PEDvolution

Interoperable solutions to streamline
PED evolution and cross-sectoral integration

Deliverable 11.2

KERs and characterisation

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1 According to Project's Quality Assurance Process

Table of Contents

List of Figures

List of Tables

Glossary of terms and abbreviations used

ABBREVIATION / TERM	DESCRIPTION
DoA	Description of the Action
DGBN	German Sustainable Building Council
DHC	District heating and cooling
DSO	Distribution System Operator
DDSG	Dynamic Decision Support Guideline
EG	Elektro Gorenjska *(PED Manager)*
ESCO	Energy Service Provider
Genotype	A positive energy district's set of genetic material, built through a unique combination of Social Technology-Interoperability-Market related aspects
EV	Electric Vehicle
ICOM	Intracom Telecom *(Solution Provider)*
IPR	Intellectual Property Rights
KER	Key Exploitable Result
MRL	Market Readiness Level
NTNU	Norwegian University of Science and Technology *(Solution Provider)*
PED	Positive Energy District
Phenotype	The set of observable characteristics of the PED resulting from the interaction of its genotype with the environment (e.g. energy market, industry, mobility, (geo)politics)
PV	Photovoltaic
SGNI	Swiss Sustainable Building Council
SRL	Societal Readiness Level
SXS	Sympraxis Team *(Communication & Dissemination Leader)*
SIN	Smart Innovation Norway *(Solution Provider)*

SWW	SWW Wunsiedel Gmbh *(PED Manager)*
TRL	Technological Readiness Level
VITO	Flemish Institute for Technological Research *(Solution Provider)*
WIN	Stadt Winterthur *(PED Manager)*
ZHAW	Zurich University of Applied Sciences *(Solution Provider)*

1 EXECUTIVE SUMMARY

This deliverable identifies and characterises PEDvolution's Key Exploitable Results (KERs), establishing a foundation of the project's overall exploitation and long-term sustainability strategy. For each KER, it outlines the solution, assesses its potential for adoption and replication across diverse Positive Energy District (PED) contexts -drawing on insights from PEDvolution's co-developer PEDs gathered to date- and analyses the main technical, regulatory and market barriers that may influence wider uptake.

The analysis covers the seven PEDvolution tools, which collectively form an integrated, interoperable, and data-driven framework to support the transition towards energy-positive, citizen-centred, and digitally connected districts. Each tool has been evaluated in terms of its readiness level, applicability, and exploitation pathways, with particular attention given to envisioned enablers, associated risks, and mitigation measures. These insights were developed in collaboration with the PEDvolution PED managers and Solution Providers.

From an exploitation perspective, this deliverable establishes the strategic groundwork for developing both the joint and individual exploitation strategies for each tool to be implemented beyond the project's lifetime. It highlights key enablers, business opportunities, and market pathways that will guide future actions towards commercialisation, replication, and scaling.

Key insights for supporting successful implementation across PED contexts derived from the analysis include early stakeholder involvement, modular system design, and clear data governance frameworks to build trust and facilitate adoption. Looking forward, the focus will shift toward enhancing interoperability and user experience to support predictive PED management.

The insights gathered here will feed directly into D12.2 "PEDvolution replication and market analysis & exploitation strategy" due at the end of the project, ensuring the alignment of technical results with business-oriented exploitation strategies and supporting the long-term exploitation and sustainability and impact of PEDvolution's innovations.

2 INTRODUCTION

This deliverable provides a comprehensive overview and analysis of PEDvolution's Key Exploitable Results (KERs) identified to date. The document presents the methodological approach for KERs identification, the characterisation process, and the assessment of their potential impact and readiness for exploitation, in alignment with the requirements of the Grant Agreement (GA). The document also details the deployment objectives for each PED co-development site, highlighting both facilitating factors and barriers associated with the solutions developed within the project's scope. Furthermore, it outlines mitigation and corrective measures to address identified challenges, thereby establishing a solid foundation for the development of a targeted exploitation and sustainability strategy (WP12 «Project Communication, Dissemination and further Exploitation (Year 3)») beyond project completion.

2.1 Mapping the Project's Outputs

This section maps PEDvolution's Grant Agreement commitments, detailing how the formal Deliverable and Task description, correspond to the project's outputs and work performed. It systematically links the task and deliverable to the associated objectives, milestones, and expected results, thereby demonstrating alignment between planned activities and their implementation within the specific work package and overall project scope.

Table 1: Adherence to Project's GA Deliverable & Tasks Descriptions.

PROJECT GA COMPONENT TITLE	PROJECT GA COMPONENT OUTLINE	RESPECTIVE DOCUMENT CHAPTER(S)	JUSTIFICATION
DELIVERABLE			
D11.2 KERs and characterisation	Identification of and characterisation using the methodology and defined attributes of PEDs. (T11.2)	Chapters 4, 5, 6, 7, 8, 9, 10, 11	This deliverable identifies and characterises PEDvolution's KERs during and beyond the project's duration. The purpose is to assist in the early detection and mitigation of potential barriers/risks, to take the necessary corrective actions in a timely manner and plan the 1st steps of the exploitation strategy for the most promising KERs in WP12. Chapters 3 - 10 detail and summarise the respective information for each KER as collected from the input forms.
TASKS			
T11.2 KERs update and characterisation	SXS will support partners in identifying and updating the Key Exploitable Results (KERs) during and beyond the project lifecycle that are identified in the	Chapters 3, 4, 5, 6, 7, 8, 9, 10, 11	The task is implemented via the collection and analysis of information related to the project's KERs during and beyond the project duration. This includes the ones already identified in the DoA and any additional ones that could be recognised.

	section 1.1.4 of this proposal. A proper follow-up will be done to the identify any additional KERs all along the project lifespan, including their characterisation, to mitigate any possible related risks and make the necessary corrections in a timely manner. (D11.2)		The results will be used as a starting point to develop the exploitation strategies for the most promising KERs. Guided by SXS with the contribution of the PED Managers and Solution Providers, relevant information is collected and analysed.

2.2 Deliverable Overview and Report Structure

This deliverable identifies, updates, and characterises PEDvolution's Key Exploitable Results (KERs), supporting the project's overall exploitation and sustainability strategy. It serves as a reference for assessing the technological, market, social, and regulatory maturity of each developed solution within the project, as well as their potential for replication across diverse Positive Energy District (PED) contexts.

The outcomes of this deliverable directly inform WP12 «Project Communication, Dissemination, and Further Exploitation (Year 3)», and more specifically lead into Task 12.3 «Sustainability plan, exploitation and replication», and the forthcoming Deliverable D12.2 "PEDvolution replication and market analysis & exploitation strategy". In addition, its findings will support the development of tasks T9.2 «PEDvolution tool refinement and technical support» and T9.3 «PEDs performance assessment».

The characterisation and analysis presented here provide essential input for defining the pathways, stakeholders, and conditions necessary for successful market uptake and long-term exploitation of the project's results.

The structure of the deliverable is outlined below:

- **Chapter 2 –** Introduction: Presents the overall purpose, deliverable scope and structure
- **Chapter 3 –** Describes the methodology applied and presents the PEDvolution solutions to be examined
- **Chapter 4 –** PED Design and Planning Toolset: Description and analysis
- **Chapter 5 –** Dynamic Decision Support Guideline: Description and analysis
- **Chapter 6 –** PED Energy Manager: Description and analysis
- **Chapter 7 –** PED Readiness Assessment: Description and analysis
- **Chapter 8 –** Business Models Innovation Tool: Description and analysis
- **Chapter 9 –** Social Innovation Tool: Description and analysis
- **Chapter 10 –** Data, Exchange and Interoperability Platform: Description and analysis
- **Chapter 11 –** Summarises the main findings and elaborates an initial overarching exploitation strategy
- **Chapter 12 –** Conclusions and next steps

Overall, this deliverable provides the analytical and evidence base for PEDvolution's exploitation development, ensuring that the consortium has a comprehensive understanding of its exploitable results, their readiness for market adoption, and the actions required to ensure long-term sustainability and impact. This deliverable is complementary to D8.1 “Monitoring and Verification Plan and Co-developer Demos Preparation”, which provides the framework for assessing PED performance and the preparation of PEDvolution co-developer demonstration sites for deployment.

3 METHODOLOGICAL APPROACH

3.1 Overview

The purpose of this deliverable is to identify, update, and characterise the project's Key Exploitable Results (KERs) during and beyond the project lifecycle, in alignment with those defined in Section 1.1.4 of the DoA. This process enables the consortium to anticipate risks and implement corrective measures in a timely manner, while laying groundwork for the development of PEDvolution's exploitation strategy.

In PEDvolution, a Key Exploitable Result (KER) is defined as *"an identified main interesting result, which has been selected and prioritised due to its high potential to be exploited - meaning to make use of and derive benefits from - downstream in the value chain of a product, process, or solution, or to serve as an important input to policy, further research, or education[2]."*

Characterisation involves describing each KER in terms of its technological, market, social, and regulatory characteristics (genotype), as well as its interaction with its environment (phenotype) including how it is deployed across different PED contexts, and the associated benefits, enablers and barriers. This approach supports a holistic understanding of each solution's readiness level, adoption potential, and replication prospects across diverse urban contexts. To assess readiness in a structured and comparable manner, three complementary maturity metrics are considered:

- **Technology Readiness Level (TRL):** assessing the technical maturity of a solution along a scale from (Basic principles) TRL 1, to TRL9 (Actual system proven in an operational environment)[3].
- **Market Readiness Level (MRL):** evaluating how prepared a solution is for market uptake, considering business models, customer validation, and regulatory alignment[4].
- **Social Readiness Level (SRL):** measuring the degree of societal acceptance, stakeholder engagement, and alignment with user needs from a scale of SRL 1 (identifying problem and identifying societal readiness) to SRL 9 (actual project solution(s) proven in relevant environment)[5].

Collectively, these scales provide a comprehensive view of a KER's potential for adoption and replication across PED contexts. The methodology for KERs characterisation as described in this deliverable, followed a structured, collaborative process coordinated by SXS, involving both Solution Providers and PED Managers, and consisting of five main steps:

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[2] https://webgate.ec.europa.eu/funding-tenders-opportunities/spaces/IT/pages/8913463/Managing+Project+Results+in+the+Horizon+Results+Platform
[3] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2025/wp-14-general-annexes_horizon-2025_en.pdf
[4] https://swforum.eu/sites/default/files/2021-05/SWForum_MTRL_Webinar_26.05.2021.pdf
[5] https://innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf

1. **Preparation of input collection forms** - joint design to capture essential information for each KER, their characterisation and respective deployment parameters in each demonstration site.
2. **Input collection** - gathering of information by Solution Providers and PED Managers for their respective KERs and demonstration sites (see input forms in Annex I and Annex II respectively).
3. **Analysis** – initial recognition of common patterns, enabling factors, and barriers to exploitation.
4. **Conduction of dedicated workshop** during the 3rd General Assembly - jointly organised by SXS and SIN, to identify the main challenges in each PED demonstration site and explore how the PEDvolution solutions can address them (see Annex III for workshop agenda).
5. **Synthesis of findings** - consolidation of all collected information, to update each KER's characterisation and to establish a baseline for the project's overall exploitation strategy (T12.3).

3.2 Respondents' profile

Data collection for this deliverable, involved inputs from both Solution Providers and PED Managers across PEDvolution's demonstration sites.

The PEDvolution Solution Providers -OFFSET, ICOM, VITO, NTNU, ZHAW, TUW, and SIN- provided detailed information on the tools under development, while PED Managers completed the dedicated form for each tool or solution planned to be tested within their demonstration sites.

Each PED site, represented by a PED Manager, reflects a distinct local context, thereby contributing to the assessment of the project's replication and transferability potential:

- Schönbrunn village, Wunsiedel (Germany) | PED Manager: SWW
- Residential neighbourhood Planina, Kranj (Slovenia) | PED Manager: EG
- Gemeinschaft Hard, Winterthur (Switzerland) | PED Manager: WIN

Table 2: Overview of KER descriptions and contributing partners.

KER	DESCRIPTION	KEY FUNCTIONALITIES	SOLUTION TYPE	SOLUTION PROVIDER(S)	CONTRIBUTING PARTNERS
PED Design and Planning Toolset	A Digital Twin planning tool that helps developers and city planners simulate and optimise energy systems at both building and district levels.	- Accurate energy modelling of buildings and district assets. - Optimised renovation pathways for district heating and cooling. - Data-driven decision-making to reduce techno-economic risks. - Optimal implementation and investment pathways of DHC	Genotype	**VITO**/TUW	EG/SWW/WIN

KER	DESCRIPTION	KEY FUNCTIONALITIES	SOLUTION TYPE	SOLUTION PROVIDER(S)	CONTRIBUTING PARTNERS
Dynamic Decision Support Guideline	A structured workflow and targeted guideline system that assists decision-makers in selecting the best technologies, urban planning strategies, and renewable energy integration approaches.	- Real-time guidance based on local conditions. - Helps PEDs assess trade-offs between cost, energy efficiency, and sustainability. - Supports urban planners and PED developers in making informed investment decisions.	Genotype	**NTNU**/VITO	EG/SWW/WIN
PED Energy Manager	A multi-level toolset for optimising energy flows, utilising flexibility within a PED, and integrating with energy markets.	- Real-time monitoring and optimal control of distributed energy processes in residential and non-residential sectors. - Demand response and flexibility management. - Holistic optimisation of energy flows across multiple energy vectors (cross sector). - Enables integration with energy markets to exploit demand-side flexibility.	Phenotype	**OFFSET**/TUW/ICOM	EG/SWW/WIN
PED Readiness Assessment	A systematic evaluation methodology to assess how well a district or neighbourhood meets Positive Energy District (PED) criteria.	- Builds on existing EU and international standards for building and community assessment. - Uses a structured system based on sets of criteria and KPIs. - Provides a lifecycle approach, highlighting potential improvements over time to guide PED evolution.	Phenotype	**ZHAW**/VITO/SIN/NTNU	EG/SWW/WIN
PED Business Models Innovation tool	A business modelling tool tailored to PEDs, helping stakeholders develop viable and scalable business models.	- Offers pre-tested business model patterns for community-based solutions. - Helps PEDs adapt models to their local context. - Supports economic feasibility and long-term market integration.	Phenotype	**SIN**	EG/SWW/WIN

KER	DESCRIPTION	KEY FUNCTIONALITIES	SOLUTION TYPE	SOLUTION PROVIDER(S)	CONTRIBUTING PARTNERS
PED Social Innovation Tool	A methodology for stakeholder engagement and community participation, ensuring that PED solutions align with local priorities and societal needs.	- Assesses the current state of community involvement. - Identifies stakeholder priorities, values, and expectations. - Guides PEDs through a three-phase engagement process: information collection and analysis, co-creation, and implementation.	Phenotype	**SIN**	EG/SWW/WIN
Data Exchange, Integration & Interoperability Platform	A secure data exchange platform that ensures seamless communication between PED assets, PEDvolution solutions, and external to the PED systems.	- Standardised data exchange interfaces for seamless connectivity. - Privacy and security compliance with GDPR and other regulations. - Enables PEDs to integrate with local DSOs, markets, and smart grid infrastructures.	Phenotype	**ICOM/**OFFSET	EG/SWW/WIN

The subsequent chapters analyse PEDvolution's KERs, outlining their characteristics, adoption enablers, potential barriers, associated risks and mitigation measures their uptake and replication. The KERs presented correspond to those initially defined in the DoA, with no additional KERs identified to date.

4 PED DESIGN AND PLANNING TOOLSET

This chapter presents the characterisation and analysis of the PED Design and Planning Toolset, based on information collected from the Solution Providers (VITO & TUW) and the PED Managers.

4.1 Description and Characterisation

The PED Design and Planning Toolset is composed of (1) a Digital Twin (DT)-based planning tool designed to support PED developers and managers in accelerating district development pathways towards establishing or enhancing a PED, and (2) The District Heating and Cooling (DHC) planning tool that is based on a techno-economic optimisation model that determines the cost-optimal supply mix, operation, and investment for a given DHC system. By representing energy systems at both the building and district levels, the tool provides techno-economic analyses that enable informed, evidence-based, decision-making during the planning and design stages.

By project completion, the tool is expected to reach Technology Readiness Level (TRL) 7, corresponding to a system prototype demonstrated in an operational environment, and to progress to TRL 9 (actual system proven in operation) within 5–7 years post-project. Its Market Readiness Level (MRL) is projected at MRL 6 (Market Entry Preparation) by project completion and MRL 7 (Initial Market Adoption) within the same timeframe.

Table 3: PED Design and Planning Toolset – Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion
PED Design and Planning Toolset	TRL7: System prototype demonstration in operational environment	TRL 9: Actual system proven in operational environment	MRL6: Market Entry Preparation	MRL7: Initial Market Adoption

The adoption of the PED Design and Planning Toolset is expected to strengthen both the genotype and phenotype dimensions across PEDvolution's three co-developer PEDs, enhancing their technical, social, and market maturity. Its inherent replicability and scalability make it adaptable across diverse urban contexts.

EXPLOITATION PATHWAYS

The PED Design and Planning Toolset is expected to follow two primary exploitation pathways: i. further research and publication and ii. commercial exploitation. Continued research and academic dissemination will support methodological refinement and strengthen the scientific foundation of the tool, while in the medium to long term, commercial exploitation will enable its uptake by professional users and organisations engaged in PED development.

Targeted stakeholder engagement and pilot demonstrations are expected to be the most effective actions to raise awareness and facilitate adoption. Demonstrating the tool's capabilities in real PED contexts will be key to showcasing its practical value, particularly among PED planners, developers, and managers, and to supporting them in developing optimal and context-specific pathways toward energy-positive districts. At this stage, the identification of specific adopters or beneficiaries remains open, and to be determined as the tool evolves. Insights from the ongoing pilot implementations will contribute to actively shape exploitation pathways and future opportunities.

4.2 Implementation in PEDvolution Demonstration Sites

4.2.1 Residential Neighbourhood Planina, Kranj

In the Residential Neighbourhood of Planina in Kranj, the PED Design and Planning Toolset anticipates to support the optimisation of energy flows, the development of renovation pathways, and scenario-based planning to improve electricity self-sufficiency and enable smarter multi-energy system control. By addressing challenges such as the efficient allocation of energy resources, optimisation of heat and electricity flows, and reduction of techno-economic risks, the tool is expected to benefit the DSO, the municipality, residents, and local industry. Over the long term, it aims to strengthen energy allocation, increase district-level self-sufficiency, and support the sustainable transition of the Kranj PED.

Its deployment in Planina is supported by technological features that enable digital integration and data-driven optimisation across multi-energy systems, forming an essential basis for robust district-level modelling. The potential for replication is reinforced by the tool's modular and interoperable simulation platform, which can incorporate district-specific data to model different PED configurations. However, its scaling-up potential is considered medium, as broader applicability is constrained by several recurring challenges. These include dependence on high-quality local data, limited municipal expertise in advanced modelling, and the complexity associated with adapting the tool to fragmented, inconsistent, or non-standardised datasets.

Additional barriers arise from regulatory uncertainty and policy variability, which may complicate PED modelling and scenario development. In Planina, this type of political barrier has a medium impact on uptake, mainly due to misalignment between national and EU regulatory frameworks. Such discrepancies can restrict the definition of accurate planning scenarios and reduce the tool's transferability to other European contexts.

To address these issues, early mapping of local and national regulations is required to anticipate constraints and adapt the modelling approach accordingly. The use of adaptive scenario planning enables the integration of changing regulatory conditions, ensuring that planning assumptions remain relevant over time. Where necessary, real-time adjustments can be applied to modelling parameters to maintain compliance and preserve the tool's contextual accuracy, supporting smoother implementation and future replication.

4.2.2 Schönbrunnn Village, Wunsiedel

In Schönbrunnn Village, the PED Design and Planning Toolset is expected to support evidence-based decision-making for PED planners, developers, and managers by providing a dual-function framework that combines the modelling of current district conditions—covering energy performance, emissions, and costs—with the development of tailored renovation pathways for district heating and cooling (DHC) systems. Through scenario planning and uncertainty analysis, the tool enables robust planning under varying technical and operational assumptions, supporting informed choices for system optimisation. The adoption of the solution primarily addresses challenges related to the efficient allocation of energy resources and the optimisation of heat energy flows within the district. By strengthening both the genotype (planning, modelling, and decision-support structures) and the phenotype (operational performance of the energy system), the tool contributes to more coherent and effective PED development. The main beneficiary of its implementation is the DSO, which gains improved visibility over system performance and enhanced capacity for strategic and operational decision-making.

The integration of the solution within the PED ecosystem is mainly facilitated by technological enablers, as the tool relies on advanced digital modelling, simulation, and data-driven optimisation capabilities. The potential for scaling up adoption beyond the pilot site is assessed as high, with applicability at district, municipal, and potentially regional levels, provided that appropriate data and institutional capacity are in place. Replication is enabled by the tool's modular and interoperable simulation and scenario analysis platform, which can be configured using district-specific inputs. Key replication factors include a data-driven modelling engine capable of representing diverse district conditions in terms of energy performance, emissions, and costs; scenario planning algorithms that support robust evaluation under uncertainty; and a standardised interface for integrating different district energy system topologies and data formats. Further enablers include the use of open standards, alignment with widely applied DHC renovation frameworks, and the ability to export renovation pathways in formats directly usable by municipalities and planners. However, replication may be hindered by several structural constraints. These include a strong dependency on the availability, quality, and accuracy of local district-level data, as well as limited technical capacity or expertise at municipal or regional levels to operate advanced modelling tools and interpret their outputs. Additional challenges arise from the complexity of calibrating and adapting the tool to heterogeneous district conditions, particularly in environments characterised by fragmented, inconsistent, or non-standardised data. Addressing these limitations will be essential to ensure wider uptake and effective transfer of the solution across diverse PED contexts.

A major barrier concerns the lack of accurate and complete data on district-level energy conditions, which poses a high-impact technological challenge. Insufficient or inconsistent datasets can compromise the reliability of energy modelling outputs, diminish stakeholder confidence, and reduce the replicability of the planning results in other contexts. To address this, mitigation measures focus on validating and enriching available data using regional statistics, partner datasets, and on-site measurements, while also enabling manual overrides and structured stakeholder validation steps. Maintaining up-to-date regional databases and standardised input templates further supports the generation of reliable and replicable modelling outcomes.

4.2.3 Gemeinschaft Hard, Winterthur

In Winterthur, the PED Design and Planning Toolset focuses on optimising energy consumption, developing new business models, and strategic planning to enhance the PED's long-term resilience. Short-term activities concentrate on maximising self-consumption by technically coupling the existing photovoltaic (PV) system with six EV charging stations, managed by a new control unit that utilises PV surplus without affecting current billing arrangements. Longer-term integration envisions expanded energy management -covering heating systems, PV extension, and decentralised heat pumps- so that the PED Manager and local energy partners can use the generated insights to guide urban energy strategies and achieve sustained cost and energy efficiency gains. Primary end-users include PED developers and managers, residents, energy consumers, and homeowners, who will benefit from more efficient, data-driven, and risk-aware PED planning.

The tool's deployment in Winterthur is enabled primarily by technological factors. However, overall replication potential which is currently assessed as medium within the Winterthur area, may be potentially hindered by the fact that each PED has unique characteristics; for example, the Hard community has hydropower plant which is not the case for other PEDs/districts.

The most important high risk barrier in the deployment process, concerns political factors and specifically the system's complexity and stakeholder dependencies: multiple parameters, actors, and regulatory interactions mean that an incomplete framework could be non-functional. Under Switzerland's decentralised, consensus-driven governance model, this political barrier carries a high impact and can cause delays and procedural complexity. To mitigate these risks, a step-by-step implementation approach is recommended, supported by careful policy coordination. Continuous stakeholder engagement through roundtable discussions will help secure alignment and collective buy-in. Corrective measures will be defined dynamically as implementation progresses, maintaining ongoing engagement to address procedural or governance-related delays and ensure the tool's effective deployment and future adaptability.

4.3 Overview of findings

The analysis of enablers, barriers, and adoption conditions across the three co-developer PEDs shows that the PED Design and Planning Toolset has potential for replication, supported by its modular architecture, interoperability, and capacity to integrate diverse local datasets for scenario-based planning. Technological enablers -such as open data compatibility and flexible integration into pilot implementations- provide a solid foundation for deployment across different urban and energy contexts. Regulatory alignment, particularly with EU directives on energy efficiency and digitalisation and with certification schemes such as DGNB/SGNI, further enhances the tool's applicability and policy relevance. Financial and market enablers, including public incentives and funding instruments, can accelerate uptake by municipalities and energy actors striving to implement energy-positive strategies.

Despite these strengths, several barriers remain. Data reliability, limited interoperability, and regulatory fragmentation continue to constrain large-scale replication, while the prevailing focus on individual building-level renovation -rather than neighbourhood-scale planning- poses a significant social barrier with high impact on adoption. This misalignment limits the exploitation of district-wide synergies and reduces opportunities for coordinated energy strategies. Across the demonstration sites, key risks consistently relate to policy alignment, data quality, and the complexity of multi-stakeholder coordination. Mitigation strategies emphasise early policy mapping, structured stakeholder engagement, adaptive planning approaches, and the establishment of robust data frameworks. Collectively, these actions are critical to maximising the toolset's impact, ensuring flexibility during deployment, and strengthening its potential for widespread adoption and replication within the PEDvolution framework.

Table 4, presents an overview of the PED Design and Planning Toolset in relation to its key exploitation dimensions, outlining the associated KER, target markets, intended exploitation pathways, key enablers supporting uptake, the main barriers that may hinder deployment, and the mitigation measures proposed to address these challenges.

Table 4: PED Design and Planning Toolset - Exploitation Overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
PED Design and Planning Toolset	• Urban planners & municipalities (PED developers and managers) • Energy & construction industry • Research & academia	• Further research & publication • Capacity building & training • Open access demonstration • Commercial exploitation	• Modular and scalable design • Integration with simulation tools • Stakeholder co-design in planning	• Fragmented data sources • Lack of standardised PED design methodologies • Limited municipal technical capacity	• Training and guidelines for planners • Use of harmonised PED modelling frameworks • Early-stage engagement of end-users and city representatives

5 DYNAMIC DECISION SUPPORT GUIDELINE

This chapter presents the characterisation and analysis of the Dynamic Decision Support Guideline (DDSG), drawing on information provided by the Solution Provider - NTNU and the PED Managers.

5.1 Description and Characterisation

The Dynamic Decision Support Guideline provides a comprehensive framework and methodological support for decision-makers involved in the design, implementation, and management of PEDs. It serves as a structured, adaptable guideline to assist stakeholders -including energy service providers (ESCOs), PED developers and managers, engineers, architects, policymakers, and standardisation bodies- in making informed decisions across the technical, social, and market dimensions of PED development.

By the end of the project, the DDSG is expected to reach TRL 7, corresponding to a system prototype demonstrated in an operational environment. Within five to seven years post project, it is projected to advance to TRL 8, as a fully qualified and validated system. From a market perspective, it is anticipated to evolve from MRL 6 (Market Entry Preparation) at project end to MRL 7 (Initial Market Adoption) in the medium term. Its Societal Readiness Level (SRL) is expected to progress from SRL 6, where it is co-developed and refined in collaboration with stakeholders, to SRL 7, where further optimisation and validation will enhance user confidence and uptake.

Table 5: Dynamic Decision Support Guideline – Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion	Expected SRL (Societal Readiness Level) by project completion	Envisioned SRL 5-7 years beyond project completion
Dynamic Decision Support Guideline	TRL7: System prototype demonstration in operational environment	TRL8: System complete and qualified	MRL6: Market Entry Preparation	MRL7: Initial Market Adoption	SRL6: Solution demonstrated in relevant environment and in co-operation with relevant stakeholders to gain initial feedback on potential impact	SRL7: Refinement of solution and, if needed, retesting in relevant environment with relevant stakeholders

The DDSG primarily strengthens all core dimensions of the PED genotype -social, technological, interoperability, and market- by supporting evidence-based planning, promoting cross-sector collaboration, and enhancing decision transparency. Its replication potential is closely linked to the increasing maturity of its technical, market, and societal dimensions, which will determine its scalability and adoption across diverse European contexts.

EXPLOITATION PATHWAYS

The DDSG targets several key markets, including the energy service providers, mobility service providers, PED developers, construction sector representatives, and the public sectors - municipalities and regional authorities. Its exploitation will follow several complementary pathways:

- Further research and publication, through contributing to methodological advancement and scientific dissemination.
- Commercial exploitation, through potential integration within PED design and management platforms.
- Capacity building and training, equipping stakeholders with the skills to apply the guideline effectively.
- Policy-science interface and knowledge sharing, supporting the standardisation and alignment of PED planning practices.

To maximise uptake and visibility, the most effective exploitation actions include targeted stakeholder engagement, open-access knowledge dissemination, liaison with EU networks, pilot demonstrations, as well as training activities and capacity building activities showcasing the DDSG's practical application to relevant end-users.

5.2 Implementation in PEDvolution Demonstration Sites

5.2.1 Residential Neighbourhood Planina, Kranj

The Dynamic Decision Support Guideline in Planina aims to provide a solid baseline for scenario building and system integration while supporting transparent, data-driven decision-making. It addresses the complexity of multi-stakeholder decision processes by ensuring that planning choices remain balanced and aligned with long-term sustainability objectives. Through this approach, the guideline reinforces all dimensions of the PED genotype by fostering collaboration among stakeholders and improving communication between technical and governance actors. Its use benefits PED managers, DSOs, municipalities, residents, and local industry, and in the long term it is expected to promote transparent, participatory, and robust decision-making that enables cost optimisation and more efficient allocation of energy resources.

Its implementation in Planina is supported by regulatory and policy enablers that facilitate replication and integration, as well as by the modular and interoperable architecture of the guideline, which enables interaction with planning data, regulatory systems, and stakeholder networks. This flexibility allows the tool to adapt easily across diverse governance and data environments. However, several barriers may affect its effective deployment, including the high resource requirements associated with stakeholder engagement, limited coordination mechanisms, and a reliance on reliable datasets and expert user input. A particularly significant barrier in Planina arises from the complex legal system and multi-level governance structure, combined with strong stakeholder independence under direct democracy. This regulatory and policy-related challenge is considered to have a medium impact, as misalignments with national legislation may slow down the adoption and operationalisation of the guideline.

To mitigate these challenges, systematic research on current and emerging legal and policy frameworks will be required to ensure alignment with all relevant governance levels. As a corrective measure, continuous updates and revisions of the guideline's components should be introduced so that it reflects the latest regulatory developments and remains compliant throughout deployment.

5.2.2 Schönbrunn Village, Wunsiedel

In Wunsiedel, the Dynamic Decision Support Guideline operates as a comprehensive decision-making framework that facilitates integrated and adaptive planning throughout PED development. It supports stakeholders in navigating complex and context-sensitive choices, ensuring that decisions remain informed, transparent, and consistent with long-term energy and climate objectives. The guideline strengthens PED readiness, accelerates progress toward climate neutrality, and helps balance energy, environmental, economic, and social considerations. Testing will be supported by an action plan defining roles, timelines, and scope, supplemented by user-feedback questionnaires assessing usability, reliability, and contextual relevance. Through this process, the DDSG reinforces both the genotype and phenotype dimensions of the PED by improving collaboration between technical and social actors. Primary beneficiaries include DSOs, residents, and local industries, who will benefit over time from more efficient resource allocation, optimised heat and energy flows, and cost reductions.

In Wunsiedel, successful integration and replication of the guideline are largely supported by technological enablers, particularly its capacity to manage and adapt to diverse data environments. The scalability of the tool depends on the availability and accuracy of local district-level data and the ability of municipal and regional stakeholders to operate and interpret advanced modelling outputs. Replication potential is considered high, provided that local users receive adequate training and targeted technical support. Remaining challenges include the need for calibration to site-specific conditions and the presence of non-standardised datasets, which may limit broader application without efforts toward data harmonisation and capacity building.

The main barrier encountered in Wunsiedel concerns regulatory uncertainty and context-specific policy requirements at both the national and EU levels, which may complicate PED modelling and scenario planning. This political barrier is assessed as having a medium impact, as the absence of clear regulatory alignment can hinder accurate scenario definition and reduce planning applicability across different European contexts. Mitigation measures include integrating early mapping of policy and regulatory frameworks into the planning process and supporting adaptive scenario modelling tailored to local conditions. If regulatory changes arise during implementation, planning scenarios should be updated in real time and adjustments incorporated into the underlying model assumptions to preserve accuracy and relevance. Maintaining a modular and flexible structure will further support replicability and ensure resilience to evolving policy frameworks.

5.2.3 Gemeinschaft Hard, Winterthur

In Winterthur, the Dynamic Decision Support Guideline establishes a structured foundation for scenario development and system integration within the PED, enabling consistent evaluation of alternative decision pathways. It reinforces the district's genotype by ensuring that planning processes remain transparent, traceable, and grounded in robust evidence. PED Managers are the primary beneficiaries, gaining enhanced oversight of planning activities and improved traceability of data-supported decisions. Over time, the DDSG is expected to strengthen transparent and accountable governance, build stakeholder confidence, and support the sustainable long-term evolution of the district.

In Winterthur, adoption of the DDSG is predominantly supported by economic enablers that emphasise cost-efficiency and added value derived from improved decision-making and planning transparency. Although the overall scaling potential is currently assessed as low, replication can still be supported through the tool's adaptable KPI-based methodology, which allows tailoring to local economic structures and planning needs. Nevertheless, replication remains limited by the need for supplemental or revised KPIs that adequately capture local district characteristics and priorities, reducing the possibility of straightforward transfer without contextual adaptation.

The main barrier in Winterthur relates to the complex legal environment and decentralised governance system shaped by direct democracy and a high degree of stakeholder autonomy. This regulatory and policy-related barrier is assessed as having a medium impact, as procedural delays and the reliance on consensus-driven processes may slow down the adoption and operationalisation of the DDSG. Mitigation measures should include comprehensive and systematic analysis of legal and policy frameworks to ensure alignment with national and cantonal requirements. If obstacles arise, periodic updates integrating the latest legal and regulatory developments will help maintain compliance and support adaptability within Switzerland's evolving legal context.

5.3 Overview of findings

The successful adoption and integration of the Dynamic Decision Support Guideline within a PED ecosystem depend predominantly on organisational and stakeholder-related enablers, particularly capacity-building, sustained stakeholder engagement, and the development of collaborative networks among key actors involved in PED planning and operation. These enablers strengthen the tool's capacity to support transparent, data-driven, and inclusive decision-making across diverse district contexts. Overall, the DDSG demonstrates a relatively high replication and scalability potential, with strong prospects for deployment at district, municipal, regional, and national levels. Replication is facilitated by structured training activities and knowledge-sharing mechanisms, supported by a user-friendly interface designed to accommodate both technical and non-technical users. Such features enhance accessibility and encourage broader uptake among municipalities, energy providers, local industries, and community stakeholders.

Despite these strengths, data availability and quality remain critical constraints, particularly in contexts where reliable, standardised, and continuously updated datasets are lacking. Strengthening data management practices and interoperability frameworks is therefore essential to support effective scaling and long-term exploitation of the DDSG. Regulatory complexity and inconsistent data governance across countries may further limit seamless integration, requiring alignment strategies and adaptive modelling practices.

A key barrier concerns limited awareness and insufficient training among target user groups. This organisational and capacity-related barrier has a high impact, as inadequate understanding of the tool's functionality, relevance, and benefits can hinder uptake and reduce the effectiveness of decision-making processes. To address this risk, targeted training programmes and awareness-raising activities should be implemented to build competence, demonstrate practical applications, and enhance user confidence. If these challenges persist, reinforced communication strategies and additional training sessions should be deployed to ensure the tool's continued usability and relevance. The wider adoption of the DDSG is supported by strong organisational and technological foundations, particularly its modular structure, flexible integration capabilities, and ability to underpin consistent and transparent decision processes. However, its scalability is shaped by regulatory diversity, data availability, and the need for ongoing user capacity development. Early engagement in capacity-building, alignment with existing and emerging policy frameworks, and the establishment of robust data infrastructures are vital to ensure effective implementation and broader uptake. Across all PEDvolution co-developer PEDs, the primary risks identified relate to regulatory uncertainty, varying levels of stakeholder capacity, and inconsistencies in data accessibility and quality. Corrective measures focus on continuous training and engagement, systematic monitoring of policy and regulatory developments, and adaptive scenario-based planning to maintain relevance under evolving conditions. The overall findings highlight that structured stakeholder collaboration, iterative tool refinement, and integration of policy and data frameworks are essential to enable effective adoption, replication, and long-term impact of the DDSG within the PEDvolution framework. These consolidated findings form the basis for the exploitation strategy of the DDSG and are summarised in the table below.

Table 6: Dynamic Decision Support Guideline exploitation overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
Dynamic Decision Support Guideline	•Municipalities & policy-makers • PED developers & managers • Research & academia	• Policy science & knowledge sharing • Integration with urban decision-making tools • Training and dissemination via networks	• Evidence-based policymaking • Dynamic link between technical and socio-economic data • Integration with PED Readiness and Planning tools	• Limited access to real-time or localised data • Complexity in translating data to actionable insights • Low engagement from policy stakeholders	• Co-development with decision-makers • Use of simplified visualisation tools • Regular updates to reflect new data and regulations

6 PED ENERGY MANAGER

This chapter outlines the characterisation and analysis of the PED Energy Manager, drawing on information provided by the Solution Providers (OFFSET, TUW, and ICOM) and the PED Managers.

6.1 Description and Characterisation

The PED Energy Manager serves as a smart operational solution designed to optimise and coordinate energy flows within a PED. Functioning as the district's digital backbone, it supports real-time data integration, energy balancing, and interaction between buildings, users, and local grids.

By providing actionable insights and control capabilities, the PED Energy Manager empowers energy service providers (ESCOs), prosumers, and residents, to make informed, data-driven decisions that maximise local self-consumption and minimise grid dependency.

From a technology maturity perspective, the PED Energy Manager is expected to achieve TRL 7 by the end of the project - corresponding to a *system prototype demonstrated in an operational environment*. Within five to seven years beyond project completion, it is projected to reach TRL 8, representing a fully qualified and validated system ready for large-scale deployment. In parallel its Market Readiness Level (MRL) is expected to advance to MRL 7, indicating initial market adoption, supported by real PED validation across multiple environments.

Table 7: PED Energy Manager – Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion
PED Energy Manager	TRL7: System prototype demonstration in operational environment	TRL8: System complete and qualified	MRL6: Market Entry Preparation	MRL7: Initial Market Adoption

The solution primarily reinforces the phenotype of PEDs, by translating their technological and social genotype into tangible, observable, and measurable performance outcomes, such as improved energy self-sufficiency, grid stability, and reduced greenhouse gas emissions.

EXPLOITATION PATHWAYS

The PED Energy Manager targets key markets in the energy, energy intensive industry sector, and energy communities where it supports the digitalisation and optimisation of district-level energy systems. Its main exploitation pathway focuses on commercial deployment, leveraging the tool's proven functionality and adaptability.

The most effective exploitation actions involve the tool's commercial exploitation and specifically:

- Targeted stakeholder engagement
- Pilot demonstrations, showcasing real-world performance and interoperability
- Liaison with market actors ensuring that the PED Energy Manager's advantages are clearly communicated and understood.

Initial adopters and potential beneficiaries already identified include UEZW Energie GmbH (https://www.uezw-energie.de/) and Stadtwerke Hasonn (https://www.stwhas.de/), both representing relevant use cases for district energy management and flexibility services.

6.2 Implementation in PEDvolution Demonstration Sites

6.2.1 Residential Neighbourhood Planina, Kranj

In the Planina demonstration site, the PED Energy Manager supports real-time monitoring and optimisation of electricity flows, enabling efficient resource allocation and maximising renewable energy self-consumption across the district. It addresses challenges related to portfolio optimisation, flexibility estimation, and energy exchange among industrial and tertiary users, while strengthening the PED phenotype by enhancing operational performance and ensuring greater transparency for stakeholders. Key beneficiaries include DSOs and local industry, with long-term impacts expected in improved energy allocation, reduced curtailment, and deeper integration of renewable sources.

Adoption in Planina is driven primarily by technological enablers, particularly IoT-enabled monitoring infrastructures, standardised APIs, embedded analytics, and cloud-based optimisation algorithms that collectively support real-time control. The scaling-up potential is considered high due to the district's relatively mature digital and renewable energy infrastructure, though replication may be limited by legacy systems, proprietary communication protocols, cybersecurity concerns, and the significant upfront investment required for sensor deployment and broader digitalisation.

The main barrier concerns the integration of real-time data from distributed assets, which is challenged by both technological and legal constraints. This barrier is assessed as having a high impact, as incomplete or missing datasets can significantly reduce optimisation accuracy and undermine the effectiveness of the PED Energy Manager. To mitigate this risk, early data availability checks should be conducted, accompanied by direct engagement with asset owners to secure reliable and continuous data access. If integration challenges arise, corrective measures include enabling partial dataset functionality and deploying fallback estimation models to preserve operational continuity and ensure informed decision-making even under constrained data conditions.

6.2.2 Schönbrunn Village, Wunsiedel

In the Wunsiedel demonstration site, the PED Energy Manager functions as an advanced digital layer enabling real-time monitoring and optimisation of district energy operations. By collecting and analysing live data from PED assets, it supports informed decision-making, efficient portfolio optimisation, and enhanced renewable energy self-consumption across the district. A key capability lies in sector coupling optimisation, where surplus solar electricity is converted into heat during periods of high production, maximising renewable energy utilisation. The system further enables flexibility aggregation by pooling capacity from households and industry to create a dynamic and responsive flexibility portfolio. Beyond the district level, it supports multi-level flexibility exchange with sister PEDs and the Super-PED, fostering integrated optimisation across interconnected PED ecosystems. The primary beneficiary is the DSO, which gains from improved resource allocation, enhanced heat flow management, and long-term cost efficiency. Over time, the PED Energy Manager is expected to strengthen cross-district coordination and system reliability, contributing to the development of multi-energy, interoperable PED networks.

Integration and scaling of the PED Energy Manager in Wunsiedel are reinforced by strong technological enablers, resulting in very high replication potential. The solution benefits from an IoT-enabled real-time monitoring framework compatible with established energy communication protocols such as Modbus and BACnet, embedded analytics for portfolio optimisation and sector coupling, and standard APIs enabling integration with national or regional data platforms, including the AURORA platform and smart metering gateways. Cloud-based control algorithms facilitate flexibility aggregation and multi-PED optimisation at the Super-PED level, enabling interoperability far beyond local boundaries. Nonetheless, the system's replication may be limited by non-interoperable legacy infrastructure, cybersecurity challenges, and the significant upfront investment required for widespread digitalisation and sensor deployment.

A key barrier concerns the integration of real-time data from distributed assets and the establishment of reliable operational control, constrained by both technological and legal limitations. This barrier is regarded as high impact, as incomplete datasets or integration gaps reduce optimisation accuracy and weaken control capabilities. To mitigate these risks, early assessments of data availability will be performed, and asset owners will be closely engaged to ensure uninterrupted data exchange. If problems arise, interfaces and backend systems will be adapted to handle partial data availability, supported by fallback estimation models that maintain operational reliability.

A second high-impact technological barrier relates to potential overreliance on centralised infrastructure, which may restrict the flexibility aggregation potential and reduce the PED's capacity to interact effectively with energy markets. To address this, decentralised EMS logic and modular flexibility units will be introduced early in the deployment process. Should this barrier materialise, corrective actions will involve adapting the flexibility aggregation algorithms to local asset and regulatory constraints while deploying distributed aggregation tiers to preserve system performance, resilience, and interoperability across the PED and wider multi-PED ecosystem.

6.2.3 Gemeinschaft Hard, Winterthur

In the Swiss demonstration site of Winterthur, the PED Energy Manager will function as a central platform for real-time monitoring and control, integrating data from diverse assets including EV charging stations, photovoltaic systems, and small hydroelectric units. Its core purpose is to enable demand response and flexibility management, dynamically balancing local energy generation and consumption while fostering end-user engagement through interactive digital interfaces. In doing so, the solution strengthens both the phenotype and genotype of the PED, combining technical optimisation with behavioural responsiveness and operational adaptability. Long-term benefits for local stakeholders -such as DSO, maintaining optimisation of energy consumption as new assets are added or modified-.

In Winterthur, adoption is primarily driven by strong technological enablers and the system's high scalability potential. Interoperability with a broad range of district assets -whether operating through real-time or delayed data streams- allows the PED Energy Manager to support multiple energy management scenarios. An edge device functions as a communication gateway, connecting local assets with cloud-based analytics via Modbus TCP, Cloud API, and additional protocols. Several replication sites have already been identified within Winterthur, highlighting local interest and a favourable environment for broader deployment. Nonetheless, scaling and replication may be affected by reluctance to share operational or personal data, as well as general concerns about data governance.

The main barrier in Winterthur relates to data availability and compliance with stringent legal requirements on data protection and storage. This regulatory and policy barrier is assessed as medium impact, as national data regulations, community consent processes, and strict governance protocols may introduce delays and limit timely access to the data needed for optimal system performance. To address this, robust data transmission and storage mechanisms will be deployed to ensure full compliance with national and EU-level data protection requirements, while guaranteeing high-security standards. Should data access challenges persist, a contingency approach ("Plan B") will be activated to maintain operational continuity and system functionality without compromising privacy or regulatory obligations.

6.3 Overview of findings

The adoption and replication of the PED Energy Manager are driven by a combination of technological, regulatory, and financial enablers. Technologically, the tool's modular architecture, interoperable design, and adherence to open data standards enable seamless integration across diverse PED infrastructures and energy systems. Real-time monitoring, embedded analytics, and support for portfolio optimisation and flexibility management strengthen both the phenotype and genotype of PEDs, enhancing operational efficiency and enabling responsive multi-energy control. Regulatory alignment with EU directives, standardisation frameworks, and certification schemes further supports market acceptance, while financial incentives, including government subsidies, facilitate initial deployment and uptake by municipalities, DSOs, and private stakeholders.

Across the co-developer PEDs, the tool demonstrates strong scalability and replication potential. In Planina, Kranj, high digital and renewable infrastructure maturity supports broad adoption, with expected long-term benefits including improved energy allocation, reduced curtailment, and enhanced integration of renewable sources. In Schönbrunn, Wunsiedel, technological enablers such as IoT-based monitoring, standard APIs, and cloud-enabled analytics, combined with sector coupling optimisation, enable high replication potential across multi-energy districts. In Winterthur, the PED Energy Manager's interoperability with diverse assets, flexible KPI-based assessment, and edge computing capabilities allow adaptation to varying local contexts, although current replication potential is moderated by regulatory and data-sharing constraints.

Despite these strengths, several barriers may constrain adoption and replication. Integration of real-time data from distributed assets, reliance on centralised infrastructure, legal and regulatory constraints on data sharing, and infrastructure readiness present high-impact challenges. Social and organisational factors, such as stakeholder coordination and capacity-building needs, further influence uptake, particularly in districts with complex governance structures or limited digital expertise.

To address these barriers, preventive measures include early technical assessments, infrastructure mapping, data readiness checks, decentralised control logic, and robust data management frameworks. Corrective measures involve adaptive integration, fallback estimation models, configuration updates, modular flexibility units, and compliance-oriented contingency planning to maintain performance and interoperability under evolving technical or regulatory conditions.

Overall, the PED Energy Manager strengthens operational and decision-making capacities in PEDs, supporting cost-effective, flexible, and data-driven energy management. Its adoption and replication across European PEDs will depend on proactively addressing technological, regulatory, and stakeholder challenges, ensuring trust, transparency, and technical readiness for sustainable, scalable deployment. Table 8, presents an overview of the tool's initial exploitation related characteristics.

Table 8: PED Energy Manager – Exploitation Overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
PED Energy Manager	• DSOs & ESCOs • Building owners & facility managers • Municipal energy agencies	• Pilot demonstrations • Integration with existing energy management systems • Commercial exploitation via ESCO partnerships	•Interoperability with smart grid platforms • Real-time energy optimisation • Alignment with EU data exchange standards	• Integration complexity across devices and platforms • Limited access to real-time data • Data privacy concerns	• Early interoperability testing • Adoption of open APIs & data models • Use of anonymised datasets and privacy-by-design measures

7 PED READINESS ASSESSMENT

This chapter offers an overview and evaluation of the PED Readiness Assessment (PED-RA), drawing on information made available by the Solution Provider - ZHAW and the PED Managers.

7.1 Description and Characterisation

The PED-RA provides a structured framework to evaluate the preparedness of districts to transition towards PEDs. Functioning as both a diagnostic and benchmarking tool, the PED-RA enables cities, planners, and developers to assess the multi-pronged strategy combining demonstration, engagement, policy advocacy, and capacity building is critical to foster awareness, accelerate adoption, and lay the foundation for replication and standardisation across European PEDs**.** It supports decision-makers in identifying critical gaps, prioritising interventions, and tracking progress over time, thereby facilitating and accelerating the transition towards climate-neutral urban ecosystems.

By the end of the project, the PED-RA is expected to reach TRL 8 (system complete and qualified), progressing to TRL 9 (proven in operational environment) within five to seven years post-project. Its MRL is projected at MRL 7 (market entry preparation) by project completion and MRL 8 (initial market adoption) in the medium term, reflecting strong commercial viability and stakeholder interest. The SRL is estimated at SRL 8, indicating that the solution and its societal adaptation plan are fully developed, validated, and ready for adoption in operational contexts.

Table 9: PED-Readiness Assessment – Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion	Expected SRL (Societal Readiness Level) by project completion	Envisioned SRL 5-7 years beyond project completion
PED-RA	TRL8: System complete and qualified	TRL 9: Actual system proven in operational environment	MRL7: Market Entry Preparation	MRL8: Initial Market Adoption	SRL7: Refinement of solution and, if needed, retesting in relevant environment with relevant stakeholders	SRL 8: Proposed solution(s) as well as a plan for societal adaptation complete and qualified

The PED-RA strengthens both the genotype and phenotype of PEDs by linking technical maturity, market viability, and social acceptance into an integrated assessment framework. Beyond evaluating technological performance, it addresses market structures, policy alignment, and user engagement - ensuring that future PEDs are replicable, inclusive, and resilient.

Its high TRL and MRL, enhance replication potential, reducing technological risk, clarifying scalability pathways, and fostering policy and market acceptance. The SRL dimension further ensures that social equity, trust, and behavioural adoption are embedded, addressing a critical enabler of PED evolution.

Target users include PED developers and managers, energy prosumers, residents, homeowners, and standardisation bodies, positioning the PED-RA as both a planning instrument and a governance enabler for the next generation of energy-positive urban districts.

EXPLOITATION PATHWAYS

PED-RA targets the energy and construction sectors, as well as public authorities and municipalities, to support large-scale PED replication through evidence-based evaluation, training, and policy alignment. Key exploitation pathways include:

- Further research and publication, advancing methodology and scientific knowledge.
- Commercial exploitation, integrating PED-RA into market-ready tools and advisory services.
- Capacity building and training, equipping stakeholders with skills to implement and interpret results.
- Policy-science interface and knowledge sharing, supporting standardisation and regulatory alignment.
- Integration with certification schemes (e.g., BREEAM, LEED, DGNB), with initial engagement already underway.

Effective exploitation actions include:

- Targeted stakeholder engagement as a cross-cutting enabler of uptake and long-term sustainability.
- Liaising with EU networks and multi-stakeholder platforms to foster collaboration, knowledge exchange, and policy coherence.
- Pilot demonstrations that showcase tangible results, building trust through real-world validation.
- Policy advocacy and engagement with regulatory bodies to support alignment and incentive frameworks.
- Peer-to-peer learning and knowledge exchange, enabling adopters to share experiences and lessons learned.
- Development of accessible knowledge and training resources, including best practice guides, online courses, and case studies to strengthen capacity and understanding.

A multi-pronged strategy combining demonstration, engagement, policy advocacy, and capacity building is critical to foster awareness, accelerate adoption, and lay the foundation for replication and standardisation across European PEDs.

7.2 Implementation in PEDvolution Demonstration Sites

7.2.1 Residential Neighbourhood Planina, Kranj

In Planina, the PED Readiness Assessment (PED-RA) evaluates district readiness through a KPI framework, benchmarking performance and identifying sustainability gaps. Integrated as an evaluation layer within the PED ecosystem, it supports planning and investment decisions while providing transparent insights to municipalities and DSOs. Long-term objectives include certification readiness and establishing the district as a regional showcase for replication and economic valorisation.

Adoption in Planina is primarily driven by regulatory and policy enablers, reflecting strong alignment of national sustainability objectives with certification frameworks. The solution's modular, KPI-based design ensures high scalability, allowing replication across municipalities. Replication is further supported by harmonised KPIs, digital dashboards for computation, and integration with national certification schemes.

However, replication may be constrained by limited availability of standardised KPI data, potential misalignment with local certification requirements, and challenges in adapting the methodology to diverse urban typologies. A key barrier relates to variations in the interpretation of market, legal, and technical readiness criteria, which may cause misalignment between the RA framework and local conditions. This legal barrier is considered high impact, as differences in policy frameworks, data availability, and infrastructural maturity can reduce transferability and uptake.

Mitigation measures include calibration of KPIs and evaluation criteria with local legal experts and alignment with EU standards during testing. Iterative revisions of RA indicators and data sources will be carried out based on stakeholder and regulator feedback, ensuring continuous improvement, regulatory coherence, and enhanced replication potential.

7.2.2 Schönbrunn Village, Wunsiedel

In Wunsiedel, the PED-RA evaluates district readiness and validates KPIs in alignment with DGNB certification frameworks, ensuring compliance with national standards and supporting scalability for future projects. Its integration with the Dynamic Decision Support Guideline (DDSG) enables data-driven decision-making and optimisation of PED processes. Over time, PED-RA is expected to serve as a model for replication and regional upscaling.

Adoption is supported by regulatory and policy enablers, particularly through alignment with established national certification systems such as DGNB and SGNI. The KPI-based methodology is modular and adaptable, allowing replication across districts and municipalities. This is further facilitated by harmonised KPIs, digital dashboards for computation, integration with national PED certification schemes, and well-documented indicator thresholds that support local adaptation while maintaining comparability.

However, replication may be limited by the availability of reliable, standardised KPI data, potential misalignment with regional or national certification systems, and challenges in adapting the methodology to diverse urban typologies and planning regulations.

Two main barriers were identified. The first is the diverse interpretation of market, legal, and technical readiness criteria, a legal barrier with high impact that may reduce framework accuracy and comparability. Preventive measures include collaboration with local legal experts and alignment with

EU frameworks, while corrective actions involve iterative revision of indicators and input data based on stakeholder and regulatory feedback. The second barrier is limited stakeholder access to high-quality input data, a technological barrier with medium impact that can delay readiness validation. Preventive measures include providing standardised data templates, validation protocols, and technical support, with corrective measures involving refinement of KPI definitions and modular operation using partial datasets.

7.2.3. Gemeinschaft Hard, Winterthur

In Winterthur, the PED-RA supports the technical optimisation of renewable energy systems, such as PV-to-charging station integration, while informing long-term strategic planning for heating, mobility, and other district infrastructures. In the short term, it strengthens monitoring and control of local assets; in the long term, it guides strategic decisions for renewable expansion and future-proof energy systems, directly benefiting the PED Manager and local governance structures.

Adoption and integration in Winterthur are primarily influenced by economic factors, as scalability and replication potential are closely linked to available resources and cost-benefit considerations. The scaling-up potential is currently assessed as very low due to the need for additional contextual adaptation. Replication depends on the modularity and adaptability of the KPI-based assessment methodology, which allows the framework to be tailored to local conditions. However, broader application may be constrained by the need to define and incorporate additional KPIs for different scenarios and local priorities, limiting cross-context comparability.

The main barrier in Winterthur relates to the definition and validation of KPIs within the Readiness Assessment framework. Categorised as a technological barrier with low impact, the challenge is balancing completeness and simplicity -ensuring the KPI set is meaningful yet manageable. Difficulties in calculating or verifying indicators may delay implementation, depending on the community's willingness and capacity to engage. To mitigate this, a stepwise implementation approach will be followed, allowing periodic adjustments and KPI redefinition as lessons are learned. Corrective measures will be defined dynamically to maintain the framework's practicality and relevance for the local context.

7.3 Overview of findings

The adoption and integration of the PED Readiness Assessment (PED-RA) within PED ecosystems is supported by a combination of technological, regulatory, financial, organisational, and social enablers. Key drivers include its modular and interoperable design, alignment with EU directives and certification schemes, government incentives, and active stakeholder collaboration facilitated through capacity-building and knowledge-sharing structures. These factors collectively enhance the framework's adaptability and scalability across diverse district contexts, while ensuring alignment with broader EU urban sustainability objectives.

The PED-RA demonstrates high potential for replication, underpinned by a harmonised KPI framework, a collaborative multi-stakeholder approach, real-world validation in operational environments, and structured knowledge exchange. Maintaining focus on PED objectives, fostering cooperation across actors, and leveraging lessons learned across projects are critical to enabling adoption in new contexts.

However, several barriers may constrain replication and adoption. Variations in PED conceptualisation, assessment methodologies, and regulatory or policy interpretations -including differences in defining “positive energy,” district scope, technology choices, and governance structures- can lead to misaligned KPIs, inconsistent evaluations, and challenges in stakeholder engagement. In addition, the dynamic nature of PEDs, with evolving technologies, policies, and data practices, requires the PED-RA to remain flexible and future-proof.

Preventive measures include early harmonisation of KPIs with the four PEDvolution genotypes, flexible indicator design, proactive policy and regulatory monitoring, and early stakeholder involvement. Corrective actions involve iterative KPI refinement, stakeholder workshops, and ongoing adaptation to feedback and emerging conditions.

Across PEDvolution co-developer sites, main risks relate to regulatory divergence, inconsistent or limited data, and stakeholder capacity gaps. Addressing these through structured engagement, iterative calibration, and adaptive data and policy monitoring is essential to ensure reliable application. Overall, the PED-RA’s effectiveness, scalability, and replication depend on maintaining a harmonised, participatory, and evidence-based framework that can guide planning, investment, and performance evaluation across diverse European PED contexts.

Table 10: PED-Readiness Assessment – Exploitation Overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
PED Readiness Assessment	• Public sector & municipalities • Research & academia • Energy & construction industry	• Further research & publication • Policy science & knowledge sharing	• Regulatory & policy alignment • Harmonised KPI methodology • Integration with national PED certification schemes	• Varied PED conceptualisations • Evolving policy & data limitations • Inconsistent local interpretations	• Calibration of KPIs with local experts • Iterative RA revisions • Stakeholder workshops & governance inclusion

8 PED BUSINESS MODELS INNOVATION TOOL

This chapter provides an analysis of the input collected from SIN, as the Solution Provider, and the PED Managers for the PED Business Models Innovation Tool.

8.1 Description and Characterisation

The PED Business Models Innovation Tool supports the development and validation of innovative, replicable, and sustainable business models within the PED context. It serves as an analytical and decision-support framework linking technical, economic, and social dimensions, to help stakeholders identify viable pathways for investment, ownership, and operation of PED-related solutions. The tool enables assessment of value creation, cost-sharing mechanisms, risk allocation, and multi-actor governance, fostering sustainable urban energy ecosystems.

By project completion, the tool is expected to reach TRL 7 with a system prototype demonstrated in an operational environment. While assessing TRL 5-7 years after project completion is inherently challenging, a focus on MRL is more appropriate. The solution is expected to achieve MRL 6 (market entry preparation), by the end of the project, progressing toward MRL 7 (initial market adoption) within five to seven years post-project. Deployment across multiple demonstration sites provides real-world validation and market insights, strengthening both its technological maturity and market acceptance.

Table 11: PED Business Models and Innovation tool– Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion
PED Business Models Innovation Tool	TRL7: System prototype demonstration in operational environment	n/a	MRL6: Market Entry Preparation	MRL7: Initial Market Adoption

The solution strengthens both genotype and phenotype aspects of PEDs - linking technological interoperability and data-driven insights (genotype) with new market structures, governance practices, and user-driven innovation (phenotype). This dual impact supports scalability, replication, and integration into diverse local ecosystems.

Target users include energy service providers (ESCOs), PED developers and managers, prosumers, municipalities, policymakers, and standardisation bodies. Key exploitation markets cover the energy and construction sectors, public authorities, and research organisations focusing on sustainable urban transitions and digital energy systems.

The Business Models and Innovation Tool bridges technical feasibility and market viability, enabling PED stakeholders to co-design adaptive business approaches that ensure financial sustainability, citizen engagement, and regulatory compliance.

EXPLOITATION PATHWAYS

The PED Business Models Innovation Tool targets multiple markets, including the energy and construction industry, public authorities, and research and innovation organisations working on sustainable urban transitions.

Its exploitation pathways combine further research and publication, capacity building and training, and policy science and knowledge sharing. These actions aim to enhance the methodological robustness, encourage adoption across policy and market domains, and ensure long-term sustainability through institutional learning.

Key exploitation actions include targeted stakeholder engagement, open-access knowledge sharing, liaising with EU networks, and policy integration and standardisation activities. Workshops and PED-focused seminars will act as main channels for demonstration and knowledge exchange, supporting co-creation and early adoption among regional stakeholders.

8.2 Implementation in PEDvolution Demonstration Sites

8.2.1 Residential Neighbourhood Planina, Kranj

In Planina, the PED Business Models Innovation Tool facilitates the co-development of context-specific business models with local stakeholders, integrating PED tools with community needs and quantifying potential value streams. It supports economic viability and fosters collaboration among DSOs, residents, and local industry actors. Adoption is primarily driven by economic enablers, including flexible modelling approaches, comprehensive stakeholder mapping, cost-benefit templates, and the integration of socio-economic data to create transferable business model archetypes. This positions the tool with strong replication potential across districts and municipalities.

Key barriers primarily concern uncertainty in revenue generation and perceived financial risks, which may undermine investor and stakeholder confidence thereby reduce uptake due to unclear returns. To mitigate these risks, business models are co-developed with local stakeholders, aligned with existing support schemes, and informed by early financial modelling. If uncertainties persist, corrective measures such as simplified demonstration cases or targeted subsidies can be applied to illustrate viability and reinforce stakeholder confidence.

8.2.2 Schönbrunn Village, Wunsiedel

In Wunsiedel, the PED Business Models Innovation Tool facilitates stakeholder engagement and value co-creation with Solution Providers by analysing the local context and stakeholder needs, identifying relevant business model patterns, and assessing financial feasibility through cost-benefit evaluations. It supports resource optimisation, cost efficiency, and the long-term sustainability of district energy operations. Adoption is primarily driven by economic enablers, and the tool's adaptable, modular structure supports high scalability. Replication is facilitated by templates for stakeholder value mapping, integration with socio-economic and market data, iterative refinement based on feedback, and a repository of adaptable business archetypes.

Key barriers include difficulty in quantifying intangible benefits, reluctance to share sensitive data, and variations in local energy markets and tariffs, which can limit standardisation. Economic risks are notable, particularly revenue model uncertainties that may weaken stakeholder engagement. Preventive measures include co-developing business models with stakeholders, aligning with existing funding schemes, and conducting early financial analyses. Corrective actions include subsidy-driven pilot demonstrations, simplified business cases, and benchmarking models against local socio-economic profiles to adapt parameters as needed. These measures ensure flexibility, maintain economic viability, and support replication across diverse contexts.

8.2.3 Gemeinschaft Hard, Winterthur

In Winterthur, the PED Business Models Innovation Tool follows a structured co-development and validation process across three phases: Adaptation, Implementation, and Validation. The tool focuses on identifying new business opportunities, such as post-hydropower concession models, validating cost and revenue streams, and enabling scaling to other communities. This approach ensures adaptability, transferability, and income diversification across different contexts. Adoption in Winterthur is primarily supported by economic and regulatory alignment, offering strong scaling potential within similar legal and administrative frameworks, such as within the same canton or municipality. Replication is facilitated by shared policy environments that allow smoother transfer of validated business models. However, replication across diverse contexts remains limited due to distinct governance systems and value structures, which affect the comparability and adaptability of business approaches.

A key barrier in Winterthur is financial and revenue generation uncertainty, which can undermine stakeholder confidence and slow adoption and poses a very high-impact risk with potential implications for the viability of the GeHa AG entity. Preventive measures include developing contingency (Plan B) financial scenarios to ensure continuity and stability. Corrective measures, to be further defined during implementation, will focus on enhancing financial resilience through robust risk management and coordinated stakeholder engagement. These challenges underscore the importance of early financial planning, participatory co-development, and adaptive economic modelling to support successful adoption and long-term sustainability.

8.3 Overview of findings

The adoption of the PED Business Models Innovation Tool is driven by strong technological, economic, and organisational enablers. Its co-development approach, adaptable framework, and capacity to integrate local socio-economic data allow stakeholders to create viable, transferable, and context-specific business models across diverse PED environments. These features enhance scalability and replication potential by effectively communicating both tangible and intangible benefits and fostering active stakeholder engagement.

However, replication and long-term adoption may be constrained by financial uncertainties, limited stakeholder participation, regulatory complexity, and variations in local economic conditions. The success of the tool relies on stakeholders' willingness to share sensitive data, which introduces risks related to confidentiality and competitive advantage.

Preventive measures focus on early co-development, continuous engagement, and stakeholder workshops to build trust, promote transparency, and refine the tool collaboratively. Corrective actions include iterative adaptation of business models based on local feedback, contingency planning, and flexible economic modelling to address financial risks and regulatory variability.

Overall, the findings highlight that early financial planning, participatory development, and transparent communication are critical for ensuring widespread adoption, effective replication, and long-term sustainability. These strategies reinforce the tool's ability to bridge technical innovation with market feasibility, supporting economic and social sustainability within the PEDvolution framework.

Table 12: PED Business Models and Innovation tool – Exploitation Overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
PED Business Models Innovation Tool	• Energy & construction industry •Municipalities & PED planners • Research & academia	• Capacity building & training • Policy-science & knowledge sharing	• Economic modelling flexibility • Stakeholder engagement • Transferable BM archetypes	• Uncertainty in revenue generation • Poor adaptability to local conditions • Regulatory complexity	• Co-develop BMs with local actors • Align with support schemes • Conduct financial modelling & periodic reassessment

9 PED SOCIAL INNOVATION TOOL

The following chapter present an analysis of the input collected from the Solution Provider - SIN and the PEDvolution co-developer PEDs regarding the deployment of the PED Social Innovation Tool.

9.1 Description and Characterisation

The PED Social Innovation Tool is a non-technological, participatory methodology designed to enhance collaboration, inclusivity, and social acceptance throughout PED development. Rather than focusing on technology deployment, it focuses on strengthening the social dimension of PEDs by facilitating community engagement, behavioural change, and co-creation processes.

Conventional TRL indicators are not directly applicable to this tool. From a market perspective, the tool stands at MRL 6 (market entry preparation), advancing towards broader adoption within PED management processes. The SRL (Societal Readiness Level) remains central to the tool's evolution, progressing from SRL 6, where it is demonstrated and refined with stakeholder feedback, to SRL 9, where it becomes an established and validated methodology within real PED environments.

Table 13: PED Social Innovation tool – Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion	Expected SRL (Societal Readiness Level) by project completion	Envisioned SRL 5-7 years beyond project completion
PED Social Innovation Tool	N/A	N/A	MRL6: Market Entry Preparation	The approach exists and is being offered as part of the SIN social innovation services catalogue. Integrated part of our toolbox	SRL6: Solution demonstrated in relevant environment and in co-operation with relevant stakeholders to gain initial feedback on potential impact	SRL 9: Actual project solution(s) proven in relevant environment

The tool reinforces both the genotype and phenotype dimensions of PEDs by embedding participatory governance, stakeholder empowerment, and trust-building mechanisms into the PED ecosystem. Through social innovation processes, municipalities, energy managers, and community actors can co-create locally tailored solutions that reflect societal needs and foster long-term behavioural transformation.

Target end-users include PED developers and managers, as well as regional and municipal authorities, who will apply the tool to facilitate community participation, ensure equitable transitions, and enhance local ownership of energy transformation initiatives.

EXPLOITATION PATHWAYS

The main exploitation markets for the PED Social Innovation Tool include the public sector, municipalities, as well as organisations and practitioners engaged in multi-stakeholder or community-driven projects within the urban energy transition domains.

Exploitation will primarily occur through further research and publication, building an evidence base for the tool's applicability across contexts and supporting its transferability via academic dissemination and policy-oriented outputs.

Key exploitation actions that would be effective in raising awareness include open-access knowledge sharing and pilot demonstrations. Showcasing successful case studies and concrete examples of implementation will be essential to raise awareness and promote adoption among municipal authorities and PED developers. Documented success stories demonstrating measurable community engagement outcomes and enhanced decision-making transparency will provide strong validation of the tool's value. These case studies will form the basis for future replication and inclusion in capacity-building initiatives.

Although no specific adopters have been identified yet, municipalities and regional authorities are considered the most relevant future users.

9.2 Implementation in PEDvolution Demonstration Sites

9.2.1 Residential Neighbourhood Planina, Kranj

In Planina, the PED Social Innovation Tool focuses on understanding stakeholder views, motivations and barriers related to integration of waste-heat from the nearby industrial area into the district heating network to support social acceptance of the initiative. After the initial feedback collection, stakeholder engagement methodologies to enhance awareness about the purpose and impact will be developed. These approaches offer high scalability, as they can be adapted to similar PED contexts. Potential challenges in application of the methodology and engagement efforts arise from local cultural dynamics, difficulties in building trust among diverse stakeholders, and the design of communication strategies that effectively address varying demographic groups.

The main concerns are related to the type of initiative, which is highly industrial and potentially difficult to grasp for an average citizen. At the same time, local residents, as owners of the district heating network, have a say in investment decisions. Preventive measures include structured participation plans, and targeted outreach, to strengthen connections between residents, municipalities, and technical actors. If challenges persist, communication strategies will be refined to emphasise visible social and community impacts that reinforce engagement and collective action.

9.2.2 Schönbrunn Village, Wunsiedel

In Wunsiedel, the PED Social Innovation Tool assesses drivers of resident participation in shared energy schemes, and specifically a community based shared battery initiative. The SI approach identifies engagement barriers, and leverage points to enhance the design and support social acceptance. By integrating community expectations into the technical planning of PED components, the tool aligns social and technical priorities, strengthening the PED's genotype and fostering broad, sustained stakeholder commitment.

Participation in the local shared battery is likely to depend on whether it can offer lower and more stable tariffs than current contracts, be perceived as fair between PV and non-PV households without creating obvious "winners and losers", remain simple, low-hassle and transparently governed by trusted local actors, such as SWW, and visibly deliver local and environmental benefits.

Main barriers are related to perceived complexity and low comprehensibility of the ESC/battery model, grid services and tariff logic, which can make people hesitate even when they are sympathetic to the initiative. Structural and regulatory constraints, such as tenancy arrangements, perceived lack of capital, or welfare rules for people on social benefits, mean that some residents have limited possibility to participate, limiting overall uptake potential. Formulating clear and stable tariff structure, ensuring that sign up and participation remain low-hassle, and targeted awareness raising and outreach tailored to different user groups are recommended to overcome some of these barriers. In addition, visual communication, such as dashboards or storytelling techniques can be used to make participation tangible and impactful.

9.2.3 Gemeinschaft Hard, Winterthur

In Winterthur, the PED Social Innovation Tool facilitates understanding of stakeholder needs and promotes dialogue within an aging community through participatory workshops and alignment activities. By fostering social cohesion, inclusive governance, and co-creation of energy solutions such as heating system redesign, the tool strengthens both genotype and phenotype aspects of the PED. The long-term objective is to enable replication of socially inclusive PED models in other communities.

Scaling in Winterthur depends on demonstrating tangible social benefits that resonate with community values. The main barrier relates to social diversity and communication challenges among community groups, which may slow decision-making and hinder alignment. This high-impact risk stems from varying levels of engagement and willingness to participate. Mitigation measures include organising regular, small-scale stakeholder workshops to maintain momentum and foster mutual understanding. The integration of the Social Innovation Tool within community-based PED ecosystems is primarily driven by organisational and stakeholder factors, and limited resources for engagement activities may hinder market potential. Hence, scalability potential of the tool is moderate considering the resource perspective.

9.3 Overview of findings

The adoption of the PED Social Innovation Tool is primarily driven by social and organisational enablers, including active stakeholder engagement, trust-building, and inclusive participation. Its scalability is considered moderate, with replication largely dependent on perceived need for sustained involvement from PED partners and community members. Key barriers across all demonstration sites include limited stakeholder availability, uneven engagement, and communication challenges, especially due to language constrains. These constraints may reduce the effectiveness of participatory processes and limit the integration of community insights into PED planning. Preventive measures focus on structured engagement plans, regular workshops, tailored communication strategies, and multi-format outreach to maximise participation. Corrective actions involve adaptive communication, hybrid engagement formats, and iterative facilitation to maintain effective feedback loops and foster sustained trust. Overall, engagement barriers are more related to the adaptation of the whole concept, which the Social innovation tool tries to tackle through information collection and engagement planning. For the adaptation of the tool itself, it is about the perceived need for a tool to support the engagement. So scalability and replication potential are overall more related to 1. how much stakeholder engagement is seen as a "problem" in PEDs, and 2. how much the SI approach can help to "overcome the problem" or not. Table 14, presents an overview of the PED Social Innovation Tool, in relation to its key exploitation dimensions, outlining the associated KER, target markets, intended exploitation pathways, key enablers supporting uptake, the main barriers that may hinder deployment, and the mitigation measures proposed to address these challenges.

Table 14 PED Social Innovation tool – Exploitation Overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
PED Social Innovation Tool	•Municipalities, local authorities and communities seeking to implement PEDs • PED developers & managers • Research and innovation projects focusing on community or place based approaches to local energy systems	• Further research & publication • Open access knowledge sharing and dissemination • Pilot demonstrations Training and capacity building activities	•Recognition of engagement as strategic component of PED success Institutional willingness to adopt participatory and iterative planning processes	•Limited organisational capacity or skills to implement engagement processes • Fragmented governance and unclear mandates for participation • Lack of time and resources for supporting engagement and iterative co-creation processes • Perception of engagement as secondary to technical development	• Provide structured participation plans, adaptable templates, and guidance for different local capacities • Offer training and mentoring for facilitators • Position SI tool as complementary to the technical tools • Use early demonstration results as provide tangible outcomes of engagement

10 DATA EXCHANGE, INTEGRATION AND INTEROPERABILITY PLATFORM

This chapter present an analysis of the input collected from the Solution Provider - ICOM and the PEDvolution co-developer PEDs for the Data Exchange, Integration and Interoperability Platform.

10.1 Description and Characterisation

The Data Exchange, Integration & Interoperability Platform is designed to provide a unified digital infrastructure enabling seamless, secure, and standardised data exchange among PED stakeholders. Its primary goal is to establish a data space framework that ensures interoperability across energy, mobility, and building systems while complying with European standards for data privacy, sovereignty, and governance.

By the end of the project, the platform is expected to achieve TRL 7 (system prototype demonstrated in an operational environment) and MRL 5 (regulatory and compliance alignment), advancing to TRL 8 and MRL 6 within five –seven years post-project. Its SRL is projected to increase from 5 to 7, reflecting stakeholder validation and trust in data-driven PED management.

Table 15: Data Exchange, Integration, & Interoperability Platform – Market Readiness Overview.

KER	Expected TRL by project completion	Envisioned TRL 5-7 years beyond project completion	Expected MRL by project completion	Envisioned MRL 5-7 years beyond project completion	Expected SRL (Societal Readiness Level) by project completion	Envisioned SRL 5-7 years beyond project completion
Data Exchange, Integration, & Interoperability Platform	TRL7: System prototype demonstration in operational environment	TRL8: System complete and qualified	MRL5: Regulatory and Compliance Alignment	MRL6: Market Entry Preparation	SRL5: Proposed solution validated by relevant stakeholders in the area	SRL7: Refinement of solution and, if needed, retesting in relevant environment with relevant stakeholders

The platform strengthens both genotype and phenotype dimensions of a PED. It enhances the genotype by improving interoperability, data governance, and cross-domain communication between systems, while influencing the phenotype through observable benefits such as optimised energy management, flexibility coordination, and citizen-centric services. Its replication potential is high due to modular, standards-based architecture enables deployment across PED contexts. Market readiness will depend on establishing sustainable business models, regulatory alignment, and stakeholder incentives for data sharing. On the societal side, the emphasis on ethical governance, GDPR compliance, and user trust contributes to long-term acceptance and widespread adoption.

Primary users include energy and mobility service providers, PED developers and managers, municipal authorities, and built environment professionals. The platform acts as an enabler for interoperability between PED-level systems and regional or national data infrastructures, forming a cornerstone for data-driven planning, operation, and replication of Positive Energy Districts across Europe.

EXPLOITATION PATHWAYS

Target markets include sectors, entities, and ecosystems that require integration of many heterogeneous data sources and systems and are connecting to many other internal/external systems, e.g. industry (or residential sector) with many assets/data sources, municipalities, research & innovation ecosystems, PED and district managers, utilities and energy service providers, building and facility managers. Exploitation pathways focus on research, publication, policy science and knowledge sharing, to support integration within European data and energy ecosystems.

Key actions to raise awareness can include targeted stakeholder engagement, open-access knowledge dissemination, pilot demonstrations, and participation in innovation hubs and living labs. These measures aim to accelerate replication, foster cross-sector synergies, and enhance platform visibility and credibility.

While specific adopters have not been identified yet, potential collaborations with municipalities, research organisations, and energy data standardisation bodies are foreseen to support market integration.

10.2 Implementation in PEDvolution Demonstration Sites

10.2.1 Residential Neighbourhood Planina, Kranj

In Planina, the Data Exchange, Integration and Interoperability Platform encourages secure and efficient data exchange between the pilot site and PEDvolution Solution Providers, enhancing system transparency and performance. It addresses challenges related to fragmented systems and data privacy, strengthening the PED phenotype and benefiting DSOs, municipalities, residents, and solution providers. Long-term impacts include improved resource allocation, cost optimisation, and overall system resilience.

Integration is supported by clear data governance rules and Intellectual Property Rights (IPR) frameworks. Medium scalability is achievable through open protocols and GDPR-compliant privacy mechanisms, facilitating interoperability with third-party tools. Replication may be constrained by IT resistance, the absence of harmonised standards, or unclear ownership and access rights, which can complicate implementation across multiple districts.

The main barrier for implementation relates to inconsistent data standards and limited interoperability across systems, which could reduce the effectiveness of real-time coordination. Preventive measures include early integration testing, adoption of open standards, and active collaboration with technology vendors. Corrective actions involve applying middleware solutions or manual harmonisation in cases where full interoperability cannot be achieved.

10.2.2 Schönbrunn Village, Wunsiedel

In Wunsiedel, the Data Exchange, Integration and Interoperability Platform facilitates data exchange between the pilot site and Solution Providers. The platform primarily expected to be utilised by DSOs, addresses challenges related to secure and efficient sharing, interoperability between systems, and ensuring data privacy and protection, thereby, strengthening the PED phenotype. In the long-run the platform will contribute to the overall development of the PED, by encouraging efficient energy allocation, optimisation of heat energy follows and cost optimisation.

Integration and adoption are supported by IPR and data governance frameworks. High scaling potential is underpinned by open protocols (e.g., IEC 61850, CIM, MQTT), open APIs/SDKs, GDPR-compliant privacy measures, and a modular architecture that allows multi-node expansion. Replication may be constrained by data ownership uncertainties, privacy compliance challenges, IT resistance, and the absence of standardised municipal data models.

Two main barriers for adoption and associated risks have been identified. The first technological high impact risk concerns inconsistent data standards and low interoperability between systems hamper integration and value chain. Without seamless interoperability, real-time coordination of assets becomes fragmented, impeding the platform’s function. This can be mitigated through open data standards, collaboration with platform vendors, early integration testing, and middleware deployment.

The second relates to legal and more specifically regulatory restrictions on cross-domain data use, which may block sector coupling and delay data sharing. Preventive and corrective measures include legal consultation, re-scoping functionalities to ensure compliance, and the use of legal mapping tools within the PED architecture to guide implementation boundaries.

10.2.3 Gemeinschaft Hard, Winterthur

In Winterthur, the Data Exchange, Integration and Interoperability Platform standardises data exchange using open standards, ontologies, and protocols. Aggregated daily data from PV systems, hydropower, EV charging, and consumption metrics is accessible via HTTPS connectors, addressing complex multi-source data management. The platform strengthens the PED genotype by enhancing technological foundations and interoperability. Primary beneficiaries include technical staff, PED managers, and solution developers. Despite anticipated high maintenance costs, it lays the groundwork for future data-driven innovation and scalability.

Technological readiness is the main enabler for adoption. However, scaling potential is currently low due to stakeholder sensitivity regarding personal data and limited willingness to share information. When properly configured, the platform can extend to other tools or PED contexts with minimal adjustment.

Key barriers include user trust and engagement in data exchange, reflecting both technical and social constraints. Additional barriers relate to data availability and legal agreements on data protection and storage. Preventive measures include prioritising privacy-compliant IoT devices with local storage to ensure secure data collection and system resilience. Corrective actions will be refined collaboratively with local stakeholders as implementation progresses.

10.3 Overview of findings

The successful integration of the Data Exchange, Integration, and Interoperability Platform in PEDs is driven by technological, regulatory, and organisational enablers. Key factors include adherence to established standards and common information models, which ensure interoperability, secure data exchange, and smooth coordination among stakeholders. Scaling potential is high, reflecting increasing emphasis on data-driven energy management and standardisation across PEDs. However, replication may be constrained by stakeholder reluctance to share data, privacy concerns, or unclear governance frameworks.

The main challenges relate to technological readiness and data availability. The first barrier concerns the maturity and timely deployment of interconnected systems, where delays could reduce piloting opportunities or prevent testing of critical functionalities. Mitigation involves continuous risk monitoring, technical workshops, and adaptive scheduling. The second barrier is limited availability of stakeholder data, which may restrict the platform's scope. Preventive measures include robust Data Management Plans (DMPs), Joint Controllership Agreements (JCAs), and Non-Disclosure Agreements (NDAs), while corrective actions focus on bilateral engagement with data providers to maintain access and resolve emerging issues.

Overall, early coordination, adherence to standards, and structured stakeholder engagement are essential to maximise the Platform's effectiveness, replication potential, and long-term impact within PED ecosystems. Table 16, presents an overview of the Data Exchange, Integration, and Interoperability Platform, in relation to its key exploitation dimensions.

Table 16: Data Exchange, Integration, & Interoperability Platform – Exploitation Overview.

KER	Target Markets	Exploitation Pathways	Key Enablers	Main Barriers	Mitigation Measures
Data Exchange, Integration & Interoperability Platform	• Energy & construction industry • Municipalities & DSOs • Research & academia	• Policy & knowledge sharing • Innovation hubs & living labs • Pilot demonstrations	• Open standards & modular design • GDPR compliance • Cross-sector data governance	• Data-sharing reluctance • Low interoperability • Legal restrictions on data use	• Early integration testing • Middleware solutions • Legal alignment via NDAs, JCAs, and DMPs

11 MAIN FINDINGS AND PATHWAY TO EXPLOITATION

11.1 Main Findings

The analysis of the seven PEDvolution tools highlights significant progress toward creating an integrated, interoperable and data-driven ecosystem to support the planning, operation, and replication of PEDs. Collectively, these tools enhance decision-making and data management, interoperability, business model innovation, social engagement, and operational monitoring within PED environments. They provide a comprehensive framework that addresses both the technical (genotype) and contextual (phenotype) dimensions of PEDs, ensuring that each solution contributes effectively to energy-positive, citizen-centred, and digitally connected districts.

By project completion, tools are expected to have reached an advanced level of technological maturity, with TRL values approaching demonstration in operational environments. Complementary metrics, including MRL and SRL, indicate that tools are expected to be well-positioned for market entry preparation and can deliver tangible societal impact, particularly in terms of governance, stakeholder engagement, and local ownership of energy transition initiatives. The combined assessment of TRL, MRL, and SRL allows the consortium to systematically monitor readiness, adoption potential, and replication prospects across multiple PED contexts.

Across the three already selected demonstration sites, several recurring challenges have been identified. These include data interoperability issues, fragmented or limited data availability, variations in regulatory and policy frameworks, and differing levels of technical and organisational readiness among stakeholders. In response, partners have identified a consistent mitigation logic centred on open data standards, iterative testing, and strong coordination mechanisms. Risk management frameworks have been recognised to track progress, adapt schedules, and ensure compliance with legal and regulatory requirements -particularly in relation to data protection and governance. Technical workshops and bilateral coordination efforts have further supported the timely resolution of integration bottlenecks.

Despite these challenges, the tools demonstrate growing functional complementarity, enabling cross-domain data exchange, joint scenario analysis, and visualisation of energy, mobility, and social metrics. Their combined implementation strengthens operational efficiency, resilience, and scalability, while providing a replicable framework for PED deployment in diverse urban contexts. Moreover, the tools collectively generate exploitable value by enabling new business models, participatory governance mechanisms, and innovative digital services aligned with EU standards for data exchange, governance, and privacy.

Preliminary insights from the demonstration sites, already highlight several practices that are expected to be critical during the upcoming deployment phase and critical to be considered when designing the project's exploitation and sustainability strategies. These include early co-design with local stakeholders, the use of modular and open tool architectures, the establishment of integrated legal and data-sharing frameworks, and the adoption of iterative validation processes. Although deployment is still ahead, these elements have been identified as key conditions for ensuring trust, usability, and eventual uptake of the tools. Initial analysis also pointed to areas for improvement such as enhanced interoperability, strengthened social engagement mechanisms, and more refined business model development. Still, it is important to note that this deliverable is complementary to deliverable D8.1 «Monitoring and Verification Plan and Co-developer demos preparation», which provides a comprehensive framework for monitoring and verifying the energy, environmental, economic, and social performance of the PEDs and offers an in-depth analysis of the preparation and modification process of the PEDvolution co-developer demonstration sites.

Further insights will be gathered during Deployment Phase (Phase 3 of PEDvolution), when the tools are implemented and tested in operational conditions across the demonstration sites. This phase will enable a deeper understanding of real-world barriers, enablers, and adoption dynamics. Moreover, additional findings will emerge once the three follower PEDs are on boarded (through the PEDvolution Open Call for demonstrators), as each of them will bring distinct contextual, regulatory, and technical characteristics. Their participation will enrich the evidence base, ensuring that the tools' applicability, replication potential, and transferability are assessed across an even broader spectrum of PED environments.

The insights, methodologies, and KER characterisations presented in this deliverable therefore represent a solid foundation for the forthcoming PEDvolution joint and individual exploitation strategies. They define the initial pathways, stakeholder roles, and conditions for future adoption and replication, while the forthcoming deployment phase will provide the additional real-world evidence required to maximise the long-term impact and scalability of the project results across Europe and beyond.

Based on the conclusions of this task, the section below presents a starting point for the development of an overreaching exploitation strategy.

11.2 Pathway to Exploitation

PEDvolution aims to maximise the exploitation of its solutions by ensuring their ongoing development, deployment, adoption, and replication in diverse PED contexts beyond the project's lifetime. The project's exploitation strategy will focus on facilitating the integration of PED tools and innovations into operational districts and existing energy markets, while supporting the long-term sustainability of PED participation through enhanced social acceptance, market competitiveness, and technological reliability.

To support this strategic objective, the project has actively implemented targeted communication and dissemination activities, ensuring that its innovations reach and engage the relevant stakeholders from early on in the project's lifetime. Since its launch, these actions -carried out via WP10 and WP11- have enhance overall outreach and impact by maintaining close engagement with key target groups that can benefit from PEDvolution results in the long term. They also establish the foundations for effective exploitation by fostering awareness, trust, and potential uptake among stakeholders. Figure 1 presents the overall timeline of the project's communication, dissemination, and exploitation activities.

Additional value is created through PEDvolution's strong involvement in EU and international initiatives and working groups -such as BRIDGE, AIOTI, IEA Annex 83, PED-EU-NET, CEN/TC 465- which support alignment with standardisation activities, policy developments, and emerging best practices, thereby strengthening the project's replication and exploitation potential. This is achieved by continuously sharing public results, raising visibility through the project website, social media, and news alerts, aligning with relevant policy initiatives, and creating pathways for the commercialisation of project innovations.

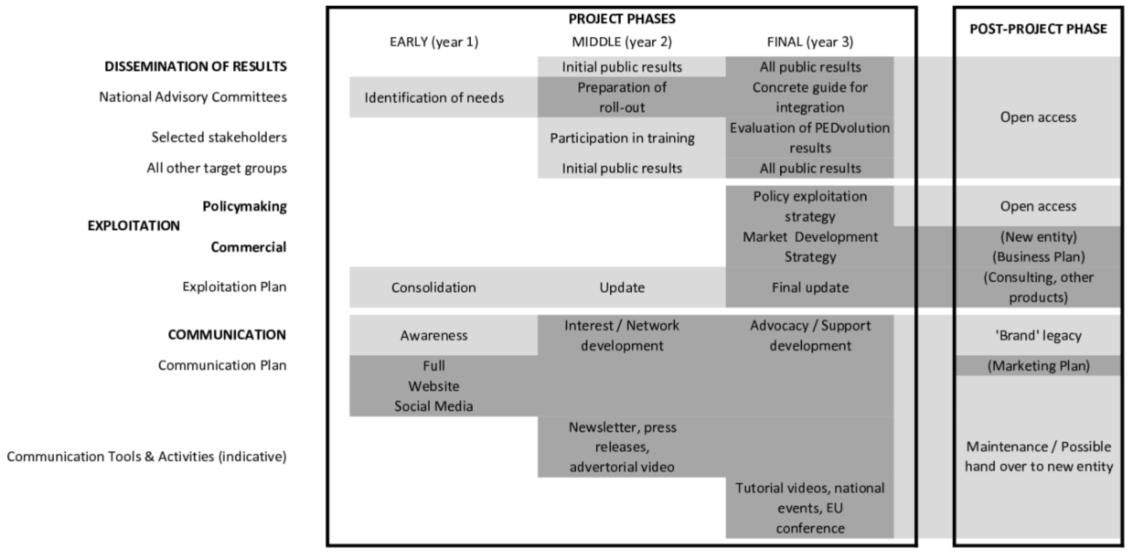

Figure 1: PEDvolution communication, dissemination, and exploitation activities timeline.

Looking ahead to Year 3 (WP12) and beyond, PEDvolution will intensify its efforts to ensure that all final outputs and public results are effectively disseminated and reach the appropriate target audiences. Relevant national and EU advisory committees will continue to be kept informed, enabling project outcomes to support policy recommendations and promote policy-level exploitation. In parallel, PEDvolution will develop both joint and individual exploitation strategies for the most promising KERs, to be implemented after project completion. Building on the KER analyses presented in earlier sections, the following table provides an initial outlook on their exploitation potential, which will be further refined and re-examined within the tasks of WP12.

Table 17: Overview of PEDvolution KERs Exploitation Pathways and Initial Exploitation Potential.

KER	Main Identified Target Markets	Exploitation Pathways	Initial Exploitation Potential
PED Design and Planning Toolset	• Urban planners & municipalities (PED developers and managers) • Energy & construction industry • Research & academia	• Further research & publication • Capacity building & training • Open access demonstration • Commercial exploitation	High
Dynamic Decision Support Guideline	•Municipalities & policy-makers • PED developers & managers • Research & academia	• Policy science & knowledge sharing • Integration with urban decision-making tools • Training and dissemination via networks	High
PED Energy Manager	• DSOs & ESCOs • Building owners & facility managers • Municipal energy agencies	• Pilot demonstrations • Integration with existing energy management systems • Commercial exploitation via ESCO partnerships	High
PED Readiness Assessment	• Public sector & municipalities • Research & academia • Energy & construction industry	• Further research & publication • Policy science & knowledge sharing	High
PED Business Models Innovation Tool	• Energy & construction industry •Municipalities & PED planners • Research & academia	• Capacity building & training • Policy-science & knowledge sharing	High
PED Social Innovation Tool	•Municipalities & communities • PED developers & managers • Research institutions	• Further research & publication • Open access knowledge sharing • Pilot demonstrations	Medium
Data Exchange, Integration & Interoperability Platform	• Energy & construction industry • Municipalities & DSOs • Research & academia	• Policy & knowledge sharing • Innovation hubs & living labs • Pilot demonstrations	Medium

Complementing this, PEDvolution's exploitation strategy and path to commercialisation will continue to be based on the initial Business model canvas (Figure 2). Integrating these aspects during Phase 3, together with iterative testing across co-developers and follower PEDs (WP9), will enable the refinement and validation of the project's solutions under real operational conditions. This process is expected to generate substantial benefits in terms of social impact, technological robustness, interoperability, market readiness, and reduced dependency on external systems, ultimately strengthening the overall value proposition of PEDvolution's KERs.

Activities under T12.3 «Sustainability plan, exploitation, and replication», will help finalise the identification of promising districts and market segments across Europe for the replication of KERs, in line with the project's defined IPR strategy. In this context, an online workshop will also be organised early on in the year with Solution Providers and PED Managers, to initiate discussion on PEDvolution solutions’ post project exploitation through new initiatives, partnerships, and long-term adoption of KERs. This targeted analysis will ensure that exploitation efforts are directed toward markets where PEDvolution solutions can offer the highest added value and achieve long-term viability. In doing so, the project will ensure a smooth transition from the project phase to the sustainability and replication phase, providing concrete opportunities for Solution Providers and other commercial and research stakeholders to initiate exploitation activities beyond the project duration.

In this light, extensive replication activities are planned to continue beyond the project’s lifetime, delivering EU-wide impacts as illustrated in Figure 3. These activities will not only support the scaling of PEDvolution’s solutions but will also strengthen the broader PED ecosystem by fostering knowledge transfer, market confidence, and cross-country uptake.

After the end of the project, PEDvolution partners intend to maintain momentum by supporting market uptake and ensuring the continued operation and refinement of PED solutions. Sustaining long-term PED participation in energy markets remains a core objective, with both Solution Developers and PED managers responsible for the ongoing maintenance, enhancement, and governance of the solutions deployed during the project. This ongoing stewardship will be essential to maximise the lasting impact of PEDvolution and ensure that project innovations remain relevant, functional, and competitive in evolving energy market landscapes.

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VALUE CREATION

PLAYERS
- PED managers and users (Residents, Commercial and Industries)
- TSOs/DSOs
- Aggregators
- Authorities
- Technology service providers
- ESCOs

ACTIVITIES
- PED engagement
- Awareness raising/education
- Energy sharing/ trading
- Collective self-consumption
- SW/HW provision for energy services
- Flexibility aggregation and trading
- Grid support services

RESOURCES
- Human resources
- RES and other energy assests
- Local energy data access
- PEDvolution SW & HW
- Integrated processes for the energy value chain

VALUE PROPOSITION

SOCIAL
- New forms of human-centred cooperation of local actors
- Increased local networking and sustainability awareness
- Fighting energy poverty

TECHNOLOGY
- Stable and secure power supply
- Losses reduction
- Automation

MARKET
- Market access to PEDs and end users
- International best PED practice examples for regulatory bodies
- PED cooperation with regulators
- Peak shaving

INTEROPERABILITY
- Integrated, interoperable and standardised systems & protocols
- Value stacking

INDEPENDENCY
- Increased self-consumption
- Reducing reliance on imports of energy sources
- Replacement of energy sources through waste-energy recouperation

VALUE CAPTURE

RELATIONSHIPS
- Customer support services
- Surveys
- Interviews
- Digital apps

USERS
- PED managers
- Individual consumers and households (B2B2C)
- SMEs
- Commercial entities
- Industrial sites

CHANNELS
- Engagement activities
- General public marketing campaigns
- Site events
- Scientific reports
- Workshops

COSTS
- Solution engineering – system integration services
- Hardware and software solution provision and support services
- Turn-key implementation
- Input costs for energy / transformation costs (e.g. biomass)
- Technical education, training
- Energy consulting for identification of waste energy potential
- Communal investments

BENEFITS
- Savings from cross energy-vector optimisation
- Innovative products with short lead-times
- Flexibility market revenues
- Recurring revenues from grid services
- Leveraging future investments in R&I for PEDs and savings through participation in national/European financing programs

Figure 2: PEDvolution Business Model Canvas.

After the end of the project, PEDvolution partners intend to maintain momentum by supporting market uptake and ensuring the continued operation and refinement of PED solutions. Sustaining long-term PED participation in energy markets remains a core objective, with both Solution Developers and PED managers responsible for the ongoing maintenance, enhancement, and governance of the solutions deployed during the project. This ongoing stewardship will be essential to maximise the lasting impact of PEDvolution and ensure that project innovations remain relevant, functional, and competitive in evolving energy market landscapes.

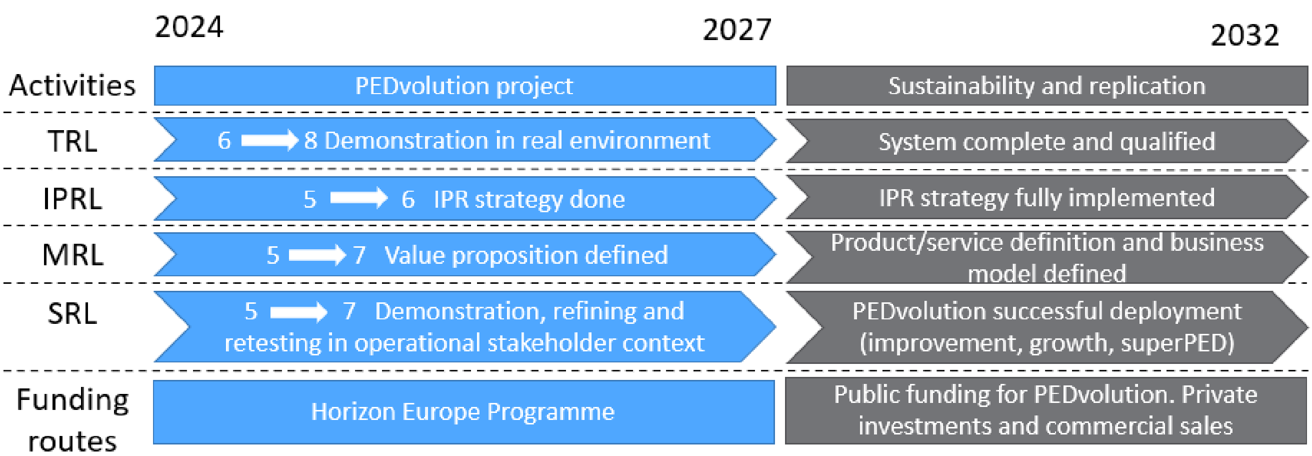

Figure 3: Planned activities after project completion.

12 CONCLUSIONS

This deliverable presents a consolidated evaluation of the seven PEDvolution tools, assessing their maturity, implementation progress, and site-specific challenges. The results confirm that, together, these tools underpin an integrated, interoperable, and data-driven framework for PEDs, directly supporting PEDvolution's mission to advance energy-positive, citizen-focused, and digitally connected district environments across Europe.

The analysis reveals strong synergies among the tools -especially in data management, interoperability, stakeholder engagement, and business model innovation- alongside recurring challenges related to data accessibility, technological alignment, and regulatory compliance. A coherent mitigation approach, based on open standards, close partner collaboration, and iterative validation, has proven effective in maintaining implementation progress and fostering cross-domain integration.

From an exploitation perspective, this deliverable establishes the foundation for the development of both the joint and individual exploitation strategies for each PEDvolution tool. By mapping their current maturity levels, enabling factors, and business potential, it provides a structured basis for defining targeted exploitation pathways and market entry actions in WP12 «Communication, Dissemination and further Exploitation». The tools' alignment with EU data governance and privacy frameworks further enhances their commercial readiness, opening opportunities for replication, scaling, and integration into broader smart city markets.

Feedback gathered through the Solution Providers, but also the PEDvolution PED Managers, reinforces the tools' practical value and validates their capacity to streamline PED deployment processes. Identified best practices include early stakeholder co-design, modular and open system architectures, and clear legal and data-sharing frameworks that strengthen trust and operational continuity. Further efforts will focus on improving interoperability, user experience, and the incorporation of AI-driven analytics for predictive and adaptive PED management.

The insights presented in this deliverable will be directly leveraged in D12.2 "PEDvolution replication and market analysis & exploitation strategy", where they will guide the formulation of the joint and individual exploitation strategies, ensuring effective scaling, market uptake, and long-term sustainability of PEDvolution's outcomes.

13 REFERENCES

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[4] Innovation Fund Denmark, *Societal Readiness Levels (SRL) defined according to Innovation Fund Denmark*, Copenhagen, DK, 2019. Available: https://innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf (accessed Dec. 2025).

ANNEX I: SOLUTION PROVIDERS' INPUT FORM

PEDvolution's KERs | IDENTIFICATION & CHARACTERISATION

This form is designed under PEDvolution task T11.2 ""KERs update and characterisation" to support the identification and collection of information on the project's ***Key Exploitable Results (KERs),*** *including their main characteristics, potential barriers, risks, proposed mitigation measures, and replication potential.*

The form should be completed by ***Solution Developers.***

For support or additional information reach out to Sympraxis.

Please complete and submit the form by ***Wednesday 30th April 2025****. Thank you in advance for your participation.*

* Indicates required question

Section 1: Respondent's Profile

1. **Name** *

2. **Partner Name** *

Section 2: Key Exploitable Results (KERs) Identification & Characterisation

This section aims to identify and detail the key characteristics and target audience of the project's KERs.

3. **KER name** *

Mark only one oval.

- PED Design and Planning Toolset
- Dynamic Decision Support Guideline
- PED Energy Manager
- PED Readiness Assessment
- PED Business Models and Innovation Tool
- PED Social Innovation Tool
- Data Exchange, Integration, & Interoperability Platform
- Other: ______________________

4. **What is the solution's expected TRL (Technology Readiness Level) by project completion** *(If different from the one stated in the DoA Section 1.1.4)*?

Mark only one oval.

- TRL6: Technology demonstrated in relevant environment
- TRL7: System prototype demonstration in operational environment TRL8:
- System complete and qualified
- TRL 9: Actual system proven in operational environment
- Other: ______________________

5. **What is the solution's envisioned TRL 5-7 years beyond project completion?** *

Mark only one oval.

- TRL6: Technology demonstrated in relevant environment
- TRL7: System prototype demonstration in operational environment TRL8:
- System complete and qualified
- TRL 9: Actual system proven in operational environment
- Other: ______________________

6. **What is the solution's expected MRL (Market Readiness Level) by project completion?** *(If different from the one stated in the DoA Section 1.1.4)*?

Mark only one oval.

- MRL5: Regulatory and Compliance Alignment
- MRL6: Market Entry Preparation
- MRL7: Initial Market Adoption
- Other: ____________________

7. **What is the solution's envisioned MRL 5-7 years beyond project completion?** *

Mark only one oval.

- MRL5: Regulatory and Compliance Alignment
- MRL6: Market Entry Preparation
- MRL7: Initial Market Adoption
- Other: ____________________

8. **If applicable, what is the solution's expected SRL (Societal Readiness Level) by project completion?** *(If different from the one stated in the DoA Section 1.1.4)*?

Mark only one oval.

- SRL5: Proposed solution validated by relevant stakeholders in the area
- SRL6: Solution demonstrated in relevant environment and in co-operation with relevant stakeholders to gain initial feedback on potential impact
- SRL7: Refinement of solution and, if needed, retesting in relevant environment with relevant stakeholders
- Other: ____________________

9. **If applicable, what is the solution's envisioned SRL 5-7 years beyond project completion?**

Mark only one oval.

- SRL7: Refinement of solution and, if needed, retesting in relevant environment with relevant stakeholders
- SRL 8: Proposed solution(s) as well as a plan for societal adaptation complete and qualified
- SRL 9: Actual project solution(s) proven in relevant environment
- Other: ____________________

10. **Which aspect of the PED do you believe the solution's adoption will most strengthen?** *

Mark only one oval.

- Genotype: Social, Technological, Interoperability, Market
- Phenotype: Set of observable characteristics resulting from the interaction of its genotype with the environment
- Both the above

11. **How do you perceive the TRL impacts the potential for replication of the solution?** (considering factors such as scalability, market adoption, and technological maturity) *

12. **How do you perceive the MRL impacts the potential for replication of the solution?** *

13. **If applicable, how do you perceive the SRL impacts the potential for replication of the solution?**

14. **Who are the solution's main target/end-users?** *

Check all that apply.

- [ ] Energy service providers (ESCOs)
- [ ] Mobility service providers
- [ ] PED Developers & Managers
- [ ] Energy prosumers
- [ ] Residence, energy consumers, & homeowners
- [ ] Engineers
- [ ] Architects
- [ ] Policy makers
- [ ] Standardisation bodies
- [ ] Regional and/or Municipal authorities
- [ ] Other professionals within the built environment/construction sector
- [ ] Other: ____________

Section 3: Market & Exploitation Pathways

This section identifies the target markets and possible pathways for exploitation (adoption and replication)?

15. **What are the solution's primary target(s) markets for exploitation**? *

Check all that apply.

- [ ] Energy & Construction Industry
- [ ] Public sector & Municipalities
- [ ] Research & Academia
- [ ] End-Users & Citizen Engagement
- [ ] Other: ______________________

16. **What exploitation pathway(s) do you envision for the solution?** *

Check all that apply.

- [ ] Further research and publication
- [ ] Commercial exploitation
- [ ] Capacity buildings & training
- [ ] Policy science & knowledge sharing
- [ ] Standardisation & certification
- [ ] Other: ______________________

17. **Which exploitation action(s) do you consider most effective in raising awareness of the opportunities provided by the solution and facilitating the uptake of the specific PEDvolution solution?** *

Check all that apply.

- [ ] Targeted stakeholder engagement
- [ ] Online/Media campaigns
- [ ] Open access knowledge sharing
- [ ] Liaising with EU networks
- [ ] Liaising with funding mechanisms
- [ ] Pilot demonstrations
- [ ] Policy integration and/or standardisation
- [ ] Training and capacity building
- [ ] Innovation hubs & living labs
- [ ] Intellectual property (IP) & licensing
- [ ] Other: ____________________

18. **Please elaborate your answer/provide any additional comments** *

____

____

____

____

____

19. **Do you already have specific adopters/beneficiaries in mind?** *

Mark only one oval.

- ( ) Yes
- ( ) No

20. **If yes, please provide any available information** *(e.g. company name, use, approach etc.)*

Section 4: Risk Identification & Mitigation Measures

This section examines what type of barriers and associated risks expected during the solution's adoption and implementation phases, along with the planned mitigation strategies.

21. **Barrier 1: Please provide a brief description of the barrier** *

22. **Which category best describes the type of barrier:** *

Mark only one oval.

- Technological
- Economic
- Environmental
- Intellectual Property Rights (IPR)
- Political
- Regulatory and Policy
- Social
- Legal
- Other: ______

23. **How would you characterise the barrier's impact?** *

Mark only one oval.

- Very Low
- Low
- Medium
- High
- Very High

24. **Please provide a brief description of the associated risk(s).** *How can the risk hinder the uptake/adoption of the solution?* *

25. **What prevention measure(s) can be implemented to ensure smooth uptake of the solution, despite the identified risk?** *

26. **What corrective measure(s) can be planned/implemented to address this challenge if it arises?** *

27. **Please provide any additional information and/or comments**

28. **Barrier 2: Please provide a brief description of the barrier**

29. **Which category best describes the type of barrier:**

Mark only one oval.

- Technological
- Economic
- Environmental
- Political
- Regulatory and Policy
- Social
- Legal
- Other:

30. **How would you characterise the barrier's impact?**

Mark only one oval.

- Very Low
- Low
- Medium
- High
- Very High

31. **Please provide a brief description of the associated risk(s).** *How can the risk hinder the uptake/adoption of the solution?*

32. **What prevention measure(s) can be implemented to ensure smooth uptake of the solution, despite the identified risk?**

33. **What corrective measure(s) can be planned/implemented to address this challenge if it arises?**

34. **Please provide any additional information and/or comments**

Section 5: Enablers for the adoption and replication of the PEDvolution solutions

This section examines the enabling factors that can contribute towards adoption and replication of the solution.

35. **From the following aspects, which would play a key role in facilitating and encouraging the solution's integration within a PED ecosystem?** *

Check all that apply.

- [ ] Technological (e.g. modular, interoperable design, open data, pilots)
- [ ] Regulatory/policy related (e.g. alignment with EU directives, standardisation and certifications)
- [ ] Financial and market enablers (e.g. government incentives/financial support/subsidies)
- [ ] Organisational and stakeholders (e.g. capacity building and training activities, strong stakeholder engagement, collaboration network)
- [ ] Social and behaviorable factors (e.g. user engagement and digital literacy)
- [ ] Other: ____________

36. **Please provide any additional information and/or comments**

____

____

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____

37. **How do you assess the potential for scaling up the solution's adoption to a broader scope (e.g. district, municipal/regional/national level)?** *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Very High

38. **What key factors would enable replication?** *Please elaborate on your answer.* *

39. **What are the key factors that would hinder replication?** *Please elaborate on your answer.* *

ANNEX II: PED MANAGERS' INPUT FORM

	PED Design and Planning Toolset	PED Readiness Assessment	Dynamic Decision Support	PED Energy Manager	Interoperability Platform	Business Models & Innovation Tool	Social Innovation Tool	Other
KER CHARACTERISATION & ADOPTION *(This section aims to identify and detail the characteristics and adoption purpose of the KER.)*								
Which process does the solution aim to improve/optimise?* How will it be integrated within the PED and hat is the goal?								
Which PED challenge(s) does the adoption of the solution aim to overcome?*								
Which PED aspect is its adoption expected to strengthen?*								
Which stakeholders are expected to benefit the most from its implementation?*								
In the long-run (beyond project completion), how do you expect the solution to contribute to overall development and evolution of the PED?								

RISK IDENTIFICATION & MITIGATION MEASURES *(This section examines what type of barriers and associated risks expected during thesolution's adoption and implementation phases, along with the planned mitigation strategies.)*								
Barrier 1: Please provide a brief description of the barrier *								
Which category best describes the type of barrier?*								
If "other" please explain								
How would you characterise the barrier's impact?*								
Please provide a brief description of the associated risk(s). How can the risk hinder the uptake/adoption of the solution?*								
What prevention measure(s) can be implemented to ensure smooth uptake of the solution, despite the identified risk?*								
What corrective measure(s) can be planned/implemented to address this challenge if it arises?*								
Please provide any additional information and/or comments								
Barrier 2: Please provide a brief description of the barrier								
Which category best describes the type of barrier?								
If "other" please explain								
How would you characterise the barrier's impact?								
Please provide a brief description of the associated risk(s). How can the risk hinder the uptake/adoption of the solution?*								
What prevention measure(s) can be implemented to ensure smooth uptake of the solution, despite the identified risk?								
What corrective measure(s) can be planned/implemented to address this challenge if it arises?								
Please provide any additional information and/or comments								

ENABLERS FOR THE ADOPTION AND REPLICATION OF THE PEDVOLUTION SOLUTIONS *(This section examines the enabling factors that can contribute towards the solution's adoption.)*								
From the following categories, which would play a key role in facilitating and encouraging the solution's integration within a PED ecosystem?*								
ENABLERS FOR REPLICATION OF THE PEDVOLUTION SOLUTIONS *(This section examines the enabling factors that can contribute towards replication of the solution.)*								
How do you assess the potential for scaling up the solution's adoption to a broader scope (e.g. district, municipal/regional/national level)?*								
What key factors would enable replication? *Please elaborate on your answer.* *								
Do you already have a potential replication site in mind - if so where? *								
What are the key factors that would hinder replication? *Please elaborate on your answer.* *								
Please provide any additional information and/or general comments								

ANNEX III: KERs UPDATE AND CHARACTERISATION WORKSHOP AGENDA

PEDvolution

WORKSHOP 1: KERs UPDATE & CHARACTERISATION

WORKSHOP OBJECTIVES

- To collectively identify, refine, and prioritise potential exploitation pathways for each PEDvolution KER, supporting the development of the project's overall exploitation strategy (WP12)
- Kick-start the transition from KER characterisation (D11.2) to exploitation planning (D12.2).
- *Bridge the gap between research outputs and their real-world application.*

- **PART 1: Identified KERs & Exploitation Pathways** *(5 mins)*
- **PART 2: Elaborating PEDvolution's KERs** *(40 mins)*
- **PART 3: PEDvolution's Legacy – post project exploitation & sustainability** *(15 mins – if time allows)*

Before we begin:

*- Share one word /phrase definition of «**exploitation**» for PEDvolution solutions*

PEDvolution

ELABORATING PEDVOLUTIONs KERs (T11.2)

- Break-out groups: SWISS PED, GERMAN PED, SLOVENIAN PED (30 mins)
- **What is the main challenge(s) in each PED demonstration site and which PEDvolution solutions can contribute towards addressing this challenge**
- KER exploitation canvas – to identify potential exploitation, enablers, barriers, mitigation measures for each tool's uptake
- Any other KERs?
- Each group to present their results briefly (10 mins total)

Key Exploitable Result (KER)

An identified main interesting result, which has been selected and prioritised due to its high potential to be exploited — meaning to make use of and derive benefits from — downstream in the value chain of a product, process, or solution, or to serve as an important input to policy, further research, or education.

KER	TARGET MARKETS	EXPLOITATION PATHWAYS	KEY ENABLERS	BARRIERS	MITIGATION/ CORRECTIVE MEASURES
PED Design and Planning Toolset					
Dynamic Decision Support Guideline					
PED Energy Manager					
PED Readiness Assessment					
PED Business Models & Innovation tool					
PED Social Innovation Tool					
Data Exchange, Integration & Interoperability Platform					

