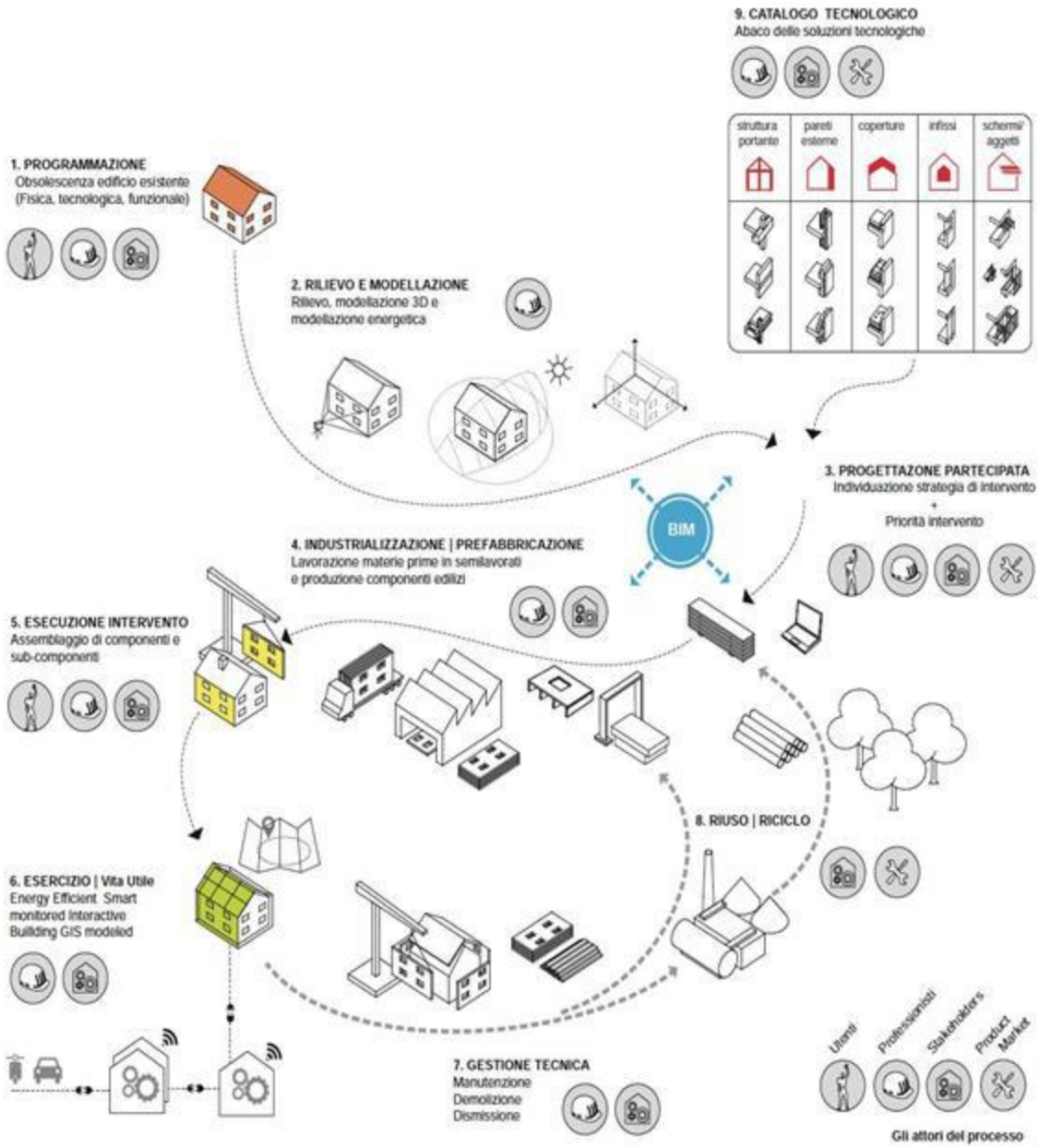
MIRO results	P1	P2	P3	P4	P5	P6	P7	P8
WHY Why a PED roadmap is needed? What is the final scope?	Helps Admin and PI to plan and design the background and tools for PED implementation, try to consider in a picture all the issue and flow chart to be considered and start creating the basis for services and tools	to help municipality in framing the problem of energy transition starting from a 'piece' of the city	roadmaps help actors to work and communicate the steps needed very useful in stakeholder engagement to not invent each time wheel again :)	Developing policies to help achieve climate goals Transferring theoretical knowledge into practice	A roadmap is for creating PEDs easily. Final scope is better understanding outputs of the PEDs.	Avoid previous mistakes and challenges Facilitate and promote the implementation	Direct guidance for PED development Lead direction of PED development	Supports sustainable/resilinent neighbours PED pathway is an opportunity to support Public Engagement Why A comprensive /integrated roadmap to PED is needed to to all Positive Impacts of PEDs increases community well-being and quality of life Supporting Communities for being Energy Efficient

WHAT Which features a PED roadmap should have?	-step-by-step approach; -focus on renovation; -KPIs calculation; -scenario simulation; -digitalisation; -context-based approach; stakeholder engagement'	context-based we need to understand the specifi challenges of each district/city renovation vs newly built	communication examples (with different stakeholders) effort estimations? mistakes in PED process and how to deal with it roles description access to detailed info easy to understand	perspective of municipalities and private companies and individuals practical easy to understand illustrative Roadmap generalisable to different types of weather conditions, building type and other characteristics that will be different in each district	applicable realastic the role of participants	Customer oriented Low-threshold and easy-to-use	Direct informaiton Comprehesive figures and tables Concise Popular language	Influences Legislative Influences Administrative Influences Application Influences/Guidelines
WHO Are private investors and public administration the main target for the roadmap?	common roadmap? or a roadmap for each stakeholder group? common > but define stakeholders role in each step	EC > a tool towards PEDs > there is already a concrete legislative framework in many countries	energy communities	municipal technicians energy communities local governments	Universities Research Centers	Depending on the business / ownership model, as citizens could play a key role in the implementation	Yes Don't forget gneral citizens	Policymakers in different scales Local energy communities Municipal workers in the related departments responsible for energy transition/efficiency (planning, finance, strategy dev...)
WHEN According to the short-term vision (2030), in which process step can we use the roadmap?		2025 is the SET Plan' s goal > 100 PEDs 2030 Climate Neutral City Mission						

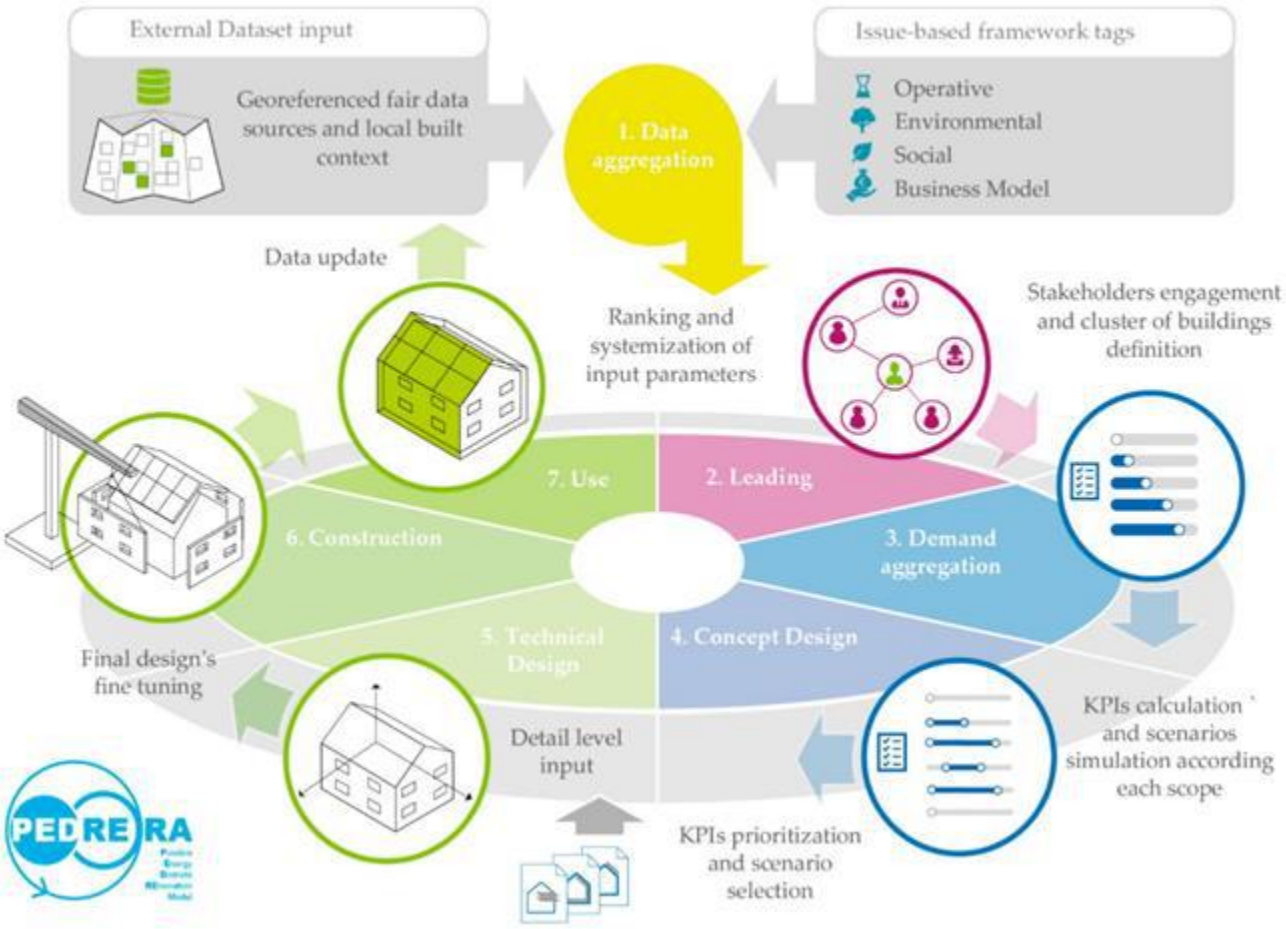
* P stands for Participant.

Annex B. Inspirational examples

Roadmaps overview from Literature & Projects



Civiero 2007
Tecnologie per la riqualificazione
978-8891621993

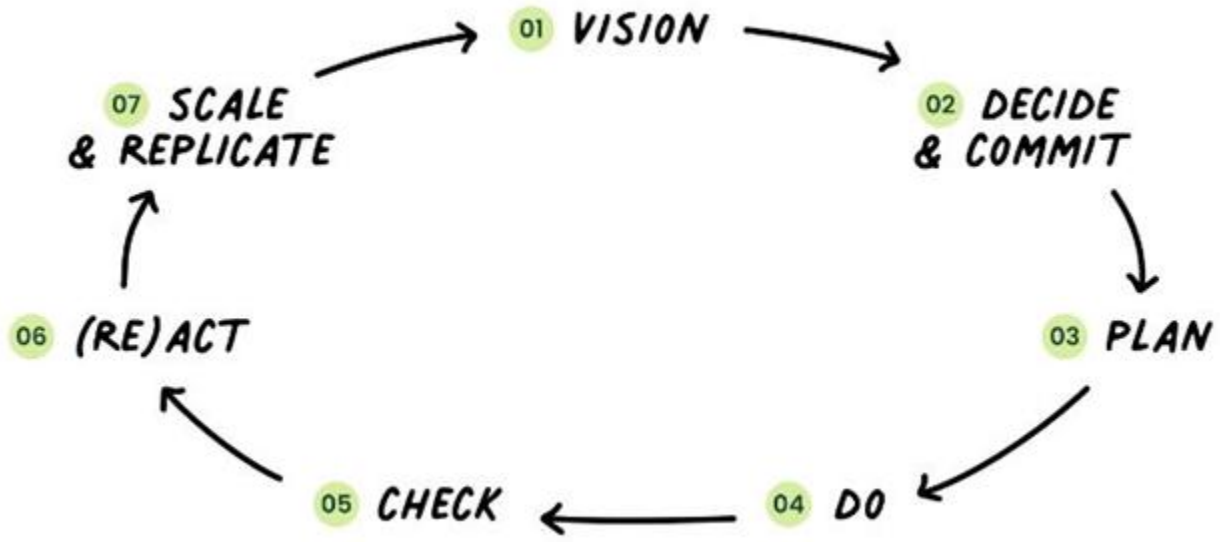


Civiero et al. 2021

https://doi.org/10.3390/en14102833

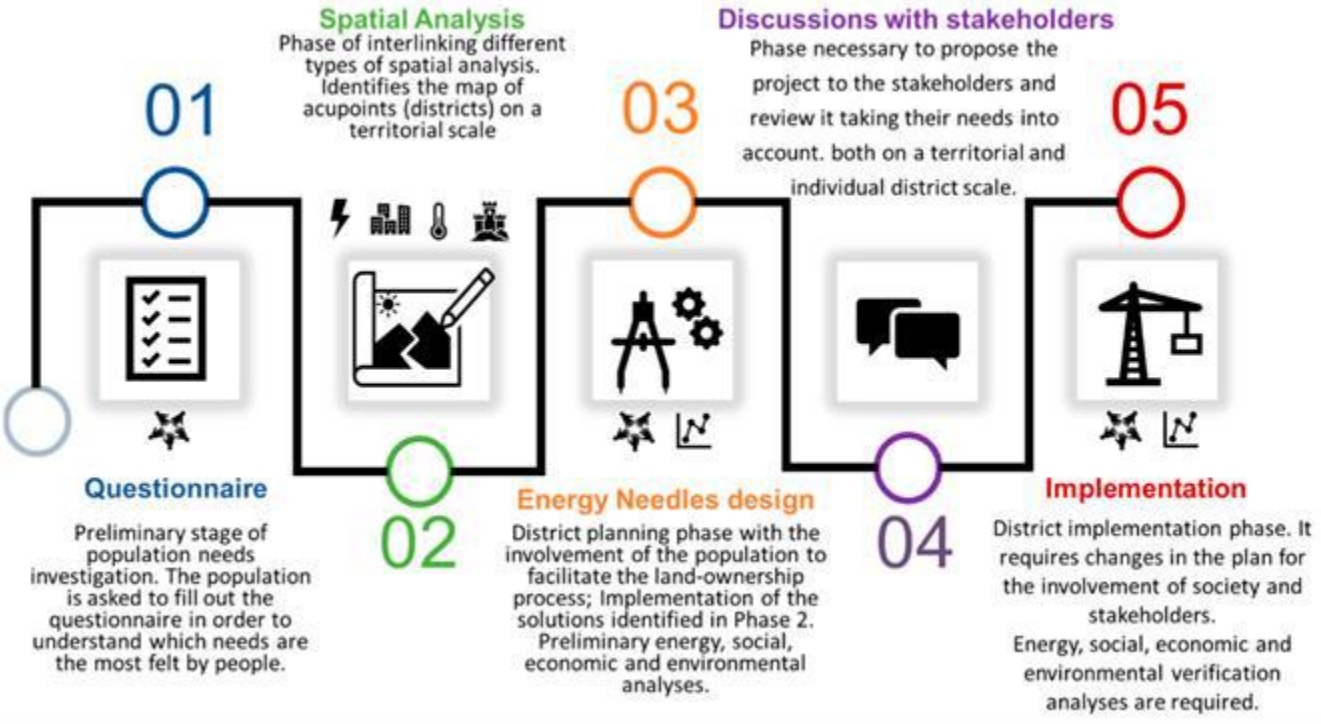
Cutore et al. 2024

https://doi.org/10.3390/su15108118



The CrAFt Cookbook
https://craft-cities.eu/craft-cookbook/

Syn.ika
https://www.synikia.eu/



Leone et al. 2024
https://doi.org/10.3390/su15054046

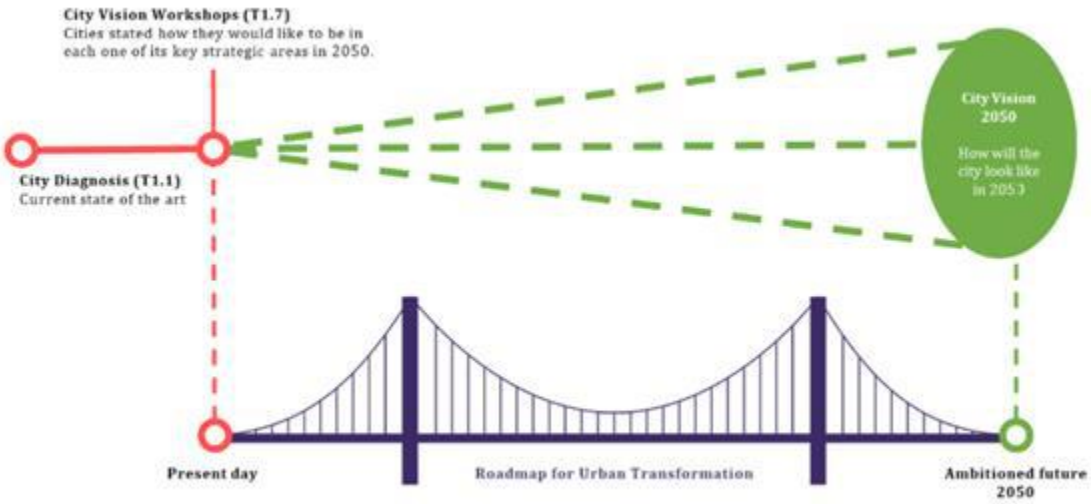


Figure 1. Illustrative diagram representing the roadmapping process

SPARCS
https://sparcs.info/en/

B. Espoo's detailed graphic roadmaps

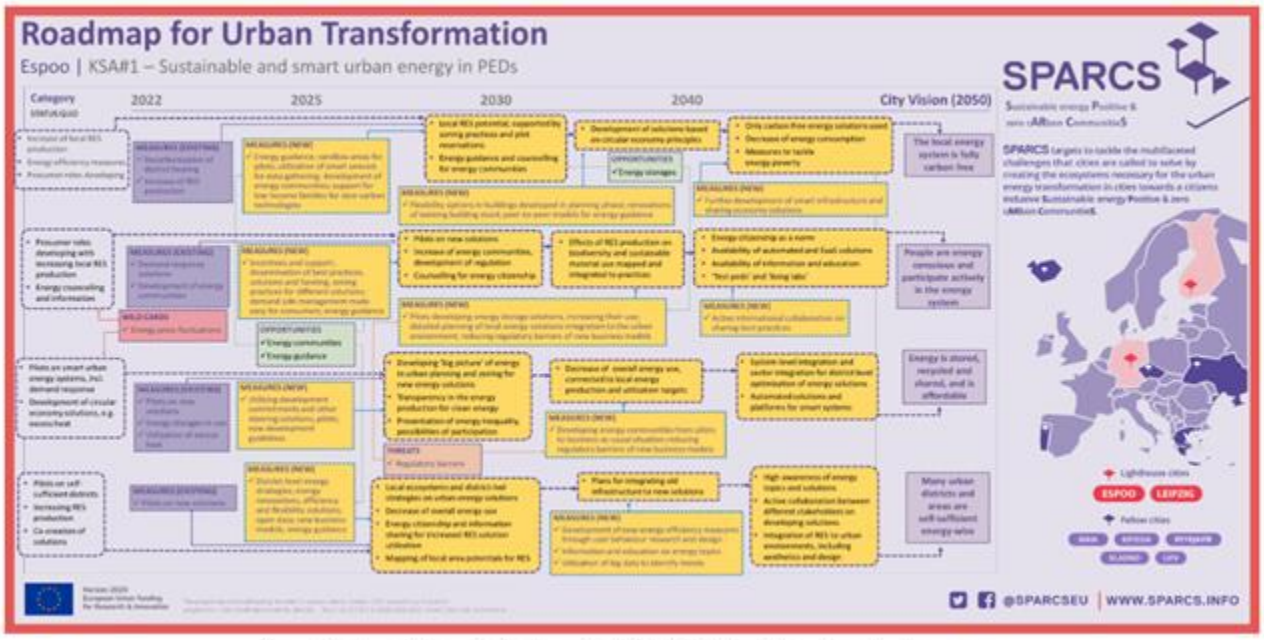


Figure 23. Espoo's Graphic Roadmap for KSA1 - Sustainable and smart urban energy

SPARCS
https://sparcs.info/en/

How to PED. The +CityxChange Cookbook
https://cityxchange.eu/

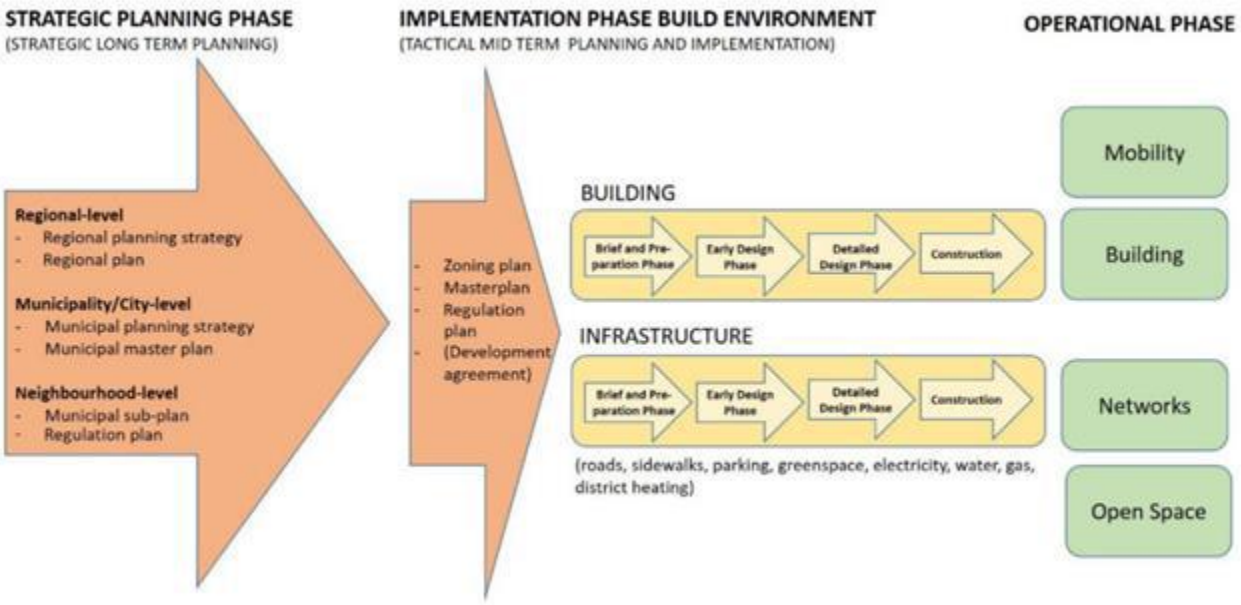
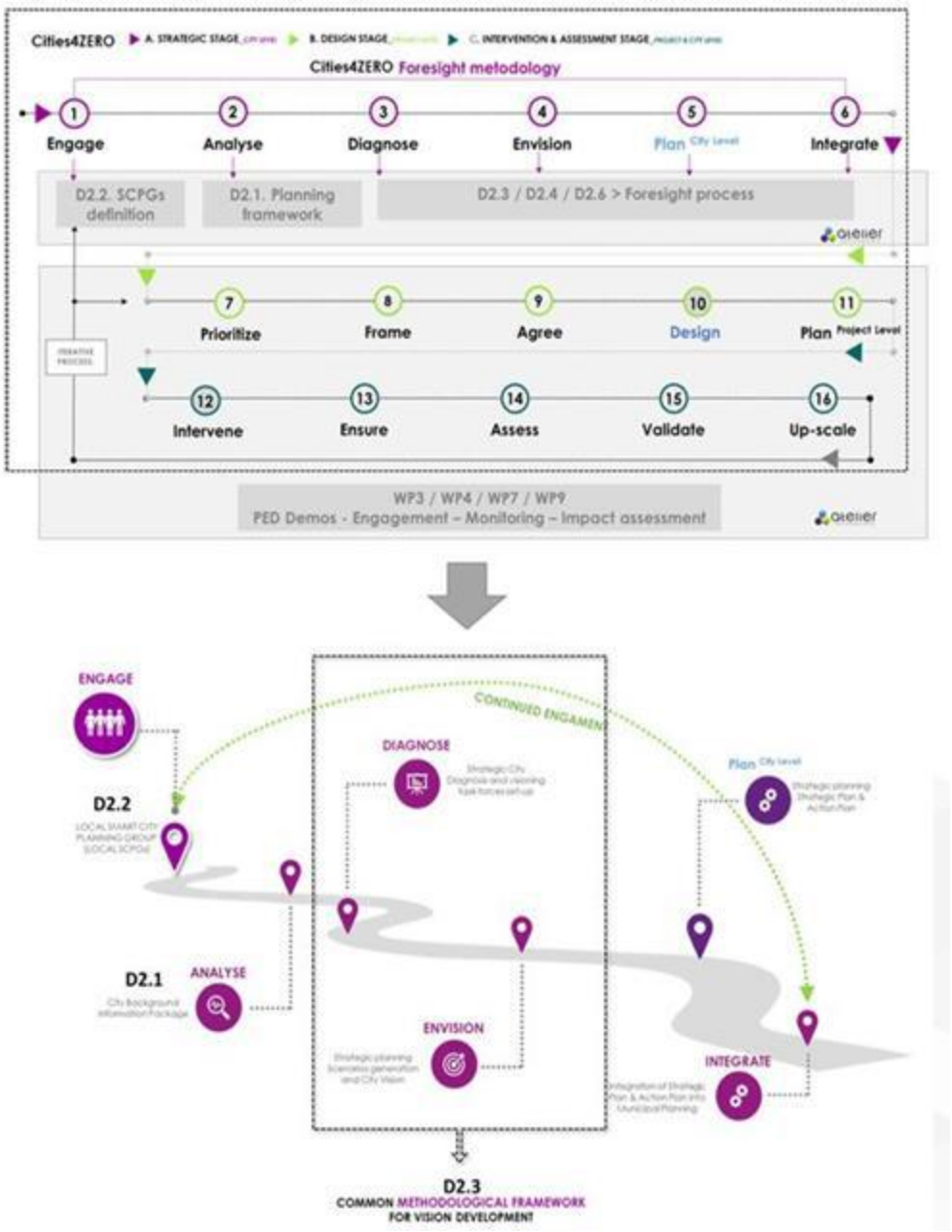


Figure 5. Diagram explaining the three project phases in ZEN.

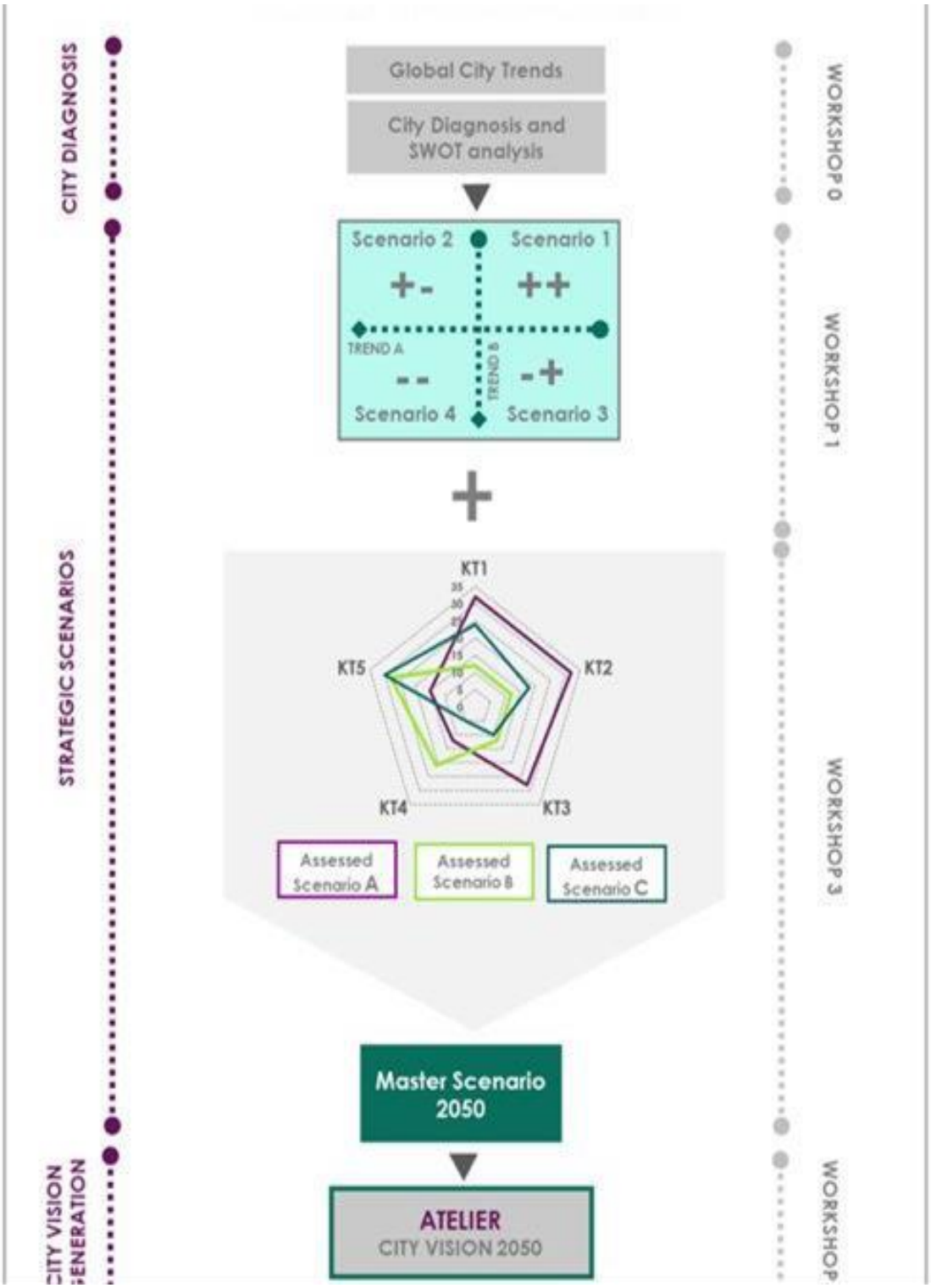
ZEN REPORT No. 45 - 2022
https://fmezen.com/

CITIES4PEDS. Towards co-ownership and inclusive PED development
https://energy-cities.eu/project/cities4peds-resources/

TRANS-PED. A Typology Framework for Positive Energy Districts
https://trans-ped.eu/



ATELIER. Common methodological framework for Vision development
https://smartcity-atelier.eu//

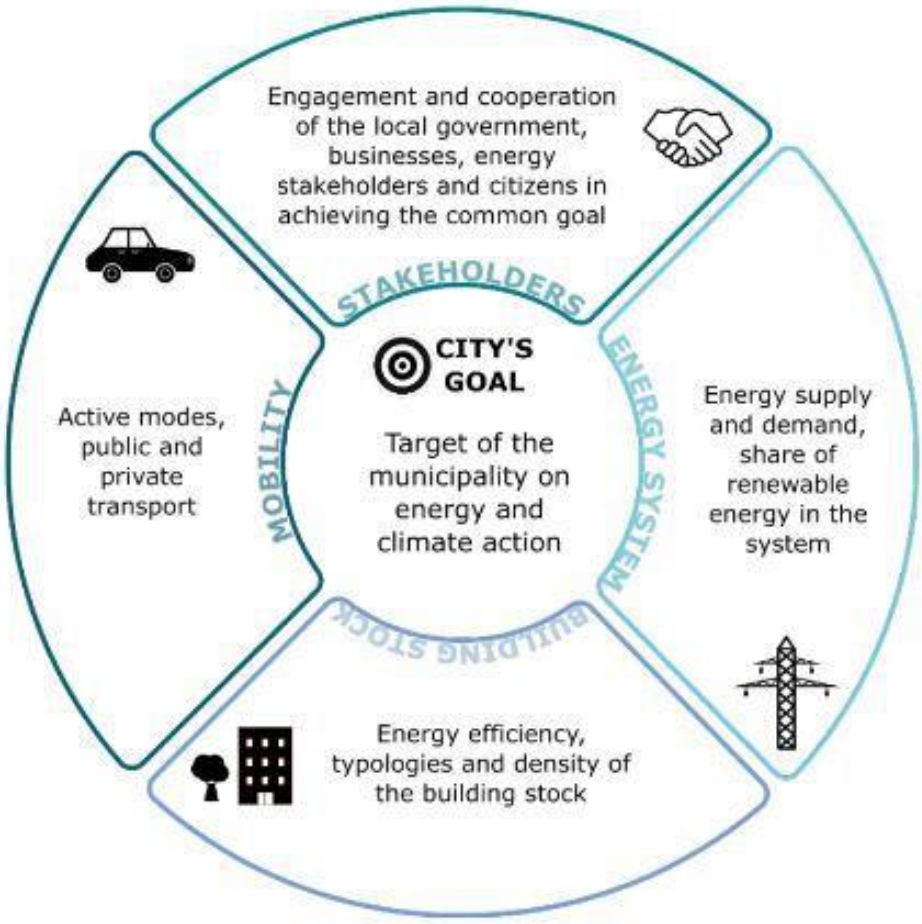


ATELIER. Common methodological framework for Vision development

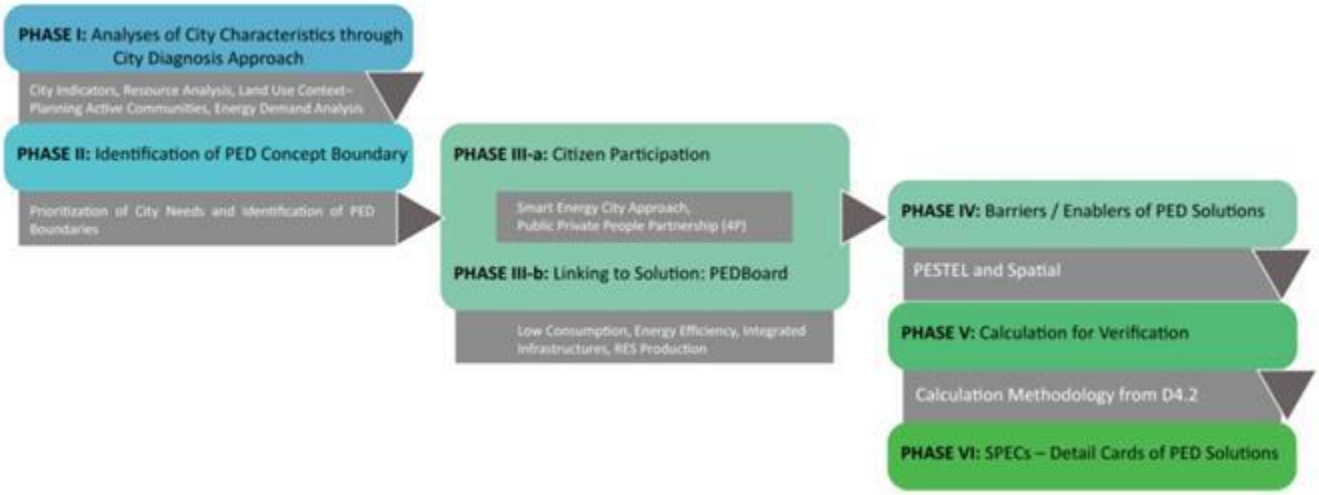
https://smartcity-atelier.eu//

Figure 13. From City Vision to Action Plan. Source: own elaboration

ATELIER. Common methodological framework for Vision development
https://smartcity-atelier.eu//



Smart-BEEjS. Techno-economic Aspects and Pathways towards Positive Energy Districts
https://smart-beejs.eu/



MakingCity. Methodology and Guidelines for PED design
https://makingcity.eu/

ID	Objetivo/ Tareas	Fecha Cumplimiento
1.	**Definición y enfoque para desarrollo de los PEDs (según objetivos del SET-PLAN WG 3.2)**	Corto plazo: 2021-2022
1.1	Desarrollo conceptual. I+D para la definición de metodologías, KPIs, herramientas y procedimiento óptimo de cálculo de balance energético anual.	2021
1.2	Planificación urbana: Identificación de las zonas de la ciudad más susceptibles de implementar un PED.	2021
1.3	Análisis de barreras para el desarrollo y Diseño PED: Planteamiento de cada uno de los componentes que permitan alcanzar el balance energético positivo.	2022
2.	**Medidas y herramientas para el diseño e implementación de PEDs (según objetivos del Marco sobre clima y energía para 2030)**	Medio plazo: 2022-2030
2.1	Despliegue de proyectos piloto: En diferentes barrios de ciudades españolas, o PED labs, realización de proyectos PED.	Desde 2022 hasta 2025
2.2	Monitorización y Evaluación	Desde 2022 hasta 2025
2.3	Implementación comercial de las soluciones. Roll-out de los componentes industriales	Hasta 2030
2.4	Replicación de las soluciones ejecutadas con éxito en casos estudios reales de la ciudad o en PED labs.	Hasta 2030
3.	**Estrategias nacionales a largo plazo para el despliegue e integración de modelos PEDs en las ciudades**	Largo plazo: desde 2030
3.1	Integración en políticas de planificación urbana y energética	>2030
3.2	Plan de despliegue de los PED a largo plazo (2030-2050)	2030-2050

Plataforma Tecnológica Española de Eficiencia Energética. Distritos de Energía Positiva
https://www.pte-ee.org/

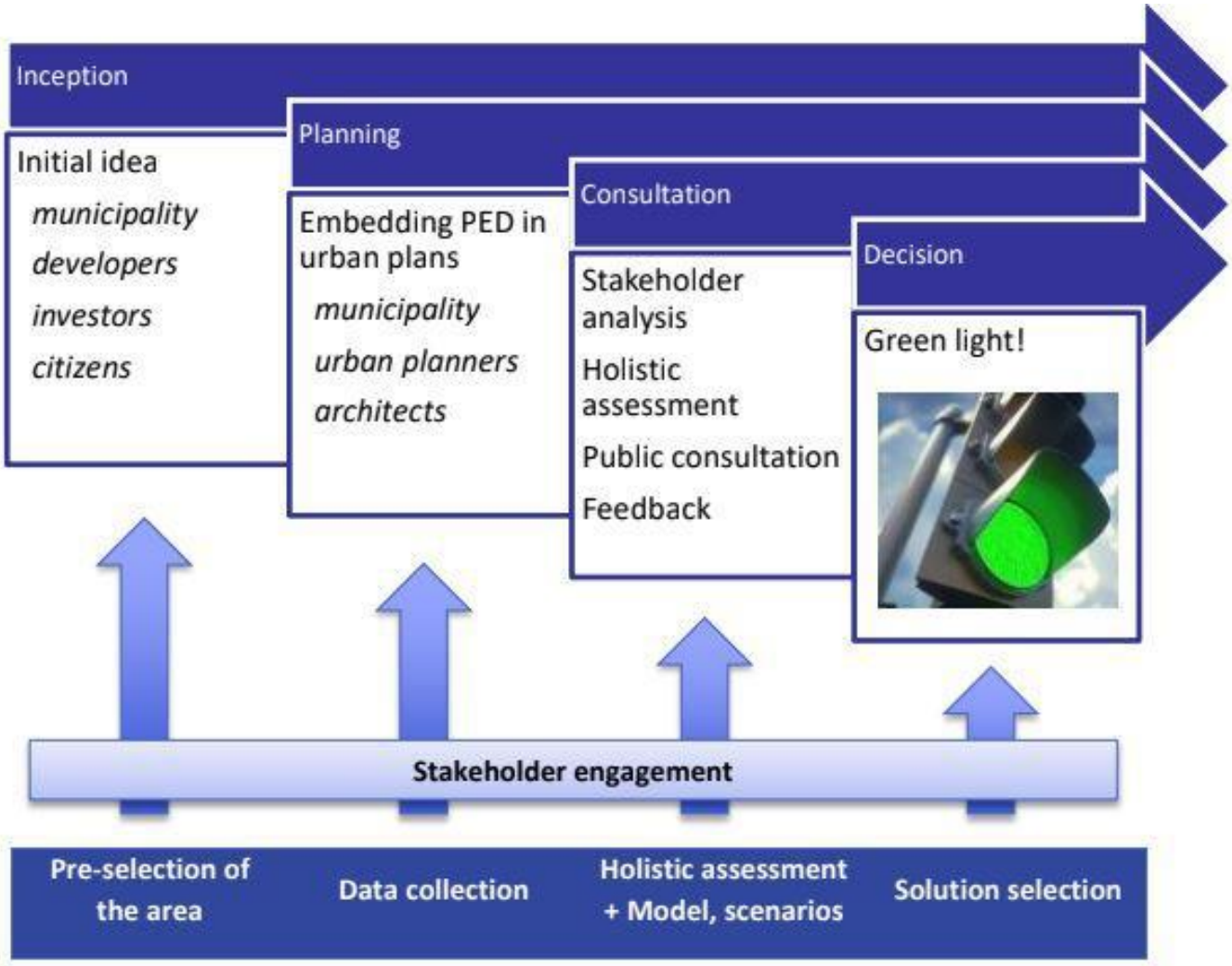


Figure 4 Early-stage steps of a PED project

PED-ID. Holistic assessment method in early development phase of potential PED areas
https://sustainableinnovation.se/projekt/ped-id-innovative-stakeholder-involvement-process-for-identification-of-positive-energy-districts/

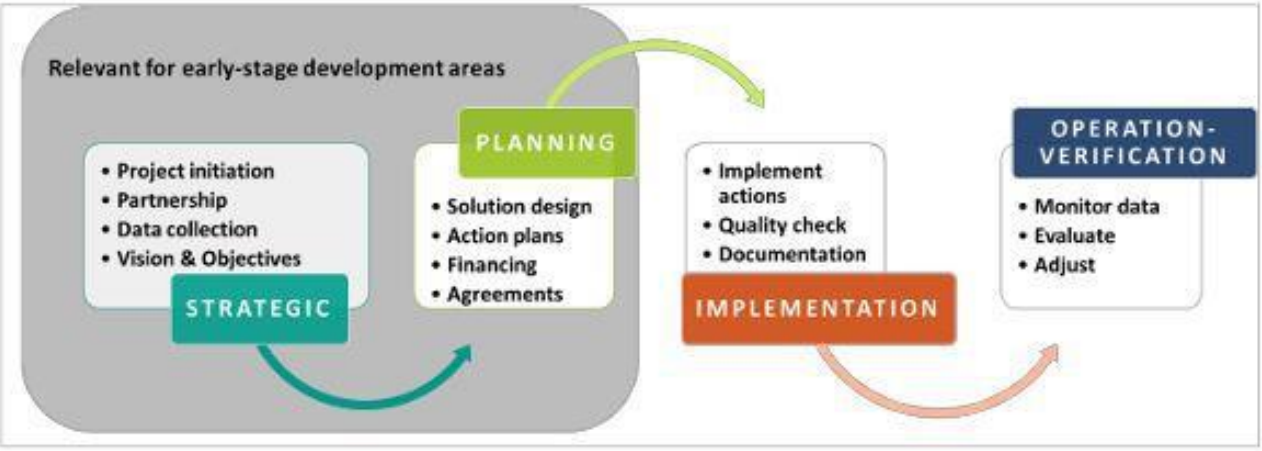
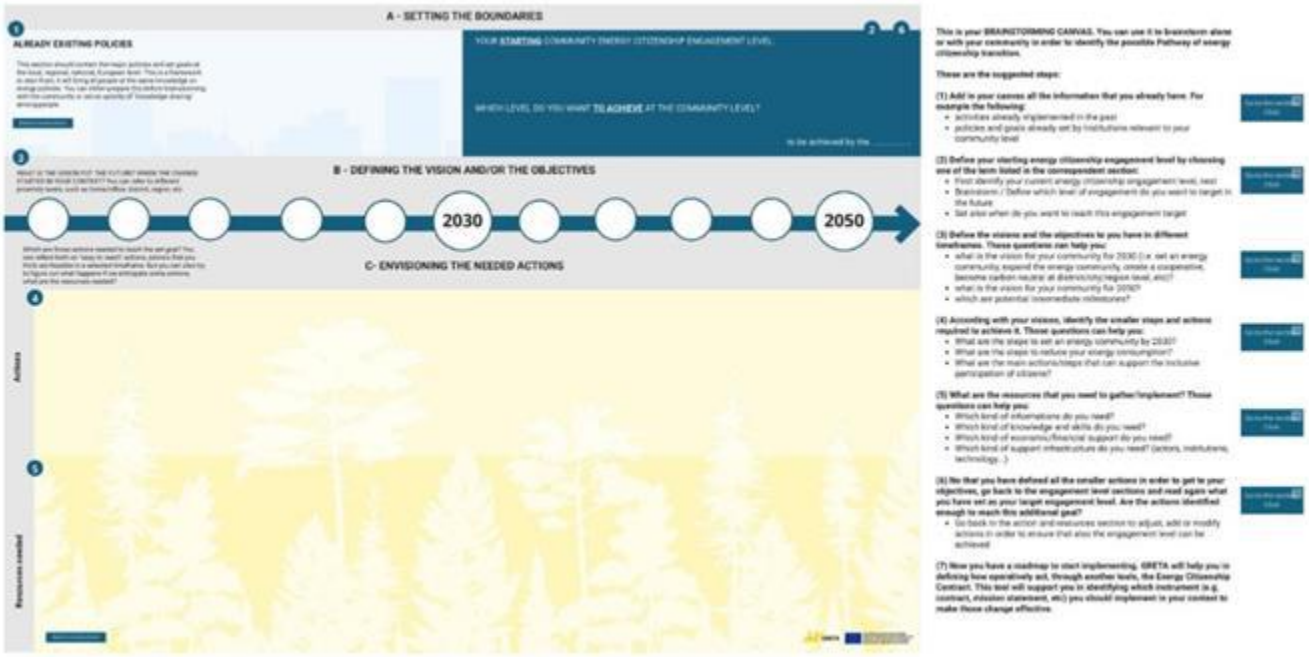
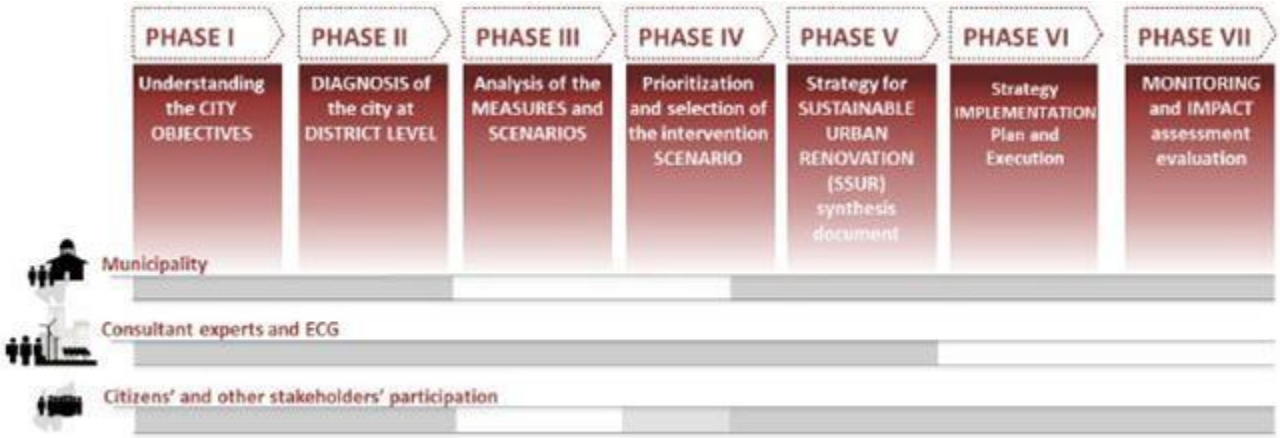


Figure 5 Phases of a PED project

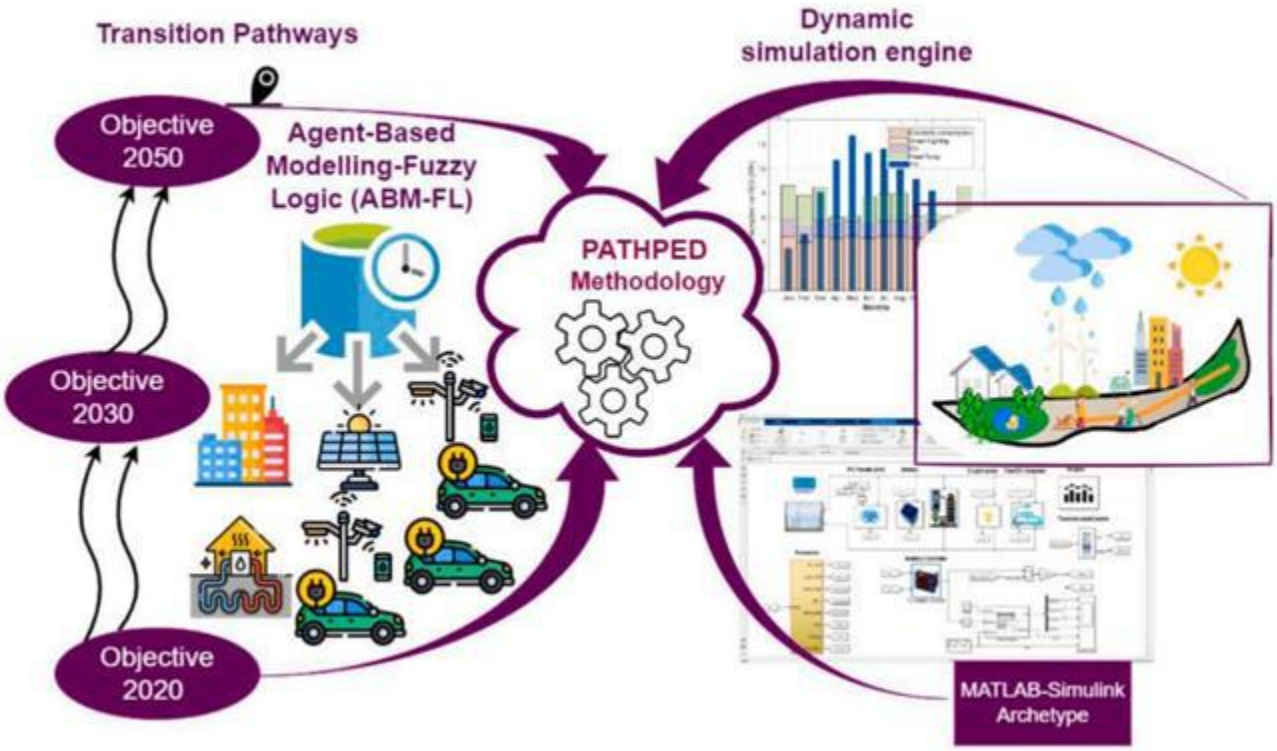
PED-ID. Holistic assessment method in early development phase of potential PED areas
https://sustainableinnovation.se/projekt/ped-id-innovative-stakeholder-involvement-process-for-identification-of-positive-energy-districts/



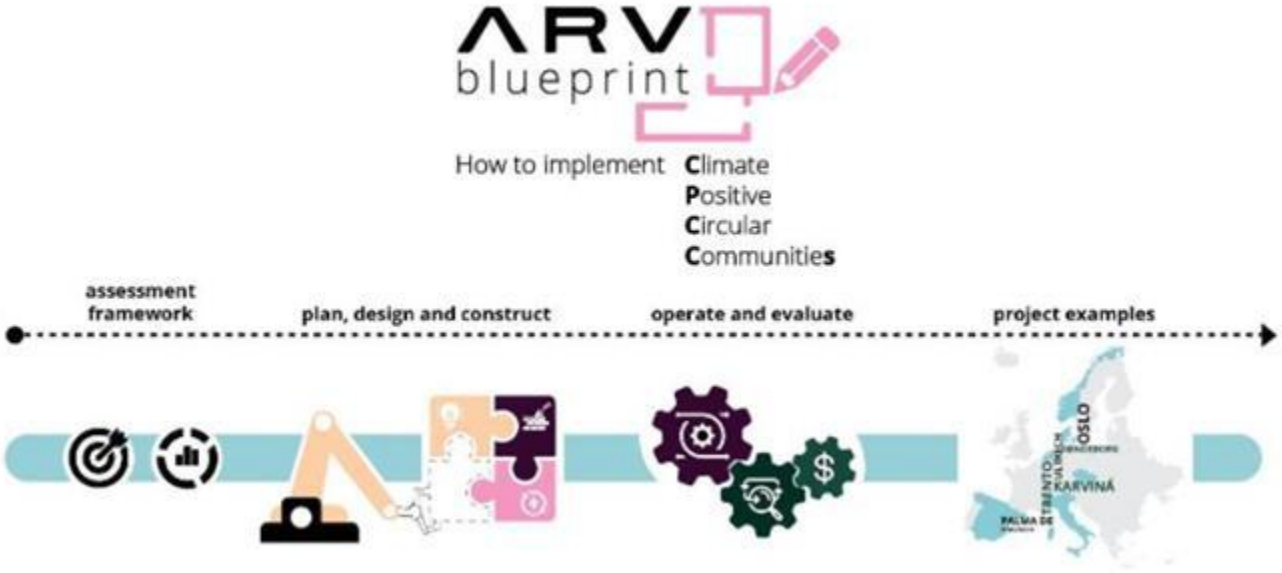
GRETA. Roadmap for Community Transition Pathways - Guidelines
https://projectgreta.eu/



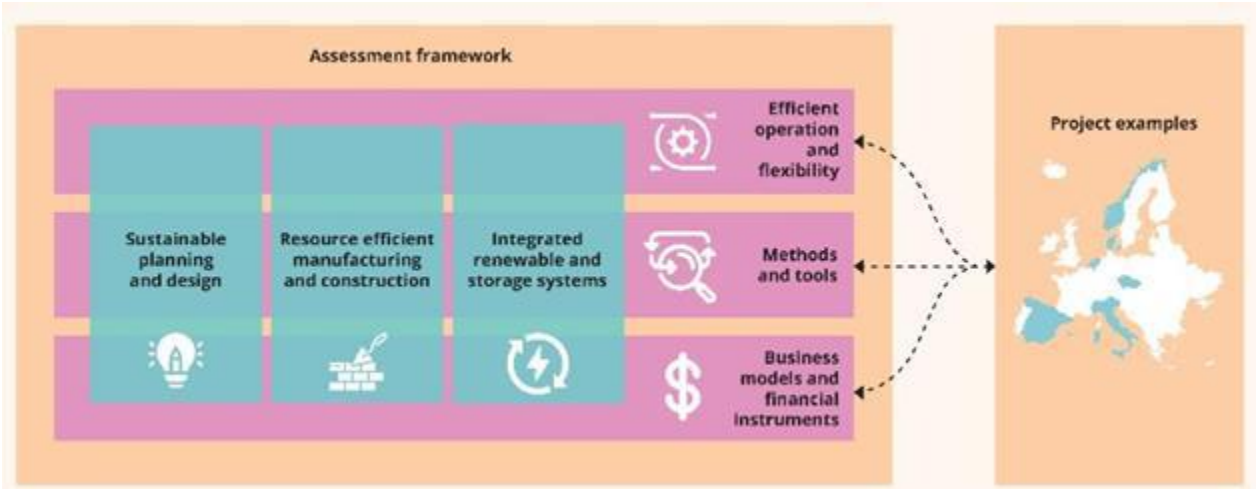
CITIFIED Methodology for city renovation at district level. Systemic approach



Castillo-Calzadilla et al. 2023
https://doi.org/10.1016/j.scs.2022.104375



ARV. A blueprint for planning, (re)design, (re)construction, operation, and use of climate positive circular communities
https://greendeal-arv.eu/



ARV. A blueprint for planning, (re)design, (re)construction, operation, and use of climate positive circular communities
https://greendeal-arv.eu/

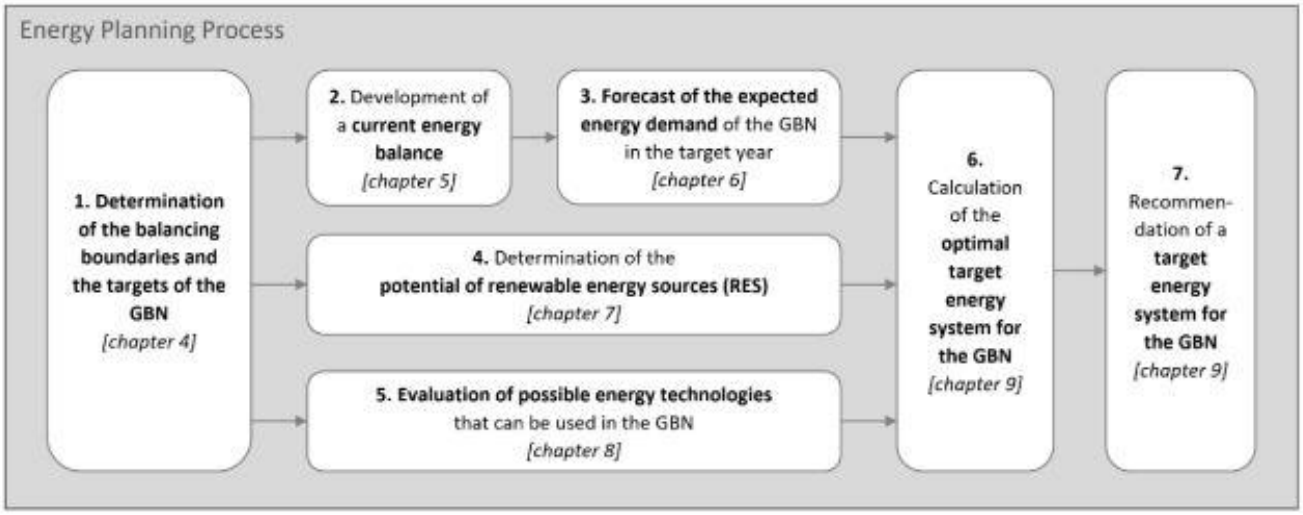
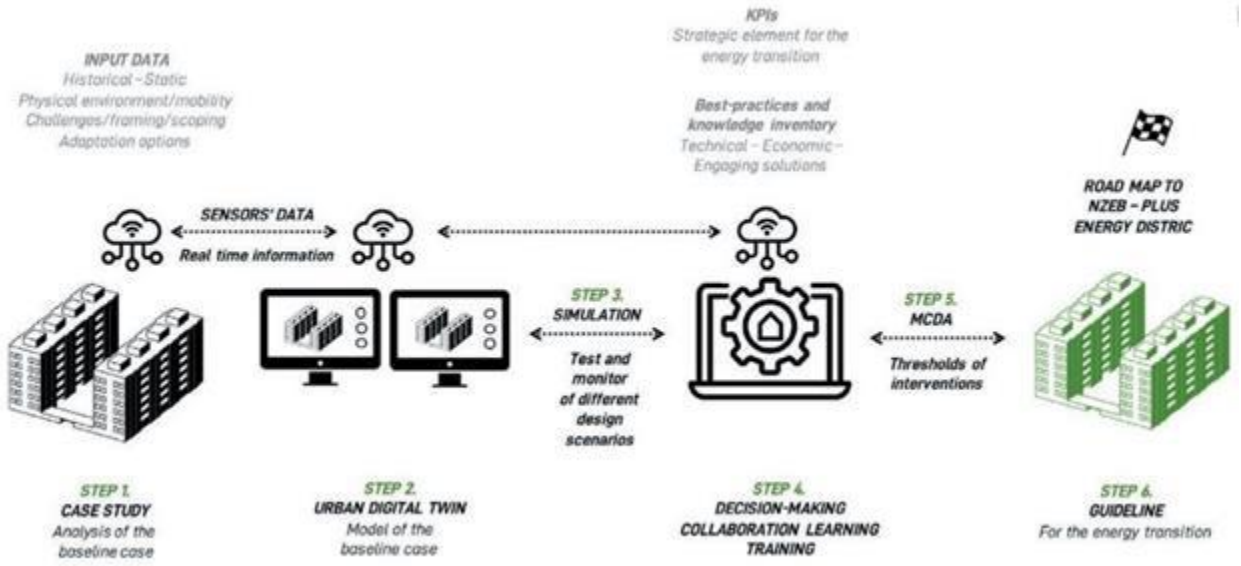
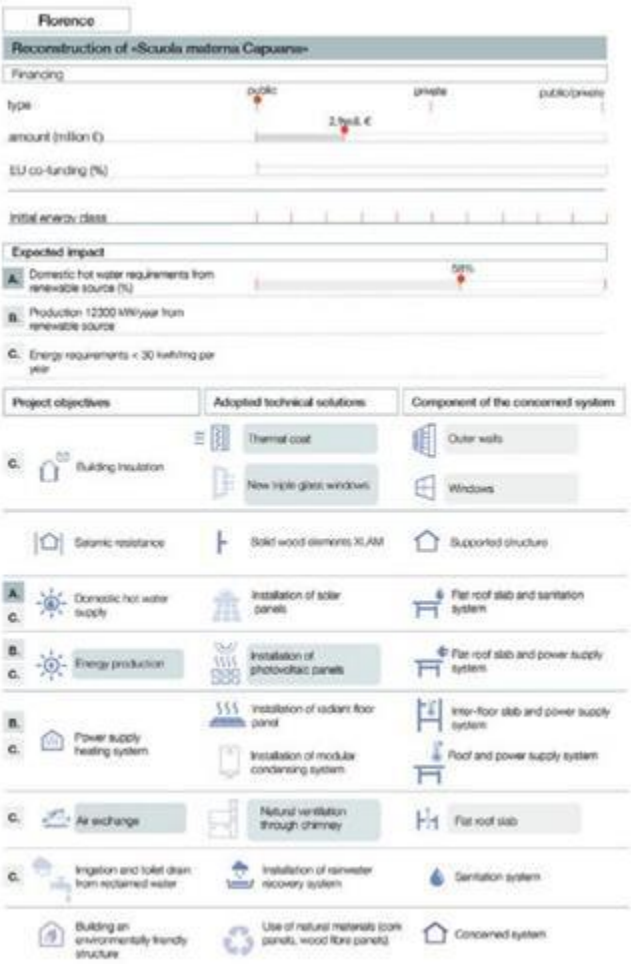


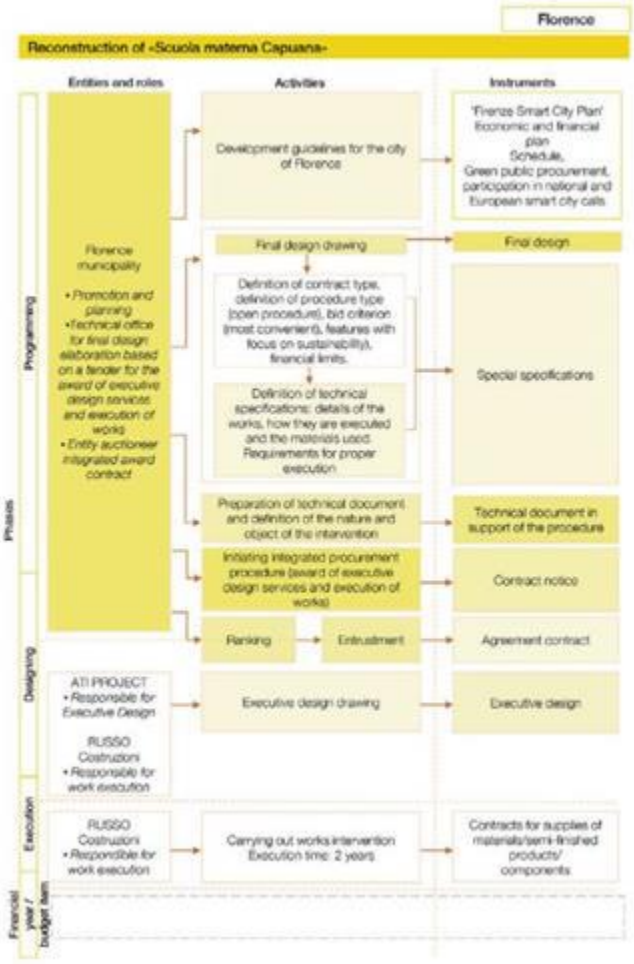
Figure 1: Process of energy planning for GBNs step by step, described in this document (with links to the chapters, which describe the steps)

PRONOBO. Energy Planning Guideline for GBNs
https://probonoh2020kb.eu/

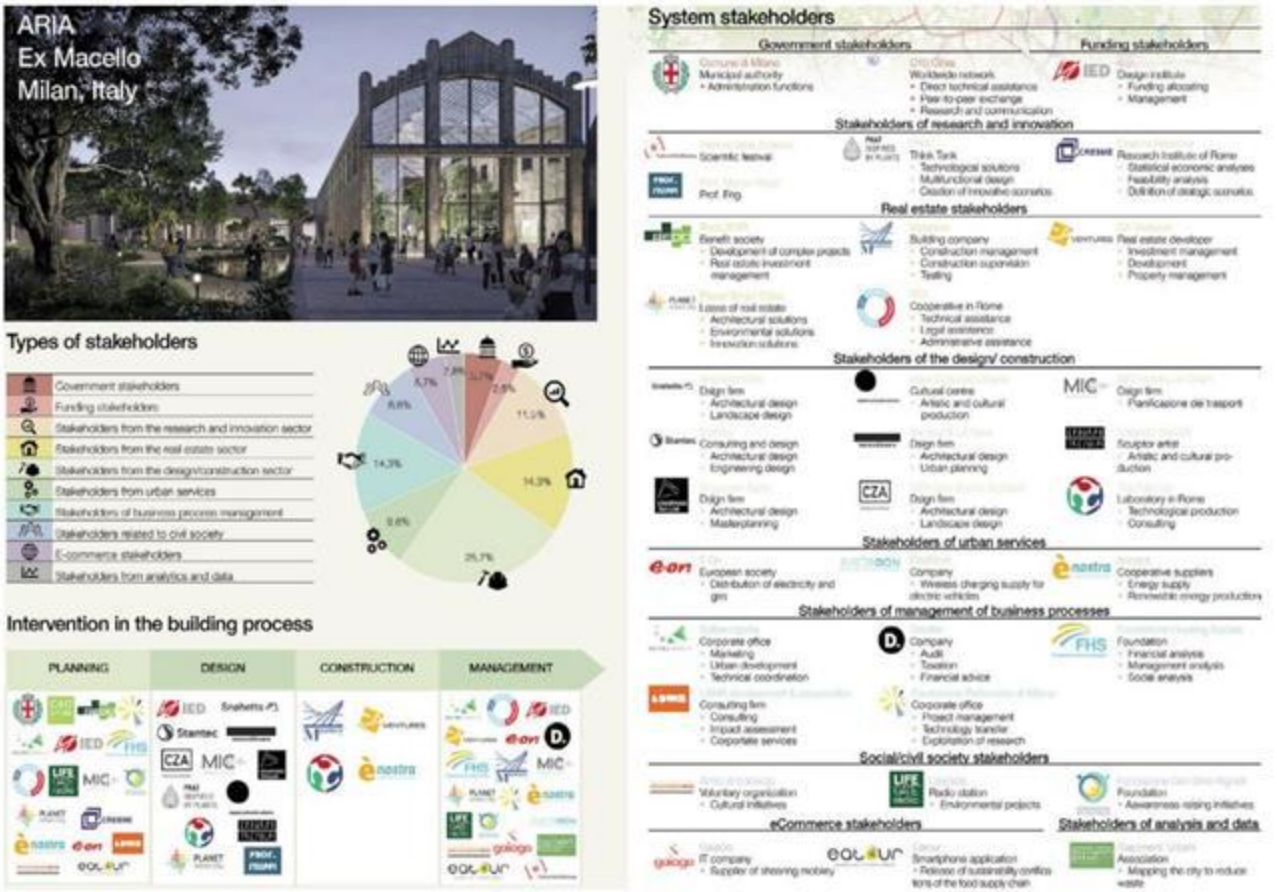


Piaia et al.2022
https://doi.org/10.36253/techne-12117





Ferrante et al.2023
https://doi.org/10.19229/2464-9309/13162023



Ferrante et al.2023
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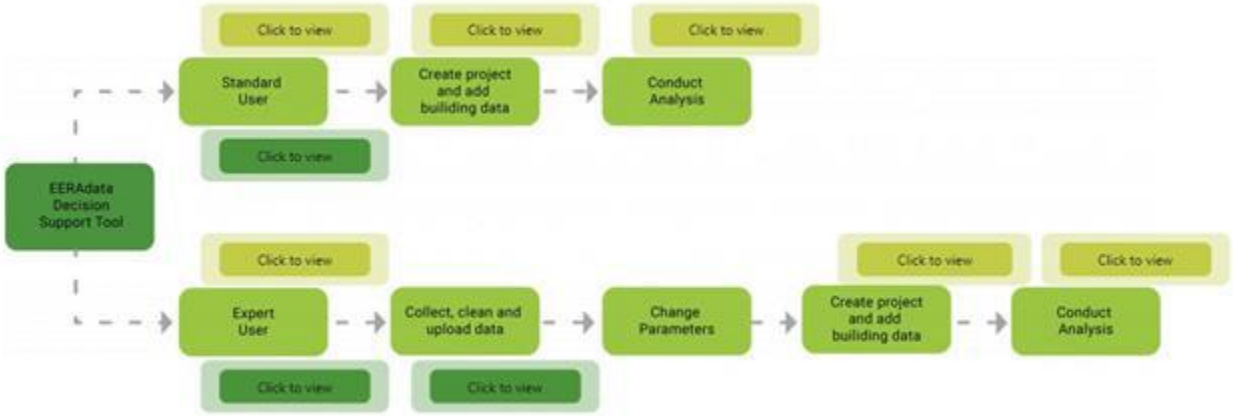
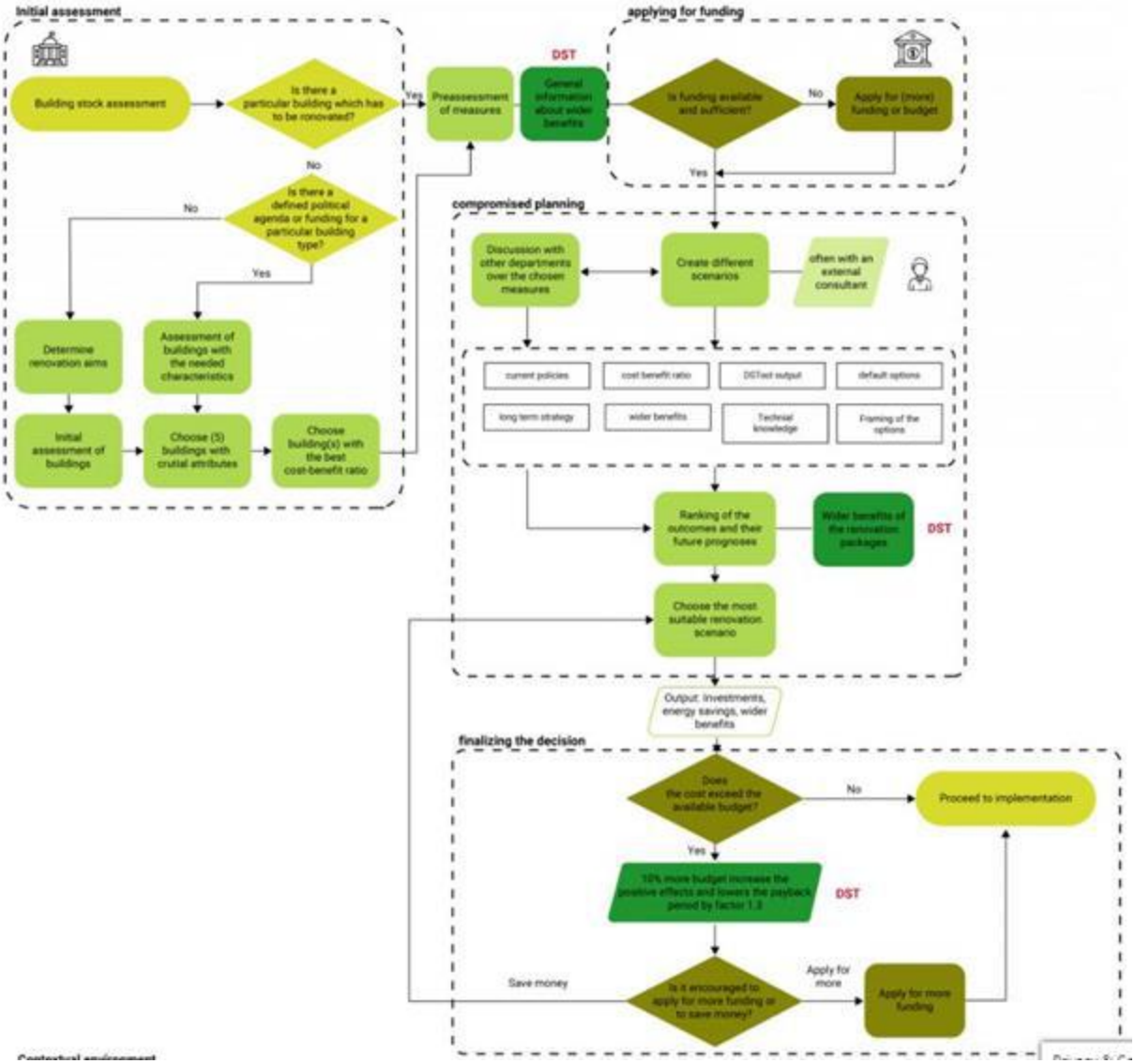
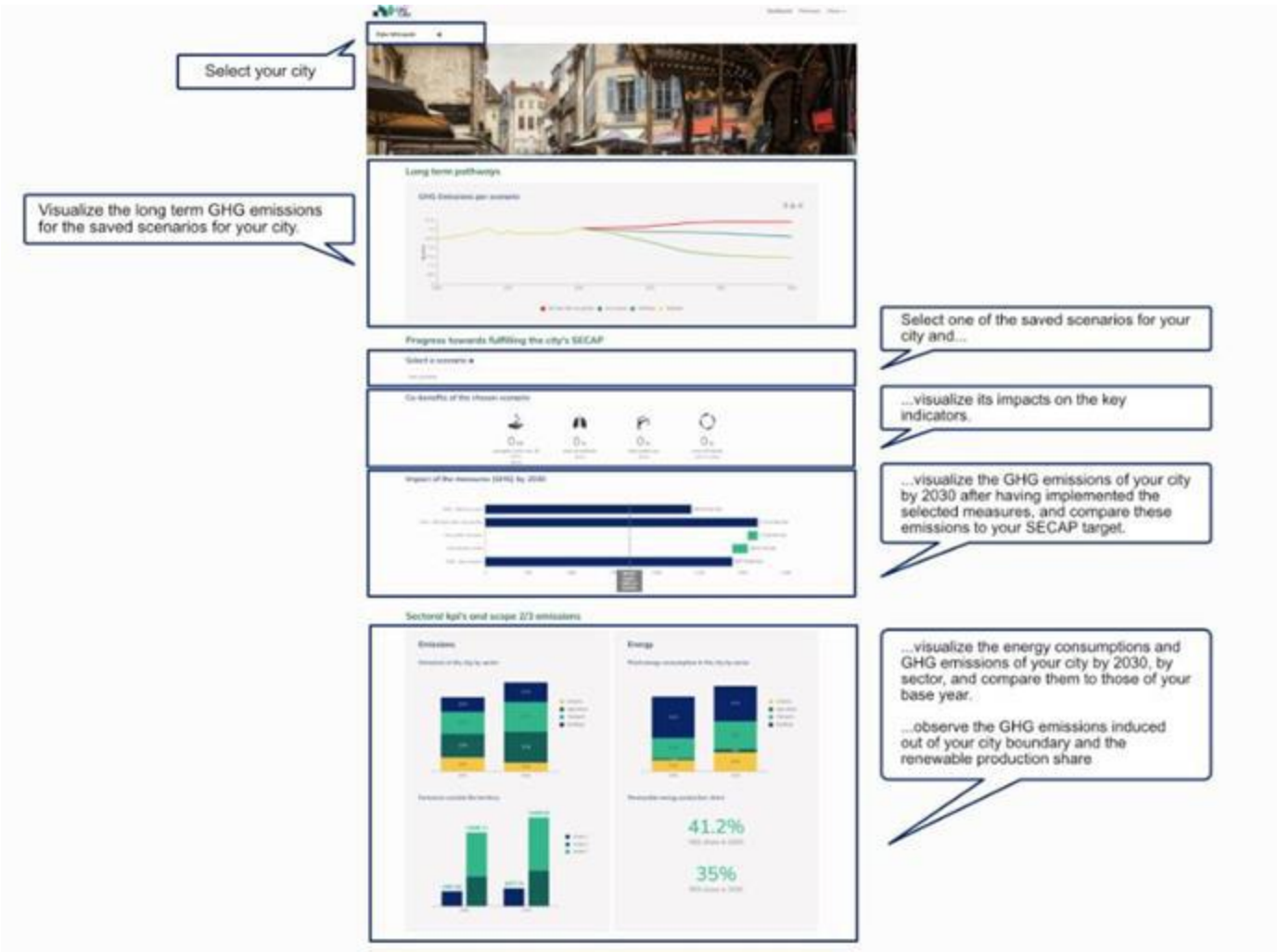


EERA. Technical Guide Logical framework and data infrastructure
https://www.eera-set.eu/

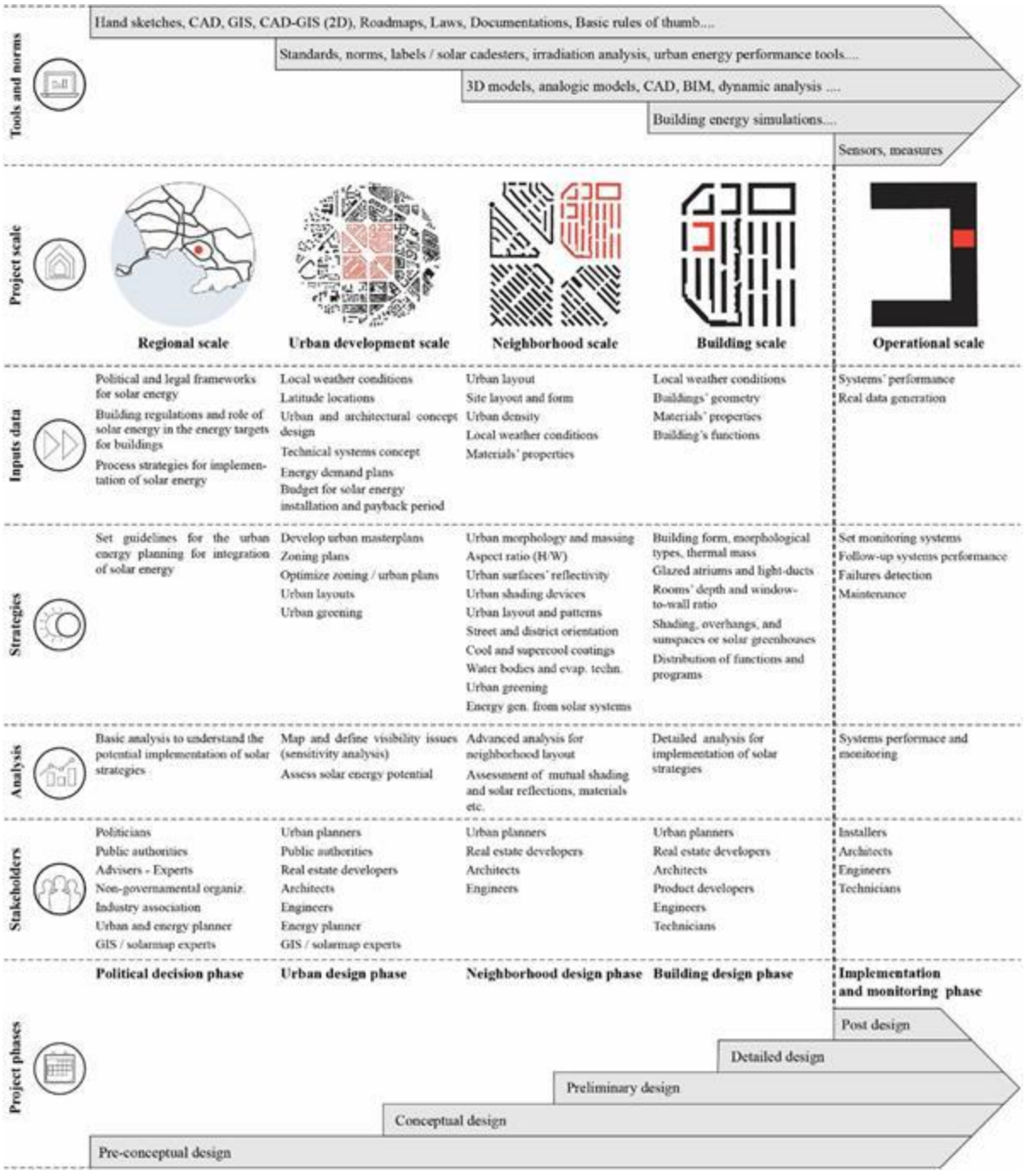


EERA. Technical Guide Logical framework and data infrastructure
https://www.eera-set.eu/



The EU City Calculator
https://europeancitycalculator.eu/the-eu-city-calculator/

Green Cities Wiki
https://smart-cities-marketplace.ec.europa.eu/insights/green-cities-wiki



Manni et al. 2023

https://doi.org/10.1016/j.buildenv.2023.110946

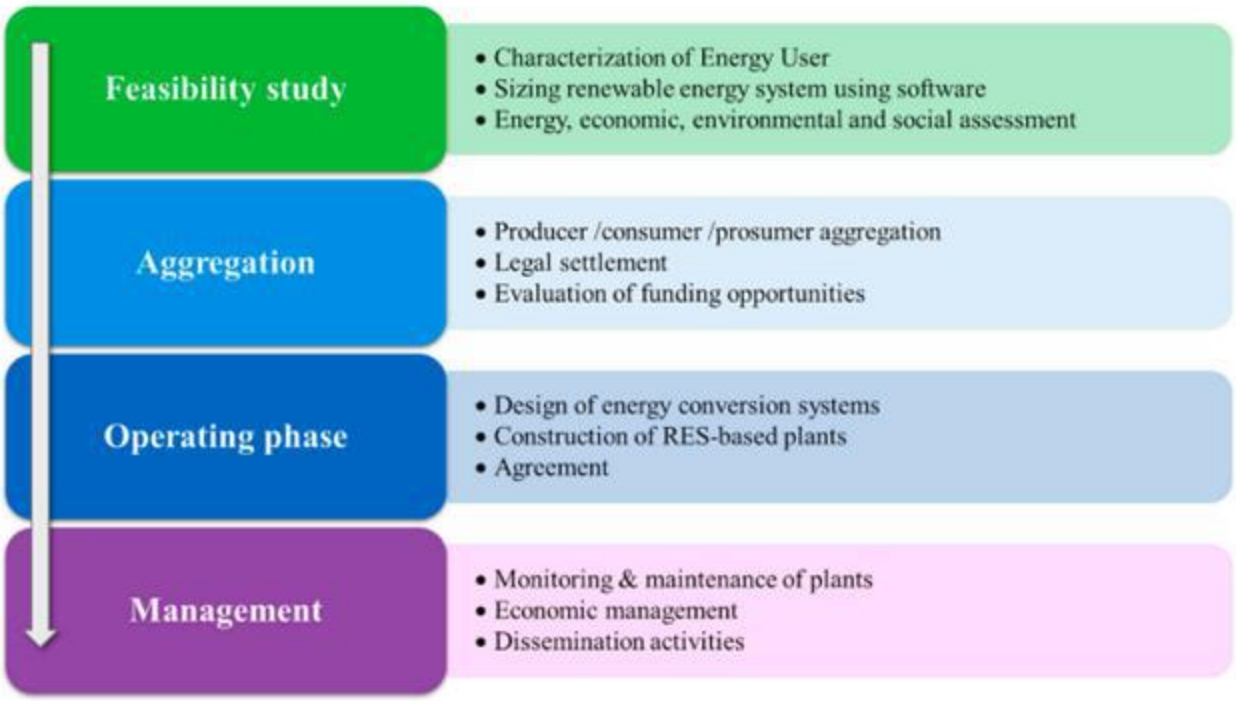


Fig. 3. REC implementation roadmap: phases and sub-phases.

Esposito et al. 2024

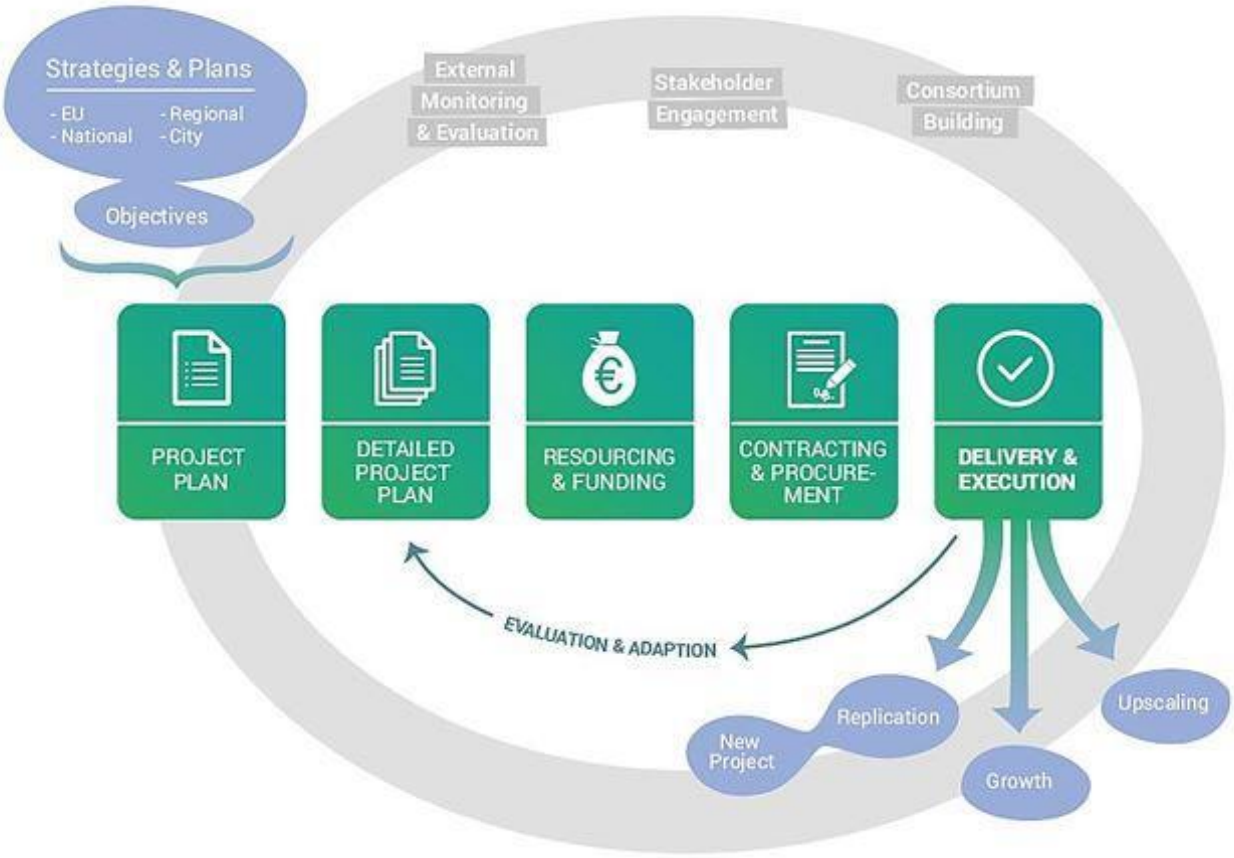
https://doi.org/10.1016/j.heliyon.2024.e28269

Figure 1. Eight steps to meeting a community's emissions reduction goals. The key personas for each step are defined. A sustainability champion (in yellow), a GIS manager (in blue), and an energy modeler (in green).

Berzolla et al. 2023
https://doi.org/10.1088/2634- 4505/ad025d

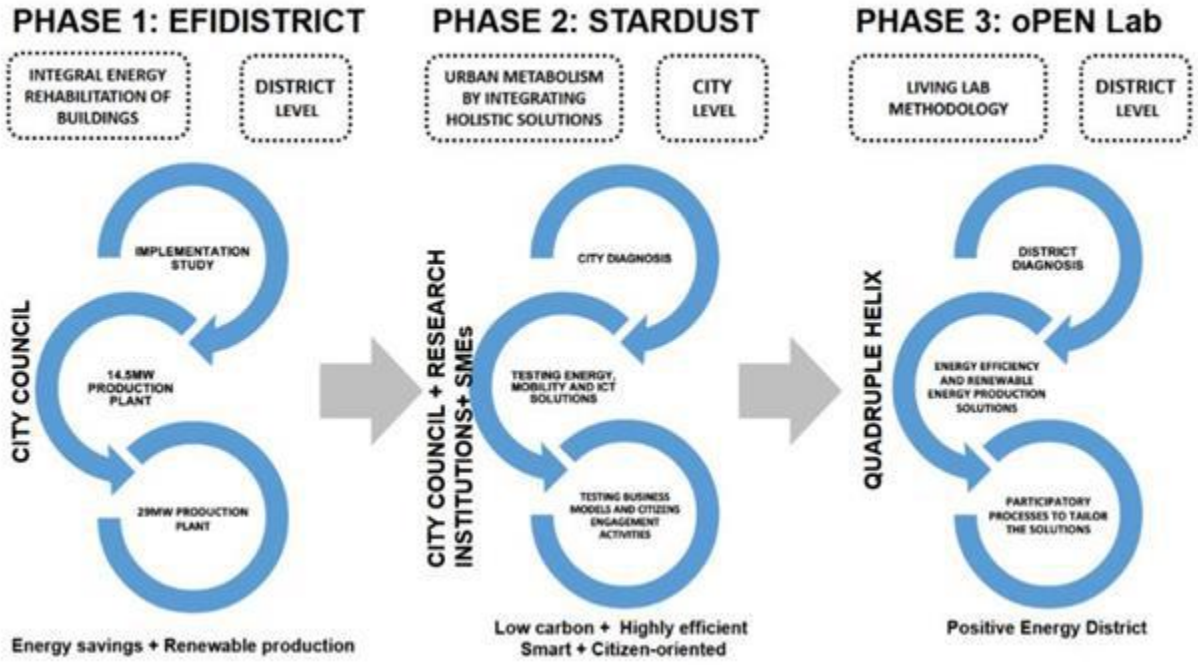
Table 2: Timeline of the replication activities in four (4) phases

RESPONSE. Dijon Smart City Replication Roadmap and Planning
https://h2020response.eu/

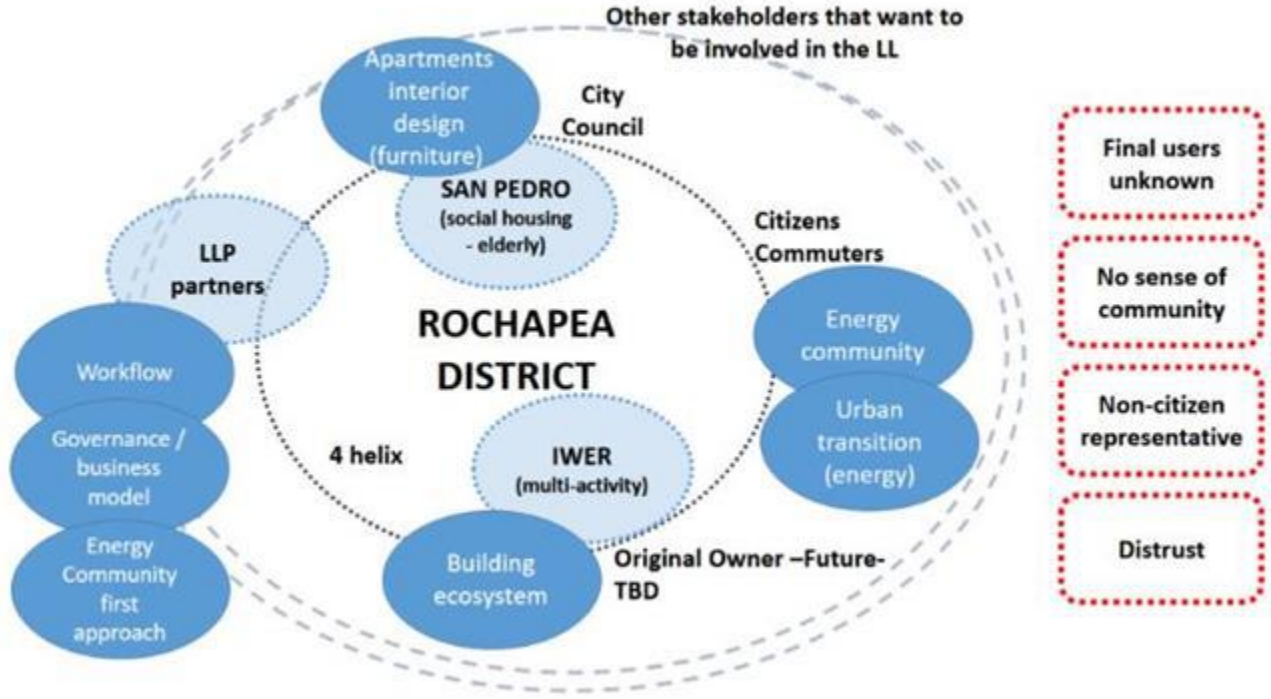


RESPONSE. Dijon Smart City Replication Roadmap and Planning
https://h2020response.eu/

Jradi et al. 2023
10.5334/fce.200



Kalms et al. 2023
10.1088/1742-6596/2600/8/082029



Kalms et al. 2023
10.1088/1742-6596/2600/8/082029

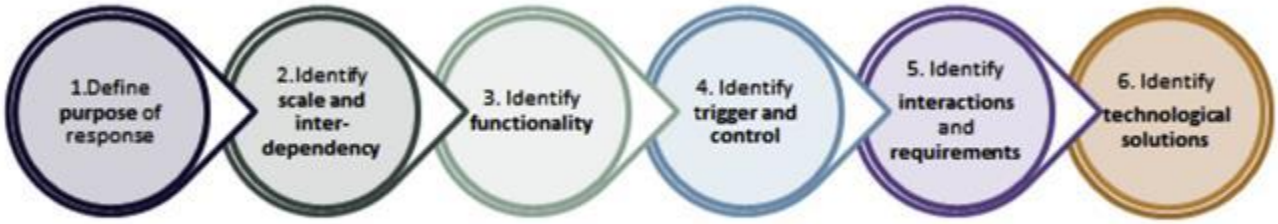


Fig. 1. The six-step performance goal strategy.

Taveres-Cachat. 2019
https://doi.org/10.1016/j.buildenv.2018.12.045

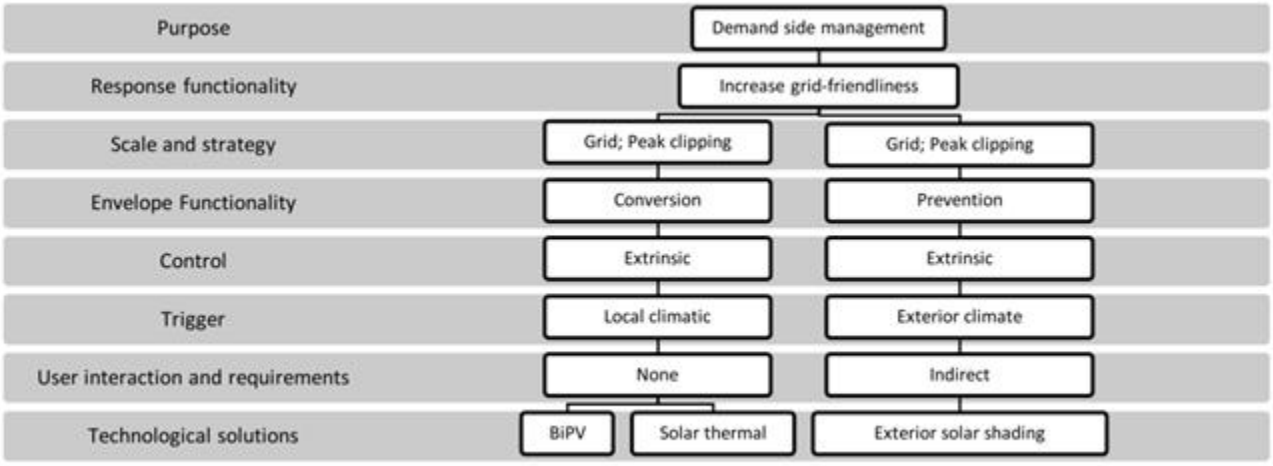


Fig. 6. Example of pathways to achieve good demand side management.

Taveres-Cachat. 2019
https://doi.org/10.1016/j.buildenv.2018.12.045

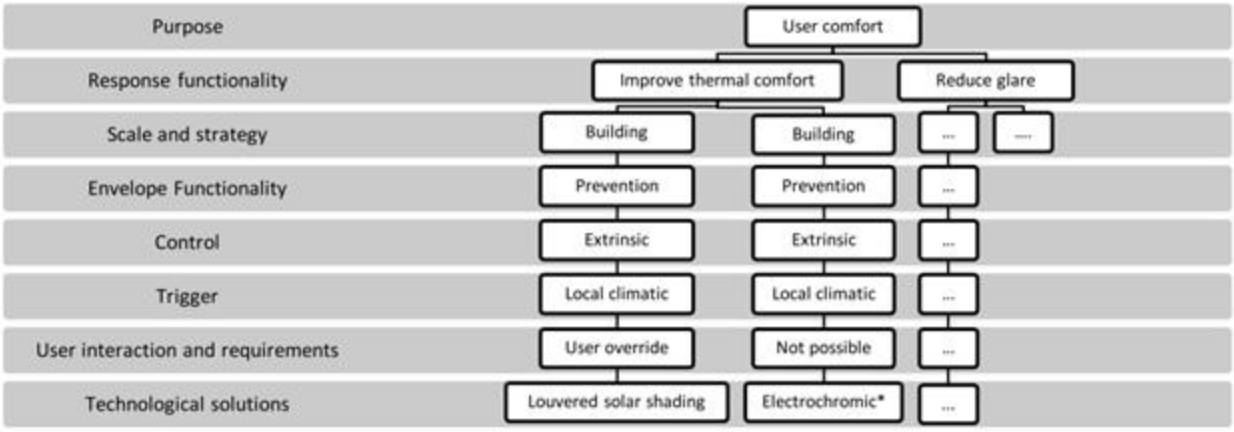


Fig. 7. Example of pathways to achieve desirable user comfort.

Taveres-Cachat. 2019
https://doi.org/10.1016/j.buildenv.2018.12.045

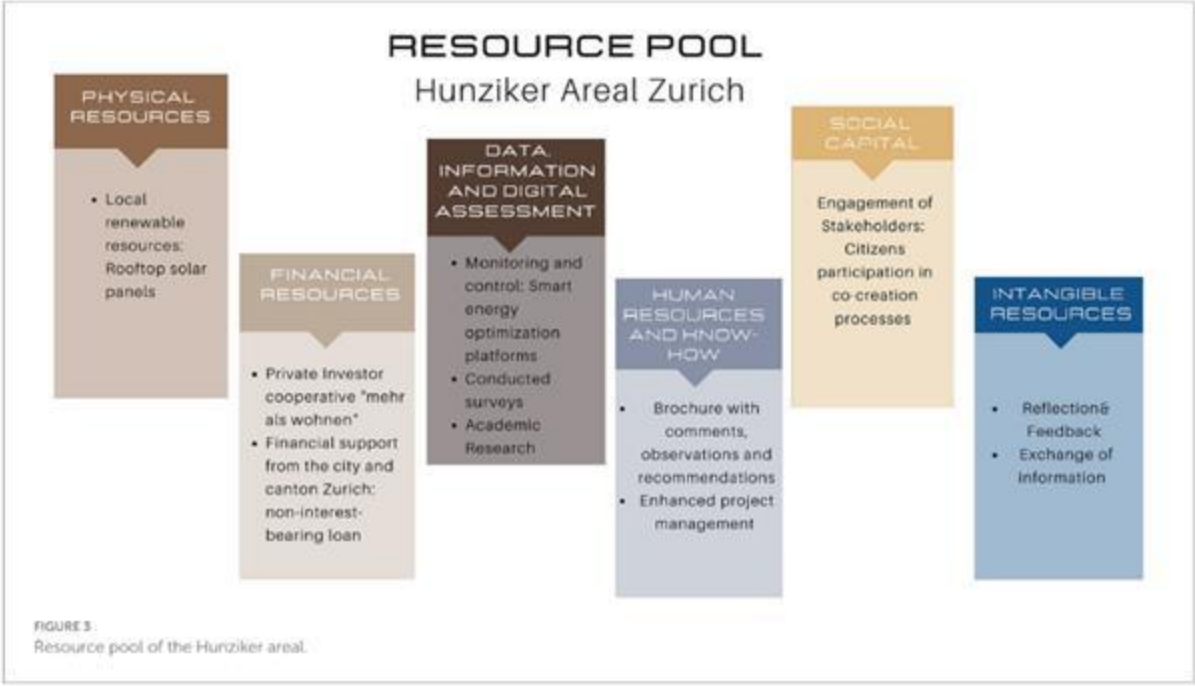


FIGURE 3
Resource pool of the Hunziker areal.

Zapata-Riveros et al. 2023
https://doi.org/10.3389/frsus.2023.1266126

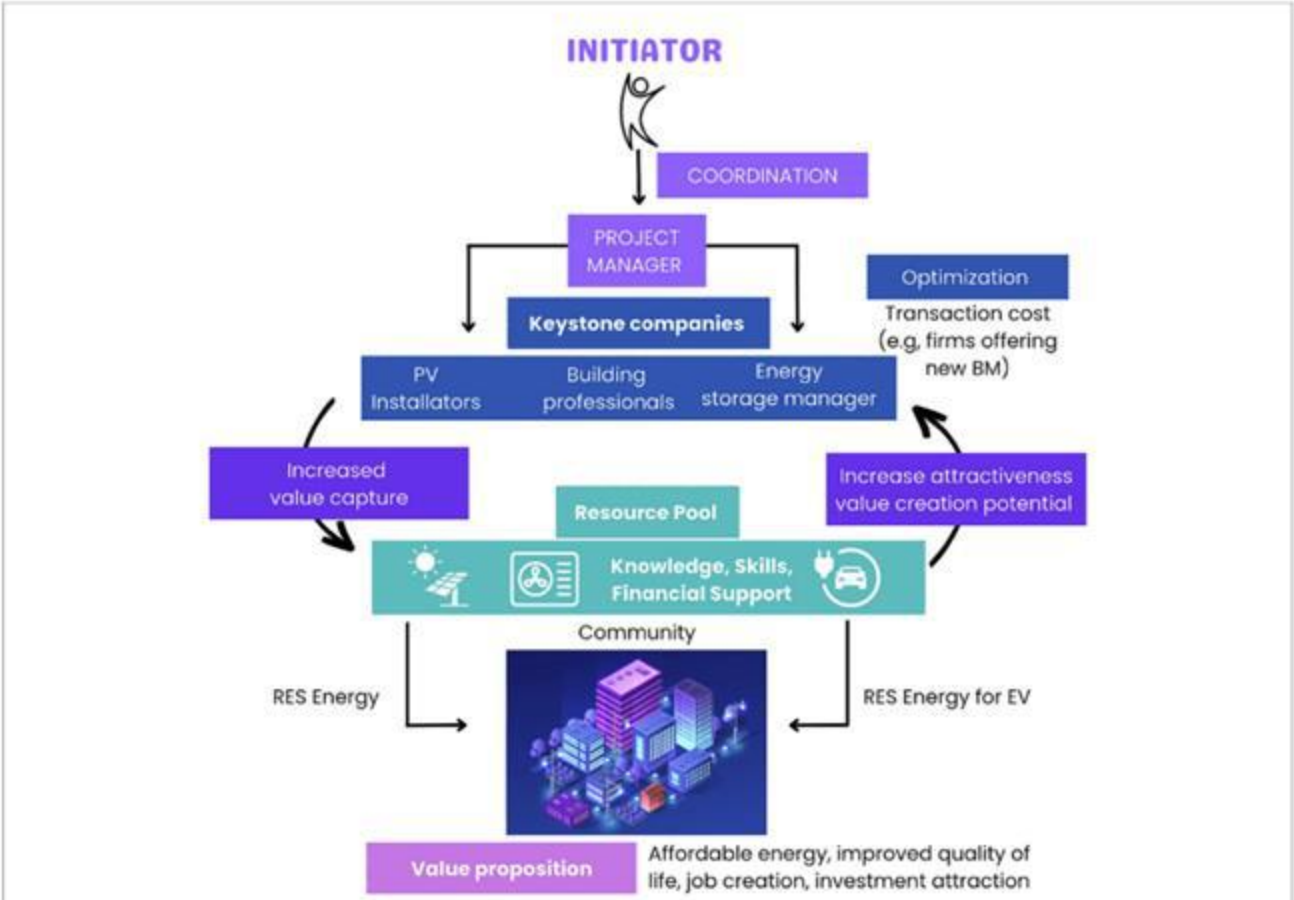
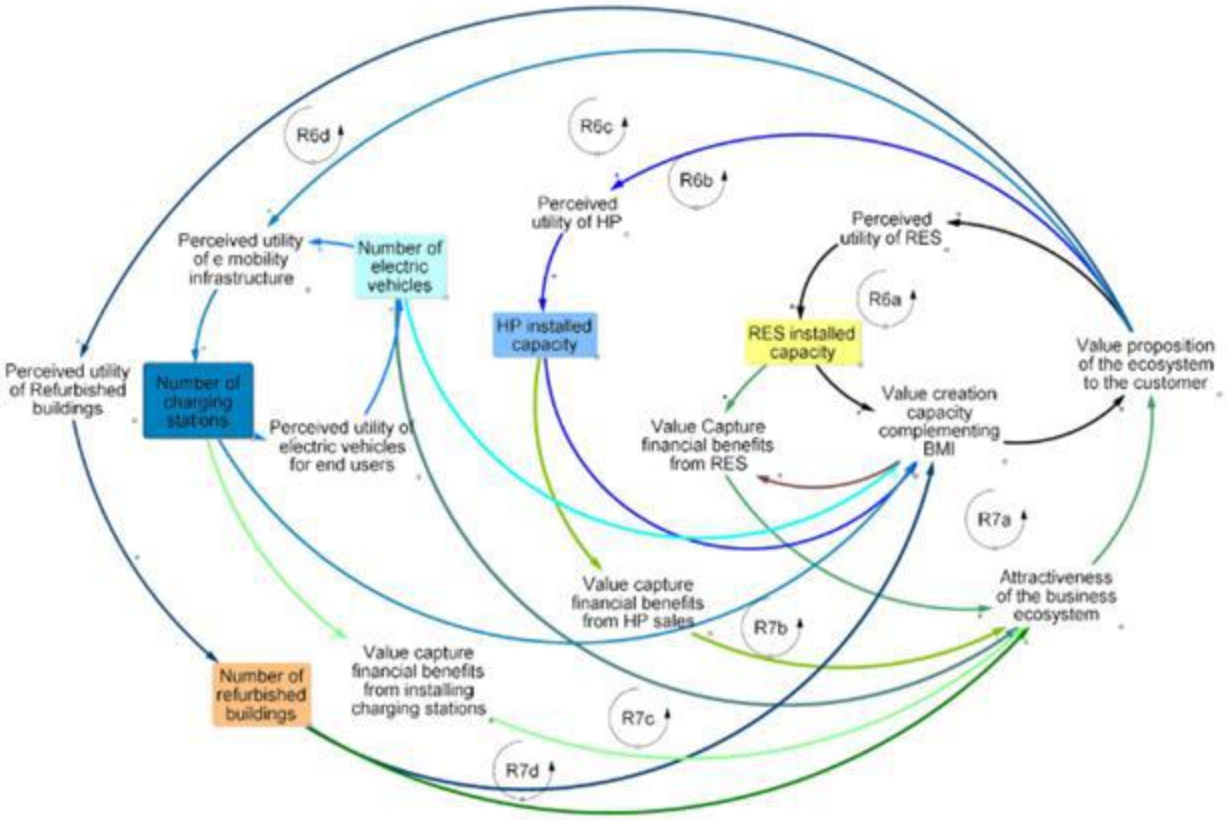


FIGURE 4
Conceptual model of the PED business ecosystem

Zapata-Riveros et al. 2023
https://doi.org/10.3389/frsus.2023.1266126



Zapata-Riveros et al. 2023
https://doi.org/10.3389/frsus.2023.1266126

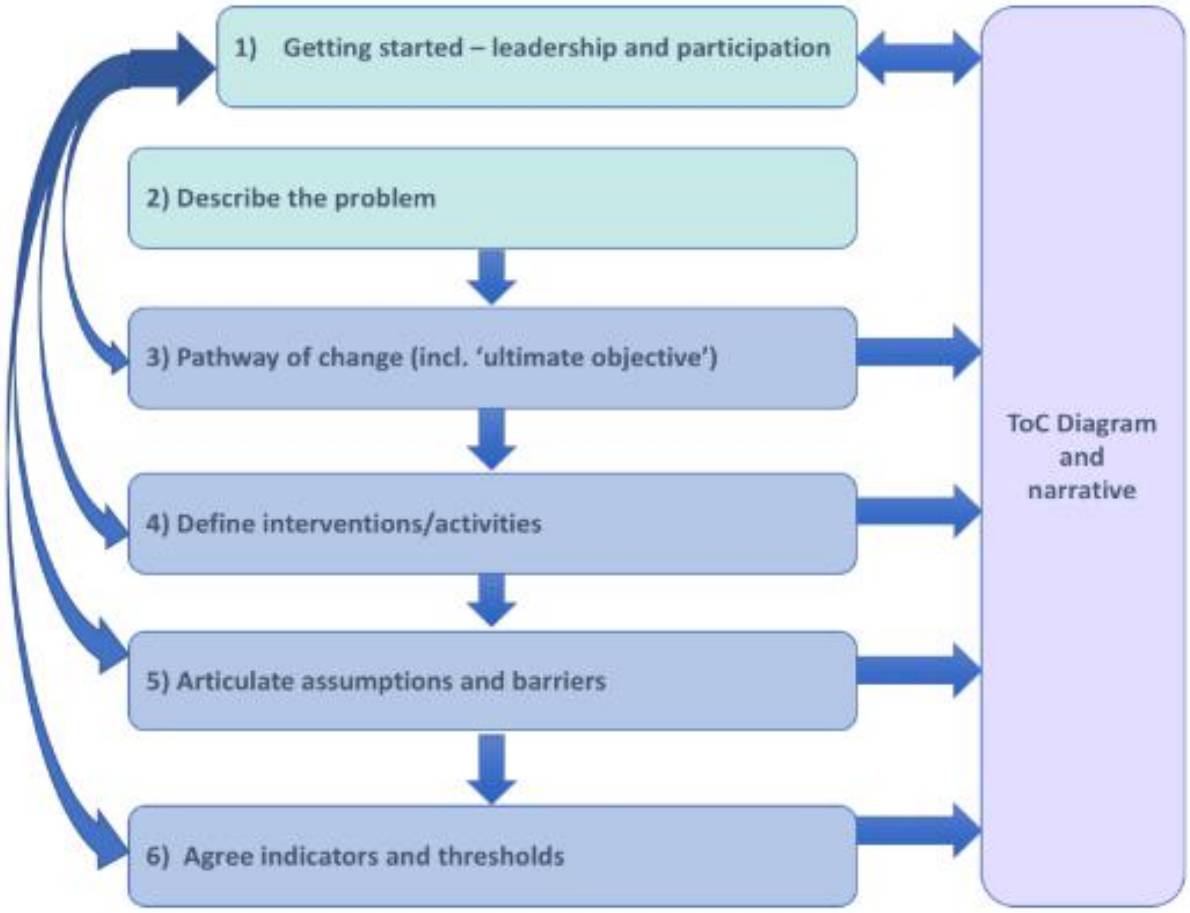


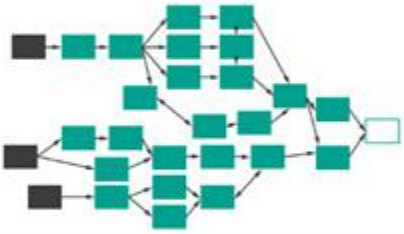
Figure 1 Steps in developing a Theory of Change

1. Expected impact

2. Expected outcomes

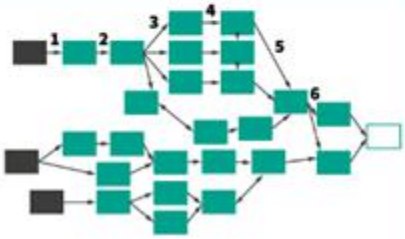
3. Strategies

4. Cause - effect relations



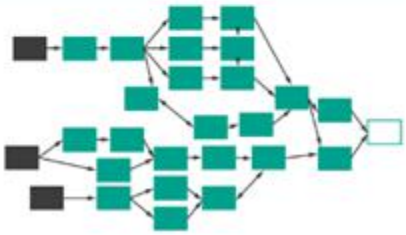
5. Causal assumptions

1: If we do X, Y happens.
2: We expect that when this outcome happens, the next outcome happens because Z.
3: Etc.

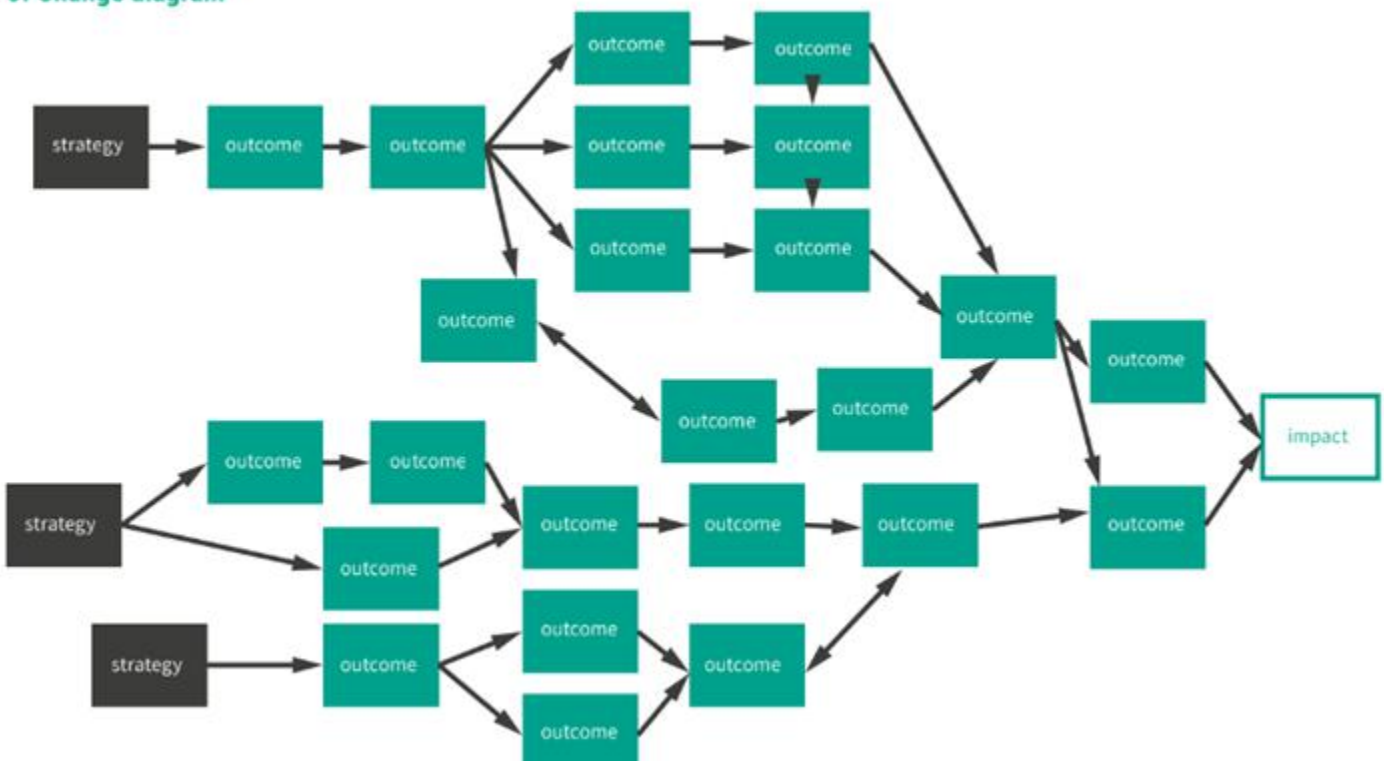


6. Theory of change diagram

See next page for larger model.



Theory of Change diagram



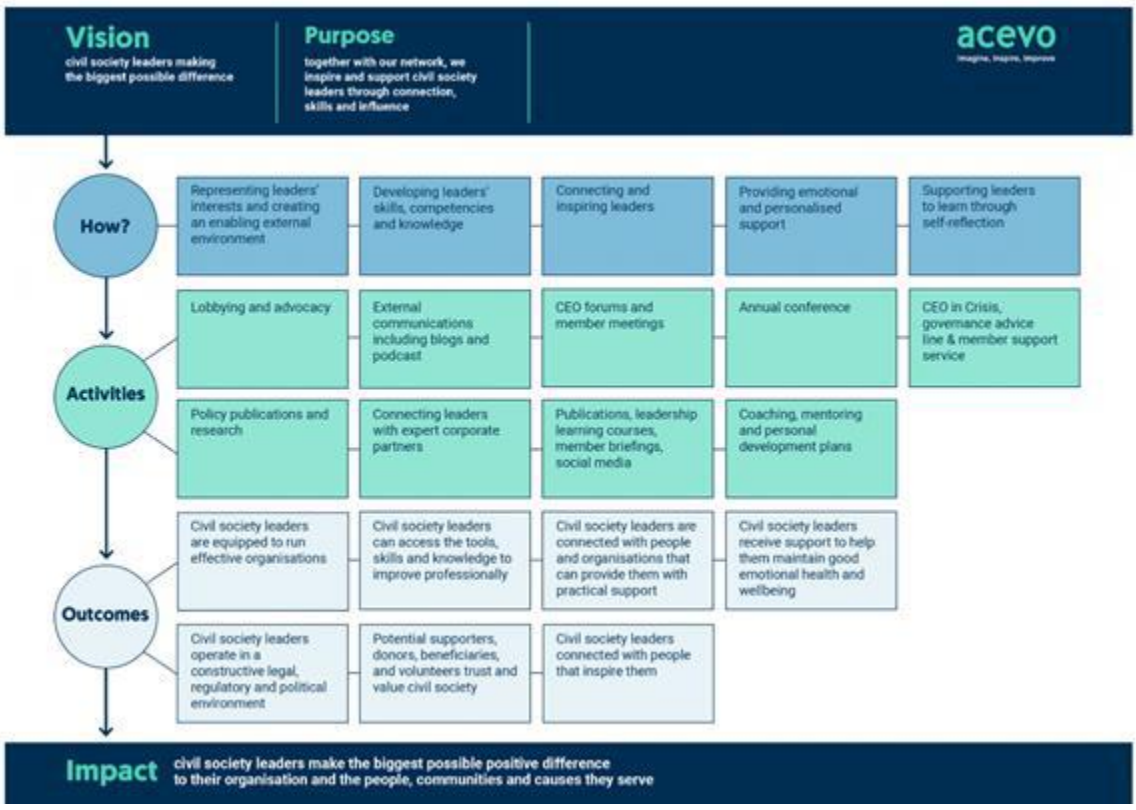
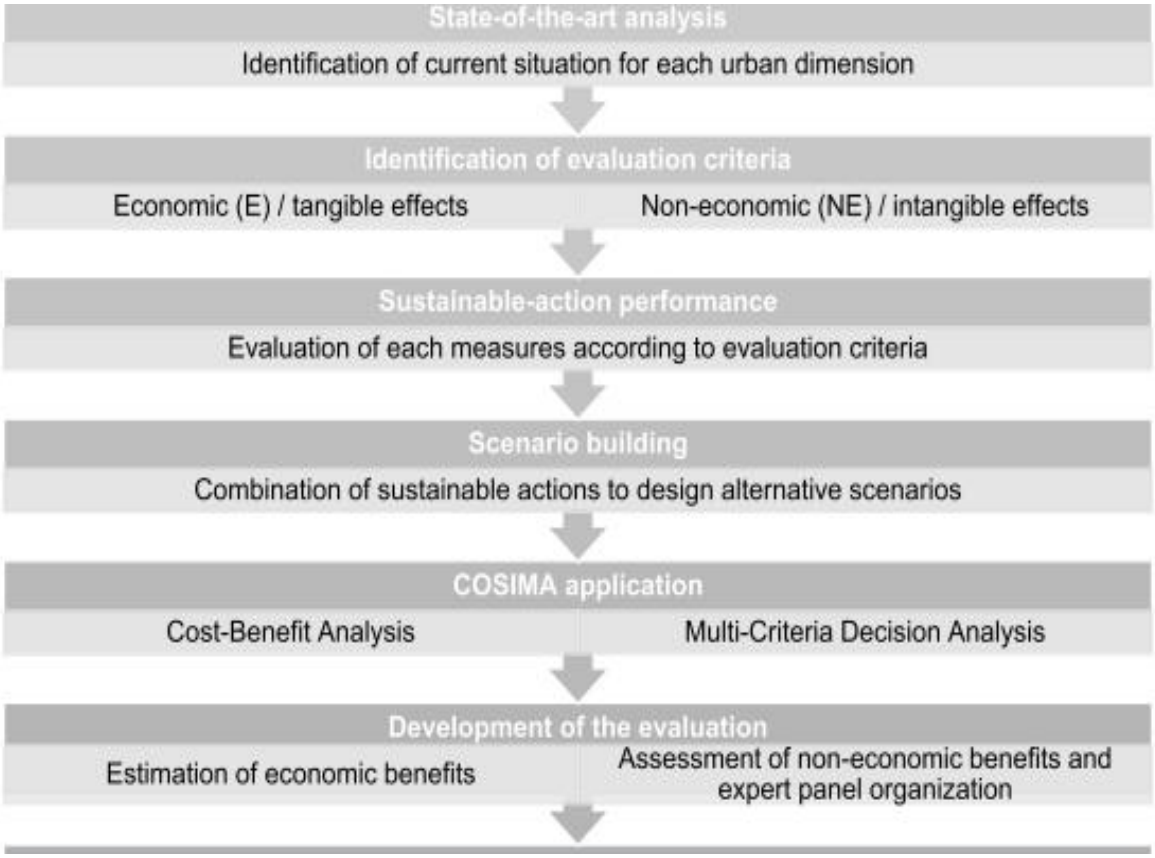

Vision
civil society leaders making the biggest possible difference
Purpose
together with our network, we inspire and support civil society leaders through connection, skills and influence
acevo
How?
Representing leaders' interests and creating an enabling external environment
Developing leaders' skills, competencies and knowledge
Connecting and inspiring leaders
Providing emotional and personalised support
Supporting leaders to learn through self-reflection
Activities
Lobbying and advocacy
External communications including blogs and podcast
CEO forums and member meetings
Annual conference
CEO in Crisis, governance advice line & member support service
Policy publications and research
Connecting leaders with expert corporate partners
Publications, leadership learning courses, member briefings, social media
Coaching, mentoring and personal development plans
Outcomes
Civil society leaders are equipped to run effective organisations
Civil society leaders can access the tools, skills and knowledge to improve professionally
Civil society leaders are connected with people and organisations that can provide them with practical support
Civil society leaders receive support to help them maintain good emotional health and wellbeing
Civil society leaders operate in a constructive legal, regulatory and political environment
Potential supporters, donors, beneficiaries, and volunteers trust and value civil society
Civil society leaders connected with people that inspire them
Impact
civil society leaders make the biggest possible positive difference to their organisation and the people, communities and causes they serve

Figure: The steps in calculating the energy performance of a PED. Adapted from MAKING-CITY guidelines.

Dirk Ahlers et al. 2020. POSITIVE ENERGY DISTRICTS SOLUTION BOOKLET



Becchio et al. 2021

10.1007/978-3-030-57332-4_3

Table 1 Economic and non-economic impacts in redevelopment project at the district scale

Evaluation criteria	Unit	Criteria type		Urban sectors				
		E	NE	B	M	P	W	WM
Energy saving	€/kWh	×		×		×		
CO_2 emission avoided	€/CO_2ton	×		×	×	×		×
PM_{10} emission avoided	€/PM_{10}ton	×		×	×	×		×
Real estate market value increase	€/m^2	×		×			×	
New green jobs	€/new green job	×		×			×	
Fuel costs avoided	€/kg or €/l	×			×			×
Increase in public transport passengers	Passenger/km		×		×			
Reduction of drinking water usage	l/per capita		×				×	
Covering renewable energy sources	%		×	×				
Visual impact	Qualitative scale		×	×	×		×	×
Reliability of technology	Qualitative scale		×	×	×		×	×
People acceptance	Qualitative scale		×	×	×		×	×

Becchio et al. 2021

10.1007/978-3-030-57332-4_3

Table 1 – Three-stage strategy to reach full-scale implementation of FI-RECs

	Stage 1: Preparation and pilot phase	Stage 2: National strategy	Stage 3: Fast promotion
	(6 years)	(1 - 2 year)	(5 years)
Regulation	Adapt the current market structure to better mirror the physical flows of electricity and incentivize its implementation	Specify instructions about the roles of and within fully integrated energy community and their structures	Establish local schemes and standards for the support and facilitation of energy community deployment
	Detail standards for creation and operation of local energy markets and detail the market rules for integration into the adapted market structures	Guarantee legal framework and resources needed for the deployment of fully integrated Energy Communities	Establish local electricity markets to enable energy communities to participate in the market
Technology	Detail the standards for chain controls in power systems and customer plants in accordance with the *LINK* holistic architecture (communication and control) including replicability, scalability, and data protection by design		Continues improvement: Regular revision of technical Norms, further R&D, etc.
	Develop standards for technology providers and manufacturer to incorporate features for automated operation with controlling units in customer plants		Facilitate the upgrade to automatically integrated technology on customer level
Behaviour & Stakeholders	Establish and motivate pilot implementations as best practices, through supporting structures (policy, umbrella organizations etc.).	Enable and engage stakeholder participation through clear participation models with defined responsibilities, supported through local, trusted intermediaries, accompanied by participatory processes and capacity building at all levels	
Research & Development	Launch fully integrated Energy Community pilots in suitable locations for proof of concepts.	Disseminate information about results and verified benefits to support large scale roll-out	

INTERACT.Roadmap for the implementation of the designed INTERACT Energy Community in general and for the specific local perspectives
https://www.ped-interact.eu/