PEDvolution

Interoperable solutions to streamline PED evolution and cross-sectoral integration

Deliverable No 1.1

Local community analysis and initial engagement plan

Co-funded by the European Union

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement Nº 101138472.

The Swiss project participants received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Document Summary Information

Grant Agreement No	**101138472**	Acronym	**PEDvolution**
Full Title	**Interoperable solutions to streamline PED evolution and cross-sectoral integration**		
Start Date	**01/01/2024**	Duration	**36 months**
Project URL	**https://www.pedvolution.eu/**		
Deliverable	**D1.1 Local Community Analysis and Initial Engagement Plan**		
Work Package	**WP 1: User-centered analysis**		
Contractual due date	**31.10.2024**	Actual submission date	**31.10.2024 (first submission)** **09.02.2026 (resubmission)**
Nature	**R - Report**	Dissemination Level	**PU - Public**
Lead Beneficiary	**SIN**		
Responsible Author	**Minna Kuivalainen (Smart Innovation Norway)**		
Contributions from	**Veronika Sabikova (Smart Innovation Norway)** **Pascal Kienast (ZHAW)** **Jonas Giger (ZHAW)** **Alessandro Conte (ZHAW)** **Vicente Carabias (City of Winterthur)** **Aleš Ažman (Elektro Gorenjska)** **Matjaž Eržen (GEK)** **Agnia Dewi Lasarati (SWW)** **Evyatar Littwitz (SWW)** **Rainer Haertl (SWW)**		
Reviewed by	**Maria-Ioanna Pavlopoulou (SXS)** **Reda El Makroum (TUW)** **Markos Psimitis (INLE)**		

Disclaimer

PEDvolution - This project has received funding from the Horizon Europe Framework Programme (HORIZON) under the GA No. 101138472.

Revision history (including peer reviewing & quality control)

VERSION	ISSUE DATE	% COMPLETE[1]	CHANGES	CONTRIBUTOR(S)
v0.1	18.06	5 %	Initial Deliverable Structure	SIN
v.0.2	12.07	7 %	Official table of contents	SIN, SXS, INLE, TUW
v.0.3	30.08	40 %	Draft chapters 2, 3, and 4	SIN
v0.4	27.09	80 %	Contributions from PED partners	City of Winterthur, EG, GEK, SWW, ESG, ZHAW
v0.5	08.10	90 %	Integrating partner contributions and finalising the draft for review	SIN
v0.6	15.10	95 %	Review and quality control	SXS, TUW, INLE
v0.9	29.10	99 %	Integration of comments and final draft	SIN
v1.0	30.10.24	100 %	Approval of the final version	SIN, TUW, INLE
v1.1	30.10.25	102 %	Correcting broken link and specifying linkages to future deliverables in the Conclusions section.	SIN
v1.2	03.02.26	108 %	Further detailing methodological choices and specifying relation with future deliverables.	SIN
V1.2	04.02.26	108%	Approval of version for resubmission	INLE

[1] According to Project's Quality Assurance Process

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Abbreviations

ABBREVIATION / TERM	DESCRIPTION
BAFA	Federal Office of Economics and Export Control (in Germany)
BEG	Federal Promotion for Efficient Buildings (support scheme in Germany)
BESS	Battery Energy Storage Systems
CHP	Combined Heat and Power
GeHa	Gemeinschaft Hard AG (company managing the local community at the Swiss site)
CSC	Collective Self-consumption
DSO	Distribution System Operator
EBW	Energie Bewegt Winterthur
EEG	Renewable Energy Sources Act (in Germany)
EG	Elektro Gorenjska (Slovenian project partner)
ESC	Energy Sharing Community
ESG	Es-geht! Energiesysteme GmbH (German project partner)
EV	Electric Vehicle
FPP	Future Power Plant
GA	Grant Agreement
GEK	Gorenjske Elektrarne d.o.o. (Slovenian project partner)
ICT	Information and Communication Technology
IoT	Internet of Things
KfW	Kreditanstalt für Wiederaufbau (German Federal Development Bank)
LEC	Local Energy Communities
NRW	North Rhine-Westphalia
PED	Positive Energy District

P2G	Power-to-Gas
P2H	Power-to-Heat
PV	Photovoltaic
RE	Renewable Energy
SET-Plan	Strategic Energy Technology Plan
SME	Small and Medium-sized Enterprises
SWW	SWW Wunsiedel GmbH (German project partner)
TSO	Transmission System Operator
VAT	Value Added Tax
VPP	Virtual Power Plant
WP	Work Package
ZEB	Zero Energy Buildings
ZHAW	Zurich University of Applied Sciences (Swiss project partner)
ZENOB	Zukunfts Energie Nordostbayern GmbH (German project partner)

Glossary of terms

ABBREVIATION / TERM	DESCRIPTION
Positive Energy District (PED)	Energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy.
Energy-Sharing Community (ESC)	A community-based structure that allows local participants, including households and businesses, to share renewable energy.
Super PED	A system that integrates multiple Positive Energy Districts to create a larger district-level energy system.
Energy Management Systems (EMS)	Systems used to monitor, control, and optimize energy use within a building or district.
Virtual Power Plant (VPP)	A system that aggregates distributed energy resources (like solar, wind, and battery storage) to operate as a unified power source.
Combined Heat and Power (CHP)	A system that simultaneously generates heat and electricity from a single fuel source.
Power-to-Gas (P2G)	A technology that converts electricity into gas, typically hydrogen or synthetic natural gas.
Power-to-Heat (P2H)	A technology that converts electricity into heat for direct use or for storage.
Battery Energy Storage Systems (BESS)	Technology used to store energy in batteries for later use, often for balancing energy supply and demand.
Photovoltaic (PV)	Technology that converts sunlight into electricity, commonly used in solar panels.
Zero Energy Buildings (ZEB)	Buildings that generate as much energy as they consume over the course of a year, typically through renewable energy sources.
Demand response	A system where consumers adjust their energy use based on supply conditions, often incentivized by lower energy prices during off-peak hours.
Prosumer	A participant who both produces and consumes energy, typically generating renewable energy and sharing or utilizing excess energy within a local energy community or the grid.
Prostormer	A prosumer with energy storage capabilities, allowing them not only to generate and consume energy but also to store excess energy for later use or for sale back to the grid.
Flexibility provider	An entity that adjusts its energy production or consumption in response to market signals or grid needs to help balance supply and demand.

Aggregator	A service provider that groups multiple consumers or prosumers to offer collective energy flexibility to the grid or other markets.
Energy cooperative	A community-driven organization where members jointly invest in and benefit from energy projects, often focused on renewable energy generation.

1 EXECUTIVE SUMMARY

Positive Energy Districts (PEDs) are urban energy initiatives that aim to achieve a positive annual renewable energy balance. They do this by integrating different technologies, such as renewable energy generation, smart grids, and storage systems to optimise energy use and increase efficiency. At the same time, they aim to respond to the overall objectives of environmental, social and economic sustainability.

The planning and design of PEDs requires a unique design that considers the specific characteristics of each area, including available energy resources, consumption patterns and socio-economic conditions. This report provides an account of the main socio-economic characteristics of the pilot sites in the PEDvolution project, which in combination with Deliverable 1.2 "Functional and operational requirements for the demo sites and reference use cases" [1] provides a broad outline of the main characteristics of the project.

The PEDvolution project includes demonstration sites in Germany, Slovenia and Switzerland, which are different in their nature and characteristics, such as in their main typologies and governance structures, their way of interacting within distinct regulatory frameworks and their contextual characteristics (see Table 1 below).

Table 1: Overview of key pilot site characteristics.

	SCHÖNBRUNN	KRANJ	WINTERTHUR
Location	Schönbrunn, Wunsiedel, Bavaria, Germany	Labore industrial zone and Planina neighborhood, Kranj, Slovenia	Hard community, outskirts of Winterthur, Canton of Zurich, Switzerland
Building characteristics	Detached houses (~400 households), small businesses, apartment buildings, public buildings	1970s-80s apartment blocks (~12,500 residents), industrial zone	Mixed-use: 45 apartments, 40 businesses (~250 residents)
Energy sources	Solar PV, CHP (wood pellets)	Waste heat, solar PV, hydropower	Solar PV, hydropower, central gas heating
Technological infrastructure	Energy-sharing community, local heating network, "Future Power Plant" concept	District heating, CHP, integration of waste heat, rooftop PV installations	Solar PV, smart meters, charging infrastructure for electric vehicles, shared mobility, central gas heating
Regulatory enablers	Feed-in tariffs for solar, Zero VAT Tax relief on solar panels and	100 Climate Neutral and Smart Cities by 2030, Act on the Promotion of the	Electricity Act, Net Zero 2040, Energy and Climate Concept as well as local

	SCHÖNBRUNN	KRANJ	WINTERTHUR
	installation, The federal KfW Development Bank Programs, Federal Promotion for Efficient Buildings (BEG), Bavarian Energy Loan, Battery Energy Storage Subsidy, KfW Program 270, progres.NRW, the L-Bank Energy Efficiency Loans	Use of Renewable Energy Sources, Act on the Efficient Use of Energy, updated tariff system for electricity, funding schemes for renewable energy	Energy plan from the city of Winterthur, national renewable energy policies
Key actors	SWW, WUNpellet, local brewery, residents	Elektro-Gorenjska, Gorenjske Elektrarne, companies in the industrial zone, Planina boiler house, Boiler house citizen representative group	Gemeinschaft Hard AG, local SMEs, residents, municipality, Hard community – community members
Barriers to implementation	Regulatory barriers to energy communities, high storage costs, limited participation by residents	High upfront investment costs, technical challenges with integrating waste heat	Historical preservation constraints, limited financial resources, challenges with integrating new energy systems

The Swiss site involves a local community that shares sustainability-related values and has a history of community-based action. They are now looking for further ways to develop green energy production. The German site involves a local DSO that has a goal to integrate a range of actors, from local residents and prosumers to local commercial actors, to flexibility-related activities and further greening of the energy mix. The Slovenian site involves the integration of industrial waste heat into the district heating network to reduce emissions and dependence on gas for heating with the involvement of actors from the local industrial zone.

The sites involve a range of different actors and are influenced by a number of stakeholders. Through initial stakeholder mapping and analysis, this report outlines the key actors within each site's ecosystem, identifying roles and potential influence on the activities to be implemented. Based on this analysis and combined with early discussions and feedback sessions with some of the key stakeholders, stakeholder engagement strategies have been developed to ensure that the project is aligned with the ambitions of each site.

Looking forward, this document provides information to guide engagement efforts and strengthen the alignment between the PEDvolution activities and the needs of each pilot site.

In summary, this report sets out the context and associated opportunities and challenges identified at each pilot site, acting as a baseline for the development of sustainable, flexible and community-driven positive energy districts.

2 INTRODUCTION

Positive Energy Districts (PEDs) represent a significant advancement in urban energy management, characterised by their ability to produce more energy than they consume. The concept gained a formal recognition through initiatives such as the European Union's Strategic Energy Technology Plan (SET-Plan) Action 3.2, which aims to establish 100 PEDs by 2025 [2]. The overarching goal of PEDs is to facilitate a shift from traditional energy consumption patterns towards a more sustainable and self-sufficient model that reduces carbon emissions while enhancing energy security and resilience [3], [4], [5].

PEDs evolved from earlier concepts such as Zero Energy Buildings (ZEBs), which primarily focused on individual structures. In contrast, PEDs emphasize energy systems at the district level, where interconnected buildings and infrastructures manage energy flows dynamically [6]. The European Union defines PEDs as "*energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability*" [2].

In terms of technical infrastructure, PEDs leverage advanced technologies such as smart grids and energy storage systems to optimize energy use and enhance the efficiency of energy distribution [7], [8]. The integration of these technologies allows for real-time monitoring and management of energy flows, enabling districts to adapt to fluctuations in energy production and consumption. Furthermore, the deployment of renewable energy systems, such as solar panels and wind turbines, is a critical component of PEDs, as it directly contributes to achieving the desired positive energy balance [7], [8]. The combination of these elements supports the operational efficiency of PEDs while contributing to the broader goal of reducing greenhouse gas emissions [2], [3].

In addition to the technical fabric of PEDs, their development is fundamentally linked to the principles of stakeholder and community engagement and community involvement. Effective implementation requires a framework that facilitates communication among various stakeholders, including local governments, residents, and energy providers [8], [9]. Moreover, the design and planning of PEDs requires an approach that considers the unique characteristics of each urban area, including its energy resources, consumption patterns, and socio-economic context [11], [12].

In light of the above, the PEDvolution project addresses the complex and evolving nature of PEDs, with the focus on technology, market, social and interoperability layers – the PED genotype – and their interaction with the existing context that gives shape to the PED phenotype – the set of observable characteristics of the PED, forming unique PEDs that are created and that operate in line with the possibilities of the techno-economic and social construct and opportunities and limitations set forth by the local context.

To achieve this, the project will develop and implement seven key solutions: *a PED Design and Planning Toolset, PED Readiness Assessment, Dynamic Decision Support Guideline for PED Development, PED Energy Manager, Interoperability Platform, PED Business Models Innovation Tool, and a Social Innovation Tool*. These solutions will be tested and validated in three real-life PEDs across Europe, ensuring their adaptability and scalability. In general, the project aims to create sustainable urban energy ecosystems capable of evolving with transitions on environmental and social conditions.

Figure 1 illustrates the PEDvolution understanding of the multiple layers and evolutionary dimensions of PEDs.

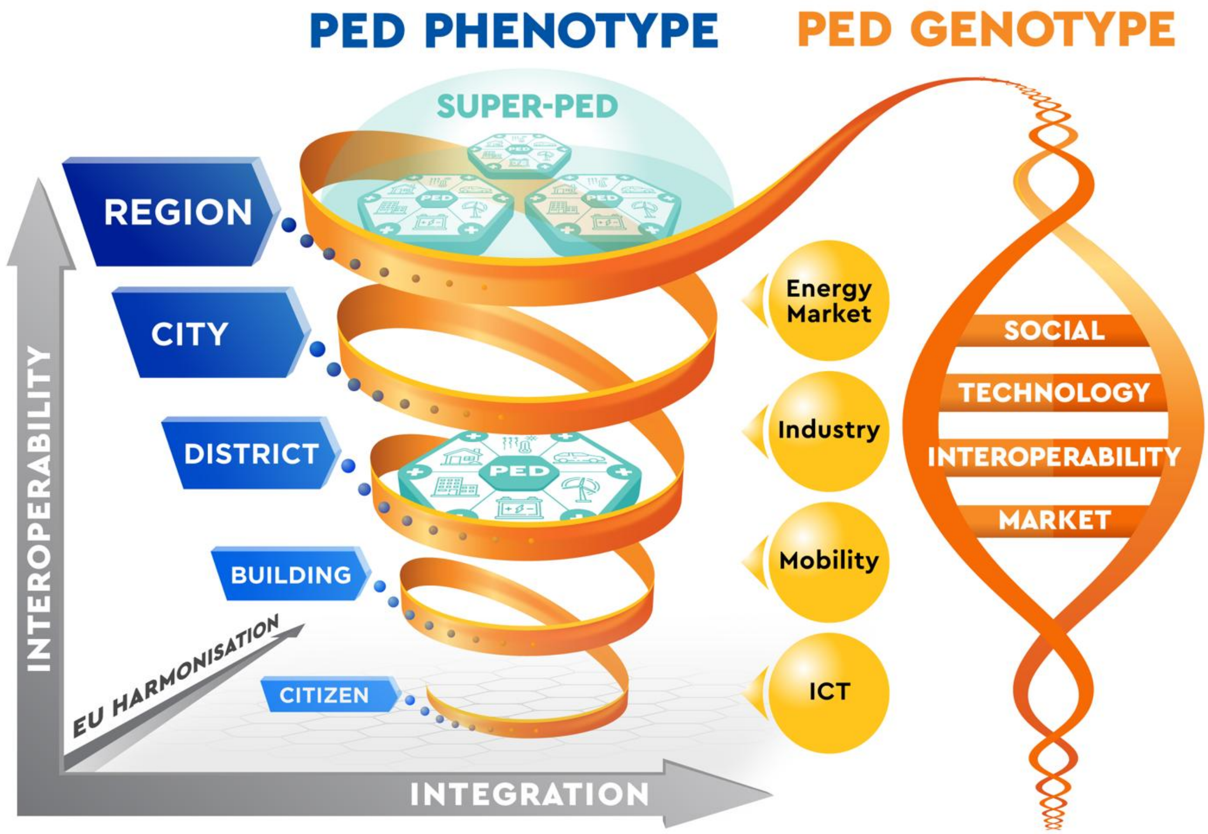

Figure 1: Multiple dimensions and evolutionary nature of PEDs.

The PEDvolution tools and solutions will be tested in three pre-defined locations, or pilot sites. Additionally, at least three more pilot sites will be selected through an open call in year 2 of the project. The current pilot sites include the following:

The PED in the village of Schönbrunn, Germany, focuses on deploying energy management tools that enable automated energy and flexibility management. The PED has an energy sharing community as a core part of the local system, and it further seeks to integrate existing prosumers as well as to transition consumers into prosumers or prostormers (prosumers with storage). Additionally, the PED aims to support the integration of consumers without houses into energy communities or offer possibilities for energy flexibility.

The PED in Kranj, Slovenia, will include integration of waste heat from an industrial area to support the district heating system serving the nearby residential area. The PED will further explore incorporation of various renewable energy sources, such as solar PV and hydropower, into its operation.

The PED in Hard community in the outskirts of the City of Winterthur, Switzerland, includes a community-driven local energy system with local hydropower and solar PV production seeking ways to reduce dependency on gas heating and further reduce emissions of the energy consumed at the site.

The piloting activities will help demonstrate not only the tools to be developed in the PEDvolution project, but also highlight the distinct PED phenotypes resulting from the implementation of the PED tools in distinct settings within different levels of evolutionary process. The piloting will also reveal further information on the market potential and prospects of the PEDvolution tools.

In general, the PEDvolution tools provide support to planning, operating, and assessing local energy systems. Looking at each tool individually, the market potential for the PED Design and Planning Toolset involves a high demand from municipalities, utility companies, and energy service companies seeking data-driven and reliable energy planning tools. The Dynamic Decision Support Guideline offers a strong potential for municipalities and private stakeholders involved in sustainable city planning and development, requiring flexible and adaptable planning tools. The potential for the PED Energy Manager focuses on decentralized energy markets, enabling PEDs to provide flexibility services, engage in real-time optimization, and capitalize on new revenue streams. The Data Exchange and Interoperability Platform has strong market potential for energy companies and local communities needing secure, transparent, and GDPR-compliant data exchange systems that facilitate new business models. The PED Readiness Assessment can be used for municipalities and developers seeking certification to meet sustainability goals, enabling consulting services and technical audits. The PED Business Models target strong demand from energy cooperatives and service providers, especially in regions with support for community-owned energy projects and local energy markets. The PED Social Innovation Tool can be lucrative for municipalities and energy cooperatives looking to foster social acceptance and active participation in the energy transition for a just and inclusive transformation.

This deliverable seeks to shed light on the contextual opportunities and limitations associated with PEDs in the project's currently defined pilot sites. Topics covered include socio-economic characteristics, legal frameworks, and current stakeholder engagement practices. It further introduces the first steps for stakeholder engagement through mapping the stakeholders present in each PED and understanding their role in the PED development, as well as turning the information into general engagement roadmaps for each site.

Understanding the local conditions and the types of local actors influencing and shaping the implementation of the PEDs is vital. This understanding helps to anticipate and address opportunities, risks, and challenges related to the implementation of local energy initiatives as well as enhances the uptake of the initiatives through active collaboration and co-creation of the solutions. It will further help to assess better the market prospects of the technology in similar settings.

2.1 Mapping the Project's Outputs

This deliverable is related to the PEDvolution project, in which a consortium of partners will develop tools for management and operation of PEDs, to be tested in practice in three pilot sites. The project tasks and deliverables are interrelated and jointly contribute towards wider expected outcomes. The purpose of this section is to map project's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed to highlight the role and position of the deliverable within the wider project context.

Table 2: Adherence to project's GA deliverable & task descriptions.

PROJECT GA COMPONENT TITLE	PROJECT GA COMPONENT OUTLINE	RESPECTIVE DOCUMENT CHAPTER(S)	JUSTIFICATION
DELIVERABLE			
D1.1: Local community analysis and initial engagement plan	Local community analysis and definition of initial end-user engagement activities for the proposed PEDvolution solutions.	Deliverable 1.1 covers the entire task 1.1.	The deliverable is divided into two sections: the Chapter 3 sets each PED demonstration site into the wider context by accounting for local contextual factors, such as regulation, institutions, and social and environmental parameters. Chapter 4 then proceeds to build stakeholder engagement roadmaps, including stakeholder feedback.
TASKS			
T1.1: PED social analysis and stakeholder engagement	This task conducts an initial analysis of the PEDs from social, community and market perspectives and provide recommendations for stakeholder engagement to activate the engagement of the local society and the end-user across the proposed solutions to be developed in the project. The initial community analysis provides information on local demographics, dynamics, structures and	The deliverable demonstrates the results of the entire task.	Chapter 3 gives an overview of the PED context and dynamics, including the local socioeconomic perspectives, such as local demographics, as well as regulatory and market considerations, jointly accounting for the "initial community analysis". Chapter 4 starts with presenting the methodology to develop stakeholder engagement plans, such as the stakeholder analysis exercise, before providing recommendations for stakeholder engagement through the engagement roadmaps to be presented. The development process of the engagement

	overall views of the stakeholders towards the concept of PEDs. The task includes a stakeholder analysis to inform initial engagement planning (D1.1). It will further enable the engagement of the end-users facilitating the creation of the Super PED concept.		roadmaps includes stakeholder consultations. As a deviation from the original task description, this document does not address stakeholder involvement in the concept of "super-PED". It was deemed more suitable to tackle this topic at a later stage, when more maturity in the project planning and integration of the tools would allow more structured discussions and feedback from the stakeholders. The German PED has been identified as a suitable candidate for the feedback session(s).

2.2 Deliverable Overview and Report Structure

The objective of this deliverable is twofold, providing both foundational context and actionable insights for the PED pilot sites within the PEDvolution project. This deliverable aims to:

1. Contribute to the understanding of local operational contexts: This involves a detailed analysis of the socio-economic, governance, and regulatory frameworks that shape the development and success of PEDs in the selected pilot sites—Germany, Slovenia, and Switzerland. Each site is embedded in its unique local setting, and this section will explore the key factors such as local economic conditions, institutional structures, and policy landscapes that influence energy transition efforts. By understanding these conditions, we can better anticipate challenges and opportunities for implementing energy innovations.
2. Identify and assess relevant local actors and their roles: A critical element for the success of PEDs is stakeholder engagement. This deliverable maps out the key stakeholders, ranging from local authorities, utility companies, and residents to businesses and regulatory bodies and assesses their level of involvement in the PEDvolution project. Understanding the different perspectives, interests, and potential contributions of these actors helps to tailor engagement strategies, ensuring active participation and co-creation throughout the project.

By doing so, this deliverable extends from the D1.2 "Functional and operational requirements of the demo sites and reference use cases," [1] and D1.3 "System architecture and technical specifications," which define the technological and systemic dimensions of the PEDs and associated system architecture in PEDvolution, including an analysis of available technologies, associated use cases, and actors in the system. The contextual look provided in this deliverable helps to determine the potential evolutionary pathways from the societal perspective and ensures that relevant stakeholders are involved in this process.

The structure of the deliverables is the following:

Chapter 3 provides an overview of each of the three PEDs to be developed during the project, namely:

- the PED in Schönbrunn, Bavaria, Germany,
- the PED in Kranj, Slovenia, and
- the PED in Hard community in Winterthur, Switzerland.

The chapter offers a short overview of the context, a description of the status of the PED from the actor and governance perspectives, market considerations, and an analysis of the regulatory framework and potential barriers or limitations for implementation.

Chapter 4 focuses on the stakeholders and actors present within the PEDs. It starts by presenting the results of the stakeholder mapping and analysis exercise conducted in each of the PEDs, before having a short overview of feedback collected from the stakeholders at this initial phase of the project. Both sections contribute to the stakeholder engagement plan or roadmap presented in the last part of chapter 4.

Given the deliverable's objective to provide foundational context and actionable insights for the *pilot sites*, the analysis adopts a site-centred, contextual lens. Consequently, market-related insights are treated as enabling conditions for local implementation, rather than as a full commercial market assessment of the PEDvolution toolset, that will be prepared closer to the end of the project.

Methodologically, this deliverable maintains the pilot sites at the centre, adopting a pilot-specific approach. The information collection has been done through existing information and data sources, and no primary research was conducted. Stakeholders have been engaged in different ways depending on the pilot site, primarily to function as primary informants on their views on PEDs in general and the PEDvolution approach in particular, and to inform the initial stakeholder engagement planning.

While a stand-alone deliverable, the findings are expected to contribute to the future activities of PEDvolution. This report feeds in especially on the development of the social innovation tool and social innovation activities to be implemented within the project, and it further guides the business modelling process, both to be tackled starting from the second year of the project. The deliverable also supports the piloting activities in the second and third year of the project. Tool specific market considerations will be further explored in a separate market analysis deliverable (PEDvolution replication and market analysis & exploitation strategy) due the end of the project.

The expected contribution to the piloting activities is twofold: the early stakeholder consultations help to identify gaps and bottlenecks related to stakeholder needs and expectations that should be accounted for, and the stakeholder engagement plans help to pave the way for the stakeholder management and associated activities along the project. The implementation process on key selected areas will be also supported through the social innovation tool developed in the project.

3 PEDVOLUTION PILOT SITE CHARACTERISTICS

The aim of this chapter is to describe the basic characteristics of the PEDvolution pilot sites. It explores various societal and contextual factors relevant to understanding the potential forms of development or evolution of PEDs. Such contextual factors typically include factors such as local vision, regulatory frameworks and supporting policies, cultural and social norms, traditions and values that shape behaviour, natural resource endowments and technological specialisations, followed by more general socio-economic conditions [13], [14]. Indeed, a number of variables come into play to explain the potentially different nature of the evolutionary paths of local or community-based energy systems, even when they have similar technologies at their disposal.

This chapter provides an account on the factors contributing to the development of the PEDvolution pilot sites. This includes descriptions of the municipality or the district, the characterization of the PED through various variables, including socio-economic characterisation, the political landscape and regulatory considerations, and any initiatives or resource endowments that facilitate or hinder the implementation of the PED or similar activities in the area.

The information in this chapter is drawn from publicly available sources, and where detailed data were limited, rough estimates were used to provide a general characterization of each site.

3.1 German pilot site

The German pilot site is located in Schönbrunn, a village within the administrative district of Wunsiedel in Bavaria, surrounded by the Fichtel Mountains (see Figure 2: Schönbrunn village.Figure 2**Error! Reference source not found.** below). Along with the district of Furthammer, it has around 1,400

Figure 2: Schönbrunn village.

inhabitants, while the population of Wunsiedel reaches around 9,000 inhabitants. Schönbrunn features small businesses, craft enterprises, and fewer than ten farms.

Schönbrunn is characterized by its rural character and is located away from Wunsiedel on a slight slope. The location lies on a river and is surrounded by agricultural fields and forests. The village is mainly made up of detached houses for around 400 households, but also a few apartment buildings, complemented by a kindergarten, a church, small businesses, a brewery and an inn. Most houses are owner-occupied. Transportation options here are limited to private transport by car or bicycle and occasionally by public or school buses.

Schönbrunn is a place that has retained its charm and traditions over the years, even though it has grown steadily. The commitment of its inhabitants still characterizes the community. Particularly the clubs, such as the volunteer fire department, the air sports club, as well as the local church, play a central role in village life. They bring people together and strengthen the sense of togetherness that is so important in small communities like Schönbrunn. In the past, villagers shared ice cellars to keep food fresh for longer. This communal use of resources reflects the close cohesion that still characterizes the identity of the village today.

Another centerpiece of Schönbrunn is the local brewery, which has been brewing beer according to traditional recipes for many years. In the associated pub, which is popular with locals and visitors alike, the Bavarian way of life can be enjoyed to the full. People meet here to get together after a long day.

Schönbrunn embodies everything that makes a classic Upper Franconian town: tradition, cohesion and an awareness of its roots. Despite its growth, the town has not lost its soul and remains a place where people live together and value their shared culture.

Economically, Schönbrunn is characterized by a reliance on small businesses and local industries, particularly agriculture and the production of wood pellets for its district heating network. This economic structure makes Schönbrunn's economy relatively undiversified. In contrast, nearby urban centers like Bayreuth and Hof benefit from more diversified economies that include sectors like manufacturing, services, and education, leading to higher average income levels and more job opportunities. The village experiences a population decline, partly due to younger residents moving to urban areas for better job opportunities and amenities.

The region of Upper Franconia, to which Wunsiedel belongs, has a more thriving economy. The urban centres of Bamberg, Bayreuth and Hof are the driving forces of the region, with sustained population growth, while the more rural areas face declining population and urban migration [15]. Overall, the region has low unemployment rate of 2.9% and the employment rate is amongst the highest in Europe, with 82.1% of the working-age population participating in the labour market. Out of these, 42 % were working in highly-skilled positions [16].

3.1.1 PED characterisation

The German PED includes the deployment of the Schönbrunn PED, and integration of an existing energy-sharing community within Wunsiedel to test and form a Super-PED. Hence, there are two PEDs in the German demo, creating the so-called "super PEDs" (see Figure 3 below). This chapter mainly focuses on the Schönbrunn PED, which is a new development and where most efforts will be directed.

The 2nd PED takes place in Wunsiedel. This already existing PED consists of sizable heating customers, co-generation units with Power-to-Heat capabilities, prosumers, prostormers (prosumers with storage systems), and public buildings.

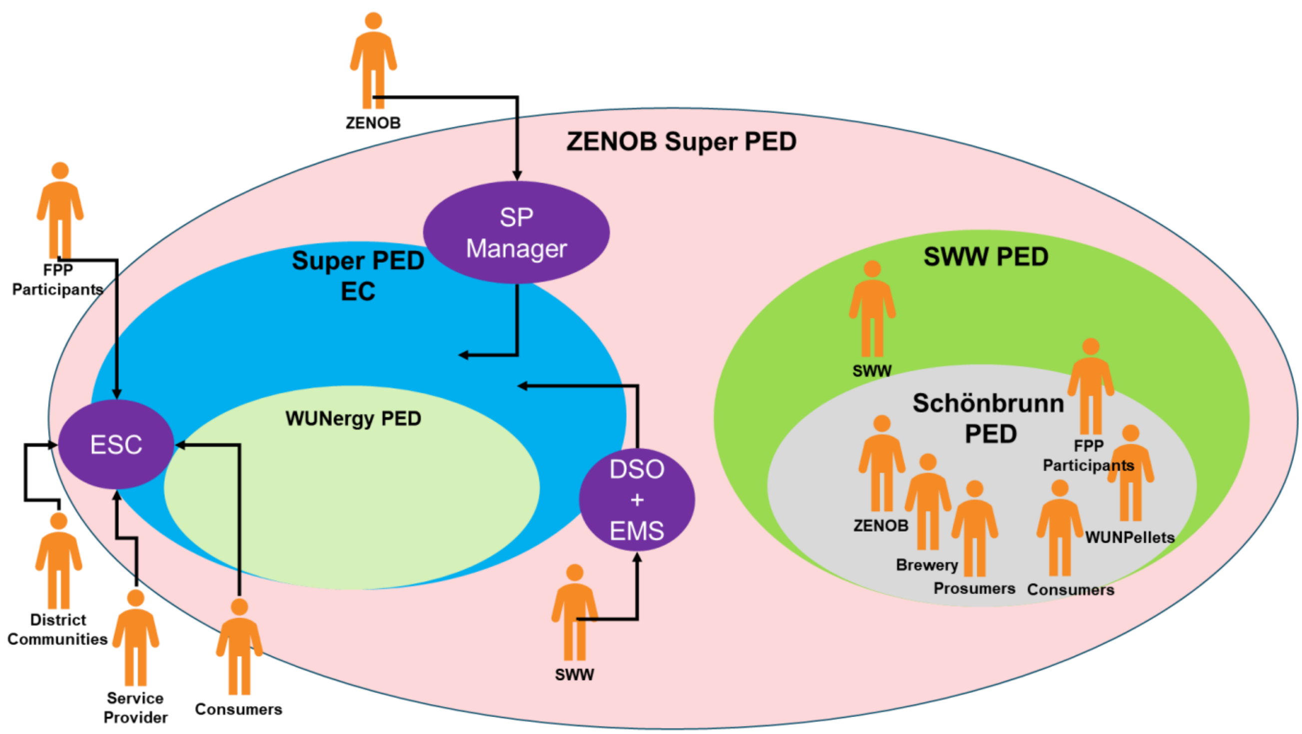

Figure 3: The German PED – two PEDs and a super-PED.

Within the Schönbrunn PED, the infrastructure includes a cogeneration unit (CHP) and distributed PV production systems to supply renewable electricity and heat. Locally produced wood pellets are utilized to supply the CHP plant. Furthermore, the CHP operates from locally produced pellets and supplies heat via the local heating network to the Schönbrunn PED participants.

SWW Wunsiedel GmbH (SWW), the utility company managing the district heating network in the region, plays a critical role in operating the CHP plant and supplying heat to approximately 180 households within Schönbrunn. The existing heating network has the capacity to cover the entire village, which comprises around 400 households. A recently established energy-sharing community forms a central part of the Schönbrunn PED, currently involving two consumers, seven prosumers, four industrial entities (one brewery and three hospitality facilities), and the SWW “Future Power Plant” (FPP), which operates as a decentralized generation entity (see Figure 3 above).

Many of the households in the village have invested in their own PV panels, and the aim is to explore integration of these households into the energy-sharing community. The local brewery acts as an industrial customer with significant potential for energy flexibility.

The concept of the “Future Power Plant” or "Zukunftskraftwerk", a building equipped with PV, energy storage, and potentially Power-to-Gas (P2G) or Power-to-Heat (P2H) facilities, producing more energy than it consumes, is under development. This initiative envisions individual homes acting as energy cells – small power plants equipped with storage systems – aggregated via IoT platforms by the DSO or an aggregator. These energy cells aim to consume their own generation as much as possible and trade flexibility among themselves. Aggregated into a Virtual Power Plant (VPP), these energy cells can offer flexibility services to local, regional, and national grids, addressing both fast and slow dynamics issues.

3.1.1.1 Vision

The vision for the PED in Schönbrunn focuses on several key goals for the coming years. The primary aim is to deploy energy management tools that enable automated energy and flexibility management. This will optimize sector-coupled units and complex customers, providing both economic benefits and a stable power supply. An online optimization system will be implemented to identify and utilize surplus energy effectively.

Integration of existing prosumers and the transition of consumers into prosumers or prostormers status are crucial steps. Additionally, the PED aims to support the integration of consumers without houses into energy communities or offer possibilities for energy flexibility.

3.1.1.2 Energy sharing community as a basic construct for PED

The form of energy cooperative, the Energy Sharing Community (ESC), set up in Schönbrunn, at the German pilot site is a form of local energy community with a structure that meets the German legislative regulations and enables energy sharing.

The ESC aims to create a decentralized energy supply system that local participants, including households, businesses, and public entities can join. The ESC can generate, consume, and share renewable energy. The main objective of the ESC is to optimize the use of locally produced renewable energy (such as solar and wind) to decrease reliance on external sources, reduce energy costs, and contribute to environmental sustainability. SWW acts as the coordinator, providing the infrastructure and tools needed to implement and manage this community-based energy system. The format of ESC has been set up, as the German energy laws impose limitations on the full implementation of energy-sharing models as envisioned by EU directives. The EU's Clean Energy for All Europeans package introduces the concept of energy communities, allowing for more flexible energy-sharing between citizens, prosumers, and renewable energy producers. However, Germany has not fully transposed these provisions into national law.

While Germany has made progress with energy cooperatives, which are supported under the Renewable Energy Sources Act or “Erneuerbare-Energien-Gesetz" (EEG), these cooperatives are mainly limited to self-consumption models. Germany's legal framework restricts the creation of broader energy-sharing systems across multiple households or entities, which are envisioned under the EU's Citizen Energy Communities (CECs) or renewable energy communities (RECs) frameworks. Instead, German energy communities must comply with strict regulatory guidelines, especially regarding grid connections, energy flows, and ownership structures [17].

The ESC in Schönbrunn operates within these limits by adhering to the rules regarding energy flows, ownership, and market communications to ensure compliance with German market regulations. This includes defining roles such as producers, consumers, and prosumers (participants who both produce and consume energy). By adhering to market communication regulations, the ESC ensures that energy flows, usage data, and transactions are tracked accurately and transparently. It operates with a cooperative structure whereas ownership and shared responsibility among community members take place. This structure also offers tax benefits, making participation more attractive, while ensuring that decisions about the community's operations are made democratically by its members.

The ESC also provides flexibility in managing energy, which helps stabilize the grid. By adjusting energy consumption and storage in response to supply and demand conditions, the community can prevent grid overloads and improve the overall resilience of the energy system. Additionally, this flexibility can be monetized by participating in energy markets, where excess energy or flexibility services (such as demand response) can be sold to external entities, generating additional revenue for the community.

By integrating modern technology, dynamic pricing, and community cooperation, the ESC is designed to deliver a sustainable energy solution that benefits both individual participants and the wider region. The community-based structure makes it an ideal construct of a PED, and the project aims to demonstrate the viability of such systems in contributing to the district level energy systems and broader energy transition.

3.1.2 Current practices in stakeholder engagement

SWW has extensive experience in stakeholder engagement. User engagement is seen as crucial for enhancing grid operation efficiency. This approach aligns with the three pillars of sustainability—economic, environmental, and societal – by optimizing resource allocation, reducing power generation losses, and fostering community empowerment. SWW has actively promoted this strategy and developed it further within past research projects such as GOFLEX and edgeFLEX projects. Through GOFLEX, consumers and asset owners were engaged through various incentives and equipped with new Energy Management Systems (EMS). To facilitate user engagement, SWW conducted design thinking workshops and published articles to raise awareness. These efforts encouraged participants to contribute to the energy supply chain, benefiting all stakeholders involved. Some users even provided feedback and ideas, showcasing the success of the engagement strategy.

This collaborative approach led to higher acceptance rates, as customers were involved in co-creating the flexibility system from the outset. During the project SWW created a mutually beneficial flexibility system for both residential and industrial customers, that enabled participants to join the local flexibility market, generating additional income. The results indicated that participants had basic knowledge and were willing to learn more, expressing satisfaction with the outcomes of the GOFLEX project.

The attitude and acceptance of customers toward these innovative solutions have been essential for SWW's strategic ventures. Stakeholders, barriers, and their knowledge regarding energy provision and supply were carefully assessed. SWW recognized the importance of early-stage user engagement in several subsequent projects and successfully maintained customer loyalty throughout observation periods, leading up to their involvement in new pilots in Wunsiedel.

SWW continues to promote citizen participation through design thinking workshops and stakeholder engagement activities as part of the day-to-day activities.

3.1.3 Market considerations

As a general concept, PEDs are intended to be replicated across Europe, especially in regions striving for sustainability and energy independence, as well as in rural and urban areas aiming to reduce carbon emissions and enhance local economies. In the Schönbrunn PED demo site, the integration of local renewable sources (e.g., PV, CHP, pellets) with advanced storage and multi-vector systems offers a scalable and replicable model that is attractive for municipalities and energy stakeholders looking to adopt decentralized, low-carbon energy systems.

Germany has a long tradition of cooperative and collaborative forms of energy production, and since 2015 a rapid increase in renewable energy communities has been observed, even if this growth has been more moderate in recent years [18]. Corresponding to the individual PEDvolution tools, factors such as the long-term presence of local energy cooperatives and companies in Germany could indicate demand for the types of planning and technical management tools developed in PEDvolution. The lack of digital infrastructure, such as slow roll out of digital metering, on the other hand, could work as a barrier for further adoption of digital tools [18] – while it can also present an opportunity for new digital tools to enter the market.

3.1.4 Policy framework and institutional landscape

This section describes some of the main governmental programmes to support the investments in local renewable energy production and improve building energy efficiency, followed by an overview of existing governance structures relevant to district level urban energy initiatives. Upfront investment costs, unclear or complicated legislative framework for energy communities, as well as multi-layered governance systems for local level initiatives remain barriers to the further expansion and development of local energy systems despite the available tax and funding schemes available. From the regulatory perspective, the unclear definition of energy communities in the current legislation and limitations for energy sharing create barriers to full application of community-based initiatives in the energy market.

3.1.4.1 Feed-in tariffs and tax reliefs

Two schemes, the feed-in tariff for solar power generation and Value Added Tax (VAT) exemptions on solar panel installations support investments of residential homeowners in solar power generation. The renewable energy sources act grants a feed-in-tariff for solar power generation. The feed-in tariff for solar power generation has been in place for electricity generated through solar power since 2009, and it has been set to last until 2029 with a declining rate. Many prosumers have been benefiting from this programme. As the subsidy programme is about to end for many customers, the motivation to utilize as much energy as possible at home increases. Battery Energy Storage Systems (BESS) would support self-consumption, but many homeowners cannot afford the investment.

Since 2023, solar modules and their installation have been exempted from VAT for residential and commercial PV systems up to 30 kWp for single residential homes or 15 kWp per residential unit. The same scheme applies to storage systems in residential buildings where there is no limit set to the size of the system. The scheme is expected to boost investment in PV despite declining feed-in tariff.

3.1.4.2 Federal programs to support investment in renewable energy production and to support energy-efficient construction and refurbishment

Several federal and state-level programmes exist to support investment in renewable energy or investing in energy efficiency renovations of buildings, often relevant to PEDs, including the following:

The Federal Development Bank or “Kreditanstalt für Wiederaufbau” (KfW) Programs: KfW provides low-interest loans and grants to finance up to 100% of the costs for photovoltaic systems and energy storage. For instance, KfW's "Renewable Energies – Standard" (Program 270) helps homeowners finance the purchase and installation of solar PV and battery systems.

Federal Promotion for Efficient Buildings or "Bundesförderung für Effiziente Gebäude" (BEG): Administered by the Federal Office of Economics and Export Control or "Bundesamt für Wirtschaft und Ausfuhrkontrolle" (BAFA), this program provides subsidies for energy-efficient building renovations, including installing renewable energy systems. It can also support measures that improve the energy efficiency of homes, such as battery storage or combined heat and power systems.

Germany's energy-efficient construction and refurbishment scheme is primarily driven at the federal level through KfW and BAFA, but states also offer complementary programs to encourage sustainable building practices. KfW's Federal "Energy-efficient Construction and Refurbishment" Programs (261/262) provide:

- ❖ Low-interest loans of up to €150,000 for energy-efficient renovations, or €60,000 for individual measures.
- ❖ Repayment subsidies up to 45% based on the level of energy efficiency achieved.
- ❖ Funding for projects that include insulation, window replacement, heating system modernisation, and renewable energy installations.

3.1.4.3 State-level programs and subsidies

In addition to the federal programmes, different German states have additional programmes to support energy-efficient renovations and investments in renewable energy or energy storage systems. For example, the state of Bavaria offers multiple initiatives for energy efficiency improvements:

Bavarian Energy Loan: This program complements federal KfW programs by providing low-interest loans for energy-efficient renovations and new construction, specifically targeting homeowners. It can also be used to finance renewable energy technologies.

Battery Energy Storage Subsidy: Bavaria also has a solar-plus-storage program offering grants up to €3,200 for homeowners who install battery storage systems alongside their solar PV installations. The program is part of Bavaria's broader push towards renewable energy and reducing the need for grid reinforcement.

This program is also aligned with Germany's federal-level support for energy storage, such as the KfW Program 270, which offers low-interest loans covering up to 100% of the installation costs for renewable energy systems. Together, these subsidies aim to ease the transition to solar energy, reduce reliance on the grid, and support electric vehicle charging infrastructure.

Similarly, other German states have state-specific programmes available to support initiatives locally. While these would be out of scope for local actors in Bavaria, understanding the multiple layers of the support system in Germany would be important for any planned exploitation and replication activities of the project partners. Examples of the schemes in other German states include:

North Rhine-Westphalia (NRW): NRW has the progres.NRW initiative, which provides support to energy efficiency and renewables integration through grants for energy-efficient heating systems, including subsidies for biomass boilers and heat pumps, specific funding for energy-efficient buildings, covering both construction and refurbishment, as well as programs supporting photovoltaic installations and combined CHP units.

Baden-Württemberg: This state is a leader in green energy in Germany and offers the L-Bank Energy Efficiency Loans, which provide low-interest loans for energy-efficient new buildings and refurbishments, focus on renewable heating systems, such as heat pumps and solar thermal installations, as well as bonus programs for replacing old oil-based heating systems.

Despite a range of incentives and concessional programs to support the uptake of renewable energy initiatives and energy retrofits, there are still barriers that prevent the progress, including high initial investment costs, bureaucratic complexity and lengthy approval processes, limited public awareness and understanding, technical challenges and grid integration, space limitations in urban areas, financing barriers for low-income households, and lack of skilled installers and technical support.

3.1.4.4 Governance structures of local energy initiatives relevant for PEDs

At the district and housing level, there are various organizational and governance structures in Germany that are highly relevant for the development of PEDs. These structures are essential for managing energy, housing, and community resources efficiently and for fostering collective participation in energy initiatives. The types of actors involved, and the respective governance structures shape the development and decision-making processes in the PED.

Energy Cooperatives: These cooperatives are a popular model in Germany, where local communities collectively invest in renewable energy projects, such as solar parks, wind farms, or district heating systems. These cooperatives:

- ❖ Allow residents to become part-owners of energy infrastructure, fostering local participation and ensuring that the benefits (e.g., financial returns, lower energy costs) stay within the community.
- ❖ Provide a democratic governance structure where decisions are made collectively, ensuring local input into energy projects.

This model is highly compatible with PEDs, as it encourages local engagement, shared investment, and collective management of energy resources. However, a potential risk for PEDs is the variation in engagement levels within communities, where some members may not have the financial capacity or interest to participate fully.

Housing associations: In Germany, these associations play a significant role in managing residential buildings and ensuring they meet energy efficiency standards. They are involved in:

- ❖ Retrofitting buildings for energy efficiency, integrating renewable energy sources, and managing collective heating systems.
- ❖ Implementing smart energy management systems that track and optimize energy use at the building or district level.

While housing associations can support the development of PEDs by organizing large-scale energy projects (e.g., rooftop solar, shared heat pumps), they may also pose risks if they lack sufficient expertise or resources to implement these projects. In some cases, the governance structure of housing associations, which often focuses on maintaining affordable housing, may lead to conflicts between energy efficiency goals and cost control.

District Heating Systems: In many German cities, district heating systems provide centralized heating to residential areas. These systems can incorporate renewable energy sources such as geothermal, solar thermal, or biomass, making them compatible with the goals of PEDs.

- Governance of district heating is typically managed by municipal or regional authorities, but residents and housing associations often have some level of involvement.
- Transitioning existing district heating systems to fully renewable energy sources may pose challenges in terms of cost, infrastructure upgrades, and public acceptance.

Smart Energy Communities: Emerging smart energy communities are structured around the use of digital technologies to manage energy production, consumption, and storage across districts. They use:

- Smart meters and digital platforms to optimize energy flow, shifting consumption to times when renewable energy is most available.
- Local energy markets, where residents can trade surplus energy, creating a flexible and self-sustaining energy ecosystem.

One challenge with smart energy communities is the data privacy and security concerns associated with digital energy platforms, which could pose risks for resident acceptance and regulatory compliance.

Despite the number of available structures and governance models around which a PED can be integrated, these models also portray risks and challenges. The typical risks for PEDs at the district/housing level are:

Financial inequality: The success of energy cooperatives and other shared governance models depends on broad community participation. Economic disparities could limit engagement, particularly in low-income districts where residents may not have the financial means to invest in energy projects.

Conflicting objectives: Housing associations, tasked with maintaining affordability, might prioritize cost control over energy upgrades, potentially slowing down or complicating PED implementation. This is especially true if the associations are managing older buildings requiring costly retrofitting.

Complex governance structures: In large housing cooperatives or multi-district projects, decision-making can become cumbersome, especially if multiple stakeholders (municipalities, housing associations, private owners) are involved. This could lead to delays or misalignment in energy goals.

In summary, while there are many supportive structures in place at the district and housing level, the success of PEDs depends heavily on effective governance, community engagement, and financial support. Collaborative models like energy cooperatives are well-suited for PEDs, but barriers such as financial inequality, complex decision-making processes, and potential conflicts of interest within housing associations need to be managed carefully to ensure the initiative's success.

3.1.4.5 Local level support and incentives

Citizens in the Fitchel Mountains region are generally supported by an initiative of the district administration called "Freiraum für Macher" (Free space for doers), which also draws attention to energy issues in the region. The initiative is a regional development campaign led by the district of Wunsiedel and it is designed to promote innovation, entrepreneurship, and community engagement by offering resources and support to local residents and businesses. The initiative provides spaces for creative work and collaboration, hosts workshops, and promotes sustainable projects, particularly around innovation, and climate protection.

A key aspect of this initiative is its focus on making the region more attractive to professionals, young families, and entrepreneurs by providing opportunities for economic growth and addressing sustainability challenges. Through platforms like the Fichtel-LAB and the FichtelApp, the program facilitates connections between local citizens, businesses, and government services to encourage active participation in the region's development.

The program's activities also extend to promoting energy awareness, making it relevant for the citizens of Schönbrunn, who can take advantage of the local heating network and PV systems by contacting SWW Wunsiedel.

In addition, there is a local representative who represents Schönbrunn on the Wunsiedel town council. Schönbrunn does not have its own housing cooperative, but residents can take advantage of the above-mentioned offers and contact SWW Wunsiedel if they are interested in PV systems or connecting to the local heating network, for example.

3.1.4.6 Regulatory barriers

In Germany, the most relevant national legislation governing local renewable energy systems and energy communities include the Renewable Energy Sources Act and the Energy Industry Act. The governance models are further guided by the legislation on legal company models such as the law on cooperatives.

Despite available models for local collective energy production and local energy systems, such as the energy cooperatives and limited liability company format to some extent, current legal restrictions in Germany prevent the formation of official energy communities, such as the Citizen Energy Community and Renewable Energy Community defined in the EU Renewable Energy Directive (2018/2001/EU).

One of the major limitations of the current legislation on local and collective forms of renewable energy production is the limited possibilities for energy sharing amongst the members. Despite the legal hindrances concerning the establishment of energy communities, local energy sharing has been enabled in Schönbrunn and Wunsiedel through ESCs organised by SWW.

3.2 Slovenian pilot site

The Slovenian pilot site is located in the industrial zone of Labore within the city of Kranj.

Kranj is the third-largest city in Slovenia, with a municipality population of approximately 57,171 and an area of 143 km². The City Municipality of Kranj is located in the northwestern part of Slovenia, in the Gorenjska region. The city of Kranj, the administrative centre, is situated at the confluence of the Sava and Kokra rivers, about 25 km from Ljubljana (see Figure 4 below).

Figure 4: Location of Kranj.

The city is strategically positioned with a central location that serves as a transit hub, and it is known for its technological and alpine cultural background. In 2022, Kranj was designated as a participant in the "100 Climate Neutral and Smart Cities by 2030" initiative, aiming to become Slovenia's premier smart and climate-neutral urban centre by 2030.

Kranj is mainly an industrial city with significant electronics and rubber industries with significant sectors including electronics, machinery, textiles, and chemicals. The city also hosts a technology park that supports high-tech companies. Kranj's economy benefits from a diverse industrial base and well-developed infrastructure, making it one of the more prosperous areas in Slovenia.

The industrial zone of Labore in Kranj (see Figure 5 below), is a key area for economic activities, housing various companies and businesses, which significantly contribute to the local economy. The Kranj-Planina boiler house supplies more than 4,300 homes and public institutions with heat and hot domestic water, with an average annual consumption of 7 million S/m³ of natural gas, producing about 60,000 MWh/year of heat.

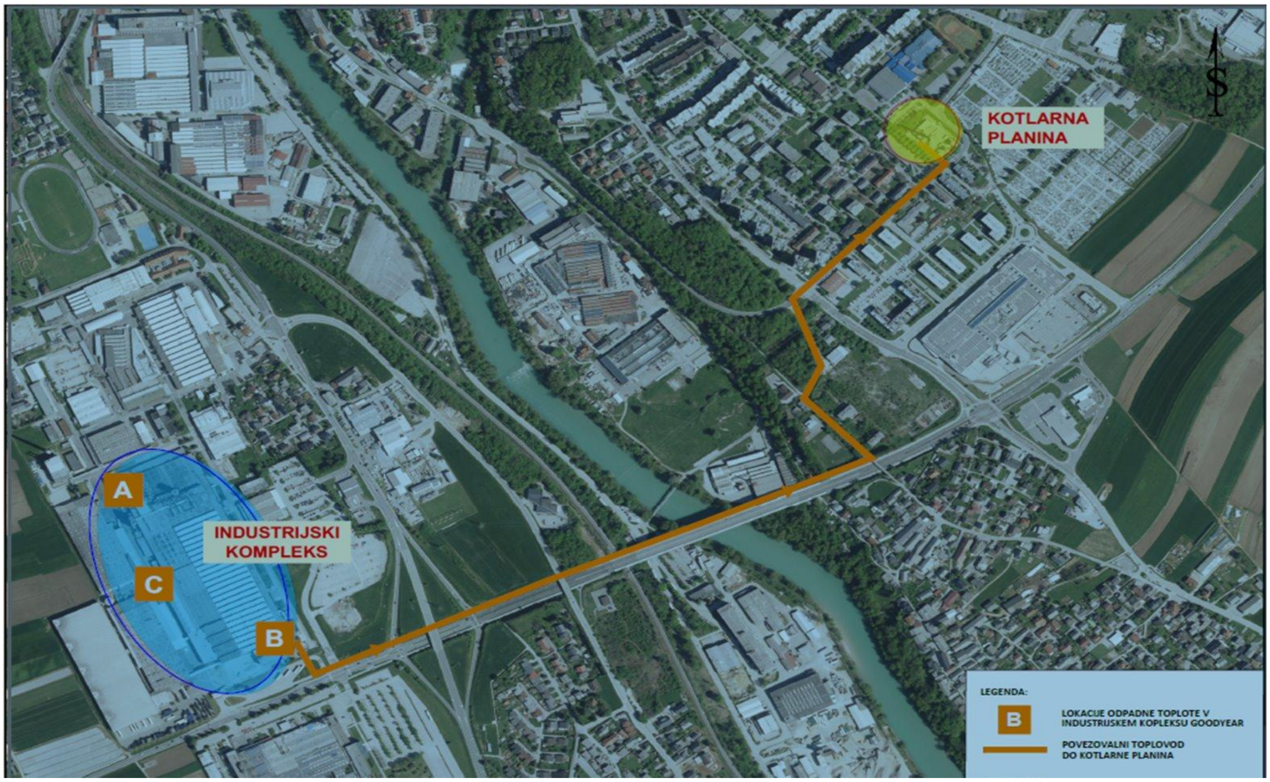

Figure 5: The industrial zone Labore and Planina Kranj.

The residents of the urban neighbourhood Planina are amongst the beneficiaries of the Slovenian PED. Planina is a neighbourhood mostly built in the 70s and 80s, with 140 apartment buildings and around 12,500 residents. While the neighbourhood used to be characterized as a socially disadvantaged area, it has gone through a significant transformation led by the municipality from 2015 onwards, when the area was defined as a pilot area for urban renewal in the Sustainable Urban Strategy of the Municipality of Kranj. The process has been conducted with a high level of citizen participation, where the residents have been part of both defining and designing the renewal of the area.

3.2.1 PED characterisation

The PED in Kranj is under development, and the project is expected to witness the gradual integration of different energy sources into it. The focus is on the connection of waste heat within the industrial zone of Labore into the district heating network to reduce dependency on gas and on the integration of renewable energy sources.

Key energy sources include a CHP unit with a 5 MW excess heat potential, a central boiler house in Planina, and hydropower production. There is also a significant waste heat potential in the industrial zone of Labore, and the project aims to measure the exact amount of waste heat available from the industrial zone. Current estimates suggest that waste heat could cover up to 60-70% of district heating in Planina Kranj. Additionally, future plans include the installation of rooftop PV for suitable identified buildings, primarily public buildings like schools. Electric boilers will be used in the district heating system to stabilize the electricity grid and utilize excess electricity generated during the day from solar power. Nearby hydropower plants will be virtually connected to the PED, and a new energy community will provide renewable energy with long-term fixed electricity prices to reduce risks related to energy markets. New software solutions integrated with the PEDvolution toolset will enable automatic dynamic demand response of individual buildings and industrial equipment, allowing the system to adapt cost-efficiently to the upcoming new tariff system. PEDvolution tools will provide insight into the feasibility of this initiative.

Long-term goals focus on achieving a net-positive energy balance for both heat and electricity and enhancing the environmental and economic sustainability of the local energy system. Several external factors will influence the development of the PED in Kranj and achieving the long-term goals, both positively and negatively, with a balance towards a supporting environment for the development of sustainable energy initiatives. The presence of waste heat in the industrial zone of Labore offers a significant resource that can be integrated into the district heating system. In addition, solar potential is high, with rooftop PV installations planned to leverage this resource. Hydropower plants in the vicinity provide additional renewable energy potential. On the other hand, the city’s proximity to groundwater resources could impose limitations on the types of technologies used, particularly in regard to large-scale geothermal or other ground-based energy systems.

The presence of a strong industrial base and initiatives to promote energy efficiency and sustainability support the uptake of local energy projects, whereas the municipal "100 Climate Neutral and Smart Cities by 2030" initiative provides a favourable policy context for energy innovation. Kranj’s expertise in industrial manufacturing and technological innovation could support the integration of advanced energy technologies, such as dynamic demand response systems and smart grid solutions, into the PED.

The potential for energy trading and flexibility is supported by the plans to establish a local energy community, which allows for more flexible energy trading and the integration of various energy streams (e.g., solar, hydropower, waste heat). This flexibility is crucial for optimizing energy usage and responding dynamically to changes in energy supply and demand.

Potential barriers for further implementation include high initial capital costs for the installation of renewable energy technologies (e.g., solar panels, electric boilers), which could slow the implementation rate, and potential resistance from actors with a stake in traditional energy sources, such as natural gas. In addition, technical concerns, such as the complexity of integrating waste heat and renewable energy sources into the existing district heating network, could present technical challenges.

In conclusion, the Kranj PED offers substantial opportunities for sustainable energy development, leveraging local resources like waste heat and hydropower, along with strong community engagement.

3.2.2 Current practices in stakeholder engagement

Elektro-Gorenjska (EG), the electricity distributor in the region, maintains regular communication with the key stakeholders such as the Kranj municipality and the companies within the Industrial Zone Labore. The municipality is one of the key actors facilitating communication between commercial actors on the topics of sustainability and clean energy.

The users of the district heating are also partial owners of the heating network, including the residents in the Planina neighbourhood. A specific citizen group represents citizen-owners towards the district heating operator and is one of the main channels of communication between the citizens and the district heating operator.

The citizen group maintains regular contact with residents through existing spaces and structures such as building or neighbourhood associations and other neighbourhood-level instances. Decreasing interest of residents to participate in these instances has been reported – a common tendency in many European countries in current times.

3.2.3 Market considerations

The PEDvolution tools hold considerable market potential in Kranj and Slovenia, with various actors—municipalities, industries, energy providers, and communities—likely to benefit from their ability to optimize energy use and transition toward renewable energy sources.

As discussed above, Kranj is an area with substantial potential for sustainable energy development, and there can be estimated to be significant market potential for the PEDvolution toolset in Kranj and in Slovenia in general. PEDvolution tools, especially energy management tools which enable dynamic demand response and optimize energy consumption, are well-suited to the evolving energy landscape in Slovenia. In Kranj, industrial actors, energy providers, and local communities would benefit from these tools, as they provide cost-efficient methods for managing energy consumption and balancing supply with demand. Furthermore, as Slovenia pursues its climate-neutrality goals, demand for innovative energy management solutions will likely increase in the future. The PEDvolution tools can be adopted by municipalities, energy communities, utility companies, and industrial firms seeking to optimize energy use and transition towards more sustainable practices.

One of the indications for the market potential of the tools and replicability of the PED concepts is the presence of energy communities within the region. While still new as a concept, energy communities have begun to emerge in Kranj and across Slovenia as local responses to energy challenges, driven by a desire for greater self-sufficiency, cost control, and environmental sustainability. In the context of the Slovenian PED, a new energy community is expected to form, focusing on renewable energy supply at long-term fixed prices. This will reduce the risks associated with fluctuating energy markets. On a broader scale, Slovenia has been actively encouraging the development of energy communities, particularly in rural and suburban areas, in alignment with EU directives aimed at promoting decentralized, community-led energy production. The potential for energy communities in Kranj is high, particularly given the presence of strong local networks and community engagement traditions, as demonstrated by the transformation in Planina.

3.2.4 Policy framework and institutional landscape

Slovenia supports the Green Transition with five components:

- Renewable energy sources and efficient use of energy in the economy
- Sustainable renovation of buildings
- A clean and safe environment
- Sustainable mobility
- Circular economy with efficient use of resources

The state has adopted regulations on the use and promotion of renewable energy resources, which include the Act on the Promotion of the Use of Renewable Energy Sources and the Act on the Efficient Use of Energy. These include a transposition of the concepts for renewable and citizen energy communities based on the EU Renewable Energy Directive (2018/2001/EU).

The National Energy and Climate Plan is in the process of being updated. The current draft suggests an increase in the goal for the share of renewable energy sources in total energy consumption to be updated to 33 % by 2030. The plan also includes targets to level the targets in emissions cuts to the EU level of 55% with a baseline year of 2005. It has objectives for increasing the share of renewable energies in industry, including the integration of waste and surplus heat.

In Slovenia, a renewal of the tariff system for calculating electricity network charges was introduced in autumn 2024. In principle, the new system introduces a change from peak and off-peak tariffs to multiple time bands, where charges fluctuate by the time of the day and season. While the effects of the change to the electricity costs on a household level is expected to be small, it has been anticipated that the change might increase the cost of electricity supply to owners of self-sufficient solar power plants and commercial companies. However, the Act on the Promotion of the Use of Renewable Energy Sources allows owners of self-sufficient solar power plants to reduce the contribution of electricity produced by renewable energy sources, potentially alleviating the effect. Hence, the final effect of this change should be monitored to better understand the impact on prosumers.

Some funding schemes are available for companies and households for investment in renewable energy sources:

- Slovenia's state-owned Eko Fund (Eko skald) offers favourable co-financed loans for environmental investments in Slovenia. This includes renewable energy investments, such as self-sufficient solar power plants.
- The state-owned company and electricity market operator Borzen offers non-refundable financial subsidies for companies and households undertaking investments in renewable energy production or energy storage systems.
- European Union package to Slovenia to accelerate the green transition and reduce dependency on fossil fuels includes grants for companies, cooperatives and local authorities to promote renewable energy, heat and storage investments.

On a municipal level, the municipality of Kranj, where the Slovenian PED is located, is included in the mission of 100 climate-neutral and smart cities by 2030. Planned measures to achieve this goal include the establishment of district heating with renewable energy sources, the establishment of infrastructure for e- and hydrogen vehicles and the utilization of waste heat from industrial and office buildings, which is highly compatible with the PEDvolution project.

Overall, the current regulatory framework is estimated as satisfactory and suitable for local renewable energy initiatives such as PEDs to be developed.

3.3 Swiss pilot site

The Swiss pilot site is located on the outskirts of Winterthur, the sixth-largest city in Switzerland, with a population of approximately 122,000. Winterthur belongs to the Canton of Zürich and is located about 20 km northeast of the city of Zürich, emphasising its role as a satellite city for the capital of the Canton.

Over the years, Winterthur has undergone a transition from an industrial city to one focused on culture, education, innovation, and smart city initiatives. The city has been certified with the European Energy Award Gold and is committed to achieving Net Zero by 2040, with Winterthur's Smart City strategy in place since 2018 and currently being revised. The city also hosts the Zurich University of Applied Sciences (ZHAW), with approximately 14,000 students. Approximately 70% of the population have completed either non-mandatory upper secondary education or higher education.

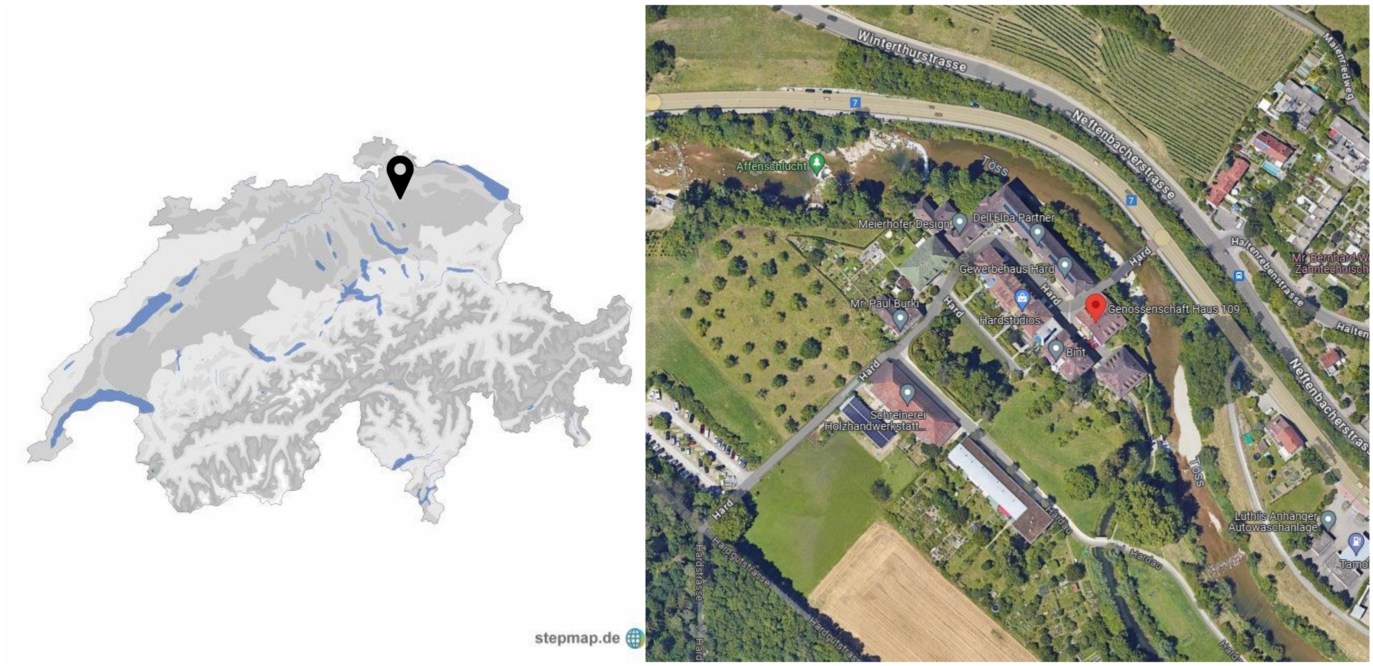

Figure 6: Location of the city of Winterthur and the Hard community.

The Hard community, where the PED is focused (see Figure 6 above and Figure 7 below), consists of 45 apartments housing approximately 250 residents, and around 40 businesses,. There is a high representation of older residents with lower financial income. The residents and employees of the community have made the preservation of the historical site and a focus on ecology their common goal, for example through a value placed on the use of sustainably produced energy.

The genesis of the Hard community traces back to the bankruptcy of the Stüdli company. Artists, graphic designers and architects have been renting the cheap and large rooms of the company since 1985. When the entire facility was put up for sale, the tenants collectively purchased it in 1986, founding the 'Gemeinschaft Hard AG' (Hard Community Ltd.) to manage the site. The idea of a residential and commercial community soon developed. Concepts, organizational forms, financing and procedures were discussed in countless meetings. The purchase price was 8 million francs, and the community has since operated as a joint stock company. In this case, the existence of an already established energy community thus provides a strong foundation for further developing the PED.

The buildings in the Hard community are listed as historical buildings, and this presents specific challenges. Any renovation work, energy efficiency included, needs to accommodate the conditions set by the Canton and the municipality, and the cost of renovation tends to be more elevated. In this context, basic maintenance activities on the building stock are a priority and must also be done within a strict budget, given that many of the residents are elderly and have limited financial means.

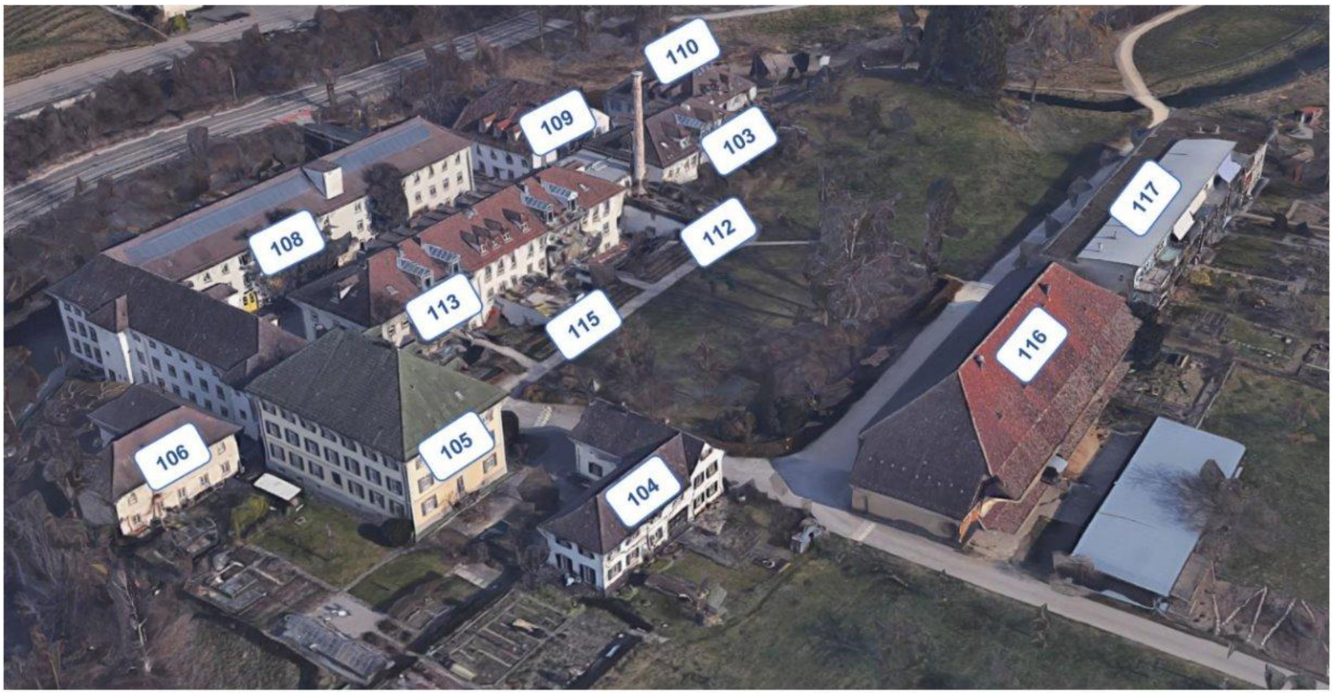

Figure 7: The Hard community.

3.3.1 PED characterisation

The PED utilises a combination of renewable energy sources, including hydropower and solar energy, to supply electricity and heat to the district. Locally produced energy is primarily self-consumed, with any excess fed into the grid. Heat is supplied by a central gas heating system paired with a solar plant, and since 2021, the site has been generating its own electricity via a newly installed photovoltaic system. The district is also equipped with electric vehicle (EV) charging stations and smart meters that provide insights into energy consumption.

The PED utilizes hydropower and solar energy, which powers approximately 725 households. Solar collectors provide hot water, and agricultural land is cultivated according to organic guidelines. The local grid is fully connected, and the community manages a shared parking lot with EV charging stations.

Key stakeholders include the 45 households and 40 businesses in the Hard community, which collectively house around 250 residents. Governance is handled by the ‘Gemeinschaft Hard AG’ (GeHa), a non-profit, self-managed stock corporation that oversees the district’s energy matters, including hydropower, solar energy, and EV-chargers. Local residents and enterprises volunteer their time to support community initiatives, and regular events are held to ensure active engagement. The municipality, technical and consulting Small and Medium-sized Enterprises (SMEs), and various local service providers (e.g., electricians, IT specialists) also play essential roles in maintaining the PED.

The Hard community operates democratically, with major decisions made during general meetings held three to four times a year. The board of directors leads the community, supported by finance, audit, and design committees. Each building within the district operates as a specific building association, responsible for its own investment decisions, such as energy efficiency improvements or photovoltaic installations.

One of the supporting factors for the PED establishment is Winterthur's commitment to achieving Net Zero by 2040, along with its established Smart City strategy, while the community's long-standing focus on sustainability and shared decision-making provides a foundation for future energy projects.

3.3.1.1 Vision

The vision for the PED includes expanding the use of renewable energy sources, enhancing self-consumption, and integrating shared mobility options. The goal is to further develop sustainable living within the community while exploring innovative energy solutions.

Future avenues for the energy community can be multiple, and one of the aims of the PEDvolution project is to provide tools to support the planning and evolution of the site. The development strategy focuses on ensuring positive feedback from stakeholders and implementing planned activities effectively. One of the options is to assess the possibility of establishing an association for self-consumption or "Zusammenschluss zum Eigenverbrauch" (ZEV), a Swiss form of energy community, at the site. The implementation of self-consumption communities is being evaluated at the building level before broader community integration.

The expansion of PV systems is community-driven and requires organization within the community to manage and implement. The growth of e-mobility depends on user adoption, with the current infrastructure capable of supporting more users. Shared mobility options, including both electric and fossil-fuel-based vehicles, are under the testing and evaluation phase besides sustainable mobility modes such as bicycles (direct bicycle path to the city centre) and walking to public transportation. The site is fully equipped with a utility smart meter. Some additional submeters offer insights into electricity production and consumption.

Strategic discussions are ongoing to include hydropower in the community's long-term energy mix, with existing contracts set to expire in 10-15 years. Regarding thermal energy, the Stadtwerk Winterthur which functions as gas supplier will phase out gas by 2040, and new forms for supply of thermal energy should be introduced. Due to belonging to a groundwater area which does not allow geothermal heating solutions, options for modernisation of heating seem to point towards air-to-water heat pumps combined with solar energy.

A revised decision guideline is necessary to support the district's evolution over the next 10-20 years. This includes addressing the needs of responsible personnel who require better support to channel their efforts. Improving the decision-making process and recognizing individual contributions are important for the community's success.

3.3.2 Current practices in stakeholder engagement

Within the Hard community, social engagement is extremely important in both the living and working contexts, where people interact daily. For instance, when a mandate for a PV system is implemented, the entire community decides on it and expects positive outcomes. The community typically meets at least once a year for the GeHa general assembly, and additional two events are usually organized for social activities and in-depth discussions on specific topics, such as energy.

Since the community operates on voluntary basis, some residents contribute their free time to support specific initiatives. One such example is the installation of charging stations which was driven by the efforts of a community member who advocated for its implementation. Local SMEs are involved in providing technical and consulting services. For example, IT consulting companies provide backend solutions for charging systems and evaluate energy solutions like heat pumps.

In addition, climate-related NGOs, such as the association *Energie Bewegt Winterthur (EBW)*, contribute to the community's energy initiatives, although their focus may differ from the specific objectives of the PEDvolution project.

3.3.3 Market considerations

Supporting the national and regional energy strategies, such as increasing energy efficiency, renewable energy supply, and achieving climate protection goals like Net Zero GHG emissions by 2050 at the national level and 2040 at the municipality level in cities like Winterthur and Zurich, PEDs play a crucial role in driving progress within Switzerland. PEDs align with Switzerland's vision of a sustainable energy future, making them integral to achieving these ambitious targets. As such, there is an enhanced market potential for PEDvolution tools and solutions, given the increasing number of PED initiatives anticipated across Switzerland.

Growing interest in decentralised energy is visible, for example, through the popularity of energy communities. Currently, Switzerland boasts approximately 10,000 energy communities, and this number is rapidly growing every year. These communities typically engage in collective self-consumption (CSC) (in German ZEV and EVG), where multiple consumers (residents, businesses, or industrial players) pool together to share locally produced renewable energy, mainly from solar power. With the increasing popularity of renewable energy sources, these communities are key players in the decentralized energy transition.

The potential market for PEDvolution solutions within these energy communities is substantial, as the need for enhanced energy management, storage capabilities, and grid integration solutions becomes more pronounced. The demand for tools that allow these communities to optimize their renewable energy usage, storage, and distribution in a self-sufficient manner is expected to grow significantly. PEDvolution could support these communities by providing real-time energy management, forecasting, and balancing tools.

The market potential for PEDvolution tools is bolstered by several key factors and developments ongoing in Switzerland. Growing interest in decentralised energy and the increasing number of energy communities and collaborations are creating a market for tools to manage these systems. Technological advances increase the feasibility and attractiveness of local energy communities.

Supportive government incentives are also making it easier for energy communities to invest in PEDs, and municipal-level climate targets in cities such as Zurich and Winterthur are creating strong demand for PED solutions that align with urban sustainability plans.

The next steps for expanding the market potential for PEDs and supporting solutions like PEDvolution should focus on several key areas:

Increasing stakeholder participation: Fostering collaboration between municipalities, energy suppliers, technology providers, urban planners, and the community is essential to scaling PEDs. This could involve incentivizing private investments, strengthening public-private partnerships, and creating pilot programs for local energy communities to test and adopt PEDvolution solutions.

Enhancing energy storage capabilities: Integrating energy storage solutions, particularly batteries and vehicle-to-grid systems, will be critical to ensure a reliable and self-sufficient energy supply within energy communities. Policy incentives to support storage installations will encourage communities to adopt PEDs.

Integrating renewable energy sources: The successful scaling of PEDs relies on optimizing the integration of solar PV, wind, and hydropower at the community level. Encouraging the use of energy-efficient appliances, demand-response systems, and real-time energy management tools will allow communities to maximize their renewable energy use.

Policy frameworks and incentives: To accelerate the adoption of PEDs, further regulatory refinements are needed to simplify the process of forming energy communities and accessing energy markets. Expanding the Swiss energy certificates market could also support energy trading between local communities and the broader energy grid, making PEDs more attractive.

Education and awareness campaigns: Educating local communities about the benefits of PEDs and how they can participate will be key to increasing adoption. This includes providing information on financial incentives, technical support, and long-term benefits for energy security, cost savings, and environmental impact.

By fostering collaboration among municipalities, science, solution providers, urban planners, policymakers, and local communities, PEDs can become a cornerstone of sustainable urban development and Switzerland’s energy transition.

3.3.4 Policy framework and institutional landscape

Switzerland has a robust regulatory framework supporting the development of local energy communities (LECs), energy cooperatives, and decentralized energy systems. The revised Energy Act (Energiestrategie 2050), adopted in 2017, lays the foundation for this transition. It promotes the development of renewable energy sources and energy efficiency through financial incentives like feed-in tariffs and investment subsidies. Moreover, regulations now allow private households, cooperatives, and local communities to generate and distribute energy independently, enabling the creation of LECs.

The Self-Consumption Regulation (Eigenverbrauch), revised in 2018, allows energy communities to produce energy collectively, which has spurred the growth of solar PV installations. Furthermore, the Swiss Energy Strategy 2050 encourages decentralized and renewable energy generation, energy storage systems, and the optimization of energy consumption at the local level.

The Swiss citizens recently voted for a law, “the Federal Act on Secure Electricity Supply from Renewable Energy Sources,” that further facilitates deployment of renewable energy technologies, requiring, for example, solar PV to be installed to new buildings exceeding 300 m2, and further favouring the implementation of LECs that extend beyond buildings. This law, coming into effect by 2025, will allow LECs such as the Hard community to expand their local energy systems.

The Climate and Innovation Act, another initiative to come into force in 2025, aims to support introduction of measures to reduce energy consumption and reliance on fossil-fuels. It introduces incentives to replace fossil fuel-based heating systems with climate-friendly ones. It will also grant support for companies in their efforts for decarbonisation.

At the municipal level, Winterthur has committed to achieving Net Zero by 2040, with specific measures aimed at phasing out fossil fuels, particularly natural gas, which is being actively discouraged by the local utility. The Department of Safety & Environment recognizes the urgent need to address climate change, especially in urban areas. Winterthur has implemented an action plan for the years 2021 to 2028, focusing on heat supply, photovoltaic systems, and sustainable mobility.

Winterthur's climate plan prioritizes the expansion of district heating networks and the widespread installation of photovoltaic systems. By 2025, the city council aims to install 100 additional photovoltaic systems on public roofs. The "Energy Winterthur" funding program offers financial support to homeowners for installing photovoltaic systems, renovating building envelopes, or connecting to heating networks. For example, owners can receive a subsidy of up to 50% for systems generating less than 30 kWp, along with federal incentives. For a 25 kWp PV system, this translates to approximately 9,500 CHF in support.

The city also offers financial incentives for connecting buildings to heating networks. While the Hard community is currently outside the planned heating network, there is potential for future development. The incentive includes 8,000 CHF per 15 kWth connected, with additional bonuses based on further connections. The community could explore the creation of a new thermal network, provided it meets requirements such as limiting fossil fuel use to 20% or less.

The national policies strongly support the development of energy communities and the reduction of fossil fuel reliance. The framework encourages local energy initiatives through financial incentives, grants, and tax schemes. However, expanding energy infrastructure, such as thermal networks, may face challenges if the necessary community trust or long-term investment commitments are lacking.

Overall, the Swiss regulatory framework and available financial incentives make it easier for energy communities to invest in PEDs, storage solutions, and energy management platforms. To accelerate the adoption of PEDs, further regulatory refinements to simplify the process of forming energy communities and accessing energy markets would be beneficial. Expanding the Swiss energy certificates market could also support energy trading between local communities and the broader energy grid, making PEDs more attractive.

To conclude, national policies strongly support the development of energy communities and the reduction of fossil fuel reliance. The framework encourages local energy initiatives through financial incentives, grants, and tax schemes for renewable energy installations. However, expanding energy infrastructure, such as thermal networks, may face challenges if the necessary community trust or long-term investment commitments are lacking.

4 STAKEHOLDER ENGAGEMENT AND ENGAGEMENT ROADMAPS

This section describes the methodology and process utilized for early stakeholder engagement and development of engagement roadmaps within the PEDvolution project. The chapter starts with a short overview of typical actors and stakeholders in PEDs, before moving to present the methodology for stakeholder analysis and construction of engagement roadmaps for each PED.

The following sub-sections present the results of the process. These include summaries of the stakeholder mapping and analysis exercises. In addition to stakeholder mapping, the pilot sites involved selected key stakeholders in the project development in ways defined as meaningful considering the context and maturity of each pilot site, of which main learnings are presented. Finally, the chapter discloses high-level engagement strategies and focus areas for engagement for each PED, that were defined in joint sessions with the task leader Smart Innovation Norway (SIN) and the pilot owners or PED managers.

4.1 Stakeholders and actors in PEDs

PEDs can be seen as complex ecosystems where a range of actors collaborate and hold both commercial and non-commercial relationships to achieve a common goal. As discussed in the PEDvolution D1.2 "Functional and Operational Requirements of the Demo Sites and Reference Use Cases" [1], mapping and understanding the role of the relevant actors and stakeholders, including "internal stakeholders" consisting of the core actors forming the "PED genotype" and context-related stakeholders that shape and influence the "PED phenotype" is a key starting point to ensure that the multiple dimensions of a PED will be addressed comprehensively.

A list of typical PED members was compiled to the project purposes to highlight the types of actors that typically take part in such settings, and their potential roles in the ecosystem. The PED members include:

- **Certifier**: Certifies the sustainability of apartments, buildings, neighbourhoods, or cities based on an established PED framework. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.
- **Investor**: An entity interested in investing in the development and/or operation of a PED.
- **Manager**: Manages the day-to-day operation of a PED, ensuring the functioning of a PED including infrastructure and interfaces with context, as well as data availability/ accessibility for further research and innovation development.
- **Planner**: Designs the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.
- **Promoter**: Promotes and eases the creation/sustainability of a PED, being a member (or not) or supporter of the PED once it is created. Usually, it is a public institution.
- **Resident**: Person/entity living/working in the geographical boundaries of the PED.
- **Participant**: An entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.
- **Solution Provider**: Supports the design, implementation, certification and operation of the PED by providing services to other PED stakeholders.

Depending on the exact composition of a PED, a combination of these actors can form a core group of a PED. In addition, external stakeholder groups include actors that have the capacity to influence the operational environment and conditions under which a PED operates.

In this context, the generic definition of a stakeholder is used, referring to an entity that either influences or is influenced by the PED activities. Due to the complexity of the PEDs, and the multiple layers they contain, current literature highlights the importance of stakeholder management and collaboration to navigate uncertainties and align expectations [19], to facilitate the work towards common goals, such as energy savings or emission reductions [9], to ensure compatibility with the local context [13], or to support community involvement and local ownership and to ensure all community members benefit from energy initiatives [19] [20] [21].

"Stakeholder engagement" is commonly defined as "practices that the organization undertakes to involve stakeholders in a positive manner in organizational activities" [23]. In the context of PEDvolution, stakeholder engagement is approached through systematic processes that involve individuals, groups and organisations in the PED development and implementation. As often discussed, complexity of the systems, such as PEDs, increases the efforts that are required for stakeholder engagement [19]. To enhance collaboration in such complex settings, early involvement of stakeholders is required together with a dynamic process covering the whole project cycle. Therefore, identification of stakeholders, first encounters with them, and stakeholder engagement planning are all part of the first activities of the project.

4.2 Methodology

This chapter presents a methodology for stakeholder mapping, analysis and engagement planning at the PEDvolution pilot sites. While each PED is different based on its characteristics and the types of technology involved, a unified process to identify stakeholder and define strategies for engagement was applied. The process included the following steps:

- ❖ Initial stakeholder mapping exercise at the PEDvolution General Assembly in February 2024, in Athens. In this presential group exercise, with the participation of most project partners, relevant stakeholders for each pilot site were identified, and their relationship to the project was assessed utilising a power-influence matrix, further elaborated on in Chapters 4.3.1, 4.4.1 and 4.5.1.
- ❖ Creation of a generic stakeholder list for typical stakeholders and actors within PEDs, in coordination with other tasks in WP1 and the rest of the project partners. This list is available in D1.2 "Functional and Operational Requirements of the Demo Sites and Reference Use Cases" [1].
- ❖ Revisiting the stakeholder matrix together with PED managers in separate online sessions with each pilot site during the Spring of 2024. Any missing stakeholders were added to the initial stakeholder matrix utilising the generic stakeholder list as guidance and a discussion was held on the expected roles and/or goals for different stakeholders or stakeholder groups in the specific PED.
- ❖ Each PED conducted activities, such as consultation sessions, site visits or project presentations with selected stakeholders utilising approaches and methods defined as meaningful taking into consideration the context and type of the pilot site.

- Online workshops with SIN and PED managers and pilot partners to define and develop a high-level understanding of the engagement needs for different stakeholder groups during Autumn 2024. These online workshops were held individually for each site and were aided by an exercise based on "behavioural shift canvas" utilised in the online whiteboard Miro, to identify objectives, drivers and barriers for the engagement of the main stakeholder groups.

The results of the process disclosed above are presented in the following manner: the stakeholder mapping exercises are presented in the "stakeholder mapping" subchapters for each pilot site, the results of the analysis of engagement needs are presented in the "stakeholder engagement: a gap analysis" sub-sections, the key conclusions of the stakeholder engagement activities are reported in the "stakeholder views" section, followed by the engagement roadmaps in the subsections with the same name.

Given the dynamic nature of the PEDs and the notion that the PEDvolution project is at an initial phase, a stakeholder engagement strategy or "engagement roadmap", in this context, consists of identifying main stakeholders and actors, presenting overall goals for their engagement, and determining the timing and level of engagement or participation in the project.

Strategic stakeholder engagement can consist of one-way information, two-way communication, and internal structures [24]. Another way to assess the type of participation is through Arnstain's ladder of citizen participation, scaling from "no participation" through "information" and "collaboration" to full empowerment and citizen-led action [25]. Multiple variations of the ladder of citizen participation exist, and the approach is often utilised or seen as relevant to research and innovation projects in the energy sector (see, for example, [26]). The benefits of active citizen participation in the energy transition, including PEDs, are generally accepted, meaning that higher levels of the ladder with higher roles of the participants are preferred out of the lower ones, but as the composition of the PEDs differ, the level and type of participation should be determined according to the type of intervention and local context.

For the purposes of PEDvolution, we will apply a classification building on the above models but simplified for practical purposes, varying from "low", "medium", and "high" levels of stakeholder engagement. These categories refer to the level, not frequency, of engagement, where "low" refers to mainly one-way communication and considers the stakeholder group more as information recipients rather than participants in collaborative action, "medium" involves two-way interaction such as stakeholder consultations and co-creation, and "high" refers to a full partnership or co-ownership of the process. The role of each stakeholder group has been estimated using this categorisation in the engagement roadmap, with further detailing information on the type and frequency of the interaction expected.

The status of the stakeholders should be revised frequently to assess and update the level of engagement as the project progresses and new information will be obtained. For example, the PEDs are still at the phase of planning and designing the demonstration activities and any changes could also affect the role of stakeholders in the PED.

4.3 German pilot site

4.3.1 Stakeholder mapping

A stakeholder mapping was conducted to identify the key stakeholders at the PED in Winterthur, and their potential relationship with the project. The aim of the exercise was to understand who the key actors and stakeholders at the pilot site are, and how might they influence the project, or be influenced by the project. The key actors and stakeholders are presented in the Figure 8 below.

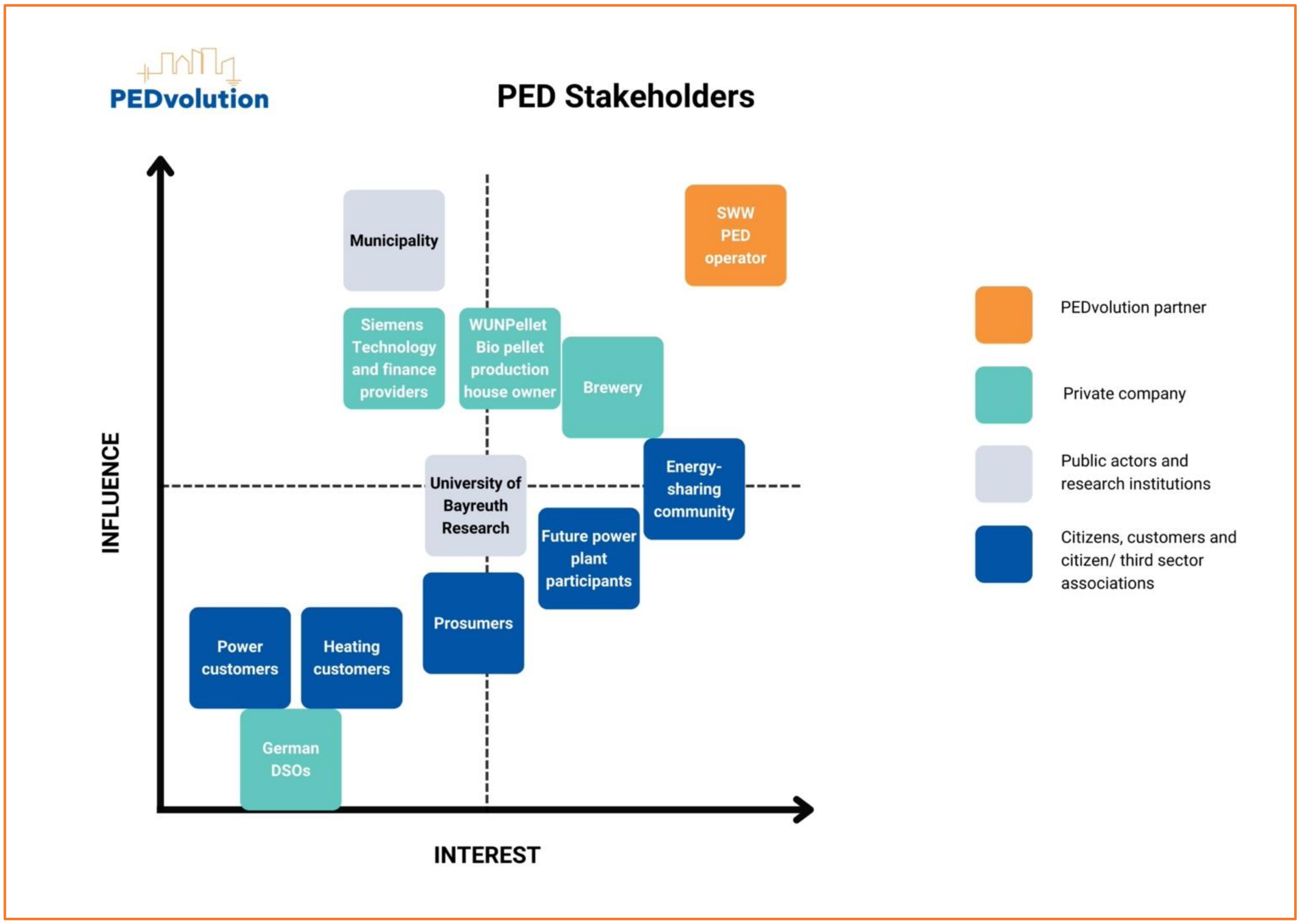

Figure 8: Stakeholder map, German pilot site.

Core partners – maintain communication and commercial relations

In the German PED, SWW will operate as the PED manager, and in addition will have multiple roles in the PED as a DSO, district heating operator, local CHP operator, and flexibility aggregator. Hence, in this case, a single actor will cover a range of roles sometimes played by a number of actors.

The additional suppliers and commercial actors include WUNpellet, a local company supplying biomass for the CHP plant, and a local brewery with significant flexibility potential to function as a core partner in the PED demo site with whom SWW has established commercial relations. From the stakeholder engagement perspective, the continuation of this relationship is expected.

The Schönbrunn PED includes a recently established energy-sharing community consisting of private and commercial actors. The energy-sharing community will form a part of the local PED, and the learnings from the operation of the types of cooperative models of energy management will offer important insight into the development, operation, and evolution of PEDs.

Being a municipally owned company, SWW has established communication channels with the municipality, that is also kept up to date on the project. Hence, no further new strategies are expected to be created.

Residential customers – encouraging active participation

The German PED seeks to convert customers from passive energy users into adopting more active roles in the local energy system. Different roles can be offered based on the type of customer and residential status, ranging from automated and manual flexibility offering, to participation in shared renewable energy initiatives, to support for prosumers, and to exploring options for shared storage. Increased energy flexibility and renewable energy production at the site will help the PED to balance the grid and explore opportunities for energy sharing at the level of a super PED combining local initiatives in Schönbrunn and central Wunsiedel.

In this setting, residential heating and electricity customers in Schönbrunn are an important stakeholder group in the project. While being estimated as "low" in their ability to influence the project, active participation is required to demonstrate the potential of the PED concept and tools. The local PED has already started involving customers in the PED development by holding a session to discuss the different forms of participation and collecting customer feedback on it. This high level of customer involvement is recommended to be maintained to achieve the expected levels of participation. With a track record of good levels of customer activation, reaching out to more diverse types of customers could be explored. A barrier analysis includes a lack of awareness on energy-related topics, motivation, and trust as topics to be tackled to enhance participation. Financing models for activities requiring upfront investment will help to lower barriers to joining. Data security concerns are expected to play only a minor role but should not be neglected.

Awareness-raising and educational activities are among the planned activities. A general understanding is that a vast majority of citizens do not have energy-related issues as a first concern, and, hence, gaining better insight into effective ways of motivating the residents could be an avenue to explore during the project.

Keep up to date with technology providers, suppliers, and research organisations

Technology provider and financing partners can bring additional value to the PED ecosystem in the techno-economic field and may help to shape the outcome, but the role will be indirect and will be further assessed during the project. In addition, the other stakeholders, such as nearby DSOs have more indirect role in the day-to-day operation of the project but can be relevant partners when looking at the scalability, replicability and exploitation sides of the project. Hence, keeping the stakeholders up to date on the general achievements and results of the project may help to identify future opportunities.

4.3.2 Stakeholder engagement: a gap analysis

This section presents the results of the analysis of barriers and opportunities for stakeholder engagement, with an aim to identify what are the main topics and focus areas for stakeholder and citizen engagement at the site.

The main engagement goal for the Schönbrunn PED is to have customers, residential, and industrial alike, taking active roles in the local energy system – the PED – as flexibility providers, members of the energy-sharing community, as prosumers or as “future power plant” customers, to name a few.

A track record of customer and end-user engagement and innovative models available for a range of customer types to participate actively in local energy systems and the local energy market facilitates the participation of industrial actors and residents in Schönbrunn PED. Counting with a range of models for participation and positive case studies from previous projects, coupled with customers that are already familiar with SWW, some of which have been already active in the local energy market, build a solid ground to continue activating customers to join local level energy initiatives. In this case, the level and extent of participation could be of focus in the future.

Indeed, past experiences suggest that barriers exist for further activation of residential electricity or heating customers; while a number of citizens are eager to join the new local energy schemes and take more active roles, this number does not still reach the majority. On the contrary, it tends to be the same enthusiastic groups of people who join the activities and options available. In the case of Schönbrunn, the elderly groups are the most active. One of the goals would be to explore the integration of wider groups or residents as well.

Awareness, motivation, and trust are among the factors estimated to be limiting the participation of citizens in masses, yet also business and financial models are needed to incentivise residents to invest in their own renewable energy production or to upgrade their status from prosumers to prostormers. The lack of clear legislative structures for energy communities, especially in terms of energy sharing, further limits the expansion of collective forms of energy production and consumption in formats supportive of effective grid management.

Understanding better the barriers and motivations for customers to opt for solutions to become active members in the energy market or to join local collective energy initiatives and finding further innovative models for participation would be needed to support local or district-level energy initiatives such as the PEDs. This should be done with consideration, as one of the current risks for engagement includes the potential oversaturation of residents with energy-related information and surveys.

Overall, active industrial and residential customers are the ground pillars for achieving flexible and efficient management of the PED.

4.3.3 Stakeholder views

On September 24th, 2024, SWW Wunsiedel organised an energy evening workshop with Schönbrunn residents with the participation of around 30 people. 23 of them are connected to the local heating network, one has a heat pump. Four of them have an electric car in combination with a wall box. To form an overview of the expected future participation rates at the site, SWW contacted about 900 residents in Schönbrunn with an invite for each household to attend the event.

The aim of the event was to inform residents and customers about the coming developments under PEDvolution and collect citizen feedback on the different forms of participation in the local energy market. In four groups everybody answered the following questions: What is a balanced energy district? How do local energy communities work? How do I influence my own energy price? What does all this have to do with my neighbourhood?

Feedback from the residents of Schönbrunn:

- **Perceived advantages:** There have been discussions about renting roofs from neighbours and using these areas to generate PV electricity in the form of contracting. This requires the need to improve communication between homeowners to be able to make such agreements. The community must decide how to get involved, who invests, and how the benefits are shared, but most of the people were open to this possibility. In addition, most participants are interested in providing flexibility in their electricity consumption and, for example, limiting or postponing their maximum power consumption as long as they are compensated for this in monetary terms and can deactivate this artificial limitation in an emergency. Many would like to have a storage facility that is operated jointly in order to strengthen the community and avoid the construction of many individual storage facilities that everyone uses just for themselves.
- **Perceived barriers:** Operating a storage facility is too expensive for most people, financing models and support from SWW are desired here. This could lead to citizens encouraging SWW to build and operate electricity storage facilities and to share the costs with the citizens within a local energy community in the form of citizen participation. Some felt they had less control within a PED because they are the “last link in the chain” and the concept of a PED is new to them.
- **Learnings:** In the case of a PED, they would also like to have an app that allows them to see the performance of the district to get feedback, as for many participants the idea of a PED was not always comprehensible or measurable (“electric power is not visible”). It is crucial for a successful energy community that everyone involved is well-informed and involved. Citizens expect to be “taken along” and receive concrete offers in the future. The concerns range from technical challenges (e.g. electricity storage) and economic hurdles (costs) to social and organizational issues (communication and participation). In order to create a successful local energy community, these factors must be carefully planned and clarified in an open dialogue between the parties involved. In general, people don't just want to focus on the electricity supply within a PED but also include the heat supply (sector coupling). They would rather keep their PED regional and invest the money for a storage facility locally, for example, in order to create added value for future generations. The inclusion of electric cars in a PED was conceivable for the owners present. Doing together, not just talking was the trend at this event.

In summary, the residents of Schönbrunn are generally open to energy issues. Many of them are part of the existing local heating network, and the recently founded energy-sharing community generates interest. It was noticeable here that only older citizens and pensioners in particular are interested in the topic of energy. Accordingly, there are still many people who can be reached. In general, the people of Schönbrunn receive many surveys on energy issues throughout the year, which can be a reason for that.

4.3.4 Engagement roadmap

The chapter 4.2.1 looked at the roles of the identified stakeholders in the German PED, and the barriers and opportunities related to the engagement of these stakeholders. Based on the information obtained, this section will present a high-level action plan for engagement including the main stakeholder groups, expected level of participation, general estimations of timing, objectives and high-level estimations on the types of activities intended. These plans will be further detailed during years 2 and 3 of the project.

Goals:

The main goals for the stakeholder engagement in the German PED are:

- Establish active collaboration between the PED participants to ensure smooth integration of assets and services to support grid management and energy supply stability.
- Enhance the participation of residents and support them in the transition from passive consumers into active actors in the local energy network.

Target groups

The main target groups include PED partners and PED participants, such as the commercial participants and energy-sharing communities, as well as the residential customers in Schönbrunn. The secondary target groups include technology providers, suppliers, other DSOs, and citizens in Wunsiedel in general. Table 3 below presents the high-level action lines.

Table 3: Stakeholder engagement plan, German pilot site.

Stakeholder type	Timing	Level of participation	Objective or motivation for engagement	Activities
Municipality	Throughout the project	Medium	Municipality as an enabling actor for green energy transition, SWW is municipality owned.	Maintain close relationship
Brewery (and similar commercial or industrial actors)	Planning Implementation	High Medium/ high	Commercial relationship, energy flexibility provision.	
SWW residential	Planning	High	Support the transition of customers into active	Customer feedback on the

Stakeholder type	Timing	Level of participation	Objective or motivation for engagement	Activities
customers in Schönbrunn			actors in the local energy system through different opportunities for participation, including passive and active flexibility provision, shared and private PV production options and shared storage options.	participation models available to them. Awareness raising on the options available, and education on the benefits and role of active participation in the energy transition, including PEDs. Active recruitment.
	Implementation	Medium	Regular two-way communication to ensure continuous participation.	Maintain communication with the existing PED members to understand and address barriers for continuous long-term participation. Communication of results of the project. Highlight local sustainability considerations and value to the customer/ community.
Energy sharing community (Schönbrunn, also Wunsidel)	Throughout the project	Medium	Demonstration of citizen-based cooperative energy initiatives, and their evolutionary potential, including integration into a PED	Collect and share information on the experiences of the energy sharing community and

Stakeholder type	Timing	Level of participation	Objective or motivation for engagement	Activities
				the applicability of the concept to PED development.
Citizens in Wunsidel	Throughout the project	Low	Improve general awareness of opportunities to become active actors in local energy systems. (most citizens would also classify as SWW customers)	Generic non-technical information on the findings and results
DSOs	Implementation, exploitation	Low/ medium	Relevance especially for scalability and replicability considerations	Two-way communication when required
Technology provider and investor	At specific milestones	Low/ medium	Relevance especially for scalability and replicability considerations	Generic information on the findings and results, two-way communication when required
Others (research institutes, other commercial actors)	At specific milestones	Low/ medium	Relevance especially for scalability and replicability considerations	Generic information on the findings and results, two-way communication when required

4.4 Slovenian pilot site

4.4.1 Stakeholder mapping

A stakeholder mapping was conducted to identify the key stakeholders at the PED in Kranj, and their potential relationship with the project. The aim of the exercise was to understand who the key actors and stakeholders at the pilot site are, and how might they influence the project, or be influenced by the project. The key stakeholders are presented in Figure 9 below:

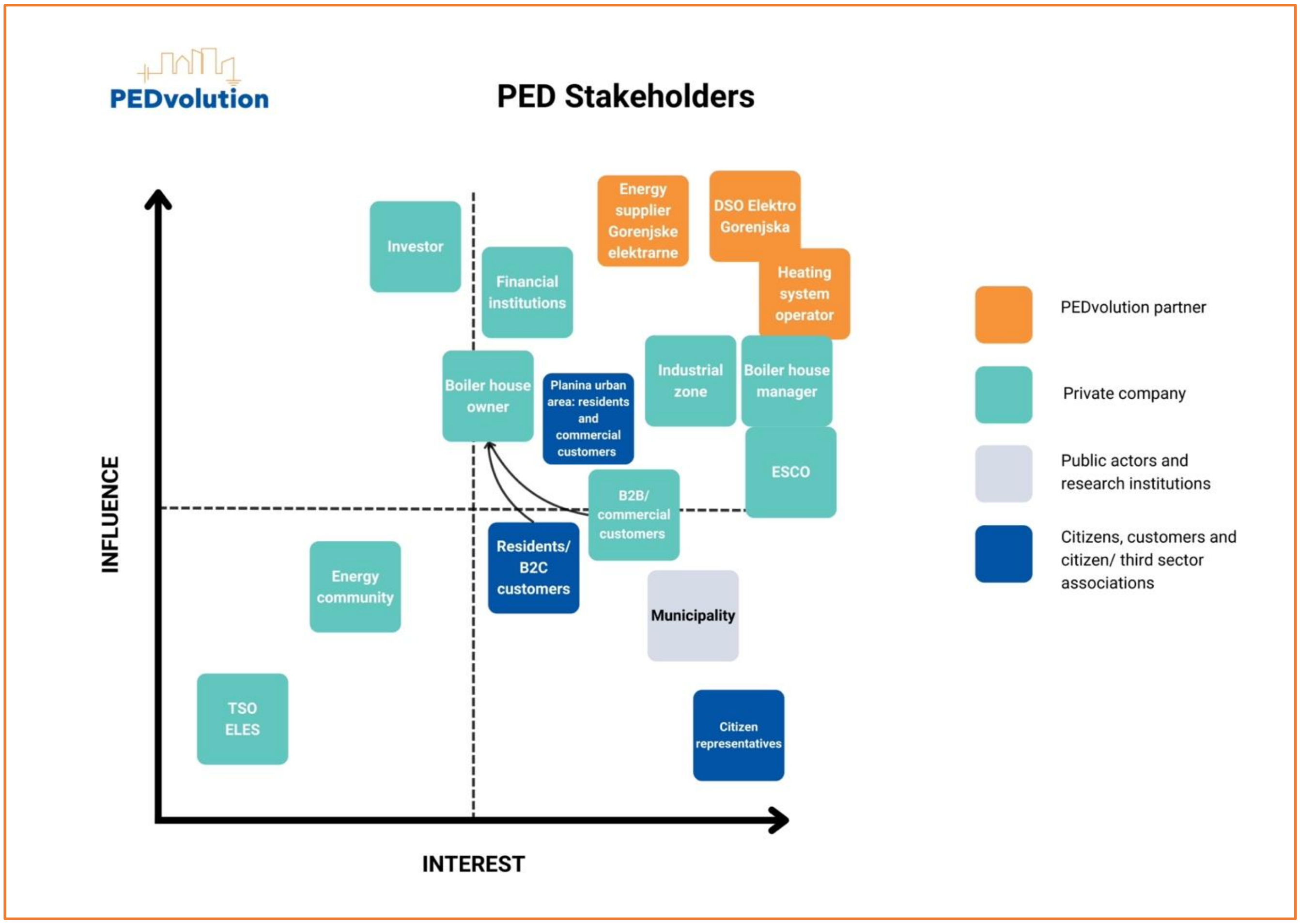

Figure 9: Stakeholder map, Slovenian pilot site.

Core partners – foster commercial relationships

The main actors involved in the PED include EG, which owns the distribution network and acts as the contractor for the National System Distribution Operator. EG covers approximately 10% of Slovenia's territory and supplies about 10% of the electrical energy to consumers, with 44% of this energy coming from their sources, including 11% from renewable sources.

Over the past ten years, initiatives by EG and the boiler house have renewed the district heating system, insulated approximately 90% of buildings, and achieved a 50% reduction in heat use due to increased efficiency. Gorenjske Elektrarne d.o.o. (GEK) plays a crucial role in electricity production and leverages hydroelectric power plants, solar power plants, and high-efficiency cogeneration facilities. Domplan d.d. manages the boiler house at Planina, Kranj. These entities collaborate to supply energy to over 4,300 homes and public institutions in the area. Domplan shares the interest in transitioning from natural gas to alternative sources due to legal and environmental pressures.

Industrial zone companies are showing interest in the project, as they are expected to benefit economically and environmentally from the planned usage of waste heat.

Residents – keep them up to date on the progress

Residents of the Planina neighbourhood will participate directly through the district heating network, which they own and manage. The Planina neighbourhood area includes approximately 16,000 residents, who collectively own the district heating system and are keen on lowering energy prices while ensuring reliable supply. They have dual roles as both customers and owners of the district heating system. A specific citizen group represents citizens towards the district heating plant and operator and is one of the main channels of communication between the citizens and the district heating operator.

Other actors – foster collaboration and offer active updates

The Municipality of Kranj actively supports the project and the carbon-neutral initiative. The municipality has additional roles as a co-owner of the district heating network, and customer through public buildings in the area being served by the district heating network. Investors and financial institutions are estimated as an important stakeholder group to follow up as planned investments in renewable energy entail high upfront investments. Financial institutions are potential sources of funding, with green investment funds being particularly relevant for the types of solutions developed within the project.

Overall, the PED ecosystem in the Kranj area consists of actors motivated to reduce the CO_2 emissions of the local energy system and to find ways to bring economic benefits to the participants through win-win solutions supporting energy efficiency and potentially lower energy prices. Potential risks include negotiating reasonable contracts for waste-heat supply within the industrial zone of Labore. Companies in the zone anticipate some profit from this project, and it is crucial to develop a mutually beneficial business model to onboard them effectively. This risk is estimated as low. Additionally, there are risks related to communication with residents. Currently, the boiler house manager holds regular meetings with residents, providing a platform for addressing issues and informing resident representatives.

4.4.2 Stakeholder engagement: a gap analysis

The Slovenian PED aims to become carbon neutral within five years through energy supply from local renewable energy sources, minimizing the use of natural gas and increasing the use of waste-heat. The Slovenian PED is focused on the integration of waste-heat into the district heating network and further integration of renewable energy sources. These activities tend to be quite centralized and “top-down” in their nature, involving mostly industrial actors and the municipality to a certain extent.

In this case, the key focus areas for stakeholder engagement activities constitute of business ecosystem building with the intended industrial and commercial partners. While this ecosystem partially exists, and several companies frequently collaborate together, formalization of business relations and contracts is required to achieve the goals of waste-heat integration. While the estimated economic benefits from the integration of waste heat sources are not yet fully known, expected sustainability-related benefits will bring additional value to the whole ecosystem. Sharing information on the project experiments and sustainability-related results between the PED members and the wider public might help to support the local ambitions.

The municipality, while not an official project partner, has good established relations with EG, the PED manager. The municipality with its clear sustainability goals functions as a facilitator in promoting sustainability-related and green initiatives and, for example, provides opportunities for local businesses to come together and interact. The municipality is a strategic partner and maintaining close working relationship is expected throughout the project.

While the residents and commercial establishments in Planina urban area are an important end-user group as users of the district heating network and owners of it, the direct impact of the project on the end-users is estimated to be limited. Successful outcomes could lead to increased energy efficiency or reductions in energy prices, but the impact will depend on a range of internal and external factors. As the infrastructure at the building level is already in place, no major disturbances are expected to the daily life of the residents. In this case, keeping residents and the wider public informed about the progress and expected gains is important to maintain public support.

The boiler house citizen representative group is the main channel of communication between the residents and the district heating operator and has an important function in channelling the views of the residents and functioning as a communication channel towards them. Maintaining the established relationship and constant communication is a way to ensure resident views are represented in the coming project activities as well.

The other stakeholders identified such as the investors, financing bodies or the TSO have a more indirect role in the project. For example, many of the investment decisions have been already made, and are not under the direct influence of the project. Keeping the relevant stakeholders informed, however, on the progress towards the green ambitions and the project results will help to foster the relationship towards the future and support scalability and replicability efforts.

4.4.3 Stakeholder views

The PED Manager in Kranj conducted two meetings with key stakeholders including the municipality, district heating operator and citizen representative group to present the project, collect feedback and address any topical issues. Altogether 50 people participated in the sessions. The stakeholder feedback includes the following:

- **Perceived advantages**: the participants recognized the potential of renewable energy and waste heat utilization to improve energy efficiency and reduce costs. Furthermore, the project aligns with Kranj's goal of becoming a climate-neutral and smart city by 2030. The integration of renewable sources (hydro, solar, and biomass) and waste heat was seen as a key driver to achieving energy targets, reducing CO_2 emissions, and lowering energy costs.

- **Perceived barriers**: overcoming the current reliance on natural gas for heating in the Planina district is a significant technological challenge, and there are technical and infrastructural concerns related to the integration of these new energy sources, especially the synchronization of waste heat from industrial processes with the existing district heating network. Stakeholders also have concerns about the financial and logistical complexities of transitioning from natural gas to renewable energy.

Overall, engagement with stakeholders has reinforced understanding of the importance of cross-sectoral cooperation and the need to integrate both energy and non-energy sectors effectively (e.g., mobility and ICT). The interaction with local authorities and companies highlighted the necessity of flexibility and scalability in the solutions being proposed, ensuring they align with local conditions and long-term sustainability goals. The importance of citizen engagement was also highlighted to ensure a long-lasting adoption of energy solutions.

4.4.4 Engagement roadmap

Based on the information obtained through stakeholder mapping and analysis exercises, this section presents a high-level action plan for engagement including the main stakeholder groups, expected level of participation, general estimations of timing, objectives, and high-level estimations on the types of activities intended. These plans will be further detailed during years 2 and 3 of the project.

Goals:

The main goals for the stakeholder engagement in the Slovenian PED are:

- Strengthen and maintain active collaboration with the identified PED participants, especially in the industrial zone Labore, to enhance integration of renewable energy sources and waste heat in the local PED.
- Maintain the residential and commercial customers in the Planina neighbourhood informed on the planned activities and results, to leverage support for the efforts to phase out gas and find green alternatives for energy supply.

Target groups:

The main target groups include PED partners and PED participants, including the district heating operator and the companies in the industrial zone Labore, as well as the municipality as a facilitator of green initiatives in the area. The secondary target groups include residential and commercial customers in the Planina urban area, citizens in general, as well as other commercial and industrial actors. Table 4 below presents the high-level action lines.

Table 4: Stakeholder engagement plan, Slovenian pilot site.

Stakeholder type	Timing	Level of participation	Objective	Activities
Municipality	Throughout the project	Medium	Strategic partner facilitating the communication between business entities, also a client for the district heating network, and channel of communication with residents	Continuous collaboration, Use of municipal media to highlight some of the project goals and achievements
Companies in the industrial zone labore	Planning Implementation	High Medium/ high	Business role and interaction through integration of waste energy sources.	Commercial partnership with companies with excess heat sources
Planina Boiler House	Throughout the project	High	Business role and interaction through integration of waste energy sources.	
Boiler house citizen representative group	Throughout the project	Medium	A key channel of informing the residents and channeling their views.	Regular meetings to update the citizen representative group on the progress of the project. Allow group to bring in any potential concerns of the residents.
Planina urban area residents	Throughout the project	Low	Customers and owners of the district heating network, maintain informed about the project and the results	Regular information about the progress of the project through citizen representative group, webpage, local media.
Citizens in general	Throughout the project when there are relevant	Low	Dissemination of information about the progress of the project;	Local media Webpage

Stakeholder type	Timing	Level of participation	Objective	Activities
	developments to report		decarbonization of the district heating network, through citizen representative group, webpage, local media.	
Others **(investors, TSO)**	Throughout the project, especially when results to report	Low	Indirect stakeholders	Generic information on the findings and results

4.5 Swiss pilot site

4.5.1 Stakeholder mapping

Finally, stakeholder mapping was also conducted to identify the key stakeholders at the PED in Winterthur and their potential relationship with the project. The aim of the exercise was to understand who the key actors and stakeholders at the pilot site are and how they might influence the project or be influenced by the project. The key actors and stakeholders are presented in Figure 10 below.

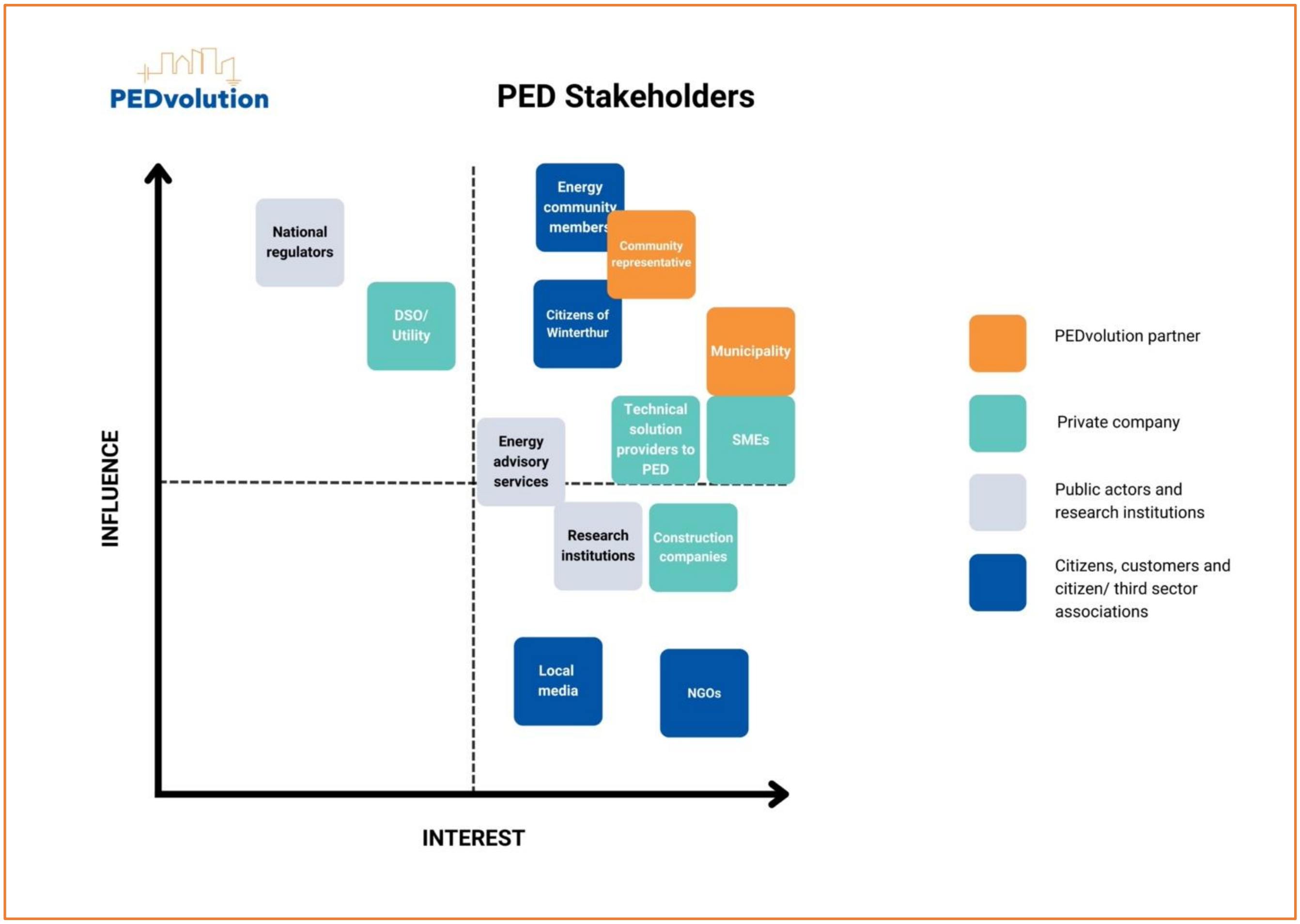

Figure 10: Stakeholder map, Swiss pilot site.

The Swiss pilot site involves several critical stakeholders. These include the municipality, Hard community members, community management company (Gemeinshaft Hard AG, GeHa), local SMEs and service providers. The municipality of Winterthur is a key strategic partner, that actively supports the PED project as part of the city's broader goals of achieving Net Zero by 2040 and the Smart City strategy. The municipality is also responsible for energy management and governance across the city.

The local utility operates independently from the city administration but plays a crucial role as a stakeholder. Although not directly involved in day-to-day community activities, the utility has historically been highly cooperative and is likely to continue providing essential support for the development of the PED's energy infrastructure.

The Hard community consists of around 250 residents and 40 businesses, which are critical to the PED's success. However, many residents, particularly the elderly, face financial constraints and may lack the technical expertise required to fully engage with the energy systems. Despite these challenges, they show interest in improving energy efficiency and have relatively high levels of energy literacy. The community members are the direct beneficiaries of the PED's energy initiatives and manage its governance indirectly through the community representatives in the GeHa management board as well as through decision-making at the owner-occupied multi-storey apartments.

GeHa is the operational body responsible for managing the Hard community's day-to-day governance and energy activities. The company operates as a stock corporation, with a board composed of community members. However, there is a distinction in how decisions are made: while the board is involved, the CEO, who is based outside Winterthur, oversees broader operational decisions but is not involved in everyday community life. The company is involved in the energy investment decisions at the community level, but in cases in which private buildings are involved, decisions are made at the building level. This governance model has led to slow decision-making on energy projects, and the two-layered governance needs to be fully taken into account when planning future initiatives.

Local SMEs, including IT consulting firms and energy solution providers, play a significant role in supporting the PED's technical infrastructure, as these businesses offer services such as implementing smart meters, managing electric vehicle charging stations, and evaluating renewable energy solutions like heat pumps. Some of the local SMEs also volunteer their time and skills for the local community development.

4.5.2 Stakeholder engagement: a gap analysis

The Swiss pilot site in Winterthur has a primary goal of integrating renewable energy sources into the energy community. Achieving this goal requires active engagement of the key stakeholders, including the municipality, community members, the community management company, and local SMEs. However, several gaps in stakeholder engagement must be addressed to make this vision a reality.

A significant gap in stakeholder engagement arises from the decentralized decision-making structure within the Hard community. Part of the energy investment decisions, as well as the daily energy management, is managed by GeHa AG, while individual building associations have substantial autonomy regarding decisions affecting their buildings, resulting in fragmented and slow decision-making processes. This two-layered decision-making process, typical to many communities involving owner-occupied apartment buildings, hinders the timely implementation of energy investment decisions, as consensus among groups is often delayed. While it is not possible to change the governance structure altogether, investigating possibilities for streamlining decision-making through aligning goals and improving information flows, could be investigated.

Another critical challenge is the low prioritization of energy topics among community members. Although there is an interest in sustainability, many residents do not put their primary focus on energy initiatives. Additionally, while some residents demonstrate high energy literacy and take on voluntary roles, such as leading the installation of EV charging stations, overall participation remains limited. The technical knowledge gap among residents further exacerbates these challenges as many community members lack the expertise needed to fully participate in energy-related decision-making.

To address these gaps, several strategies have been proposed and are currently under discussion with the project partners. These include showcasing successful case studies from similar projects, leveraging role models within the community, and providing educational workshops to increase technical understanding and engagement.

The municipality plays a crucial role as a strategic partner, aligning the PED's objectives with the city's Net Zero by 2040 goal and facilitating cooperation among stakeholders. Similarly, the local utility has been a cooperative entity in past projects and remains crucial for the integration of renewable energy sources into the community's energy grid.

4.5.3 Stakeholder views

We conducted a series of engagement activities with GeHa, involving key meetings to discuss project objectives and gather feedback. Notably, we held two crucial meetings:

- **Meeting 1** occurred on July 3rd, 2024, at Hard with ZHAW and city representatives. This meeting focused on decision-making within GeHa, energy management strategies, and specific challenges around infrastructure, heating solutions, and energy autonomy for the house groups. Both meetings allowed for productive exchanges on project goals, stakeholder roles, and specific challenges relevant to the project.
- **Meeting 2** took place on September 2nd, 2024, with a member of the GeHa responsible for infrastructure and energy-related aspects. This meeting introduced the key project areas and explored her responsibilities in relation to energy infrastructure, collaboration with building owners, and ongoing project requirements.

The stakeholders, particularly GeHa, provided insightful feedback regarding the project:

- **Perceived advantages:** The decentralised decision-making structure within GeHa allows for flexibility and autonomy for individual house groups. Many were open to exploring renewable energy options, such as PV installations and different heating systems (e.g., heat pumps, wood pellets). The cooperative's commitment to sustainability and energy efficiency was clear, and stakeholders generally support integrating modern and environment-friendly systems.
- **Perceived barriers:** However, there were challenges due to the complexity of managing independent house groups within the cooperative. Each group has autonomy over its energy decisions, which could lead to a lack of a unified strategy. Furthermore, technical constraints exist, such as zoning restrictions (due to historical preservation) that limit larger insulation efforts and protected groundwater areas where certain heating technologies (e.g., ground probes) are not permitted. The end of the hydropower subsidy in 2035 also poses a longer-term challenge for energy strategy.
- **Learnings:** One key takeaway is the need to remain flexible and possibly decentralize energy strategies, allowing house groups within GeHa to continue making their own decisions regarding PV installations and heating systems. The feedback highlighted the importance of

accounting for individual autonomy within the cooperative, while still fostering collaboration where possible. Additionally, sustainability and energy efficiency emerged as critical priorities. The discussions emphasized that the implementation phase must prioritize energy efficiency, renewable energy sources, and low-environmental-impact technologies to meet the project's sustainability goals. Lastly, the legal and technical constraints discussed will need to be carefully addressed during the implementation phase. Solutions must be developed that are feasible within protected zones and comply with zoning laws, while still effectively meeting the cooperative's energy needs.

In summary, the stakeholder engagements have provided crucial input that will guide both the design and execution of the project, with particular focus on balancing autonomy and coordination among house groups, as well as ensuring sustainable and legally compliant infrastructure.

4.5.4 Engagement roadmap

Chapter 4.5.4 discusses the relevant stakeholders in the Swiss PED, and barriers and opportunities related to their engagement. Based on the information obtained, this section will present a high-level action plan for engagement including the main stakeholder groups, expected level of participation, general estimations of timing, objectives and high-level estimations on the types of activities intended. These plans will be further detailed during years 2 and 3 of the project.

Goals:

The main goals for the stakeholder engagement in the Swiss PED are:

- ❖ Support the bottom-up decision-making processes within the Hard community to create future avenues for the local energy system, supporting increased generation and consumption of green energy.
- ❖ Demonstrate alignment with the city climate goals, particularly the net zero targets by 2040, as well as the smart city strategies.

Target groups:

The main target groups include the Hard community energy cooperative, residents and commercial actors present in the community. The City of Winterthur, also a partner of the project, is an important collaborator. The secondary target groups include utilities, service providers, non-profit actors such as local media, and citizens of Winterthur in general. The status of these groups should be revised during the project and might change depending on the evolution of the local energy community. Table 5 below presents the high-level action lines.

Table 5: Stakeholder engagement plan, Swiss pilot site.

Stakeholder type	Timing	Level of participation	Objective or motivation for engagement	Activities
Municipality	Throughout the project	Medium	The municipality of Winterthur is a partner of the project. Interests are related especially to climate goals, smart city initiatives and innovation action.	Maintain close relationship through established channels
Hard community – GeHa and energy manager	Throughout the project	High	A core partner in the project and the main channel of communication between the project and the Hard community.	Maintain close communication through established channels
Hard community – community members	Planning	High	The community operates through bottom-up approach. Involve the community members in the planning of activities and follow the decision-making levels present in the community.	Awareness raising on energy related topics and the options available. Joint vision building. Education on the benefits and role of active participation in the energy transition, including PEDs.
	Implementation	High	Regular communication on the progress and results obtained to enhance interests in energy-related issues	Maintain communication with the community members, through the energy manager. Identify other preferred communication channels.

Stakeholder type	Timing	Level of participation	Objective or motivation for engagement	Activities
				Potentially expert support and/ or educational workshops. Communication of results of the project. Highlight local sustainability considerations and value to the customer/ community.
Hard community - SMEs	Throughout the project	High/ Medium	Involve the local SMEs in the planning of activities.	Regular communication on the progress and results obtained. Assess how to leverage on the expertise of the local SMEs to support the community.
Citizens in Winterthur	Implementation	Low	General awareness raising	Generic non-technical information on the findings and results
Local utility company	Implementation	Low/ medium	Potential partner for the community, depending on the chosen avenues for the energy solutions to be implemented.	To be defined
Other commercial actors (service providers, construction companies)	Implementation	Low	General awareness raising, assess potential partnerships during the project	Generic dissemination

Stakeholder type	Timing	Level of participation	Objective or motivation for engagement	Activities
Other non-commercial actors, such as local media	Implementation	Low	Potential dissemination channels	Generic dissemination

5 CONCLUSIONS

The ongoing trends towards decentralisation of energy production, digitalisation and increased availability of technologies such as smart grids and storage options are creating the conditions for energy solutions at community and district levels. While some of the European countries have a longer tradition of collective and cooperative forms of energy production, the European Green Deal package and the revised Renewable Energy Directive (EU 2018/2001) continue to pave the way for the development and implementation of these initiatives, further supporting the role of decentralised production and the role of citizens in the energy sector. PEDs, as new forms of decentralised energy production, benefit from the development of this enabling environment.

Through these processes, the demand for tools such as those developed and tested in PEDvolution is expected to increase. Successful scaling of PEDs depends on optimising the integration of solar PV, wind, and hydropower at the local level. Promoting the use of energy efficient appliances, demand-response systems, and real-time energy management tools will enable districts, neighbourhoods, and communities to maximise their use of renewable energy. Strategies to support stakeholder engagement and alignment, fostering collaboration between municipalities, energy suppliers, technology providers, urban planners, and the community are essential to scaling up PEDs and fostering their role in the energy transition.

Even with a generally positive environment for the development of PEDs, these initiatives are essentially rooted in local contexts and dynamics. Understanding the key characteristics of the PEDs to be developed at national and local levels and integrating local needs and considerations into the development of PEDs, is essential to enhance the longevity and scalability of the initiatives.

The three PEDs to be developed in the PEDvolution project are all being developed in very different contexts and by different actors, ranging from a community-based PED in Switzerland to energy sector actors seeking to involve urban stakeholders in neighbourhood-level initiatives in different ways: one focusing more on energy flexibility activities with local commercial and residential actors in Germany, and the other on emissions reduction through integration of waste heat into the district heating network in Slovenia. Each of the sites encompasses unique socio-economic and cultural characteristics that influence the interest and motivation of the local actors to participate in urban renewable energy initiatives.

Through stakeholder mapping and analysis, this document helps to outline the potential roles and influence of a range of different stakeholders present in the localities, ranging from local government to utilities, and from resident associations to industry partners. The approach supports design principles for early stakeholder engagement to ensure that the final solutions fit the community's specific energy ambitions and socio-economic landscape.

The results of the stakeholder mappings show that the three different types of PEDs also involve different stakeholders requiring different approaches to stakeholder interaction. The Swiss site, being a bottom-up initiative, has the local community at its core, while the Slovenian site has an industrial focus. The German site, although DSO-led, relies on mobilising customers to develop a PED that is flexible and adaptable to fluctuations in renewable energy production. In all sites, municipalities play a key role in creating the enabling conditions for PEDs through climate strategies and as facilitators of communication between local actors on innovation, energy and climate related issues.

While this deliverable provides an account of the context in which the three, already defined pilot sites of the PEDvolution project are being developed, some open questions and avenues for further work remain. The results of this deliverable are based on information available from public sources, with some limitations on the data available. Information on socio-economic indicators at neighbourhood level is rather limited. The GDPR regulations further limit the possibility to extract information from more unconventional sources, such as existing customer databases. As a result, some knowledge gaps have been identified that may need to be addressed by other means, such as collecting complementary background information during stakeholder interviews at a later stage. These knowledge gaps include basic background information on residents, as well as further understanding of the level of energy awareness and energy literacy of citizens in contexts where citizen participation is key.

In line with the pilot-centred focus and reliance on desk-based evidence, the market perspective included in this report is limited to site-level enabling conditions that shape feasibility and uptake in the three pilot contexts. These enabling conditions include institutional landscape, actor roles and governance arrangements, regulatory and policy considerations, and practical adoption prerequisites. A more dedicated market analysis would therefore be beneficial to address tool-level topics that fall outside of the scope of this deliverable, such as customer segmentation beyond the pilots, market sizing, competition and existing alternative solutions, and go-to-market and scaling considerations for the PEDvolution toolset. Market focused information related to the PEDvolution tools will be collected at a later stage and presented in the deliverable D12.2 “PEDvolution replication and market analysis & exploitation strategy”, to support exploitation and scaling purposes.

This document presents preliminary stakeholder engagement roadmaps for the project, and more specifically, for the pilot sites. The development of these roadmaps is based primarily on the project partners’ understanding of their sites, combined with stakeholder engagement activities, such as site visits and consultation sessions. These roadmaps are deliberately generic and represent a “best guess” at the start of the project, to be revisited and reviewed at a later stage to assess the need for further alignment. In addition, the limited interests of citizens in energy related matters, and the need to compete about their attention were recognised as challenges by most pilot sites. These challenges need to be taken into account when planning citizen engagement activities.

Future activities of the project will build on the work initiated with this deliverable. The development of the “PED Social Innovation Tool” and its implementation will further improve the understanding of stakeholders’ views on PEDs and the solutions to be implemented. Similarly, other tools, such as the “Business Modelling Tool” will contribute to the development of new business models appropriate to the local contexts. The second phase of the project will see this “localisation” of the more generic approaches having developed in the first year, followed by implementation in the final phase of the project.

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