

Mainstreaming governance, co-investment and technology solutions for Positive Energy Districts in monument protected areas (MonuPED)

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D5.1 Living Lab Design

Workpackage 5: Living Labs – concept, solution, validation and co-creation with stakeholders



MONUPED



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Contact person responsible for this deliverable:	Email: Nadja Riedel, City of Leipzig (LEI) Nadja.riedel@leipzig.de Lucy Fröhlich, City of Leipzig (LEI) lucy.froehlich@leipzig.de
Authors:	Zdenko Malík, Wojciech Belch (CVUT) Nadja Riedel, Lucy Fröhlich (LEI) Tudor Drambarean, Ovidiu Boc, Valentin Voinica (AIM) Sandra von Schirp, Sonja Neubauer (CEN) Crtomir Tavzes (ZVKKDS) Lukas Unterpertinger (FB)
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1 EXECUTIVE SUMMARY

The report *D5.1 Living Labs – concept, solution, validation and co-creation with stakeholders* explores the implementation of Positive Energy Districts (PEDs) within heritage contexts through the lens of Living Labs, focusing on three Living Labs in Leipzig (Germany), Prague (Czechia) and Alba Iulia (Romania) and two case studies in Koper (Slovenia) and Pinkafeld (Austria).

The primary objectives are to identify key challenges in integrating PEDs with heritage protection, develop a framework for stakeholder engagement and concrete next steps (roadmap) for stakeholder engagement in 2025.

Living Labs (LLs) are user-centered, open innovation ecosystems that integrate research and innovation processes in real-life settings, particularly in urban contexts known as Urban Living Labs (ULLs). These labs aim to address issues such as energy efficiency, sustainability, and heritage preservation. PEDs, which produce more energy than they consume, are crucial for achieving climate neutrality goals. However, integrating modern energy systems into historic buildings and districts presents significant challenges due to preservation requirements and structural limitations.

D5.1 outlines a Living Lab framework for stakeholder engagement in the three MonuPED Living Labs, emphasizing the importance of collaborative decision-making and community involvement. Key stakeholders in each of the MonuPED Living Labs are identified and grouped in three categories (target groups, partners and multipliers). Also connections to existing local strategies and projects either related to monument protection affairs but also sustainable energy and climate protection plans (SECAPS) as well as energy efficiency strategies are identified.

The aim is to obtain a comprehensive overview of the local situation in each of the three MonuPED Living Labs and the two case studies.



2 INTRODUCTION

A Living Lab is a real-world environment in which new technologies, services, and processes are tested, developed, and refined through active collaboration between researchers, companies, public institutions, and citizens. Unlike traditional research settings, Living Labs are embedded in actual communities, making them ideal for experimenting with, validating and adapting solutions in realistic, complex, and dynamic environments. Living Labs often uncover challenges that research labs would not, offering a more comprehensive testing field.¹

Building on this foundation, Living Labs represent open innovation ecosystems that employ a systematic co-creation approach. They specifically address the limitations of linear innovation models by creating spaces where global sustainability ambitions can be translated into local solutions through direct engagement with communities. This approach is particularly valuable in urban contexts, where they serve as policy experimentation arenas that bring together the quadruple helix of actors: citizens, government, industry, and academia.

The Living Lab concept operates on three interconnected levels:

- The **organizational** level (entities institutionalizing Living Lab principles)
- The **project** level (specific initiatives applying these approaches)
- The **activity** level (concrete methods and tools)

What distinguishes Living Labs is their problem-driven methodology, where each activity is carefully designed based on:

- The specific challenges being addressed
- The stakeholders who need to be involved
- The expected outcomes and potential for scaling solutions

By testing innovations in real urban environments with active community participation, Living Labs not only identify implementation challenges early but also create pathways for developing socially grounded, practical solutions that are more likely to succeed when scaled.²

Establishing Living Labs in Prague, Alba Iulia, and Leipzig will validate concepts, recommendations, and tools from WP2, 3, and 4, activating MPA ecosystems with stakeholders like building owners, MP authorities, energy providers, universities and residents. Customized approaches and co-creation techniques will address local challenges and develop solutions.

The primary goal is to map stakeholder ecosystems and develop a Living Lab framework. Cross-stakeholder collaboration aims to create a shared vision for energy transition aligned with local climate strategies. Solutions developed in WP4 will be showcased and evaluated in Living Labs, providing direct feedback. Community engagement events like on-site visits and workshops will raise awareness and address community needs regarding PED development in MPAs/MPBs.

¹ Trinity College Dublin. Living Labs. <https://www.tcd.ie/sustainability/resources/living-labs/#:~:text=What%20Are%20Living%20Labs?,to%20the%20area%20of%20sustainability.>

² European Network of Living Labs enoll. <https://enoll.org/living-labs/>



3 METHODOLOGY

This chapter presents the methodology for designing the Living Labs at the three MonuPED sites: Prague 6, Alba Iulia, and Leipzig. A mixed-method approach is utilized, incorporating individual online workshops tailored for each Living Lab, a consortium-wide alignment workshop, and standardized tools. This approach aims to identify key actors, define co-creation activities, and establish a timeline for the initial Living Lab activities, set to continue through the end of 2025.

Adapted from the DUT Partnership's Online-Training on Implementing Urban Living Labs, the process is guided by six key questions for Urban Living Labs, as defined in the DUT Partnership's "Online-Training on Implementing Urban Living Labs"³:

1. Why do we want a Living Lab?
2. Which results do we wish to obtain?
3. Who do we need to involve in our Living Labs to address the issue?
4. Which activities should be carried out in the Living Labs to achieve our goal?
5. What do we want to learn from the Living Lab?
6. How does the city as a whole benefit from these results?⁴

A Living Lab (ULL) is a collaborative, real-life testing environment designed to co-create, experiment, and evaluate innovative solutions to urban challenges by involving residents, researchers, policymakers, and private stakeholders. The goal is to generate practical, scalable results such as improved urban services, sustainable technologies, and inclusive governance models that are grounded in local context. Through the Living Labs, we aim to learn what works in complex urban systems, how different communities respond to interventions, and how collaborative planning processes can be optimized. Ultimately, cities benefit by reducing the risks of large-scale implementation, enhancing public participation, and enabling data-driven, evidence-based policymaking that fosters more resilient, equitable, and livable urban environments. The ambition of the MonuPED Living Labs is also outlined in chapter 7.

This deliverable (D5.1) focuses on questions 3 (stakeholder involvement) and 4 (planned activities), which are essential for establishing the operational foundation of the Living Labs. Addressing these areas systematically ensures alignment among engagement strategies, co-creation goals, and the integration of WP4's digital tools, studies, and pilots. Questions 5 (expected learnings) and 6 (benefits to the city) will be addressed in deliverable D5.2 Living Lab Evaluation (M24).

The design for the three MonuPED Living Labs was developed in a three-step process:

Phase 1: Online Workshops

Separate online workshop sessions were conducted with the Living Lab Leads from Leipzig, Prague, and Alba Iulia, utilizing a standardized Miro template. These workshops aimed to map the spatial context of each area, identify key actors, connect existing networks and related projects, outline the primary engagement format, and establish a timeline extending to the end of 2025. Following this initial stage, the results were independently reviewed and further refined by the partners.

³ The terms Urban Living Labs or Living Labs can be used synonymously.

⁴ Johannes Riegler, Training for DUT Projects on Implementing Urban Living Labs 13/05/2025



Phase 2: Cross-Partner Alignment Workshop

During the first MonuPED in-person meeting, all project partners convened to discuss and enhance the stakeholder maps in alignment with WP4 tools. The session commenced with brief presentations from each Living Lab team, detailing their local contexts, key stakeholders, and planned activities through the end of 2025.

Structured as a world café, the meeting progressed into five thematic roundtable discussions, featuring two 15-minute rotations. These discussions focused on digital tools (such as Prague's RoofMatchApp and Leipzig's GIS-based Energy Map), studies and concepts (including Prague's roofs and facades study), and implementation pilots (like Leipzig's temperature mapping). This collaborative workshop not only refined the stakeholder lists but also established concrete connections between actors, tools, and activities and MonuPED workpackages, ensuring that the Living Labs would yield valuable insights at both the local and cross-city levels.

Phase 3: Iterative Refinement

Finally, the Living Lab teams validated and refined these plans, adjusting timelines to avoid scheduling conflicts. This iterative process ensured that the final Living Lab designs—documented in this deliverable—are both grounded in local realities and strategically aligned with MonuPED's objectives. The result is a set of tailored yet interconnected Living Labs, each with a stakeholder ecosystems and initial activity roadmaps, ready to test, learn, and scale solutions.



4 MONUPED LIVING LABS

4.1 Definition and Objectives of Living Labs within MonuPED

MonuPED establishes Living Labs in Prague, Alba Iulia, and Leipzig as real-world testing environments. These Living Labs serve a crucial function in validating the concepts, recommendations, and tools developed throughout the project's work. By implementing customized co-creation approaches, the Living Labs address specific local challenges while activating the Monument Protection Building and Area (MPBs/MPAs) ecosystems.

The primary objectives of these Living Labs are threefold: First, they systematically map the stakeholder ecosystems to understand the complex network of actors involved in energy transitions within heritage contexts. Second, they develop a robust Living Lab framework that can guide implementation across different urban contexts. Third, they facilitate cross-stakeholder collaboration to create a shared vision for energy transition that aligns with local climate strategies. Additionally, the Living Labs provide platforms to showcase and evaluate practical solutions from WP4, while community engagement events ensure local needs are addressed throughout the process.

MonuPED Living Labs are built upon experience and existing stakeholder networks from existing PED initiatives in each city deriving from national or EU-funded projects including SPARCS in Leipzig and Prague, ASCEND in Prague and Alba Iulia, and INTERPED in Alba Iulia⁵. These connections ensure continuity with ongoing urban transformation efforts while allowing MonuPED to contribute specific expertise regarding heritage contexts.

Additionally to the three Living Labs MonuPED includes two case studies in Koper, Slovenia and Pinkafeld, Austria where digital tools are developed and applied. Both studies are described shortly in the case study chapter of this report.

4.2 Spatial characteristics of the MonuPED Living Labs and case studies

The categorization of monument protected buildings (MPBs) and areas (MPAs) can be based on various criteria.

There are different framework conditions and criteria for buildings and areas being declared as monuments in the six MonuPED countries (Czechia, Romania, Germany, Austria, Slovenia and Iceland).

In Germany e.g., there are several types of historic monuments, each categorized based on different criteria such as their historical significance, architectural style, and usage. Main types of monuments include: architectural monuments (Baudenkmale), technical monuments (Technische Denkmale) or monument ensembles (Denkmalensembles).⁶

Due to these specific national framework conditions, the characterization of the MonuPED Living Labs should not be based on the respective national legislations but on other criteria like the building structures, use and functions, as well as the age of the MPAs/MPBs.

⁵ www.sparcs.info; <https://www.ascend-project.eu/> and <https://interped.eu/> .

⁶ Wernicke, S., & Knapp, W. (Eds.). (2016). *Denkmalschutz und Denkmalpflege in Deutschland: Ein Handbuch*. (Monument Protection and Preservation in Germany: A Handbook). Berlin: Jovis Verlag;

Deliverable Report

Table 1: Overview MonuPED Living Labs

Living Lab Leipzig Baumwollspinnerei	Living Lab Prague 6 Břevnovský klášter	Prague 6 Archiepiscopal Seminary	Living Lab Alba Iulia The Princely Palace, Principia Museum
 Figure 1: Baumwollspinnerei Leipzig, (source: Knut Maurive, Cenero Energy GmbH)	 Figure 2: Prague 6 / Břevnovský klášter	 Figure 3: Prague 6 / Archiepiscopal Seminary	 Figure 4: The Princely Palace, Principia Museum (source: https://palatulprincipilor.ro/)
Building structure			
Building ensemble, industrial building (MPA)	Individual building (MPB)	Part of the district covered by monument protection (MPA)	Individual building (MPB)
Age of construction			
1884	Baroque	20 th century	Medieval (mid-16th century)
Current use and function			
Commercial mixed use (e.g. offices, galleries, cinema, call center) (former industrial area)	Public use, library	Public use, University building, Office building	Municipal building, partially renovated, currently used as a museum and for cultural events



Table 2: Overview MonuPED Case Studies

Case Study Slovenia Old Town of Koper		Case study Austria Town hall Pinkafeld	
			
<i>Figure 5: Old Town of Koper (source Jaka Jerasa)</i>		<i>Figure 6: Town hall Pinkafeld (source: Nora Kirchknopf)</i>	
Building structure			
Building ensemble (MPA)		Individual building (MPB)	
Age of construction			
Spanning from late 13th to late 15th century, with many renovation campaigns, especially in the second half of 20th centur		1951-54	
Current use and function			
Mixed use (housing, retail, public buildings)		Public use, town hall	

4.3 Role of Living Labs in Enabling PEDs in MPAs/MPBs

Living Labs play a pivotal role in implementing Positive Energy Districts (PEDs) within Monument Protection Areas and Buildings by creating structured engagement platforms.

A comprehensive stakeholder approach is fundamental to this process. The MonuPED project identifies and works with:

- municipalities,
- individual homeowners, including citizens/small owners, owner associations (e.g. churches), tenants, and the commercial real estate sector
- monument protection authorities (public authorities at the state and city level, municipalities, and local communities/associations)
- financing institutions (banks), insurance companies, and utilities form a third (supporting) group of stakeholders.



Figure 7: Key Stakeholder Categories

MonuPED categorizes these stakeholders into three groups according to their engagement level. **Partners** are those who actively participate in project activities and decision-making processes. **Supporters** and multipliers, while not directly involved in implementation, play crucial roles in promoting project outcomes and expanding their reach. **Target groups** represent the primary beneficiaries whose needs directly shape the solutions we develop.

This categorization proves valuable as it helps tailor engagement methods, from co-creation workshops with partners to awareness campaigns for target groups. The distinction also guides resource allocation and helps measure impact across different stakeholder categories. MonuPED communication and involvement strategies will consider the various motives and logics of action of the stakeholder groups.



4.4 Integration of Living Labs with other work packages (WP2, WP3, WP4)

Within the MonuPED framework, the Living Labs (WP5) serve as the testing ground for solutions developed in WP4, while maintaining strong connections to the conceptual work in WP2 and the financial/regulatory analyses in WP3. This integration ensures that validated solutions are not only technically sound but also feasible within existing policy and financing frameworks.

The Living Lab approach thus creates a bridge between theoretical research and practical implementation, particularly for the context of energy transitions in heritage areas. By combining stakeholder engagement with real-world testing, the Living Labs ensure that solutions are both technically robust and socially embedded.

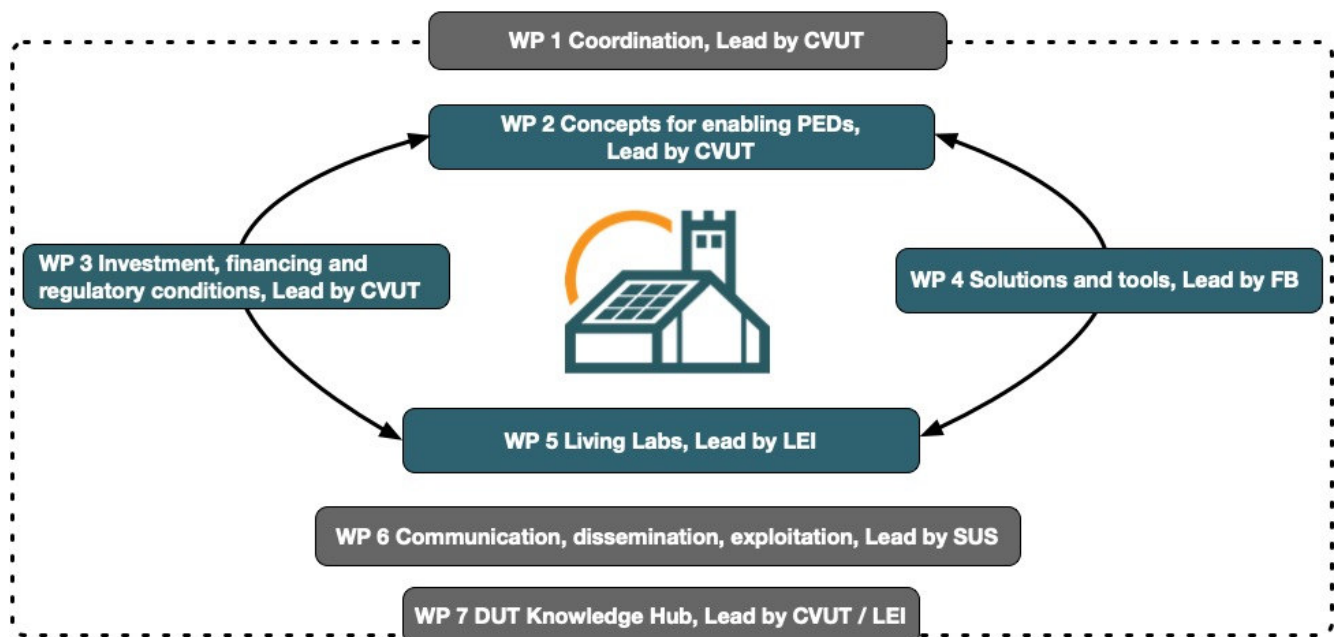


Figure 8: Overview of the MonuPED Work packages

The MonuPED Living Labs will ensure the **validation of the developed concepts, recommendations, tools, and studies from WP2, 3, and 4**. The Living Labs will activate and expand the MPA ecosystems incl. building owners, investors, heritage protection officers, residents, universities and energy solution providers, etc. in the three pilot cases. Via a customized approach for each Living Lab, co-creation techniques are used in different workshop formats to identify local challenges, align them with findings from WP2 + 3, but also develop solutions for MPA/MPB-related development challenges. The primary objective is to create a **comprehensive mapping** of the relevant stakeholder ecosystem on the local level and generalize an **MPA ecosystem type (Living Lab framework)**, incl. their respective logics of behaviours and demands regarding concrete solutions for the uptake of PEDs. Second, the cross-stakeholder collaboration enables the development of a **shared vision for the energy transition** in the three MPA/MPB pilot cases and to align them with the existing local climate neutrality strategies.

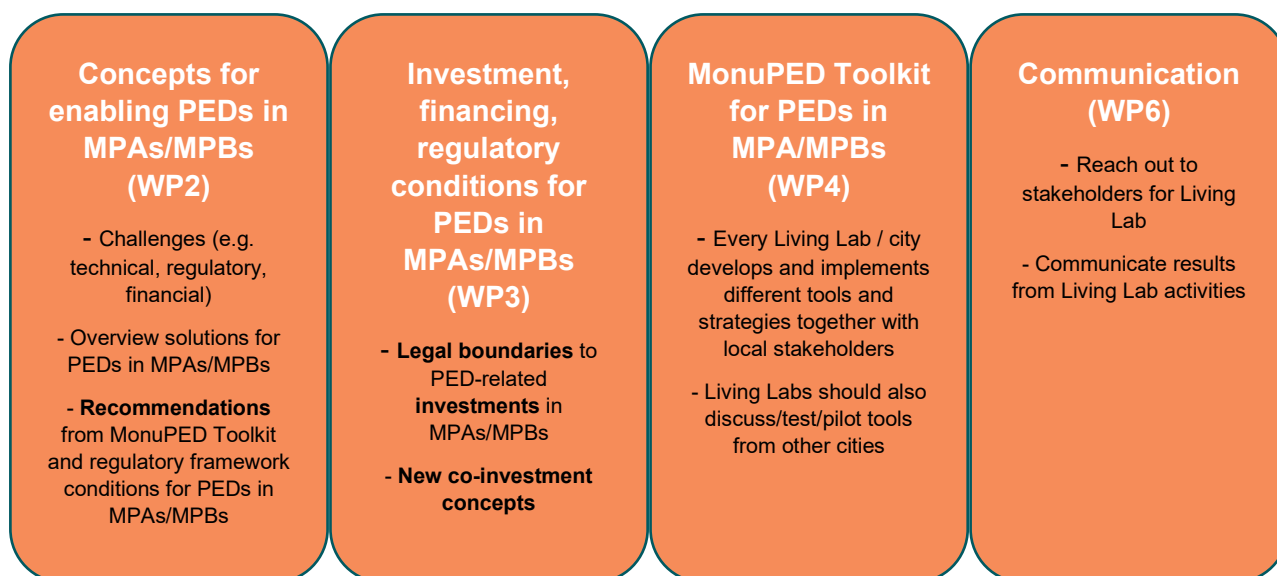


Figure 9: Summary of MonuPED Work packages

Connection to WP2 and WP3 – Concepts for enabling PEDs in MPAs/MPBs

The Living Labs Design contribute directly to WP2 by documenting challenges, stakeholder dynamics, and testing contexts for implementing PEDs in monument-protected areas. It supports T2.1 through detailed descriptions of ownership structures, regulatory and technical barriers, and engagement processes across Leipzig, Prague 6, and Alba Iulia. It also feeds into T2.2 by outlining how existing and adapted PED tools (e.g., RoofMatch App, Thermal Profiling) are being tested in real-life conditions. They provide essential empirical input by surfacing technical, legal, and user-based challenges and showcasing stakeholder reactions to proposed solutions. This supports WP2's broader aim of shifting from restrictive "don'ts" to actionable "dos" aligned with the New European Bauhaus principles.

The design and planned activities provide a structured environment in which economic and legal boundaries to PED implementation in MPAs can be identified and tested in practice. For T3.1, it sets up stakeholder constellations, engagement formats, and feasibility studies (e.g. Leipzig's shared geothermal heat storage concept, Prague's RoofMatch App testing, and tenant engagement for thermal profiling) that will allow WP3 to observe and document regulatory hurdles and cost factors as they manifest in real cases. The Living Lab Design ensures that WP3 has access to real-time data from stakeholders, permitting processes, and implementation challenges, which will be essential for creating the regulatory and funding overview planned in D3.1.

For T3.2, the Living Lab framework provides the groundwork for piloting co-investment concepts in concrete local settings. Leipzig's Living Lab, for example, explores collaborative models involving private property owners, public authorities, and facility managers - offering an ideal context for testing non-ownership-based investment schemes. Prague 6 Living Lab's activities around the RoofMatch App and energy potential mapping are also designed to support investment matchmaking and will inform the investment matrix foreseen in D3.2. In this sense, the Living Labs operationalize WP3's conceptual tasks by setting up the multi-actor engagement, testing environments, and feedback mechanisms needed to validate emerging business and investment models under real-world conditions.

Connection to WP4 – MonuPED Toolkit for PEDs in MPA/MPBs



WP4 focuses on the development of the MonuPED Toolkit, which is described in Deliverable D4.1 and includes five digital tools, two technical interventions, and two conceptual studies designed to support the implementation of Positive Energy District (PED) solutions in Monument Protected Areas (MPAs) and Buildings (MPBs). These solutions are developed in collaboration with local and thematic partners and reflect a wide range of approaches to address heritage-related challenges in the energy transition.

The tools and interventions developed within WP4 will be showcased and iteratively tested in the Living Labs established in Leipzig, Alba Iulia, and Prague (WP5). This agile evaluation framework enables direct feedback from local stakeholders and end-users, which will help refine and adapt the tools throughout their development and implementation. At the same time, the Living Labs benefit from early access to context-sensitive, innovative PED solutions, fostering stakeholder engagement and supporting local energy transition efforts.

Some tools - such as the Digital Twin for Urban Heritage Areas (Slovenia) or the Digital Tool developed in Pinkafeld (Austria) - are not being developed within a Living Lab context due to the project's structure and timelines. However, these two tools are considered MONUPED case studies and will be reflected upon with selected stakeholders. They may also be shared with the Living Lab stakeholders for feedback and validation. This ensures that even tools developed outside the Living Labs can be adapted to the broader needs and constraints of MPAs.

Aligned with the project's co-creation principles, the Living Labs are also encouraged to discuss, pilot, or test tools developed in other cities. This cross-site exchange enhances knowledge transfer and strengthens the replicability and applicability of the MonuPED Toolkit across different urban and heritage contexts.

These tools contribute to the development of tailored renovation strategies, investment concepts, and stakeholder engagement activities. WP4 thus acts both as a technology provider and a feedback loop partner for WP5, ensuring that the MonuPED Toolkit evolves in close alignment with the real-world needs and input from local actors.

Table 3: Overview of WP4 Tools and their development locations

Tool / Solution	Living Lab / Case Study	Country
Heating storage system (concept)	Living Lab Leipzig West	Germany
Roofs and facades study (concept)	Living Lab Prague 6	Czech Republic
Leipzig Energy Map (internal/external)	Living Lab Leipzig West	Germany
PV Potential Map	Living Lab Prague 6	Czech Republic
Digital Twin Slovenia	Case study Koper	Slovenia
Digital Tool Austria	Case study Pinkafeld	Austria
RoofMatch App	Living Lab Prague 6	Czech Republic
Thermal Precision Profiling	Living Lab Leipzig West	Germany
Energy & Solar Mapping Tool	Living Lab Alba Iulia	Romania



4.5 Possible formats in the context of Living Labs in PEDs (practical examples)

In the context of Living Labs in Positive Energy Districts (PEDs), various formats can be employed to explore challenges and opportunities effectively. Already several toolkits are available online that give a good overview on different engagement and co-creation formats. For the definition of the MonuPED Living Lab formats the following tool collections were considered:

- <https://www.citizen-engagement.eu/>
- <https://enoll.org/knowledge-hub/>

Each of the MonuPED Living Labs and case studies reflected possible formats based on the stakeholders to be involved (see individual chapters for each Living Lab). The following formats were discussed with the MonuPED partners and were declared as suitable formats for stakeholder engagement.

Discussions of Challenges and Opportunities for PEDs in MPAs

Living Labs serve as dynamic platforms to identify and address barriers and opportunities for Positive Energy Districts in monument protected areas through various participatory methods. Different formats can be employed to facilitate these discussions, including:

- **Focus workshops** represent one key method, enabling stakeholders to examine specific challenges through hands-on activities. For example, participants might test approaches for integrating renewable energy systems into historic buildings without compromising aesthetic value, or simulate negotiations between urban planners and heritage conservation bodies to overcome regulatory barriers.
- **Case studies** offer another valuable approach, providing tangible references for discussion. These might examine successful implementations, such as a renovated historic quarter achieving energy neutrality, or analyse less successful attempts to identify common pitfalls like inadequate infrastructure or unexpected regulatory hurdles.
- **Structured interviews** with key stakeholders serve as a third important method. By engaging heritage architects, local residents, and energy providers, we can uncover innovative approaches (like utilizing traditional building materials for thermal mass) while also identifying procedural bottlenecks in permitting processes.

These examples illustrate how Living Labs employ diverse methodologies to transform theoretical discussions into practical knowledge. The interactive nature of these formats - from hands-on workshops to in-depth case analysis - ensures challenges and opportunities are explored from multiple perspectives within the real-world context of the Living Lab environment.



Figure 10: Site visit to the Baumwollspinnerei as part of the SPARCS project (source: city of Leipzig)



Figure 11 Stakeholder discussion between city, grid operator and cenero Energy on Living Lab Baumwollspinnerei within SPARCS project (source: City of Leipzig)

Co-Creation of MonuPED Toolkit Solutions

The Living Lab methodology drives the development of the MonuPED Toolkit through iterative real-world engagement and refinement. The co-creation process unfolds across three key phases, each employing specific methods to ensure the toolkit meets practical and technical demands:

Design Phase

- Co-Creation Workshops: Stakeholders, including property developers and municipal planners, collaborate in interactive sessions. Techniques like role-playing scenarios are used to evaluate financial models for heritage-compliant retrofits, ensuring the tools align with real-world decision-making processes.
- Development of User Stories: These narratives capture diverse stakeholder perspectives, guiding the toolkit's functionality and usability from the outset.

Prototype Testing



- Testing Workshops with End Users: Local stakeholders, such as SMEs, trial toolkit components at demonstration sites. This hands-on approach validates the tools' applicability, particularly in the context of protected heritage buildings.

Feedback on Implementation

- Surveys: Structured feedback is collected to assess user satisfaction and identify areas for improvement.
- User Group Meetings: Regular discussions with practitioners provide qualitative insights, ensuring the toolkit remains responsive to evolving needs.

This iterative process, supported by direct observations and continuous input, refines the toolkit's design—whether through clarifying technical terms, enhancing visual aids, or optimizing workflows. The result is a field-validated solution that balances precision with practicality, empowering users to implement PEDs in heritage-sensitive environments effectively.

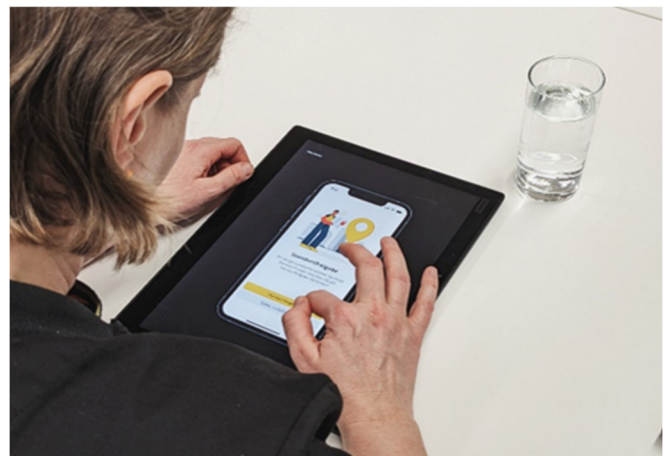


Figure 12: Usability test for the Leipzig App (source: Lukas Schroll)



Figure 13: Inter-department workshops for Leipzig Energy Map (source: City of Leipzig)



Communicating Results

In Living Labs, the effective communication of project outcomes is essential to engage stakeholders, demonstrate the feasibility of digital solutions, and foster knowledge transfer—especially in the sensitive context of monument-protected areas and buildings. To ensure broad and targeted dissemination, results should be shared through practical, interactive, and audience-specific formats. Key approaches include:

- Best-practice collections & Digital Knowledge Sharing
 - Curated collections of successful implementations, lessons learned (e.g., publications/interactive PDFs, web-based repositories)
 - Visual Storytelling: Short videos, 3D models to illustrate how digital solutions integrate with historic structures without compromising their integrity
- On-site visits (e.g., Guided Tours & Open House Events: Organized during key occasions like National Monuments Day)
- WP6 materials (e.g., MonuPED website, partner websites)



Figure 14: Overview digital participation platform DIPAS with story telling on energy sources for SPARCS demo district (source: City of Leipzig)



Figure 15: On-site presentation of activities in the SPARCS project on the project website



4.6 Evaluation Approach

The MonuPED Living Lab evaluation will employ a **mixed-methods approach**, combining **process and outcome evaluation** to ensure a comprehensive understanding of both implementation dynamics and achieved impacts. This dual focus allows to assess not only *what* results were generated but also *how* and *why* they emerged—providing valuable insights for both current and future initiatives.

Why Process and Outcome Evaluation?

Process Evaluation

- Examines the feasibility and adaptability of digital solutions within heritage constraints (e.g., structural limitations, preservation requirements).
- Identifies stakeholder collaboration dynamics—how architects, conservation experts, energy planners, and residents engage with the solutions.
- Tracks regulatory and technical barriers (e.g., compliance with heritage protection laws, integration with historic infrastructure).

Rationale: Without understanding how interventions were delivered, outcome results may be misinterpreted—e.g., low impact could stem from implementation barriers rather than flawed solutions.

Outcome Evaluation

- Measures **short- and medium-term effects** (e.g., reduced consumption, renewable energy integration).
- Assesses **user acceptance** among residents, businesses, and authorities—critical for long-term adoption.
- Evaluates **broader impacts**, such as improved building functionality or increased public awareness of sustainable heritage preservation.

Rationale: Success in PEDs depends not just on technical performance but also on social and cultural fit—especially in monument protected areas.

Data Collection Methods

To capture both technical and human dimensions, we will use:

Quantitative data:

- Standardized surveys at three key stages:
 - Baseline (pre-implementation)
 - Mid-term (during implementation)
 - Post-implementation

Qualitative data:

- Focus workshops with Living Lab Managers
- Open-response questionnaires gathering in-depth perspectives

Flexibility and Next Steps

This outline provides an initial framework, while the detailed evaluation concept is currently being developed (until M12) and will be fully elaborated in Deliverable 5.2 (Living Lab Evaluation Report) – including refined KPIs, case comparisons, and scaling lessons.



5 LIVING LAB LEIPZIG WEST

5.1 Living Lab Leipzig West - Introduction

In the context of Leipzig West, the Living Lab serves as a practical testbed for sustainable urban redevelopment, particularly focusing on energy efficiency, decarbonization of heating systems, energy sharing, and integration of digital monitoring tools. By engaging directly with building owners and tenants of Baumwollspinnerei, local service providers, and municipal stakeholders, the lab enables co-creation: solutions are not only tested for the community, but with the community.

Leipzig West is a unique district where industrial heritage meets dynamic urban transformation. Once a hub of manufacturing—and the pollution that often accompanied it—the area experienced economic decline following the reunification of East and West Germany, as many industrial businesses closed or relocated. For years, numerous buildings stood vacant and deteriorating.

Today, the district is undergoing rapid change. Its growing popularity has sparked the revitalization of many former industrial buildings, many of which are now under monument protection situated in architecturally significant yet energy-inefficient structures. This creates a valuable opportunity: to explore how sustainability measures can be effectively integrated into heritage-protected sites—directly on location, and in collaboration with local actors.

The following are key objectives of the Leipzig West Living Lab:

- To explore the feasibility of energy sharing communities, thereby increasing access to sustainable heating sources for local residents and increasing the efficiency of the use of resources.
- To design, test, and validate a digital tool that provides the baseline for data-driven retrofitting recommendations for property owners, ensuring alignment with both monument protection regulations and energy efficiency goals.
- To establish effective collaboration among all stakeholders, creating a solid foundation for innovation and sustainable transformation, without compromising the district's cultural and architectural heritage.

The Living Lab aims to pave the way for future projects in the area by setting an example of best practices, highlighting challenges and corresponding solutions, and fostering collaboration across a wide range of stakeholders.

One of the greatest challenges in the context of developing PED in monument protected areas or buildings is the lack of clear guidelines and regulations. Monument-protected projects in Germany are handled on a case-by-case basis with minimal guidance. Identifying the appropriate contact person and establishing efficient communication methods is often difficult, leading to project delays and increased costs. Furthermore, application processes are lengthily and complicated.

Additionally, tenant or community communication and collaboration can be challenging. The Living Lab is primarily a commercially used property, and business owners are not always present on-site. Employees, in turn, may not be as invested in participating in the project. Communication and engagement must be handled sensibly.



Description of the Living Lab buildings and areas

Built in 1884 as the largest cotton mill in Europe, the Leipziger Baumwollspinnerei has evolved into a vibrant hub for art, culture, and community. Covering 100,000 m² of floor space and comprising 20 individual buildings, the site now hosts:

- Over 100 art studios
- 14 galleries
- Workshops, a theatre, a dance center, cinemas, print shops, and non-profit institutions

The historic brick buildings and halls retain their distinctive architectural character—once used for cotton storage, processing, and training—now repurposed for modern, mixed use.

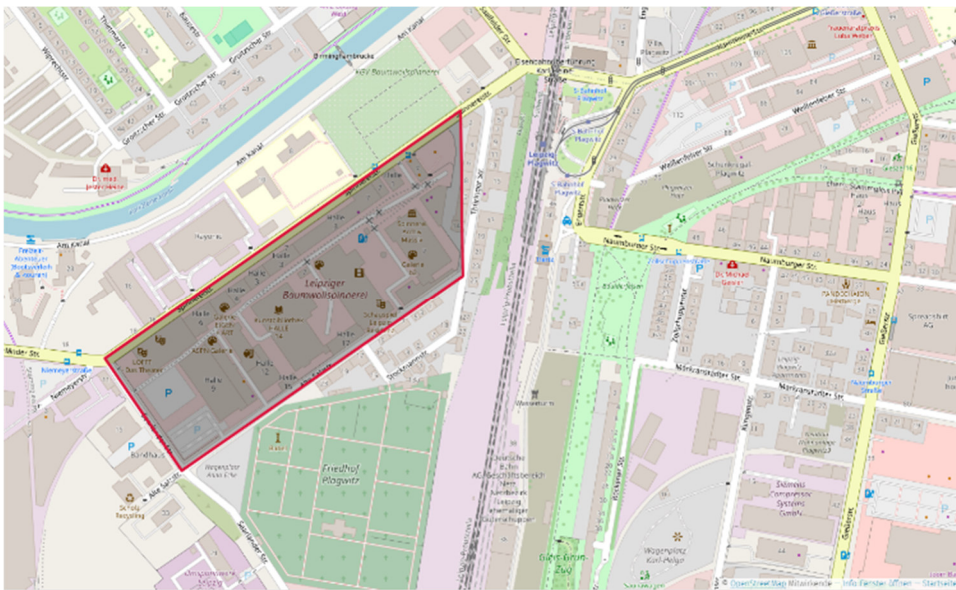


Figure 16 Location of Baumwollspinnerei Leipzig - Living Lab Leipzig West, © OpenStreetMap, created with uMap



Figure 17: Areal picture of the Leipziger Baumwollspinnerei, © Knut Maurive, Cenero Energy GmbH

Within the SPARCS project, already several PED solutions were developed and implemented on site. The Leipziger Baumwollspinnerei was equipped with an extensive network of LoRaWAN meters,



sensors, and remote technologies. These enabled detailed monitoring of energy consumption and generation on-site, allowing for optimisation, loss reduction, and increased user awareness around energy efficiency. The energy management platform *cenero.one* was enhanced throughout the project.

A 70 kWp photovoltaic system was installed on Hall 10, along with a 50 kW lithium-ion battery for local energy storage. Load management was introduced to coordinate on-site generation with flexible consumers, such as electric vehicles, and with storage systems, thereby forming a microgrid. Bidirectional charging was also tested with load management



Figure 19: 70 kWp photovoltaic plant installed on Hall 10 of the Leipziger Baumwollspinnerei, © Knut Maurive, Cenero Energy GmbH)



Figure 18: CHP and Boilers of the current heating network of the Baumwollspinnerei, © Cenero Energy GmbH

In addition, an intelligent heat demand control concept was developed and implemented. A valve was installed in the heating circuit, and smart radiator thermostats were used to detect heating demand. If no demand was registered, a signal was sent by *cenero.one* to close the valve—effectively avoiding unnecessary heating and reducing energy waste



Connections to existing local strategies/networks/projects Strategies

- Energy and Climate Protection Program Leipzig (EKSP): **The Energy and Climate Protection Programme 2030** describes the guidelines for the coming years towards climate neutrality. It formulates climate protection policy objectives and specifies the concrete implementation steps for achieving these objectives in the form of a detailed catalogue of measures. Amongst others,
 - Sustainable energy and heat supply
 - Climate-friendly urban district development

are two of ten success factors where the MonuPED Living Lab will deliver sustainable solutions.

EU-Mission Climate and Smart Cities/ Climate City Contract

- The **municipal heating plan** is a key instrument for shaping a climate-neutral heating supply by 2038, preferably by 2035, within sustainable integrated urban development and is also a key component of the City of Leipzig's Energy and Climate Protection Programme 2030. The heating plan in Leipzig is being developed by the city administration, in particular in cooperation with Leipzig municipal utilities and Leipziger Wohnungs- und Baugesellschaft.
- **The Digital Agenda** is a basic document for shaping the digital transformation of the City of Leipzig. It applies to the city administration, the municipal enterprises and the municipal associated companies. The agenda describes guiding principles, responsibilities, procedures for decision-making processes and concrete steps for realising the goals. Developing urban data platform and digital twins in co-creative processes to speed up planning processes towards climate neutrality is a key element of this strategy. MonuPED will enhance Leipzig's Digital Energy Twin. The Living Lab in Leipzig will create the possibility to involve a broad group of stakeholders in the development process.

Projects

- Pilot projects as the Horizon 2020 project **SPARCS** (2019-2024) on the development of Positive Energy Districts (PEDs) gave valuable insights in the prerequisites and feasibility of the PED concept in social housing and monument protected areas. Learnings from the project and esp. replicating developed solutions help to speed up the transition of the building stock. (www.sparcs.info, www.sparcs-leipzig.info)
- The **Enercircle Project** is a communal heat storage system that enables sustainable, centrally managed heating and cooling solutions by connecting decentralized geothermal probes across urban districts. By allowing the community to share the use of these probes, it reduces drilling costs, increases resource efficiency and availability, and supports the decarbonization of the heat supply by 2045. As part of the MonuPED project, a feasibility study will be conducted with a primary focus on evaluating the relevant legal and regulatory frameworks. In addition, the study will explore the potential for implementing geothermal drilling in public spaces, such as streets, as a way to further expand and enhance the concept.
- The former "**Auf AEG**" site in Nuremberg (160,000 m²) has transformed from an industrial heritage site into a hub for innovation and energy research. In addition to geothermal systems, photovoltaic installations, and e-mobility infrastructure, an extensive LoRaWAN network with digital meters and sensors has been implemented across the site. To reduce heating demand, one office building was equipped with a wide range of sensors, including window contact sensors, people counters, CO₂ sensors, and temperature sensors. The visualization in Figure 24 shows the so-called "showroom" of the project—a conference



room that served as the reference for the remaining office areas. This initiative is closely aligned with the thermal precision profiling tool of the MonuPED project.



Figure 20: A cenero.one visualisation of the sensors in the showroom at Auf AEG Nürnberg, © Cenero.one GmbH

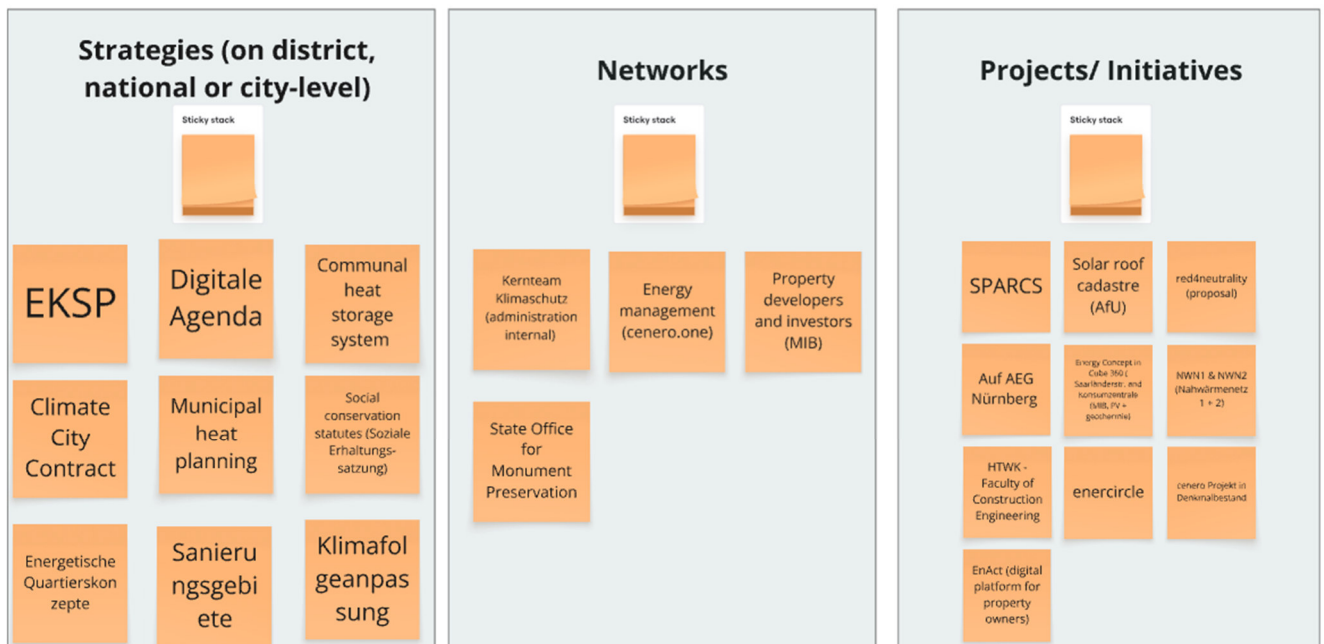


Figure 21: Results of the initial brainstorming session: existing strategies, networks and projects in Leipzig related to MonuPED, © Miro board screenshot



5.2 Stakeholders of Living Lab Leipzig West

TARGET GROUPS

- **Tenants of Baumwollspinnerei:** The tenants of the Baumwollspinnerei are mostly commercial — including art studios, galleries, and workshop spaces — and are participating in the MonuPED project by making their premises available for a study on reducing flow temperatures in the heating system while maintaining comfortable indoor conditions. The involvement of each tenant within the selected heating circuit is crucial, and tenant engagement must be handled with care. Over-engagement may lead to frustration and discourage participation, while under-engagement can cause uncertainty or confusion. Communication should come from a trusted source (e.g. the landlord or property management) and be concise and transparent. Tenant participation not only enables the exploration of energy-saving measures but also offers them the opportunity to reduce their energy consumption and costs. Spinlab is an example of a tenant at the Baumwollspinnerei who is particularly interested in sustainable measures and the results and findings of the project. Spinlab is a start-up accelerator, who occupies a large area on the second floor of Hall 14.
- **Property owners:** The Leipziger Baumwollspinnerei Verwaltungsgesellschaft mbH, a subsidiary of MIB AG, is the property owner responsible for managing, maintaining, and restoring the historic Baumwollspinnerei site. They oversee the rental of spaces and play an active role in the MonuPED Living Lab by facilitating access to buildings, providing site documentation and plans, and coordinating with tenants on project-related matters. Through their involvement, they support the exploration of energy efficiency measures that could increase property value and reduce operating costs. They will be responsible, together with Cenero, for coordinating the presentation of the tool's recommendations to decision-makers and investors for potential implementation.
- **Other municipalities:** Other municipalities may be interested in the thermal precision tool and its findings from the project. With the real-time digital results, municipalities can identify similar buildings suitable for connection to future low-temperature district heating networks. Moreover, the results can support the development of appropriate monument protection regulations and the development of subsidy structures for minimally invasive renovations. The findings from the feasibility study on the shared heat storage concept may be particularly relevant for municipalities aiming to develop sustainable heating strategies. This concept could provide a transferable solution to other cities, especially those facing limitations due to space constraints or monument protection regulations. On the other hand, we could also learn from projects, policies and challenges in other municipalities.

PARTNERS

- **Municipality** Energy transition, urban planning and monument protection are topics addressed by various departments across the municipality. Fostering exchange and cooperation between the different departments is essential to develop sustainable framework conditions for PEDs in MPAs/MPBs. In the MonuPED Living Lab regular workshops and meetings with city offices (amongst them: Office for Monument Protection, Office for Culture and Arts, Office for Residential Construction and Urban Renewal, Office for City Planning, Sustainable Development and Climate Protection Office) will be held and feedback on the MonuPED toolkit solutions will be collected.



- **Project developer MIB**

The MIB AG is the holding company responsible for the overall management of the Baumwollspinnerei site. It plays a central role by making key strategic decisions and providing the necessary financial resources for the site's development and maintenance. In the context of the MonuPED Living Lab, MIB AG supports the project by enabling the implementation of innovative energy measures, contributing to the long-term sustainability and economic efficiency of the site.

- **Energy management company Cenero.one GmbH**

The company offers a software solution for the digitalization, reporting, and billing of complex commercial properties, helping to increase efficiency and reduce energy consumption. In the MonuPED project, their expertise in IoT, monitoring and analysis supports the setup of a comprehensive digital network of meters and sensors, the creation of dashboards and visualizations, the implementation of validation and plausibility checks, and the evaluation of data.

SUPPORTERS/MULTIPLIERS

- **Foundations and NGOs:** In Germany, multiple foundations and NGOs are addressing issues related to monument protected buildings and areas on federal, state but also on local level. Amongst them are Denkmalnetz Sachsen (Monument network Saxony), Leipziger Denkmalstiftung (Leipzig Monument Foundation) and the Meyersche Häuser Foundation. Including their deep-rooted networks in monument protection and local governance, plus the trust of property owners, regulatory authorities and community stakeholders can be a valuable contribution to the MonuPED activities. Discussing the MonuPED Toolkit but also framework conditions can ensure, that developed measures are not only technically and legally sound, but also broadly accepted and sustainably implemented. Additionally foundations and NGOs have a wide membership network to promote MonuPED toolkit to house owners, property developers and other municipalities.
- **SAENA (Saxon Energy Agency):** SAENA is the independent advisory, information and competence center of the Free State of Saxony, dedicated to renewable energies, future-proof energy supply, energy efficiency and sustainable mobility. Their mission is to empower businesses, municipalities and citizens to actively shape the transition to an environmentally friendly energy system. Drawing on deep technical expertise, hands-on experience and a spirit of innovation, SAENA helps Saxony move toward a cleaner, more efficient and resilient energy future. Within MonuPED SAENA will act a supporting partner for providing data for the Leipzig Energy Map (WP4), contribute with their knowledge on state regulations on energy efficiency and help to disseminate Leipzig Energy Map to relevant target groups.
- **State and Federal ministries:** Implementing PED solutions in MPAs/MPBs are often influenced by national and state regulatory framework conditions but also funding opportunities for property owners and developers. The results and recommendations of the project are therefore communicated to the responsible ministries at federal and state level at irregular intervals. Possible contacts/multipliers are the Federal Ministry for Housing, Urban Development and Construction or the Saxon Ministry for Economy, Labour, Energy and Climate Protection.

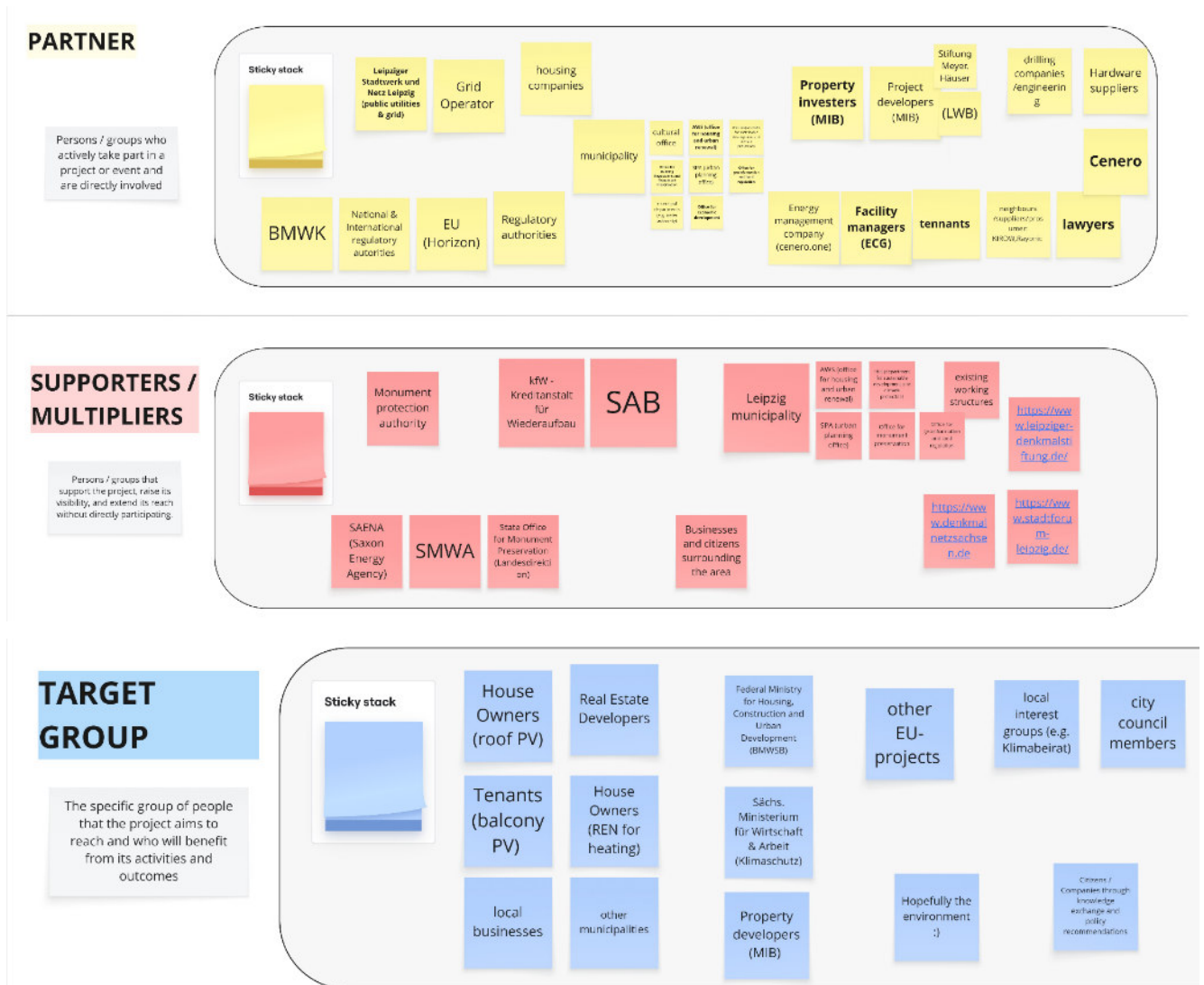


Figure 22: Results of the initial brainstorming session: partners, supporters and target groups in Living Lab Leipzig, © Miro board screenshot

5.3 Connection Living Lab Leipzig to other MonuPED WPs

Although the project is still in its early stages, initial synergies can already be identified between the thermal precision profiling tool (D4.9) developed in the Leipzig West living lab and the digital twin-like tool in Pinkafeld (D4.8), which is being applied to a specific use case building. Both tools from WP4 focus on improving building performance by collecting, analysing, and simulating detailed energy consumption data. They aim to provide targeted recommendations for building owners, particularly in relation to retrofitting and efficient energy use. By comparing methodologies, data interpretation strategies, and user engagement approaches, both sites can benefit from mutual learning and shared experiences.

In the medium term, simulation results from one tool may complement or validate findings from the other, especially where building types or usage patterns are similar. This cross-site collaboration can contribute to more robust and transferable outcomes across the MonuPED project. Furthermore, ongoing exchange between the teams can support the strategic development of both tools beyond the



project's timeline—facilitating the exploration of predictive capabilities, automation features, and broader integration into municipal energy planning frameworks.

5.4 Roadmap and formats of Living Lab Leipzig West

The Living Lab Leipzig West applies a multifaceted engagement approach that includes both formal and informal interaction formats with a wide range of stakeholders. Internal focus groups involving the project team from CENERO and cenero.one serve as collaborative platforms for technical planning, operational strategy, and the ongoing alignment of budgeting, goals, and scheduling. These sessions foster agile responses to emerging challenges and provide a structured environment for adaptation and coordination.

Regular meetings with property owners and developers, including Leipziger Baumwollspinnerei Verwaltungsgesellschaft mbH and MIB AG, offer opportunities to share project updates, discuss property-specific requirements, and align on long-term development strategies. Topics include site plans, property access, and communication with tenants—key elements for ensuring smooth project implementation.

To assess technical feasibility and compatibility with existing infrastructure, several site visits and consultations have been conducted with facility managers from E-C-G Facility Management GmbH. These visits support the refinement of implementation concepts and help clarify requirements. Close collaboration with the facility management team is essential, particularly as they will be assigned to lower the flow temperature during stress tests for the thermal precision profiling tool. They may also play a role in aspects of hardware implementation.

Tenant communication will be handled through detailed information letters. Drafted by Cenero and distributed by the Leipziger Baumwollspinnerei Verwaltungsgesellschaft mbH, in order to ensure trust and familiarity. The communication will explain the project's scope, the planned measures in tenanted spaces, the potential benefits for tenants, and will offer an opportunity to object to participation by a specified date. Based on experience, passive opt-out mechanisms result in higher participation rates than requiring active consent.

One-on-one consultations with industry leaders and legal experts have taken place to explore the legal and technical frameworks surrounding a shared heating network. These exchanges generate new impulses, strengthen the project's conceptual basis, and enable deep-dive discussions on regulatory, commercial, and technical matters.

In the first year of the project, the team plans to initiate meetings with the Department for the Preservation of Historic Monuments to better understand relevant regulations, constraints, and opportunities. These meetings also serve to establish trust and build long-term relationships. Toward the final quarter of the year, a cross-departmental workshop is planned involving various municipal bodies, including the Department of Mobility and Civil Engineering and the Department for the Digital City. The aim is to explore the use of public spaces—such as roads—for geothermal drilling and to align interests and expectations across public and private stakeholders.

Public and stakeholder engagement is further supported through a variety of outreach formats, including open site visits for municipal representatives, engagement events for tenants, local businesses, and residents, and digital communication via LinkedIn posts and newsletters. Together,



these formats ensure that the Living Lab is not only technically sound but also socially embedded and broadly supported within the community.

In 2025, the focus will be on establishing contact and holding initial workshops with the identified stakeholders. The focus will also be on the local and general challenges for the development of PEDs.

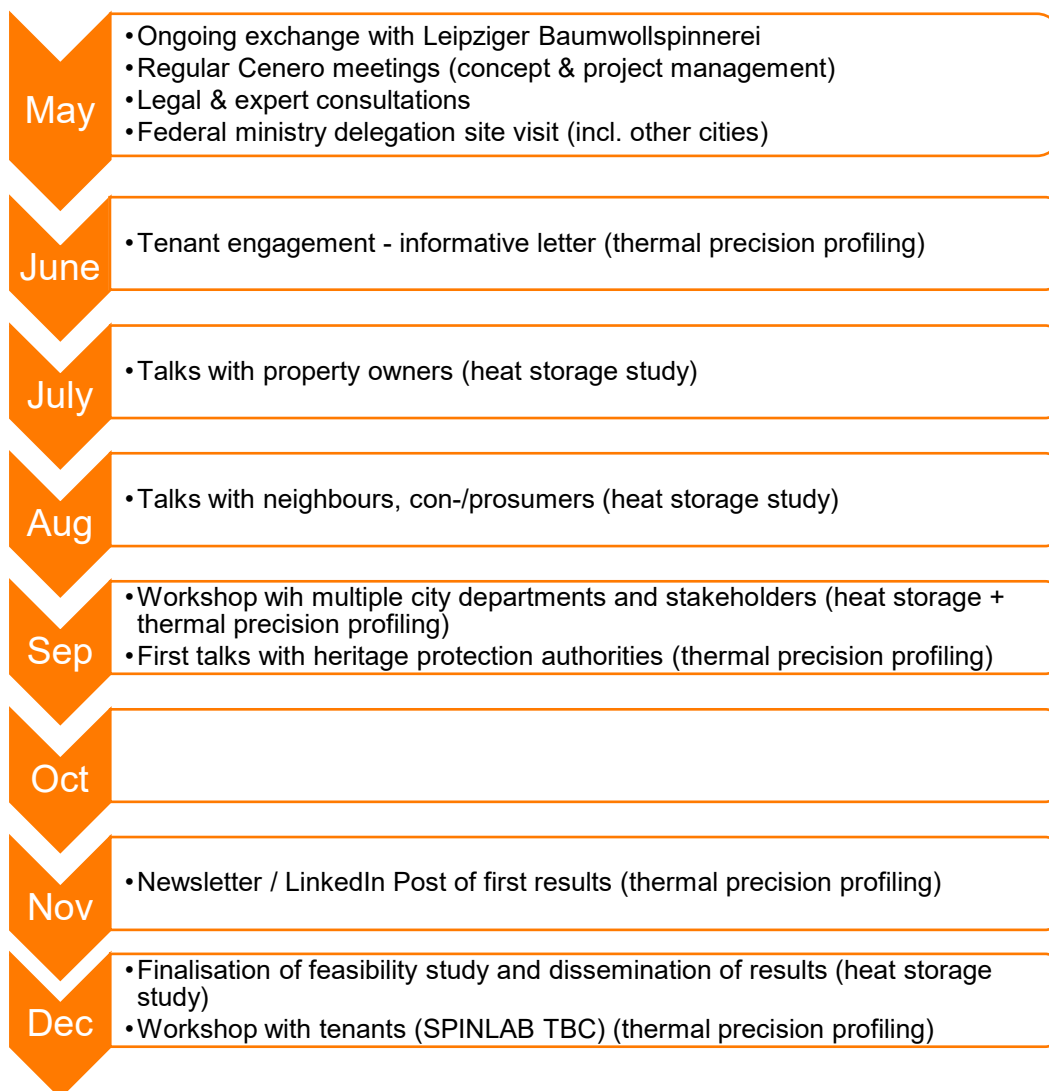


Figure 23: Road Map Living Lab Leipzig 2025



Table 4: Possible engagement formats MonuPED Living Lab Leipzig:

WORKSHOP WITH CITY DEPARTMENTS	
Involved stakeholders/ stakeholder groups	Target Group: • Energy Service Provider and Supplier (Implementers of the concept) • Property Owners (Leipziger Baumwollspinnerei) as the intended (main) users • Department of Mobility and Civil Engineering • Department for the Digital City • Surveying and Geoinformation Office • Water Authority • Building and Planning Authority
Estimated no. of participants/ duration of the event/ format	10 - 16 120 Mins
Frequency**/when should take place for the first time?	Once During the development and concept creation phase (feasibility)
Related to which MonuPED phase*/topic/ WP activities?	WP 4: MonuPED Toolkit (Heat Storage System Leipzig)
How will involvement support your MonuPED activities?	1. Present details of the concept idea 2. Gain insights on the goals and challenges of each department and create an understanding for each other's goals. 3. Align interests and identify possibilities 4. Identify and discuss possible use cases and the alignment with city, national and international climate goals
What organizational requirements are necessary? Special budget?	1. Meeting date, location and time need to be agreed upon. 2. Strategic selection of required participants to ensure maximum productivity in sessions. 3. Flip charts, stationery, sticky notes, digital screen for presentation. 4. An agenda needs to be prepared. 5. Workshop activities should be clearly structured in advance. One suggested format includes dividing participants into two groups: one representing municipal departments and the other representing private sector stakeholders. Each group will take part in two 15-minute sessions, followed by a 30-minute joint discussion and comparison. In the first session, each group is asked to reflect on the perspective of the <i>other side</i> by identifying what they believe to be the goals and challenges of their counterpart. In the second session, participants will then articulate their <i>own</i> goals and challenges. This format encourages empathy, mutual understanding, and lays the groundwork for a more constructive and solution-oriented dialogue. 6. Someone should be assigned to take minutes / notes during the discussions.
Location of the event (physical set-up) or technical requirements to carry out the event	A workshop venue with the option to divide participants into two separate rooms for workshop activities. Workshop materials such as flip charts, sticky notes, and stationery. Alternatively, digital collaboration tools like Miro boards (not as



	practical in physical meeting as may waste time and limit to one member to add the input. A suitable technical setup for presentations (e.g., screen, projector, good room audio) and a stable internet connection are also essential.
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STAKEHOLDER ROUNDTABLE	
Involved stakeholders/ stakeholder groups	Target Groups: • Energy Service Provider and Supplier (Implementers of the concept) • Property Owners • Property managers
Estimated no. of participants/ duration of the event/ format	4-6 45 - 60 Mins
Frequency**/when should take place for the first time?	Three times Before implementing the tool, during the development and concept creation phase
Related to which MonuPED phase*/topic/ WP activities?	WP 4: MonuPED Toolkit (Thermal Precision Profiling)
How will involvement support your MonuPED activities?	• Gain insights on tenant structure, usability, and best tenant communication practices • Gain insights on building, technical spaces, accessibility, renovation status and future plans • Discuss strategies for communicating with heritage protection authorities
What organizational requirements are necessary? Special budget?	• Meeting date and time need to be agreed upon. • Strategic selection of required participants to ensure maximum productivity in sessions. • Digital or face-to-face meeting. Due to key participants being out of the country, digital format selected. • Someone should be assigned to take minutes / notes
Location of the event (physical set-up) or technical requirements to carry out the event	Event held digitally to accommodate all participants Stable internet connection, good headsets or sound technology. Quiet private rooms.



6 LIVING LAB PRAGUE 6

6.1 Living Lab Prague 6 - Introduction

Prague 6 serves as a Living Lab, offering a rich and complex urban environment where monument protection, diverse ownership structures, and energy transition goals intersect. The district is home to a high concentration of heritage-listed residential buildings, institutional properties, and public facilities, many of which face technical and regulatory barriers to energy retrofitting. This makes Prague 6 an ideal testbed for developing and validating governance tools, co-investment models, and retrofit strategies specifically tailored for Positive Energy Districts (PEDs) in culturally sensitive areas.

The goal of the Living Lab is a close collaboration with municipal authorities, planners, and residents, enabling real-time feedback, co-creation of solutions, and participatory testing. Piloting integrated energy and heritage approaches in Prague 6 not only addresses local challenges but also generates replicable knowledge for other cities, balancing decarbonization with cultural preservation.

The objectives of the Living Lab Prague 6 are to effectively develop, test, and get relevant feedback on the tools and approaches created in the MonuPED project. The main tools for this Living Lab are the Solar Potential Map, Concept: Roofs and Facades Study, Roof Match App, and a process-oriented output guiding the citizens through the design and approval process of technologies enabling the creation of PEDs.

Solar Potential Map is intended to be a GIS dataset usable in various applications. Within the Living Lab, it is developed specifically for Prague 6 but will be ready for scaling for the whole City of Prague. The Living Lab will provide feedback from stakeholders on its form, structure, and level of detail in order to guarantee the applicability in online tools such as the Prague 3D model, as well as in strategic decision-making on the municipal level.

The Concept: Roofs and Facades study leverages the position of the CTU university campus within Prague 6. This allows for testing the proposed workflow on-site, confirming the results of computer simulations on the visibility from the near and far viewpoints, and discussing the results with the local monument protection authorities.

The Roof Match App also leverages the diversity of the Prague 6 built environment and different levels of monument protection within the area. As the Solar Potential Map is also developed for the Prague 6 area, it provides an upgrade opportunity in terms of precise generation estimates. All stakeholder groups for the tool development are represented within the Living Lab (building owners, potential investors, and authorities).

The guidelines for the citizens are built on the real-life experience of the local stakeholders. The past experiences with the approval process will be examined. Based on the research of available technologies in WP2, a new approach will be proposed and tested on the Living Lab buildings.

However, the complexity of Prague 6 also presents potential challenges, particularly in aligning the diverse interests of stakeholders who may be reluctant to compromise or pursue joint solutions. In this context, the project aims to foster mutual understanding and trust by offering transparent, data-driven tools that support decision-making. The goal is to enable constructive dialogue and promote the mainstreaming of Positive Energy Districts without bias, while respecting both heritage values and energy ambitions.

Description of the Living Lab buildings and area

Figure 24 shows the location of the two selected Living Lab Buildings within the Prague 6 area. First building is a listed complex of the Břevnov Monastery. The complex is outside of the UNESCO



monument reservation and is not part of any listed Monument Protected Area. It is, however, a part of the buffer zone, and it is itself listed as a National Monument. More information about the 21 protected components can be found under [Břevnovský klášter - Památkový Katalog](#). The second building is the Archbishopal Seminary. This building itself is not a monument, but it is a part of the Dejvice, Bubeneč, upper Holešovice Monument Protected Area.

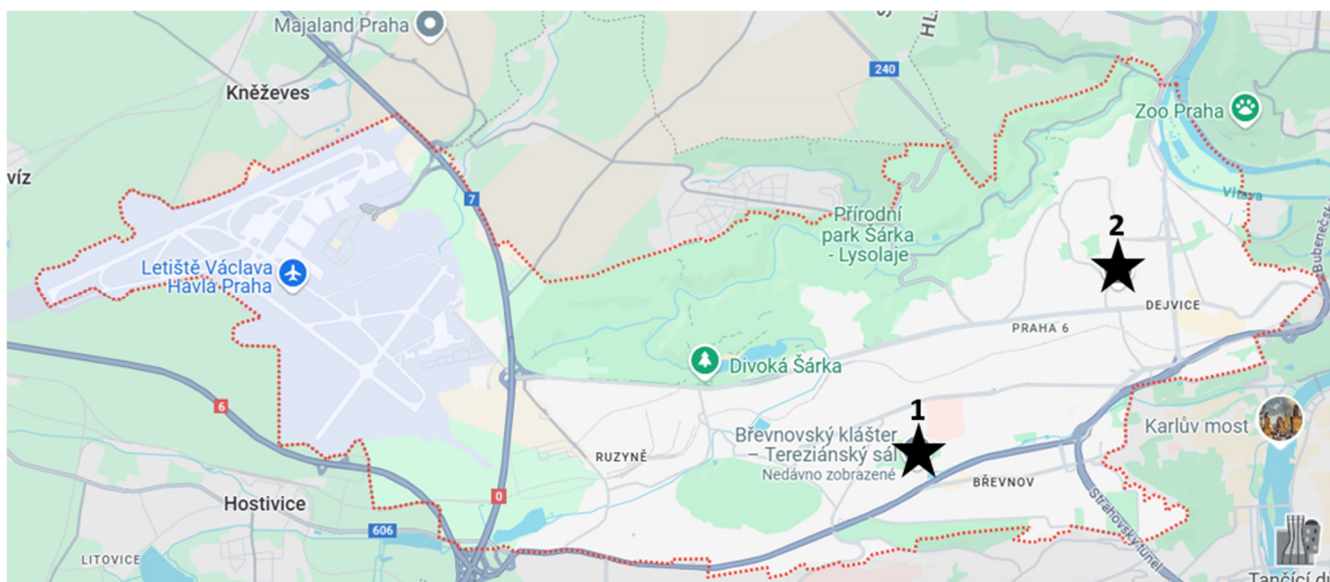


Figure 24: Map showing the 2 buildings within the Prague 6 area. 1 - Břevnov Monastery, 2 - Archbishopal Seminary © Google Maps

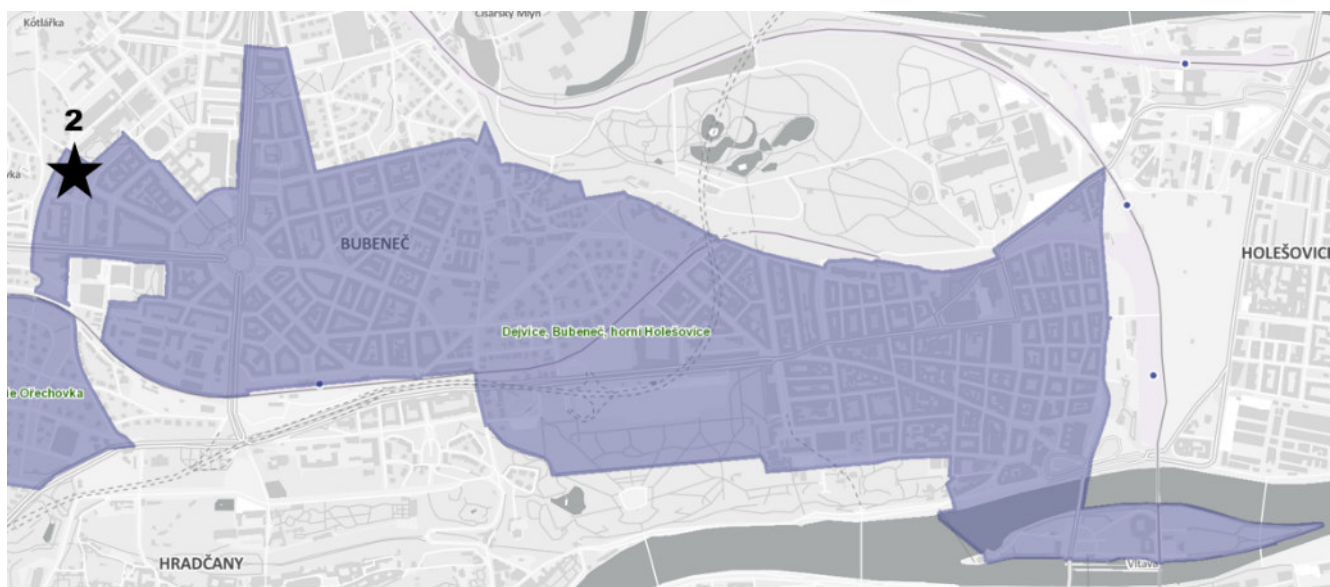


Figure 25: Map of the Dejvice, Bubeneč, upper Holešovice Monument protected area and the position of the Archbishopal Seminary (2) © Institut Plánování a Rozvoje, Praha

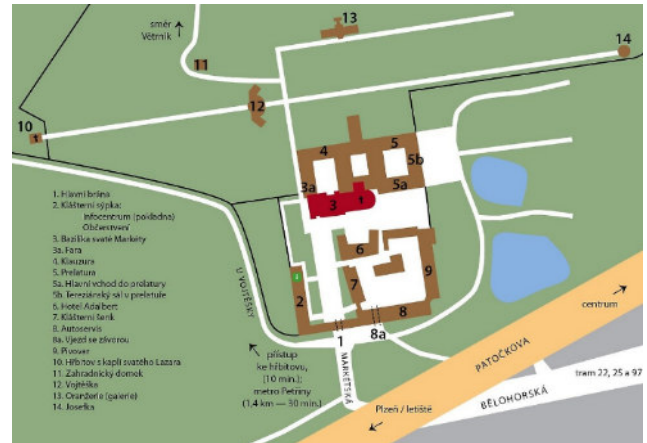


Figure 26: Břevnov Monastery, © Břevnov klášter celek.jpg - Wikimedia Commons) and map of the complex (Fotogalerie)

Břevnov Monastery. Founded in 993 AD, it is the oldest male Benedictine monastery in Bohemia and has evolved into a historically layered ensemble comprising the Baroque basilica of St. Margaret, monastic buildings, gardens, courtyards, and a functioning brewery. The entire site is protected as a national cultural monument, making any intervention subject to strict conservation regulations.

Today, the complex serves multiple purposes - religious, cultural, residential, and commercial – illustrating the challenges faced when aiming to implement Positive Energy District strategies in monument-protected environments. With varied ownership and usage patterns, uneven energy performance across the buildings, and a need to preserve visual and structural integrity, it faces significant drawbacks in the approval processes for any further refurbishment.

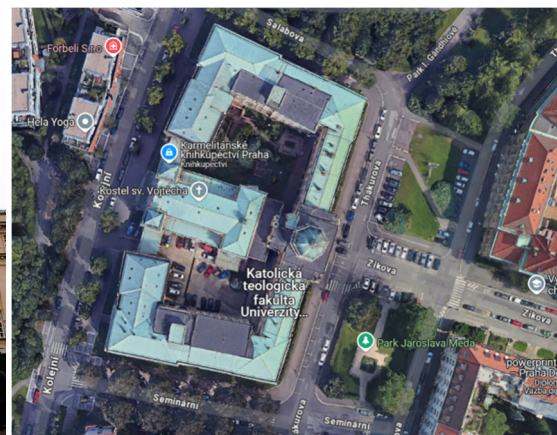


Figure 27: Archiepiscopal Seminary, © Praha Arcibiskupský seminář.JPG – Wikipedie and satellite view (Google)

Archiepiscopal Seminary. Located in Prague 6 and forming part of a historically valuable district, the seminary building itself is not individually heritage-listed but lies within a designated monument protection area. As such, any planned interventions must still comply with broader conservation guidelines that aim to preserve the architectural character and historical coherence of the urban landscape.

The massive, solitary building in the neoclassical style (built between 1925 and 1927) has its wings enclosing a large courtyard, in the center of which the Church of St. Adalbert was built at the same time. The complex includes 1) the building of the Archbishop's Seminary - Catholic Theological Faculty No. 676, 2) the Church of St. Adalbert, plot No. 685, 3) the grounds of the building with English courtyards



and fencing, with plots No. 686/1, 686/2 and 686/3, 4) the seminary courtyards and gardens with plots No. 687 and 688, and a set of 6 items from the furnishings and decorations of the building of the Archbishop's Seminary in Dejvice from the interwar period.

Connections to existing local strategies/networks/projects

Strategies, networks and projects concerning the Prague 6 Living Lab have been identified within the Living Lab workshop and are shown on Figure 29.

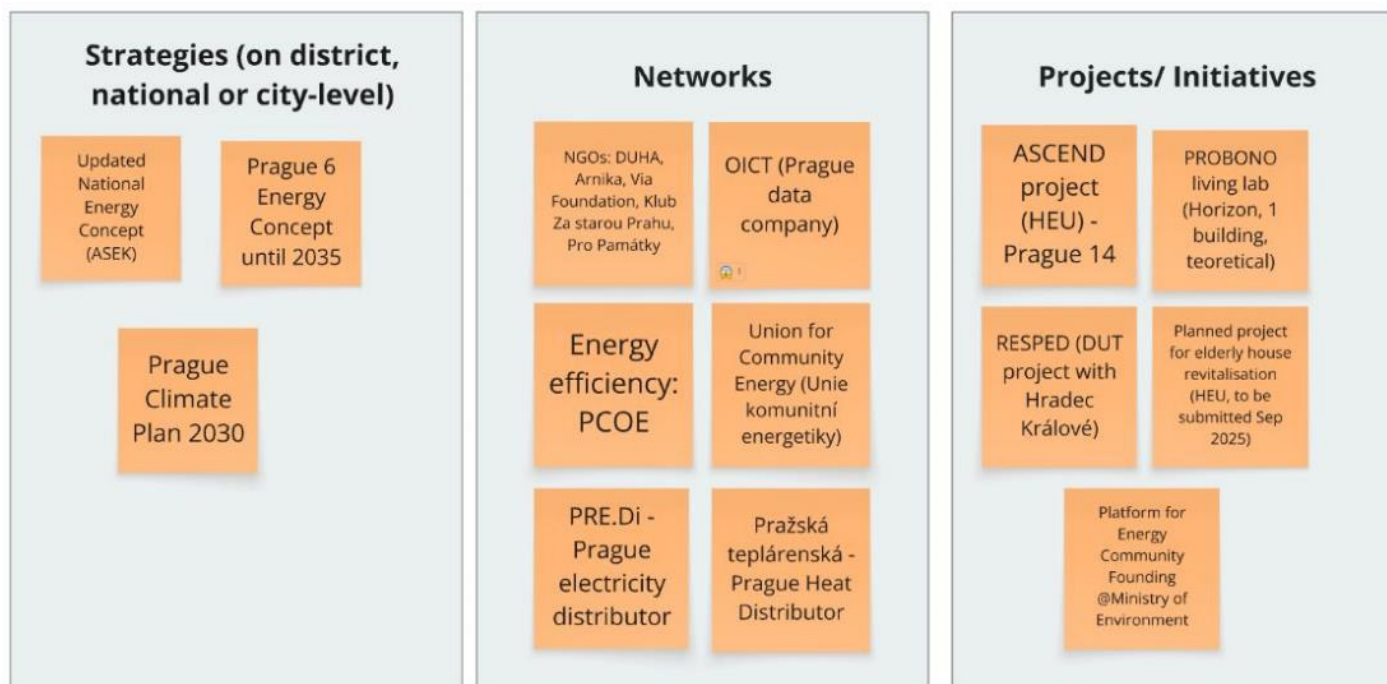


Figure 28: Results of the initial brainstorming session: existing strategies, networks and projects in Prague related to MonuPED, © Miro board screenshot

On the national level, the **National Energy Concept** was updated in 2024. The recent update of the Czech Republic's State Energy Policy (SEK) provides a timely and supportive policy context for the MonuPED project and its activities in the Prague 6 Living Lab. With a national goal of **reducing greenhouse gas emissions by 63% by 2030** and achieving near climate neutrality by 2050, the SEK reinforces the urgency of developing scalable Positive Energy Districts. For Prague 6, a district combining heritage-sensitive areas with complex stakeholder dynamics, this alignment enables MonuPED to act as a practical demonstration of how national energy targets can be pursued at the local level through tailored governance models, co-investment strategies, and retrofitting approaches that respect both cultural values and technical constraints. The SEK's commitment to a stable investment framework and socially acceptable decarbonization further supports local experimentation and long-term implementation.

Closely linked to the SEK is the **Climate Plan of the City of Prague**, specifying the climate goals for Prague itself. The Climate Plan of the City of Prague (2021) provides a highly relevant strategic framework for the MonuPED project and its Living Lab activities in Prague 6. With its target of **reducing CO₂ emissions by 45% by 2030** and achieving carbon neutrality by 2050, the plan outlines extensive measures in sustainable energy, building renovations, and renewable energy deployment - key themes that align directly with MonuPED's focus on decarbonizing monument-protected districts. Prague's



strong emphasis on localized renewables, energy-efficient retrofits, and smart energy management—especially in municipal buildings—offers practical synergies for piloting the MonuPED tools. Moreover, the plan’s vision of polycentric urban development and support for community energy systems further complements MonuPED’s mission to integrate heritage preservation with energy innovation in historically layered neighborhoods such as those found in Prague 6.

The Local **Energy Concept (MEK) of Prague 6** establishes a detailed strategic and technical roadmap for energy management in the district, creating a highly relevant foundation for the MonuPED Living Lab. The MEK outlines key objectives such as **reducing CO₂ emissions by 34% by 2035**, increasing energy efficiency in public buildings, and expanding renewable energy production, especially through photovoltaics and the development of community energy systems. It specifically highlights a significant solar photovoltaic potential on municipal properties, projecting that installed PV systems could produce 949.05 MWh per year by 2035. One of MEK’s six strategic energy goals specifically named "Development of renewable energy sources and community energy", indicating explicit support not only for decentralized production, but also for community-based energy models. The document outlines support measures such as consultancy, awareness-raising, and subsidy advice aimed at properties owned by third parties (individuals or cooperatives), to enable them to participate in community energy initiatives. These priorities directly align with MonuPED’s focus on testing tools, governance models, and co-investment strategies in heritage-sensitive urban environments. Moreover, MEK’s emphasis on data-driven planning, energy audits, stakeholder collaboration, and the implementation of energy management systems provides fertile ground for piloting MonuPED interventions in real-world municipal settings. The document’s ambition to turn Prague 6 into a leader in sustainable urban energy positions it as an ideal demonstrator site for Positive Energy District strategies.

6.2 Stakeholders of Prague 6 Living Lab

PARTNERS

The project partners form the operational and strategic foundation of the Prague 6 Living Lab. This group includes institutional stakeholders such as the **Czech Bishop Conference**, the **Municipality of Prague 6**, **SNEO, a.s.** (the municipal real estate management company), **KITT6** (provider of ICT services for Prague 6), and representatives of **residential building owners** and **housing cooperatives**. Together, they coordinate the planning, piloting, and evaluation of Living Lab activities, contributing local knowledge, operational capacity, and decision-making authority. Their collaboration ensures that energy retrofits and district-level strategies are rooted in real-world governance, ownership, and technical conditions.

SNEO, a.s.: As the municipal real-estate management company of Prague 6, SNEO oversees a broad portfolio of district-owned buildings, including residential, administrative, and utility properties. Their mission spans construction, maintenance, and energy provision—making them uniquely positioned to pilot retrofit strategies that combine technological upgrades (like efficient heating systems) with heritage-sensitive renovations. SNEO can act as a Living Lab anchor by offering access to municipal properties, supervising implementation, and tracking performance outcomes for scalable PED solutions.

Municipality of Prague 6: Through its policies on spatial planning and district strategy, Prague 6 drives both regulatory frameworks and local sustainability targets. The municipality can integrate MonuPED initiatives into municipal energy planning, set district-level policy incentives for retrofits, and actively engage citizens. Its support is essential for aligning heritage conservation guidelines with the project’s PED objectives, enabling faster permitting, and legitimizing co-investment structures via local council backing.



SUPPORTERS / MULTIPLIERS

Supporters and multipliers contribute to the project by extending its visibility, credibility, and technical scope. Public infrastructure and service organizations such as **OICT** (Prague's data and digital services company) and **PRE.Di** (Prague electricity distributor) enable data integration and support for energy systems planning. Civil society organizations like **DUHA Movement**, **Arnika**, and the **Via Foundation** provide community outreach, sustainability advocacy, and public participation expertise. Specialist institutions and networks such as **PCOE**, the **Prague Renewable Energy Centre**, **Monument Protection Authorities**, **Pro Památky**, and the **Club for Old Prague** contribute professional knowledge on heritage conservation, architecture, and energy efficiency—amplifying the Living Lab's ability to integrate multiple policy and technical domains.

OICT (Operátor ICT): This municipal ICT company specializes in smart city projects, open data, and digital infrastructure, and is recognized for its transparency and innovation ethics. Their experience with civic apps and urban data analysis offers essential tools for participatory governance in heritage contexts as well as the development of digital tools.

DUHA Movement (Friends of the Earth Czech Republic): A leading Czech environmental NGO focused on climate, clean air, and sustainable energy transitions, DUHA engages communities through campaigns, expert reports, and public consultations. In the Living Lab, DUHA can mobilize and educate residents, amplify public dialogue on retrofits in monument-protected areas, and monitor policy implementation. Their involvement helps ensure interventions are socially legitimate and aligned with broader climate justice principles.

Klub za starou Prahu (Club for Old Prague): As one of the oldest heritage-focused civic associations in the country, Klub za starou Prahu is deeply committed to preserving the historical and architectural integrity of Prague. The Club plays a prominent role in public debates around urban development and conservation, often acting as a critical voice in discussions about sensitive interventions in historic environments. Within MonuPED, the Club can contribute by offering expert reviews of retrofit designs, advocating for heritage-conscious solutions, and ensuring that energy upgrades respect the character of monument-protected areas. Through its publications, public events, and cultural programming, the Club can also help raise awareness, engage residents, and legitimize MonuPED interventions in the eyes of heritage-conscious stakeholders.

TARGET GROUP

Target groups are the key audiences and stakeholders who are directly impacted by the Living Lab activities and whose engagement is critical to the project's success. These include **residents of Prague 6**, **owners of heritage and non-heritage buildings**, **housing cooperatives**, and **potential green investors** interested in sustainable urban development. Academic and technical collaborators—such as the **Czech Technical University**, particularly its **Faculty of Electrical Engineering**—support the development of decision-making tools, behavioral modeling, and economic frameworks. Their participation ensures that MonuPED's solutions respond to user needs while remaining technically robust and scalable. The list goes on beyond Prague 6, including cities within the New European Bauhaus community and other cities in the Czech Republic with similar issues of high heritage protected building share (e.g. Český Krumlov). Secondary target group are municipalities with MPAs and MPBs in the Czech republic and Europe.



Czech Technical University (CTU) – Faculty of Electrical Engineering: With deep expertise in management, economics, and energy systems, CTU plays a vital co-creation and evaluation role in MonuPED. They can provide feedback on stakeholder behaviors, and support the testing of governance and co-investment tools. Their involvement as a stakeholder will verify technical feasibility and socio-economic viability of retrofit pathways within Prague 6's Living Lab environment.

Residents of Prague 6: As the primary users and beneficiaries of energy improvements, residents can actively participate through surveys, workshops, and retrofit co-design processes. Their lived experience will inform priorities (comfort, costs, aesthetics), especially in heritage contexts. Engaging residents early ensures MonuPED solutions are socially accepted and reflect local needs—crucial for scaling PED models beyond the Living Lab.

Practitioners and the consulting community (businesses and NGOs) covering the topic through their awareness campaigns are also recipients of MonuPED content (e.g., Czech Passivhaus Brown, CPD, etc.).

6.3 Connection Living Lab Prague to other MonuPED WPs

The core focus of Living Lab Prague 6 lies on testing digital and process-oriented tools such as the Solar Potential Map, the Roof Match App, and the Concept: Roofs and Facades Study from WP4 - all tailored to the complex regulatory and spatial context of a monument-rich district. These tools are being validated in close collaboration with local stakeholders, including municipal authorities, church institutions, and building owners, particularly in two pilot sites: the listed Břevnov Monastery and the Archiepiscopal Seminary located in a monument-protected zone.

In the medium term, the Living Lab aims to generate transferable insights for integrating renewable energy systems in heritage areas by combining real-world testing with stakeholder feedback on digital workflows and approval processes, utilizing the outputs of WP2. This includes guiding citizens through retrofit planning within existing legal frameworks and refining co-investment models that support building upgrades across diverse ownership structures. The close alignment with national and municipal strategies - such as the updated State Energy Policy, the Prague Climate Plan, and the Local Energy Concept of Prague 6 - ensures strong policy anchoring. Continued exchange with other MonuPED sites will further enhance the predictive and governance capacities of the tested tools, offering a roadmap for culturally and technically feasible Positive Energy Districts in complex urban environments.

6.4 Roadmap and formats of Living Lab Prague 6

As part of the stakeholder engagement strategy in the Prague 6 Living Lab, the project will implement a recurring **Walt Disney workshop format** - a structured yet creative method designed to assess, refine, and co-develop key tools and processes related to Positive Energy Districts (PEDs). This format brings together selected stakeholders from different backgrounds to assume complementary roles: **dreamers**, who explore ambitious possibilities; **makers**, who focus on implementation; and **critics**, who test assumptions and highlight risks. Facilitated by a moderator, the session enables a dynamic yet balanced discussion of innovative approaches within the sensitive heritage and regulatory context of Prague 6.

The first workshop is planned for **Month 9** of the project and will involve around **seven participants**, including representatives from **SNEO, a.s., owners of listed buildings**, and the **Club for Old Prague**. Hosted in a physical setting such as a university, municipal, or church-owned meeting room, the half-



day event will also include a coffee break to foster informal exchange. The focus will be on providing **quick, context-specific feedback** on WP4 outputs—such as the Solar Potential Map, Roof Match App (hereinafter in this chapter as “app”), and the citizen guidelines—testing their feasibility in real-life scenarios, and exploring how they can be integrated into the local planning and decision-making ecosystem.

The workshop will also help build **mutual understanding among stakeholders** with diverse perspectives and priorities, bridging technical, conservation, and administrative considerations. This format will be repeated **annually**, serving as a recurring touchpoint to evaluate progress, adapt strategies, and sustain momentum throughout the MonuPED project timeline. Through this collaborative setup, the Prague 6 Living Lab ensures that the PED concept evolves in a way that is both **ambitious and achievable**, grounded in lived experience and local governance realities.

In parallel with stakeholder feedback loops and technical testing, the Prague 6 Living Lab will host a series of structured **co-creation sessions** grounded in **design thinking methodology** to guide the iterative development of the Roof Match App. This app is a key digital tool within the MonuPED project, aiming to connect building owners with investment opportunities for deploying solar energy solutions, particularly in heritage-sensitive districts. The co-creation sessions will be designed as focused sprints—starting in **Month 12**—and will bring together **target users and technical partners** in small, agile working groups of approximately **five participants per session**.

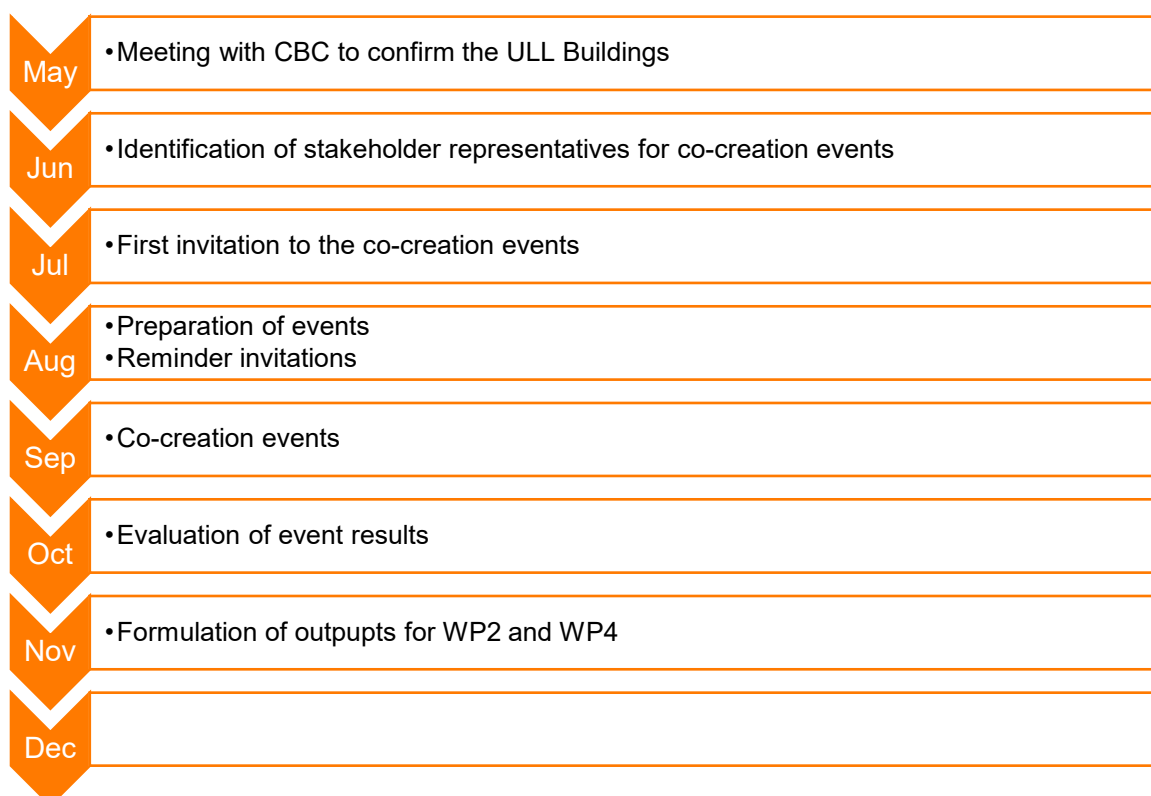


Figure 29: Road Map Living Lab Prague 2025

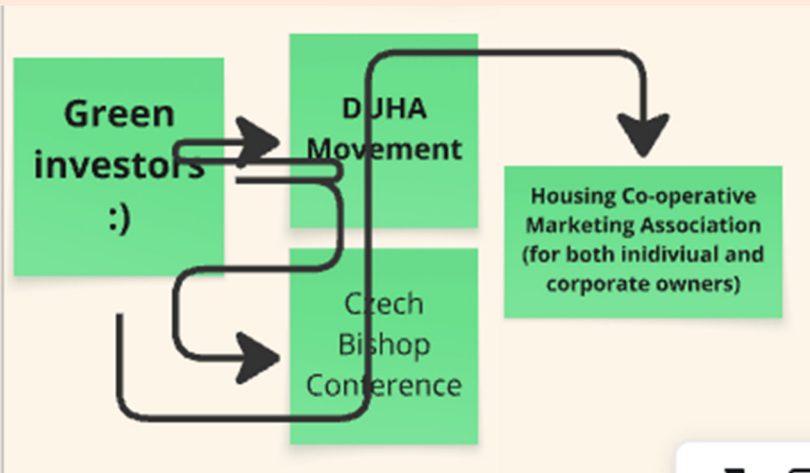
Stakeholders involved in these sessions will include representatives from **PRE.Di** (the Prague electricity distributor), **OICT** (Prague’s data company), and **owners of listed buildings**, who together represent key user types and infrastructure gatekeepers for the app’s deployment. The aim is to collect concrete insights into **user needs, technical constraints, and decision-making behaviors** that can shape the



app's features, data visualizations, and business logic. Over the course of the year, **three iterations** of this activity are planned, each comprising **three to four separate focus groups** to ensure breadth and depth of input.

The sessions will be hosted in **Prague 6** to maintain proximity to the Living Lab context, with additional **online validations** conducted with stakeholders from other MonuPED Living Labs (ULLs). Some validations may also be aligned with **consortium meetings** in 2026 to ensure cross-site learning. Beyond usability testing, this activity is designed to **validate business models**, gauge the **app's capital engagement potential**, and ensure it serves as a practical, scalable interface for matching solar-ready rooftops with community and private investors. The iterative format guarantees that the app is not only **technically sound** but also **deeply user-centered**, reflecting the regulatory, economic, and architectural realities of monument-dense urban areas.

Table 5: Possible engagement formats MonuPED Living Lab Prague:

CO-CREATION SESSIONS à Design thinking sprint à Focus groups with users à information campaign	
Involved stakeholders/ stakeholder groups	• PRE.Di - Prague electricity distributor • OICT (Prague data company) • owners of listed buildings  <pre> graph LR GI[Green investors :)] --> DM[DUHA Movement] DM --> CB[Czech Bishop Conference] CB --> GI DM --> HCA[Housing Co-operative Marketing Association (for both individual and corporate owners)] HCA --> DM </pre>
Estimated no. of participants/ duration of the event/ format	5 people/event
Frequency**/when should take place for the first time?	3-4 groups / iteration 3 iterations within a year Start: M12
Related to which MonuPED phase*/topic/ WP activities?	WP2, WP3
How will involvement support your MonuPED activities?	• gathering insights into needs that the app will react to • ensuring future usability potential • ensuring there is enough capital involved in the game • creating a viable business model for the app in the future



What organizational requirements are necessary? Special budget?	• Meeting spaces • development budget was included in the plan
Location of the event (physical set-up) or technical requirements to carry out the event	• Prague 6 • Online validations with other ULLs, possibly some personal validations during consortium meetings (during 2026)

CO-CREATION SESSIONS à Design thinking sprint à Focus groups with users à information campaign	
Involved stakeholders/ stakeholder groups	• SNEO, a.s. - Municipal company - manages real estate owned by the Prague 6 district • owners of listed buildings • Club for Old Prague - Klub za Starou Prahu
Estimated no. of participants/ duration of the event/ format	7 people (2 dreamers, 2 makers, 2 critics, moderator)
Frequency**/when should take place for the first time?	once a year - to assess the development M9
Related to which MonuPED phase*/topic/ WP activities?	WP4 - PED concept, Tools, Process outputs
How will involvement support your MonuPED activities?	Give relevant and quick feedback on feasibility of the approach Foster communication and understanding
What organizational requirements are necessary? Special budget?	spaces, coffebreak
Location of the event (physical set-up) or technical requirements to carry out the event	Either university, CBC or Municipal meeting room



7 LIVING LAB ALBA IULIA

7.1 Living Lab Alba Iulia - Introduction

Alba Iulia is a medium city (below 100.000 inhabitants), seat of Alba County, situated in the heart of Transylvania, but has over 2.000 years of local history and continuous living. Alba Iulia has a rich history, from neolithic age (near Mures river), to Dacians, to the most important castrum and municipia in Roman Dacia, to capital of medieval Transylvania; last Vauban type fortress (1713) is the biggest in Romania (70 ha). The Vauban fortress is located in the middle of the city, built on Roman castrum ruins and medieval fortress ruins.

The fortress has the form of a star with seven corners and 3 rows of defensive walls. It is the biggest and important fortifications in Romania and it was never conquered. It served as a strategic fortification to defend the Habsburg Empire against the military efforts of the Ottoman Empire and to consolidate Habsburg power locally. The walls - slightly sloping - were built of brick and stone using a technique without unevenness, in order to cause the metal cannonballs to ricochet. From the old medieval fortress, however, the two bastions built in the 17th century were used, which became cavaliers - firing platforms within two new bastions. The Citadel has 7 gates. The construction of the Vauban fortress, begun in 1713, involved the partial incorporation of the bastion fortress which - in turn - is tributary to ancient and medieval built structures. Construction stages in the territory of the fortress¹ In Alba Iulia, on the plateau above the city, the following fortifications succeeded each other:

1. Roman earthen castrum (post 106 AD)
2. Roman stone castrum (2nd-4th centuries)
3. Fortified medieval settlement (9th-1550 centuries)
4. Bastion fortress (1551/1553-1711)
5. Stellar fortress (1711- 1715) - actual fortress

Inside the stellar fortress (Vauban Citadel) are several important monumental buildings (Princely Palace, Principia, Romano – Catholique Cathedral (oldest cathedral in Transylvania), Orthodox Cathedral, Bathyanem Library, Old building of Alba Iulia University, the Manutance, Old ruins of Roman castrum walls and south gate, the gates of the Vauban fortress). All the area of the Vauban fortress is a historical protected area and it is relevant to mention that the fortress is still a living place. You can find also inside the Fortress old particular houses (from 18th century) still inhabited by private owners.

Alba Iulia Living Lab inside the Vauban Fortress will validate concepts, recommendations, and tools from WP2, 3, and 4, activating MPA ecosystems with stakeholders like building owners, MP authorities, energy providers, universities and residents.

Importance of a MPAs/MPBs Living Lab in Alba Iulia

In its strategic development documents (like Integrated Development Strategy, Energy Efficiency Improvement Plan, Climate Mitigation Plan, etc.) Alba Iulia Municipality identified as of major importance the necessity of improving the energy efficiency in buildings (which represents the main consumers) and usage of innovative renewable energy sources as main contributor in lowering consumptions and emissions. As the municipality is a member of several EU associations (like Covenant of Mayors, Net Zero/ M100 Cities, Green Building Council), its objectives for energy at 2030 horizon are aligned with European ones. The municipality has an extensive experience in implementing energy related projects (starting with buildings refurbishment, implementation of RES solutions) or innovative ones, including combinations of solutions and building automation (like those implemented



at Senior's home, Olympic Swimming Pool), and photovoltaic park. For public municipal buildings, energy efficiency projects are prioritised based on historical consumption and impact. Also, the area of energy communities, which is in the starting phase in Romania, is tested in several areas during several EU projects (like Ascend, Interped, Emerge, ShareRes). The MonuPED Living Lab is important because:

- Alba Carolina Fortress area is a central one and includes the majority of historical buildings (about 50 buildings) of the city;
- As buildings owners are diverse, there are no centralized data about energy needs, or energy consumption (just estimations);
- Is a continuation of implementing activities with energy and buildings stakeholders, using the model of Intelligent Cities Challenge, but adapted to the specific case of monument buildings;
- Many of the buildings were rehabilitated in last years from the construction point of view, during long processes of design and approvals, in order to preserve buildings aspect but not all possible energy efficiency/ RES solutions were considered;
- Living Lab will offer the opportunity to identify possible solutions for improving energy efficiency of monument buildings, and ease their implementation, aspect of major importance for all owners, considering continuous raise of energy costs.

Estimated Living Lab results, based on its objectives

The following are key objectives of the Alba Iulia Living Lab:

- To map stakeholders and to build cross – stakeholders' activities in order to create a shared vision for energy transition with local climate strategies and aligned with laws regulations related to monument buildings;
- To increase communication between local stakeholders (local construction companies, NGOs, universities, architects, RES solutions companies, citizens) through meetings, workshops, roundtables;
- Take place regularly in order to foster a better communication and endorsement at local level, explore the feasibility of energy sharing communities, thereby increasing access to sustainable energy efficiency sources for authorities, for local residents and private owners and increasing the efficiency of the use of resources;
- To design, test, and validate tools that provides the baseline for data-driven retrofitting recommendations for property owners—ensuring alignment with both monument protection regulations and energy efficiency goals;
- To establish effective collaboration among all stakeholders, creating a solid network for innovation and sustainable transformation—without compromising the district's cultural and architectural heritage.

Living Lab as a learning instrument

During the MonuPED Living Lab we want to better understand what the energy needs and possible energy efficiency solutions for monument buildings and areas are, together with a recommended process of implementation of such solutions, in order to minimise energy consumption and emissions in those areas.

Living Lab implementation challenges

- a) Technical challenges



The fortress area is physically delimited from the rest of the city by ditches and walls, making it difficult to expand utility networks; there is no distribution network for heating/cooling and hot water at the city and area level; utility networks (electricity, gas, water/sewer) are managed by private companies; because the entire fortress area is a protected area, new utility works are difficult, requiring special approvals and archaeological discharge; some current technical solutions for using renewable resources can visually impact the appearance of buildings and their specificity.

b) Legislation / Regulatory challenges

Unlike new construction, historic buildings have a cultural significance that cannot be replaced and must be preserved and passed on to future generations with minimal intrusion. In the case of historic buildings, experts recommend a straightforward approach: do what is necessary to maintain a place and keep it in use, but change as little as possible so that the cultural significance is preserved. Thus, any intervention on historic buildings must maintain its authenticity and character, and must be documented and reversible. Therefore, the rehabilitation interventions of historical buildings are carried out only within the limits of national and EU legislation and regulations, requiring special approvals. It follows that in the analysis of solutions in this framework must be known and applied, in order to promote solutions able to ease implementation. In Romania, Law 422/2001 on the protection of historical buildings is the main legislation along with others following the status of historic monuments and buildings.

c) Stakeholders' involvement challenges

The first stakeholders to be involved are the owners of the historic buildings, who can provide important information on the condition of the buildings, their energy consumption and the existence of rehabilitation projects. It is also advisable to involve experts specialized in the rehabilitation of historic buildings (historians, architects, builders, solution providers), whose number is quite small locally. All these stakeholders must be convinced to actively get involved in the Living Lab activities, starting from its importance for all parties involved and the practical applicability of the identified solutions.

Description of the Living Lab buildings and area

Municipality owns 2 buildings in citadel area: The Princely Palace (XV -cen) and Principia Museum (covering roman Principia). Figure 2 show us the Princely Palace witch was the residence of the Princes of Transylvania from 1542 to 1699 and the central location for significant political decisions. Foreign chroniclers have been mentioning in their works over the centuries all the intrigues, alliances, betrayals, court life, culture and customs of princes and their guests from all over Europe.

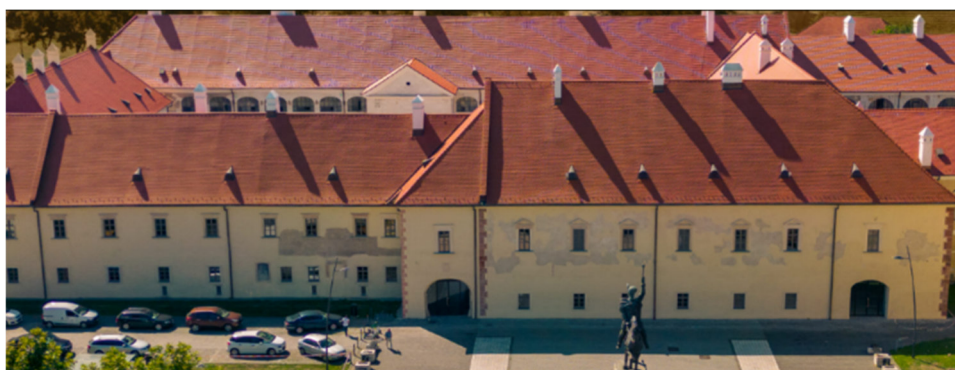


Figure 30: The Princely Palace of Transylvania; Alba Iulia, Militari Street, No. 4, © <https://palatulprincipilor.ro/>



The Princely Palace of Transylvania has an very important historical Significance: residence of the Princes of Transylvania from 1542 to 1699 central location for significant political decisions; Regarding architectural palace has an important diversity and a melange of architectural styles including Gothic, Renaissance, and Baroque; The palace is also an important symbol of national unity and culture, hosting important figures such as Mihai Viteazul. Here, in this palace for a few months lived the first unifier of all Romanian territories, who in Alba Iulia in 1600 achieved the first union of all Romanians. Built in successive stages beginning in the mid-15 th century, numerous renovations and expansions, reflecting its evolving use and the artistic currents of the time. The Princely Palace has also an archaeological Importance: remnants from various historical periods, including Roman walls and medieval structures. By uncovering the walls, fragments of old decorations that had accidentally escaped destruction were found: medieval and Renaissance decorative plasters, Baroque or Rococo paintings, various stone carved frames, of Roman, Romanesque, Gothic, and Renaissance style. Now, the palace is a public municipal building with mixed usage: museum, interactive exhibition space, cultural hub, research centre, event space, place of study, relaxation and leisure.

The structure of this palace is formed by 7 wings features two inner courtyards. Just E wing was renovated and used at this moment and is functionally now. When you look to this Palace you can see several construction phases from the medieval period to the Baroque era. During restauration of E wing, some energy efficiency solutions applied (thermal insulated windows, LED lighting, heat pumps, radiators). Regarding RES: just heat pumps (not reversible); low consumption due to insulation (over 1 m walls). Renovated E wing has 3114 m² (actually used); other wings under project. Connected to electrical grid; LED lighting; heating based on heat pumps and radiators; Electricity consumption: 8800 kWh/year; There are some challenges that we as municipality already facing when implementing PED solutions in this area:

- The installation of individual air conditioning devices in historical monuments will be located in areas where they are not visible or discreetly placed and do not affect the perception of the public space on the historical monument;
- Paintings and interior paints at historical monuments, buildings in protection areas – only few paints are allowed
- The location of GSM antennas and other telecommunications networks on historical monuments – only in in areas hidden from the public eye with special agreements
- interventions limited or forbidden not only on the monument itself but throughout the historical area. Each monument also has a protective area where it cannot be intervened through interventions that can bring damage or change the historical appearance of the area
- Being a historical site and an area built by historical monuments of national and European importance (Catholic Roman Cathedral in immediate proximity) cannot be intervened by excavations, geothermal pumps and other solutions related to the basement
- Legal restrictions related to constructions and monuments protection
- Technical restrictions; Wind based RES solutions are not possible; Solar thermal/ PV solutions limited to 30% of not visible areas; geothermal solution not possible; heat pumps must be hidden; rehabilitations of exterior/ interior must not change aspect; new anti-fire norms related to RES;
- The approval of interventions on historical monument buildings is subject to strict rules – they can only be executed based on the approval of the Ministry of Culture and National Identity or of decentralized public services, **WITH** the consultation of the National Commission of Historical Monuments and/or the zonal commissions of historical monuments.



PRINCIPIA - Museum (municipal building), Address: Alba Iulia, Piata Cetatii nr.1

<https://albaiuliaqr.ro/muzeul-principia/> ; <https://castrul.apulum.ro/>

Principia is a modern building, covering the the headquarters of the XIII Gemina Legion, the only legion that was stationed on the territory of Dacia throughout the entire period of Roman occupation. The museum is one of the places where you can learn the story of the camp built by the Romans at Apulum.

The Principia has only been researched and highlighted in part, as a good part of the ensemble is located under the nearby street and under the "1 Decembrie 1918" University. The interior area preserves important traces of the Principia in situ. Visitors can see the rooms where the treasury was kept, the banners, where the officers and soldiers of the Legion were trained. Also inside, the original floor of some rooms or the hypocaust, the well-known heating system of the Romans, is also highlighted. Glass and steel construction, opened in 2014 Principia as public municipal building is used as museum and host for cultural events. Important historical (UNESCO) monument hosting the treasury, the banners, the meeting room; inside, the original flooring of some rooms or the hypocaust, the well-known Roman heating system, is also preserved. Museum hosts reconstructions of military outfits and equipment. Principia has one floor, 780 m², reversible heat pumps for heating and cooling; electricity from grid, heating and cooling based on ventilation; Electricity consumption is 88 MWh/ year;

Main challenge : Modern building with book shape, made by steel & glass, covering roman castrum headquarters; modifications difficult to be approved;

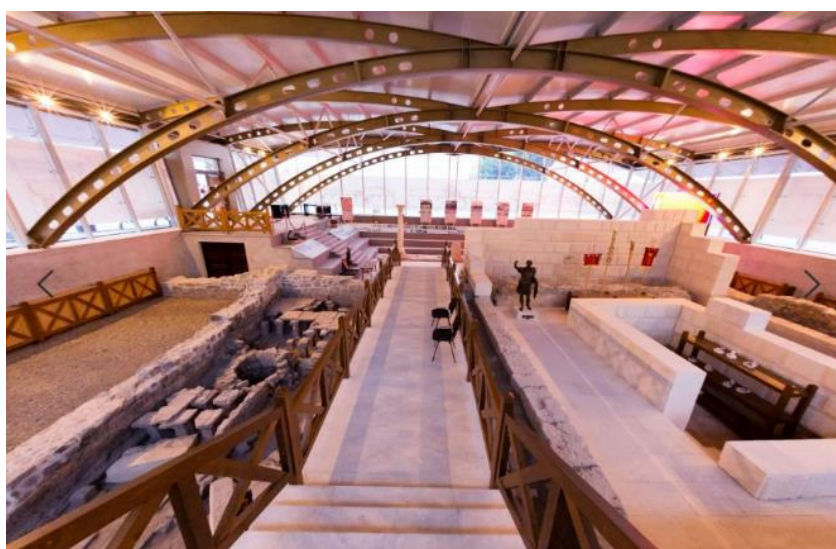


Figure 31: Principia Museum (source: © <https://turism.apulum.ro/destinations/muzeul-principia/> National Center for Tourist Information and Promotion Alba Iulia); <https://castrul.apulum.ro/galerie/> ; <https://albaiuliaqr.ro/muzeul-principia/>



Alba Carolina Fortress area



Figure 32: Alba Iulia fortress, aerial view, © Google maps/ Map Builder - Snazzy maps

Alba Iulia fortress is a Vauban type one, with a star shape, well delimited by rest of the city by walls and trenches, which includes about 50 different buildings, administrated by different entities. The entire area is a historical one of national importance, with some Unesco sites. Majority of buildings are contemporary to Vauban citadel construction (XVIII-th cen) with some notable exception, considering its usage as administrative site, military importance and cultural/ religious site.

Connections to existing strategies/networks/projects or initiatives

Strategies and programs:

The national strategy for the protection of historical monuments

The national strategy for the protection of historical monuments starts from the premise that cultural heritage is an essential resource for the identity of Romania and for the development of a prosperous society, based on social inclusion and participation, a strategic resource that must add economic, social and cultural value to the community, through modern and efficient management. The document establishes the priorities for action in the field of historical monuments and immovable cultural heritage as a whole, and will have a role in structuring and coordinating the activity in the sector, also indicating the general direction, principles, new theoretical and practical guidelines and the main solutions for the protection of immovable cultural heritage, within a 10-year time horizon. This new strategic approach to historical monuments and immovable cultural heritage responds to the needs identified in practice, including by correlating them with the objectives of the 2030 Agenda for Sustainable Development developed by the United Nations and with the European Union Agenda for Culture 2021-2027 and aims to redefine the general framework for understanding historical monuments and immovable cultural heritage, in the context of restructuring the legislation in the field of heritage protection, by developing the Cultural Heritage Code; recognize cultural heritage as a national strategic objective, defining for the



sustainable development of the built environment; update the approach regarding the protection and valorization of historical monuments and immovable cultural heritage, by analyzing the evolution of concepts, legislative measures and strategic directions at European and international level; facilitate the understanding of historical monuments and immovable cultural heritage as a driver of local development and as a non-renewable resource essential in combating climate change; promoting good practices in the protection and valorization of cultural heritage as sustainable solutions and pursuing the extension of the lifespan of historical monuments.

National Monument Restoration Program – 2023

The National Restoration Program was established in 1997 following the initiative of the Minister of Culture, Ion Caramitru. Between 1997 and 2018, the restoration of approximately 400 historical monument objectives was completed, including monuments on the UNESCO World Heritage List.

The National Institute of Heritage annually finances restoration works of historical monuments included in the National Restoration Program, a program that is carried out in accordance with the regulations provided for by Order no. 2978/2019, issued by the Ministry of Culture and National Identity, for the approval of the Methodological Norms regarding the elaboration and implementation of the PNR, financed from the state budget, through the budget of the Ministry of Culture and managed by the INP. These norms establish the application method, eligibility conditions, prioritization criteria and the evaluation procedure of the objectives included in the National Restoration Program.

Alba County Council - Alba County Strategy in the Field of Energy

The strategy aims to identify the existing situation - Diagnostic Analysis - of the field, an analysis that integrates economic, social and environmental aspects, followed by a SWOT analysis, and as conclusions of the approach, to create an action plan for the period 2018-2023. Like any strategic planning approach, the document is prepared in consultation with stakeholders in the energy field: local authorities, competent institutions, consumer associations, service providers, entities involved in the production, distribution and supply of energy; it is important to obtain the support and involvement of citizens in promoting energy efficiency and in the use of renewable energy sources. The document, developed under the coordination of the Alba County Council with the technical support of the Alba Local Energy Agency, aims to include the points of view, opinions and perspectives of those who are directly or indirectly related to the energy field at the level of Alba County.

Zonal Urban Plan - Protected Area of the Alba Iulia Fortress

The purpose of the documentation is to ensure coordination and the legal and regulatory basis for the protection and sustainable development of the urban ensemble with exceptional cultural value, the Alba Iulia Fortress.

Energy Efficiency improvement programm (PIEE) of Alba Iulia Municipality

Its main purpose is to evaluate energy consumption in Alba Iulia and identify measures to increase energy efficiency and reduce emissions. This program makes an inventory of main energy categories of consumption (buildings, mobility, services), emissions inventory and sets priorities for energy efficiency projects.

Sustainable Energy and Climate Plan (SECAP)

SECAP is a key document for municipalities in Romania and other European countries, which sets specific objectives and actions to reduce greenhouse gas emissions, improve energy efficiency and promote renewable energy. It is both a political and technical tool that facilitates the implementation and monitoring of environmental and climate actions at the local level.



Integrated Urban Development Strategy

The development strategy is a basic document in defining the framework that ensures the implementation of a coherent vision of integrated evolution of the development sectors specific to a community. As a planning tool, an integrated strategy must have as its starting point the analysis of local development needs and this must be done within a participatory process, with the involvement and collaboration of the community, thus laying the foundations for a long-term continuity of the development vision outlined as a result of this approach. The ultimate goal of an integrated development strategy must be to define as clearly and coherently as possible the role and place that a locality will occupy in the region, what it will look like in ten years or even more: how it will be perceived by its inhabitants, how interesting it has become for the business environment and investors, how it manages to capitalize on and promote its cultural heritage, how attractive it has become for tourists and, last but not least, how it offers resources that motivate people to stay and live there, and even more so, to convince people from other places to consider it "home".

Alba Iulia Smart City Strategy 2021-2030

The development strategy of Alba Iulia Municipality as a Smart City practically targets all the strategic objectives of Alba Iulia Municipality for the next 10 years of development of the urban ecosystem, namely those of becoming:

- A smart, accessible and coherent city, based on citizen-centered digital solutions;
- A green city, with efficient public services, supported by computerized platforms and green technologies;
- A competitive and creative city, based on the development of smart education solutions/platforms;
- A European cultural and tourist objective, supported by digitalized solutions for the tourist and cultural field. The major directions of the strategy are concretely and efficiently oriented towards increasing the quality of life of citizens by ensuring sustainable development, this generic objective being detailed as follows:
 - Increasing the quality of services offered to citizens, entrepreneurs and tourists;
 - Increasing the efficiency and monitoring of all activities carried out by municipal employees and those of subordinate structures;
 - Supporting the local business ecosystem from an IT point of view;
 - Creating, through the multiplier effect, a living and business environment that attracts strategic investors and a highly qualified workforce.

Climate Change Mitigation and Adaptation Plan

The Climate Change Mitigation and Adaptation Plan - PAASC", is developed for the period 2022-2030. The document will allow the Municipality of Alba Iulia to rigorously plan its concrete actions for climate change mitigation and adaptation, in accordance with the national and international strategies in force

NETWORKS

- **Alba Iulia is twinned with 19 cities** https://www.apulum.ro/index.php/primaria/orase_infratite
- **Green building council (Romanian association)** is a non-profit, apolitical association, formed by organizations active throughout the country. We promote environmental responsibility and energy efficiency throughout the life cycle of a building (from design, construction to operation and deconstruction).
- **NetZeroCities** helps Europe in its ambition to achieve climate neutrality.



- **Association of Municipalities** - The Romanian Municipalities Association (AMR), set up in 1990, is an NGO dedicated to Local Authorities support and representation. AMR includes 101 municipalities and the 6 districts of Bucharest Municipality and is a legal person of private right, without patrimonial aim and apolitical, established in view of promoting and protecting the common interests of the local public administration authorities. AMR aims to contribute to the achievement of real local self-determination, according to the principles stipulated in the Constitution of Romania and in the European Charter of Local Autonomy in view of solving the public needs in the citizens' benefit and also for ensuring their participation in the decision process regarding the local communities.
- **Covenant of Mayors** -The EU Covenant of Mayors for Climate & Energy is an initiative supported by the European Commission bringing together thousands of local governments that want to secure a better future for their citizens. By joining the initiative, they voluntarily commit to implementing EU climate and energy objectives.
- **Intelligent Cities Challenge** - is a European Commission initiative supporting European cities towards the green and digital transition of their local economies, through Local Green Deals. ICC helps European cities harness the power of cutting-edge technologies, while improving their economic competitiveness, social resilience and their citizens' quality of life.
- **Green Deal**- is the EU's growth strategy, launched in 2019, which aims to transform the EU into a fair and prosperous society, with a modern, competitive and resource-efficient economy. The main goal is to achieve climate neutrality by 2050, with at least a 55% reduction in greenhouse gas emissions by 2030 compared to 1990 levels.
- Partnership with European Bank of Development
- Innovation Norway

PROJECTS

- >40 projects related to energy efficiency/ RES in last 15 years;
- Various projects with various financing schemes (Regional funds, Environment funds, Resilience and Recovery Plan, Interreg, Horizon, Innovation Norway, etc.);
- **InterPED** - The InterPED project will develop the technical and business ecosystem to convincingly demonstrate the potential of positive energy districts (PEDs), by integrating local renewable energy and waste/excess heat (E/WH) sources with local energy systems, to bring economic benefits, improve the stability and robustness of energy networks, contribute to the energy system by decarbonising and reducing the carbon footprint. This will be achieved by fulfilling the overall objectives of the project, setting the conditions for large-scale replicability in city districts across Europe.
- **ASCEND** - The "ACCELERATE POSITIVE CLEAN ENERGY DISTRICTS" project - acronym ASCEND aims to facilitate the transition from radical energy consumption of currently used fuels to the use of renewable energy sources in communities.
- **Intelligent Cities Challenge** - finalized with 6 Local Green Deals for energy, mobility and tourism; in energy field, priorities are energy management platforms and energy communities.

EVENTS

nZEB Days Fair (May 2025)

nZEB Days transforms the Citadel Square in Alba Iulia into a hub dedicated to sustainable and energy-efficient construction. The event brought together:



- 🔑 Hands-on demonstrations of innovative solutions and technologies
- 🏠 Free consulting sessions with nZEB building experts
- 🤝 Networking with professionals, authorities, developers and suppliers
- 🎓 Interactive workshops for children, pupils and students

Green Energy Fair (September, each year, with ALEA)

The fair is dedicated to the energy sector, equipment and complete solutions related to energy efficiency, renewable energy production, SMART solutions for buildings, electric mobility. The aim of the event is to promote the development of the local market in this sector by addressing the general public, local authorities, companies and institutions.

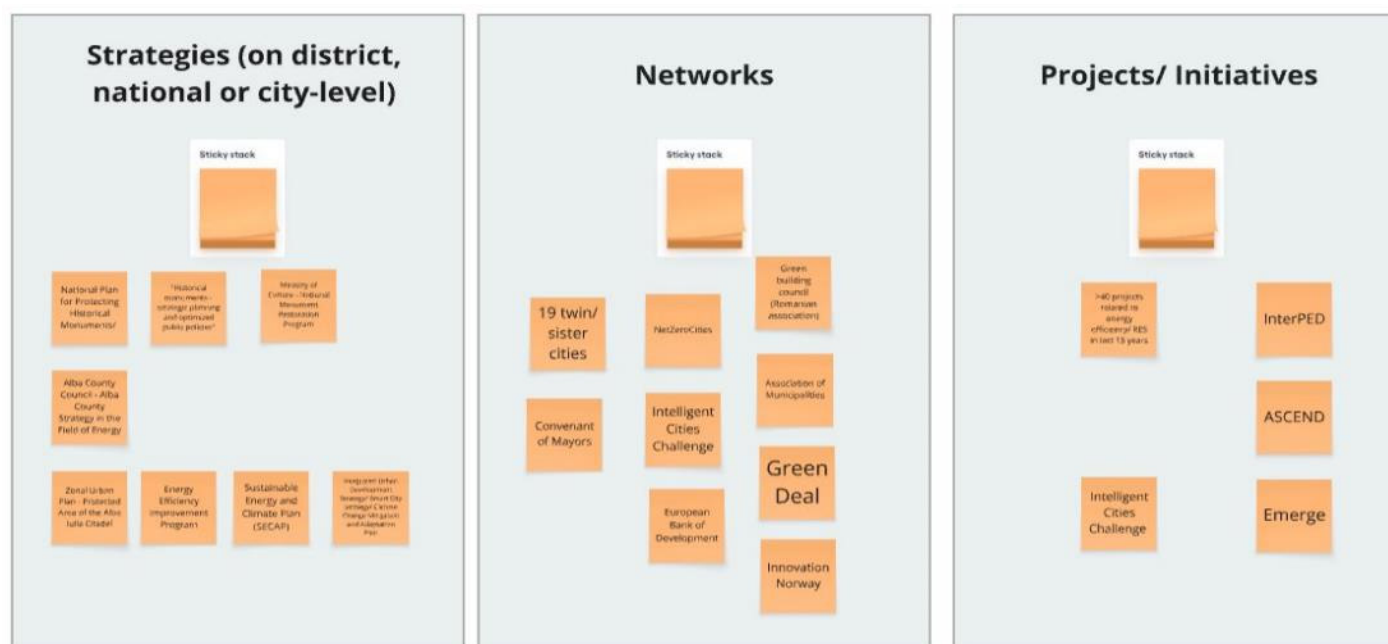


Figure 33: Results of the initial brainstorming session: existing strategies, networks and projects in Alba Iulia related to MonuPED, © Miro board screenshot

7.2 Stakeholders of Living Lab Alba Iulia

PARTNERS

1 Decembrie 1918 University of Alba Iulia – is one of the most important partners for Alba Iulia Municipality and is situated inside the Vauban Fortress into several historical buildings. For example, from 2024, Alba Iulia Municipality and the University of Alba Iulia are partners within the Local Partnership for the Green Transition, namely for the Development of energy management platforms, respectively for the Development of local energy communities.

Technical University of Cluj Napoca (Faculty of Construction) - The Technical University of Cluj-Napoca (UTCN) also has an extension in Alba Iulia, which functions as a structure of the university. UTCN offer technical support and expertise in several projects as trusted partner of Alba Iulia Municipality

Alba County Council - is the management structure at the county level, a trusted partner for the municipality of Alba Iulia, especially regarding transport projects targeting the Alba metropolitan area,



but also regarding infrastructure, cultural and educational projects, and heritage. Alba District Council is also managing several buildings in the citadel area.

Local Energy Association (ALEA) - established in 2008 with the support of the Intelligent Energy Europe program – is a non-governmental, non-profit association that contributes to the sustainable development of Alba County by improving the situation in the field of energy efficiency, energy management and the use of energy from renewable sources. ALEA aims, on the one hand, to become a competent authority in promoting the sustainable development of Alba County - by improving the current energy situation, and on the other hand, to be a decisive factor in changing the mentality of citizens regarding their behavior as energy consumers.

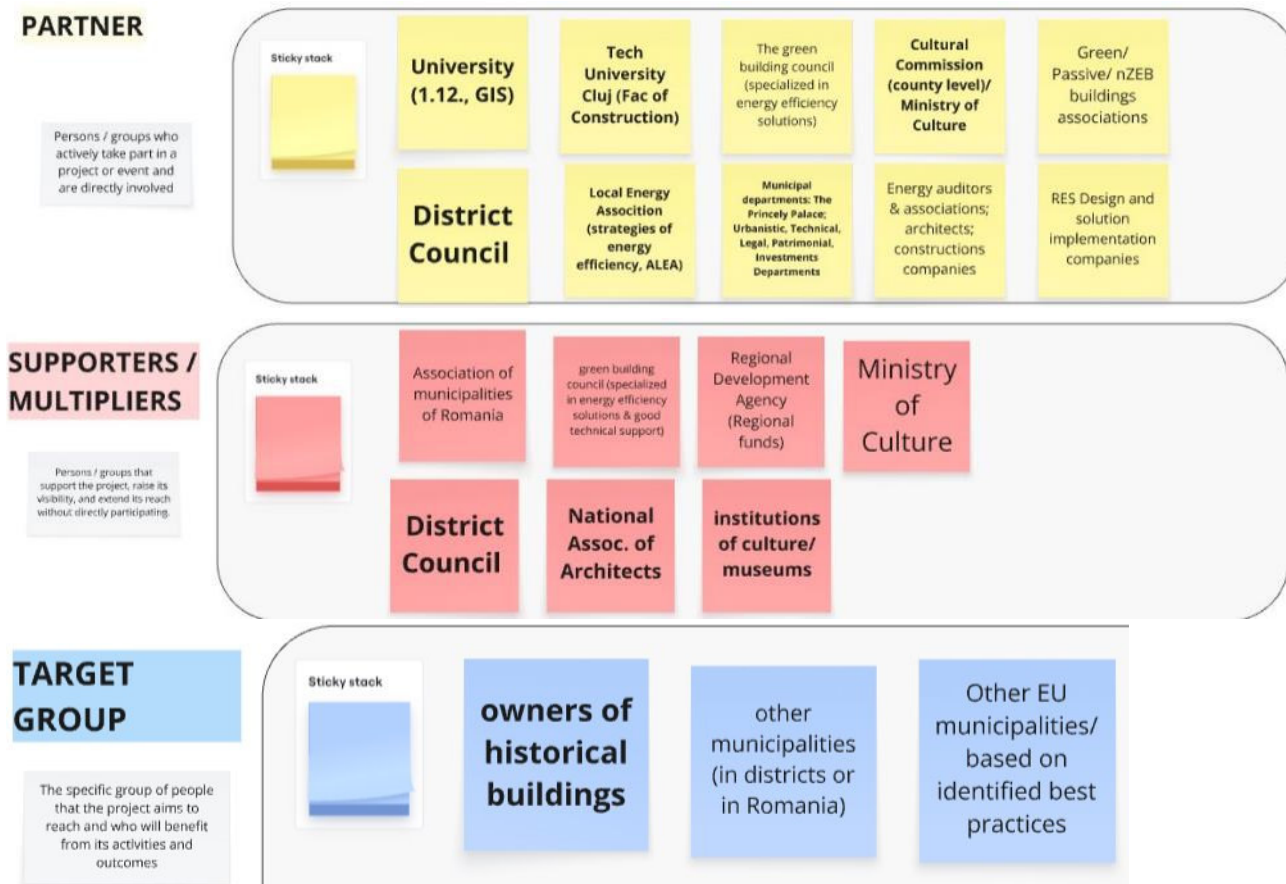
Princely Palace – established in 2023 the institution is not only an important museum but also the main organizer of events in Alba Iulia, being mandated by the Local Council. It will provide an important partner for Alba Iulia municipality in this process.

TARGET GROUPS

- **Public owners of historical buildings** (especially the owners of the buildings in the Vauban fortification) : Orthodox Archdiocese of Alba Iulia (owner of Orthodox cathedral and the entire architectural ensemble of the Cathedral of the Coronation of Kings Ferdinand and Maria); Roman Catholic Archdiocese of Alba Iulia (owner of the oldest cathedral in Transylvania); National Museum of the Union; Princely Palace Museum; Bathyanem Library (Romanian Academy); University of Alba Iulia; Alba County Council, Principia Museum; Museikon.
- **Private owners/ managers of historical buildings:** private persons/ companies, owners or managers of old houses/ locations inside the fortress (like Medieval Hotel, Pub 13, Carolina Heritage, Nicii, etc.);
- Other municipalities from Romania, especially them within Alba Iulia has partnerships
- EU municipalities (also the municipalities twinned with Alba Iulia)

SUPPORTERS/MULTIPLIERS

- Union of Architects – Romania;
- AAECR – auditors for buildings association;
- SAMER – energy auditors and managers association for companies/ industry;
- nZEB cluster;
- ARACO – constructor's association;
- RES solutions companies;
- ARM - Association of Romanian Municipalities;
- Other municipalities/ cities with historic buildings/ areas (like Sebes, Cluj, Oradea, etc.);
- Culture Ministry/ local representatives



7.3 Connection Living Lab Alba Iulia to other MonuPED WPs

The meeting of the consortium of partners, which took place on May 15, 2025 in Prague, was important to better understand the typology of the project areas and how the tools developed within the project can accelerate energy efficiency projects in historical buildings and areas. If in terms of the construction of the buildings similar elements can be identified (brick walls, plaster with artistic elements, tiled roof) in terms of the availability and management of utilities, major differences appear, in the case of the city of Alba Iulia not having a thermal energy distribution network, and the distribution of utilities being ensured by private companies, without the involvement of the municipality. Also, in Alba Iulia the property regime in the citadel area is diverse, and a real-time energy data network is not currently available for the city area, so some tools (such as Digital Twin - Slovenia, Digital Tool Pinkafeld - Austria, Thermal Precision Profiling - Leipzig) are difficult to implement locally. Other tools (GIS Energy Map) developed within MonuPED require dedicated software (ArcGIS) which is not available, a thermal network which does not currently exist (Heating storage - Leipzig). In these conditions, we estimate that there may be synergies especially with the tools developed in Prague (Roofs and facades, PV Potential Map).

The Living Lab which will be implemented in WP5, offers a collaboration framework for involvement of local stakeholders in analysis, implementation, testing and validation activities for solutions and tools developed during MonuPED. That's why WP5 is closely related in initial phases to WP2 (concepts) which provides a collection of technical challenges and possible energy efficiency/ RES solutions in historical buildings and to WP3, which validates possible solutions from the legal and regulatory point of view, together with aspects related to possible fundings. Also, WP5 is strongly connected to WP4, in which tools are developed and tested, together with some small scale implementation pilots. In this



case, Living Labs offers the proper form for developing, testing, validating concepts and implementation of tools and processes, together with promotion of results, based on active implication of stakeholders and all interested parties.

7.4 Roadmap and formats of Living Lab Alba Iulia

Stakeholders' involvement is critical in implementing Living Lab activities. That's why, it is important to engage them early in the process of the Living Lab implementation, in order to shape project goals, expectations, tailored communication channels, to build trust based on transparent responses to their needs and concerns, involve them in decision making and avoid possible disagreements.

For successfully involvement of relevant stakeholders and for maximizing their contribution to the Living Lab, we will use a structured engagement methodology, based on 4 steps:

- Identify and analyze stakeholders – based on their expertise, influence, their roles, needs, expectations and project impact (a tool like stakeholders mapping can be useful);
- Initialize a minimal engagement plan for all stakeholders with mix communication channels and engagement desired goals & outcomes;
- Engagement implementation – using clear, regular and transparent communication, encourage stakeholders inputs and feedback, provide clear answers, incorporate their answers in project documents;
- Evaluate and improve stakeholders' involvement strategy, based on engagement monitoring and feedback, outcomes evaluation.

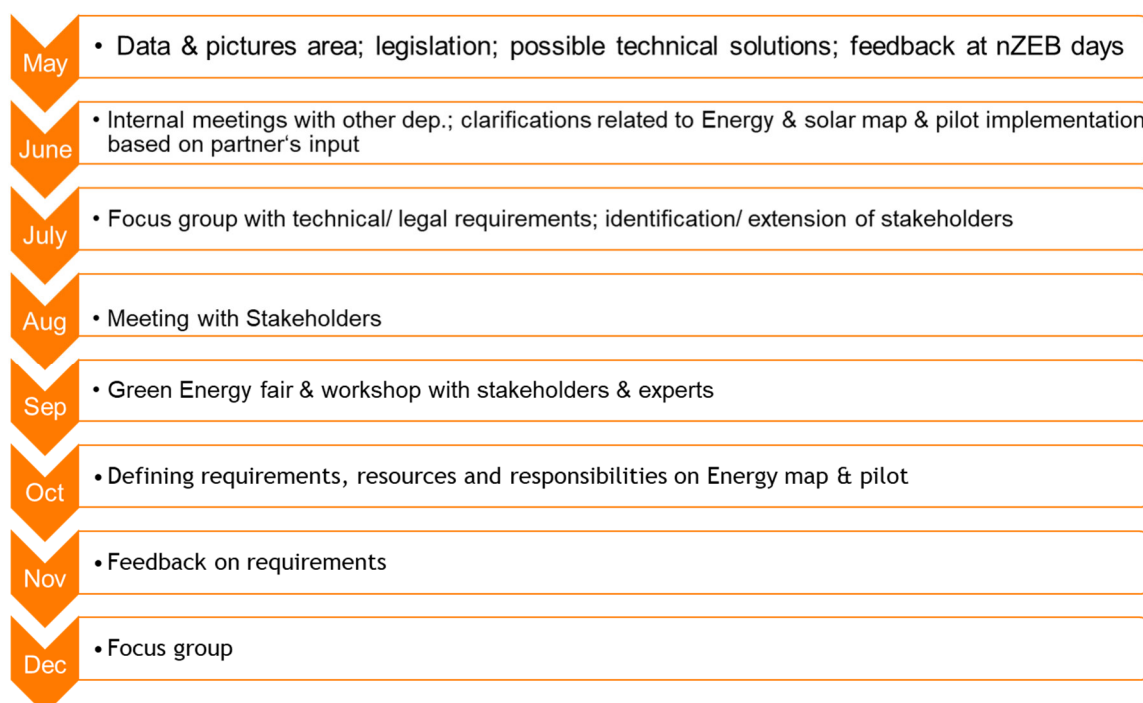


Figure 34: Figure 35: Road Map Living Lab Alba Iulia 2025



For Living Lab implementation in Alba Iulia, we will use 3 main formats.

Table 6: Possible engagement formats MonuPED Living Lab Alba Iulia:

FOCUS GROUP (non-academic format)	
Objective	Provide feedback on needed implementation actions at various stages
Involved stakeholders	Representatives of internal departments; selected stakeholder's experts
Participants, duration	5-10, 1-2 h
Frequency	1-3; Recommended for initial stage, info & data gathering, necessary experts, development, testing and feedback related to tools
MonuPED topics/ WP	WP4, WP5
How will support MonuPED	Obtain feedback on developing tools, target users engagement; components to be improved/ adjusted; tailoring tool
Organizational/ Budget needed	Clear objectives & goals; participants demographics/ expertise; logistic planning / technology; prepare effective discussions; ensuring trust/ confidentiality; feedback collection; reduced budget
Location/ requirements	In person - venue available from municipality; online tools for hybrid
ROUND TABLES/ WORKSHOP	
Objective	Present development stages, tools, evolutions, contributions, test and validate, feedback
Involved stakeholders	Internal and external experts; building owners (like District Council, University, Museums, Culture Direction), energy agency (ALEA)
Participants, duration	> 15, 3-4h
Frequency	At 4-6 months, according to evolutions
MonuPED topics/ WP	WP2 - Concepts, WP3 Investing, finance, regulatory; WP4 Toolkits, pilot, WP5 Living Lab
How will support MonuPED	Legal, regulatory, technical consultancy; development of toolkits; feedback and financing; small scale pilot implementation
Organizational/ Budget needed	Clear objectives; stakeholders involvement and responsibilities; collaborative tools; documentation and repository; reduced budget needed
Location/ requirements	Municipal location available; in person/ online/ hybrid



PUBLIC EVENTS

Objective (later stage of project)	Present MonuPED project and tools; communication - dissemination; exterior feedback
Involved stakeholders	Living Lab stakeholders; external stakeholders - cities, institutions, companies, public
Participants, duration	> 20; 1 h
Frequency	1 or 2
Monuped topics/ WP	WP2, 3, 4, 5
How will support MonuPED	Exterior feedback; ease implementation/ fine tuning of solutions
Organizational/ Budget needed	Municipal and stakeholders involvement; clear presentation and objectives; Q&A session; feedback tools; medium budget
Location/ requirements	Possible municipal building or collaboration; in person & hybrid; recommended collaboration on a larger event (like energy fair, conferences etc)



8 CASE STUDIES SLOVENIA AND AUSTRIA

8.1 Case study Koper, Slovenia

Short Description of the Area

Koper is located on the north-western coast of Istria, at the mouth of the Badaševica River, on what was once an island. The origins of the settlement date back to a time when Istria was part of the Roman Empire. The development of the settlement on the island can be traced through the legend of Aegis and in historical references to a fortified settlement known as Capris. During the Byzantine era, the town was referred to as Justinopolis, and later, under the Patriarchs of Aquileia, it was known as Caput Histriae. By this time, the majority of the island had already been urbanised.

By the late 13th century, the urban structure of the town was well established, including the main streets, squares, and public spaces. Under Venetian rule, the city was renamed Capo d'Istria. Its elliptical urban plan resembles a convex lens, with the highest elevation found in the main town square in front of the cathedral. The main streets cross from north to south and from east to west, and meet at the main town square, while smaller connecting streets follow the outline of the former island.

Koper's urban development was significantly influenced by the social structure of its inhabitants. The city includes both religious and secular architecture—palaces and typical Mediterranean urban houses arranged along the streets and clustered around two central squares, Titov trg and Brolo, as well as eight peripheral squares, some of which once bordered the harbours. Most squares featured a church, while fountains were a defining element of the marketplace.

Prešeren Square, situated at the main city gate, Porta Muda, held a key role in the city's spatial organisation. It was the starting point of the only road connection to the mainland, which crossed a bridge, followed the embankment, and passed through the Lion's Castle.

The salt pans formed an integral part of Koper's landscape and economic activity until the early 20th century. Today, these areas are repurposed for sports and recreational use, while urban expansion increasingly extends into their former territory.

The prevailing construction materials found in the historic buildings are stone, brick, and mortar. The majority of buildings have very thick outer walls, as these were the main structural and load-bearing units. The floor dividers were mainly wooden, often with gravel filling. The roofing structure is typically mediterranean, with wooden beams as support and characteristically shaped clay shingles. It can be assumed that the most prevalent incline of the roof surfaces is 24 degrees, as the shingles shape and the technology of installation precluded higher inclines.



Figure 36: A schematic presentation of the Koper Old Town,
(c) Ministry of Culture of the Republic of Slovenia, GisKD pregledovalnik (GIS Cultural Heritage brow)

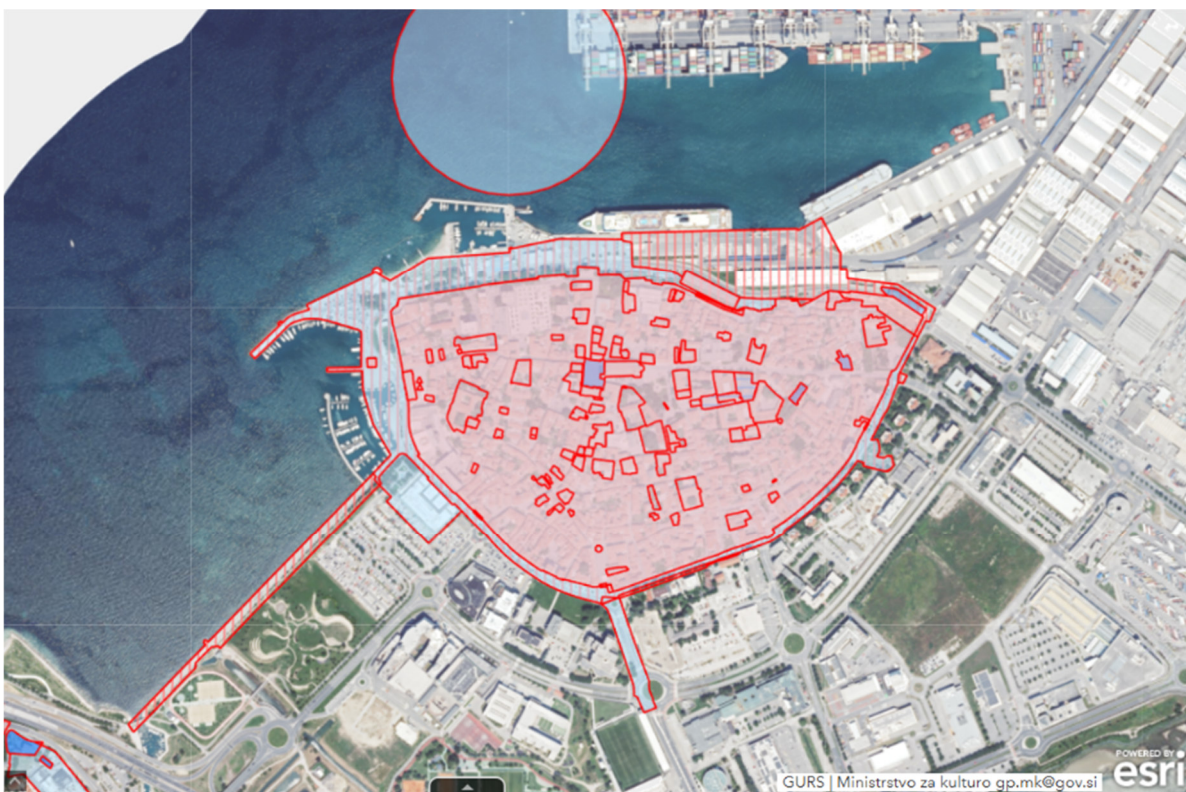


Figure 37: A GIS-based snapshot of the Koper Old Town, with cultural heritage-protected buildings and areas indicated in red.
(c) Ministry of Culture of the Republic of Slovenia, GisKD pregledovalnik (GIS Cultural Heritage browser),
<https://geohub.gov.si/ghap>

Key Challenges in Deploying PED Solutions

Buildings in the historical center of Koper are considered cultural monument of local importance, and therefore any interventions (e.g. retrofitting, reconstruction, demolition) must be approved by the



Institute for the Protection of Cultural Heritage of Slovenia (ZVKDS). With the long history described above, it is evident that the area is also on the “red” list of archaeological areas.

Therefore, geothermal energy production was ruled out as a possible source of green energy, and wind-generated electricity (the propellers, turbines, and columns cannot be aesthetically incorporated in cultural heritage-protected areas) as well. In historical towns in the Mediterranean, protected as cultural heritage, where thick stone walls offer a reasonably good thermal insulation and phase delay, roof retrofitting is a pivotal component in enhancing building energy efficiency. It reduces energy loss through better insulation and sealing air leaks. PV panels installation may be in some cases permitted by the cultural heritage protection authorities, as it can be done without negatively impacting building structures and material composition (can be absolutely reversible). Moreover, it can be done in such a way that the panels are not visible from the streets. If not, energy-community types of installations can provide off-site PV electricity production. Koper may be a very good example thereof, as the Old Town is located in close proximity to the city's port, where large areas of buildings and other infrastructure could serve as good areas for PV panels installation. Roof retrofitting and PV installations were therefore identified as the most likely (if not the only possible) interventions in decarbonization effort of the Koper Old Town,

The tool that we are preparing for the Case study Koper is a digital twin-like tool that will help to understand the influence of cultural heritage protection regulations and other measures (e.g. subsidies, non-financial support, etc.) on the decision-making process of property owners regarding interventions for energy use reduction and renewable energy production. It will demonstrate its capabilities in the use case of Koper Old Town. It is an agent-based model of citizen engagement in creating a net-positive energy district that is protected by cultural heritage preservation regulations. With its digital simulation-based implementation of the agent-based models of citizen engagement, it models the users and their behaviour through their interaction with cultural heritage concerning the energy consumption and creation (see also description on MonuPED report D4.1). It will provide information on regulatory/subsidy changes that would spur energy transition in cultural heritage protected districts.⁷

Connection to Existing Local Strategies, Networks, and Projects

A holistic Sustainable Urban Strategy for the decarbonisation of the Koper municipality is currently in preparation, and preliminary results of MONUPED project will be a good input for its finalisation. It will be based on several strategic documents, which we can also use in the preparation of the agent-based model digital simulation:

Analysis of vulnerability and risks of the Koper municipality due to climate change (Analiza ranljivosti in tveganja zaradi podnebnih sprememb za občino Koper (Golea, 2020))

Koper urban municipality action plan for sustainable energy (Akcijski načrt za trajnostno energijo Mestne občine Koper (Golea, 2019))

Istria, Brkini, Karst regions regional development programme 2021-2027 draft (Regionalni razvojni program Regije Istra, Brkini, Kras za obdobje 2021-2027 - Strateški del (osnutek, delovno gradivo) (RRC Koper, 2019))

Koper urban municipality spatial plan draft (Občinski prostorski načrt Mestne občine Koper (MOK, osnutek 2020))

⁷ <https://www.koper.si/regulation/odlok-o-razglasitvi-historicnegamestnega-jedra-kopra-za-kulturni-spomenik-lokalnega-pomena/>



Koper urban municipality concept of sustainable mobility (Koncept trajnostne mobilnosti v Mestni občini Koper (Biro Obala d.o.o., 2015))

Koper Smart City strategy (Strategija »Koper- Pametno mesto« (Harpha sea d.o.o., 2015))

Koper urban municipality local energy concept (Lokalni energetske koncept Mestne občine Koper (Boson d.o.o., 2013))

Koper urban municipality municipal environment protection programme (Občinski program varstva okolja MOK 2021-2025 (Boson d.o.o., 2020))

Historical towns of Slovenia development strategy (Historical towns of Slovenia Association, 2015)

Furthermore, the Port of Koper is obliged to allocate some funds annually, to offset the negative influence of its activities on the well-being of the Koper inhabitants. Some of their annual calls tackled also the issue of energy efficiency of buildings (building envelope insulation, windows replacement, etc.), although they were primarily focusing on reduction of noise pollution.

Key Stakeholders and Their Roles

Municipality and National policy- and decisionmakers are the main foreseen users of the Digital Twin-like tool to support urban heritage areas' decarbonization. It will enable them to test their planned measures (legislative, executive, subsidy policy, etc.) intended to spur decarbonisation of heritage-protected urban districts in various scenarios, supported by sound econometric and social behaviour knowledge, and data/information. However, with slight modification of input data, a digital simulation of behaviour towards energy refurbishment could be performed also on the level of single building or a cluster of buildings. In that case, building/dwelling owners could be its users.

The main beneficiaries of the Digital Twin-like tool are the property owners in the cultural heritage protected urban district. As the main users (described above), they will be able to make better informed and tailored decisions on legislative, regulatory, executive and subsidy-preparation level, that will help them to be good stewards of cultural heritage and the environment with less regulatory and financial barriers to overcome.

Urban planners, construction sector and energy companies, underwriters (banks, investment funds, insurance, etc.) and supporters (public funds, NGOs, etc.) of energy transition, and the general public are undisputed stakeholders in the process of decarbonization of cultural heritage-protected urban districts, and therefore also of this digital tool.

8.2 Case study Pinkafeld, Austria

Short Description of the Area and Building

The City Hall of Pinkafeld is centrally located on the main square of Pinkafeld, a small town in Burgenland, Austria, which is home to about 6.000 residents. Built between 1951 and 1954 in the typical Pannonian style, the building features round arches and an alley, blending historical architectural elements with more recent renovations. It houses the offices of the mayor, municipal council, and various administrative departments, serving as the primary point of contact for citizens and local businesses. The surrounding area is characterized by low-density residential and commercial buildings, with limited high-rise development, reflecting the city's modest scale and community-oriented urban fabric. Nearby landmarks include the parish church and the historic Batthyány Castle, underscoring the town's rich heritage.



The following figures show the location of the City Hall in the center of Pinkafeld and the exterior view of the building.

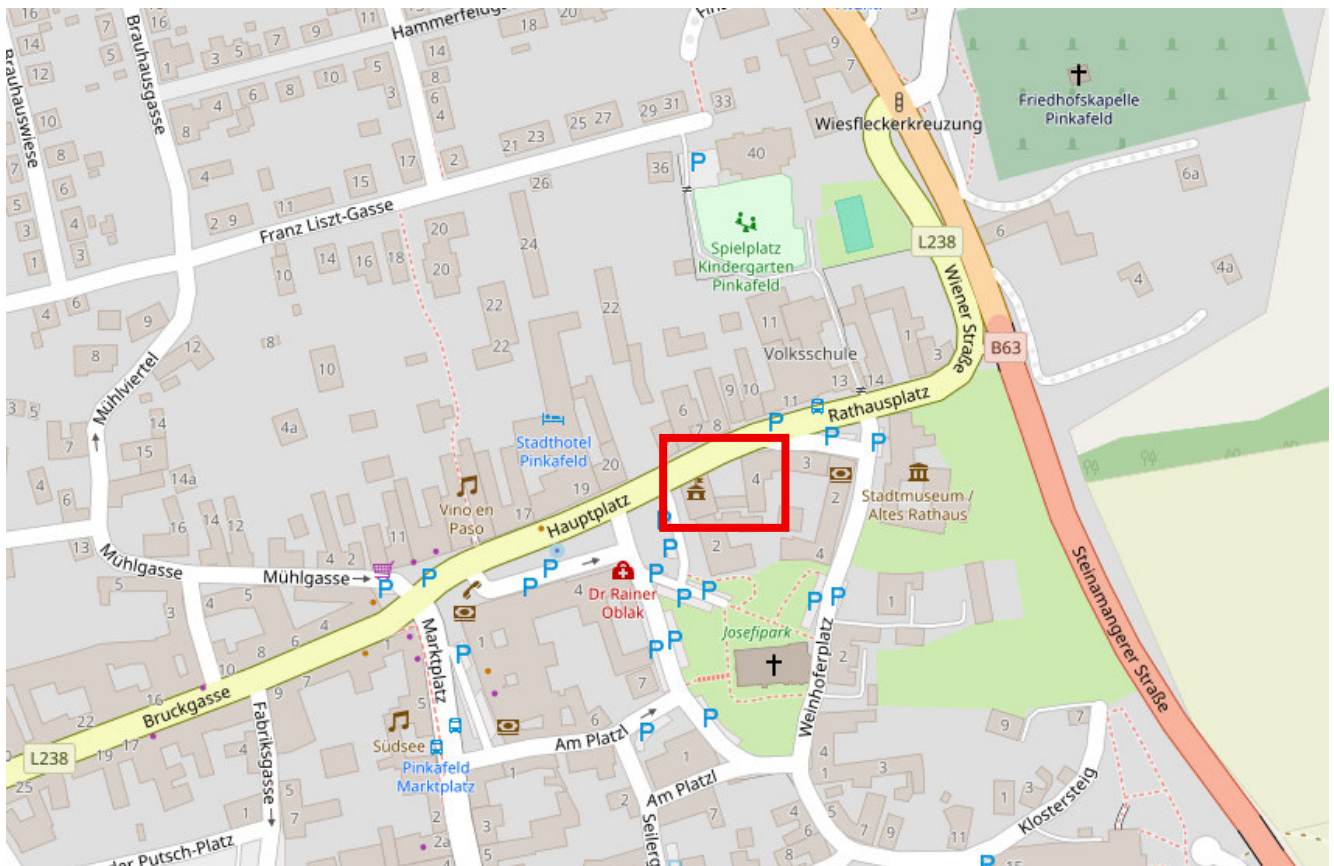


Figure 38: Location of Pinkafeld City Hall in the town center. Map excerpt from OpenStreetMap ©, accessed June 6, 2025. (OpenStreetMap contributors, 2025)



Figure 39: Exterior view of Pinkafeld City Hall, (c) Nora Kirchknopf

Key Challenges in Deploying PED Solutions

Deploying Positive Energy District solutions in the context of Pinkafeld's City Hall presents several specific challenges:

- **Energy Efficiency Constraints:** The building's older sections and heritage features limit the extent of structural modifications possible for energy upgrades.
- **Spatial Limitations:** The compact site and preservation requirements restrict the installation of large-scale renewable energy systems such as photovoltaic (PV) panels.
- **Aging Infrastructure:** Integrating smart energy systems is complicated by outdated electrical and heating infrastructure in the City Hall.
- **Stakeholder Engagement:** The PED concept is relatively new to many local actors, necessitating targeted awareness and capacity-building efforts.
- **Regulatory and Policy Barriers:** Heritage protection laws and municipal regulations can slow or complicate the implementation of innovative energy solutions.

Connection to Existing Local Strategies, Networks, and Projects

The PED activities at Pinkafeld City Hall are closely connected to several regional and local strategies and initiatives:

- **Burgenland's Regional Energy Strategy 2030:** This strategy sets ambitious goals for climate neutrality and the expansion of renewable energy across the region, providing a supportive policy environment for PED activities.



- **Climate and Energy Model Regions (KEM):** Pinkafeld is part of this national initiative, which supports local energy transition efforts through tailored funding, advisory services, and knowledge exchange.
- **Collaboration with Hochschule Burgenland:** The University of Applied Sciences Burgenland, located in Pinkafeld and Eisenstadt, is a key partner, offering applied research and technical expertise in sustainable energy and smart technologies.
- **Interreg and Smart City Projects:** Pinkafeld participates in EU-funded projects such as Interreg and Smart City initiatives, which facilitate knowledge transfer and the replication of PED solutions.
- **KLAR! Network (Climate Change Adaptation Model Region):** The town is part in the KLAR! network, which promotes climate resilience and adaptation strategies at the municipal level.

Key Stakeholders and Their Roles

The following table provides an overview of the key stakeholders involved in the project, along with their respective roles and contributions.

Table 7: Key stakeholders and their roles in Case Study Pinkafeld

Stakeholder	Role and Contribution
Municipality of Pinkafeld	Project owner and main target group; ensures integration with urban planning and local policy
University of Applied Sciences Burgenland	Research partner; provides technical expertise and R&D support for smart energy systems
Energie Burgenland (utility)	Partner; enables integration of smart grids and renewable energy solutions
Local residents and businesses	Target group; benefit from improved municipal energy services and participate in co-creation/testing
Regional development agencies	Multipliers; promote replication of successful solutions and facilitate access to funding
Construction and tech suppliers	Partners; implement energy-efficient retrofits and smart building solutions
KLAR! Network	Supporter/multiplier; amplifies results through regional climate adaptation initiatives
Local media and civic groups	Supporters; raise awareness and foster community engagement

The City Hall of Pinkafeld serves as a representative and practical use case for PED implementation in a small town in Austria. The project leverages the central role of the building, the town's strong regional partnerships, and the presence of networks such as KEM and KLAR! to address the unique challenges of integrating innovative energy solutions in a heritage context. The involvement of diverse stakeholders



- from city staff and residents to research institutions and utilities - ensures a holistic approach to achieving climate and energy goals in line with regional and national policies.



9 SUMMARY AND NEXT STEPS

The report D5.1 Living Lab Design provides an overview of the essential elements of the three MonuPED Living Labs in Leipzig (Germany), Prague (Czechia) and Alba Iulia (Romania) and the two case studies in Koper (Slovenia) and Pinkafeld (Austria).

The emphasis is on the mapping of relevant stakeholders as basis for the broad implementation of the Living Labs and outlining a roadmap with next steps for stakeholder engagement in 2025.

The MonuPED Living Lab approach and content is strongly linked to the activities within the other MonuPED workpackages, namely the conceptual work on challenges and possible solutions for PEDs in MPA/MPBs (WP 2) and new financial and regulatory approaches (WP3). Furthermore the Living Labs (WP5) serve as the testing ground for digital solutions and concepts developed in WP4.

In the MonuPED Living Labs a diverse range of stakeholder groups is engaged to ensure comprehensive and inclusive project implementation. These groups include local authorities and urban planners play a crucial role in shaping policies and regulations that support sustainable energy initiatives while preserving heritage.

Heritage protection agencies are involved to ensure that historical integrity is maintained throughout the transformation process. Research institutions and universities contribute technical expertise and innovation, facilitating the development of advanced energy solutions. Private sector companies, including those specializing in renewable energy and smart technologies, provide resources and practical solutions for implementation. Additionally, non-governmental organizations (NGOs) focused on environmental sustainability and monument protection can be multipliers in all three cities to enhance public awareness and engagement.

The identification of stakeholders lays the foundation for the formulation of activities aimed at effectively implementing the Living Labs' objectives:

The implementation of the Living Labs is designed as an iterative process, i.e. feedback is obtained after each interaction and key points are evaluated. The focus here is on the necessary identification and involvement of further stakeholders and the (further) development of the participation formats used. In addition, the interim results from work packages 2, 3 and 4 are discussed and fed back to the respective target groups at irregular intervals.



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