PEDvolution

Interoperable solutions to streamline PED evolution and cross-sectoral integration

Deliverable 1.2

Functional and Operational Requirements of the Demo Sites and Reference Use Cases

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Lead Beneficiary	**ICOM**		
Responsible Author	**Nikolaos Charitos (ICOM)**		
Contributions from	**Ilia Pietri (ICOM)** **Igyso Zafeiratou (ICOM)** **Isidoros Kokos (ICOM)** **Amin Kouti (VITO)** **Mohsen Sharifi (VITO)** **Nirav Patel (TUW)** **Reda El Makroum (TUW)** **Evyatar Littwitz (ESG)** **Rainer Härtl (ESG)** **Pascal Kienast (ZHAW)** **Matthias Haase (ZHAW)** **Mihaela Meslec (ZHAW)** **Andreas Lucas (SWW)** **Gerhard Meindl (SWW)**		

	Vicente Carabias (WIN) **Minna Kuivalainen (SIN)** **Alemu Belay (SIN)** **Martin Vodnik (OFFSET)** **Sašo Brus (OFFSET)** **Inger Andresen (NTNU)**
Reviewed by	**Zoran Marinšek (OFFSET)** **Martin Vodnik (OFFSET)** **Sašo Brus (OFFSET)** **Markos Psimitis (INLE)** **Foivos Galatoulas (INLE)** **Reda El Makroum (TUW)**

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Glossary of terms and abbreviations used

ABBREVIATION / TERM	DESCRIPTION
BMI	Business Models Innovation
BUC	Business Use Case
BRP	Balance Responsible Party
CEC	Citizen Energy Community
CHP	Combined Heat and Power
EC	Energy Community
DDSG	Dynamic Decision Support Guideline
DER	Distributed Energy Resource
DHO	District Heating Operator
DHC	District Heating/Cooling
DHS	District Heating System
DR	Demand Response
DRMS	Demand Response Management System
DSO	Distributed System Operator
Dx.y	Deliverable
ESC	Energy Sharing Community
HEMRM	Harmonised Electricity Market Role Model
OX	Objective X of the project or UC
PED	Positive Energy District
PV	Photovoltaic
RA	Readiness Assessment
REC	Renewable Energy Community

RES	Renewable Energy Source
ROI	Return On Investment
SGCG	Smart Metering Coordination Group
SWOT	Strengths, Weaknesses, Opportunities, Threats
UC	Use Case

EXECUTIVE SUMMARY

The PEDvolution project supports the European key initiative towards the transition to a climate-neutral society by 2050. For its accomplishment, this project focuses on transforming the built environment through innovative, district-level solutions that consider PED dynamics, cross-sector dependencies and synergies with the aim to enhance overall PED assets and system interoperability. With an estimated 97% of dwellings not meeting the current requirements, the project recognizes the necessity of moving beyond isolated technological adjustments. Hence, it aims to implement interoperable solutions which enhance energy efficiency, integrate local renewable energy sources, and effectively deploy power excess at a district level. Ultimately, the approach empowers citizens to collectively engage with regional energy, mobility, and ICT systems and initiatives while fostering social innovation, aligning with the principles of the Renovation Wave and the concept of Positive Energy Districts (PEDs).

The primary objective of the PEDvolution project is to facilitate the cross-sectoral integration and continuous evolution of PEDs, looking into the dynamic characteristics and interplay of four fundamental district variables: a) the social setting; b) the market landscape; c) the technological ecosystem; and d) interoperability of digitalised assets, processes and systems. To achieve this, the project will develop and implement seven key solutions: *a PED Design and Planning Toolset, PED Readiness Assessment, Dynamic Decision Support Guideline for PED Development, PED Energy Manager, Interoperability Platform, PED Business Models Innovation Tool, and a Social Innovation Tool*. These solutions will be tested and validated in three real-life PEDs across Europe, ensuring their adaptability and scalability. In general, the project aims to create sustainable urban energy ecosystems capable of evolving with transitions on environmental and social conditions.

This report presents the work of analysing the project's requirements and as-is conditions of the pilot PED sites, towards guiding the implementation and demonstration of PEDvolution's innovations. Leveraging previous work in the domain, the documented work provides a comprehensive framework for their effective integration and continuous evolution within PEDs. PEDvolution – inspired by biology – introduces the concept of PED genotype (being its set of genetic material, built through a unique combination of Social-Technology-Interoperability-Market-related aspects) and phenotype (being 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)).

The requirements analysis is following a multi-faceted approach. Initially, it analyses a set of representative **Business Use Cases (BUCs)** corresponding to the concerns of the stakeholders involved in the use of the seven key solutions of the project, driven by the specificities of the three co-developer PED pilots. Towards this, a role model was constructed **mapping PED roles and their interactions**, as well as their relation to the **Harmonised Electricity Market Role Model** (HEMRM). Next, the technical analysis follows a systemic approach on the PEDvolution solutions and how they address the business needs of the BUC analysis towards serving the design, operation and evolution of PEDs, by documenting **High-Level Use Cases (HLUCs).** The approach followed is derived from the methodology of **IEC 62559-2** standard. The HLUCs provided aim to document the main interactions among systems aligned with the business processes of the BUCs, which will be specialised for the case of each PED pilot according to the local constraints. The technical analysis is complemented by analysis of **individual requirements**, capturing interoperability, security, performance and other non-functional requirements of PEDvolution's solutions. The UC analysis enclosed in this report comprises a 1st version of the

functional and non-functional requirements that will be supported in PEDvolution and will be further adapted and fine grained in the course of the project.

The documented work will guide the design activities of T1.3 “System architecture and technical specification” towards defining the PEDvolution architecture and the high-level technical specifications, as well as the rest of the technical work in the detailed design, implementation and demonstration of the PEDvolution’s solutions.

It is noted that the security and privacy requirements for the PEDvolution project will be fully documented in D7.3, “Data exchange platform and connection with EU Data Spaces,” which will be submitted in June 2026.

1 INTRODUCTION

The PEDvolution project main goal is to drive Europe towards a climate-neutral future by developing and implementing integrated, district-level solutions for PEDs. This deliverable takes into account the objectives (O's) essential to achieve the main goal of the project:

O1. Develop methodologies and tools for integrated PED modelling using Digital Twins, which provide a virtual representation of physical assets for enhanced planning and analysis;
O2. Advance solutions for real-time energy asset management, ensuring efficient and adaptive energy usage;
O3. Design a robust interoperability platform that enables seamless data exchange and integration across various systems and sectors;
O4. Establish a certification framework that standardizes and validates PED solutions, ensuring their quality and efficacy;
O5. Demonstrate efficiency of the PED solutions in real-world settings;
O6. Develop innovative business models, crucial for the practical application and financial sustainability of the project; finally,
O7. Ensure that the knowledge gained and solutions developed are effectively shared and replicated through a comprehensive communication and dissemination strategy.

The approach to achieving these objectives will involve a collaborative process among expertise in PED conceptualisation, implementation, and tool development. The project will employ advanced digital technologies, real-time data analytics, and stakeholder engagement to create adaptable and scalable solutions. This deliverable provides a detailed outline of the use cases and requirements necessary to develop and implement these solutions, ensuring their successful integration and continuous improvement. The use case scenarios are defined following the methodology proposed by IEC 62559-2 standard [1] and taking into account the needs of the three PEDvolution pilots to identify PED-related stakeholders and their expectations. This high-level analysis will constitute the basis for continuing the work in T1.3 with the definition of the system architecture, as well as the analysis of more detailed specifications for the project's innovations, in the context of technical work packages.

1.1 Mapping Project Outputs

This section maps the PEDvolution Grant Agreement commitments, detailing how the formal Deliverable and Task descriptions align with the project outputs and the work to be performed. By systematically cross-referencing each commitment with the corresponding results and activities, we provide an overview of our adherence to the project's objectives. This includes the development of integrated PED modelling tools using Digital Twins, real-time energy asset management solutions, an interoperability platform, and a certification framework. Additionally, it covers the demonstration of PED solutions in real-world settings, the creation of innovative business models, and the execution of a robust communication and dissemination strategy. In Table 1 a short description of D1.2 and its pertinent tasks are depicted.

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

PROJECT GA COMPONENT TITLE	PROJECT GA COMPONENT OUTLINE	RESPECTIVE DOCUMENT CHAPTER(S)	JUSTIFICATION
DELIVERABLE			
D1.2 Functional and operational requirements of the demo sites and Reference use cases	Requirements analysis & capturing of as-is conditions of the co-developers' districts, buildings and systems.	Chapters 2-6	A methodology is described concerning the analysis of the use cases and requirements. The formed PEDvolution ecosystem is then introduced, with its basic concepts, the involved stakeholders and actors. The conditions of the demonstration sites are documented. The business requirements are analysed with the definition of PEDvolution role model as well as the relevant BUCs. Finally, the system requirements are provided with the description of the HLUCs.
TASKS			
Task 1.2 Requirements Analysis & capturing of as-is conditions	ST1.2.1 Requirements analysis	Chapters 4, 5. Annexes II, III.	Analysis of the business and technical requirements of the project and documentation in the form of a set of Business Use Cases (BUCs) and High-Level Use Cases (HLUCs) respectively.
Task 1.2 Requirements Analysis & capturing of as-is conditions	ST1.2.2 Collection of districts, buildings and systems information	Chapter 3. Annex IV.	The PEDvolution ecosystem, including business and technical actors, is presented, while key information on the three pilots of the project is also exposed.

1.2 Deliverable Overview and Report Structure

This report aims to provide an analysis of the requirements for the PEDs and their stakeholders defining a set of use case scenarios and individual requirements that are relevant to PEDvolution project. It identifies the requirements for the implementation and integration of the PEDvolution interoperable solutions according to the project objectives and its pilots' needs. The use case analysis covers both the business and technical requirements identified, following the process indicated by the adopted methodology.

The work presented in this deliverable is related to T1.3 and all other WPs paving the way for the definition of the system architecture and the tools specifications and detailed design to be followed as the project progresses.

The report is structured as follows:

- Chapter 1 (the present section) is an introductory chapter of the report.
- Chapter 2 describes the methodology followed for the analysis of the use cases and requirements.
- Chapter 3 introduces the formed PEDvolution ecosystem with its basic concepts, the involved business and technical actors and the project pilots.
- Chapter 4 analyses the business requirements with the definition of PEDvolution role model and the relevant Business use cases (BUCs).
- Chapter 5 provides the system requirements with the description of the High-level use cases (HLUCs).
- Chapter 6 concludes the report with main findings and future steps.
- The detailed use cases (BUCs and HLUCs), along with the Use Case template utilised for their definition, can be found in the annexes of the document.

2 METHODOLOGY

This section describes the approach followed for the requirements analysis and elaboration to achieve the project's objectives, ensuring that the solutions developed are sustainable, adaptable, and effective in real-world scenarios.

2.1 Basic Terms

The basic UC-related terminology used throughout the document is the following:

- ***Use Case***: According to the Unified Modelling Language's (UML) specification (ISO/IEC 19505-2:2012 [2]), it is "the specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system."
- ***Actor*****:** According to the same standard, an actor specifies a role played by an external entity that interacts with the subject (i.e. a system). This entity can be a human user of the designed system, or another system, application or device.
- ***Party*****:** Legal entity, i.e. either natural person or judicial person (organisation) that can bundle and play out different roles according to their business model.
- ***Role***: It represents the intended external behaviour (i.e. responsibility) of a party. Parties cannot share a role. Parties carry out their activities by assuming roles, e.g. system operator. Roles describe external business interactions with other parties in relation to the goal of a given business transaction e.g. PED Manager, PED Planner.
- ***Relationship***: Relationships represent the interrelations between parties or roles (logical connections such as: association, aggregation, generalisation, etc.)
- ***Requirement***: A statement which translates or expresses a need and its associated constraints and conditions.

2.2 Requirements Classification

PEDvolution adopts a methodology defined by the international standard IEC 62559-2 [3] for the Use Case (UC) analysis, which has been the basis for many recent research and innovation projects focused in the smart grids and smart energy domains (e.g. FEVER [4], iFlex [5]). The adoption of this standard also enables PEDvolution to contribute to the relevant UC repository that was created by the BRIDGE initiative [6]. There are different classifications in the literature for the use case analysis covering different domains (e.g., energy, mobility, ICT) [7] and levels (e.g., context, services, business, data processing) [8] appropriate to cover each project needs. According to the adopted UC classification by the Smart Grid Coordination Group (SGCG) [9] [4]:

- Use case concepts (or High-Level Use Cases - HLUC) describe a general idea by defining the roles (generic actors) involved and sketching their responsibilities but not the underlying business models or processes. The target audience is system engineers, business developers, regulators and key experts in standardisation having a very good overview on the whole Smart Grid landscape.
- Conceptual business requirements are refined in one or several Business Use Cases (BUCs) written by business architects or regulators which describe them within an enterprise scope (i.e.,

the operation of businesses) and the interaction between different roles, e.g., to contract or negotiate services.

- Refinement of the technical view is added by specifying one or multiple device/system use cases to realise the goal of a business use case. For these technical use cases we can define the device/system boundaries and interactions between the system(s) and external actors to fulfil a goal for the actor(s). The target audience is mostly HW/SW engineers.

A device/system use case can take the form of a Primary Use Case as a use case implemented in a specific system characterised by a defined boundary; Secondary Use Case is used to describe core functionalities that are used by multiple Primary Use Cases. In the context of this document, this level of granularity is out of scope.

The approach followed in PEDvolution, involves the system functionality being analysed based on the first two perspectives of the classification described above. Initially, a Business Use Case (BUC) models the business interactions between the stakeholders omitting the technical interactions. It emphasises on the business scenario (or scenarios) that aims at reaching the goals of the functionality to be developed and describes the interactions between the different roles. Next, refinement of the technical view is added to High-Level Use Cases (HLUCs), which are defined to realise the goals of the business use cases. Each HLUC elaborates on the functionalities of a PEDvolution solution, considering amongst other aspects its objectives, relevant assumptions and preconditions, involved business and technical actors, as well as a step-by-step analysis of the HLUC and a set of relevant requirements. Finally, it is noted that each HLUC is mapped to one or more of the four PED genes, namely society, market, technology and interoperability, as can be seen in Section 5.2. More information on the four genes is presented in Section 3.1 of this report.

2.3 Scope and Boundaries

A common understanding of the application domain and the environment, where the system to be developed will be operating, is necessary for the process of the requirements analysis. The following concepts are defined in requirement engineering (also shown in Figure 1):

- ***Domain***: The general field of business or technology in which the system under design will be used;
- ***Context***: The part of a system's environment being relevant for understanding the system and its requirements;
- ***System***: A combination of interacting elements organised to achieve one or more stated purposes;
- ***System Boundary:*** The boundary between a system and its surrounding Context;
- ***Scope***: The range of things that can be shaped and designed when developing a system.

The requirements analysis in the project considers the requirements within the system boundary, as well as the business constraints and assumptions in the context of the system as derived from the pilots and the business stakeholders' expectations.

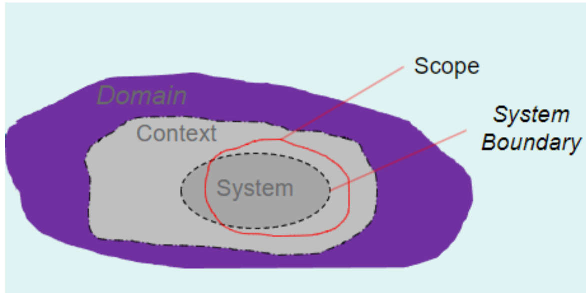

Figure 1: Scope and boundaries of the system.

It is noted that the security and privacy requirements for the PEDvolution project will be fully documented in D7.3, "Data exchange platform and connection with EU Data Spaces," which will be submitted in the third year of the project.

2.4 Requirements Analysis Methodology

The process of requirements analysis in PEDvolution is described in this section and illustrated in Figure 2, and involves the identification of BUCs, HLUCs as well as individual non-functional requirements:

- The Business Context was analysed through workshops with PED project partners, organised under WP1, where the objectives of different domain stakeholders were analysed, involving System Operators, Energy Suppliers, Prosumers, Energy Communities, PED Managers, PED Planners, PED Solution Providers, etc.
- A list of Business Use Cases (BUCs) was formulated describing how PEDvolution solutions will enable the realisation of the business objectives, involving WP8 and WP2 partners.
- An iterative process was initiated, where each BUC was analysed, refining the scope, objectives, actors, and KPIs, as well as documenting the narrative, assumptions and preconditions. When the maturity of the BUCs was adequate the work shifted to the Systemic analysis.
- The System Context was analysed through workshops with PED solution providers, whilst a draft architecture was designed to provide a systemic view of the PEDvolution solutions and their interactions with external systems and end-users.
- The High-Level Use Case (HLUC) list was devised, addressing the needs of the business processes documented in the BUC and covering all the scope of all the PEDvolution solutions.
- An iterative process was initiated, where each HLUC was analysed, refining the scope, objectives, KPIs and actors and analysing the narrative, assumptions and preconditions. Furthermore, a basic scenario was defined, which was subsequently analysed step-by-step. Finally, the Information Exchanged and relevant Requirements within the scope of the HLUC were analysed and documented.
- Upon completing the iteration on each Use Case list (i.e., BUCs and HLUCs), the UCs were analysed for missing functionalities, and the overall level of detail provided by the UC model. In case any of the above checks provided a non-acceptable result, the UC was refined (e.g. scope refinement, UC merging) and a new iteration cycle of the analysis began.

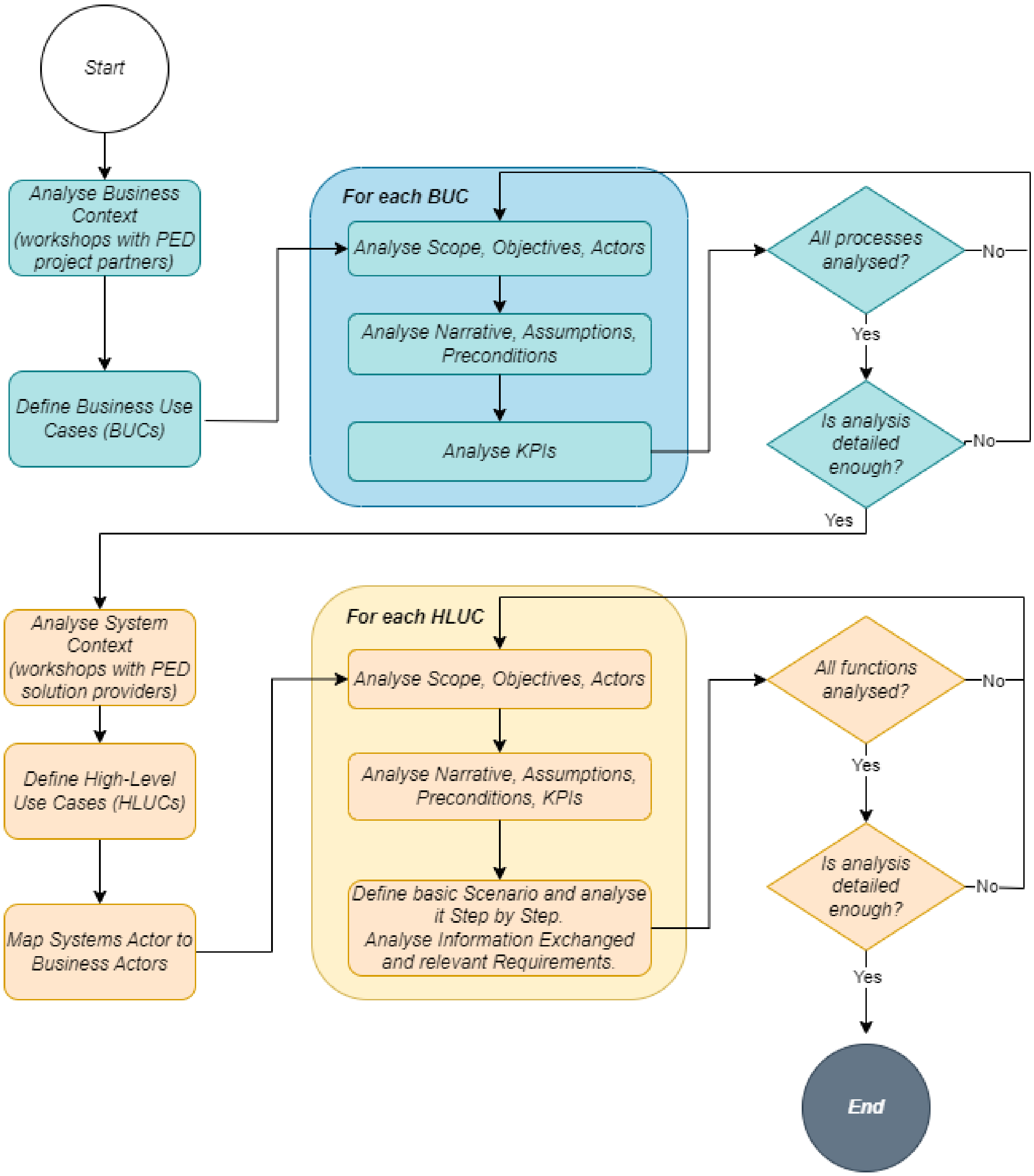

Figure 2: PEDvolution use case analysis methodology.

As regards the UC template that has been utilised for PEDvolution, this is based on IEC 62559-2 that was mentioned earlier. This template accounts for scope, objectives, KPIs and involved actors of a UC. Furthermore, short and complete narratives of the UC are presented, as well as assumptions and preconditions relevant to the UC. A UC diagram shows the interactions of the involved actors, which lead to the realisation of the UC. Furthermore, the scenarios of interest can be documented, as well as a step-by-step analysis for each scenario. Finally, the template includes sections for the exchanged information and relevant requirements. The complete template can be found in Annex I. It is noted that this template is widely utilised in HORIZON research projects and a relevant UC repository was created by the BRIDGE initiative [6].

3 PEDVOLUTION ECOSYSTEM

3.1 Basic Concepts

The urban energy transition is a dynamic and ongoing process, where Positive Energy Districts (PEDs) should be viewed as 'living and evolving entities' rather than mere endpoints. PEDs continuously adapt to changing conditions, driven by a variety of evolving factors such as social contexts, urban development, legislation, novel technologies, the proliferation of electric vehicles and their storage capacities, more dynamic energy markets, variations in the carbon intensity of electricity, and fluctuating energy prices. In the following, definitions of PED ecosystem highlight the various perspectives and criteria used by researchers, policymakers, and other stakeholders to develop PEDs. These definitions help explain the multifaceted nature of PEDs and provide a comprehensive understanding of their role in a sustainable environment. The concept of PED embodies not only energy related concern on the design and operation district but also PEDs but also social, economic and environmental ones.

According to Joint Programming Initiative Urban Europe [10], *Positive Energy Districts "…are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability."*

Another definition [11] describes PEDs similarly – highlighting the importance of the multi-sectorial approach as well: "Positive *Energy Districts are energy-efficient districts with net zero greenhouse gas emissions and an annual positive energy balance. They prioritise the use of local renewable energy and resources. They seek to optimise the interaction and integration between buildings, the users, mobility, energy, and ICT systems. Positive Energy Districts strive to bring positive impacts to the wider energy system as well as social, economic, and environmental benefits to the communities. The assessment of the annual energy balance is open to any methods that are well defined and grounded on sound principles."*

The importance of the selection of PED's boundaries and its interaction with the wider energy system are highlighted by the MAKING-CITY project [12], which defines a PED as "*an urban area with clear boundaries, consisting on buildings of different typologies that actively manage the energy flow between them and the larger energy system to reach an annual positive energy balance*".

Within PEDvolution project, the analogy of evolution is applied by natural selection to emphasise a dynamic and integrated approach for the development and adaptation of PEDs. As urban environments continuously evolve, PEDs must adapt to changing social, technological, and market conditions. The project's solutions aim to support this constant evolution, ensuring that PEDs remain effective and sustainable over time.

The PEDvolution solutions will pave the way for cross-sectoral integration of ever-evolving PEDs, by designing, processing, optimising and strengthening the PEDs genotype- and/or phenotype, aiming to create adaptable, resilient, and efficient energy ecosystems:

- The genotype of a PED represents its set of 'genetic material', which includes a unique combination of social, technological, interoperability, and market-related aspects. This genotype is foundational and defines the core characteristics and capabilities of the PED. The DNA of PEDs genotype include the following 4 genes:

- *Social*: This gene encompasses the social dynamics, stakeholder engagement, and community participation within the PED. It involves the ways in which local actors and citizens interact with and contribute to the energy ecosystem.
- *Technology*: The technological gene involves the deployment and integration of innovative technologies for energy generation, storage, and management. This includes the use of digital twins, renewable energy sources, and advanced energy management systems.
- *Interoperability:* Interoperability refers to the ability of various systems and technologies within the PED to communicate and work together seamlessly. This includes the integration of data exchange platforms, compliance with open standards, and the ability to connect with broader energy markets and infrastructures.
- *Market:* The market gene involves the economic aspects and business models that support the PED. This includes the development of innovative business models, participation in energy markets, and strategies for economic sustainability and community engagement.

- The phenotype of a PED is the set of observable characteristics that result from the interaction of its genotype with the environment. This includes various external factors such as energy markets, industry, mobility, and geopolitical conditions.

By focusing on the genotype and phenotype of PEDs and leveraging the four genes of social, technology, interoperability, and market aspects, the project aims to create adaptable, resilient, and efficient energy ecosystems (Figure 3).

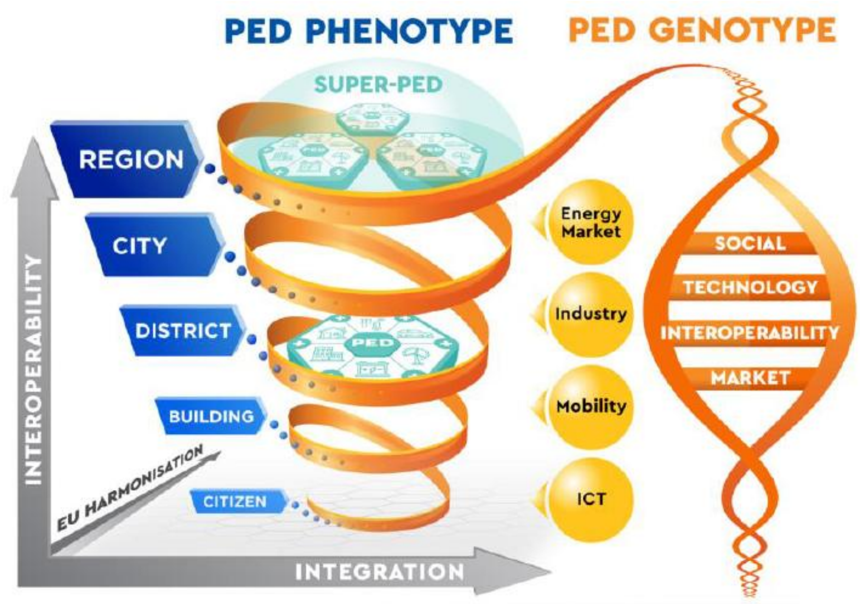

Figure 3: PEDvolution concept.

Once this goal is achieved, PEDs that fulfil certain criteria, such as proximity to each other, could evolve further by forming a SuperPED. By enabling appropriate PEDs to evolve into **SuperPEDs**, higher levels of integration and optimisation across multiple sectors and communities can be reached. The concept of a SuperPED represents, thus, the next hierarchical level in the evolution of PEDs. It involves the holistic optimisation of multiple interconnected PEDs, allowing for internal compensation of energy surpluses and shortages, and achieving overall system efficiency. The SuperPED model facilitates broader energy management, integrating various energy vectors and enhancing overall operational stability and performance.

3.2 PEDvolution solutions

Below the different technical solutions are presented linked to the objectives of the project (see Chapter 1 for details on project's objectives):

3.2.1 PED Design and Planning Toolset (O2)

The district energy and planning methods currently on the market lack consideration for the dynamic nature of a PED and the uncertainty and risks it bears. One of the key barriers to PED planning and growth is insufficient confidence in anticipated outcomes and performance gaps for various stakeholders (e.g. developers, local governments, financiers, end-users). A Digital Twin planning tool can empower PED developers and managers to accelerate district development pathways towards achieving or enhancing a PED. The tool will provide accurate energy models of buildings and district assets as a basis to generate renovation pathways along district heating/cooling (DHC) grids based on local conditions. The models will be further fine-tuned and calibrated iteratively via data-driven techniques by leveraging pilot sites' measurements to close the performance gap for reliable predictions of future energy modelling for PED planning or development stages. In addition, a robustness framework for PED technical solutions will guarantee optimal future-proof solutions regardless of the uncertainty in the final performance. This will support decision makers and designers in the reduction of risk in their planning, foresee the dynamics of the PED and follow its evolution.

3.2.2 PED Energy Manager (O3)

The energy system in PED is dynamic and interconnected across various energy vectors. However, existing solutions and tools typically manage only a portion of PED's energy system, leading to suboptimal performance. This narrow focus often results in issues like curtailed renewable energy sources (higher ROI for RES), and underutilised energy such as waste heat. Therefore, there's a need for an advanced tool "the PED Energy Manager" that optimises and manages PED's assets holistically for global optimum.

The PED Energy Manager will advance energy asset management by integrating data from various sources, offering real-time monitoring of PED assets (buildings, energy systems, mobility systems), and supporting automated decision-making for energy optimisation and demand response. It will assess and utilise energy flexibility, optimise operations across multiple energy sectors. PED Energy Manager will be able to monitor and control energy flows, predict demand, and adjust usage close to real-time. Additionally, it will provide a user-friendly interface for PED Residents to view and manage their energy use, with feedback on their performance.

The PED Energy Manager will consist of two systems: one platform for industrial and commercial sector, and another for households. The industrial and commercial solution will support sector-coupled operations (focus on electrical and thermal energy), allowing PEDs to achieve global optima and contribute to overall efficiency. It will also enable horizontal and vertical expansion, integrating energy vectors into an automated solution for near real-time optimisation. Optimised schedules will ensure efficient operation, treating various energy vectors equally. At the building level, the solution will support demand response optimisation of distributed PED assets, such as home appliances, heat pumps, electric vehicles, and battery energy storage systems. The flexibility extracted from these assets will provide added value to the PED and support its energy management by effectively balancing supply and demand. Appropriate interfaces for different energy market stakeholders (e.g., Aggregators, residential users) will be provided.

3.2.3 PED Readiness Assessment Framework (O4)

The PED Readiness Assessment is a new methodology merging several initiatives into a framework for planning, assessment and evaluation of PEDs, able to support the whole planning process via the dynamic decision support tool (see section 3.2.5), but also widely usable as a freely available methodology. The suggested framework will respect country-specific needs and market constrains, as well as further advance existing work on the integration of sector coupling (buildings and mobility), energy and emissions, and consider the constant evolution of PEDs.

3.2.4 Interoperability Platform (O4)

The Interoperability Platform will provide all the necessary mechanisms for semantic and syntactic interoperability to enable secure and interoperable data exchanges between the developed PEDvolution solutions, PED assets, external platforms, applications and third parties [13]. It will also include and develop all the necessary mechanisms for the interfacing with the energy market and interconnection with other Energy Data Spaces to allow PEDvolution data and services to be also exposed to the energy market and the EU Data Space ecosystem [14]. The adopted mechanisms will ensure that data exchanges between the different systems will comply with established security mechanisms while appropriate privacy policies will be considered in cases where sensitive data are involved.

3.2.5 Dynamic Decision Support Guideline for PED Development (O5)

Within several ongoing Horizon projects such as ARV [15], oPENlab [16], and syn.ikia [17] frameworks and guidelines are being developed for the planning and design of sustainable plus energy buildings and neighbourhoods (Figure 4). They provide insight and knowledge about technologies and performances and guide decision-makers towards life cycle based and high performing buildings and neighbourhoods. Also, frameworks for identifying and assessing key performance indicators (KPIs) of positive energy buildings and neighbourhoods, are available. While such frameworks and guidelines provide useful insight into how to achieve a multitude of performance goals for PEDs, they are static in their nature, and are not designed to be updated in line with different user needs and changing conditions and evolution of technologies, markets, policies, and social context.

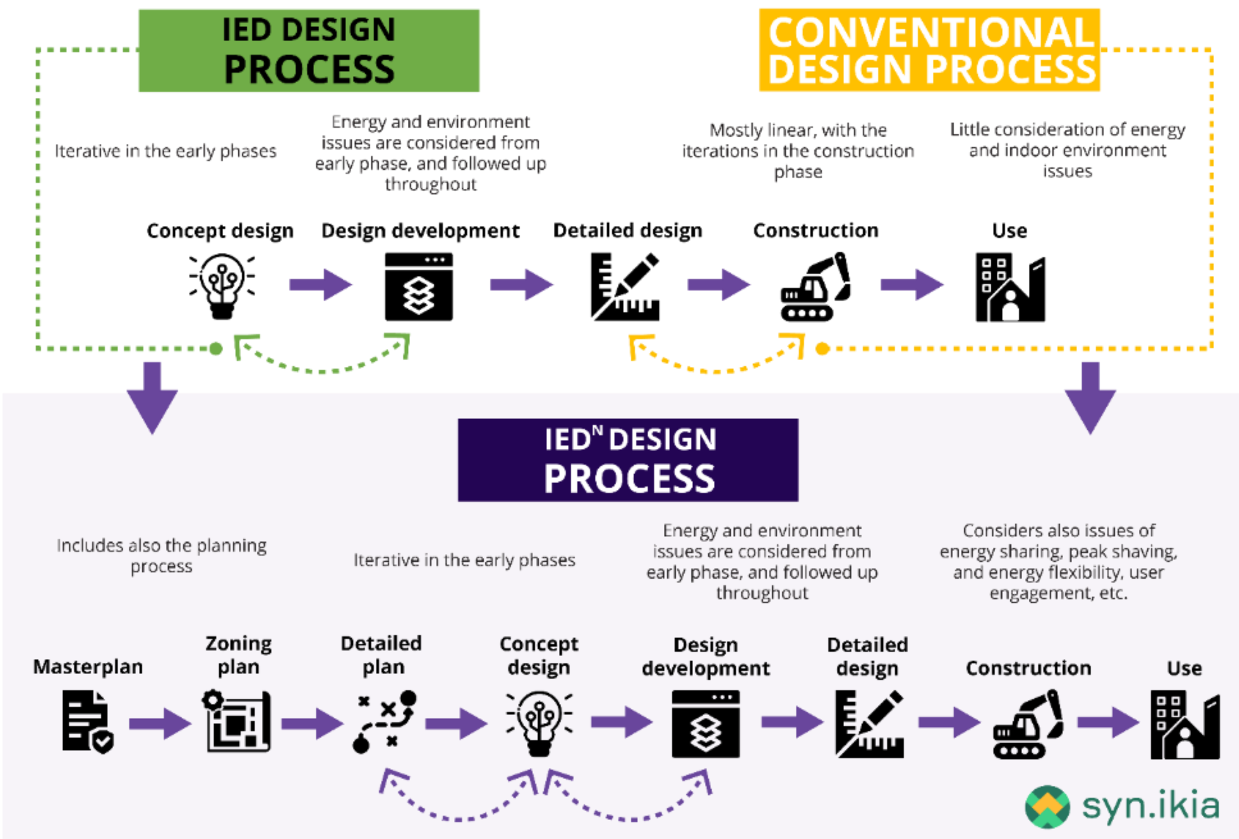

Figure 4: Illustration of the process developed for the Integrated Energy Design Guideline of Sustainable Plus Energy Neighbourhoods (IED^N) in the syn.ikia H2020 project [18].

The decision-support guideline of PEDvolution goes beyond the state-of-the-art by providing a dynamic and interactive platform where PED planners and solution providers can get streamlined and tailored decision support based on their local contexts and needs, and the changing environment. The guideline will provide decision-makers with updated data about the performance of different solutions, their interoperability, and give insight into trade-offs between different goals and needs. As such, the dynamic guide will assist the PED planners by providing them with a set of alternative scenarios on the further development of a PED, considering different investment options and/or modified context (e.g., energy prices).

3.2.6 PED Business Models Innovation Tool (O7)

Leveraging the work of E-LAND's Business Model Innovation tool [19], the PEDvolution project, will adapt and customise it to the PED needs which will provide a set of building blocks, known as 'business model patterns,' that have been proven successful in community-oriented business solutions. The Business Models Innovation (BMI) tool process will enable PEDs to adapt business model patterns to the local context and combine them to create promising business models. In PEDvolution, we will incorporate additional business tools to understand the pains and gains, challenges and opportunities, driving and restraining forces for the individual and the integrations of PEDs (e.g., customised value proposition tool, SWOT analysis, etc.). All business tools will be implemented with active involvement of all PEDs, other solution providers and technology developers. A well-structured process of the business model innovation tool will be introduced and applied.

3.2.7 PED Social Innovation Tool (O7)

PEDs are complex ecosystems with multiple stakeholders involved and in constant evolution of energy efficiency to achieve positive energy balance requires stakeholders to change practices related to energy production and consumption. Local actors will have a stronger role as active participants in the energy domain, yet there might be multiple views, interests and priorities amongst them, and decision-making processes can be complex in local decentralised renewable energy systems. The PED social innovation tool, based on the E-LAND Common Impact Model [20], is a methodology that will help to bring local stakeholder needs, values and priorities at the centre of the planning process. The aim is to help multiple stakeholder alignment, decision-making and stakeholder engagement within PEDs as they evolve.

3.3 Stakeholders

3.3.1 Business Roles

PEDs are complex ecosystems constituted of a multitude of actors either as full members of a PED, actors providing services to it, or actors influencing the context in which the PED operates. A PED is frequently interacting with actors from multiple sectors, such as energy, construction, real estate, and building sector more in general [21], with the involvement of stakeholders such as municipal actors, energy system designers, contractors, building and homeowners, as well as tenants and residents. To address the multiple dimensions of a PED such as the social, technological, market and interoperability aspects forming the “PED genotype” combined with context related actors influencing the PED phenotype, mapping the relevant stakeholders and/ or actors is a key starting point to ensure that the multiple dimensions of a PED will be addressed comprehensively.

In PEDvolution, a first step in the stakeholder identification and mapping accounted generating a collective understanding of typical stakeholders in PEDs, including a list of potential actors with joint definitions. In addition, these actors were classified based on the work of [21], and upgraded to the language and type of actors identified in PEDvolution. From here we end up with a categorisation of “internal stakeholder groups” and “external stakeholder groups”, with examples of typical stakeholder groups and roles within these categories (as depicted in Table 2 below). Internal stakeholder groups include PED members and actors having a commercial relationship with PEDs either as suppliers, service providers or customers to PED. External stakeholder groups include actors that have the capacity to influence the operational environment and conditions under which a PED operates.

In the evolving ecosystems of PEDs, different roles arise to support the business processes that will support their design, implementation, certification and operation, which are identified as PED Members:

- **Certifier**: Certifies the sustainability of apartments, buildings, neighbourhoods, or cities based on an established PED framework. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.
- **Investor**: An entity interested in investing in the development and/or operation of a PED.

- **Manager**: Manages the day-to-day operation of a PED, ensuring the functioning of a PED including infrastructure and interfaces with context, as well as data availability/ accessibility for further research and innovation development.
- **Planner**: Designs the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.
- **Promoter**: Promotes and eases the creation/sustainability of a PED, being a member (or not) or supporter of the PED once it is created. Usually, it is a public institution.
- **Resident**: Person/entity living/working in the geographical boundaries of the PED.
- **Participant**: An entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.
- **Solution Provider**: Supports the design, implementation, certification and operation of the PED by providing services to other PED stakeholders.

In addition to direct business actors, PEDs interact with a range of individuals, actors and organisations that can influence or are influenced by the outcomes of the PED. Hence, using a broader concept of "stakeholders" rather than "business actors" allows for the identification of stakeholders and actors that also have more indirect influence on the business processes of a PED, allowing for the identification of leverage points and potential risks in the business environment, such as changes in the regulatory framework or limited stakeholder acceptance. Since PEDs vary in shape and format, the stakeholders present in each PEDvolution demonstration site will be further mapped and presented in PEDvolution's work, in D1.1 [22].

An initial mapping of stakeholders group and roles in the PED ecosystems is presented in Table 2.

Table 2: Types of stakeholders within PEDs

PED stakeholder group	Example roles
Internal stakeholder groups *Include PED members, actors providing value added services to the PED and direct customers.*	
PED management and operation	PED Manager (aka PED Operator) PED Resident PED Participant PED solution provider
PED planning and development	PED Planner PED Investor PED Promoter PED Certifier
PED suppliers	Energy supplier

	District heating operator Energy retailer Energy community Distribution system operator (DSO) Balance responsible party
PED service providers and other industry actors (=actors conducting value adding activities)	PED solution provider Energy Service Company (ESCO) Real estate agency Certification bodies Aggregator Construction company Building owners, building managers
PED external stakeholders Actors that influence the conditions under which PED operates	
Financial actors	Funding agencies Investors Banks
Technological actors (beyond PED solution providers)	Research institutions Universities Intermediary actors (energy advisory bodies, energy associations etc.) Patent offices Certification bodies
Third sector actors and networks Media	Local networks and associations, such as neighbourhood associations Environmental associations Local media Citizen networks and groups

3.3.2 Solution Providers

The solution providers of PEDvolution project who bring unique and innovative approaches to accomplish the goals of the project are presented in Table 3. By showcasing their solutions, we highlight the collaborative efforts that are driving the realisation of multi-domain proper operation of the Positive Energy Districts, paving the way for a sustainable future. A short description of the different solutions has been presented in Section 3.2.

Table 3: PEDvolution's solution providers.

Provider	Solutions
OFFSET	Energy Manager
VITO	Design and Planning Toolset
SIN	Business Models Innovation Tool Social Innovation Tool
ZHAW	Readiness Assessment Framework
ICOM	Interoperability Platform Energy Manager
TUW	Design and Planning Toolset Energy Manager
NTNU	Dynamic Decision Support Guideline

3.3.3 End Users

The following table presents a mapping of possible end users and corresponding PEDvolution solutions.

Table 4: End user categories of PEDvolution's solutions.

Solution	End User
PED Design and Planning Toolset	PED Planners are the primary end users of the PED Design and Planning Toolset, involving both public (e.g. Municipality) and private developers (e.g. Real-estate agencies, Construction companies). PED managers and other members of the planning team could also be involved, as well as PED residents/owners for awareness and possible contribution.
PED Energy Manager	The end users of the tool concern the PED Managers, as well as PED Residents and PED Participants, who will use it to optimise the energy operations of the PED, considering both residential and commercial end-uses and local production. PED managers will gain a comprehensive overview of energy flows, maximise the utilisation of renewable energy sources (RES), leverage flexibility across various energy vectors, and automate asset operations to achieve the global optimum for the entire PED. On the other hand, the tool can be used by

	PED Residents and PED Participants, providing the ability to view and control their individual energy usage and local production (if any).
PED Readiness Assessment framework	The end users of the PED Readiness Assessment are mainly PED Managers but can also be PED Planners, residential/commercial consumers/prosumers, construction companies, financing bodies, and policy makers. If included in a community certification scheme, the tool can be used to minimize risks and maximize investments into PEDs.
Dynamic Decision Support Guideline for PED Development	The end users of the Dynamic Decision Support Guideline are primarily the PED Planners. It could be a municipality or a private developer with associated planning teams consisting of consultants and solution providers.
Interoperability platform	The Interoperability Platform provides access to the data to be exchanged from PEDvolution solutions, external systems or other third-party solutions, hence the end users are mostly systems and applications requiring data exchanges. End use interfaces for the administration of the data exchanges can also be relevant.
PED Business models	The end-users of the business model innovation tool will be the PEDs, and the BM process can be adapted to any business actors which have business ambitions. If there is a specific request by business actors, the various business tools proposed will be adapted to do a specific business case analysis for the actors in need.
PED Social Innovation Tool	The social innovation tool is directed to PED managers, planners, and promoters to identify and understand the views, values and priorities of relevant stakeholders, to support informed decision making and align multiple stakeholder needs. All PED members are indirect end-users of the tool, as it entails a collaborative process involving stakeholders. The participating stakeholder groups will be defined based on the type of PED, but typically involve residents, energy managers, commercial and/ or industrial actors, municipal actors, and potentially third sector actors.

3.4 PEDvolution Pilots

This section describes the current state of the demonstration sites of PEDvolution projects, which will enable the validation of PEDvolution solutions and promote replication, upscaling and mainstreaming. These three demonstrators are:

1) Wunsiedel-DE (partners SWW Wunsiedel - SWW, ZENOB, Es-Geht - ESG),
2) Kranj-SI (partners Elektro Gorenjska - EG, Gorenjske Elektrarne Proizvodnja Elektrike - GEK) and
3) Hard Community Winterthur-CH (partner Stadt Winterthur - WIN).

Besides being demonstrators, the involved partners have a key role as co-developers of the solutions.

3.4.1 German PED

Figure 5 German demonstration site.

Basic information

The German PED is located in Schönbrunn area. Following a vertically nested system architecture, Schönbrunn site participates in the next-level PED, encompassing the whole network of local utility SWW, whereas it also leverages ZENOB coalition, where a multitude of municipalities participate in the exchange of flexibilities and jointly offer services to the highest-level system operators.

SWW is already leading project WUNergy in Wunsiedel, implementing an Energy Sharing Community to advance the local energy transition. Utilising the existing decentralised and fragmented supply structure of SWW, the ESC will integrate various local renewable energy sources, enabling direct participation of both large and small-scale energy producers and consumers. The ESC is structured within the current legal framework, appealing to energy market regulations. Detailed roles for participants are defined, including prosumers, consumers, and commercial entities. This concept will be implemented with specially designed software for monitoring, controlling, and billing energy flows to enhance transparency and efficiency. In addition, dynamic tariffs for energy will be introduced to reflect the availability of renewable energy and market price fluctuations, incentivising smart energy consumption and trading. The plan is to leverage the local community's flexibility to improve grid stability, avoid energy congestion, and generate additional revenue.

The aim is to ensure that by generating and sharing renewable energy locally, the ESC reduces dependency on external energy sources and enhances energy security. Further key elements include efficient energy management and reduced transmission losses which contribute to overall energy efficiency. Increased use of renewable energy sources will contribute to the reduction of greenhouse gas emissions, promoting sustainable energy practices and supporting climate protection initiatives at the local level. The cooperative structure aims at fostering a sense of community and collective responsibility among participants, giving local residents and businesses greater control over their energy usage and costs, leading to increased energy literacy and empowerment.

Furthermore, the insights and models developed in Wunsiedel can be transferred to other regions, promoting broader adoption of ESCs. The initiative aims to demonstrate the viability and benefits of ESC.

Location

Schönbrunn is a small village, located in the district of the city of Wunsiedel in Franconia, in the northern part of Bavaria. The region has a rural character which includes a high volume and density of RES. The village is driven by locally produced renewable energy in several sectors including heat, electricity and transport, including the utilisation of locally produced pellets as energy source for heating networks. This way local knowledge and competences are used and enhanced.

Building stock

There are 550 electricity customers. Of these, 115 have electronically readable meters and 435 that are read annually. These customers consume around 24 GWh per year. In addition, there is one industrial customer - the "Lang" brewery, which consumes 95 MWh per year. Finally, there are 80 heat customers who consume 1,856 GWh of heat per year. The heating network currently serves around 180 households, with the capacity to cover the entire village.

Basic infrastructure

The cogeneration unit (CHP) combined with the distributed PV production supply renewable electricity and heat. Innovative multi-vector storage facilities and trunks between neighbouring villages enable this PED to grow vertically and horizontally. There are **58 PV systems with a total installed capacity of 716.58 kWp**. The **total nominal output of the inverters is 702.03 kW**. One PV system is equipped with **a battery with a capacity of 3.5 kVA**. The pellet powered **CHP unit has a nominal output totalling 1890 kW,** of which **80 kWp PV** system, which in total gives **1430 kWheat and 380 kWel**. The **CHP also has a heat storage tank** with a volume of with a volume of **80,000 litres** and a **heating rod with the nominal output of 1.1 MW**, the installation of which is planned but not yet available. The heating rod is planned to be in operation half of the time throughout the year, enabling the support of the heating network, when the CHP is not in operation, by leveraging local RES production to heat water in the storage tank (estimated duration of operation is 4380 hours/annum). In this sense, it is possible to utilise either the pellet boiler and the heating rod at the same time or the pellet boiler alone and the heating rod separately.

3.4.2 Slovenian PED

Basic information

Figure 6: Slovenian demonstration site.

Slovenian PED site accommodates approximately 16,000 residents across its expansive 74-hectare landscape. To meet the heating demands of this community, the Planina neighbourhood relies on the Planina communal boiler house, which currently boasts two boilers with a combined capacity of 17 MW, fuelled by natural gas. Additionally, the facility features two CHP aggregats, enabling the simultaneous generation of electricity and heat. In the nearby Labore industrial zone, waste heat is abundantly produced as a by-product of industrial processes, presenting a valuable resource. A fraction of this heat can be directly employed for district heating, while innovative methods, like heat pumps, extracting waste heat from low-temperature dirty condensate, can harness the remainder. This surplus heat is directed towards supplying the adjacent Planina district heating network. Additionally, there are ongoing initiatives to integrate an electric boiler into the Planina boiler house, ensuring the smooth operation of system services, notably negative secondary control.

Location

Situated in Kranj (selected in the list of EU Mission Climate Neutral and Smart Cities), Slovenia's third-largest city, the Planina residential neighbourhood stands as the largest residential area not only in Kranj, but also in the broader Gorenjska region.

Building stock

- Size covered: 740,000 m^2
- No. Of residents: 16,000
- No. Of households/apartments: 4,300 apartments
- No. Of businesses: 40 businesses

Basic infrastructure

The Planina Energy District (PED) comprises two hydropower plants, the use of waste heat from the Labore industrial zone, numerous rooftop photovoltaic installations, a Combined Heat and Power (CHP) system with a surplus heat capacity of 5 MW, system services facilitated by an electric boiler, and strategically located electric vehicle charging stations.

Table 5: Basic characteristics of Slovenian PED sources.

FACILITY	Current		Planned	
	POWER	ENERGY	POWER	ENERGY
Central boiler house	17 MW	30,000 MWh/y	17 MW	-
Electric boilers	-	-	1 MW	4,000 MWh/y
PV	-	-	793 kW	790 MWh/y
HPP	345 kW	2,000 MWh/y	2 MW	12,000 MWh/y
CHP	4,300 KW	10,000 MWh/y	4.300 kW	-
Waste heat potential	-	-	-	30,000 MWh/y
EV-Charging systems	300 kW	-	1000 kW	-

3.4.3 Swiss PED

Figure 7 Swiss demonstration site.

Basic information

The Hard community in Winterthur consists of the residents and employees of 45 apartments and around 40 businesses whose common goals focus around preserving ecological, cultural and historical values of the community and its surroundings. The Hard hydroelectric power station supplies electricity for around 725 households. A solar plant and gas boiler generate heat while, since the end of 2021, the site has been producing its own electrical energy with an attached photovoltaic plant. In addition, charging stations for several electric vehicles are available on the nearby parking field. All households and businesses are coupled to smart meters for metering energy use through the regional DSO.

Location

The city of Winterthur is a residential and commercial community on the edge of the 6th largest city in Switzerland,

Building stock

- Status: in operation
- Size covered: 80’000 m^2
- No. Of residents: 250
- No. Of households/apartments: 45 apartments
- No. Of businesses: 40 businesses

Basic infrastructure

Table 6: Basic characteristics of Swiss PED sources.

FACILITY	Current		Planned	
	POWER	ENERGY	POWER	ENERGY
Central gas heating	150 kW	820 MWh/y	-	-
Central heat pump	-	-	To be defined	900 MWh/y
Hydropower	575kW	2550 MWh/y	-	-
PV-System	48kWp	60000 kWh/y	To be defined	To be defined
EV-Charging systems	-	10000 kWh/y	To be defined	-

4 BUSINESS REQUIREMENTS

This chapter focuses on documenting the Business Use Cases (BUCs) of the PEDvolution project. These BUCs provide a structured approach to capturing and articulating the functional and operational needs essential for the successful implementation of PEDs sustainable functionality. Each use case (UC), developed by the corresponding project partners, outlines specific scenarios, actors, interactions, and outcomes aligning with PEDvolution strategic objectives and High-level use cases (HLUCs) scenarios (see Chapter 5). This chapter serves as a foundational reference, guiding the development and deployment of interoperable, sustainable, and community-driven energy systems across Europe.

4.1 Role model

An analysis of the main business roles involved in the Business Use Cases of PEDvolution is presented in this section. The description of the stakeholders and the interactions between them is based on the Harmonised Electricity Market Role Model (HEMRM) [23], whereas the extensions introduced by BRIDGE [24] were also considered, especially flexibility related roles which are not part or the HEMRM. Considering the PED ecosystem's roles, assumed by various business stakeholders, corresponding actors were mapped to the relevant roles of the HEMRM creating a consistent view of PED relevant stakeholders, including other aspects apart from electricity which are relevant to PEDs scope, such as district heating, building renovation, etc.

Figure 8 in the next page, presents the role model of the PEDvolution project.

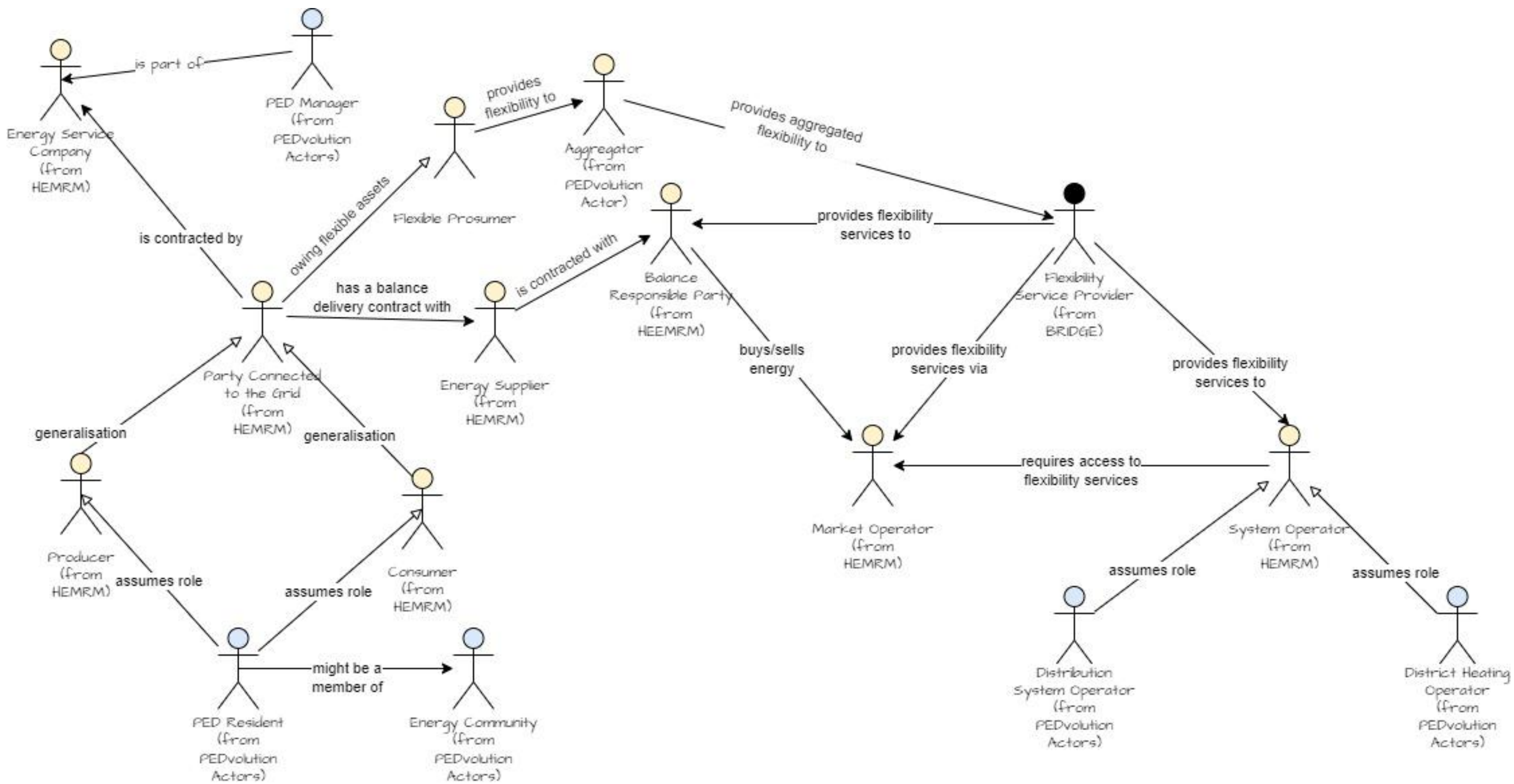

Figure 8: PEDvolution role model.

4.2 Business Actors

Table 7 depicts the business actors which will play a pivotal role in the Business Use Case analysis.

Table 7: Business actors.

Actor Name	Acronym	Description
(Flexibility) Aggregator	-	A party that aggregates flexibility for providing flexibility as a resource to a Flexibility Service Provider.
Balance Responsible Party	BRP	A Balance Responsible Party is responsible for its imbalances, meaning the difference between the energy volume physically injected to or withdrawn from the system and the final nominated energy volume, including any imbalance adjustment within a given imbalance settlement period.
Certification Body	-	An entity that certifies, based on a framework, the sustainability of apartments, buildings, neighbourhoods, or cities. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.
Construction Company	-	An entity that constructs various buildings, properties, facilities, housing, roads, and other construction projects relevant to the PED.
Consumer	-	A party that consumes electricity. This is a Type of Party Connected to the Grid.
Distribution System Operator	DSO	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.
District Heating Operator	DHO	A party responsible for the distribution of district heating to the PED.
Energy Community	EC	A legal entity that empowers citizens, small businesses and local authorities to produce, manage and consume their own energy. It covers various parts of the energy value chain, including production, distribution, supply, consumption, and aggregation. Energy communities may vary depending on their location, involved actors and provided energy services.
Energy Service Company	ESCO	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may provide insight services as well as energy management services.

Energy Supplier	-	An Energy Supplier supplies electricity to or takes electricity from a Party Connected to the Grid at an Accounting Point.
Flexibility Service Provider	FSP	A party that offers flexibility services based on acquired (aggregated) Resources. Additional information: Flexibility is used to meet the needs of System Operators or other energy market participants on different energy-, power- or capacity marketplaces. Flexibility Services may be balancing services, non-frequency ancillary services, congestion management services etc.
Flexible Prosumer	-	A prosumer that owns and manages dispatchable DER generation/ consumption/ storage asset(s).
Market Operator	-	A party that provides a service whereby the offers to sell energy are matched with bids to buy energy. Based on: Consolidated text: Regulation (EU) 2019/943 [10]. Additional information: This activity can be conducted in the forward, days-ahead and/or intraday timeframes, and can be combined with transmission capacity allocation in the context of market coupling. This is usually an energy/power exchange or platform. Market Operator can also be specialised in the sub-distribution domain (i.e. microgrid, Energy Community) as a Local Market Operator.
Municipality	-	The local government of a city or town. May assume an active (e.g. design, implementation) or passive (e.g. data provision) in the planning and operation of a PED
Party Connected to the Grid	-	A party that contracts for the right to consume or produce electricity at an Accounting Point.
PED Certifier	-	An entity that certifies, based on a framework, the sustainability of apartments, buildings, neighbourhoods, or cities. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.
PED Investor	-	An entity interested in investing in the development and/or operation of a PED.
PED Manager	-	A party that assumes this role, manages the functioning of a PED and/or ensures data availability and/or accessibility for further research and innovation development.

PED Participant	-	An entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.
PED Planner	-	A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.
PED Promoter	-	A party that assumes this role, promotes and eases the creation/sustainability of a PED, being a member (or not) or supporter of the PED once it is created. Usually, a public institution.
PED Resident	-	Person/entity living/working in the PED (geographically located in the PED).
PED solution provider	-	An entity providing services to PED residents, PED Participants and PED Managers.
PED members	-	The superset of PED stakeholders, consisting of: PED Promoter, PED Manager, PED Planner, PED Resident, PED Participant.
Producer	-	A party that generates electricity. This is a Type of Party Connected to the Grid.
Prosumer	-	A party that both consumes and generates electricity.
Real estate agency	-	An entity that arranges the selling, renting, or management of homes, land, and buildings for their owners. Can assume a role in the planning and operation of a PED
System Operator	SO	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of energy. Based on: Consolidated text: Directive (EU) 2019/944 [11]

4.3 Business Use Cases

Based on the project methodology (presented in Chapter 2), the main stakeholders were identified, as well as their goals and concerns and a set of Business Use Cases (BUCs) were defined. The following figure presents a summary of the project's BUCs and their main actor, whereas a brief analysis of their scope, objectives and pre-conditions are analysed in the next subsections. A more in-depth analysis, following the IEC UC template is presented in Annex II.

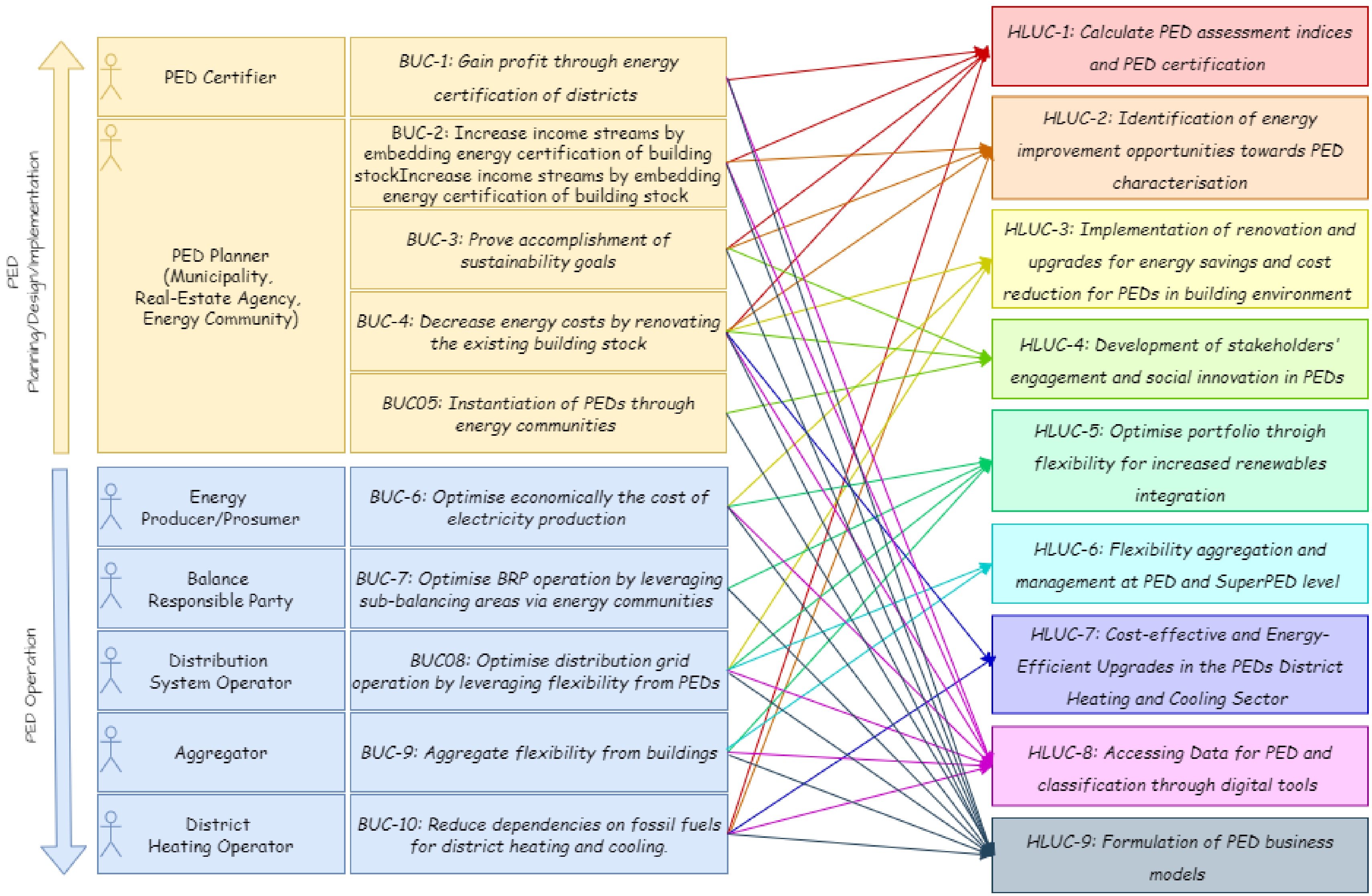

Figure 9: PEDvolution business use cases.

4.3.1 BUC-1: Gain profit through energy certification of districts

Scope:

The main objective of BUC-1 is to rate and classify the energy topology and potential of a PED by a certification body. Hence, the PED Certifier aims to deliver a report to the PED Planner or Manager, providing a holistic overview of the PED, detailing the local energy consumption, generation and storage assets across different energy vectors, as well as smart readiness and energy efficiency indicator of buildings, allowing a final classification of the district in terms of energy balance.

The first step in identifying a PED is to take stock of the local energy topology. This should include all producers, consumers, and prosumers to draw up a production and consumption balance. The result can be a negative, neutral, or positive energy district and can be divided into further categories based on the size and period of the deficit or surplus. In addition, all producers, consumers, and prosumers must be checked for their theoretical and, in the best case, practical flexibility potential with the help of the DSO and DHO. This allows a rough flexibility potential of the entire district to be determined. Furthermore, the average energy efficiency of buildings could be determined. Finally, the district should be evaluated in a standardised way in combination with the amount of energy deficit/surplus and the flexibility potential, so that it can be compared with other PEDs, and its "value" is immediately apparent.

Assumptions:

- A certification scheme for PEDs can be standardised and is of added value for PED Managers/Planners.
- The PED Certifier has access to the needed data.
- In PEDvolution the role of the Certifier will be assumed by project's solution providers.

Preconditions:

The municipality/DSO/DHO grant full access to the required data.

4.3.2 BUC-2: Increase income streams by embedding energy certification of building stock

Scope:

In BUC-2, a real estate agency shall aim at introducing the certification of assets for sale or rent within districts towards boosting their value and increasing profitability. This strategy will focus on defining certification standards, involving relevant stakeholders, and managing certification processes to monitor and report enhanced financial outcomes. By setting clear certification standards and working closely with stakeholders like property owners and local communities, the agency aims to increase income, cut operational costs, enhance the attractiveness of properties on the market, and improve their environmental footprint. This will be achieved by data-driven decision-making.

These efforts also pursue and promote positive changes in PEDs, benefiting both the local community and the municipality. While the Real Estate Agency leads these initiatives, the active involvement of the community and local government is crucial, ensuring that the benefits extend widely.

Regarding the accomplishment of BUC-2's main goal that concerns the increasing income streams by embedding energy certification of building, the following are involved:

Identifying Suitable Districts and Buildings, where implementing energy certifications would have the most significant impact. Factors such as energy consumption, building design, and potential for improvements will be evaluated to determine suitability.

Follow Certification Standards. The involvement of a PED Certifier is needed to follow standards that will provide clarity to stakeholders and ensure consistency in evaluating buildings' energy efficiency and sustainability and the energy balance of the PED.

Plan and implement targeted actions. With the support of PED Solution providers, the PED Manager/Planner can utilise data-driven decision making. Data analytics will be utilised to promote decision-making processes, allowing for more informed and strategic choices to reach a positive energy balance. Towards this, solutions enabling increased energy efficiency through renovation of buildings, as well as improved energy management and exploitation of the flexibility potential of buildings can be deployed, subsequently leading to improving the whole district.

Engaging stakeholders such as:

PED Residents: By achieving energy certifications, they can benefit from reduced operational costs through improved energy efficiency. Additionally, certified buildings may command higher rental or sales prices, leading to revenue generation opportunities.

Municipality and Local System (i.e., Distribution System, District Heating) Operators: Supporting data collection for achieving certification and for implementation of renovation and sustainability actions.

The PEDvolution ecosystem will enable the realisation of this business case by offering solutions towards achieving a positive energy balance within a district and embedding certification of building stock scenarios.

Assumptions:

A standard scheme exists for the certification of the PED and the buildings within it.

4.3.3 BUC-3: Prove accomplishment of sustainability goals

Scope:

This BUC focuses on demonstrating the successful achievement of sustainability objectives within PEDs, thereby contributing to overall urban sustainability. More specifically, it focuses on the comprehensive benefits that arise from achieving sustainability goals in a district, viewed from the municipality's perspective. The Municipality - acting as a PED Planner and Manager - in collaboration with PED solution providers, will analyze the current energy consumption patterns and inefficiencies within the existing building stock and develop sustainable transition pathways that suit the local conditions and local community (e.g., utilising social innovation tools). Targeted renovations and upgrades will be implemented in collaboration with relevant stakeholders (PED members) to optimize energy usage and significantly reduce environmental emissions and operational costs at the individual level. Simultaneously, these efforts contribute to broader collective goals such as the decarbonisation of the built environment towards achieving sustainability goals (e.g., netzerocities).

Buildings are a crucial component of energy transition, as they account for a significant proportion of worldwide energy use and greenhouse gas emissions. For the municipality, demonstrating the achievement of sustainability goals can attract investment and foster a sustainable and resilient/future proof community and energy system—key responsibilities of municipal governance. For PED planners and managers, proving the accomplishment of sustainability goals can enhance project viability, attract investment, and differentiate their developments in the market. It establishes a compelling value proposition by showcasing the economic, environmental, and social benefits of PEDs, thereby increasing investor confidence and fostering long-term sustainability. Similarly, for building owners and municipalities, achieving sustainability standards or goals in PEDs can lead to various benefits, including reduced energy costs, enhanced resilience to climate change, improved air quality, and increased community satisfaction. By embracing sustainable practices within PEDs, building owners/residents and municipalities can demonstrate leadership in environmental stewardship, attract residents and businesses, and create vibrant, liveable communities for future generations.

Assumptions:

- Availability of data to assess the current state of a PED and subsequently the potential for improvements.
- Willingness of involved stakeholders (e.g., municipality, PED Residents) to support the required actions for achieving sustainability goals.

The actions on sustainability goals have a positive ROI at least in the long-term.

Preconditions:

- Favourable legal framework for implementing sustainability-related actions.
- Willingness of municipality to invest in sustainability-related actions.

4.3.4 BUC-4: Decrease energy costs by renovating the existing building stock

Scope:

This BUC focuses on the economic benefits of decreasing energy costs through the renovation of existing building stock. From the perspective of PED Residents, the renovation actions lead to decreased energy costs, reduce carbon emissions, enhance comfort and smartness, enable interoperability, and achieve a positive return on investment (ROI) and improved daily life through more advanced systems (e.g., automation of processes). Energy Service Companies are also important for this BUC, as they benefit economically from providing the required renovation services.

The municipality, in collaboration with PED solution providers and other stakeholders (building owners/users, ESCOs), will analyse current energy systems, energy consumption patterns within the building stock and develop renovation strategies that suit local conditions in a cost-optimised way. Led by the PED planner, targeted renovations and upgrades will be implemented in collaboration with relevant stakeholders (PED members) to optimise energy usage, increase energy production, reduce operational costs, and improve occupant well-being and comfort, while addressing energy poverty. The PED planner can serve as intermediary between ESCOs, who provide renovation services, and PED Residents, who are interested in decreasing their energy costs through renovations. Within this context, the PED planner can facilitate the orchestration of renovation of the building stock at the PED level.

Renovation of existing building stock comes with main benefits from the municipality's perspective of PED Residents such as reduced energy costs and emissions and side benefits such as enabling flexibility in buildings (for ESCOs) and enhanced occupant wellbeing and comfort (through advanced/smart renovations for building users). The municipality, in collaboration with PED solution providers and other stakeholders (building owners/users, ESCOs), will analyse current energy systems, energy consumption patterns, and inefficiencies within the building stock and develop renovation strategies that suit local conditions in a cost-optimised way.

The above efforts contribute collectively to broader collective goals for the municipality and local community, such as the decarbonisation and energy efficiency improvement of the built environment.

Assumptions:

- Availability of data to assess the current state of PED buildings and subsequently the potential for improvements.
- Willingness of building owners to invest in renovations.

Preconditions:

Availability of effective renovation measures

4.3.5 BUC-5: Implementation of PEDs through energy communities

Scope:

Energy communities (EC) have been evolving as one of the cornerstones of the energy transition, enabling a bottom-up approach of the operation of the energy system. Towards this, the PED concept can complement the existing business models of ECs, enabling a more holistic approach on the operation of urban environment. By adopting the PED concept, ECs can explore new strategies to enhance quality of life, focusing especially on the synergistic benefits of shared energy resources and sustainability practices by enabling collective and citizen-driven energy actions in open and voluntary approach to support the clean energy transition, with participatory and democratic processes. More specifically, ECs' purpose is to provide social, economic and environmental benefits to the community members or shareholders rather than profits. ECs are increasing public acceptance of renewable energy projects and attracting more private investments in the clean energy transition.

In the context of EU legislation, ECs are classified as Renewable Energy Communities (REC) and Citizen Energy Communities (CEC). RECs are geographically limited and organised in the proximity of renewable energy projects owned and developed by that community and present a unique opportunity to achieve the concept of PEDs fostering locally produced energy (and flexibility) or to support the efficient operation of the urban grid, towards enabling carbon-neutral urban districts and promoting sustainability.

The EC Operator leads efforts to adopt – through implementation of a PED – novel concepts of sustainable energy actions and energy-related services through strategic integration in the scope of the Energy Community. The integration process includes:

- Understanding EC Needs through analysis will help identify and understand the specific requirements of each EC, laying the foundation for strategic integration.

- Developing a strategy allowing the Operator to create a tailored action plan to integrate locally produced energy and products into ECs, making them more relevant and valuable, whilst considering novel market concepts, such as flexibility services.
- Technological Compatibility assessment will ensure that integrated products align with existing infrastructure and community needs, allowing their integration and future adaptability.
- Ensuring Regulatory Compliance within ECs to reduce regulatory risks, thus increasing the perceived value of integrated products.
- Actively Engaging the Community and involve stakeholders: Local Businesses, Municipality, Aggregators, and the DSO, enabling the realisation of the action plan.
- Implementing Continuous Monitoring and Optimisation for improvement of efforts ensuring integrated products evolve alongside changing community needs and technological advancements, driving ongoing enhancements and maximising value.

The overall goal of the EC within the PEDvolution ecosystem is to increase positive impact to the society and the environment through new EC scenarios, enabled by PED solution providers and involving local stakeholders (e.g., the PED Manager/EC Operator, and the PED Residents and PED Participants/EC members), providing solutions and customised strategies to fit the local needs.

Assumptions:

- There are technological providers that can support the actions of the strategic action plan.
- Energy communities (cooperative, sharing, etc.) are allowed in the local country regulation.

Preconditions:

- Existence of EC/Motivation of the EC members to participate in the PED.
- Energy Community members equipped with digitally enabled infrastructure (EMS, SM, etc.).
- Availability of energy meter data for energy balancing calculations.

4.3.6 BUC-6: Optimise economically the cost of electricity production

Scope:

The ever-increasing installed capacity of RESes holds opportunities to optimise the costs of production for Producers. This business use case will thrive to achieve that. To this aim, the Producer will conduct an analysis of the current state of the grid occurrences, thereunder production, consumption and assets available within the grid, to draw conclusions on optimisation methods for the costs of production. It involves analysing existing generation and storage infrastructure, energy consumption patterns, and renewable potential within PEDs. Strategies will be developed to integrate renewable sources efficiently, utilise smart grid technologies, and implement demand-side management to minimise generation costs. Regulatory frameworks will be considered to ensure alignment with policy objectives and incentives for sustainable energy adoption. Continuous monitoring and evaluation will be conducted to assess cost-effectiveness and identify areas for improvement. Optimisation of co-generation of heat and electricity production, considering cost of production in both energy vectors, should be conducted when possible based on the existing generation infrastructure (e.g., CHP plants).
New business models for a Producer that lead to selling energy to a PED should be examined.

The following measures will be taken as part of this BUC:

- Gathering data on grid aspects like production, consumption, and available assets, including information on infrastructure, energy consumption patterns, and renewable potential.
- Energy generation forecasting for the different technologies included in the portfolio.
- Examining limitations of grid infrastructure causing curtailment of local RES production.
- Analysing energy consumption patterns to identify ability for improved RES absorption through demand-side management strategies.
- Developing strategies to efficiently integrate renewable energy sources into the grid, identifying suitable locations for installations of RES and storage assets.
- Conducting ongoing monitoring and evaluation to assess the cost-effectiveness of strategies, tracking key performance indicators like production costs, energy efficiency, and renewable energy penetration rates to identify areas for improvement over time.

The goal of the PEDvolution ecosystem, is to optimise local electricity production in economic and sustainability aspects. Examination of local assets, consumption patterns, grid constraints and regulatory limitations can contribute to more sustainable local production. Improvements will be achieved through customised strategies for PED investments in renewable production and/or storage assets, updated production schedules, and utilisation of local flexibility in collaboration with the PED Manager and the DSO.

Assumptions:

- The focus of the analysis is on large-scale Producers, with controllable generation.
- Data is available in order to assess the current state of electricity production in the PED.
- Control infrastructure regarding generation is available.
- Business models support different control scenarios on electricity generation.

4.3.7 BUC-7: Optimise BRP operation by leveraging sub-balancing areas via energy communities

Scope:

A Balance Responsible Party (BRP) can be in charge of managing electricity flows within a sub-balancing area defined through an Energy Community (EC) who has formulated a PED to optimize grid operations. Leveraging the energy contributions of the PEDs, the BRP can increase its ability to balance more efficiently, while maintaining a safe, secure and available energy to the end users. In addition, the BRP aims to optimize its position in the energy market by leveraging the positive balance of a PED, enabled by an EC, market as a sub-balancing area. The profile of the PED enables the BRP to achieve improved performance of portfolio forecasting, better mitigation of balancing risks, and reduced need of balancing energy transport.

The BRP focuses on the effective management and optimisation of its position in the energy market by effectively incorporating demand and consumption balancing within its portfolio. By integrating an increased proportion of renewable energy sources and implementing real-time energy management, the BRP aims to improve operational efficiency, and foster sustainable investments within its responsibility area.

The BRP employs several key strategies:

- Forecasting to enable the BRP to anticipate demand and generation changes.

- Real-time energy monitoring of energy flows to allow the BRP to address fluctuations in demand and supply, maintaining grid balance.
- Flexibility schemes to adjust the energy profile of the EC to the needs of portfolio balancing. This also involves optimisation of integration of renewable energy with storage.

The PEDvolution ecosystem will enable the realisation of this BUC by offering solutions to the BRP to leverage flexibility within the Energy Community, exploited to balance its portfolio whereas it can also support the SuperPED concept, allowing cross-sectorial balancing. The PED Manager in this case, will represent the EC community, optimally aggregating flexibility from the EC Members/PED Residents and PED Participants to meet the flexibility needs of the BRP. PED solution providers will examine how energy is currently used in the BG areas and analyse the profiles of the electricity flow. New strategies will be sought after to help improve grid control talking into account the specific needs of the local area.

Assumptions:

- BRP is allowed to offer flexibility Demand Response (DR) schemes for load, generation or storage assets.
- Energy community is allowed by regulation.
- Energy Community can have its own sub-balancing area.
- Energy Community is constrained to one BRP.
- In case of a SuperPED formulation, both PEDs interact with the same BRP.

Preconditions:

- Energy Community has formulated a PED.

4.3.8 BUC-8: Optimise distribution grid operation by leveraging flexibility from PEDs

Scope:

The rise of renewables shifts towards electrification of energy consumption (e.g., mobility and heating/cooling) and gradual phase-out of centralised generation units within the context of decarbonisation, actions which are increasing the needs of system operators for flexibility at the level of the distribution system. On the other side, the Distribution System Operator (DSO) is responsible for maintaining the Low/Medium Voltage distribution grid in a cost-effective way and for providing secure and high-quality power to end users. Leveraging flexibility from Positive Energy Districts (PEDs) can facilitate the DSO in the aforementioned tasks, being the main objective of BUC-8. More specifically, in order to manage the grid problems such as voltage issues and congestions, the DSO requests flexibility from a PED(s). The flexibility can be activated implicitly (i.e. through price signals) or explicitly through a PED Manager, who offers the aggregated flexibility to the DSO via bilateral contracts or through an open market.

The PEDvolution ecosystem will enable the realisation of this BUC by offering solutions for flexibility management at PED level, exploiting sector coupling such as EV charging and Power2Heat assets, as well as the concept of a super PED. The set of solutions that PEDvolution considers the preferences of the PED Residents and PED Participants for exposing the aggregated flexibility (see BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.)), such as individual residential and/or commercial Consumers and/or Prosumers, as well as at aggregated level (e.g., facility/building).

Assumptions:

- The DSO can offer implicit DR schemes for network tariffs or explicit DR incentives.
- The PED Manager acts as an Aggregator in the electricity market and sells available flexibility directly or through intermediaries (i.e. Flexibility Service Providers) to the market.

4.3.9 BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.)

Scope:

BUC-9 is centred on the successful aggregation of flexibility from all types of buildings (like residential, commercial and others), enabling a PED manager to fully exploit their potential, generating value from this flexibility without a negative impact to local business operations and prosumer comfort and quality of life. The flexibility of buildings varies greatly depending on their use type and occupancy patterns. Hence, there is a need to effectively combine them and increase their impact towards optimal management of a PED. The main objectives include analysing the existing building types within the PED and examining the current tools available for flexibility aggregation in the building sector.

PED solution providers will analyse the current amount and type of buildings in their PED. Their responsibility is to look up existing ways to aggregate and identify flexibility from these households and choose which tool they can use in the most sufficient way for this purpose. An aggregator is responsible for managing these flexibilities from energy assets and energy communities within the PED. In the best case, standard software is used to enable transferability for other PEDs. The aim of the aggregation is to combine all buildings so that even small flexibilities can be used in total.

PED Managers, who also function as aggregators, must always be aware of the flexibility potential of their PED(s). To achieve this, it is not only important to include large consumers and producers, but also smaller prosumers or even consumers. Private households or small businesses usually have fluctuating or small flexibility potential, particularly due to the higher possibility of impacting the quality of life of residents who live and interact within the PED. However, as these participants in a PED usually occur in large numbers, it is important for an aggregator to consider them and bundle their potential to make them valuable for the local Positive Energy District. Hence, tools that enable the analysis of a big portfolio of the building and analyse their flexibility potential under different methodologies/schemes (enabling tailored solutions), are crucial for the aggregation of PED's flexibility. Furthermore, the PED manager is in need of solutions offering the optimal operation of the aggregated portfolio enabling self-balancing or selling aggregated flexibility to the market.

Assumptions:

- The PED Manager acts as an Aggregator in the electricity market and sells available flexibility directly or through intermediaries (i.e., Flexibility Service Providers).
- PED Manager has recruited PED Residents and PED Participants to participate in DR programs.
- Smart infrastructure is present in the buildings to enable data acquisition and control strategies.

4.3.10 BUC-10: Reduce dependencies on fossil fuels for district heating and cooling.

Scope:

The European Union's Climate Law and the Green Deal target to reach carbon neutrality by 2050. Heating and cooling transition are crucial in this target as they constitute nearly half of the EU's final energy consumption and have traditionally been dominated by fossil fuels such as natural gas, oil, and coal. The primary focus of BUC-10 is on analysing current heating demand, local renewable resources, and inefficiency in heating systems within the district. Based on this assessment, solution providers will design efficient heating supply scenarios and investment strategies tailored to the local conditions. Led by the PED manager and the District Heating Operator (DHO), targeted measures and upgrades will be implemented in collaboration with relevant stakeholders to optimize district heating operation and significantly reduce fossil fuel dependencies at the district level.

PED solution providers will analyse the existing heating infrastructure, along with the current and future heating demand within the district. Based on this assessment, they will design efficient heating supply scenarios and investment strategies tailored to the local conditions, which will also include renovation pathways to consider the future heat demand. Led by the PED manager and the DHO, targeted measures and upgrades will be implemented. The overarching goal is to develop optimal implementation and investment pathways for district heating infrastructure. This includes creating supply portfolios based on locally available Renewable Energy Sources (RES) and excess heat potentials, which will substantially decrease the reliance on fossil fuels for DHS at the district level.

5 SYSTEM REQUIREMENTS

The System Requirements of PEDvolution were documented in the form of HLUCs, based on the project UC template (see Annex I). Each HLUC primarily concerns a specific PEDvolution solution, either system or methodology, detailing further its functionalities. In this Chapter, a summary of the technical actors involved in the set of PEDvolution's HLUCs is first provided to the reader. Then, the scope, assumptions, preconditions and the UC diagram for each HLUC are presented, while the complete documentation of all HLUCs can be found in Annex III. In this chapter, a summary of the individual requirements' categories is also provided. Finally, a preliminary mapping of UCs to the three co-developer pilot sites is presented, based on the most recent information.

5.1 Technical Actors

A summary of the technical actors, which are considered in the HLUCs, is presented in Table 8, below.

Table 8: PEDvolution technical actors.

Actor Name	Acronym	Actor Type	Description	Notes
Advanced Metering Infrastructure	AMI	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect, and manage data from smart meters.	Commercial product
ANODE	-	System	A system that will optimise energy management in a PED. Part of the Energy Manager.	To be developed in PEDvolution by OFFSET.
AURORA	-	System	A system that will handle sector-coupling in a PED, as well as energy transactions between PEDs, according to the concept of a SuperPED. Part of the Energy Manager.	To be developed in PEDvolution by OFFSET.
Data Spaces	-	System of Systems	Interlink with EU Energy Data Spaces will enable the offering of data and services of PEDvolution in the EU Data Space Ecosystem.	To be interlinked with PEDvolution ecosystem.
Demand Response Management Optimisation Tool	-	System	A system that will harness flexibility in a PED by generating optimal schedules for flexible assets.	To be developed in PEDvolution by TUW.
Distribution Management System	DMS	System	A system utilised by the DSO, which provides the functionalities for advanced monitoring and control of the distribution grid from a centralised location, typically the control centre.	Commercial product

District Heating Management System	-	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	Commercial product
District Heating & Cooling Planning Tool	-	System	A system that will provide optimal implementation and investment strategies for the District Heating and Cooling Infrastructure of a PED.	To be developed in PEDvolution by TUW.
Dynamic Decision Support Guideline for PED Development	DDSG	System	A system that will specify how different technologies, strategies, goals and KPIs should be interconnected for the optimal development of a PED.	To be developed in PEDvolution by NTNU.
Energy Management System	EMS	System	The system responsible for monitoring and controlling DER assets. EMS extracts the potential flexibility from DER assets with regards to their operational status and constraints. Diverse types of EMS may be considered in the project: Home Energy Management System (HEMS), which controls residential locations; Building Energy Management System (BEMS), which controls apartment or commercial buildings; Charging Energy Management System (CEMS), which controls electric vehicle charging stations, etc.	Commercial product
ENTSO-E Transparency Platform	-	Application	Application of the European Transmission System Operators, which provides data on electricity generation, transportation, and consumption data, as well as market data. In PEDvolution, it can be utilised to get data on the energy mix of the country, as a base to calculate CO_2 emissions.	Commercial Product
External Platform	-	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider	Commercial Products

			context of PEDvolution and will not be developed in the project.	
Interoperability Platform	-	System	A system that will provide mechanisms for secure data exchanges with the under-development PEDvolution solutions, as well as with external systems and applications.	To be developed in PEDvolution by ICOM.
PED Asset	-	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Commercial Product
PED Business Models Innovation Tool	PED BMI Tool	Methodology	A tool that will co-develop the business models of each PED.	To be developed in PEDvolution by SIN.
PED Design and Planning Toolset	-	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	To be developed in PEDvolution.
PED Energy Manager	-	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	To be developed in PEDvolution.
PED Readiness Assessment Framework	-	Methodology	A methodology that will assess PEDs in terms of energy balance, as well as individual buildings considering their energy performance and smart readiness.	To be developed in PEDvolution by ZHAW.
PED Readiness Assessment & Dynamic Decision Support Guideline for PED Development	-	Set of systems	A set of systems that consists of the under-development solution in WP4 (PED Readiness Assessment, Dynamic Decision Support Guideline for PED Development).	To be developed in PEDvolution.
PED Renovation Planning Tool	-	System	A system that will generate renovation pathways.	To be developed in PEDvolution by VITO.
PED Social Innovation Tool	-	Methodology	A tool that will implement roadmaps for stakeholder engagement, including the involvement in energy communities.	To be developed in PEDvolution by SIN.
Sensor	-	Device	Device that measures certain variables within the end-user's premises, e.g. room temperature. Information to be provided to the	Commercial product

			Interoperability Platform probably via an EMS.	
Smart Meter	-	Device	Device that provides real-time metering data (e.g. energy consumption, energy generation). Data to be provided to the Interoperability Platform through AMI.	Commercial product
Sub-meter	-	Device	Device that provides real-time metering data (e.g. energy consumption, energy generation) of a specific Distributed Energy Resource (DER). Data to be provided to the Interoperability Platform via an EMS or AMI.	Commercial product
Supervisory Control and Data Acquisition	SCADA	System	A system in charge of overall monitoring and control of the distribution and transmission grid. It integrates communication, remote monitoring and control, signal processing and logic, and data storage functionalities. It includes a user interface called control centre room.	Commercial product
Weather Service	-	Application	Application that provides access to weather data (historical, forecast).	Commercial Product

5.2 High-Level Use Cases

This section presents a summary of a mature version of the HLUCs of PEDvolution, exposing the scope, relevant assumptions and preconditions, and the UC diagram for each of them. The detailed analysis of all the HLUCs, based on the UC template, is documented in Annex III. Table 9 lists the HLUCs, maps them to specific PEDvolution solutions, and indicates the relevant PED genes, according to their definition in Section 3.1.

Table 9 Mapping of HLUCs to PEDvolution solutions and PED genes.

HLUC	Related PEDvolution Solution	Relevant PED genes
1 – Calculation of PED assessment indices and PED certification	PED Readiness Assessment Framework	Social, Market, Technology, Interoperability
2 – Identification of energy improvement opportunities towards PED characterisation	Dynamic Decision Support Guideline	Social, Market, Technology, Interoperability

3 – Planning of renovation and upgrades for energy savings and cost reduction for PEDs in building environment	PED Design and Planning Toolset	Market, Technology, Interoperability
4 – Development of stakeholders' engagement and social innovation in PEDs	Social Innovation Tool	Social, Interoperability
5 – Portfolio optimisation through flexibility for increased renewables integration	PED Energy Manager	Market, Technology, Interoperability
6 – Flexibility aggregation and management at PED and SuperPED level	PED Energy Manager	Market, Technology, Interoperability
7 – Planning of Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector	PED Design and Planning Toolset	Market, Technology, Interoperability
8 – Accessing Data for PED operation and classification through digital tools	Interoperability Platform	Market, Technology, Interoperability
9 – Formulation of PED business models	Business Models Innovation Tool	Social, Market, Technology, Interoperability

5.2.1 HLUC-1: Calculation of PED assessment indices and PED certification

Scope:

The PED Readiness Assessment (RA) framework of PEDvolution goes beyond the state-of-the-art by providing a framework for the dynamic and interactive platform where PED planners and solution providers can get streamlined and tailored decision support based on their local contexts and needs, and the changing environment. The PED RA framework will provide updated data about the performance of different solutions, their interoperability, and give insight into trade-offs between different goals and needs. As such, the PED RA framework forms the basis for reducing risks for PED planners, as well towards achieving a higher overall performance of the PED, based on the multitude of sustainability issues. Furthermore, it is noted that PED certification is useful also for benchmarking PEDs.

Within several ongoing Horizon projects such as ARV [15], oPENlab [16], and syn.ikia [17] frameworks are being developed for the planning and design of sustainable plus energy buildings and neighbourhoods. Thus, frameworks for identifying and assessing KPIs of positive energy buildings and neighbourhoods, are available. Such frameworks and guidelines provide useful insights into how to achieve a multitude of performance goals for PEDs, as well as information on needs of different users, and changing conditions and evolution of technologies, markets, policies, and social context.

Generation of report on PED Readiness

The PED Readiness Assessment (RA) Framework gets data on the four PED dimensions from external systems in the PED's context (e.g., AMI, DH Management System) and PEDvolution solutions (e.g., PED Design and Planning Toolset, PED Energy Manager), which serve as inputs for calculating the various KPIs.

KPIs should be in units that allow comparison of different PEDs, e.g., electricity consumption per inhabitant, installed PV capacity per m^2. Each KPI is mapped to one or more of the four PED genotypes (technology, market, social, interoperability). It is highlighted that the various dimensions of a PED should be balanced. Based on the scores of all relevant KPIs, a total score per genotype (i.e., PED dimension) is calculated by the PED RA Framework.

The inputs are given for the current situation of the PED, in terms of environmental, social, economic performance, Indoor Air Quality (IAQ) and flexibility indicators. The PED RA framework measures the readiness and can thus be used to provide scenarios in dynamic decision-making tools. The inputs may partly be provided by the PED Planner or can be taken from available public data and/or other PED tools.

The PED RA Framework provides the PED Planner with a report assessing the PED on the aspects of technology, market, social and interoperability. This report can be used as a basis to develop scenarios for decision making, e.g., users can choose different development pathways of the PED that they would like to explore by utilising the Dynamic Decision Support Guideline (DDSG) for PED development subsequently to the PED RA Framework. Furthermore, the PED Planner, along with the PED Manager, can exploit this report in consultations with potential PED investors to attract investments in the further development of their PED.

The framework will provide output on technological aspects (e.g., energy performance, SRI and flexibility, GHG emissions), market aspects (e.g. costs, affordability, etc.), social aspects (e.g. thermal comfort, air quality, social innovation), and interoperability.

The total score of a PED is calculated based on its scores on all the PED dimensions. Furthermore, PEDs can be classified based on the total score, thus enabling PED benchmarking. The PED RA framework can also be integrated into Community certification schemes, such as SGNI/DGNB. In the context of the PEDvolution pilots, ZHAW will assume the role of the PED Certifier, as the solution provider of the PED RA framework.

Assumptions:

- All needed data (i.e. related to Energy flows, Weather, Energy Prices, Built Environment characteristics) for assessing a PED are available.
- PED Planners and Managers are interested in getting an assessment for their districts/PEDs.

Preconditions:

- Data accessible via Interoperability Platform (HLUC-8 Access Data for PED Operation and Classification through Digital Tools).

UC diagram:

The UC diagram of HLUC-1 is presented in Figure 10, detailing its main actors and functions and their interactions.

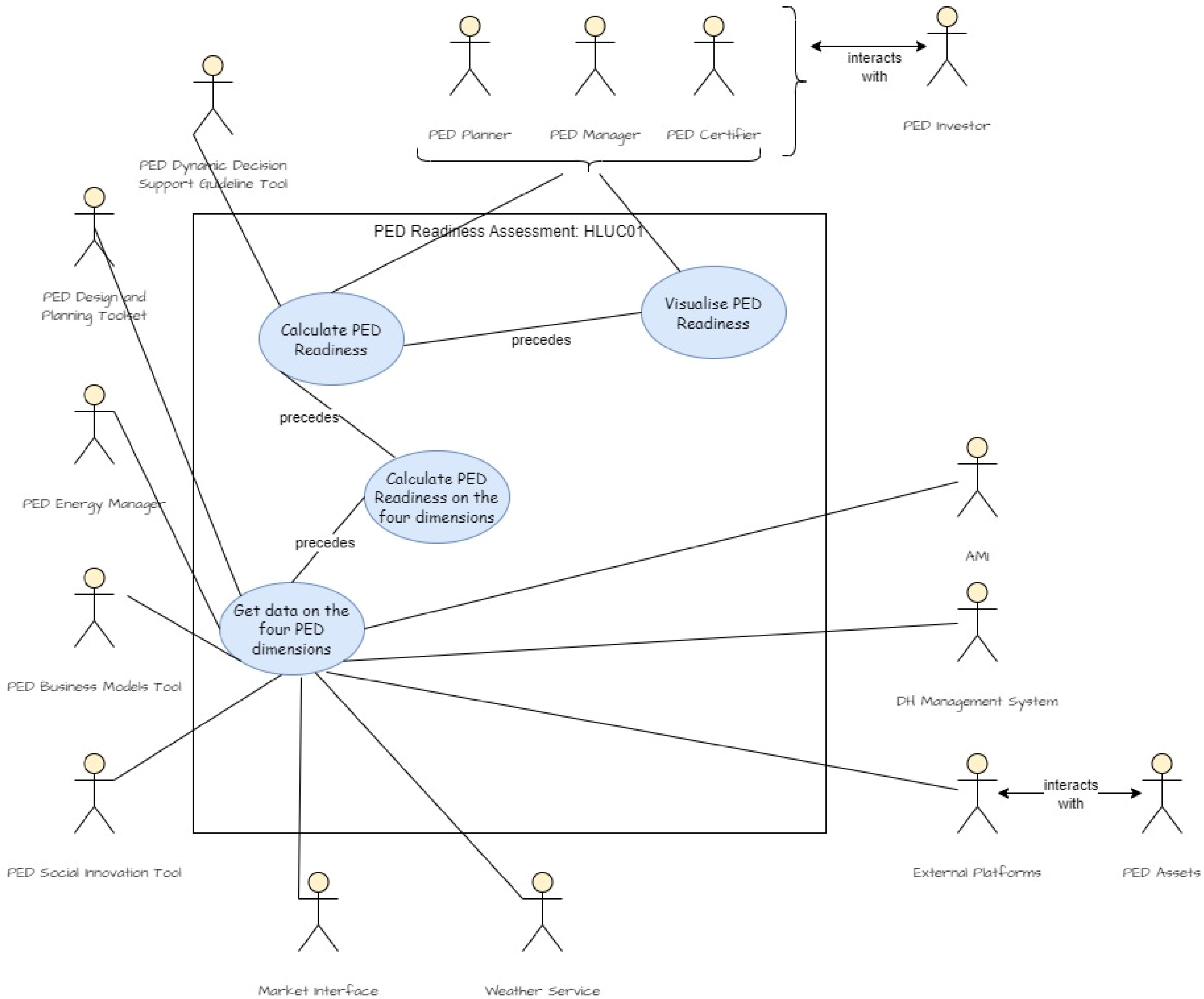

Figure 10: HLUC-1 – UC Diagram.

5.2.2 HLUC-2: Identification of energy improvement opportunities towards PED characterisation

<u>Scope</u>:

The decision support guideline of PEDvolution aims to assist PED Planners in exploring different development pathways and making strategic decisions by providing them with a set of scenarios on the further development of their districts. It goes beyond the state-of-the-art, as opposed to other static frameworks and guidelines, providing a dynamic and interactive platform, where PED planners and solution providers can get streamlined and tailored decision support based on their local contexts and needs and the changing environment, accounting for evolution of technologies, markets, policies, and social context. The guideline will provide decision-makers with updated data about the performance of different solutions, their interoperability, and give insight into trade-offs between different goals and needs. As such, the dynamic guide will be able to reduce risks for PED planners and guide them towards achieving a higher overall performance of the PED, based on the multitude of sustainability issues.

In order to generate the set of alternative scenarios on the development of a PED, the Dynamic Decision Support Guideline (DDSG) first gets a report on the current status of the district by the PED Readiness Assessment (RA) Framework. Furthermore, the DDSG needs data from all the PEDvolution solutions – technical actors (e.g., PED Energy Manager, PED Design and Planning Toolset, etc.) to assess their current performance and the interoperability between them, as well as from systems, interfaces and applications in the context of each PED (e.g., AMI for power generation/consumption data, etc.). It is noted that the various input data should be up-to-date. The needed inputs – amongst others – include:

Thermal and electric energy and power demand: As regards buildings, data such as type, size, location, form, shading conditions, storage, use profiles, controls, and costs of energy renovation are needed. Information on energy demand at PED level include also mobility, EV charging, street lighting, etc.

Energy generation and storage assets: Needed data per asset concern type, energy/power yield, life cycle GHG emissions, location, size, and costs. Asset categories of interest include solar, biomass, heat pump systems, batteries, fossil fuel installations, etc.

Energy prices: Data on (retail and network) electricity prices (including taxes), as well as district heating prices. Furthermore, data on fuel prices for each relevant fuel (including taxes) are needed.

Financing availabilities: Data on any available incentives that could be leveraged for the development of PED should be gathered, such as tax reductions, green loans, etc.

Geospatial data: Data on the local climate and environment, such as weather measurements and forecasts and long-term climate projections, dust, etc.

Legislation and area specifications: Data of interest – if available – under this category may concern area use (e.g., requirement for green spaces, etc.), noise, pollution, destruction caused by past wildfires, architectural requirements (e.g., heights/volumes), daylight and solar access, energy sharing, mobility (e.g., street design).

Business models: Information on business models, which can be applied to a district, such as development of an energy community, energy performance contracts, etc.

Once the needed inputs are received by the DDSG, they are formatted according to the KPIs structure, which is utilised by the tool. The end users of the DDSG, namely PED Planners, can set their goals and preferences for the development of a PED through a dedicated User Interface (UI). Subsequently, the DDSG, considering also the user inputs, develops scenarios on the further development of a PED, considering the impact of alternative decisions on the various PED genes (i.e., technological, social – including environmental aspects – economic, and interoperability aspects). Indicative examples of questions into which the tool can provide insight are: 'If we were to construct 1000 m^2 of new residential buildings with passive house standard and roof-integrated PVs and related EVs, what kind of energy generation and storage solutions would most effectively satisfy the energy needs to a lowest possible cost?', or: 'What are the trade-offs between renovating the existing buildings to passive house standard or investing in a common PV system for the area?'. Relevant questions that the tool should provide, should be explored in cooperation with the PED Planners.

Upon calculating the set of alternative scenarios, the output is presented through the UI of the DDSG to the PED Planners, so that they can decide on their preferred one. The outputs will be presented in a compilation of scenarios with the related KPIs, primarily concerning energy balance and energy

performance, GHG emissions, and costs, while they may be supplemented by different energy/power KPIs, SRI and flexibility indicators, economic KPIs, environmental KPIs (e.g., thermal comfort, air quality), and social KPIs (e.g., affordability).
It is noted that PED Planners, based on the generated set of scenarios, can reassess their goals and preferences for the further development of the district and update them through the dedicated UI, thus generating a new set of scenarios.

Assumptions:

All needed data for calculating the alternative scenarios of the PED development can be provided.

Preconditions:

Data accessible via Interoperability Platform (HLUC-8 Access Data for PED Operation through Digital Tools).

UC Diagram:

The UC diagram of HLUC-2 is presented in Figure 11, detailing its main actors and functions and their interactions.

Figure 11: HLUC-2 – UC Diagram.

5.2.3 HLUC-3: Planning of renovation and upgrades for energy savings and cost reduction for PEDs in building environment

Scope:

The PED Design and Planning Toolset – in particular the PED Renovation Tool – concerns renovation and upgrading of existing buildings within PEDs to enhance energy efficiency and reduce costs, as well of increase in RES production and utilisation. These renovation actions are vital for the long-term development of a PED. Functionalities of the PED Design and Planning Toolset include analysing current energy consumption patterns, identifying inefficiencies, and implementing targeted renovation measures. The scope includes collaboration among PED solution providers, PED managers, building owners, and municipalities to ensure successful execution and monitoring of renovation activities.

Building renovation is essential for achieving positive energy districts by significantly enhancing energy efficiency. Through measures such as upgrading building insulation, improving heating, cooling, and ventilation systems, energy consumption can be drastically reduced. These renovations not only lower energy demand, but also improve occupant comfort, wellbeing, and productivity. Additionally, renovated buildings are better equipped with RESs, such as PV or solar thermal, which allow on-site energy production and exchange. This enables energy flexibility, facilitating more effective demand-side management and contributing to lower energy costs and the overall sustainability of the district.

Objectives:

- Reduce - compared to the business as usual (BAU) case - overall energy consumption and costs after implementation, to meet or exceed local energy efficiency standards and regulations, resulting in significant individual cost savings and a corresponding reduction in carbon emissions.
- Enhance the comfort and smartness of the existing building stock to improve occupants' well-being and productivity.
- Increase (compared to BAU) in overall renewable energy production by integrating renewables in the built environment.

Renovation of existing building stock comes with main benefits from the perspective of PED Residents, such as reduced energy costs and emissions, and side benefits, such as enabling flexibility in buildings and enhanced occupant wellbeing and comfort (through advanced/smart renovations for building users).

The PED planner (e.g. Municipality), in collaboration with PED solution providers and other stakeholders (building owners/users, ESCOs), will analyze current energy systems, energy consumption patterns, and inefficiencies within the building stock and develop renovation strategies that suit local conditions in a cost-optimised way as described in the following steps. Assuming the data on current energy consumption (and production), building stock characteristics and district assets are available, and there is willingness of stakeholders in investing in renovation.

The PED Design and Planning Toolset (PED Renovation Planning Tool) (1) conducts a thorough analysis of current energy consumption and identifies areas for improvement based on the data available from the PED (e.g., retrieved by the AMI and the DH Management System) and information collected from the PED Planner and PED Residents. (2) Based on this analysis, the PED Design and Planning Toolset (PED Renovation Planning Tool) creates tailored renovation plans to address inefficiencies and leverage local conditions and comply with the regulatory framework. (3) The results are communicated to relevant stakeholders (e.g., the PED Planner and building occupants – namely PED Residents), so that they can access respectively the analysis on the district level and the renovation plan for each building. (4) Annual monitoring process will be established to keep track of transition process by retrieving updated data from the PED (e.g., through the AMI), while PED Residents shall update their building and asset data (such as updates on renovation actions) through a dedicated User Interface. The results can be exploited by the PED Design and Planning Toolset to reassess and further calibrate renovation actions. The updated renovation action plan is provided to the PED Planner (i.e., district level) and PED Residents (i.e., building level).

Within this context, through the toolset the PED Planner can facilitate the orchestration of renovation of the building stock at the PED level, promoting targeted renovations and upgrades in collaboration with relevant stakeholders (PED members), which optimize energy usage and significantly reduce operational costs at the building level. Simultaneously, these efforts contribute to broader collective goals for the municipality and local community, such as less pollution (due to decarbonisation) and emissions reduction.

Expected Outcomes:

- Reduction in overall energy consumption and operational costs for building owners and residents.
- Improved energy efficiency ratings and compliance with local energy standards.
- Enhanced comfort, health, and well-being of occupants through improved indoor environment.
- Increased adoption of renewable energy technologies and reduced carbon footprint of buildings.
- Creation of job opportunities and economic benefits for local communities through renovation activities.

Assumptions:

- Availability of accurate data on current energy consumption and building characteristics.
- Willingness of stakeholders to invest in renovation activities.
- Positive ROI for renovation investments in the long term.
- Construction and implementation are out of scope of this HLUC.
- Access to advanced renovation technologies and skilled labour.
- Communication channels between residents, PED manager (e.g., Energy Community) and PED Planner.

Preconditions:

- Favourable regulatory framework and incentives for energy-efficient renovations.
- Data accessible via Interoperability Platform (HLUC-8: Access Data for PED Operation and Classification through Digital Tools).

UC diagram:

The diagram of HLUC-3 is shown in Figure 12.

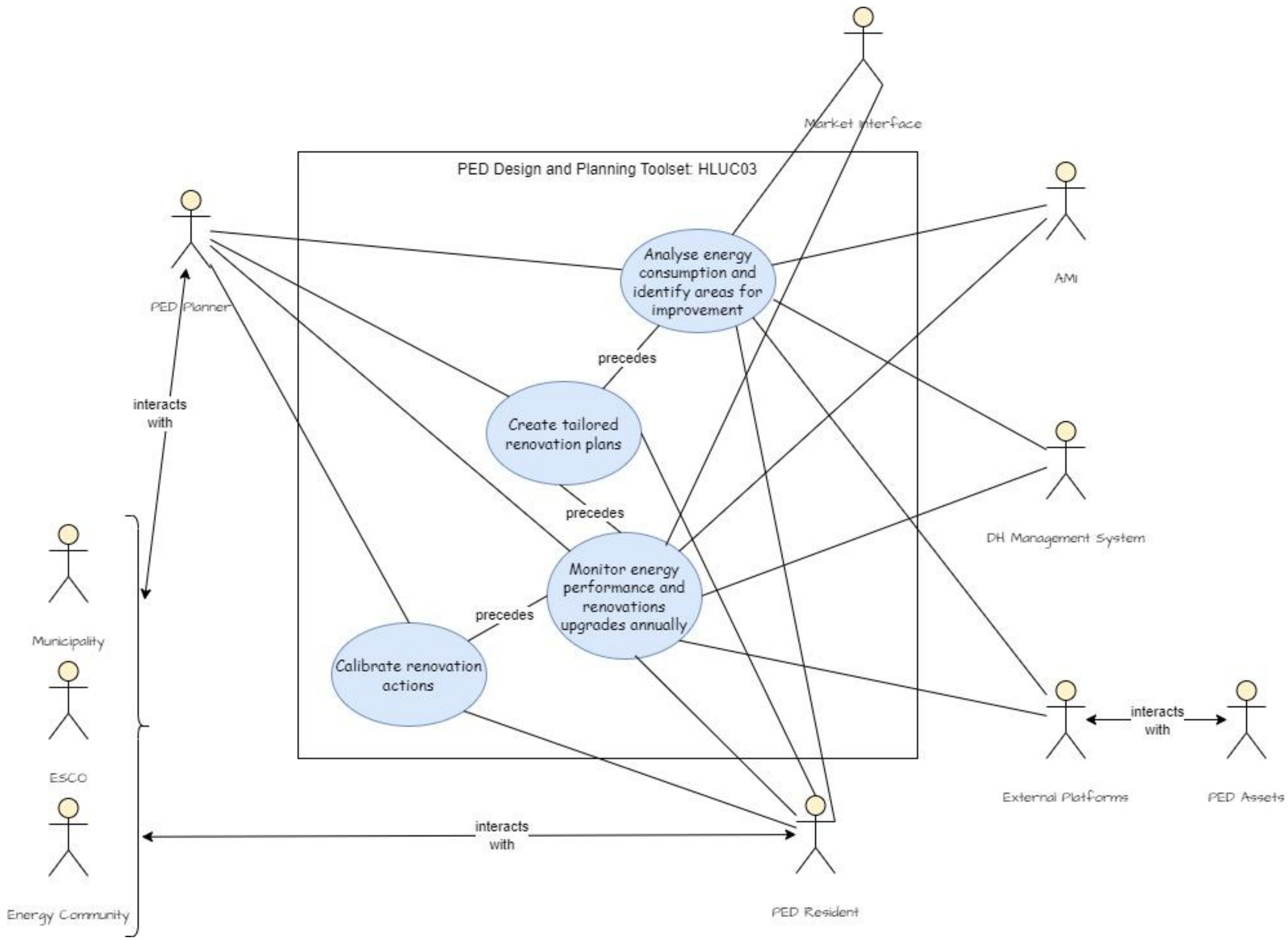

Figure 12: HLUC-3 – UC Diagram.

5.2.4 HLUC-4: Development of stakeholders' engagement and social innovation in PEDs

Scope:

PEDs are complex systems in which multiple stakeholders operate and have multiple needs and priorities. At the same time, PEDs are home to a number of people whose daily life may be influenced by the planned action. In this context, stakeholder alignment, engagement, and social innovation are key elements in building long lasting local energy systems. This use case aims to support stakeholder alignment and value creation beyond economic value through stakeholder engagement planning, joining, operating and evolvement of PEDs.

PED manager and PED planner will be the leading actors to ensure the incorporation of stakeholder engagement and social innovation activities in the PED planning and operation through the following process:

Identify relevant stakeholders: PED manager, potentially together with PED planner and/or PED promoter identifies relevant local actors that will be involved in the PED planning, operation and implementation, including local residents and businesses, as well as any other relevant stakeholder groups present in the area. The analysis results in the development of the stakeholder map.

Understand stakeholder views: PED manager, potentially together with PED planner and/or PED promoter, will discuss with representatives of different stakeholder groups to collect information on their views on the proposals to be implemented, including concerns, potential for mutual benefits and foreseen value, as well as perceived barriers. PED characterisation fact sheets will be generated from the stakeholder consultations and analysis.

Define strategies: Based on the consultations, identify common grounds, define strategies to address concerns and barriers, as well as leverage points where further stakeholder engagement will bring added value towards developing the PED engagement plan.

Implement, monitor and adjust: Implement the planned activities with monitoring of the success. Engage stakeholders in monitoring through feedback collection. Adjust the strategies when needed.

Ensure constant communication with the relevant stakeholder groups: Ensure continuous communication with the relevant stakeholder groups through all the phases. Actions and results will be presented based on what is relevant to each one of the stakeholder groups (e.g., municipality, Energy Community, residents, commercial businesses, etc.) to further enhance engagement and long-term commitment

Assumptions:

PED manager has allocated time and resources for stakeholder consultations.

Preconditions:

- PED manager has a high-level overview of the type of action planned to the site, and the basic structures in place or PED manager is committed in obtaining this overview as part of the process.
- A suitable actor with a capacity to conduct interviews and facilitate workshops is either available at the site or can be contracted.

UC Diagram:

The diagram of HLUC-4 is shown in Figure 13, below:

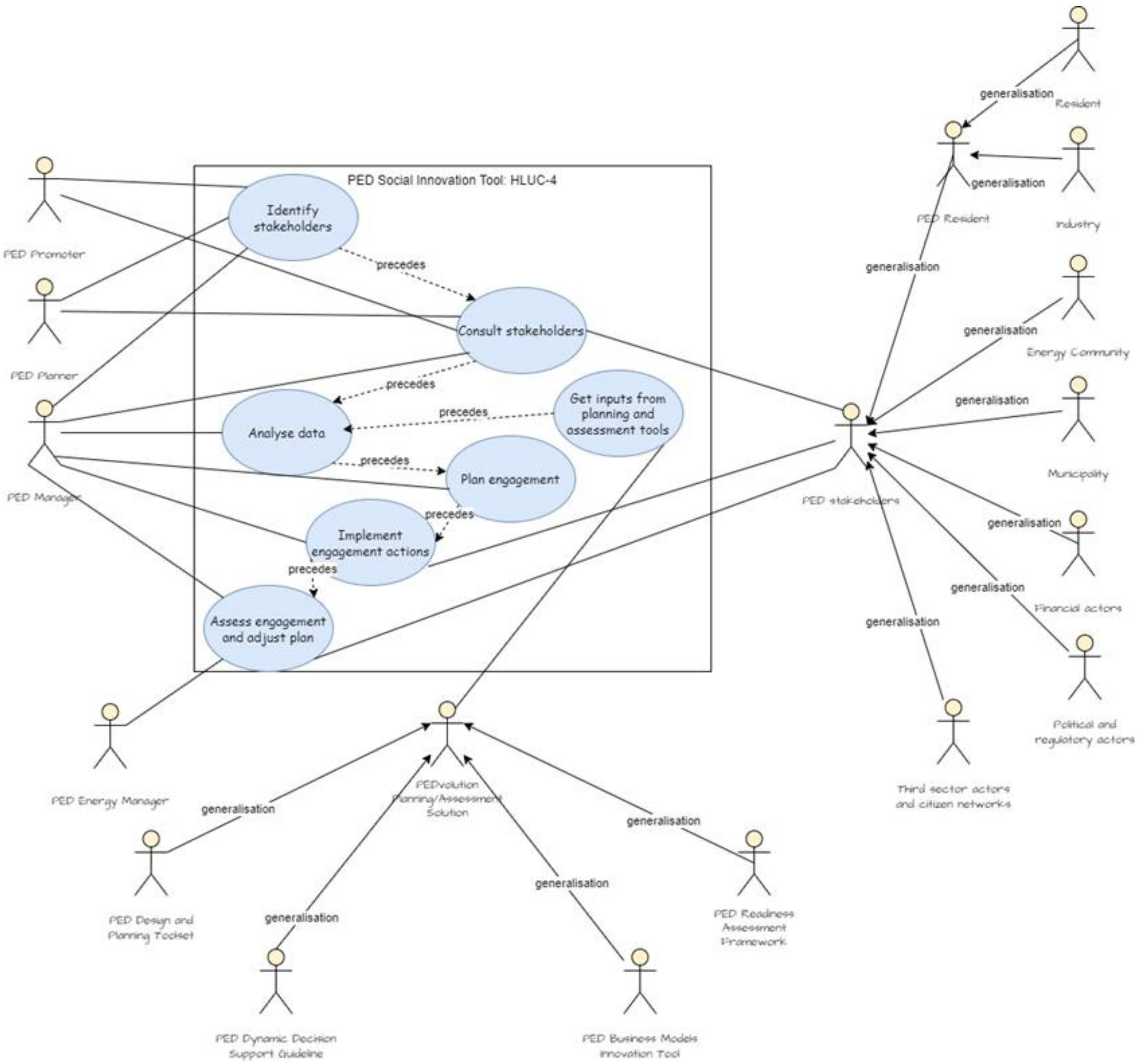

Figure 13: HLUC-4 – UC Diagram.

5.2.5 HLUC-5: Portfolio optimisation through flexibility for increased renewables integration

Scope:

RES assets within PED can operate in non-optimal way due to grid or market constraints. PED Manager wants to optimize the PED combined portfolio in order to better exploit the available assets, reduce dependency and offer additional income streams to the asset owners, while better exploiting the local RES production. Using PED Energy Manager tools, consumption, production and flexibility are forecasted, matched locally, while the remaining potential is offered to relevant outside players and markets.

Using flexible resources within PED, increased RES integration can be achieved by offsetting the local RES production by demand response and/or storage facilities within PED, effectively reducing the grid disturbances on the PED coupling point, allowing higher share of RES to be deployed and operated (avoiding curtailment). Cooperation with local DSO is envisaged. On top of that, PED Manager can offer flexibility to energy market actors (bilaterally or via the energy market) (HLUC-6).

Depending on the concrete local situation, RES-based production assets can be curtailed when congestions occur (or are forecasted to occur) in the local distribution system. Similarly, redistribution mechanisms, such as Redispatch in Germany[2], can have negative impact on asset operation. On the market side, volatile prices can force a RES asset to temporary stop production. All these situations reduce the amount of locally generated RES energy, prolong the ROI and limit the new RES installations (in case of saturated networks). This can also affect the energy balance of a PED, even leading to negative equilibriums in case the annual reduction from curtailment is significant.

To reduce (or eliminate) the aforementioned difficulties, RES aggregated flexibility can be offered to interested third parties, either directly or through the market.

<u>Calculation of flexibility potential</u>

In order to efficiently manage the flexibility of a PED, PED Energy Manager first needs to calculate the flexibility potential of the various Consumers and Prosumers (residential, commercial, and industrial) of the district, considering their preferences – as declared by them through a dedicated User Interface (UI). Hence, both power and heat consumption and production measurements from smart meters should be obtained by the relevant external systems (e.g., AMI, DH Management System), as well as weather measurements and forecasts from an external Weather Service. Furthermore, access to other External Platforms (e.g. IoT Platforms, Energy Market) is needed to acquire energy measurements, so as to calculate the flexibility potential of individual PED Assets (e.g., smart loads, EVs, batteries, thermal storage).

<u>Local exploitation of available flexibility</u>

PED Energy Manager performs the techno-economic matching of flexibilities in the local system – minimisation of imbalance in one or more vertically nested subsystems within PED. This way, stress on the grid coupling point is reduced, allowing a higher share of RES to be exploited on that level of the system. Furthermore, energy transfer costs are reduced, since energy is generated and consumed locally.

<u>Offer of aggregated flexibility (HLUC-6)</u>

The aggregated non-exploited flexibility will be offered by PED Energy Manager to interested energy market actors through appropriate Market Interfaces or forming a SuperPED.

<u>Optimal flexibility management (HLUC-6)</u>

PED Energy Manager should devise an optimal strategy for activating flexibility from PED Assets by creating flexibility events.

<u>Validation and remuneration of requested flexibility (Asset monitoring and control)</u>

[2] https://neon.energy/Neon-Market-based-redispatch-BMWi.pdf

PED Energy Manager should validate after the completion of explicit DR events that the requested schedule has indeed been executed by a PED Asset. For this purpose, data from a smart meter or a dedicated sub-meter should be accessed. It is also noted that effective execution of such schedules can be facilitated through automated control, which is enabled by appropriate control equipment (i.e., relays, etc.). Once participation in a flexibility event is validated, the final remuneration should be calculated and communicated to the PED Resident(s) or PED Participant(s) owning the PED Asset.

Assumptions:

- PED Manager acts as an Aggregator and Flexibility Service Provider or has business agreement with one in the electricity market and sells available flexibility directly or through intermediaries to the market.
- PED Manager has recruited PED Residents and PED Participants to participate in DR programs.
- Metering infrastructure is available for DR verification.
- Smart infrastructure is present in the buildings to enable data acquisition and control strategies.
- RES assets are available and controllable.

Preconditions:

- Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation through Digital Tools).
- In case of SuperPED, the PED Manager can represent all PEDs of the cluster in the energy market.

UC diagram:

The diagram of HLUC-5 is shown in the Figure 14, below.

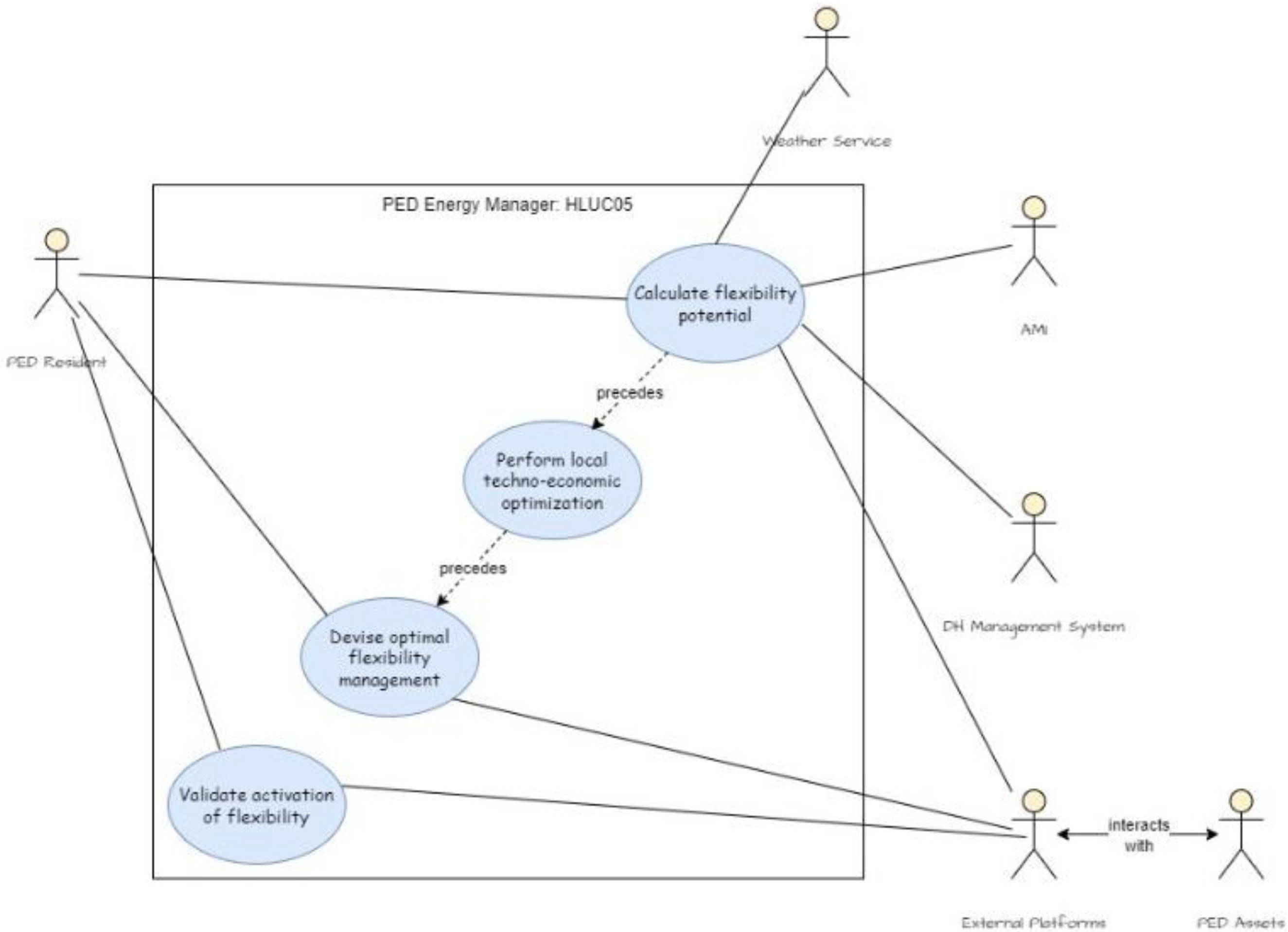

Figure 14: HLUC-5 – UC diagram.

5.2.6 HLUC-6: Flexibility aggregation and management at PED and SuperPED level

<u>Scope</u>:

PEDs can act as a source of flexibility, enabling market actors to provide services in the energy market. PED Manager wants to increase PED's income by selling the aggregated flexibility to the energy market. Thus, the flexibility potential of the PED needs to be calculated, so that appropriate flexibility offers can be submitted. Flexibility events will be dispatched to aggregate the needed flexibility. Performance of PED Residents and PED Participants in these events will be validated, and they will be remunerated accordingly.

The PED Energy Manager solution can assist the PED Manager in optimising the flexibility of a PED, thus securing an additional income flow through offering the aggregated flexibility to interested third parties, either directly or through the market.

<u>Calculation of flexibility potential</u>

In order to efficiently manage the flexibility of a PED, PED Energy Manager first needs to calculate the flexibility potential of the various Consumers and Prosumers (residential, commercial, and industrial) of the district, considering their preferences – as declared by them through a dedicated User Interface (UI). Hence, both power and heat consumption and production measurements from smart meters should be obtained by the relevant external systems (e.g., AMI, DH Management System), as well as weather measurements and forecasts from an external Weather Service. Furthermore, access to other External Platforms is needed to acquire energy measurements and price information, so as to calculate the flexibility potential of individual PED Assets (e.g., smart loads, EVs, batteries, thermal storage).

Offer of aggregated flexibility

The aggregated flexibility will be offered by PED Energy Manager to interested energy market actors (e.g. DSO, BRP, etc.) through appropriate Market Interfaces (either bilaterally or via the energy market). Furthermore, there is also the option to manage flexibility of multiple PEDs forming a SuperPED, thus offering aggregated flexibility.

Optimal flexibility management

PED Energy Manager should devise an optimal strategy for activating flexibility from PED Assets by creating flexibility events. For this purpose, apart from the calculated flexibility potential, preferences of PED Residents and PED Participants should be accounted for, as well as their energy prices (retail and network electricity prices, DH prices). These data can be exploited to improve the processes of participants' selection in flexibility events, and calculation of the offered incentives (explicit case) or prices (implicit case). Hence, energy prices data should be extracted from relevant External Platforms. PED Energy Manager is also responsible for dispatching the control or price signals to the PED Assets.

Validation and remuneration of requested flexibility (Asset monitoring and control)

PED Energy Manager should validate after the completion of explicit DR events that the requested schedule has indeed been executed by a PED Asset. For this purpose, data from a smart meter or a dedicated sub-meter should be accessed. It is also noted that effective execution of such schedules can be facilitated through automated DR, which is enabled by appropriate control equipment (i.e., relays, etc.). Flexibility validation data should be communicated to the energy market, so that the settlement between the market and the PED Manager can be completed. Subsequently, once participation in a flexibility event is validated, the final remuneration should be calculated and communicated to the PED Resident(s) or PED Participant(s) owning the PED Asset.

Assumptions:

- PED Manager acts as an Aggregator and Flexibility Service Provider or has business agreement with one in the electricity market and sells available flexibility directly or through intermediaries to the market.
- PED Manager has recruited PED Residents and PED Participants to participate in DR programs.
- Metering infrastructure is available for DR verification.
- Smart infrastructure is present in the buildings to enable data acquisition and control strategies.

Preconditions:

- Data accessible via Interoperability Platform (HLUC-8 Access Data for PED Operation and Classification through Digital Tools).
- In case of SuperPED, the PED Manager can represent all PEDs of the cluster in the energy market.

<u>UC diagram</u>:

The diagram of HLUC-6 is shown in Figure 15.

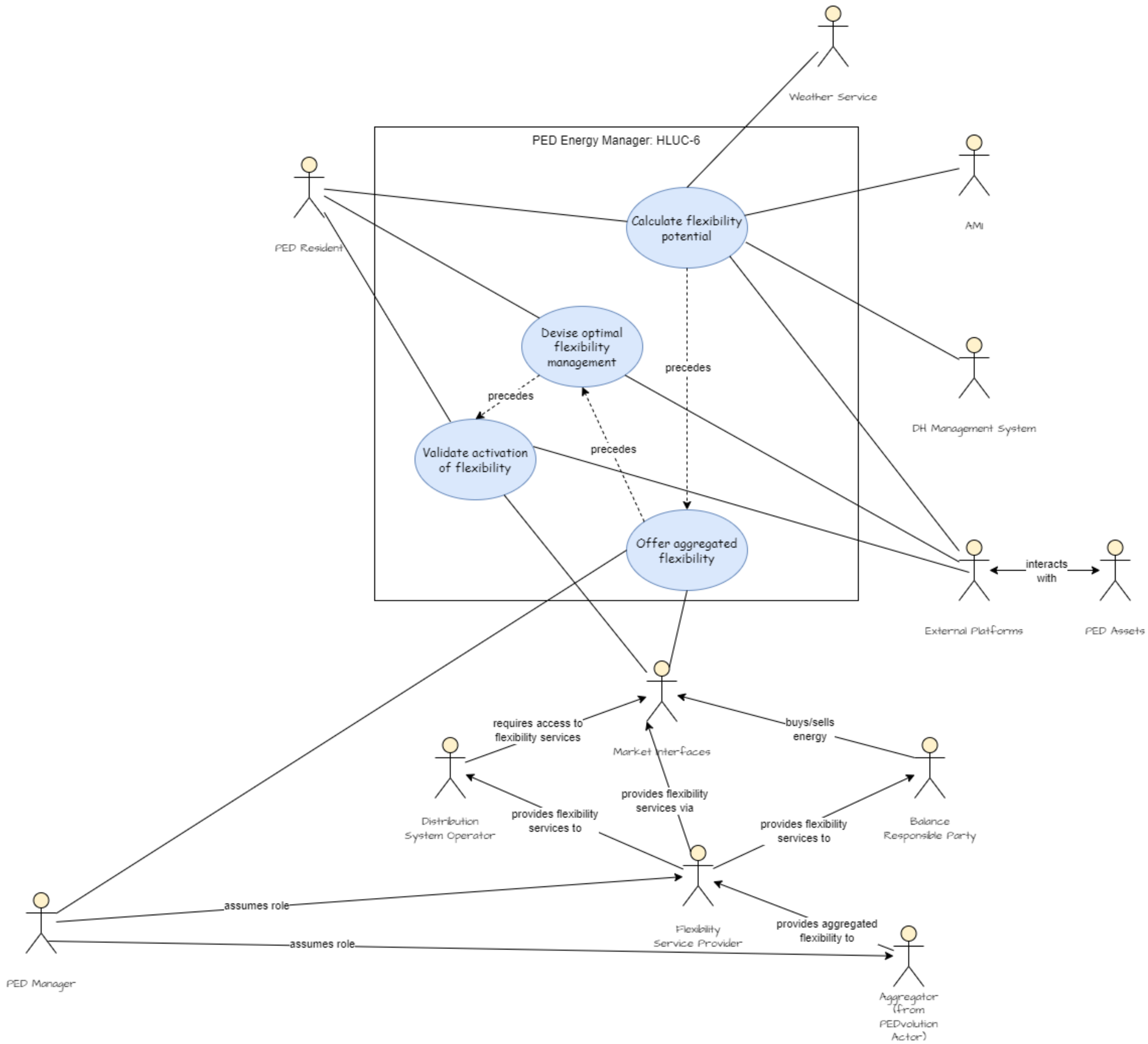

Figure 15: HLUC-6 – UC diagram.

5.2.7 HLUC-7: Planning of Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector

<u>Scope</u>:

Implementation of cost-effective and energy-efficient upgrades in district heating and cooling systems are essential for the long-term development of a Positive Energy Districts (PED). The PED Design and Planning Toolset (District Heating and Cooling Planning Tool) is the responsible solution for this task in the context of PEDvolution. The main goal by implementing its plan is to achieve significant energy savings and reduce operational costs through renovations and technological advancements. For this purpose, collaborative effort by PED solution providers, PED Planners, district heating operators (DHOs), and municipalities is needed to ensure the successful execution of renovation activities in the district heating and cooling sector.

District Heating and Cooling Planning Tool lays the groundwork by strategically integrating energy-efficient technologies. PED Planners then oversee the implementation of these upgrades, ensuring they align with the broader goals of the PED. The DH management system handles the daily operations, maintaining and optimising the heating systems to achieve peak efficiency. Municipalities facilitate the regulatory support needed for smooth collaboration, while technical experts provide specialised knowledge, which is crucial for successfully integrating renewable energy sources and optimising heating systems.

The PED Design and Planning Toolset (District Heating and Cooling Planning Tool) identifies improvement areas relevant to the DHC system, utilising data from the PED (e.g., DH Management System) and collecting feedback from the PED Planner and PED Residents. Subsequently, the tool devises a plan with the proposed upgrades, which is communicated to the PED Planner. Based on this plan, the PED Planner can lead the activities related to the implementation of the suggested renovation and upgrades in the DHC system. Finally, the performance of the system should be monitored continuously by fetching data from the PED (e.g., DH Management System), so that the upgrades concerning the DHC system can be reassessed and calibrated periodically (e.g., annually). The updated plan on renovation and upgrades of the DHC system should be communicated to the PED Planner.

Objectives

- Energy Efficiency: Achieve significant improvements in energy efficiency for district heating and cooling systems within PEDs.
- Cost Reduction: Lower operational and maintenance costs associated with heating and cooling infrastructure.
- Sustainability: Promote sustainable practices and reduce the carbon footprint in line with environmental regulations and targets.

Expected Outcomes

- Achieve significant improvements in energy efficiency for district heating and cooling systems, leading to lower energy consumption and operational costs.
- Reduce operational and maintenance costs associated with heating and cooling infrastructure, resulting in long-term financial savings for PEDs by implementing infrastructure upgrades.
- Promote sustainable practices by integrating renewable energy sources and reducing the carbon footprint, in line with environmental regulations and targets.

Assumptions:

- Sufficient financial resources are available to support the comprehensive audit, technological upgrades, and ongoing maintenance.
- Construction and implementation are out of scope of this HLUC.
- Sufficient historical and real-time data on current energy consumption and system performance is available for analysis and optimisation.
- Access to advanced renovation technologies and skilled labour.

- Willingness of stakeholders to invest in renovation and upgrade activities.

Preconditions:

- A preliminary assessment has been conducted to identify the need for upgrades and the potential benefits within the PED.
- Favourable regulatory framework and incentives for energy-efficient renovations.
- The local community has been informed about the project, and there is a strategy in place for ongoing communication and involvement.
- Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation and Classification through Digital Tools).
- An initial audit of the performance of the District Heating System must be provided.

UC diagram:

The diagram of HLUC-7 is shown in Figure 16.

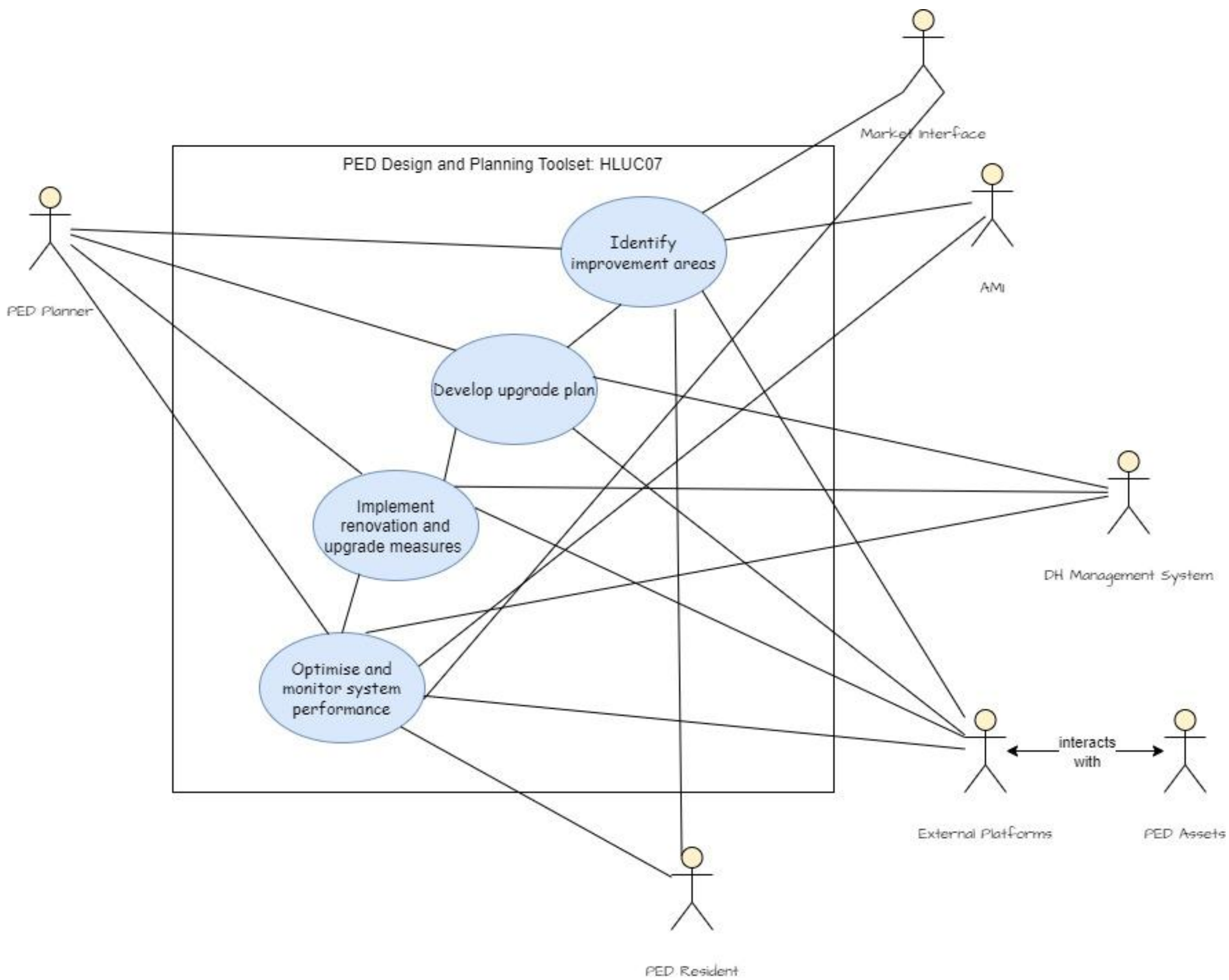

Figure 16: HLUC-7 – UC Diagram.

5.2.8 HLUC-8: Accessing Data for PED operation and classification through digital tools

Scope:

Interoperability Platform enables data exchange and sharing across external systems and field devices in the PEDs on the one hand, and solutions developed by PED Solution Providers on the other hand, as well as with energy markets and EU data spaces.

Access to and data collection from various sources in PEDs in an abstract way

The Interoperability Platform aims to provide an abstraction layer of PED Assets (e.g., smart loads, EVs, etc.) for IoT data exchanges in a homogenised way for transparent application development, building upon a common information model for the energy domain, which considers existing standards and ontologies (e.g., SAREF, IEC CIM). These data exchanges will be utilised for PED monitoring and certifications purposes (e.g., power/heat generation and consumption data by the PED Design and Planning Toolset, and the PED Energy Manager), as well as for dispatching control signals to PED Assets (e.g., in relation to flexibility services). Furthermore, data collection on weather data (i.e., forecasts and measurements) from an external Weather Service should be facilitated, as these data are needed to support various functionalities of the PEDvolution solutions (e.g., calculation of PED's flexibility potential by the PED Energy Manager). Data on the built environment characteristics (e.g., technical, economic and social characteristics of the districts, geospatial data, etc.) should also be communicated, so that features relevant to PED certification and design can be realised by the PED Readiness Assessment, PED Social Innovation Tool, PED Business Models Innovation Tool, etc. Finally, data related to energy prices as well as prices for grid services should be accessible from the different market interfaces.

Integration and data sharing between the various PEDvolution solutions and services through interoperable APIs

Data produced and exposed by PEDvolution solutions may be used as input from other solutions. For example, PED energy balance assessment and classification reports can be used for the identification of energy improvements opportunities and implementation actions. For the development and functioning of the different PEDvolution solutions, communication between them should be facilitated. Communication and data sharing must thus be realised through interoperable and open APIs and the adoption of secure data exchange protocols and connectors supporting semantic and syntactic interoperability.

Energy market interfacing

Also, data and services provided by the PED Energy Manager can be consumed by external services or third parties such as system operators (DHO, DSO, Aggregator etc). More specifically, the PED's aggregated flexibility can be offered to the energy market, utilising state-of-the-art protocols, such as FlexOffer.

Exposure of PEDvolution data and services to EU Data Spaces

Data and services of the project may also be exposed for use by third parties through their provisioning as interoperable offerings in the EU Data Space Ecosystem. Open-source connectors and federation services need to be implemented and deployed towards the interconnection with Energy Data Spaces.

Data exchanges between various systems concerning all the previously described functionalities of the Interoperability Platform should comply with established security and authorisation mechanisms (trust, data sovereignty etc), while sharing of sensitive data should be bounded by appropriate privacy policies. Moreover, interfacing will be based on open and standard protocols – when possible – to ensure compatibility and extensibility of the solutions offered.

Assumptions:

- Data providers will specify the data sharing policies (data classification).
- Data providers will make their data available (e.g., smart infrastructure is present in the buildings to enable data acquisition and control strategies, metering infrastructure is present).
- Solution providers want to make their services/data interoperable.

Preconditions:

- Data connectors/infrastructure need to be implemented & deployed.
- Pre-existing/ state-of-the-art standards and protocols.
- PEDvolution solutions will be provided and deployed.
- Energy market(s) exist in the target country and are accessible (pre-qualification, legal and technical viability) by the PED Manager and/or its partners.
- GDPR procedures (e.g., filling in consent forms, data processing agreements, etc.) have been followed.

UC diagram:

The diagram of HLUC-8 is shown in Figure 17.

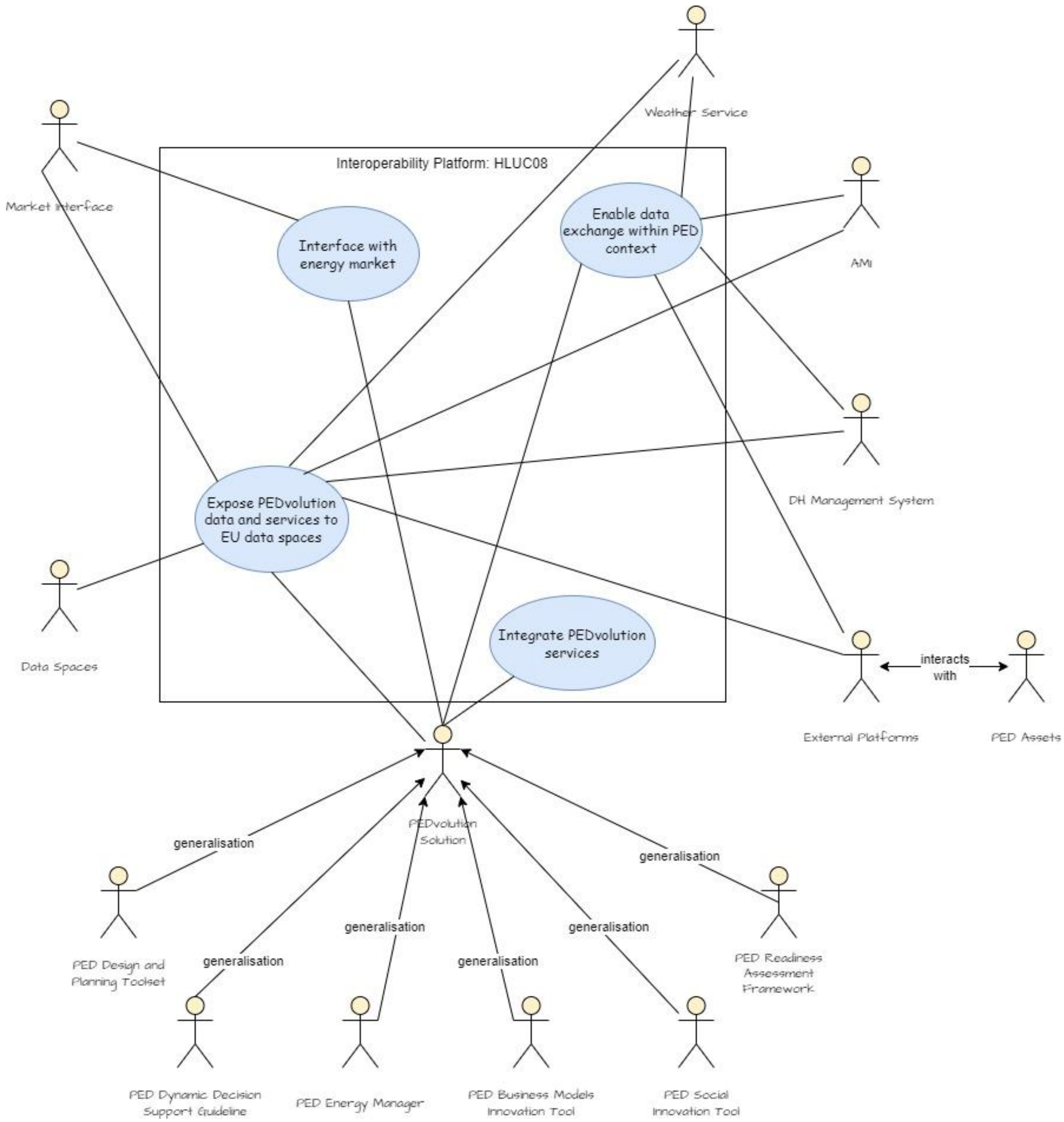

Figure 17: HLUC-8 – UC diagram.

5.2.9 HLUC-9: Formulation of PED business models

Scope:

The Business Models (BM) co-development process aims to build a promising business model for each demonstration PED and further investigate the business opportunities with replicator PEDs. The process incorporates various brainstorming business tools, the analysis of various BM patterns, and the adaptation of energy community-oriented BM innovation tools. By engaging all responsible entities of PEDs (e.g., PED managers), the business outcome of the operation of the proposed PEDvolution interoperable solutions in each PED (concerning all the relevant BUCs) will be analysed.

The overall narrative of this HLUC outlines the implementation of the business model development processes, considering learnings and experiences from previous projects, new and emerging business model options/patterns based on field research, as well as various business typologies. In general, the business model process can be divided into the following distinct phases over the project timeline:

<u>Initiation and Adaptation</u> (WP1, WP2)

Following the initiation phase (includes the WP1 BUCs and requirements definition and tool identification), the Business Model Innovation (BMI) tool adaptation will be done together with the PED Managers. The E-Land community-based BMI tool[3], adapted and customised to the PEDs' needs, will provide a set of building blocks, known as 'business model patterns,' that have been proven successful in community-based business solutions. The BMI tool adaptation process will enable PEDs to adjust business model patterns to the local context and combine them to create promising business models. All required tools will be prepared to understand the pains and gains, as well as driving and constraining forces for individual and integrations of PEDs (e.g., customised value proposition tool, force field analysis, SWOT analysis, etc.). In the initiation and adaptation phases, the BMI tool developers will be in consultation with the PED Managers, Planners, Certifiers and solution providers in order to formulate appropriate Business Models for each PED.

<u>Implementation</u> (WP6)

The specifically developed and adapted business model innovation tools for each PED will be implemented with active involvement of all PED managers, tools and technology developers. Business model innovation (BMI) tool: In this task, a well-structured process of the business model innovation tool will be introduced and applied to co-develop the business models of each PED. In this regard, various business model options will be provided for each PED through a series of workshops. SIN will provide a step-by-step guidance for PEDs starting from initiations, followed-up by ideation, integration & implementation and validation. In a co-development process, all pains and gains of PEDs will be considered for better exploitation of the values proposed by PEDvolution. This includes potential approaches for energy community implementation, integration of key partners, the potential for social entrepreneurship, value of energy grid robustness regarding dependencies to energy supplies, local legislation regarding price tariffs, etc. All tools adapted at Communication & Dissemination & Exploitation will be tailored and used together with best practices from similar community-based solutions. In the implementation phase, the BMI tool developers will continue their discussions with the main PED-related actors (i.e., Manager, Planner, Certifier, solution providers), and will also get data from systems in the PED context (e.g., AMI, DH Management System) and the PEDvolution solutions (e.g., PED Energy Manager, PED Design and Planning Toolset), once they will be deployed.

<u>Validation</u> (WP8, 9)

This phase will ensure a comprehensive assessment and validation of the PEDvolution demonstration considering various technical, business, societal and regulatory aspects. To enhance and optimize the

[3] https://elandh2020.eu/business-model-innovation-tool-for-energy-communities/

business model, a continuous follow up will be done starting from the demo set up, use case and scenario definition, implementation and documentation of relevant findings. For this purpose, active participation and engagement of the PEDs in the business model development and validation are crucial, involving the PED Manager, Planner, Certifier, solution providers, as well as the PED Residents and PED Participants. The validation will be done in parallel with the systems' integration and operation in the PEDs, monitoring the demonstration, collecting performance/measurement data from PEDvolution solutions (e.g., PED Readiness Assessment Framework, PED Dynamic Decision Support Guideline) and external systems in the PED context (e.g., various External Platform interfacing the PED Assets) and calculating KPIs for technical validation, while gathering economic data for business case validation. The validated outcomes will be utilised to evaluate the replication activities, considering the replicator PEDs' setting and contexts.

Assumptions:

- Each PED will have 1 primary business model during the project and explore if there are some business case opportunities with business actors. After the project, each replicator will develop additional BMs based on PEDvolution solutions, while co-developers will assemble secondary business models.
- The demonstration PEDs and replicators, will have at least one energy community to be approached to investigate business opportunities.
- Business actors and communities in the area of each PED seek to explore business opportunities.

Preconditions:

- Engagement of PEDs and solution developers in the BM development.
- Each PED and solution provider will clarify the relevant BUCs, define the baselines together with SIN, measure the KPIs connected to BUCs' KPIs to realize the value propositions and revenue streams.
- Data accessible via Interoperability Platform (HLUC-8 Access Data for PED Operation and Classification through Digital Tools).
- Additional data to be retrieved from the PED Manager and PED solution providers if needed (ad-hoc).

UC Diagram:

The diagram of HLUC-9 is shown in Figure 18.

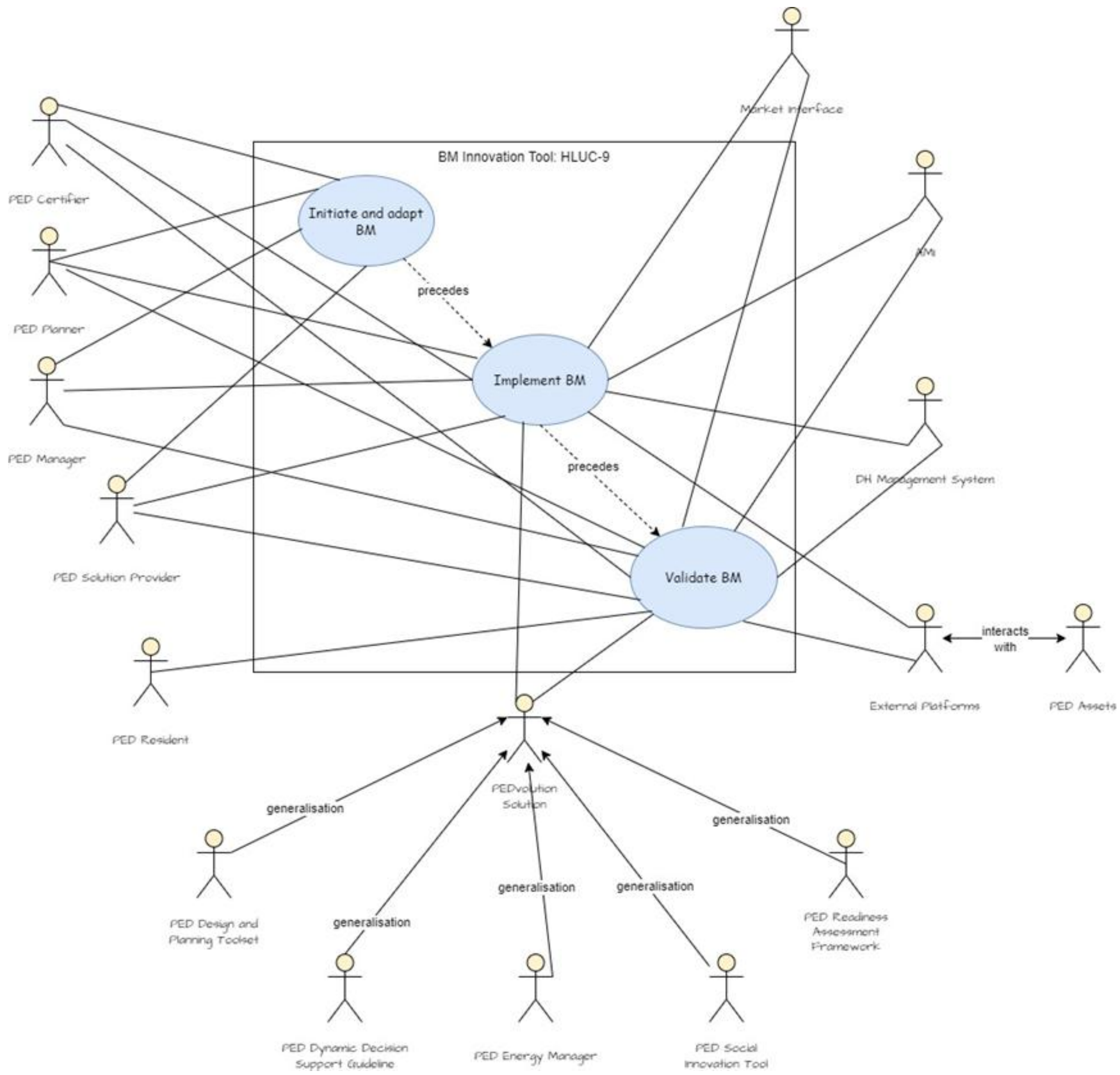

Figure 18: HLUC-9 – UC Diagram.

5.3 Individual Requirements

The individual requirements' categories, which were identified as necessary while analysing the PEDvolution HLUCs, are presented in Table 10. As can be seen, these categories concern interoperability, performance, privacy and security, as well as usability. In Annex III, detailed individual requirements under these categories are specified for each one of the HLUCs, detailing the specific needs that the various PEDvolution solutions should meet.

Table 10: Categories of individual requirements.

Categories ID	Category name	Category description	Summary
INT	Interoperability	Compliance with information models/standards and communication protocols	In order to achieve interoperable solutions within the project and facilitate the integration with the pilots' context, compliance with state-of-the-art standards for data objects, such as energy time series, weather time series, energy price time series, and communication protocols, such as FlexOffer for flexibility, should be met.
PER	Performance	Performance of the system	The duration of certain operations should be completed within certain time thresholds, depending on the relevant business requirements. Similarly, the business requirements also dictate the frequency of information (e.g., periodically or ad-hoc) exchange between different parties, as well as the relevant protocol specifications.
SEC	Security & Privacy	Security and privacy related requirements	Proper mechanisms should be established for safeguarding the security of stored and transmitted data (sharing policies, anonymisation etc.) and for ensuring confidentiality of sensitive data adopting appropriate mechanisms, such as anonymisation, etc. It is also highlighted that compliance with the GDPR regulation should be achieved where sensitive user data are involved.
USY	Usability	Usability of provided solutions	The information provided to end users of PEDvolution solutions should be clear and the graphical User Interfaces – when applicable – should be as intuitive as possible.

5.4 Preliminary co-developer PED pilots to UC mapping

Given the first collection of asset, system and data source information and specifications from all three co-developer PED pilots presented in Section 3.4 as well as the complete directory of BUC and HLUC descriptions, a preliminary mapping of PED pilots to BUCs and HLUCs (Table 11) has been drafted in order to guide implementation and roll-out of PEDvolution tools (Section 3.2) in the frame of WP8. Although each tool will not be tested in all pilots, the matching of tools, BUCs, HLUCs to pilots' functions maximizes complementarity, enabling a concise evaluation of the effectiveness of the solutions' as a whole in enhancing interoperability and integration of renewable assets within PEDs.

Table 11: PEDvolution pilots to UCs mapping.

PEDvolution pilot	Key Objective	Corresponding BUC	Corresponding HLUC
Schönbrunn, DE	Automated control and optimisation of existing and new RES, integration with local energy grids and market interface. Efficient operation of assets to utilise district heating network subject to maximum decarbonization potential through increase of RES penetration in the energy mix. Every building fulfills the requirements to become part of the PED supporting energy generation and storage facility, energy flexibility and aggregation.	BUC-1, BUC-2, BUC-3, BUC-5, BUC-6, BUC-7, BUC-8, BUC-9, BUC-10.	HLUC-1, HLUC-3, HLUC-4, HLUC-5, HLUC-6, HLUC-7, HLUC-8, HLUC-9.
Kranj, SL	Calculate accurately waste-heat energy output. Hydropower plants will be virtually connected to the industrial complex (VPP compound). Creation of a new energy community. Waste-heat recuperation. Automatic dynamic demand response of individual buildings and industrial equipment in order to most cost-efficiently adapt to the upcoming new tariff system.	BUC-1, BUC-3, BUC-4, BUC-5, BUC-6, BUC-7, BUC-8, BUC-10.	HLUC-1, HLUC-2, HLUC-5, HLUC-6, HLUC-7, HLUC-8, HLUC-9.
Winterthur, CH	Transitioning to a fully RES-powered district heating and cooling network. Energy cost reduction by the implementation of an energy community reduction in the use of fossil resources by increasing the share of renewable energies in the individual areas. Reduction of CO_2 emissions. Increase acceptance of solar energy, e-vehicles and p2p energy sharing. Optimised energy usage.	BUC-1, BUC-2, BUC-3, BUC-4, BUC-5, BUC-7, BUC-9, BUC-10.	HLUC-1, HLUC-3, HLUC-4, HLUC-6, HLUC-7, HLUC-8, HLUC-9.

6 CONCLUSIONS

This document aims to elicit and analyse the requirements for PEDs and their involved stakeholders to serve as the basis for the design, implementation and integration of the seven core PEDvolution's solutions to support PEDs' constant evolution and potentially their interconnection towards the formation of superPEDs. The overall analysis takes into account both PED's genotype (i.e., social, technology, interoperability and market related PED aspects) and phenotype (i.e., PED's characteristics derived from its interaction with the surrounding environment, such as the energy market, industry, mobility or (geo)politics) to design sustainable and adaptable solutions according to local environment's conditions.

The approach adopted in the requirements analysis activities was based on the methodology of IEC 62559-2 standard to identify and report a set of business and technical use cases that are relevant to PEDvolution project. An iterative and collaborative process involving all project's stakeholders was followed to recursively refine and eventually come up with acceptable and detailed (in the degree possible at this stage) use cases which collectively capture and address all different business objectives, without conflicting or overlapping with each other as much as possible.

Initially, the business actors benefiting from PEDvolution's solutions and their provided services were listed, while investigating their motivations, concerns and business objectives in a set of relevant business use cases. PEDvolution's role model depicting all involved PED roles and their interactions was derived and mapped to the electricity market role model. The following stakeholders were identified as PED Members, and any relevant links with the electricity market were identified:

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

Next, the technical actors and their operational boundaries were analysed resulting in the definition of nine relevant HLUCs fully aligned with the BUCs' business processes, which will be specialised for each pilot case to serve the specific PED's constraints. The documented HLUCs reveal the requirements of each of the seven solutions to be developed within the PEDvolution project, namely the *PED Design and Planning Toolset, the PED Readiness Assessment, the Dynamic Decision Support Guideline for PED Development, the PED Energy Manager, the Interoperability Platform, the PED Business Models Innovation*

Tool, and the Social Innovation Tool. An individual requirements analysis accompanies the technical analysis of the HLUCs to define any interoperability, security, privacy, performance or other non-functional requirements. The UC analysis enclosed in this report consists of a 1st version of the functional and non-functional requirements that will be supported in PEDvolution and will be further adapted and fine grained in the course of the project. Furthermore, a preliminary mapping of UCs to the three co-developer PED pilots has also been conducted, which will be reassessed based on the evolving needs of the PEDs.

As the project progresses, the requirements will be further elaborated to refine the system specifications in the subsequent project activities, being adjusted according to the users' interaction and feedback.

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ANNEX I: USE CASE TEMPLATE

<UC Title>

General information

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status

Scope and objectives of the use case	
Scope	
Objectives	
Related business case(s)	
Related user experience goal(s)	
Name of author(s)	

References						
No.	Type	Reference	Status	Impact	Originator / Organisation	URL

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**

Classification information
Relation to other use cases
Level of Depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

High-Level Analysis

Narrative of use case
Short description
Complete description

Use case conditions
Assumption(s)
Precondition(s)

General Remarks

Diagram(s) of use case

Technical details

Actors			
Actor name	Actor type	Actor description	Further information

Step by step analysis of use case

Scenario Conditions

Scenario Name	Scenario description	Primary Actor	Triggering Event	Pre-condition	Post-condition

<Scenario Name>								
Step No.	Event	Name of Process/ Activity	Description of Process/ Activity	Service	Inf. Producer (Actor)	Inf. Receiver (Actor)	Inf. Exchanged	Requirements, R-ID
<Scenario Name>								

Information exchanged

Information exchanged			
Information exchanged ID	Name of information	Description of information exchanged	Requirements R-ID

Requirements

Requirements		
Categories ID	Category name	Category description
Requirements ID	Requirement name	Requirement description

ANNEX II: BUSINESS USE CASE ANALYSIS

BUC-1: Increase market value of districts through certification

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	28.03.2024	Rainer Härtl (ESG)	First draft.	
0.2	07.05.2024	Rainer Härtl (ESG)	Second draft.	
0.3	09.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)	Scope and Objectives, narration section, Assumptions, Actor List.	Major revisions done. Further refactoring is needed.
0.4	22.05.2024	Rainer Härtl (ESG)	KPIs, review of changed text by ICOM (no changes here).	
0.5	31.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM) Andreas Lucas (SWW) Vicente Carabias (WIN) Matthias Haase (ZHAW) Mihaela Meslec (ZHAW)		Approved.

Scope and objectives of the use case	
Scope	Rate and classify the energy topology and potential of a PED by a Certification body. The PED Certifier aims to deliver a report to the PED Planner, providing a holistic overview of the PED, detailing the local energy consumption, generation and storage assets across different energy vectors, as well as smart readiness and energy efficiency indicator of buildings, allowing a final classification of the district in terms of energy balance.
Objective	1. Overview of the relevant energy production topology in a PED (production PED Assets). 2. Overview of all consumption and storage PED Assets. 3. Overview of the average energy efficiency and smart readiness indicators of buildings.

	4. Classification of the PED based on a standard predetermined evaluation methodology.
Related business case(s)	• BUC02: Increase income streams by embedding energy certification of building stock • BUC03: Prove accomplishment of sustainability goals

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC1_1	Access to all needed data	Accessibility of all needed data (in percentage, 0-100%).	O1-O4
KPI_BUC1_2	Review power generation	Review of all energy production in the PED (in percent, 0-100%).	O1
KPI_BUC1_3	Review consumption and storage	Review of all consumption and storage assets in the PED (in percentage, 0-100%).	O2
KPI_BUC1_4	Review energy efficiency and SRI for buildings	Review the average energy efficiency and smart readiness indicators of all buildings (in percentage, 0-100%).	O3
KPI_BUC1_5	Classification of the PED	Classification of the PED utilising all the reviewed data to clearly express the PED positivity and balance (in percentage, 0-100%).	O4

Classification information
Relation to other use cases
HLUC-1: Calculate PED assessment indices and PED certification HLUC-8: Accessing Data for estimation of PED balance through digital tools HLUC-9: Formulation of PED business models
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case

Business
Further keywords for classification
Classification, certification, smart readiness, energy efficiency, energy balance.

Narrative of use case
Short description
A **PED Certifier** can cover the needs of **PED Planners** and **PED Managers** for recognisable and trusted affirmation of a PED or SuperPED. For this purpose, an inventory as well as a classification of an existing PED or a potential PED (or group of PEDs) is created by the PED Certifier, utilising information from the PED Planner and/or Manager and a standard methodology for calculating the energy balance of the district or group of districts as well as other indexes such as energy efficiency and smart readiness.
Complete description
The complexity of the modern energy-related infrastructure, which spans across different vectors - whilst supporting the conversion from one vector to another – and concerns numerous assets, can complicate the calculation of the energy balance of a district and the classification of a Positive Energy District (PED). What's more, the concept of the SuperPED, a hierarchically structured set of PEDs where surpluses and shortages can be compensated internally across different PEDs of the structure, complicates even more the calculation process. **PED Planners** and **PED Managers** need recognisable and trusted affirmation of PED and SuperPED regions. Based on a credible methodology involving a detailed overview of the relevant generation, consumption and storage assets' topology of buildings, flexibility potential and measurement data from field devices, the **PED Certifier** calculates **energy balance** of the **PED** and **SuperPED** and other indexes such as **energy efficiency** and **smart readiness** at building level and provides its classification. Towards improved credibility of calculation, data from energy meters of the **Distribution System Operator (DSO)** and the **District Heating Operator (DHO)** are utilised. Data on the building stock enabling the calculation of supporting indexes such as the SRI and energy efficiency metrics, can be provided by the Municipality.

Use case conditions
Assumption(s)
• A certification scheme for PEDs can be standardised and is of added value for PED Managers/Planners. • The PED Certifier has access to the needed data. • In PEDvolution the role of the Certifier will be assumed by project's solution providers.
Precondition(s)
The municipality/DSO/DHO grant full access to the required data.

Actors

Actor name	Actor type	Actor description	Further information
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	Provides the required data for PED certification calculations.
District Heating Operator (DHO)	Business Entity	A party responsible for the distribution of district heating.	Provides the required data for PED certification calculations.
Municipality	Local authority	The local government of the city or town.	Provides the required data for PED certification calculations.
PED Manager	Business Role	A party that assumes this role, manages the functioning of a PED and/or ensures data availability and/or accessibility for further research and innovation development.	Manages a PED and wants to certify it.
PED Planner	Business Role	A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.	Wants to create/further develop a PED.
PED Certifier	Business Entity	An entity that certifies, based on a framework, the sustainability of apartments, buildings, neighbourhoods, or cities. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.	Wants to make profit from PED certification.

BUC-2: Increase income streams by embedding certification of building stock as an added value service

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status

0.1	25.03.2024	Evyatar Littwitz (ESG)		
0.2	10.05.2024	Nikolaos Charitos (ICOM) Ilia Pietri (ICOM) Isidoros Kokos (ICOM)	Scope and Objectives, narration section, Assumptions, Actor List	Further refactoring is needed.
0.3	31.05.2024	Nikolaos Charitos (ICOM) Ilia Pietri (ICOM) Isidoros Kokos (ICOM) Andreas Lucas (SWW) Vicente Carabias (WIN) Matthias Haase (ZHAW) Mihaela Meslec (ZHAW)	KPIs	Approved

Scope and objectives of the use case	
Scope	A real estate agency aims at proceeding to the required upgrades and renovation to achieve certification of assets for sale or rent within districts to boost their value and increase its profitability. This strategy will focus on following certification standards, involving relevant stakeholders providing PED management solutions, implementing the needed measures and supporting the certification processes.
Objective	1. Achieving certification of buildings energy efficiency and smart readiness. 2. Obtain commitments of local businesses and residents within targeted districts. 3. Reduced carbon emissions within certified districts. 4. Increase the share of renewable energy sources in district self-consumption. 5. Identify, prioritise, and implement energy efficiency and sustainability measures towards certification of the PED, in respect to different business models allowed by the local regulation (e.g., PV sharing in a roof of an apartment building).
Related business case(s)	• BUC-1: Gain profit through energy certification of districts.

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives

KPI_BUC2_1	Reduction in energy costs within certified PEDs	Reduction in energy costs within certified districts.	O1
KPI_BUC2_2	Building certification	Percentage of certified buildings within the PED area.	O1
KPI_BUC2_3	Stakeholder satisfaction	Level of satisfaction among stakeholders surveyed.	O2
KPI_BUC2_4	Carbon reduction	Reduction in carbon emissions within certified buildings (/districts) annually compared to baseline.	O3
KPI_BUC2_5	Increase of consumed RES-generated energy	Percentage of self-consumed energy from local renewable sources.	O4
KPI_BUC2_6	Stakeholder participation	Number of participating stakeholders.	O2
KPI_BUC2_7	Revenue stream from PED's ancillary services	Revenue streams from PED's ancillary services offered to the DSO or other market entities.	O1
KPI_BUC2_8	Data-driven optimisation	Efficiency improvements achieved based on data-driven decisions e.g. Increased flexibility (both heat and electricity) through PED design/implementation actions.	O.5

Classification information
Relation to other use cases
HLUC-1: Calculate PED assessment indices and PED certification HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-5: Optimise portfolio through flexibility for increased renewables integration HLUC-8: Accessing Data for PED operation through digital tools HLUC11: Formulation of PED business models
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification

Flexibility, Certification, Renovation, Sustainability measures/services

Narrative of use case
Short description
This Business Use Case (BUC) focuses on a **Real Estate Agency** aiming at certifying properties for sale or rent to boost their value and profitability. By setting clear certification standards and working closely with stakeholders like property owners and local communities, the agency aims to increase income, cut operational costs, enhance the attractiveness of properties on the market, and improve their environmental footprint. This will be achieved by data-driven decision-making. These efforts also pursue and promote positive changes in PEDs, benefiting both the local community and the municipality. While the Real Estate Agency leads these initiatives, the active involvement of the community and local government is crucial, ensuring that the benefits extend widely.
Complete description
This BUC outlines a strategic approach of a **Real Estate Agency,** acting as a **PED Manager/Planner** that leverages certifications for buildings to enhance profitability while promoting efficiency and sustainability. Increasing income streams by embedding certifications for buildings involves: **Identifying Suitable Districts and Buildings,** where implementing energy certifications would have the most significant impact. Factors such as energy consumption, building design, and potential for improvements will be evaluated to determine suitability. **Follow Certification Standards.** The involvement of a **PED Certifier** is needed to follow standards that will provide clarity to stakeholders and ensure consistency in evaluating buildings' energy efficiency and sustainability and the energy balance of the PED. **Plan and implement targeted actions.** With the support of **PED Solution providers**, the PED Manager/Planner can utilise data-driven decision making. Data analytics will be utilised to promote decision-making processes, allowing for more informed and strategic choices to reach a positive energy balance. Towards this, solutions enabling increased energy efficiency through renovation of buildings, as well as improved energy management and exploitation of the flexibility potential of buildings can be deployed, subsequently leading to improving the whole district. **Engaging stakeholders** such as • **PED Residents**: By achieving energy certifications, they can benefit from **reduced operational costs** through improved energy efficiency. Additionally, certified buildings may command higher rental or sales prices, leading to revenue generation opportunities. • **Municipality** and **Local System** (i.e., Distribution System, District Heating) **Operators**: Supporting data collections for achieving certification and for implementation of renovation and sustainability actions. The PEDvolution ecosystem will enable the realisation of this business case by offering solutions towards achieving a positive energy balance within a district and embedding certification of building stock scenarios. PED solution providers will examine how energy is currently produced, stored and used in buildings and identify areas where improvements can be made. This may also involve adoption of flexibility schemes, enabling a more strategic view of when to consume energy.

They'll then come up with strategies to help increase income, considering the local area's specific needs. Working closely with the PED manager and other stakeholders, they'll carry out renovations and upgrades designed to save energy, increase RES penetration, improve energy balance and potentially reduce energy costs. These efforts not only benefit the landowner or the individual PED Residents, but also the larger goal of making our living environment more sustainable.

Use case conditions
Assumption(s)
A standard scheme exists for the certification of the PED and the buildings within it.
Precondition(s)

Actors			
Actor name	Actor type	Actor description	Further information
PED Manager	Business Bole	Ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Operates the PED by managing local assets
PED Planner	Business Role	A party that assumes this role, ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Responsible for the design of the PED.
PED Certifier	Business Entity	An entity that certifies, based on a framework, the sustainability of apartments, buildings, neighbourhoods, or cities. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.	Provides PED certification.
PED solution provider	Business Entity	An entity providing services to PED Residents, PED Participants and PED Managers.	Provides solutions enabling the formulation of the PED and its certification.
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Wants to reduce energy costs and/or increase sustainability. Beneficiary of increased property value and market appeal.
Real-estate Agency	Business Entity	An entity that arranges the selling, renting, or management of homes, land, and buildings for their owners.	Certify assets for sale or rent to increase its profitability.

Municipality	Local authorities	The local government of the city or town.	Plays a crucial role in enabling and facilitating the certification processes by promoting regulatory changes and providing incentives (if possible). Also, provides the required data for PED certification calculations.
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	Provides the required data for PED certification calculations.
District Heating Operator (DHO)	Business Entity	A party responsible for the distribution of district heating.	Provides the required data for PED certification calculations.

BUC-3: Prove accomplishment of sustainability goals

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	05.04.2024	Amin Kouti (VITO)		
0.2	13.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)	Comment to refactor main actor and scope	
0.3	21.05.2024	Amin Kouti (VITO)	Revision on some objectives and narrative	Approved

Scope and objectives of the use case	
Scope	The business case centers on demonstrating the successful achievement of sustainability objectives within positive energy districts, thereby contributing to overall urban sustainability.

Objective	• Reduction (compared to BAU) in operational carbon equivalent emissions and therefore reducing environmental impact. • Reduction (compared to BAU) in overall energy consumption. • Increase (compared to BAU) in overall renewable energy production. • Improving energy poverty rate by energy cost savings. • Prove, monitor and demonstrate the social and economic benefits of PEDs, including job creation, community engagement, and improved quality of life for residents.
Related business case(s)	BUC-1: Gain profit through certification of districts. BUC-2: Increase income streams by embedding energy certification of building stock (added value service). BUC-4: Decrease energy costs by renovating the existing building stock BUC-10: Reduce dependencies on fossil fuels for district heating and cooling by integrating local excess and waste heat resources.

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC3_1	Baseline energy consumption reduction	Reduction in total energy consumption compared to baseline.	O2
KPI_BUC3_2	Energy consumption optimisation	Reduction in energy consumption per square meter of building space.	O2
KPI_BUC3_3	Specific system energy reduction	Decrease in energy consumption for specific systems (e.g., heating, cooling, lighting).	O2
KPI_BUC3_4	EPC enhancement	Energy efficiency rating improvement according to Energy Performance Certificate (EPC) assessments.	O2
KPI_BUC3_5	Operational carbon emission reduction	Reduction in operational carbon equivalent emissions.	O1
KPI_BUC3_6	RES increase	Increase in on-site renewable energy generation and storage	O3
KPI_BUC3_7	Energy poverty	Monitoring the percentage of households spending a high proportion of their income on energy costs.	O4

KPI_BUC3_8	Energy Cost Savings	Monitoring the energy cost saving due to efficiency measures.	O4
KPI_BUC3_9	Job creation	Create jobs directly and indirectly within a specific timeframe (e.g., 50 after one year, 100 after 3 years…)	O5

Classification information
Relation to other use cases
HLUC-1: Calculate PED assessment indices and PED certification HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-4: Development of stakeholders' engagement and social innovation in PEDs
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Sustainability, decarbonisation.

Narrative of use case
Short description
The BUC focuses on the comprehensive benefits that arise from achieving sustainability goals in a district, viewed from the municipality's perspective. The **municipality**, in collaboration with **PED solution providers**, will analyze the current energy consumption patterns and inefficiencies within the existing building stock and develop sustainable transition pathways that suit the local conditions and local community (e.g., utilising social innovation tools). **PED solution providers** will analyse the current energy consumption patterns and inefficiencies within the existing building stock and develop renovation strategies that suit the local conditions. Led by the **PED planner**, targeted renovations and upgrades will be implemented in collaboration with relevant stakeholders (**PED members**) to optimize energy usage and significantly reduce, environmental emissions and operational costs at the individual level. Simultaneously, these efforts contribute to broader collective goals such as the decarbonisation of the built environment.
Complete description

Buildings are a crucial component of energy transition, as they account for a significant proportion of worldwide energy use and greenhouse gas emissions. Objectives: • Reduction (compared to BAU) in operational carbon equivalent emissions and therefore reducing environmental impact. • Reduction (compared to BAU) in overall energy consumption. • Increase (compared to BAU) in overall renewable energy production. • Improving energy poverty rate by energy cost savings. • Prove, monitor and demonstrate the social and economic benefits of PEDs, including job creation, community engagement, and improved quality of life for residents. For the municipality, demonstrating the achievement of sustainability goals can attract investment and foster a sustainable and resilient/future proof community and energy system—key responsibilities of municipal governance. For **PED planners**, proving the accomplishment of sustainability goals can enhance project viability, attract investment, and differentiate their developments in the market. It establishes a compelling value proposition by showcasing the economic, environmental, and social benefits of PEDs, thereby increasing investor confidence and fostering long-term sustainability. Similarly, for **building owners** and **municipalities**, achieving sustainability standards or goals in PEDs can lead to various benefits, including reduced energy costs, enhanced resilience to climate change, improved air quality, and increased community satisfaction. By embracing sustainable practices within PEDs, **building owners/residents** and **municipalities** can demonstrate leadership in environmental stewardship, attract residents and businesses, and create vibrant, liveable communities for future generations.

Use case conditions
Assumption(s)
• Availability of data to assess the current state of a PED and subsequently the potential for improvements. • Willingness of involved stakeholders (e.g., municipality, PED Residents) to support the required actions for achieving sustainability goals. • The actions on sustainability goals have a positive ROI at least in the long-term.
Precondition(s)
• Favourable legal framework for implementing sustainability-related actions. • Willingness of municipality to invest in sustainability- related actions.

Actors			
Actor name	Actor type	Actor description	Further information
PED solution provider	Business Entity	An entity providing services to PED Residents, PED Participants and PED Managers.	In this case, renovation strategies.
PED Planer	Business Role	A party that assumes this role, ensures the functioning of a	Responsible for the design of the PED.

		PED incl. infrastructure, living and interfaces with context.	
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	
Municipality	Authority	The local government of a city or town. An entity that constructs various buildings, properties, facilities, housing, roads, and other construction projects.	
Energy Service Company	Business Entity	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may provide insight services as well as energy management services.	

BUC-4: Decrease energy costs by renovating the existing building stock

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	05.04.2024	Amin Kouti (VITO)		
0.2	13.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)		
0.3	21.05.2024	Amin Kouti (VITO)	Revision on some obj and narrative	Approved

Scope and objectives of the use case	
Scope	The BUC focuses on the economic benefits of decreasing energy costs through the renovation of existing building stock. From the municipality's perspective, the renovation actions lead to decreased energy costs and improved daily life through more advanced systems (e.g., automation of assets). Energy Service Companies are also important for this BUC, as they benefit economically from providing the required renovation services.

Objective	• Reduction (compared to BAU) in overall energy consumption after implementation, to meet or exceed local energy efficiency standards and regulations, resulting in significant individual cost savings and a corresponding reduction in carbon emissions. • Enhance the comfort and smartness of the existing building stock to improve occupants' well-being and productivity. • Enabling interoperability and flexibility of the building to facilitate integration with the grid or other buildings, promoting efficient energy management and utilisation. • Generate a positive return on investment (ROI) within 20xx years through decreased energy expenses and increased operational efficiency, supporting long-term financial sustainability while advancing environmental responsibility. • Increase (compared to BAU) in overall renewable energy production by integrating renewables in the built environment.
Related business case(s)	BUC-1: Gain profit through energy certification of districts. BUC-2: Increase income streams by embedding energy certification of building stock (added value service). BUC-3: Prove accomplishment of sustainability goals. BUC-5: Increase value of products by integrating them in energy communities. BUC-8: Optimise grid operation by leveraging flexibility from PEDs. BUC-10: Reduce natural gas dependencies with optimised district heating operation

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC4_1	Total energy reduction	Percentage reduction in total energy consumption compared to baseline.	O1
KPI_BUC4_2	Buildings energy consumption reduction	Reduction in energy consumption per square meter of building space.	O1
KPI_BUC4_3	System-specific energy reduction	Decrease in energy consumption for specific systems (e.g., heating, cooling, lighting).	O1
KPI_BUC4_4	EPC optimisation	Energy efficiency rating improvement according to Energy Performance Certificate (EPC) assessments.	O1

KPI_BUC4_5	SRI satisfaction rating	Occupant satisfaction surveys or ratings related to comfort and smart features (SRI rating).	O2
KPI_BUC4_6	Flexibility metrics improvement	Increase in flexibility metrics such as load shifting capability or demand response participation (flexibility factor).	O3
KPI_BUC4_7	Payback for energy efficiency upgrades	Payback period: Time taken to recoup the investment made in energy efficiency upgrades.	O4
KPI_BUC4_8	NPV of energy costs	Net present value (NPV) of energy cost savings over the project's lifespan.	O4
KPI_BUC4_9	RES increase	Increase in on-site renewable energy generation and storage	O5

Classification information
Relation to other use cases
HLUC-1: Calculate PED assessment indices and PED certification HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-3: Implementation of renovation and upgrades for energy savings and cost reduction for PEDs in building environment HLUC-5: Optimise portfolio through flexibility for increased renewables integration HLUC-7: Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector HLUC-8: Accessing Data for PED operation through digital tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Energy efficiency, decarbonisation.

Narrative of use case
Short description
The BUC focuses on the economic benefits of decreasing energy costs through the renovation of existing building stock, from the **municipality**'s perspective as a PED Planner. The municipality, in collaboration with PED solution providers and other stakeholders (building owners/users, ESCOs), will analyze current energy systems, energy consumption patterns within the building stock and develop renovation strategies that suit local conditions in a cost-optimised way. Led by the PED Planner, targeted renovations and upgrades will be implemented in collaboration with relevant stakeholders (PED members) to optimize energy usage, increase energy production, reduce operational costs, and improve occupant well-being and comfort, while addressing energy poverty.
Complete description
Buildings are a crucial component of energy transition, as they account for a significant proportion of worldwide energy use and greenhouse gas emissions. In Europe, more than 220 million buildings were built before 2001, making up 85% of the EU's building stock. Many of them aren't energy efficient according to today's standards. Many use fossil fuels for heating and cooling, old appliances and outdated technology. Therefore, renovation is imperative to decrease energy costs, reduce carbon emissions, enhance comfort and smartness, enable interoperability, and achieve a positive return on investment (ROI). Objectives: • Reduce energy costs for residents and businesses through the implementation of energy-efficient technologies and practices. • Enhancing energy efficiency (compared to BAU) by reducing overall energy consumption after implementation, resulting in significant individual cost savings and a corresponding reduction in carbon emissions. • Enhance the comfort and smartness of the existing building stock to improve occupants' well-being and productivity. • Enabling interoperability and flexibility of the building to facilitate integration with the grid or other buildings, promoting efficient energy management and utilisation. • Generate a positive return on investment (ROI) within xx years through decreased energy expenses and increased operational efficiency, supporting long-term financial sustainability while advancing environmental responsibility. Renovation of existing building stock comes with main benefits from the municipality's perspective as a PED Planner, such as reduced energy costs and emissions and side benefits such as enabling flexibility in buildings (for ESCOs) and enhanced occupant wellbeing and comfort (through advanced/smart renovations for building users). The municipality, in collaboration with PED solution providers and other stakeholders (building owners/users, ESCOs), will analyze current energy systems, energy consumption patterns, and inefficiencies within the building stock and develop renovation strategies that suit local conditions in a cost-optimised way. The PED planner can serve as intermediary between ESCOs, who provide renovation services, and PED Residents, who are interested in decreasing their energy costs through renovations. Within this context, the PED planner can facilitate the orchestration of renovation of the building stock at the PED level, promoting targeted renovations and upgrades in collaboration with relevant stakeholders (PED members), which optimize energy usage and significantly reduce operational costs at the building level. Simultaneously, these efforts contribute to broader collective goals for the

municipality and local community, such as decarbonisation and energy efficiency improvement of the built environment.

Use case conditions
Assumption(s)
Availability of data to assess the current state of a building and subsequently the potential for improvements. Willingness of building owners to invest in renovations.
Precondition(s)
Availability of effective renovation measures

Actors			
Actor name	Actor type	Actor description	Further information
PED solution provider	Business Entity	An entity providing services to PED Residents, PED Participants and PED planners and managers.	In this case, renovation strategies.
PED Planner	Business Role	A party that assumes this role, ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Responsible for the design of the PED.
PED Resident/ building owner	Person	Person/entity living/working in the PED (geographically located in the PED).	
Energy Service Company	Business Entity	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may provide insight services as well as energy management services.	
Municipality	Authority	The local government of a city or town.	

BUC-5: Implementation of PEDs through energy communities

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	25.03.2024	Evyatar Littwitz (ESG)	First draft.	
0.2	30.05.2024	Isidoros Kokos (ICOM)	Modification of scope, Reference, Modification of Narration.	Minor revisions needed.
0.3	03.06.2024	Isidoros Kokos (ICOM), Evyatar Littwitz (ESG), Pascal Kienast (ZHAW), Gerhard Meindl (SWW)	Final polishing in objectives, KPIs, Assumptions.	Accepted.

Scope and objectives of the use case	
Scope	Energy communities have been evolving as one of the cornerstones of the energy transition, enabling a bottom-up approach of the operation of the energy system. Towards this, the PED concept can complement the existing business models of Energy Communities, enabling a more holistic approach on the operation of urban environment. By adopting the PED concept, Energy communities can explore new strategies to enhance quality of life, focusing especially on the synergistic benefits of shared energy resources and sustainability practices.
Objective	• Identify and analyse energy community needs towards PED characterisation. • Develop a strategic action plan for reaching a PED state. • Leverage the community acceptance of the action plan toward active engagement. • Implement continuous monitoring and optimisation strategies. • Elaborate revenue generation models, operational costs reduction, and improved sustainability matrix (Improvements both in economy and sustainability).
Related business case(s)	BUC-2: Increase income streams by embedding energy certification of building stock (added value service). BUC-3: Prove accomplishment of sustainability goals BUC-4: Decrease energy costs by renovating the existing building stock

References		
Reference	Impact	URL
Energy Communities Definition	Energy Communities Definition	https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en
Positive Energy Districts Factsheet	PED vs Energy Communities	https://smart-cities-marketplace.ec.europa.eu/sites/default/files/2021-06/Positive%20Energy%20Districts%20Factsheet.pdf

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC5_1		Action plan is defined.	O1
KPI_BUC5_2		Percentage of strategic action plans for reaching PED state implemented.	O2
KPI_BUC5_3		Percentage of energy community members involved and engaged.	O3, O1
KPI_BUC5_4		Percentage of PED goals reached.	O4
KPI_BUC5_5		Energy cost and CO_2 reduction (% or €, t of CO_2).	O5

Classification information
Relation to other use cases
HLUC-5: Optimise portfolio through flexibility for increased renewables integration
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Flexibility, demand response, business models, local energy communities, self-consumption, decarbonisation.

Narrative of use case
Short description
Energy communities (ECs) present a unique opportunity to achieve the concept of Positive Energy Districts (PEDs) fostering locally produced energy (and flexibility) to its own needs or to support the efficient operation of the urban grid, towards enabling carbon-neutral urban districts and promoting sustainability. Towards this, energy communities are in need of tools enabling the design of PEDs, the planning of energy-related interventions towards achieving positive energy balance through targeted investments and optimised operation, as well as tools for capacity building/engagement of local stakeholders and adoption of new business models.
Complete description
Energy community (EC) is a new scheme of collective and citizen-driven energy actions to support the clean energy transition, with participatory and democratic processes. It involves both private

and public sectors in collective actions in open and voluntary approach, while their purpose is to provide social, economic and environmental benefits to the community members or shareholders rather than profits. ECs are increasing public acceptance of renewable energy projects and attracting more private investments in the clean energy transition. In the context of EU legislation, Energy communities are distinguished to Renewable Energy Communities (REC) and Citizen Energy Communities (CEC). RECs are geographically limited and organised in the proximity of renewable energy projects owned and developed by that community and present a unique opportunity to achieve the concept of PEDs fostering locally produced energy (and flexibility) or to support the efficient operation of the urban grid, towards enabling carbon-neutral urban districts and promoting sustainability. The Energy Community Operator – acting as a PED Planner - leads efforts to adopt (through implementation of a PED) novel concepts of sustainable energy actions and energy-related services through strategic integration in the scope of the Energy Community. The integration process includes: 1. **Understanding EC Needs** through analysis will help identify and understand the specific requirements of each EC, laying the foundation for strategic integration. 2. **Developing a strategy** allowing the Operator to create a tailored action plan to integrate locally produced energy and products into ECs, making them more relevant and valuable, whilst considering novel market concepts, such as flexibility services. 3. **Technological Compatibility** assessment will ensure that integrated products align with existing infrastructure and community needs, allowing their integration and future adaptability. 4. **Ensuring Regulatory Compliance** within ECs to reduce regulatory risks, thus increasing the perceived value of integrated products. 5. Actively **Engaging the Community** and involve stakeholders: Local Businesses, Municipality, Aggregators, and the DSO, enabling the realisation of the action plan. 6. **Implementing Continuous Monitoring and Optimisation** for improvement of efforts ensuring integrated products evolve alongside changing community needs and technological advancements, driving ongoing enhancements and maximising value. The overall goal of the Energy Community within the PEDvolution ecosystem, is to increase positive impact to society and the environment through new EC scenarios, enabled by PED solution providers and involving local stakeholders (e.g., the PED Manager/EC Operator, and the PED Residents and PED Participants/EC members), and providing solutions and customised strategies that fit the local needs.

Use case conditions
Assumption(s)
• There are technological providers that can support the actions of the strategic action plan. • Energy communities (cooperative, sharing, etc.) are allowed in the local country regulation.
Precondition(s)
• Existence of EC/Motivation of the EC members to participate in the PED. • Energy Community members equipped with digitally enabled infrastructure (EMS, SM, etc.).

- Availability of energy meter data for energy balancing calculations.

Actors			
Actor name	Actor type	Actor description	Further information
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	Provides access to data for supporting the preparation of the strategic plan of the EC. Procures flexibility services.
Aggregator	Business Entity	A party that aggregates resources for usage by a Balancing Service Provider for energy market services.	Aggregates several consumers and/or prosumers for flexibility services.
PED Manager/Operator	Business Entity	Ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Wants to sell flexibility of PED Residents (consumers/prosumers) via an Aggregator as an additional flow of income.
PED Planner	Business Role	A party that assumes this role, ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Responsible for the design of the PED.
Energy Community member	Person	Party that consumes/produces electricity and is member of an Energy Community scheme. This is a Type of Party Connected to the Grid.	Wants to reduce energy costs and/or increase sustainability.
Technological provider	Business Entity	A party that provides the infrastructure, marketplace or platform to allow a functioning business system	Possibly linked with IoT systems, meters and or control systems
Local businesses	Business Entity	Local businesses such as plumbers, electricians, builders active on the ground and implementing the solutions	Typically, hard to reach and innovation resistant. Can support the local works when executing the action plan.
Municipality	Local authorities	The local government of a city or town.	The final interest is to increase tax revenues. Provides access to data for

			supporting the preparation of the strategic plan of the EC.

BUC-6: Optimise economically the cost of electricity production

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	25.03.2024	Evyatar Littwitz (ESG)		
0.2	31.04.2024	Nikolaos Charitos (ICOM) Martin Vodnik (OFF)	Modifications in Scope and Narrative	
0.3	05.05.2024	Evyatar Littwitz (ESG)	Actors List updated	Approved

Scope and objectives of the use case	
Scope	The ever-increasing installed capacity of RESes holds opportunities to optimise the costs of production for Producers, which is the primary goal of BUC-6. To this aim, the Producer will conduct an analysis of the current state of the grid occurrences, thereunder production, consumption and storage assets available within the grid, to draw conclusions on optimising the costs of production.
Objective	• Identify optimisation opportunities within positive energy districts (PEDs) and energy communities. • Integrate renewable energy sources efficiently into the distribution grid. • Minimise generation costs through efficient renewable energy utilisation and coordination of different types of generation plants. • Establish monitoring mechanisms to continuously evaluate cost and sustainability metrics. • Engage stakeholders to promote awareness and collaboration. • Adapt strategies to evolving technological and market conditions.
Related business case(s)	BUC-5: Increase value of products by integrating them in energy communities. BUC-7: Optimise BRP operation by leveraging electricity flows within the energy community. BUC-8: Optimise grid operation by leveraging flexibility from PEDs. BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.).

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives

KPI_BUC6_1	Renewable energy penetration rate	Percentage of electricity generated from renewable sources compared to total electricity generation.	O2
KPI_BUC6_2	Cost savings from renewable energy integration	Monetary savings achieved through the efficient utilisation of renewable energy sources in generation.	O3
KPI_BUC6_3	Cost efficiency ratio	Ratio of energy generation cost to output, monitored and evaluated regularly to ensure continuous improvement.	O4
KPI_BUC6_4	Stakeholder engagement level	Number of stakeholder meetings held, surveys conducted, and participation levels in collaborative initiatives.	O5
KPI_BUC6_5	Renewable energy dependency reduction	Percentage decrease in the use of non-renewable energy sources over a specified period.	O1, O3
KPI_BUC6_6	Strategy adaptation rate	Number of strategy revisions made in response to changes in technology and market trends.	O6
KPI_BUC6_7	Minimisation of RES curtailment	Minimise the curtailment of RES production due to distribution grid constraints.	O2, O3

Classification information
Relation to other use cases
HLUC-3: Implementation of renovation and upgrades for energy savings and cost reduction for PEDs in building environment HLUC-5: Optimise portfolio through flexibility for increased renewables integration HLUC-7: Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector HLUC-8: Accessing Data for PED operation through digital tools
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Energy forecasting, energy storage, RES integration, scheduling optimisation, flexibility, demand response.

Narrative of use case
Short description

The ever-increasing installed capacity of RESes holds opportunities to optimise the costs of production for Producers. To this aim, the Producer will conduct an analysis of the current state of the grid occurrences, thereunder production, consumption and assets available within the grid, to draw conclusions on optimisation methods for the costs of production.
Complete description
The ever-increasing installed capacity of RESes holds opportunities to optimise the costs of production for Producers. This business use case will thrive to achieve that. To this aim, the Producer will conduct an analysis of the current state of the grid occurrences, thereunder production, consumption and assets available within the grid, to draw conclusions on optimisation methods for the costs of production. It involves analysing existing generation and storage infrastructure, energy consumption patterns, and renewable potential within PEDs. Strategies will be developed to integrate renewable sources efficiently, utilise smart grid technologies, and implement demand-side management to minimise generation costs. Regulatory frameworks will be considered to ensure alignment with policy objectives and incentives for sustainable energy adoption. Continuous monitoring and evaluation will be conducted to assess cost-effectiveness and identify areas for improvement. Optimisation of co-generation of heat and electricity production, considering cost of production in both energy vectors, should be conducted when possible based on the existing generation infrastructure (e.g., CHP plants). New business models for a Producer that lead to selling energy to a PED should be examined. The following measures will be taken as part of this BUC: • Gathering data on grid aspects like production, consumption, and available assets, including information on infrastructure, energy consumption patterns, and renewable potential. • Energy generation forecasting for the different technologies included in the portfolio. • Examining limitations of grid infrastructure causing curtailment of local RES production. • Analysing energy consumption patterns to identify ability for improved RES absorption through demand-side management strategies. • Developing strategies to efficiently integrate renewable energy sources into the grid, identifying suitable locations for installations of RES and storage assets. • Conducting ongoing monitoring and evaluation to assess the cost-effectiveness of strategies, tracking key performance indicators like production costs, energy efficiency, and renewable energy penetration rates to identify areas for improvement over time. The goal of the PEDvolution ecosystem, is to optimise local electricity production in economic and sustainability aspects. Examination of local assets, consumption patterns, grid constraints and regulatory limitations can contribute to more sustainable local production. Improvements will be achieved through customised strategies for PED investments in renewable production and/or storage assets, updated production schedules, and utilisation of local flexibility in collaboration with the PED Manager and the DSO.

Use case conditions
Assumption(s)
• The focus of the analysis is on large-scale Producers, with controllable generation. • Data is available in order to assess the current state of electricity production in the PED. • Control infrastructure regarding generation is available.

• Business models support different control scenarios on electricity generation.
Precondition(s)

Actors			
Actor name	Actor type	Actor description	Further information
(Electricity) Producer	Person/Business Entity	A party responsible for the production of electricity. Connected to the grid.	Wants to optimise economically the generation of electricity.
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	Wants to ensure the stable and economic operation of the distribution grid, while integrating an increasing share of RES assets into it.
Aggregator	Business Entity	A party that aggregates resources for usage by a Balancing Service Provider for energy market services.	Aggregates several consumers and/or prosumers for flexibility market services.
PED Manager/Operator	Business Entity?	Ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Wants to sell flexibility of PED Residents (consumers/prosumers) via an Aggregator as an additional flow of income.
Consumer/Prosumer	Person/Business Entity	A party that consumes electricity. This is a Type of Party Connected to the Grid. / A party that both consumes and generates electricity. This is a Type of Party Connected to the Grid.	Wants to reduce energy costs and/or increase sustainability.
BRP	Business Entity	A party responsible for imbalances in its balancing area within a	Can assist the Producer in case of imbalances between forecast and actual generation by leveraging

		given imbalance settlement period.	energy consumption/generation within its portfolio.

BUC-7: Optimise BRP operation by leveraging sub-balancing areas via energy community

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	25.03.2024	Evyatar Littwitz (ESG)		
0.2	30.05.2024	Isidoros Kokos (ICOM)	Modification of title & scope	Approved

Scope and objectives of the use case	
Scope	The Balance Responsible Party (BRP) is in charge of managing electricity flows within a sub-balancing area defined through an Energy Community (EC) who has formulated a PED to optimize grid operations. The BRP coordinates closely with the Distribution System Operator (DSO) to ensure that electricity distribution is maintained at optimal levels across the Low/Medium Voltage grid. Leveraging the energy contributions of the PEDs, The BRP can increase its ability to balance more efficiently, while maintaining a safe, secure and available energy to the end users.
Objective	• Improved portfolio management in electricity sector • Promote and integrate more renewable energy sources into the portfolio. • Improve economic benefits through efficiency and stability, and reduce operational costs. • Lower risk in management of portfolio
Related business case(s)	BUC-5: Implementation of PEDs through energy communities I BUC-6: Optimise economically the cost of electricity production. BUC-8: Optimise grid operation by leveraging flexibility from PEDs. BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.).

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC7_1	RES percentage in mix	Increase RES share in BG energy	O1
KPI_BUC7_2	Cost savings	Reduction by employing efficient operation management by x% over Y years.	O5
KPI_BUC7_3	RES integration	Achieve new installed renewable capacity.	O3
KPI_BUC7_4	Stakeholder engagement rate	Level of stakeholder involvement in energy-related initiatives.	O4

Classification information
Relation to other use cases
HLUC-5: Optimise portfolio through flexibility for increased renewables integration
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Flexibility, demand response, scheduling optimisation. balance, RES, Grid Operations

Narrative of use case
Short description
The Balance Responsible Party (BRP) aims to optimise its position in the energy market by leveraging the positive balance of a PED, enabled by an energy community, market as a sub-balancing area. The profile of the PED enables the BRP to achieve improved performance of portfolio forecasting and better mitigation of balancing risks.
Complete description
The BRP focuses on the effectively manage and optimize it position in the energy market effectively balancing of demand and consumption in its portfolio. By integrating an increased proportion of renewable energy sources and implementing real-time energy management, the BRP aims to improve operational efficiency, and foster sustainable investments within its responsibility area. Improved operation of its portfolio is achieved by the management of an Energy Community who has formulated a PED, providing a geographically constrained positive balanced area to the BRP. The BRP employs several key strategies: • Forecasting to enable the BRP to anticipate demand and generation changes. • Real-time energy monitoring of energy flows to allow the BRP to address fluctuations in demand and supply, maintaining grid balance. • Flexibility schemes to adjust energy. This also involved optimisation of integration of renewable energy with storage. The PEDvolution ecosystem will enable the realisation of this business case by offering solutions to the BRP to leverage flexibility within the Energy Community, exploited to balance its portfolio whereas it can also support the super PED concept, allowing cross-sectorial balancing. The PED Manager/Operator in this case, will need to represent the EC community, optimally allocating the

flexibility needs of the BRP to the EC Members/PED Residents and PED Participants. PED solution providers will examine how energy is currently used in the BG areas and analyse the profiles of the electricity flow. New strategies will be sought after to help improve grid control taking into account the specific needs of the local area.

Use case conditions
Assumption(s)
• BRP is allowed to offer flexibility schemes for load, generation or storage. • Energy community allowed by regulation • Energy Community can have its own sub-balancing area • Energy Community is constrained to one BRP • In case of SuperPED formulation, both PEDs interact with the same BRP.
Precondition(s)
Energy Community has formulated a PED.

Actors			
Actor name	Actor type	Actor description	Further information
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Provider of flexibility aggregates flexibility from several consumers and/or prosumers for flexibility market services.
PED Participant	Person	An entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.	Provider of flexibility aggregates flexibility from several consumers and/or prosumers for flexibility market services.
PED Manager/Operator	Business Entity	Ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	
Consumer/Prosumer	Person	A party that consumes electricity. This is a Type of Party Connected to the Grid. / A party that both consumes and generates electricity. This is a Type of Party Connected to the Grid.	Wants to reduce energy costs and/or increase sustainability.
BRP	Business Entity	A party responsible for imbalances in its balancing area within a given imbalance settlement period.	Optimise energy consumption / generation within its portfolio leveraging the flexibility of the energy community.
Energy Community (EC)	Business Entity	A legal entity that empowers citizens, small businesses and local authorities to produce,	

		manage and consume their own energy. It covers various parts of the energy value chain, including production, distribution, supply, consumption, and aggregation. Energy communities may vary depending on their location, involved actors and provided energy services.	

BUC-8: Optimise distribution grid operation by leveraging flexibility from PEDs

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	02.04.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)		
0.2	09.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)	Objectives, KPIs	
0.3	30.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)	KPIs, Preconditions updated	Approved

Scope and objectives of the use case	
Scope	The **Distribution System Operator (DSO)** is responsible for maintaining the Low/Medium Voltage distribution grid in a cost-effective way and for providing secure and high-quality power to end users. Leveraging flexibility from Positive Energy Districts (PEDs) can facilitate the DSO in these tasks.
Objective	1. Manage economically the distribution system deferring costly grid reinforcement investments 2. Ensure uninterrupted and high-quality power supply 3. Increased RES penetration 4. Improved Outage management
Related business case(s)	BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.)

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC8_1	Increased RES penetration	Increased RES penetration without grid reinforcement investments	O1, O3
KPI_BUC8_2	Increased RES absorption	Increased RES penetration due to reduced curtailments	O2, O3
KPI_BUC8_3	Reduced technical losses	Reduced technical losses due to improved local balancing	O1
KPI_BUC8_4	Reduced disruption of service	Reduced duration of power disruptions compared to cases where flexibility is not available?	O4

Classification information
Relation to other use cases
HLUC-4: Development of stakeholders' engagement and social innovation in PEDs HLUC-6: Flexibility aggregation and management at PED and SuperPED level HLUC-8: Accessing Data for PED operation through digital tools
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Flexibility, demand response, active management of distribution grid, grid investments deferral

Narrative of use case
Short description
The **Distribution System Operator (DSO)** is responsible for maintaining the Low/Medium Voltage distribution grid in a cost-effective way and for providing secure and high-quality power to end users. In order to manage grid problems such as voltage issues and congestions, the DSO requests flexibility from a PED(s) within its system. The flexibility can be activated implicitly (i.e. through price signals) or explicitly through a **PED Manager**, who offers the aggregated flexibility to the DSO via bilateral contracts or through an open market.
Complete description
The rise of renewables, general shift towards electrification of energy consumption (e.g., mobility and heating/cooling), and gradual phase-out of centralised generation units within the context of

decarbonisation are increasing the needs of system operators for flexibility at the level of the distribution system. DSOs may request flexibility for: • Voltage control, as increased/decreased voltage levels can occur in the local grid when renewable systems generate significant reverse power flows, or respectively when local consumption highly exceeds production. • Congestion control, as further increase/decrease of voltage over the limit (normally ±10% of the rated voltage) in case of high production or consumption may lead to a power outage. Furthermore, by reducing peak loads, the lifetime of grid components can be extended. • Reducing technical network losses by reducing peak loads (since the energy lost during transportation is physically proportional to the square of the transported energy). • Smoother black out management, as demand is usually increased after a power outage event and restoration procedures may be significantly challenged. The PEDvolution ecosystem will enable the realisation of this business case by offering solutions for flexibility management at PED level, exploiting sector coupling such as EV charging and Power2Heat asset, as well as the concept of a super PED. Flexibility can be activated by the **DSO** implicitly (i.e. through price signals) or explicitly through a **PED Manager**, who offers the aggregated flexibility to the DSO via bilateral contracts or through an open market. The set of solutions of PEDvolution consider the preferences of the **PED residents** and **PED Participants** for exposing the aggregated flexibility (see BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.)), such as individual residential and/or commercial **Consumers** and/or **Prosumers**, as well as at aggregated level (e.g., facility/building).

Use case conditions
Assumption(s)
• The DSO is allowed to offer either implicit DR schemes for network tariffs or explicit DR incentives. • The PED Manager acts as an Aggregator in the electricity market and sells available flexibility directly or through intermediaries to the market.
Precondition(s)
• Metering infrastructure available for DR verification. • PED Manager has recruited PED residents and PED Participants to participate in DR schemes. • Smart infrastructure is present in the buildings to enable data acquisition and control strategies

Actors			
Actor name	Actor type	Actor description	Further information
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a	Utilises the flexibility from PED(s) to defer costly capacity upgrades and optimise the system’s operation.

		given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	
Aggregator	Business Entity	A party that aggregates resources for usage by a Balancing Service Provider for energy market services.	Aggregates several consumers and/or prosumers for flexibility market services.
PED Manager	Business Entity	Ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Wants to sell flexibility of PED Residents and PED Participants (consumers/prosumers) as an Aggregator.
Consumer/Prosumer	Person	A party that consumes electricity. This is a Type of Party Connected to the Grid. / A party that both consumes and generates electricity. This is a Type of Party Connected to the Grid.	Wants to reduce energy costs and/or increase sustainability.
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Provides flexibility via implicit/explicit schemes.
PED Participant	Person	Person/entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.	Provides flexibility via implicit/explicit schemes.

BUC-9: Aggregate flexibility from buildings

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.2	28.03.2024	Evyatar Littwitz (ESG) Rainer Härtl (ESG)	2	
0.3	29.03.2024	Reda El Makroum (TUW)		
0.4	03.05.2024	Reda El Makroum (TUW)		
0.5	09.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM)	Objectives, Narrative, Assumptions	Refactoring needed

		Isidoros Kokos (ICOM)		
0.6	16.05.2024	Reda El Makroum (TUW)		
0.7	29.05.2024	Reda El Makroum (TUW)		Approved

Scope and objectives of the use case	
Scope	The business case centers on the successful aggregation of flexibility from all types of buildings (like residential, commercial and others), enabling a **PED manager** to fully exploit their potential, generating value from this flexibility without a negative impact to local business operations and prosumer comfort and quality of life.
Objective	1) Estimation of aggregated flexibility using different methodologies. 2) Generate profits from aggregate flexibility management. 3) Ensure no negative impact to the quality of life of prosumers.
Related business case(s)	BUC-5: Increase value of products by integrating them in energy communities. BUC-6: Optimise economically the cost of electricity production. BUC-7: Optimise BRP operation by leveraging electricity flows within the energy community. BUC-8: Optimise grid operation by leveraging flexibility from PEDs.

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC9_1		Accuracy of Flexibility Aggregation Estimates	O1
KPI_BUC9_2		Amount of Profit Generated	O2
KPI_BUC9_3		Impact on Quality of Life	O3

Classification information
Relation to other use cases
HLUC-6: Flexibility aggregation and management at PED and SuperPED level HLUC-8: Accessing Data for PED operation through digital tools
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Flexibility, demand response, scheduling optimisation

Narrative of use case
Short description
PED solution providers will analyze the current amount and type of buildings in their PED. They have to look up existing ways to aggregate and identify flexibility from these households and choose which tool they can use in the most sufficient way for this purpose. An **aggregator** is responsible for managing these flexibilities from energy assets and energy communities within the PED. In the best case, standard software is used to enable transferability for other PEDs. The aim of the aggregation is to combine all buildings so that even small flexibilities can be used in total.
Complete description
The flexibility of buildings varies greatly depending on their use type and occupancy patterns, so there is a need to effectively combine them and increase their impact in optimal management of a PED. The objectives include analysing the existing building types within the PED and examining the current tools available for flexibility aggregation in the building sector. Additionally, the evaluation will focus on determining the most efficient and straightforward methodologies for aggregating flexibility from buildings. Finally, there will be a practical review to identify the best tool for this purpose. **PED managers**, who also function as aggregators, must always be aware of the flexibility potential of their PED. To achieve this, it is not only important to include large consumers and producers, but also smaller prosumers or even consumers. Private households or small businesses usually have fluctuating or small flexibility potential, particularly due to the higher possibility of impacting the quality of life of residents who live and interact within the PED. However, as these participants in a PED usually occur in large numbers, it is important for an aggregator to take them into account and bundle their potential in order to make them valuable for the local Positive Energy District. Hence tools enabling the analysis of a big portfolio of building and analysing their flexibility potential under different methodologies/schemes - enabling tailored solutions- are crucial for the aggregation of PED's flexibility. Furthermore, the PED manager is in need of solutions offering the optimal operation of the aggregated portfolio enabling self-balancing or selling aggregated flexibility to the market

Use case conditions
Assumption(s)
• The PED Manager acts as an Aggregator in the electricity market and sells available flexibility directly or through intermediaries. • PED Manager has recruited PED Residents and PED Participants to participate in DR programs. • Smart infrastructure is present in the buildings to enable data acquisition and control strategies.
Precondition(s)

Actors			
Actor name	Actor type	Actor description	Further information
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution	Utilises the aggregated flexibility from PED(s) to defer costly capacity

		system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	upgrades while ensuring desired system operation.
Aggregator (PED Manager/Operator)	Business Entity	A party that aggregates resources for usage by a Balancing Service Provider for energy market services.	Aggregates several consumers and/or prosumers for flexibility market services.
PED Manager/Operator	Business Entity?	Ensures the functioning of a PED incl. infrastructure, living and interfaces with context.	Functions as an Aggregator within the PED and sells aggregated flexibility of PED Residents and PED Participants (consumers/prosumers) as an additional flow of income.
Consumer/Prosumer (PED Resident and/or PED Participant)	Person	A party that consumes electricity. This is a Type of Party Connected to the Grid. / A party that both consumes and generates electricity. This is a Type of Party Connected to the Grid.	Wants to reduce energy costs and/or increase sustainability.

BUC-10: Reduce dependencies on fossil fuels for district heating and cooling.

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
1	28.03.2024	Nirav Patel (TUW)		
1.1	03.05.2024	Nirav Patel (TUW)		
1.2	09.05.2024	Nikolaos Charitos (ICOM) Ilia Petri (ICOM) Isidoros Kokos (ICOM)	Narrative	Refactoring needed
1.3	14.05.2024	Nirav Patel (TUW)	Scope, Narrative	Approved

Scope and objectives of the use case	
Scope	The primary focus is on analyzing current heating demand, local renewable resources, and inefficiency in heating systems within the district. Based on this assessment, solution providers will design efficient heating supply scenarios and

	investment strategies tailored to the local conditions. Led by the **Positive Energy District (PED**) manager and the **District Heating Operator (DHO)**, targeted measures and upgrades will be implemented in collaboration with relevant stakeholders to optimize district heating operation and significantly reduce fossil fuel dependencies at the district level.
Objective	1) Fossil fuels Reduction: The primary goal is minimising fossil fuel reliance for heat generation. By doing so, the **District Heating System (DHS)** can contribute to environmental sustainability and reduce greenhouse gas emissions. 2) Efficiency Enhancement: The use case aims to improve optimize the design and operation of district heating systems. This optimisation ensures maximum efficiency in heat production, distribution, and utilisation. 3) Integration of Renewable and Waste Heat Sources: To achieve long-term sustainability, the use case promotes incorporating renewable energy sources (such as solar and geothermal) and waste heat into the DHS. This diversification helps reduce dependence on fossil fuels.
Related business case(s)	BUC-1: Gain profit through energy certification of districts. BUC-3: Prove accomplishment of sustainability goals. BUC-4: Decrease energy costs by renovating the existing building stock BUC-5: Increase value of products by integrating them in energy communities.

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
KPI_BUC10_1	Fossil Fuel Reduction Rate	Measure the percentage reduction in fossil fuel consumption for heat generation compared to the base year.	O1
KPI_BUC10_2	Greenhouse Gas Emission Reduction	Quantify the reduction in greenhouse gas emissions resulting from the optimised district heating system.	O1
KPI_BUC10_3	Renewable Energy Integration	Monitor the share of renewable energy sources in the overall heat supply. Aim for a target percentage to ensure long-term sustainability.	O3
KPI_BUC10_4	Waste Heat Utilisation	Assess the utilisation of waste heat from industrial processes or other sources.	O3
KPI_BUC10_5	Higher system efficiency	Measures the overall efficiency of the district heating system from production to utilisation.	O2

Classification information
Relation to other use cases
HLUC-1: Calculate PED assessment indices and PED certification

HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-7: Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector HLUC-8: Accessing Data for PED operation through digital tools
Level of Depth
High
Prioritisation
Medium
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
District heating and cooling, District heating operator, Renewable energy sources, waste heat

Narrative of use case
Short description
PED solution providers will analyze the existing heating infrastructure, along with the current and future and heating demand within the district. Based on this assessment, they will design efficient heating supply scenarios and investment strategies tailored to the local conditions, which will also include renovation pathways to consider the future heat demand. Led by the **PED manager** and the **District Heating Operator (DHO)**, targeted measures and upgrades will be implemented. The overarching goal is to develop optimal implementation and investment pathways for district heating infrastructure. This includes creating supply portfolios based on locally available Renewable Energy Sources (RES) and excess heat potentials, which will substantially decrease the reliance on fossil fuels for DHS at the district level.
Complete description
The European Union's Climate Law and the Green Deal target to reach carbon neutrality by 2050. Heating and cooling transition are crucial in this target as they constitute nearly half of the EU's final energy consumption and have traditionally been dominated by fossil fuels such as natural gas, oil, and coal. **PED solution** providers will analyze the existing heating infrastructure and heating demand within the district. Based on this assessment, they will design efficient heating supply scenarios and investment strategies tailored to the local conditions, which will also include renovation pathways to consider the future heat demand. Led by the **PED manager**, assumed for example by the local **municipality** managing the district heating network, and the DHO, targeted measures and upgrades will be implemented. The overarching goal is to develop optimal implementation and investment pathways for district heating infrastructure. This includes creating supply portfolios based on locally available RES and excess heat potentials, which will substantially decrease the reliance on fossil fuels for DHS at the district level. Objectives: • Fossil fuels Reduction: The primary goal is minimising fossil fuel reliance for heat generation. By doing so, the DHS can contribute to environmental sustainability and reduce greenhouse gas emissions.

- Efficiency Enhancement: The use case aims to optimize the design and operation of district heating systems. This optimisation ensures maximum efficiency in heat production, distribution, and utilisation. The use case aims to improve district heating systems. This optimisation ensures maximum efficiency in heat production, distribution, and utilisation.
- Integration of Renewable and Waste Heat Sources: To achieve long-term sustainability, the use case promotes the incorporation of renewable energy sources (such as solar and geothermal) and waste heat into the DHS. This diversification helps reduce dependence on fossil fuels.

Use case conditions
Assumption(s)
The municipality assumes the role of PED Manager.
Precondition(s)

Actors			
Actor name	Actor type	Actor description	Further information
PED solution provider	Business Entity	An entity providing solutions to the PED manager and municipality.	Aims to provide necessary technological infrastructure.
PED Manager	Business Entity	Ensures the functioning of a PED incl. infrastructure, living, and interfaces with context.	Wants to reduce the share of fossil fuel from the energy mix and meet the demand within the district.
Municipality	Authority	The local government of the city or town.	Wants to ensure the thermal comfort of citizens.
District Heating Operator	Business Entity	A party offering heating-related service within the district.	Aims to generate profit from the DHC services.
PED Resident (Consumer)	Person	A person living/working in the PED.	Wants to maintain the comfort at a low price.

ANNEX III: SYSTEM UC ANALYSIS

An overview of the HLUCs is presented in Section 5.2. In this Annex, their complete documentation is provided, based on IEC 62559-2 template.

HLUC-1: Calculation of PED assessment indices and PED certification

Version management				
Version No.	Date	Name of author(s)	Changes	Approval Status
0.1	04.07.2024	Matthias Haase (ZHAW)	First draft.	
0.2	12.07.2024	Matthias Haase (ZHAW), Nikos Charitos (ICOM)	Refactoring of scope, actors, narratives, assumptions and preconditions.	
0.3	16.07.2024	Matthias Haase (ZHAW), Mihaela Meslec (ZHAW), Nikos Charitos (ICOM)	UC diagram, basic scenario and steps.	
0.4	19.07.2024	Matthias Haase (ZHAW), Mihaela Meslec (ZHAW), Nikos Charitos (ICOM)	Information exchanged and requirements.	
0.5	24.07.2024	Matthias Haase (ZHAW), Mihaela Meslec (ZHAW), Nikos Charitos (ICOM)	Review and finalisation.	

Scope and objectives of the use case	
Scope	The PED Readiness Assessment framework of PEDvolution goes beyond the state-of-the-art by providing a framework for the dynamic and interactive platform where PED planners and solution providers can get streamlined and tailored decision support based on their local contexts and needs, and the changing environment. The PED RA framework will provide updated data about the performance of different solutions, their interoperability, and give insight into trade-offs between different goals and needs. As such, the PED

	RA framework forms the basis for reducing risks for PED planners, as well towards achieving a higher overall performance of the PED, based on the multitude of sustainability issues. Finally, it is noted that PED certification is useful also for benchmarking PEDs.
Objectives	Rating of districts with respect to PED Readiness, considering technical, social, economic and interoperability aspects.
Related business case(s)	BUC-1: Increase market value of districts through certification BUC-2: Increase income streams by embedding energy certification of building stock/area. BUC-3: Prove accomplishment of sustainability goals BUC-4: Decrease energy costs by renovating the existing building stock BUC-10: Reduce dependencies on fossil fuels
Related user experience goal(s)	-
Name of author(s)	Matthias Haase (ZHAW), Mihaela Meslec (ZHAW), Nikos Charitos (ICOM)

References						
No.	Type	Reference	Status	Impact	Originator / Organisation	URL
1	EU H2020 Project	ARV – Climate Positive Circular Communities	ongoing		NTNU	https://greendeal-arv.eu/
2	EU H2020 Project	oPENlab - Leading the transition to Positive Energy Neighbourhoods	ongoing		VITO	https://openlab-project.eu/
3	EU H2020 Project	Syn.ikia – Sustainable	ongoing		NTNU	https://www.synikia.eu/

		Plus Energy Neighbourhoods				
4	Smart Readiness Indicators (SRI)	VITO	finished		VITO	
5	Sustainable community certification scheme	SGNI	finished		SGNI	

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI_HLUC_1_1	No. of PED Readiness assessed PEDs	Number of ratings of districts with respect to PED Readiness	O1

Classification information
Relation to other use cases
HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-8: Accessing Data for PED operation and classification through digital tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic

Nature of the use case
Technical
Further keywords for classification
PED Readiness Assessment Framework, PED classification, PED certification, KPIs.

Narrative of use case
Short description
The PED RA framework measures the readiness and can thus be used to provide scenarios in dynamic decision-making tools. The inputs may partly be provided by the PED Planner or can be taken from available public data and/or other PED tools. The framework's inputs are energy performance data, built environment characteristics data, etc., exploited to calculate Key Performance Indicators (KPIs) regarding technology, market, social and interoperability. The output concerns the current situation of the PED, in terms of technology, market, social and interoperability. It can be used to assess the readiness of a PED and develop scenarios for decision making, e.g., users can choose different development pathways of the PED that they would like to explore. Relevant questions to be provided by the tool should be explored in cooperation with the PED planners. The PED RA framework can be integrated into Community certification schemes like the ones from Schweizer Gesellschaft für Nachhaltige Immobilien (SGNI) or Deutsche Gesellschaft für nachhaltiges Bauen (DGNB). The framework will provide outputs on technological aspects (e.g., energy performance, Smart Readiness Indicator (SRI) and flexibility, greenhouse gas (GHG) emissions), on market aspects (e.g., costs, affordability, etc.), on social aspects (e.g., thermal comfort, air quality, social innovation), and on interoperability.
Complete description
Within several ongoing H2020 projects such as ARV[4], oPENlab[5], and syn.ikia[6] frameworks are being developed for the planning and design of sustainable plus energy buildings and neighbourhoods. Thus, frameworks for identifying and assessing KPIs of positive energy buildings and neighbourhoods, are available. Such frameworks and guidelines provide useful insights into how to achieve a multitude of performance goals for PEDs, as well as information on needs of different users, and changing conditions and evolution of technologies, markets, policies, and social context. Generation of report on PED Readiness.

[4] https://greendeal-arv.eu/
[5] https://openlab-project.eu/
[6] https://www.synikia.eu/

The PED Readiness Assessment (RA) Framework gets data on the four PED dimensions from external systems in the PED's context (e.g., AMI, DH Management System) and PEDvolution solutions (e.g., PED Design and Planning Toolset, PED Energy Manager), which serve as inputs for calculating the various KPIs. KPIs should be in units that allow comparison of different PEDs, e.g., electricity consumption per inhabitant, installed PV capacity per m^2. Each KPI is mapped to one or more of the four PED genotypes (technology, market, social, interoperability). It is highlighted that the various dimensions of a PED should be balanced. Based on the scores of all relevant KPIs, a total score per genotype (i.e., PED dimension) is calculated by the PED RA Framework. The inputs are given for the current situation of the PED, in terms of environmental, social, economic performance, Indoor Air Quality (IAQ) and flexibility indicators. The PED RA framework measures the readiness and can thus be used to provide scenarios in dynamic decision-making tools. The inputs may partly be provided by the PED Planner or can be taken from available public data and/or other PED tools. The PED RA Framework provides the PED Planner with a report assessing the PED on the aspects of technology, market, social and interoperability. This report can be used as a basis to develop scenarios for decision making, e.g., users can choose different development pathways of the PED that they would like to explore by utilising the Dynamic Decision Support Guideline (DDSG) for PED development subsequently to the PED RA Framework. Furthermore, the PED Planner, along with the PED Manager, can exploit this report in consultations with potential PED investors to attract investments in the further development of their PED. The framework will provide output on technological aspects (e.g., energy performance, SRI and flexibility, GHG emissions), market aspects (e.g. costs, affordability, etc.), social aspects (e.g. thermal comfort, air quality, social innovation), and interoperability. The total score of a PED is calculated based on its scores on all the PED dimensions. Furthermore, PEDs can be classified based on the total score, thus enabling PED benchmarking. The PED RA framework can also be integrated into Community certification schemes, such as SGNI/DGNB. In the context of the PEDvolution pilots, ZHAW will assume the role of the PED Certifier, as the solution provider of the PED RA Framework.

Use case conditions
Assumption(s)
• All needed data for assessing a PED can be provided. • PED Managers and potential investors are interested in getting an assessment for their districts/PEDs. • In the context of the PEDvolution pilots, ZHAW will assume the role of the PED Certifier, as the solution provider of the PED RA Framework.
Precondition(s)

• Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation and Classification through Digital Tools).

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
PED Certifier		An entity that certifies, based on a framework, the sustainability of apartments, buildings, neighbourhoods, or cities. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.	Utilises the PED Readiness Assessment Framework to assess a PED.
PED Planner		A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.	The PED Planner is interested in the PED Readiness Assessment report to see the current evaluation of its PED and potentially obtain a certification.
PED Manager		A party that assumes this role, manages the functioning of a PED and/or ensures data availability and/or accessibility for further research and innovation development.	The PED Manager is interested in the report of the PED Readiness Assessment to see the current evaluation of its PED and potentially obtain a plan on how to improve the PED.
PED Investor		An entity interested in investing in the development and/or operation of a PED.	The PED Investor can get the report of the PED Readiness Assessment Framework from the PED Planner/Manager/Certifier. This report can be utilised by the PED

			Investor to decide whether to invest in a PED.
PED Readiness Assessment Framework		A framework that will assess districts with respect to PED Readiness, considering technical, social, economic and interoperability aspects.	The framework that will be utilised by the PED Certifier to assess the readiness of a district.
Advanced Metering Infrastructure	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect, and manage data from smart meters.	The advanced metering infrastructure secures the measurement and reporting of various power-related KPIs as a basis for the PED RA.
District Heating Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	The DH Management system enables a sustainable heating of the PED and is thus the basis for a good score in the PED RA.
Dynamic Decision Support Guideline for PED Development	System	A system that will specify how different technologies, strategies, goals and KPIs should be interconnected for the optimal development of a PED.	This DDSG is a dynamic tool which uses the PED RA framework as a basis to assess the current state of PEDs in terms of Readiness.
External Platform	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider context of PEDvolution and will not	External certification platforms are possible to connect with the PED RA framework. This will allow a unified approach and allows comparison of different PEDs.

		be developed in the project.	
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	The PED assets are the basis for the technology part of the PED RA framework. However, social, market and interoperability aspects will also be linked to these assets.
PED Design and Planning Toolset	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	Data derived from the PED Design and Planning Toolset can be utilised as inputs by the PED Readiness Assessment framework.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	Data derived from the PED Energy Manager can be utilised as inputs by the PED Readiness Assessment framework.
PED Business Models Tool	Methodology	A tool that will co-develop the business models of each PED.	Data derived from the PED Business Models Tool can be utilised as inputs by the PED Readiness Assessment framework.
PED Social Innovation Tool	Methodology	A tool that will implement roadmaps for stakeholder engagement, including the involvement in energy communities.	Data derived from the PED Social Innovation Tool can be utilised as inputs by the PED Readiness Assessment framework.

Diagram(s) of use case
Diagram presented in subchapter 5.2.1.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
PED Readiness Assessment	PED RA evaluation according to framework	PED Certifier	Request for Readiness Assessment	All needed information for PED RA available	Evaluation of PED RA according to RA framework

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	PED Planner asks for an assessment of the current state of its PED.	Get PED Readiness inputs	All KPIs relevant for PED RA are collected	GET	3rd Party Platforms & Field Devices, DH Management System, AMI, PED DEsign and Planning Toolset, PED Energy Manager, PED Social Innovation Tool, PED Business Models Tool	PED Readiness Assessment Framework	Existing inputs in the context view, additional from external platforms (e.g. power and heat generation/consumption data), outputs of other PEDvolution solutions (e.g. Implementation actions report by PED design and planning toolset)	SEC-1, SEC-2
2	1	Calculate PED Readiness	Calculation of PED Readiness based on the above KPIs for the different PED dimensions (market, social, interoperability, and technology, accounting for	CREATE	PED Readiness Assessment Framework	-	Calculation of all needed KPIs for each one of the PED dimensions (in relevant units)	

			both planning and management).					
3	2	Evaluate/Rate PED Readiness	Evaluation of the PED Readiness against a 0-100% PED in 4 (or 5) dimensions.	CREATE	PED Readiness Assessment Framework	-	PED Readiness Assessment in each one of the PED dimensions (scaled)	USY-1
4	3	Rating	Output of the PED RA (in 4 or 5 dimensions)	CREATE	PED Readiness Assessment Framework	PED Certifier	Total PED Readiness Assessment	USY-1
5	4	Visualisation	Visualisation of the PED RA assessment (e.g. spider diagram)	CREATE	PED Readiness Assessment Framework	PED Certifier	Visualisation of PED Readiness Assessment (including ratings on the separate dimensions and the total rating)	USY-1

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Sensing Data	• Power consumption/production measurements • Sub-meter data • Heat consumption/production measurements • Energy storage measurements • Etc.	INT-1
INF-2	Weather Data	Weather measurements and forecasts	INT-2
INF-3	Energy Price Data	Energy price data, consisting of (when applicable): • Retail electricity price data • Network electricity price data • DH price data • Feed-in tariffs	INT-3
INF-4	PED & built Environment Characteristics	• District Technical Characteristics • District Economic Characteristics • District Social Characteristics/Assessment • PED Business Models • District Geospatial Data • Building Stock Characteristics • HVAC/Solar panels/Battery systems characteristics • Fossil Fuel Consumption Data • CO_2 Emissions Data	INT-4, INT-5

Requirements		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**
Requirements ID	**Requirement name**	**Requirement description**
INT-1	Sensing data standards	Compliance with state-of-the-art standards in energy time series.
INT-2	Weather data standards	Compliance with state-of-the-art standards in weather time series.
INT-3	Energy price data standards	Compliance with state-of-the-art standards in energy price time series.
INT-4	Interoperability on building characteristics data	Compliance with state-of-the-art standards concerning data on building characteristics (i.e., data on physical properties of buildings).
INT-5	Interoperability on PED data concerning various aspects (e.g., social, business models, economic, etc.)	Compliance with common data models that will be utilised by all the relevant PEDvolution solutions.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.

USY-1	Clarity of information presented	The information presented to end users (e.g., calculation of KPIs, rating of PED in various dimensions, etc.) should be clear.

HLUC-2: Identification of energy improvement opportunities towards PED characterisation

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	28.06.2024	Inger Andresen (NTNU)	1st draft	
0.2	02.08.2024	Jesus Daniel Garcia Melo (NTNU)	Added content in narration, UC diagram, step-by-step analysis.	
0.3	06.08.2024	Inger Andresen (NTNU) Jesus Daniel Garcia Melo (NTNU) Nikos Charitos (ICOM)	Added content in information exchanged and requirements. Reviewed document.	

Scope and objectives of the use case	
Scope	The decision-support guideline of PEDvolution aims to assist PED Planners in exploring different development pathways and making strategic decisions by providing them with a set of scenarios on the further development of their districts. It goes beyond the state-of-the-art, as opposed to other static frameworks and guidelines, providing a dynamic and interactive platform, where PED planners and solution providers can get streamlined and tailored decision support based on their local contexts and needs and the changing environment, accounting for evolution of technologies, markets, policies, and social context. The guideline will provide decision-makers with updated data about the performance of different solutions, their interoperability, and give insight into trade-offs between different goals and needs. As such, the dynamic guide will be able to reduce risks for PED planners and

	guide them towards achieving a higher overall performance of the PED, based on the multitude of sustainability issues.
Objectives	Identification of energy improvement opportunities/scenarios towards (further) development of a PED, and the related environmental, social, and economic impacts.
Related business case(s)	BUC-2: Increase income streams by embedding energy certification of building stock/area. BUC-3: Prove accomplishment of sustainability goals BUC-4: Decrease energy costs by renovating the existing building stock BUC-10: Reduce dependencies on fossil fuels
Related user experience goal(s)	-
Name of author(s)	Inger Andresen (NTNU) Jesus Daniel Garcia Melo (NTNU) Nikos Charitos (ICOM)

References						
No.	**Type**	**Reference**	**Status**	**Impact**	**Originator / Organisation**	**URL**
1	EU H2020 Project	ARV – Climate Positive Circular Communities	ongoing		NTNU	https://greendeal-arv.eu/
2	EU H2020 Project	oPENlab - Leading the transition to Positive Energy Neighbourhoods	ongoing		VITO	https://openlab-project.eu/
3	EU H2020 Project	Syn.ikia – Sustainable Plus Energy Neighbourhoods	ongoing		NTNU	https://www.synikia.eu/

Key performance indicators

ID	Name	Description	Reference to mentioned use case objectives
KPI_HLUC_2_1	Total energy reduction	Percentage reduction in total energy consumption compared to baseline.	O1
KPI_HLUC_2_2	Buildings energy consumption reduction	Reduction in energy consumption per square meter of building space.	O1
KPI_HLUC_2_3	System-specific energy reduction	Decrease in energy consumption for specific systems (e.g., heating, cooling, lighting).	O1
KPI_HLUC_2_4	EPC optimisation	Energy efficiency rating improvement according to Energy Performance Certificate (EPC) assessments.	O1
KPI_HLUC_2_5	CO2 emissions saving	CO_2 emission savings can be tracked in comparison to a baseline scenario and/or in comparison to a starting year	O1
KPI_HLUC_2_6	SRI rating	Occupant satisfaction surveys or ratings related to comfort and smart features (SRI rating).	O1
KPI_HLUC_2_7	RES increase	Increase in on-site renewable energy generation and storage	O1

Classification information
Relation to other use cases
HLUC-1: Calculate PED assessment indices and PED certification HLUC-3: Implementation of renovation and upgrades for energy savings and cost reduction for PEDs in building environment HLUC-8: Accessing Data for PED operation and classification through digital tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Multi-criteria decision support guideline for PED development, technology, economy, society, interoperability, alternative scenarios.

Narrative of use case
Short description
The PED Dynamic Decision Support Guideline (DDSG) is designed to evaluate and improve the performance and combination of PEDvolution solutions. It gathers real-time data on various aspects, including energy needs, generation installations, energy prices, financing, geospatial data, and legislation, to help PED Planners make informed decisions. The tool allows users to develop scenarios by combining different energy needs, technologies, and costs, and then analyse the impact of these decisions on technological, social, economic, and environmental aspects. The outputs are presented as scenarios with key performance indicators (KPIs) related to energy performance, greenhouse gas (GHG) emissions, and costs, which help PED Planners explore different development pathways and make strategic decisions. The tool can answer questions relevant to optimising energy generation and storage for new buildings or assessing trade-offs between different investment options.
Complete description
Within several ongoing H2020 projects such as ARV[7], oPENlab[8], and syn.ikia[9] frameworks and guidelines are being developed for the planning and design of sustainable plus energy buildings and neighbourhoods. They provide insight and knowledge about technologies and performances and guide decision-makers towards life cycle based and high performing buildings and neighbourhoods. Also, frameworks for identifying and assessing key performance indicators (KPIs) of positive energy buildings and neighbourhoods, are available. The Dynamic Decision Support Guideline (DDSG) goes beyond the state-of-the-art, as opposed to other static frameworks and guidelines, it provides a dynamic and interactive platform, where PED planners and solution providers can get streamlined and tailored decision support based on their local contexts and needs and the changing environment, accounting for evolution of technologies, markets, policies, and social context. In order to generate the set of alternative scenarios on the development of a PED, the Dynamic Decision Support Guideline (DDSG) first gets a report on the current status of the district by the PED Readiness Assessment (RA) Framework. Furthermore, the DDSG needs data from all the PEDvolution solutions (e.g., PED Energy Manager, PED Design and Planning Toolset, etc.) to assess their current performance and the interoperability between them, as well as from systems, interfaces and applications in the context of each PED (e.g., AMI for power generation/consumption data, etc.). It is noted that the various input data should be up-to-date. The needed inputs – amongst others – include:

[7] https://greendeal-arv.eu/
[8] https://openlab-project.eu/
[9] https://www.synikia.eu/

- **Thermal and electric energy and power demand:** As regards buildings, data such as type, size, location, form, shading conditions, storage, use profiles, controls, and costs of energy renovation are needed. Information on energy demand at PED level include also mobility, EV charging, street lighting, etc.
- **Energy generation and storage assets:** Needed data per asset concern type, energy/power yield, life cycle GHG emissions, location, size, and costs. Asset categories of interest include solar, biomass, heat pump systems, batteries, fossil fuel installations, etc.
- **Energy prices:** Data on (retail and network) electricity prices (including taxes), as well as district heating prices. Furthermore, data on fuel prices for each relevant fuel (including taxes) are needed.
- **Financing availabilities:** Data on any available incentives that could be leveraged for the development of PED should be gathered, such as tax reductions, green loans, etc.
- **Geospatial data:** Data on the local climate and environment, such as weather measurements and forecasts and long-term climate projections, dust, etc.
- **Legislation and area specifications:** Data of interest – if available – under this category may concern area use (e.g., requirement for green spaces, etc.), noise, pollution, destruction caused by past wildfires, architectural requirements (e.g., heights/volumes), daylight and solar access, energy sharing, mobility (e.g., street design).
- **Business models:** Information on business models, which can be applied to a district, such as development of an energy community, energy performance contracts, etc.

Once the needed inputs are received by the DDSG, they are formatted according to the KPIs structure, which is utilised by the tool. The end users of the DDSG, namely PED Planners, can set their goals and preferences for the development of a PED through a dedicated User Interface (UI). Subsequently, the DDSG, considering also the user inputs, develops scenarios on the further development of a PED, considering the impact of alternative decisions on the various PED genes (i.e., technological, social – including environmental aspects – economic, and interoperability aspects). Indicative examples of questions into which the tool can provide insight are: 'If we were to construct 1000 m^2 of new residential buildings with passive house standard and roof integrated PVs and related EVs, what kind of energy generation and storage solutions would most effectively satisfy the energy needs to a lowest possible cost?', or: 'What are the trade-offs between renovating the existing buildings to passive house standard or investing in a common PV system for the area?'. Relevant questions that the tool should provide, should be explored in cooperation with the PED Planners.

Upon calculating the set of alternative scenarios, the output is presented through the UI of the DDSG to the PED Planners, so that they can decide on their preferred one. The outputs will be presented in a compilation of scenarios with the related KPIs, primarily concerning energy balance and energy performance, GHG emissions, and costs, while they may be supplemented by different energy/power KPIs, SRI and

flexibility indicators, economic KPIs, environmental KPIs (e.g., thermal comfort, air quality), and social KPIs (e.g., affordability). It is noted that PED Planners, based on the generated set of scenarios, can reassess their goals and preferences for the further development of the district and update them through the dedicated UI, thus generating a new set of scenarios.

Use case conditions
Assumption(s)
All needed data for calculating the alternative scenarios of the PED development can be provided.
Precondition(s)
Data accessible via Interoperability Platform (HLUC-8 Access Data for PED Operation through Digital Tools).

General Remarks
-

Diagram(s) of use case
Diagram presented in subchapter 5.2.2.

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
Dynamic Decision Support Guideline for PED development (DDSG)	System	A system that will specify how different technologies, strategies, goals and KPIs should be interconnected for the optimal development of a PED.	The DDSG identifies energy improvement opportunities/scenarios towards (further) development of a PED, and the related environmental, social, and economic impacts, assisting the PED Planner in making informed decisions on PED development.
PED Planner	Business Entity	A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with	The PED Planner is the end user of the DDSG, who aims to explore alternative scenarios for the development of a PED through it.

		environment and further stakeholders.	
Advanced Metering Infrastructure	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect, and manage data from smart meters.	Provides power consumption and production measurements to the DDSG.
District Heating Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	Provides to the DDSG data on heat consumption and production measurements, thermal energy storage, etc.
External Platform	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider context of PEDvolution and will not be developed in the project.	Provides the DDSG with data such as sub-meter data, energy storage measurements, etc.
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Data from PED Assets will be communicated to the DDSG through relevant External Platforms.
PED Readiness Assessment Framework	Methodo logy	A methodology that will assess PEDs in terms of energy balance, as well as individual buildings	Calculates a report on the current status of a PED, which is provided to the DDSG as a basis for the calculation of

		considering their energy performance and smart readiness.	alternative scenarios for the development of a PED.
PED Design and Planning Toolset	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	Data derived from the PED Design and Planning Toolset can be utilised as inputs by the Dynamic Decision Support Guideline for PED development.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	Data derived from the PED Energy Manager can be utilised as inputs by the the Dynamic Decision Support Guideline for PED development.
PED Business Models Innovation Tool	Methodo logy	A tool that will co-develop the business models of each PED.	Data derived from the PED Business Models Innovation Tool can be utilised as inputs by the the Dynamic Decision Support Guideline for PED development.
PED Social Innovation Tool	Methodo logy	A tool that will implement roadmaps for stakeholder engagement, including the involvement in energy communities.	Data derived from the PED Social Innovation Tool can be utilised as inputs by the the Dynamic Decision Support Guideline for PED development.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
Generic	Establishment of alternative scenarios for (further) development of a PED	PED Planner	Low energy efficiency, high energy bills and poor environmental performance	Existing non-PED or PED that can be further enhanced	(more mature) PED

Generic								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	Get input data	Collection of input data for DDSG	Get needed input data from other systems, so that the set of scenarios can be generated	GET	PEDvolution solutions, PED External Platforms, etc.	DDSG	Sensing data Weather data Energy price data PED and built environment characteristics	SEC-1, SEC-2
2	Format input data	Formatting of input data for DDSG	Format of input data from other solutions and/or PED	CREATE	DDSG	-	Sensing data Weather data	

			according to the needed structure for the KPIs of the DDSG				Energy price data PED and built environment characteristics	
3	PED Planner	Set user goals, criteria and weighting	Describe overall goals for the area to be transformed and select assessment criteria and related KPIs. Perform weighting between criteria.	CREATE	PED Planner	DDSG	Visualisation of KPIs and weights	USY-1
4	Create and assess future scenarios	Scenario generation and assessment by the user (i.e., PED Planner)	Set up and assess possible future scenarios of development of the PED	CREATE	DDSG	PED Planner	Visualisation of data on future possible energy and environmental performances	USY-1
5	Iterations	Iterate	If viable solution is not found, go through steps 3-4 again	GET , CREATE	DDSG	PED Planner	Visualisation of data on future possible energy and	USY-1

							environmental performances	

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Sensing Data	Power consumption/production measurements Sub-meter data Heat consumption/production measurements Energy storage measurements	INT-1
INF-2	Weather data	Weather measurements and forecasts Long-term projections on the climate of the district	INT-2
INF-3	Energy Price Data	Energy price data, consisting of (when applicable): Retail electricity price data Network electricity price data DH price data Feed-in tariffs	INT-3
INF-4	PED & built Environment Characteristics	District Technical Characteristics District Economic Characteristics District Social Characteristics/Assessment PED Business Models District Geospatial Data Building Stock Characteristics HVAC/Solar panels/Battery systems characteristics Fossil Fuel Consumption Data CO_2 Emissions Data	INT-4, INT-5

Requirements (optional)		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**
Requirements ID	**Requirement name**	**Requirement description**
INT-1	Sensing data standards	Compliance with state-of-the-art standards in energy time series.
INT-2	Weather data standards	Compliance with state-of-the-art standards in weather time series.
INT-3	Energy price data standards	Compliance with state-of-the-art standards in energy price time series.
INT-4	Interoperability on building characteristics data	Compliance with state-of-the-art standards concerning data on building characteristics (i.e., data on physical properties of buildings).
INT-5	Interoperability on PED data concerning various aspects (e.g., social, business models, economic, etc.)	Compliance with common data models that will be utilised by all the relevant PEDvolution solutions.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.

USY-1	Clarity of information presented	The information presented to end users (e.g., calculation of KPIs, rating of PED in various dimensions, etc.) should be clear.

HLUC-3: Planning of renovation and upgrades for energy savings and cost reduction for PEDs in building environment

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	4.07.2024	Mohsen Sharifi (VITO), Amin Kouti (VITO)	First version.	
0.2	16.07.2024	Amin Kouti (VITO), Nikos Charitos (ICOM), Nirav Patel (TUW)	Refactoring of scope, actors, narratives, assumptions and preconditions.	
0.3	19.07.2024	Amin Kouti (VITO), Nikos Charitos (ICOM), Nirav Patel (TUW)	UC diagram, basic scenario and steps, information exchanged and requirements.	
0.4	25.07.2024	Amin Kouti (VITO), Nikos Charitos (ICOM), Nirav Patel (TUW)	Review and finalisation.	

Scope and objectives of the use case

Scope	This use case focuses on the renovation and upgrading of existing buildings within PEDs to enhance energy efficiency and reduce costs, as well of increase in RES production and utilisation. It involves analysing current energy consumption patterns, identifying inefficiencies, and implementing targeted renovation measures. The scope includes collaboration among PED solution providers, PED managers, building owners, and municipalities to ensure successful execution and monitoring of renovation activities.
Objectives	• Reduction (compared to BAU) in overall energy consumption and costs after implementation, to meet or exceed local energy efficiency standards and regulations, resulting in significant individual cost savings and a corresponding reduction in carbon emissions. • Enhance the comfort and smartness of the existing building stock to improve occupants' well-being and productivity. • Increase (compared to BAU) in overall renewable energy production by integrating renewables in the built environment.
Related business case(s)	• BUC-4: Decrease energy costs by renovating the existing building stock • BUC-6: Optimise economically the cost of electricity production • BUC-8: Optimise gird operation by leveraging flexibility from PED
Related user experience goal(s)	TBD
Name of author(s)	Mohsen Sharifi (VITO) Amin Kouti (VITO), Nikos Charitos (ICOM), Nirav Patel (TUW)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**

KPI_HLUC_3_ 1	Total energy reduction	Percentage reduction in total energy consumption compared to baseline.	O1
KPI_HLUC_3_ 2	Buildings energy consumption reduction	Reduction in energy consumption per square meter of building space.	O1
KPI_HLUC_3_ 3	System-specific energy reduction	Decrease in energy consumption for specific systems (e.g., heating, cooling, lighting).	O1
KPI_HLUC_3_ 4	EPC optimisation	Energy efficiency rating improvement according to Energy Performance Certificate (EPC) assessments.	O1
KPI_HLUC_3_ 5	CO_2 emissions saving	CO_2 emission savings can be tracked in comparison to a baseline scenario and/or in comparison to a starting year	O1
KPI_HLUC_3_ 6	SRI rating	Occupant satisfaction surveys or ratings related to comfort and smart features (SRI rating).	O2
KPI_HLUC_3_ 7	RES increase	Increase in on-site renewable energy generation and storage	O3

Classification information
Relation to other use cases
HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-8: Accessing Data for PED operation and classification through digital tools
Level of Depth
High
Prioritisation

High
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Building renovation, energy efficiency, energy costs savings, renewables integration, occupant comfort.

Narrative of use case
Short description
Achieving a positive energy district requires minimising energy demand and maximising local energy production. One way to minimize energy use is to improve energy efficiency in buildings. This can be achieved by building renovation measures also called energy conservation management (ECM). These measures include building fabric renovation, heating, cooling and ventilation improvement, solar panel installation. ECMs also help improve occupant comfort related to improved life quality and co-benefits in the district. This initiative is a collaborative effort involving **PED solution providers, PED Planners, PED managers, building owners, municipality, energy communities, and ESCOs**. By identifying energy inefficiencies and implementing targeted renovation measures, **PED Design and Planning Toolset** aims to significantly reduce operational costs, enhance energy efficiency, and integrate renewable energy sources within buildings.
Complete description
Building Renovation Building renovation is essential for achieving positive energy districts by significantly enhancing energy efficiency. Through measures such as upgrading building insulation, improving heating, cooling, and ventilation systems, and installing solar panels, energy consumption can be drastically reduced. These renovations not only lower energy demand, but also improve occupant comfort, wellbeing, and productivity. Additionally, renovated buildings are better equipped with RESs, such as PV or solar thermal, which allow on-site energy production and exchange. This enables energy flexibility, facilitating more effective demand-side management and contributing to lower energy costs and the overall sustainability of the district.

Objectives:

- Reduce (compared to BAU) overall energy consumption and costs after implementation, to meet or exceed local energy efficiency standards and regulations, resulting in significant individual cost savings and a corresponding reduction in carbon emissions.
- Enhance the comfort and smartness of the existing building stock to improve occupants' well-being and productivity.
- Increase (compared to BAU) in overall renewable energy production by integrating renewables in the built environment.

Renovation of existing building stock comes with main benefits from the perspective of PED Residents, such as reduced energy costs and emissions, and side benefits, such as enabling flexibility in buildings and enhanced occupant wellbeing and comfort (through advanced/smart renovations for building users).

The municipality/PED manager, in collaboration with PED solution providers and other stakeholders (building owners/users, ESCOs), will analyze current energy systems, energy consumption patterns, and inefficiencies within the building stock and develop renovation strategies that suit local conditions in a cost-optimised way as described in the following steps.

Assuming the data on current energy consumption (and production), building stock characteristics and district assets are available, and there is willingness of stakeholders in investing in renovation.

The PED Design and Planning Toolset (PED Renovation Planning Tool) (1) conducts a thorough analysis of current energy consumption and identifies areas for improvement based on the data available from the PED (e.g., retrieved by the AMI and the DH Management System) and information collected from the PED Planner and PED Residents. (2) Based on this analysis, the PED Design and Planning Toolset (PED Renovation Planning Tool) creates tailored renovation plans to address inefficiencies and leverage local conditions and comply with the regulatory framework. (3) The results are communicated to relevant stakeholders (e.g., the PED Planner and building occupants – namely PED Residents), so that they can access respectively the analysis on the district level and the renovation plan for each building. (4) Annual monitoring process will be established to keep track of transition process by retrieving updated data from the PED (e.g., through the AMI), while PED Residents shall update their building and asset data (such as updates on renovation actions) through a dedicated User Interface. The results can be exploited by the PED Design and Planning Toolset to reassess and further calibrate renovation actions. The updated renovation action plan is provided to the PED Planner (i.e., district level) and PED Residents (i.e., building level).

Within this context, the PED Planner can facilitate the orchestration of renovation of the building stock at the PED level, promoting targeted renovations and upgrades in collaboration with relevant stakeholders (PED members), which optimize energy usage and significantly reduce operational costs at the building level. Simultaneously, these efforts contribute to broader collective goals for the municipality and local community, such as less pollution (due to decarbonisation) and emissions reduction. Expected Outcomes: • Reduction in overall energy consumption and operational costs for building owners and residents. • Improved energy efficiency ratings and compliance with local energy standards. • Enhanced comfort, health, and well-being of occupants through improved indoor environment. • Increased adoption of renewable energy technologies and reduced carbon footprint of buildings. • Creation of job opportunities and economic benefits for local communities through renovation activities.

Use case conditions
Assumption(s)
• Availability of accurate data on current energy consumption and building characteristics. • Willingness of stakeholders to invest in renovation activities. • Positive ROI for renovation investments in the long term. • Construction and implementation are out of scope of this HLUC. • Access to advanced renovation technologies and skilled labour. • Communication channels between residents and PED manager (e.g., Energy Community)
Precondition(s)
• Favourable regulatory framework and incentives for energy-efficient renovations. • Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation and Classification through Digital Tools).

General Remarks
Continuous energy monitoring, as well as calibration and reassessment of buildings' renovation, are functionalities of the PED Design and Planning Toolset. However, it is noted that it is difficult for these functionalities to be executed during the lifetime

of the PEDvolution project. Hence, they could be part of the post-project exploitation, but are still relevant to the scope of this HLUC.

Actors			
Actor name	Actor type	Actor description	Further information
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Provide their data, their consent to participate, their opinion for the provided plan, their financial capacity/need for the plan.
PED Planner	Business Entity	A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.	PED Planner calculates optimal plans for renovation, communicates with residents and local governments, checks for possible legal support for the plan and potential benefits, aligns with other stakeholders for business development.
Municipality	Local authorities	The local government of a city or town.	Local governments can support PED Planners/Managers while communicating with residents. Local governments can build up trust between residents and PED Planners/Managers.
Energy Community	Set of system	A legal entity that empowers citizens, small businesses and local authorities to produce, manage and consume their own energy. It covers various parts of the energy	Energy communities facilitate communications between different stakeholders of a PED.

		value chain, including production, distribution, supply, consumption, and aggregation. Energy communities may vary depending on their location, involved actors and provided energy services.	
ESCO	Company	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may provide insight services as well as energy management services.	Interacts with PED Planners and PED Residents with respect to the implementation of certain renovation actions.
PED Design and Planning Toolset	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	The PED Design and Planning Toolset (particularly the PED Renovation Planning Tool) analyses building energy consumption, identifies areas for improvement, and creates tailored renovation plans.
District Heating Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and	The District Heating Management System provides the PED Design and Planning Toolset with input

		commercial heating requirements, such as space heating and water heating.	data on heat consumption/production.
Advanced Metering Infrastructure (AMI)	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect, and manage data from smart meters.	The AMI provides the PED Design and Planning Toolset with input data on power consumption/production.
External Platform	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider context of PEDvolution and will not be developed in the project.	Other External Platforms may provide the PED Design and Planning Toolset with input data on energy prices, energy storage measurements, etc.
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Data of PED Assets will be communicated to PEDvolution solutions, including the PED Design and Planning Toolset through relevant External Platforms.

Diagram(s) of use case
Diagram presented in subchapter 5.2.3.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
All buildings are energy efficient	In this scenario, all buildings will become energy efficient in a time horizon. KPIs are calculated by PED manager and an optimal plan and design is provided.	PED Design and Planning Toolset	Low energy efficiency and high energy bills and high operational emissions.	High energy use, High operational carbon emissions, low thermal indoor environment quality, high sensitivity to energy prices.	Report on Implementation Actions Report is available. Its implementation leads to: Low energy use, low operational carbon emissions, good IEQ, low sensitivity to energy prices. Changing from consumer to prosumer (both at building and district level)

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	Baseline Studies	Energy Audit and Assessment	Conducting thorough analysis of current energy consumption and identifying areas for improvement	CREATE	PED Design and Planning Toolset	Interoperability platform	Energy consumption/generation data, building and district asset data, energy prices	SEC-1, SEC-2
2	Renovation Planning	Development of Renovation Strategies	Creating tailored renovation plans to address inefficiencies and leverage local conditions	CREATE	PED Design and Planning Toolset	Interoperability platform	Renovation plans, energy efficiency strategies	USY-1, SEC-1, SEC-2
3	Monitoring	Continuous Energy Monitoring	Continuously monitoring energy consumption and system upgrade	GET	PED Manager/Building user	Interoperability platform	Energy consumption/generation data, CO2 emissions, renovation update	SEC-1, SEC-2
4	Calibrating and Reassessment	Calibration and assessment	Annual monitoring process to keep track of transition process and reassessment	CREATE	PED Design and Planning Toolset	Interoperability platform	Updating Renovation plans and strategies	USY-1, SEC-1, SEC-2

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-01	Sensor data	Energy consumption/generation data, building and district asset data, energy prices	INT-1, INT-2, INT-3
INF -02		Renovation plans, energy efficiency strategies	INT-2
INF-03		Energy consumption/generation data, CO2 emissions, renovation update	INT-1, INT-2, INT-3
INF-04		Updated Renovation plans and strategies	INT-2

Requirements		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**
Requirements ID	**Requirement name**	**Requirement description**
INT-1	Energy consumption/generation data	Compliance with state-of-the-art standards in energy generation/generation data.
INT-2	Building and district asset data,	Compliance with state-of-the-art standards in building and districts schema.
INT-3	Energy price data	Compliance with state-of-the-art standards in energy price data.

SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.
USY-1	Clarity of information presented	The information presented to end users (e.g., Renovation measures) should be clear.

HLUC-4: Development of stakeholders' engagement and social innovation in PEDs

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	22.07.2024	Minna Kuivalainen (SIN)	First version.	
0.2	31.07.2024	Minna Kuivalainen (SIN)	Added UC diagram, Actors, step-by-step analysis.	
0.3	07.08.2024	Minna Kuivalainen (SIN) Nikos Charitos (ICOM)	Added Information exchanged and requirements. Reviewed document.	

Scope and objectives of the use case	
Scope	PEDs are complex systems in which multiple stakeholders operate and have multiple needs and priorities. At the same time, PEDs are home to a number of people whose daily life may be influenced by the planned action. In this context, stakeholder alignment, engagement, and social innovation are key elements in building long lasting local energy systems. This use case aims to support stakeholder alignment and value creation beyond economic value through stakeholder engagement planning, joining, operating and evolvement of PEDs.
Objectives	Stakeholder engagement and social innovation to enhance long lasting operation of new initiatives
Related business case(s)	BUC-3: Prove accomplishment of sustainability goals

	BUC-4: Decrease energy cost through renovating the existing building stock BUC-5: Implementation of PEDs through energy communities
Related user experience goal(s)	-
Name of author(s)	Minna Kuivalainen (SIN)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
1	Number of people involved	Number of people consulted and participating in co-creation activities	O1
2	Degree of satisfaction	Self-reported satisfaction rate after a year of implementation of activities	O1
3	Value created	Self-reported (socioeconomic) value associated with being a member of a PED.	O1

Classification information
Relation to other use cases
HLUC-8: Accessing data for PED operation and classification through digital tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Stakeholder engagement, stakeholder alignment, collective action, social innovation, social value, economic value, governance.

Narrative of use case
Short description
PED manager and PED planner can utilise the process and tools defined within the PED Social Innovation tool to understand the needs, values and priorities of relevant stakeholders and to devise an action plan based on their needs. The methodology is based on principles of design thinking and

stakeholder engagement, and can be utilised to enhance stakeholder participation and social innovation within PEDs as they evolve.
Complete description
PED manager and PED planner will be the leading actors to ensure the incorporation of stakeholder engagement and social innovation activities in the PED planning and operation through the following process: **Identify relevant stakeholders:** PED manager, potentially together with PED planner and/or PED promoter identifies relevant local actors that will be involved in the PED planning, operation and implementation, including local residents and businesses, as well as any other relevant stakeholder groups present in the area. The analysis results in the development of the stakeholder map. **Understand stakeholder views:** PED manager, potentially together with PED planner and/or PED promoter, will discuss with representatives of different stakeholder groups to collect information on their views on the proposals to be implemented, including concerns, potential for mutual benefits and foreseen value, as well as perceived barriers. PED characterisation fact sheets will be generated from the stakeholder consultations and analysis. **Define strategies:** Based on the consultations, identify common grounds, define strategies to address concerns and barriers, as well as leverage points where further stakeholder engagement will bring added value towards developing the PED engagement plan. **Implement, monitor and adjust:** Implement the planned activities with monitoring of the success. Engage stakeholders in monitoring through feedback collection. Adjust the strategies when needed. **Ensure constant communication with the relevant stakeholder groups:** Ensure continuous communication with the relevant stakeholder groups through all the phases. Actions and results will be presented based on what is relevant to each one of the stakeholder groups (e.g., municipality, Energy Community, residents, commercial businesses, etc.) to further enhance engagement and long-term commitment.

Use case conditions
Assumption(s)
PED manager has allocated time and resources for stakeholder consultations.
Precondition(s)
PED manager has a high-level overview of the type of action planned to the site, and the basic structures in place or PED manager is committed in obtaining this overview as part of the process. A suitable actor with a capacity to conduct interviews and facilitate workshops is either available at the site or can be contracted.

Diagram(s) of use case
Diagram presented in subchapter 5.2.4.

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
PED manager	Person	A party that assumes this role, manages the functioning of a PED and/or ensures data availability and/or accessibility for further research and innovation development.	PED manager or an actor appointed by PED manager will be the leading actor to ensure the implementation of the PED SI tool.
PED Planner	Person	A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.	PED manager or an actor appointed by PED manager, such as the PED Planner can take the lead to ensure the implementation of the PED SI tool.
PED Promoter	Person	A party that assumes this role, promotes and eases the creation/sustainability of a PED, being a member (or not) or supporter of the PED once it is created. Usually, it is a public institution.	PED manager or an actor appointed by PED manager, such as the PED Promoter can take the lead to ensure the implementation of the PED SI tool.
PED social innovation tool	Methodolog y	A tool that will implement roadmaps for stakeholder engagement, including the involvement in energy communities.	A methodology that will guide the stakeholder alignment and social innovation processes.
PED residents	Person	Person/entity living/working in the PED (geographically located in the PED).	PED residents are one of the key stakeholder groups within PEDs and understanding their needs will be one of the priorities for the SI tool.
PED business actors (=stakeholders)	Person/ legal entity	A person or a company present in the PED or supplying services to it.	See list of business actors in D1.2, p XX.

		The relevance of these actors varies from place to place and should be defined at the beginning of the process. These are often referred to as stakeholders.	
PED Design and Planning Toolset	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	Information retrieved from the PED Design and Planning Toolset can be utilised to communicate results to relevant stakeholders and increase their engagement and participation in the PED.
PED Readiness Assessment Framework	Methodolog y	A methodology that will assess PEDs in terms of energy balance, as well as individual buildings considering their energy performance and smart readiness.	Information retrieved from the Dynamic Decision Support Guideline for PED development can be utilised to support engagement plans, increase stakeholder engagement and participation in the PEDs and to communicate results to relevant stakeholders.
Dynamic Decision Support Guideline for PED development (DDSG)	System	A system that will specify how different technologies, strategies, goals and KPIs should be interconnected for the optimal development of a PED.	Information retrieved from the Dynamic Decision Support Guideline for PED development can be utilised to support engagement plans, increase stakeholder engagement and participation in the PEDs and to communicate results to relevant stakeholders.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response	Information retrieved from the PED Energy Manager can be utilised to observe some of the results, and to communicate results to relevant stakeholders and increase their engagement and participation in the PED.

		Management Optimisation Tool).	
PED Business Models Innovation Tool	Methodology	A tool that will co-develop the business models of each PED.	Information retrieved from the Dynamic Decision Support Guideline for PED development can be utilised to support engagement plans, increase stakeholder engagement and participation in the PEDs and to communicate results to relevant stakeholders.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
Development of stakeholder engagement and social innovation plan	PED manager will use the SI methodology and tools to create a stakeholder engagement plan to enhance stakeholder alignment and long-term participation.	PED Manager	Setting up a new PED or changes in the way assets are operated in an existing PED.	Identify relevant actors and conduct interviews with relevant stakeholders in the PED.	Enhancement of stakeholder engagement and participation.

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1.	Setting up a new PED or changes in the way assets are operated in an	Identify stakeholders	PED manager together with PED members define relevant stakeholders to be consulted	CREATE	PED Manager/ (PED Planner/PED Promoter)	PED stakeholders	Stakeholder map	

	existing PED.							
2.	Stakeholders are identified.	Stakeholder consultations	PED manager, potentially with the support of SI solution provider will conduct stakeholder consultations based on the SI tool methodology	CREATE	PED Manager/ (PED Planner/PED Promoter)	PED stakeholders	Qualitative data on stakeholder needs, values and priorities.	
3.	Stakeholders are identified	Inputs from PED planning and assessment tools		GET	PEDvolution solutions	PED Manager	Information about PED characteristics and potential future scenarios	SEC-1, SEC-2
4.	Stakeholder consultations are finalised and potential inputs from PED tools available	Analyse data and results	PED manager or the SI solution provider will analyse the information and turn it into understandable factsheets	CREATE	PED Manager	-	PED characterisation factsheets	
5.	Information from the stakeholder consultati	Plan engagement	PED manager or the SI solution provider will conduct workshops to finalise engagement plans with PED	CREATE	PED manager/ SI tool solution provider	-	PED engagement plan	

	ons is available		managing team and/ or PED members					
6.	PED engagem ent plans are finalised	Implement engagemen t action	PED manager implements the actions defined in the PED engagement plans with the participation of relevant PED Business Actors	CREATE	PED Manager	PED stakeholder s	Stakeholder participation	
7.	An engagem ent action has been implemen ted	Assess and adjust	PED Manager and/ or SI solution provider assess the action within regular intervals, including use of KPIs defined in the engagement plan. The engagement plan will be adjusted based on the feedback.	CREATE	PED Manager	PED stakeholder s	Stakeholder feedback on the function of the PED.	
8.	Through implemen tation and assessm ent of engagem ent action	Maintain communica tion with the stakeholder s	PED manager will keep the relevant stakeholders/ PED business actors informed on the developments of the PED, including on the results and impact of the	CREATE	PED Manager	PED stakeholder s	Information from the PED towards the stakeholders.	

			stakeholder engagement activities.					

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Outputs of PEDvolution solutions	PED Readiness Assessment report PED Business Models Energy Improvements Opportunities Report Energy Performance and Environmental Impact Assessment DH Optimal Implementation Actions Report	

Requirements (optional)		
Categories ID	**Category name**	**Category description**
SEC	**Security & Privacy**	**Security and privacy related requirements**
Requirements ID	**Requirement name**	**Requirement description**
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.

HLUC-5: Portfolio optimisation through flexibility for increased renewables integration

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	4.07.2024	Sašo Brus (OFFSET), Zoran Marinšek (OFFSET), Martin Vodnik (OFFSET)	First version.	
0.2	11.07.2024	Martin Vodnik (OFFSET), Sašo Brus (OFFSET), Nikos Charitos (ICOM), Ilia Pietri (ICOM), Isidoros Kokos (ICOM)	Review meeting.	
0.3	1.8.2024	Martin Vodnik (OFFSET), Sašo Brus (OFFSET)	Reviewed version.	

Scope and objectives of the use case	
Scope	PED Manager wants to better exploit – utilize the local RES production. Using flexible resources within PED, increased RES integration can be achieved by the following use cases: • Offsetting the local RES production by demand response and/or storage facilities within PED, effectively reducing the grid disturbances on the PED coupling point, allowing higher share of RES to be deployed and operated (avoiding curtailment). Cooperation with local DSO is envisaged. • On top of that, PED Manager can offer flexibility to energy market actors (bilaterally or via the energy market) (HLUC-6).
Objectives	1. Allow higher share of RES to be utilised 2. Avoid curtailment 3. Secure new income flow by selling PED's aggregated flexibility to energy market actors and BRPs for balance group optimisation (HLUC-6)
Related business case(s)	• BUC-6: Optimise economically the cost of electricity production • BUC-7: Optimise BRP operation by leveraging electricity flows within the energy community • BUC-8: Optimise distribution grid operation by leveraging flexibility from PEDs • BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.)
Related user experience goal(s)	-
Name of author(s)	Sašo Brus (OFFSET), Zoran Marinšek (OFFSET), Martin Vodnik (OFFSET)

References						
No.	**Type**	**Reference**	**Status**	**Impact**	**Originator/ Organisation**	**URL**
1	Document	Cost- or market-based? Future redispatch procurement in Germany	Completed		Beschaffung von Redispatch project	https://neon.energy/Neon-Market-based-redispatch-BMWi.pdf
2	Document	Interoperability of flexibility assets	Completed		BRIDGE	https://energy.ec.europa.eu/system/files/2021-06/bridge_wg_data_management_interoperability_of_flexibility_assets_report_2020-2021_0.pdf

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI_HLUC_5_1	Reduction of PED peak electrical demand	Highest peak in observed period before and after PEDvolution in the PED	O1, O2
KPI_HLUC_5_4	Share of controllable assets within PED		O1, O2, O3
KPI_HLUC_5_1	No. of trades (offers) performed within PED during observed period		O1, O2
KPI_HLUC_5_2	Energy and flexibility service provision	No. of different exploitation channels for PED assets / aggregates for the demonstrator PEDs	O3

Classification information
Relation to other use cases
HLUC-6: Flexibility aggregation and management at PED and SuperPED level HLUC-8: Accessing Data for PED operation and classification through digital tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Technical

Further keywords for classification
RES, asset management, flexibility management, curtailment

Narrative of use case
Short description
RES assets within PED can operate in non-optimal way due to grid or market constraints. PED Manager wants to optimize the PED combined portfolio in order to better exploit the available assets, reduce dependency and offer additional income streams to the asset owners. Using PED Energy Manager tools, consumption, production and flexibility are forecasted, matched locally, while the remaining potential is offered to relevant outside players and markets (link with HLUC06).
Complete description
Depending on the concrete local situation, RES-based production assets can be curtailed when congestions occur (or are forecasted to occur) in the local distribution system. Similarly, redistribution mechanisms, such as Redispatch in Germany [1], can have negative impact on asset operation. On the market side, volatile prices can force a RES asset to temporary stop production. All these situations reduce the amount of locally generated RES energy, prolong the ROI and limit the new RES installations (in case of saturated networks). This can also affect the energy balance of a PED, even leading to negative equilibriums in case the annual reduction form curtailment is significant. To reduce (or eliminate) the aforementioned difficulties, RES aggregated flexibility can be offered to interested third parties, either directly or through the market. <u>Calculation of flexibility potential</u> In order to efficiently manage the flexibility of a PED, PED Energy Manager first needs to calculate the flexibility potential of the various Consumers and Prosumers (residential, commercial, and industrial) of the district, considering their preferences – as declared by them through a dedicated User Interface (UI). Hence, both power and heat consumption and production measurements from smart meters should be obtained by the relevant external systems (e.g., AMI, DH Management System), as well as weather measurements and forecasts from an external Weather Service. Furthermore, access to other External Platforms is needed to acquire energy measurements, so as to calculate the flexibility potential of individual PED Assets (e.g., smart loads, EVs, batteries, thermal storage). <u>Local exploitation of available flexibility</u> PED Energy Manager performs the matching of flexibilities in the local system – minimisation of imbalance in one or more vertically nested subsystems within PED. This way, stress on the grid coupling point is reduced, allowing a higher share of RES to be exploited on that level of the system. Furthermore, energy transfer costs are reduced, since energy is generated and consumed locally. <u>Offer of aggregated flexibility (HLUC-6)</u> The aggregated non-exploited flexibility will be offered by PED Energy Manager to interested energy market actors through appropriate Market Interfaces or forming a SuperPED. <u>Optimal flexibility management (HLUC-6)</u> PED Energy Manager should devise an optimal strategy for activating flexibility from PED Assets by creating flexibility events. <u>Validation and remuneration of requested flexibility</u> (Asset monitoring and control)

PED Energy Manager should validate after the completion of explicit DR events that the requested schedule has indeed been executed by a PED Asset. For this purpose, data from a smart meter or a dedicated sub-meter should be accessed. It is also noted that effective execution of such schedules can be facilitated through automated control, which is enabled by appropriate control equipment (i.e., relays, etc.). Once participation in a flexibility event is validated, the final remuneration should be calculated and communicated to the PED Resident(s) or PED Participant(s) owning the PED Asset.

Use case conditions
Assumption(s)
• PED Manager acts as an Aggregator and Flexibility Service Provider or has business agreement with one in the electricity market and sells available flexibility directly or through intermediaries to the market. • PED Manager has recruited PED Residents and PED Participants to participate in DR programs. • Metering infrastructure is available for DR verification. • Smart infrastructure is present in the buildings to enable data acquisition and control strategies. • RES assets are available and controllable.
Precondition(s)
• Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation through Digital Tools). • In case of SuperPED, the PED Manager can represent all PEDs of the cluster in the energy market.

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Provide their DR-related preferences to PED Energy Manager through a dedicated UI.
PED Participant	Person	An entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.	Provide their DR-related preferences to PED Energy Manager through a dedicated UI.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	Calculates flexibility potential of a PED, creates flexibility events, validates performance of PED Residents in flexibility events, and offers aggregated flexibility to energy market actors.
Advanced Metering Infrastructure (AMI)	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect	Provides power consumption and production measurements to PED Energy Manager, enabling the calculation of the flexibility potential within a PED.

		and manage data from smart meters.	
District Heating (DH) Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	Provides heat consumption/ production and thermal storage measurements to PED Energy Manager, enabling the calculation of the flexibility potential within a PED.
External Platform	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider context of PEDvolution and will not be developed in the project.	Acts as an intermediary to provide needed data from various PED Assets to PED Energy Manager or to communicate to these assets control signals derived from PED Energy Manager.
Market Interface	System Interface	Interface to Energy Market or Market actor for trading flexibility	Interface that communicates with PED Energy Manager to submit a flexibility request or receive a flexibility offer from it, depending on the specific use case (e.g., bilateral transaction, market bid, etc.).
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Asset providing flexibility by modifying its schedule during a flexibility event, according to PED Energy Manager's instructions.
Weather Service	Application	Application that provides access to weather data (historical, forecast).	Provides weather measurements and forecasts, which are needed to calculate the flexibility potential, to PED Energy Manager.
Aggregator	Business Entity	A party that aggregates flexibility for usage by a Flexibility Service Provider.	The PED Manager assumes the role of aggregator of flexibility.
Flexibility Service Provider	Business Entity	A party that offers flexibility services based on acquired (aggregated) Resources. Additional information: Flexibility is used to meet the needs of System Operators or other energy market participants on different energy-, power- or capacity marketplaces. Flexibility Services may be	The PED Manager assumes the role of the Flexibility Service Provider or has a business agreement with one.

		balancing services, non-frequency ancillary services, congestion management services etc.	
BRP	Business Entity	A Balance Responsible Party is responsible for its imbalances, meaning the difference between the energy volume physically injected to or withdrawn from the system and the final nominated energy volume, including any imbalance adjustment within a given imbalance settlement period.	The PED Manager can provide flexibility services to a BRP, either directly or through the energy market.

Diagram(s) of use case
Diagram presented in subchapter 5.2.5.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
Portfolio optimisation for increased RES	PED Energy Manager calculates the flexibility potential of a PED. Local techno-economic optimisation performs matching between supply and demand. Flexibility events are calculated, and dispatch signals are communicated to the PED Assets involved. Post-event, the offered flexibility is validated and remunerated appropriately. Remaining flexibility is offered through HLUC06.	PED Energy Manager	Local imbalance / Need for flexibility identified by the PED Manager	Flexible PED Assets are available. Flexibility potential available in both supply and demand.	Local techno-economic balance provided.

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	Every hour	Get sensing data and consumer preferences for calculation of flexibility potential.	PED Energy Manager fetches needed data (e.g., power consumption/production measurements, sub-meter data) for calculating the flexibility potential of a PED.	GET	3rd Party Platforms & Field Devices, DH Management System, AMI, Weather Service	PED Energy Manager	Sensing Data Weather Data Energy Price Data PED Residents/PED Participants Preferences	SEC-1, SEC-2
2		Calculation of flexibility potential.	PED Energy Manager calculates the available flexibility potential for the remaining timeslots of the predefined time horizon considering PED Residents/PED Participants Preferences.	CREATE	PED Energy Manager	-	Flexibility Potential	PER-1
		Submit flexibility offer	Aggregate received flexibility potential of all flexible PED assets, create	CREATE	PED Energy Manager	Market interface	Flexibility Offer	SEC-1

			flexibility offer and offer it to the market					
3		Perform local techno-economic optimisation	Match supply and demand within PED.	CREATE	PED Energy Manager	-	Flexibility Schedule	SEC-1
4		Calculation of control actions.	Disaggregate schedule control actions targeted at PED Assets to provide the scheduled flexibility.	CREATE	PED Energy Manager	-	Asset Schedule	PER-2
5	At the time of the event	Dispatch control signal to PED Asset.	Send control signals to the PED Assets.	CREATE	PED Energy Manager	3rd Party Platforms & Field Devices	Control Signal	SEC-1
6		Notify for flexibility event.	Notification presented to the PED Resident/PED Participant about the participation in flexibility event.	CREATE	PED Energy Manager	PED Energy Manager UI	Flexibility Event Information	SEC-1, USY-1
7		Evaluate performance in flexibility event and settle rewards accordingly.	Settling or remuneration for participation in flexibility event.	CREATE	PED Energy Manager	PED Energy Manager	Settlement information	
8		Notify remuneration to PED Residents.	Notification presented to the PED Resident/PED Participant about remuneration from successful participation in flexibility event.	CREATE	PED Energy Manager	PED Energy Manager UI	Settlement information	SEC-1, SEC-2, USY-1

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Sensing Data	• Power consumption/production measurements • Sub-meter data • Heat consumption/production measurements • Energy storage measurements	INT-1
INF-2	Weather Data	Weather measurements and forecasts	INT-2
INF-3	Energy Price Data	Energy price data of each PED Resident/PED Participant, consisting of (when applicable): • Retail electricity price data • Network electricity price data • DH price data	INT-3
INF-4	PED Residents/PED Participants Preferences	Preferences of PED Residents/PED Participants on the operation of their Assets. Depending on the type of a PED Asset (e.g., heat pump, EV, etc.), the preferences might concern temporal (e.g., end time of charging) and/or functional aspects (e.g., temperature setpoint).	
INF-5	Flexibility Potential	The estimated flexibility that can be offered, concerning time period and amount.	
INF-6	Flexibility Offer	Based on the FlexOffer message of the FlexOffer protocol.	INT-4
INF-7	Flexibility Schedule	Based on the Schedule message of the FlexOffer protocol.	INT-4
INF-8	Asset Schedule	Disaggregated flexibility schedule at the level of PED Assets.	
INF-9	Control Signal	Control signal (e.g., operation setpoint) concerning a PED Asset, based on the requested Asset Schedule to be followed.	
INF-10	Flexibility Event Information	PED Assets owned by the PED Resident/PED Participant that participate in the flexibility event, the requested modification of their schedules, and remuneration in case of successful participation.	
INF-11	Settlement information	Information on agreed and validated flexibility, and remuneration according to the provided service.	

Requirements		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
PER	**Performance**	**Performance of the system**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**
Requirements ID	**Requirement name**	**Requirement description**
INT-1	Sensing data standards	Compliance with state-of-the-art standards in energy time series.
INT-2	Weather data standards	Compliance with state-of-the-art standards in weather time series.
INT-3	Energy price data standards	Compliance with state-of-the-art standards in energy price time series.
INT-4	Compliance with FlexOffer Protocol	Compliance with FlexOffer Protocol.
PER-1	Duration of flexibility potential calculation	The duration of the calculation for the flexibility potential of the PED should be less than 5 minutes.
PER-2	Duration of disaggregation calculation	The duration of the calculation for the dispatch of disaggregated control signals should be less than 5 minutes.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.
USY-1	Clarity of information presented	The information presented to end users (e.g., regarding control actions, remuneration, etc.) should be clear.

HLUC-6: Flexibility aggregation and management at PED and SuperPED level

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	11.06.2024	Nikos Charitos (ICOM), Ilia Pietri (ICOM), Isidoros Kokos (ICOM)	First version.	

0.2	11.07.2024	Martin Vodnik (OFFSET), Sašo Brus (OFFSET), Nikos Charitos (ICOM), Ilia Pietri (ICOM), Isidoros Kokos (ICOM)	Review meeting.	
0.3	26.07.2024	Nikos Charitos (ICOM), Ilia Pietri (ICOM), Isidoros Kokos (ICOM)	Reviewed version.	

Scope and objectives of the use case	
Scope	PED Manager wants to increase PED's income by selling the aggregated flexibility to the energy market. Thus, the flexibility potential of the PED needs to be calculated, so that appropriate flexibility offers can be submitted. Flexibility events will be dispatched to aggregate the needed flexibility. Performance of PED Residents and PED Participants in these events will be validated, and they will be remunerated accordingly.
Objectives	Secure new income flow by selling PED's aggregated flexibility to energy market actors.
Related business case(s)	BUC-8: Optimise distribution grid operation by leveraging flexibility from PEDs BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.)
Related user experience goal(s)	-
Name of author(s)	Nikos Charitos (ICOM), Ilia Pietri (ICOM), Isidoros Kokos (ICOM)

References						
No.	**Type**	**Reference**	**Status**	**Impact**	**Originator / Organisation**	**URL**
1	Document	FEVER D1.1: Flexibility at the distribution grid: Reference usage	Completed		FEVER project	https://fever-h2020.eu/data/deliverables/FEVER_D1.1_-_Flexibility_at_the_distribution_grid_-__Reference_usage_scenarios_f

		scenarios for market and system operation services				or_market_and_system_operation_services_PU.pdf

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI_HLUC_6_1	Amount of flexibility aggregated	Amount of flexibility aggregated in a specific time period	O1
KPI_HLUC_6_2	Amount of flexibility offered	Amount of flexibility offered to market in a specific time period	O1
KPI_HLUC_6_3	Amount of flexibility traded	Amount of flexibility traded in a specific time period	O1
KPI_HLUC_6_4	Flexibility activation efficacy	Percentage of flexibility activated vs. the one traded.	O1

Classification information
Relation to other use cases
HLUC-5: Portfolio optimisation through flexibility for increased renewables integration HLUC-8: Access Data for PED Operation and Classification through Digital Tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Flexibility management, end-user preferences, flexibility potential, flexibility offer, flexibility dispatch, flexibility validation, flexibility remuneration.

Narrative of use case
Short description
PEDs can act as a source of flexibility, enabling market actors to provide services in the energy market. As a first step the PED Energy Manager needs to calculate the flexibility potential that can be leveraged from various cross-sectorial PED Assets (e.g., electricity, heat), whilst considering the PED's Residents' comfort and preferences. The aggregated flexibility from a PED or multiple PEDs (SuperPED) will be offered to the energy market (e.g., through bilateral agreements, market pool).

PED Energy Manager is also responsible for sending flexibility validation data from PED Assets to the energy market and rewarding successful participation of PED Residents and PED Participants in events.
Complete description
The PED Energy Manager solution can assist the PED Manager in optimising the flexibility of a PED, thus securing an additional income flow through offering the aggregated flexibility to interested third parties, either directly or through the market. <u>Calculation of flexibility potential</u> In order to efficiently manage the flexibility of a PED, PED Energy Manager first needs to calculate the flexibility potential of the various Consumers and Prosumers (residential, commercial, and industrial) of the district, considering their preferences – as declared by them through a dedicated User Interface (UI). Hence, both power and heat consumption and production measurements from smart meters should be obtained by the relevant external systems (e.g., AMI, DH Management System), as well as weather measurements and forecasts from an external Weather Service. Furthermore, access to other External Platforms is needed to acquire energy measurements, so as to calculate the flexibility potential of individual PED Assets (e.g., smart loads, EVs, batteries, thermal storage). <u>Offer of aggregated flexibility</u> The aggregated flexibility will be offered by PED Energy Manager to interested energy market actors (e.g. DSO, BRP, etc.) through appropriate Market Interfaces (either bilaterally or via the energy market). Furthermore, there is also the option to manage flexibility of multiple PEDs forming a SuperPED, thus offering aggregated flexibility. <u>Optimal flexibility management</u> PED Energy Manager should devise an optimal strategy for activating flexibility from PED Assets by creating flexibility events. For this purpose, apart from the calculated flexibility potential, preferences of PED Residents and PED Participants should be accounted for, as well as their energy prices (retail and network electricity prices, DH prices). These data can be exploited to improve the processes of participants' selection in flexibility events, and calculation of the offered incentives (explicit case) or prices (implicit case). Hence, energy prices data should be extracted from relevant External Platforms. PED Energy Manager is also responsible for dispatching the control signals to the PED Assets. <u>Validation and remuneration of requested flexibility</u> (Asset monitoring and control) PED Energy Manager should validate after the completion of explicit DR events that the requested schedule has indeed been executed by a PED Asset. For this purpose, data from a smart meter or a dedicated sub-meter should be accessed. It is also noted that effective execution of such schedules can be facilitated through automated DR, which is enabled by appropriate control equipment (i.e., relays, etc.). Flexibility validation data should be communicated to the energy market, so that the settlement between the market and the PED Manager can be completed. Subsequently, once participation in a flexibility event is validated, the final remuneration should be calculated and communicated to the PED Resident(s) or PED Participant(s) owning the PED Asset.

Use case conditions
Assumption(s)
• PED Manager acts as an Aggregator and Flexibility Service Provider or has business agreement with one in the electricity market and sells available flexibility directly or through intermediaries to the market. • PED Manager has recruited PED Residents and PED Participants to participate in DR programs. • Metering infrastructure is available for DR verification. • Smart infrastructure is present in the buildings to enable data acquisition and control strategies.
Precondition(s)
• Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation through Digital Tools). • In case of SuperPED, the PED Manager can represent all PEDs of the cluster in the energy market.

Actors			
Actor name	Actor type	Actor description	Further information
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Provide their DR-related preferences to PED Energy Manager through a dedicated UI.
PED Participant	Person	Person/entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.	Provide their DR-related preferences to PED Energy Manager through a dedicated UI.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	Calculates flexibility potential of a PED, creates flexibility events, validates performance of PED Residents and PED Participants in flexibility events, and offers aggregated flexibility to energy market actors.
Advanced Metering Infrastructure (AMI)	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect and manage data from smart meters.	Provides power consumption and production measurements to PED Energy Manager, enabling the calculation of the flexibility potential within a PED.

District Heating Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	Provides heat consumption/ production and thermal storage measurements to PED Energy Manager, enabling the calculation of the flexibility potential within a PED.
External Platform	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider context of PEDvolution and will not be developed in the project.	Acts as an intermediary to provide needed data from various PED Assets to PED Energy Manager or to communicate to these assets control signals derived from PED Energy Manager.
Market Interface	System Interface	Interface to Energy Market or Market actor for trading flexibility	Interface that communicates with PED Energy Manager to submit a flexibility request or receive a flexibility offer from it, depending on the specific use case (e.g., bilateral transaction, market bid, etc.).
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Asset providing flexibility by modifying its schedule during a flexibility event, according to PED Energy Manager's instructions.
Weather Service	Application	Application that provides access to weather data (historical, forecast).	Provides weather measurements and forecasts, which are needed to calculate the flexibility potential, to PED Energy Manager.
PED Manager	Business Entity	A party that assumes this role, manages the functioning of a PED, including infrastructure and interfaces with context, and ensures data availability and/or accessibility for further research and innovation development.	The PED Manager wants to secure an additional income flow through offering the aggregated flexibility to interested third parties, either directly or through the market. The PED Energy Manager Toolset is utilised to assist the PED Manager in achieving this goal. PED Manager acts as an Aggregator and Flexibility Service Provider or has business agreement with one in the electricity market and sells

			available flexibility directly or through intermediaries to the market.
Distribution System Operator (DSO)	Business Entity	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	The DSO can request flexibility services, either directly from the PED Manager or through the energy market.
Aggregator	Business Entity	A party that aggregates flexibility for usage by a Flexibility Service Provider.	The PED Manager assumes the role of the Aggregator.
Flexibility Service Provider (FSP)	Business Entity	A party that offers flexibility services based on acquired (aggregated) Resources. Additional information: Flexibility is used to meet the needs of System Operators or other energy market participants on different energy-, power- or capacity marketplaces. Flexibility Services may be balancing services, non-frequency ancillary services, congestion management services etc.	The PED Manager assumes the role of the Flexibility Service Provider or has a business agreement with one.
BRP	Business Entity	A Balance Responsible Party is responsible for its imbalances, meaning the difference between the energy volume physically injected to or withdrawn from the system and the final nominated energy volume, including any imbalance adjustment	The PED Manager can provide flexibility services to a BRP, either directly or through the energy market.

		within a given imbalance settlement period.	

Diagram(s) of use case
Diagram presented in subchapter 5.2.6.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
Automated flexibility management of a PED.	PED Energy Manager calculates the flexibility potential of a PED. The aggregated flexibility can be offered to interested energy market actors. Flexibility events are calculated, and dispatch signals are communicated to the PED Assets involved. Post-event, the offered flexibility is validated and remunerated appropriately.	PED Energy Manager	Need for flexibility identified by the PED Manager.	Flexible PED Assets are available.	Flexibility provided.

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	Every hour	Get sensing data and consumer preferences for calculation of flexibility potential.	PED Energy Manager fetches needed data (e.g., power consumption/production measurements, sub-meter data) for calculating the flexibility potential of a PED.	GET	3rd Party Platforms & Field Devices, DH Management System, AMI, Weather Service	PED Energy Manager	Sensing Data Weather Data Energy Price Data PED Residents/PED Participants Preferences	SEC-1, SEC-2
2	1	Calculation of flexibility potential.	PED Energy Manager calculates the available flexibility potential for the remaining timeslots of the predefined time horizon (based on the market of interest, e.g., intra-day, etc.)	CREATE	PED Energy Manager	-	Flexibility Potential	PER-1

			considering PED Residents/PED Participants Preferences.					
3	2	Submit flexibility offer.	Offer flexibility in the market.	CREATE	PED Energy Manager	Market Interface	Flexibility Offer	SEC-1
4	Market Gate closure or Acceptance of bid	Acceptance of flexibility offer.	Offer of flexibility has been accepted and dispatch schedule is sent to PED Energy Manager.	CREATE	Market Interface	PED Energy Manager	Flexibility Schedule	SEC-1
5	4	Calculation of control actions.	Disaggregate schedule control actions targeted at PED Assets to provide the scheduled flexibility.	CREATE	PED Energy Manager	-	Asset Schedule	PER-2
6	At the time of the event	Dispatch control signal to PED Asset.	Send control signals to the PED Assets.	CREATE	PED Energy Manager	3rd Party Platforms & Field Devices	Control Signal	SEC-1
7	6	Notify for flexibility event.	Notification presented to the PED Resident/PED Participant about the participation in flexibility event.	CREATE	PED Energy Manager	PED Energy Manager UI	Flexibility Event Information	SEC-1, USY-1
8	Completion of flexibility event (end time)	Send flexibility validation data.	Retrieve sensing data for the validation of the participation in flexibility event.	GET	3rd Party Platforms & Field Devices, AMI	Market Interface	Sensing Data	SEC-1, SEC-2
9	8	Evaluate performance in flexibility event and settle rewards accordingly.	Settling or remuneration for participation in flexibility event.	CREATE	Market Interface	PED Energy Manager	Settlement information	
10	9	Notify remuneration to PED Residents.	Notification presented to the PED Resident/PED Participant about remuneration from successful participation in flexibility event.	CREATE	PED Energy Manager	PED Energy Manager UI	Settlement information	SEC-1, SEC-2, USY-1

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Sensing Data	• Power consumption/production measurements • Sub-meter data • Heat consumption/production measurements • Energy storage measurements	INT-1
INF-2	Weather Data	Weather measurements and forecasts	INT-2
INF-3	Energy Price Data	Energy price data of each PED Resident/PED Participant, consisting of (when applicable): • Retail electricity price data • Network electricity price data • DH price data	INT-3
INF-4	PED Residents/Participants Preferences	Preferences of PED Residents/Participants on the operation of their Assets. Depending on the type of a PED Asset (e.g., heat pump, EV, etc.), the preferences might concern temporal (e.g., end time of charging) and/or functional aspects (e.g., temperature setpoint).	

INF-5	Flexibility Potential	The estimated flexibility that can be offered, concerning time period and amount.	
INF-6	Flexibility Offer	Based on the FlexOffer message of the FlexOffer protocol.	INT-4
INF-7	Flexibility Schedule	Based on the Schedule message of the FlexOffer protocol.	INT-4
INF-8	Asset Schedule	Disaggregated flexibility schedule at the level of PED Assets.	
INF-9	Control Signal	Control signal (e.g., operation setpoint) concerning a PED Asset, based on the requested Asset Schedule to be followed.	
INF-10	Flexibility Event Information	PED Assets owned by the PED Resident/PED Participant that participate in the flexibility event, the requested modification of their schedules, and remuneration in case of successful participation.	
INF-11	Settlement information	Information on agreed and validated flexibility, and remuneration according to the provided service.	

Requirements		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**

PER	**Performance**	**Performance of the system**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**
Requirements ID	**Requirement name**	**Requirement description**
INT-1	Sensing data standards	Compliance with state-of-the-art standards in energy time series.
INT-2	Weather data standards	Compliance with state-of-the-art standards in weather time series.
INT-3	Energy price data standards	Compliance with state-of-the-art standards in energy price time series.
INT-4	Compliance with FlexOffer Protocol	Compliance with FlexOffer Protocol.
PER-1	Duration of flexibility potential calculation	The duration of the calculation for the flexibility potential of the PED should be less than 5 minutes.
PER-2	Duration of disaggregation calculation	The duration of the calculation for the dispatch of disaggregated control signals should be less than 5 minutes.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.
USY-1	Clarity of information presented	The information presented to end users (e.g., regarding control actions, remuneration, etc.) should be clear.

HLUC-7: Planning of Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	04.07.2024	Nirav Patel (TUW)	First version	
0.2	16.07.2024	Nirav Patel (TUW) Nikos Charitos (ICOM) Amin Kouti (VITO)	Refactoring of scope, actors, narratives, assumptions and preconditions.	
0.3	19.07.2024	Nirav Patel (TUW) Nikos Charitos (ICOM) Amin Kouti (VITO)	UC diagram, basic scenario and steps, information exchanged and requirements.	
0.4	25.07.2024	Nirav Patel (TUW) Nikos Charitos (ICOM) Amin Kouti (VITO)	Review and finalisation.	

Scope and objectives of the use case	
Scope	Implementation of cost-effective and energy-efficient upgrades in district heating and cooling systems are essential for the long-term development of a Positive Energy Districts (PED). The PED Design and Planning Toolset (District Heating and Cooling Planning Tool) is the responsible solution for this task in the context of PEDvolution. The main goal by implementing its plan is to achieve significant energy savings and reduce operational costs through renovations and technological advancements. For this purpose, collaborative effort by PED solution providers, PED Planners, district heating operators (DHOs),

	and municipalities is needed to ensure the successful execution of renovation activities in the district heating and cooling sector.
Objectives	**Energy Efficiency**: Achieve significant improvements in energy efficiency for district heating and cooling systems within PEDs. **Cost Reduction:** Lower operational and maintenance costs associated with heating and cooling infrastructure. **Sustainability:** Promote sustainable practices and reduce the carbon footprint in line with environmental regulations and targets.
Related business case(s)	• BUC-4: Decrease energy costs by renovating the existing building stock • BUC-10: Reduce dependencies on fossil fuels
Related user experience goal(s)	-
Name of author(s)	Nirav Patel (TUW)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI_HLUC_7_1	Energy Consumption Reduction	Quantify the reduction in energy consumption (kWh) per unit of heating/cooling delivered.	O1
KPI_HLUC_7_1	Operational and maintenance Cost Savings	Track the reduction in operational and maintenance costs of heating and cooling systems.	O2
KPI_HLUC_7_1	Return on Investment (ROI)	Calculate the ROI for the implemented upgrades and innovations.	O2
KPI_HLUC_7_1	Carbon Footprint Reduction	Measure the reduction in greenhouse gas emissions	O3

		(CO_2e) associated with heating and cooling systems.	
KPI_HLUC_7_1	Renewable Energy Usage	Track the percentage of energy sourced from renewable energy within the district heating and cooling systems.	O3

Classification information
Relation to other use cases
HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-8: Accessing Data for PED operation and classification through digital tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
District heating and cooling, Energy-efficient upgrades, planning, optimisation.

Narrative of use case
Short description
This use case focuses on implementing cost-effective and energy-efficient upgrades in district heating and cooling systems within Positive Energy Districts (PEDs). Achieving these upgrades involves minimising energy demand and maximising the efficiency of local energy production. One of the primary strategies

is enhancing energy efficiency through comprehensive system renovations and technological advancements. By adopting innovative system renovation measures, such as upgrading heating and cooling systems, and integrating renewable energy sources, we can significantly improve the performance of district heating and cooling systems. These upgrades reduce energy consumption and lower operational costs and enhance the district's overall sustainability. This initiative relies on collaborative efforts among PED solution providers, PED managers, PED district heating and cooling planners, district heating operators (DHOs), municipalities, and other stakeholders. By identifying inefficiencies and implementing targeted upgrades, the use case aims to achieve substantial energy savings, reduce carbon footprints, and ensure reliable and resilient heating and cooling services within PED.
Complete description
Overview District heating and cooling planning tool lays the groundwork by strategically integrating energy-efficient technologies. PED managers then oversee the implementation of these upgrades, ensuring they align with the broader goals of the PEDs. The district heating management system handle the daily operations, maintaining and optimising the heating systems to achieve peak efficiency. Municipalities facilitate the regulatory support needed for smooth collaboration, while technical experts provide the specialised knowledge crucial for successfully integrating renewable energy sources and optimising heating systems. The PED Design and Planning Toolset (District Heating and Cooling Planning Tool) identifies improvement areas relevant to the DHC system, utilising data from the PED (e.g., DH Management System) and collecting feedback from the PED Planner and PED Residents. Subsequently, the tool devises a plan with the proposed upgrades, which is communicated to the PED Planner. Based on this plan, the PED Planner can lead the activities related to the implementation of the suggested renovation and upgrades in the DHC system. Finally, the performance of the system should be monitored continuously by fetching data from the PED (e.g., DH Management System), so that the upgrades concerning the DHC system can be reassessed and calibrated periodically (e.g., annually). The updated plan on renovation and upgrades of the DHC system should be communicated to the PED Planner. Objectives • Energy Efficiency: Achieve significant improvements in energy efficiency for district heating and cooling systems within PEDs.

- Cost Reduction: Lower operational and maintenance costs associated with heating and cooling infrastructure.
- Sustainability: Promote sustainable practices and reduce the carbon footprint in line with environmental regulations and targets.

Expected Outcomes

- Achieve significant improvements in energy efficiency for district heating and cooling systems, leading to lower energy consumption and operational costs.
- Reduce operational and maintenance costs associated with heating and cooling infrastructure, resulting in long-term financial savings for PEDs by implementing infrastructure upgrades.
- Promote sustainable practices by integrating renewable energy sources and reducing the carbon footprint, in line with environmental regulations and targets.

Use case conditions
Assumption(s)
• Sufficient financial resources are available to support the comprehensive audit, technological upgrades, and ongoing maintenance. • Construction and implementation are out of scope of this HLUC. • Sufficient historical and real-time data on current energy consumption and system performance is available for analysis and optimisation. • Access to advanced renovation technologies and skilled labour. • Willingness of stakeholders to invest in renovation and upgrade activities.
Precondition(s)
• A preliminary assessment has been conducted to identify the need for upgrades and the potential benefits within the PED. • Favourable regulatory framework and incentives for energy-efficient renovations. • The local community has been informed about the project, and there is a strategy in place for ongoing communication and involvement. • Data accessible via Interoperability Platform (HLUC 08 Access Data for PED Operation and Classification through Digital Tools). • An initial audit of the performance of the District Heating System must be provided.

General Remarks

Assessment and planning actions will be executed throughout the project's duration. Implementation, monitoring, and reassessment can be carried out as part of the post-project exploitation phase.

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	Provide their data, their consent to participate, their opinion for the provided plan, their financial capacity/need for the plan.
PED Design and Planning Toolset	Set of systems	A toolset provides design and planning of PEDs including renovation and district heating and cooling planning	PED Planner calculates optimal plans for renovation, communicates with residents and local governments, checks for possible legal supports for the plan and potential benefits, aligns with other stakeholders for business development
District heating and planning tool	System	To be developed in PEDvolution by TUW.	A system that will provide optimal implementation and investment strategies for a PED's District Heating and Cooling Infrastructure.
Municipality	Set of systems	The local government of a city or town.	Local governments can support PED developers while communicating with residents. Local governments can build up trust between residents and PED developers.
PED solution provider	Business Entity	An entity providing solutions to the PED manager and municipality.	Aims to provide necessary technological infrastructure.

PED manager	Business Entity	Ensures the functioning of a PED incl. infrastructure, living, and interfaces with context.	Wants to improve energy efficiency and reduce cost in the district heating and cooling system
District heating operator	Business Entity	A party offering heating-related service within the district.	Aims to generate profit from the DHC services
District Heating Management System	System	Commercial product	Monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space and water heating.

Diagram(s) of use case
Diagram presented in subchapter 5.2.7.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
District heating and cooling systems are fully upgraded	In this scenario, all district heating and cooling systems will be upgraded to become energy-efficient over a set time horizon. KPIs are calculated by the PED manager and an optimal plan and design is provided.	PED Design and Planning Toolset	Low energy efficiency, and high operational emissions of existing district heating and cooling systems.	High energy use, high operational carbon emissions	Low energy use, low operational carbon emissions

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	Assessment	Identify improvement areas	PED Planners and District Heating Operators evaluate current energy efficiency and identify potential areas for improvement.	CREATE	PED Design and Planning Toolset	PED Manager, DH management system	Audit Findings, Energy consumption/generation data, district asset data, and energy prices	SEC-1, SEC-2

2	Planning	Develop upgrade plan	Based on audit findings and assessment, PED Planners developed a detailed upgrade plan.	CREATE	PED planner, PED Design and Planning Toolset	PED Manager, DH management system	Upgrade plan, implementation and investment strategies	USY-1, SEC-1, SEC-2
3	Implementation	Implementation of Renovation and upgrade Measures	Executing upgrade activities based on developed strategies	UPGRADE	PED Energy Manager, Municipalities	?	Construction schedules, progress reports	SEC-1, SEC-2
4	Implementation	Integration of Renewable Energy Sources (RES)	Incorporate renewable energy sources and explore options for energy storage solutions.	INTEGRATE	PED Energy Manager, Municipalities	?	Integration Plans, Renewable Energy Data	SEC-1, SEC-2
5	Monitoring	Continuous Energy Monitoring	Continuously monitoring energy performance post-upgrade	MONITOR	PED Manager/Operator	Interoperability platform	Energy consumption data, emissions, energy production and exchange, and cost savings reports	SEC-1, SEC-2
6	Calibrating and Reassessment	Calibration and assessment	Annual monitoring process to keep track of the transition process and reassessment	CREATE	PED Design and Planning Toolset	Interoperability platform	Updating upgrade plans and strategies	USY-1, SEC-1, SEC-2

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
ASSESS -1	Assessment Results	Audit Findings, Energy consumption/generation data, district asset data, and energy prices	SEC-1, SEC-2
PLAN-1	Upgrade plan & Strategies	Upgrade plan, implementation, and investment strategies	USY-1, SEC-1, SEC-2
IMPL-1	Implementation & Monitoring	Construction schedules, progress reports	SEC-1, SEC-2
IMPL-2	Integration Monitoring	Integration Plans, Renewable Energy Data	SEC-1, SEC-2
MON-01	Monitoring Data	Energy consumption data, emissions, energy production and exchange, and cost savings reports	SEC-1, SEC-2
CAR-01	Calibration	Updating Renovation plans and strategies	USY-1, SEC-1, SEC-2

Requirements		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**

Requirements ID	Requirement name	Requirement description
INT-1	Energy consumption/generation data	Compliance with state-of-the-art standards in energy generation/generation data.
INT-2	Building and district asset data,	Compliance with state-of-the-art standards in building and districts schema.
INT-3	Energy price data	Compliance with state-of-the-art standards in energy price data.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.
USY-1	Clarity of information presented	The information presented to end users (e.g., upgrade measures) should be clear.

HLUC-8: Accessing Data for PED operation and classification through digital tools

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	5.7.2024	Ilia Pietri (ICOM), Nikos Charitos (ICOM), Isidoros Kokos (ICOM)	First version.	
0.2	11.7.2024	Martin Vodnik (OFFSET), Ilia Pietri (ICOM),	Review meeting.	

		Nikos Charitos (ICOM)		
0.3	29.7.2024	Ilia Pietri (ICOM), Nikos Charitos (ICOM), Isidoros Kokos (ICOM)	Reviewed version.	

Scope and objectives of the use case	
Scope	Interoperability Platform enables data exchange and sharing across external systems and field devices in the PEDs on the one hand, and solutions developed by PED Solution Providers on the other hand, as well as with energy markets and EU data spaces.
Objectives	• Enable seamless access to and data collection from various sources in PEDs (e.g., PED Assets, External Platforms, etc.). • Facilitate integration and data sharing between the various PEDvolution solutions. • Interface with energy markets based on state-of-the-art market protocols (e.g., FlexOffer). • Expose data and services to EU Data Spaces.
Related business case(s)	• BUC-1: Increase market value of districts through certification • BUC-2: Increase income streams by embedding energy certification of building stock (added value service) • BUC-4: Decrease energy costs by renovating the existing building stock • BUC-6: Optimise economically the cost of electricity production • BUC-8: Optimise distribution grid operation by leveraging flexibility from PEDs • BUC-9: Aggregate flexibility from buildings (residential, commercial, etc.) • BUC-10: Reduce dependencies on fossil fuels for district heating and cooling by integrating local excess and waste heat resources
Related user experience goal(s)	-
Name of author(s)	Ilia Pietri (ICOM), Nikos Charitos (ICOM),

	Isidoros Kokos (ICOM)

Reference	Impact	URL
SAREF	Information model for smart cities	https://saref.etsi.org/
IEC CIM	Semantic interoperability on energy domain	https://www.mdpi.com/1996-1073/13/6/1435
FlexOffer	standard flexibility exchange protocol	https://flexoffer-community.eu/
RESTful APIs	Build REST services	https://spring.io/guides/tutorials/rest
Microservices architecture	Common architectural style	https://microservices.io/
Kafka messaging system	Asyncronous communication tool	https://kafka.apache.org/
IDSA	International dataspaces association	https://internationaldataspaces.org/
Gaia-X	A federated and secure data infrastructure	https://gaia-x.eu/
Eclipse dataspace components	Data spaces Framework	https://projects.eclipse.org/projects/technology.edc
DSSC – Dataspaces Blueprint	DataSpace Support Center	https://dssc.eu/space/BPE/179175433/Data+Spaces+Blueprint+%7C+Version+0.5+%7C+September+2023

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI_HLUC_8_1	Controllability of Assets through the platform	20% of assets controlled through the platform	O1-O4
KPI_HLUC_8_2	No. of ontologies supported	at least 3 standard ontologies supported	O1-O4
KPI_HLUC_8_3	Open Standards and Protocols	100 % of data exchanges compliant with open standards and protocols	O1-O4
KPI_HLUC_8_5	No. of communication protocols	>10 communication protocols supported	O1-O4
KPI_HLUC_8_5	Integrated services	12 outside (grid, market) platforms integrated for service provision	O1-O4
KPI_HLUC_8_6	No. of data sources	>100 data sources integrated	O1-O4

Classification information
Relation to other use cases
HLUC-1: Calculation of PED assessment indices and PED certification HLUC-2: Identification of energy improvement opportunities towards PED characterisation HLUC-3: Planning of renovation and upgrades for energy savings and cost reduction for PEDs in building environment HLUC-4: Development of stakeholders' engagement and social innovation in PEDs

HLUC-5: Portfolio optimisation through flexibility for increased renewables integration HLUC-6: Flexibility aggregation and management at PED and SuperPED level HLUC-7: Planning of Cost-Effective and Energy-Efficient Upgrades in the PEDs District Heating and Cooling Sector HLUC-9: Formulation of PED business models
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Interoperability, interfacing, data sharing.

Narrative of use case
Short description
Solution providers need to retrieve and aggregate data from different sources such as smart meters, PED assets, as well as from external systems and applications to develop solutions for PED certification, design, monitoring and operation. The aggregated data may also be exposed to data spaces, while interfacing of the developed solutions and services with the energy market will be enabled.
Complete description
The Interoperability Platform enables data sharing between PED external systems, devices and applications, energy markets, and the solutions developed by PED solution providers. <u>Access to and data collection from various sources in PEDs in an abstract way</u>

The Interoperability Platform aims to provide an abstraction layer of PED Assets (e.g., smart loads, EVs, etc.) for IoT data exchanges in a homogenised way for transparent application development, building upon a common information model for the energy domain, which considers existing standards and ontologies (e.g., SAREF, IEC CIM). These data exchanges will be utilised for PED monitoring and certifications purposes (e.g., power/heat generation and consumption data by the PED Design and Planning Toolset, and the PED Energy Manager), as well as for dispatching control signals to PED Assets (e.g., in relation to flexibility services). Furthermore, data collection on weather data (i.e., forecasts and measurements) from an external Weather Service should be facilitated, as these data are needed to support various functionalities of the PEDvolution solutions (e.g., calculation of PED's flexibility potential by the PED Energy Manager). Data on the built environment characteristics (e.g., technical, economic and social characteristics of the districts, geospatial data, etc.) should also be communicated, so that features relevant to PED certification and design can be realised by the PED Readiness Assessment, PED Social Innovation Tool, PED Business Models Innovation Tool, etc.

Integration and data sharing between the various PEDvolution solutions and services through interoperable APIs.

Data produced and exposed by PEDvolution solutions may be used as input from other solutions. For example, PED energy balance assessment and classification reports can be used for the identification of energy improvements opportunities and implementation actions. For the development and functioning of the different PEDvolution solutions, communication between them should be facilitated. Communication and data sharing must thus be realised through interoperable and open APIs and the adoption of secure data exchange protocols and connectors supporting semantic and syntactic interoperability.

Energy market interfacing

Also, data and services provided by the PED Energy Manager can be consumed by external services or third parties such as system operators (DHO, DSO, Aggregator etc). More specifically, the PED's aggregated flexibility can be offered to the energy market, utilising state-of-the-art protocols, such as FlexOffer.

Exposure of PEDvolution data and services to EU Data Spaces

Data and services of the project may also be exposed for use by third parties through their provisioning as interoperable offerings in the EU Data Space Ecosystem. Open-source connectors and federation services need to be implemented and deployed towards the interconnection with Energy Data Spaces.

Data exchanges between various systems concerning all the previously described functionalities of the Interoperability Platform should comply with established security and authorisation mechanisms (trust, data sovereignty etc), while sharing

of sensitive data should be bounded by appropriate privacy policies. Moreover, interfacing will be based on open and standard protocols – when possible – to ensure compatibility and extensibility of the solutions offered.

Use case conditions
Assumption(s)
• Data providers will specify the data sharing policies (data classification). • Data providers will make their data available (e.g., smart infrastructure is present in the buildings to enable data acquisition and control strategies, metering infrastructure is present). • Solution providers want to make their services/data interoperable.
Precondition(s)
• Data connectors/infrastructure need to be implemented & deployed. • Pre-existing/ state-of-the-art standards. • PEDvolution solutions will be provided and deployed. • Energy market(s) exist in the target country and are accessible (pre-qualification, legal and technical viability) by the PED Manager and/or its partners. • GDPR procedures (e.g., filling in consent forms, data processing agreements, etc.) have been followed.

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
Interoperability Platform	System	A system that will provide mechanisms for secure data exchanges with the under-development PEDvolution solutions, as well as with external systems and applications.	Enables data exchanges and sharing across external systems and field devices in the PEDs, PEDvolution solutions, energy markets and EU data spaces.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development	PEDvolution solution. Through the Interoperability Platform it can exchange

		solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	data with other PEDvolution solutions, PED external systems and field devices, and the energy market, as well as expose data to EU data spaces.
PED Design and Planning Toolset	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	PEDvolution solution. Through the Interoperability Platform it can exchange data with other PEDvolution solutions, PED external systems and field devices, and the energy market, as well as expose data to EU data spaces.
PED Readiness Assessment Framework	Methodology	A methodology that will assess PEDs in terms of energy balance, as well as individual buildings considering their energy performance and smart readiness.	PEDvolution solution. Through the Interoperability Platform it can exchange data with other PEDvolution solutions, PED external systems and field devices, and the energy market, as well as expose data to EU data spaces.
Dynamic Decision Support Guideline for PED Development	System	A system that will specify how different technologies, strategies, goals and KPIs should be interconnected for the optimal development of a PED.	PEDvolution solution. Through the Interoperability Platform it can exchange data with other PEDvolution solutions, PED external systems and field devices, and the energy market, as well as expose data to EU data spaces.
PED Business Models Innovation (BMI) Tool	Methodology	A tool that will co-develop the business models of each PED.	PEDvolution solution. Through the Interoperability Platform it can exchange data with other PEDvolution solutions, PED external systems and field devices, and the energy market, as well as expose data to EU data spaces.

PED Social Innovation Tool	Methodology	A tool that will implement roadmaps for stakeholder engagement, including the involvement in energy communities.	PEDvolution solution. Through the Interoperability Platform it can exchange data with other PEDvolution solutions, PED external systems and field devices, and the energy market, as well as expose data to EU data spaces.
Data Spaces	Data Spaces	Interlinking with EU Energy Data Spaces will enable the offering of data and services of PEDvolution in the EU Data Space Ecosystem.	Data and services of PEDvolution can be exposed to EU Data Spaces through the Interoperability Platform.
Advanced Metering Infrastructure (AMI)	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect and manage data from smart meters.	The Interoperability Platform retrieves from the AMI data on power consumption and production.
District Heating (DH) Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	The Interoperability Platform retrieves from the DH Management System data, such as heat consumption and production measurements, thermal energy storage measurements, etc.
External Platform	System	Term to account for various systems, which will interact with the Interoperability	The Interoperability Platform retrieves from various External Platforms and Field Devices data, such as measurements from

		Platform. These systems are within the wider context of PEDvolution and will not be developed in the project.	energy storage and sub-meters, CO_2 emissions, etc. Furthermore, it can communicate through them control signals for PED Assets (e.g., in case of a flexibility event).
Market Interface	System Interface	Interface to Energy Market or Market actor for trading flexibility.	The Interoperability Platform can facilitate the data exchange between the energy market and PEDvolution solutions.
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Interfacing between PED Assets and the Interoperability Platform is achieved through various External Platforms in the context of a PED. This interfacing should enable data collection from the PED Asset, as well as communication of control signals to it – if applicable.
Weather Service	Application	Application that provides access to weather data (historical, forecast).	The Interoperability Platform retrieves from an external Weather Service weather measurements and forecasts in the PED area.

Diagram(s) of use case
Diagram presented in subchapter 5.2.8.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
Data exchange within PED context	Data from different sources are made available through the Interoperability platform. Data providers specify any data sharing policies to allow authorised access to them. Solution providers can access any data available to the interoperability platform when required as long as they are allowed to.	PEDvolution solutions	Need from PEDvolution solutions	Data can be made available.	Data made available through the Interoperability Platform.
Services integration	Services provided by PEDvolution solutions are integrated in the Interoperability platform.	PEDvolution solutions	Need from PEDvolution solutions	Services are provided by PEDvolution solutions	Services are integrated to the Interoperability Platform
Market interfacing	Data and services of PEDvolution are interfaced with the energy market.	PED energy manager	Need from PEDvolution solutions	Services are provided by PED energy manager.	Market mechanisms and protocols are incorporated to the provided services

Exposure to data spaces	Data from PEDvolution project are opened to EU data spaces	PEDvolution solutions	Results of other scenarios generated	Data can be provided, sharing policy is specified	Data accessible via data spaces

Scenario Name								
Step No.	**Event**	**Name of Process/ IActivity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	At the time of event	Get data from PEDs/services	PED solutions ask and fetch needed data (e.g., power consumption/production measurements, sub-meter data) or services through the Interoperability platform.	GET	3rd Party Platforms & Field Devices, DH Management System, AMI, Weather Service etc	Any consumer of the Interoperability platform (PEDvolution solution, third party, etc)	Data depending on the use case (e.g. weather or smart meter data)	INF1-INF-12, SEC-1, SEC-2, SEC-3, PER-1, PER-2
2	Results generated	Share results (or control signal) from PEDvolution solutions	PEDvolution solutions utilise the retrieved data to generate their outputs and expose them through the Interoperability Platform	CREATE	Any PEDvolution solution	Any consumer of the Interoperability platform (PEDvolution solution, third party, etc)	PEDvolution solution results	SEC-1, SEC-2, SEC-3, PER-1, PER-2, USY-1

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Sensing Data	Power consumption/production measurements Sub-meter data Heat consumption/production measurements Energy storage measurements	INT-1
INF-2	Weather Data	Weather measurements and forecasts	INT-2
INF-3	Energy Price Data	Energy price data of each PED Resident/PED Participant, consisting of (when applicable): Retail electricity price data Network electricity price data DH price data	INT-3
INF-4	PED Residents/Participants Preferences	Preferences of PED Residents/PED Participants on the operation of their Assets. Depending on the type of a PED Asset (e.g., heat pump, EV, etc.), the preferences might concern temporal (e.g., end time of charging) and/or functional aspects (e.g., temperature setpoint).	INT-5
INF-5	Flexibility Potential	The estimated flexibility that can be offered, concerning time period and amount.	
INF-6	Flexibility Offer	Based on the FlexOffer message of the FlexOffer protocol.	INT-4
INF-7	Flexibility Schedule	Based on the Schedule message of the FlexOffer protocol.	INT-4

INF-8	PED & built Environment Characteristics	District Technical Characteristics District Economic Characteristics District Social Characteristics/Assessment PED Business Models District Geospatial Data Building Stock Characteristics HVAC/Solar panels/Battery systems characteristics Fossil Fuel Consumption Data CO_2 Emissions Data	
INF-9		Renovation plans, energy efficiency strategies	
INF-10		Energy consumption/generation data, CO2 emissions, renovation update	
INF-11		Updated Renovation plans and strategies	
INF-12	Asset Schedule	Disaggregated flexibility schedule at the level of PED Assets.	
INF-13	Control Signal	Control signal (e.g., operation setpoint) concerning a PED Asset, based on the requested Asset Schedule to be followed.	
INF-14	Flexibility Event Information	PED Assets owned by the PED Resident/PED Participant that participates in the flexibility event, the requested modification of their schedules, and remuneration in case of successful participation.	INT-4
INF-15	Settlement information	Information on agreed and validated flexibility, and remuneration according to the provided service.	

Requirements

Categories ID	Category name	Category description
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
PER	**Performance**	**Performance of the system**
SEC	**Security & Privacy**	**Security and privacy related requirements**
USY	**Usability**	**Usability of provided solutions**
Requirements ID	**Requirement name**	**Requirement description**
INT-1	Sensing data standards	Compliance with state-of-the-art standards in energy time series.
INT-2	Weather data standards	Compliance with state-of-the-art standards in weather time series.
INT-3	Energy price data standards	Compliance with state-of-the-art standards in energy price time series.
INT-4	Compliance with FlexOffer Protocol	Compliance with FlexOffer Protocol.
INT-5	Information models on smart city	Compliance with state-of-the-art information models on smart city such as SAREF, IEC CIM
PER-1	Latency of real time data	The timely access to real-time data streams should be adequate to support project's applications.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data (sharing policies, etc.)
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data (anonymisation, trust etc.)
SEC-3	Compliance with GDPR	Data exchanges and storage (if applicable) should comply with the GDPR regulation.

USY-1	Clarity of information presented	The information presented to end users (e.g., regarding control actions, remuneration, etc.) should be clear.

HLUC-9: Formulation of PED business models

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval Status**
0.1	23.07.2024	Alemu Belay (SIN) Christian Kunze (SIN) Ahmed Hedar (SIN)	First version.	
0.2		Alemu Belay (SIN) Ahmed Hedar (SIN) Nikos Charitos (ICOM)	Review meeting.	
0.3	06.08.2024	Alemu Belay (SIN) Ahmed Hedar (SIN) Nikos Charitos (ICOM)	Reviewed document.	

Scope and objectives of the use case	
Scope	The Business Models (BM) co-development process aims to build a promising business model for each demonstration PED and further investigate the business opportunities with replicator PEDs. The process incorporates various brainstorming business tools, the analysis of various BM patterns, and the adaptation of energy community-oriented BM innovation tools. By engaging all responsible entities of PEDs (e.g., PED managers), the business outcome of the operation of the proposed PEDvolution interoperable solutions in each PED (concerning all the relevant BUCs) will be analysed.
Objectives	Provide each PED with a future-proof and promising business model, utilising the BM innovation tool. This will be done by incorporating relevant value propositions and potential revenue streams generated from the interoperable solutions into the BMs.
Related business case(s)	All relevant BUCs will be considered and analysed for each PED.
Related user experience goal(s)	-

Name of author(s)	Alemu Belay (SIN) Christian Kunze (SIN) Ahmed Hedar (SIN) Nikos Charitos (ICOM)

References						
No.	**Type**	**Reference**	**Status**	**Impact**	**Originator / Organisation**	**URL**
1	H2020	E_LAND	completed		SIN	https://elandh2020.eu/

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
5.3	Number of business models per demonstration pilot (PED).	Each PED will co-develop one promising business model by the end of the project (in total 3 BM). Additional business case analysis and BMs could be explored with potential PEDvolution replication sites or interested business actors.	O1

Classification information
Relation to other use cases
HLUC-8: Access Data for PED Operation and Classification through Digital Tools
Level of Depth
High
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Business Model, Value Proposition, Business Case Analysis, Business Model Innovation Tool (BMI tool).

Narrative of use case
Short description
By considering business model innovation tools in the multi-vector energy systems setting, which were successfully implemented in previous projects (e.g., in E-LAND), exploring various energy communities BM typology/patterns with current and emerging design options will be explored and developed for each PED's context. PEDvolution will actively engage PEDs and relevant business actors to investigate the BM approach by adapting and incorporating additional business tools and typologies, such as the value proposition tool and a Strength, Weakness, Opportunities and Treat (SWOT) analysis. The outcomes will be utilised to understand the challenges and opportunities which are relevant to each specific PED's context. Besides the initiation phase (WP1) in the identification and requirement definition, the BM development process will be conducted in three phases: Adaptation phase (WP2), Implementation phase (WP6), and Validation and verification (WP8, 9). In the adaptation phase, various business tools will be used to brainstorm, understand the pains and gains and investigate the business ambitions and opportunities of each PED. In the Implementation phase, the business models are co-developed based on the inputs from the initiation phase (use of adapted tools) and the deployment of the PEDvolution solutions in the three PEDs. In the final phase, the co-developed business models are tested and validated in the demonstration sites (PEDs) with respect to the BUCs defined in WP1. With the help of technical solution providers and PEDs, all quantifiable outcomes of the BUCs will be tested, and compared to validate the consequences of the PEDvolution solutions. For this purpose, the baselines will be defined based on a business-as-usual (BAU) scenario and compared with the results after the PEDvolution implementation (i.e., with vs. without PEDvolution adaptations).
Complete description
The overall narrative of this HLUC outlines the implementation of the business model development processes, considering learnings and experiences from previous projects, new and emerging business model options/patterns based on field research, as well as various business typologies. In general, the business model process can be divided into the following distinct phases over the project timeline: <u>Initiation and Adaptation</u> (WP1, WP2) Following the initiation phase (includes the WP1 BUCs and requirements definition and tool identification), the Business Model Innovation (BMI) tool adaptation will be done together with the PED Managers. The E-Land community-based BMI tool, adapted and customised to the PEDs' needs, will provide a set of building blocks, known as 'business model patterns,' that have been proven successful in community-based business solutions. The BMI tool adaptation process will enable PEDs to adjust business model patterns to the local context and combine them to create promising business models. All required tools will be prepared to understand the pains and gains, as well as driving and constraining forces for individual and integrations of PEDs (e.g., customised value proposition tool, force field analysis, SWOT analysis, etc.). In the initiation and adaptation phases, the BMI tool developers will be consultation with the PED Managers, Planners, Certifiers and solution providers in order to formulate appropriate Business Models for each PED. <u>Implementation</u> (WP6)

The specifically developed and adapted business model innovation tools for each PED will be implemented with active involvement of all PED managers, tools and technology developers. Business model innovation (BMI) tool: In this task, a well-structured process of the business model innovation tool will be introduced and applied to co-develop the business models of each PED. In this regard, various business model options will be provided for each PED through a series of workshops. SIN will provide a step-by-step guidance for PEDs starting from initiations, followed-up by ideation, integration & implementation and validation. In a co-development process, all pains and gains of PEDs will be considered for better exploitation of the values proposed by PEDvolution. This includes potential approaches for energy community implementation, integration of key partners, the potential for social entrepreneurship, value of energy grid robustness regarding dependencies to energy supplies, local legislation regarding price tariffs, etc. All tools adapted at C&D&E will be tailored and used together with best practices from similar community-based solutions. In the implementation phase, the BMI tool developers will continue their discussions with the main PED-related actors (i.e., Manager, Planner, Certifier, solution providers), and will also get data from systems in the PED context (e.g., AMI, DH Management System) and the PEDvolution solutions (e.g., PED Energy Manager, PED Design and Planning Toolset), once they will be deployed. <u>Validation</u> (WP8,9) This phase will ensure a comprehensive assessment and validation of the PEDvolution demonstration considering various technical, business, societal and regulatory aspects. To enhance and optimize the business model, a continuous follow up will be done starting from the demo set up, use case and scenario definition, implementation and documentation of relevant findings. For this purpose, active participation and engagement of the PEDs in the business model development and validation are crucial, involving the PED Manager, Planner, Certifier, solution providers, as well as the PED Residents and PED Participants. The validation will be done in parallel with the systems' integration and operation in the PEDs, monitoring the demonstration, collecting performance/measurement data from PEDvolution solutions (e.g., PED Readiness Assessment Framework, PED Dynamic Decision Support Guideline) and external systems in the PED context (e.g., various External Platform interfacing the PED Assets) and calculating KPIs for technical validation, while gathering economic data for business case validation. The validated outcomes will be utilised to evaluate the replication activities, considering the replicator PEDs' setting and contexts.

Use case conditions
Assumption(s)
• Each PED will have 1 primary business model during the project and explore if there are some business case opportunities with business actors. After the project, each replicator will develop additional BMs based on PEDvolution solutions, while co-developers will assemble secondary business models. • The demonstration PEDs and replicators, will have at least one energy community to be approached to investigate business opportunities. • Business actors and communities in the area of each PED seek to explore business opportunities.

Precondition(s)
• Engagement of PEDs and solution developers in the BM development. • Each PED and solution provider will clarify the BUCs, define the baselines together with SIN, measure the KPIs connected to BUCs' KPIs to realize the value propositions and revenue streams. • Data accessible via Interoperability Platform (HLUC-8 Access Data for PED Operation and Classification through Digital Tools). • Additional data to be retrieved from the PED Manager and PED solution providers if needed (ad-hoc).

Diagram(s) of use case
Diagram is presented in subchapter 5.2.9.

Actors			
Actor name	**Actor type**	**Actor description**	**Further information**
PED Resident	Person	Person/entity living/working in the PED (geographically located in the PED).	PED Residents will be involved in the validation of the Business Models.
PED Participant	Person	Person/entity owning and/or managing an asset which consumes/produces/stores energy in the PED area.	PED Participants will be involved in the validation of the Business Models.
PED Planner	Business Entity	A party that assumes this role, plans the development and functioning of a PED incl. elements, flexibilities and interfaces with environment and further stakeholders.	The PED Planner will be involved in initiation, adaptation, implementation, and validation of the Business Models.
PED Certifier	Business Entity	An entity that certifies, based on a framework, the sustainability of apartments, buildings, neighbourhoods, or cities. Considered aspects may include human health, environmental sustainability, energy efficiency, and cost savings.	The PED Certifier will be involved in initiation, adaptation, implementation, and validation of the Business Models.
PED Manager	Business Entity	A party that assumes this role, manages the functioning of a PED and/or	The PED Manager will be involved in initiation, adaptation,

		ensures data availability and/or accessibility for further research and innovation development.	implementation, and validation of the Business Models.
PED solution provider	Business Entity	An entity providing services to PED Residents, PED Participants and PED Managers.	The PED solution provider will be involved in initiation, adaptation, implementation, and validation of the Business Models.
PED Business Models Innovation (BMI) Tool	Methodolog y	A tool that will co-develop the business models of each PED.	The BMI tool will be utilised to develop an appropriate Business Model for each PED of the project.
PED Readiness Assessment Framework	Methodolog y	A framework that will assess districts with respect to PED Readiness, considering technical, social, economic and interoperability aspects.	The framework, along with the rest of PEDvolution solutions, will be utilised by the BMI tool to formulate an appropriate business model for each PED.
Advanced Metering Infrastructure (AMI)	System	The system composed of all the devices, applications and databases that permits to measure, remotely collect, and manage data from smart meters.	Data from the AMI will be utilised in the implementation and validation phases of the BMI tool.
District Heating (DH) Management System	System	A system that monitors and controls the district heating system, which distributes centrally generated heat for residential and commercial heating requirements, such as space heating and water heating.	Data from the DH Management System will be utilised in the implementation and validation phases of the BMI tool.
Dynamic Decision Support Guideline for PED Development (DDSG)	System	A system that will specify how different technologies, strategies, goals and KPIs should be interconnected for the optimal development of a PED.	The DDSG, along with the rest of PEDvolution solutions, will be utilised by the BMI tool to formulate an appropriate business model for each PED.
External Platform	System	Term to account for various systems, which will interact with the Interoperability Platform. These systems are within the wider context of	External Platforms will be utilised to fetch data from PED Assets during the implementation and validation phases of the BMI tool.

		PEDvolution and will not be developed in the project.	
PED Asset	Device	Any device, such as load, energy storage, generation asset that can change its absorption / injection of energy upon request, providing flexibility to the system.	Data from PED Assets will be utilised in the implementation and validation phases of the BMI tool.
PED Design and Planning Toolset	Set of systems	A set of systems that consists of the under-development solution in WP3 (PED Renovation Planning Tool, District Heating & Cooling Planning Tool).	The PED Design and Planning Toolset, along with the rest of PEDvolution solutions, will be utilised by the BMI tool to formulate an appropriate business model for each PED.
PED Energy Manager	Set of systems	A set of systems that consists of the under-development solution in WP5 (ANODE, AURORA, Demand Response Management Optimisation Tool).	The PED Energy Manager, along with the rest of PEDvolution solutions, will be utilised by the BMI tool to formulate an appropriate business model for each PED.
PED Social Innovation Tool	Methodology	A tool that will implement roadmaps for stakeholder engagement, including the involvement in energy communities.	The PED Social Innovation Tool, along with the rest of PEDvolution solutions, will be utilised by the BMI tool to formulate an appropriate business model for each PED.

Scenario Conditions					
Scenario Name	**Scenario description**	**Primary Actor**	**Triggering Event**	**Pre-condition**	**Post-condition**
Business Model Formulation per PED	Development of an appropriate Business Model for each PED	BMI Tool	PED Planners, Managers and solution providers' need for development of Business Models	Engagement of PED Managers and solution providers in the BM development.	Validated Business Model for each PED.

Scenario Name								
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Inf. Producer (Actor)**	**Inf. Receiver (Actor)**	**Inf. Exchanged**	**Requirements, R-ID**
1	PED Manager/Planner requests a BM for its PED	Initiation and adaptation of Business Models	Initiate	CREATE	BMI Tool	PED Manager/Planner	Initial PED Business Model	
2	1	Implementation of Business Models	Adapt business model patterns to the needs of each PED, based on relevant BUCs.	CREATE	BMI Tool	PED Manager/Planner	Adapted PED Business Model	
3	2	Get data from PEDs	Data from PEDvolution	GET	External PED	BMI Tool	Sensing Data	SEC-1, SEC-2

			solutions and external systems in the context of each PED will be fetched to serve in the validation process.		systems (e.g., AMI, DH Management system, etc.) and PEDvolution solutions (e.g., PED Readiness Assessment Framework)		Energy Price Data PED & built Environment Characteristics	
4	3	Validation of Business Models	Validate the BM of each PED by calculating relevant KPIs for the BUCs incorporated in the BM.	CREATE	BMI Tool	PED Manager/Planner	Validated PED Business Model	

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements R-ID**
INF-1	Sensing Data	Power consumption/production measurements Sub-meter data Heat consumption/production measurements Energy storage measurements	INT-1
INF-2	Energy Price Data	Energy price data, consisting of (when applicable): Retail electricity price data Network electricity price data DH price data Feed-in tariffs	INT-2
INF-3	PED & built Environment Characteristics	District Technical Characteristics District Economic Characteristics District Social Characteristics/Assessment PED Business Models District Geospatial Data Building Stock Characteristics HVAC/Solar panels/Battery systems characteristics Fossil Fuel Consumption Data CO_2 Emissions Data	INT-3, INT-4

Requirements (optional)		
Categories ID	**Category name**	**Category description**
INT	**Interoperability**	**Compliance with information models/standards and communication protocols**
SEC	**Security & Privacy**	**Security and privacy related requirements**

Requirements ID	Requirement name	Requirement description
INT-1	Sensing data standards	Compliance with state-of-the-art standards in energy time series.
INT-2	Energy price data standards	Compliance with state-of-the-art standards in energy price time series.
INT-3	Interoperability on building characteristics data	Compliance with state-of-the-art standards concerning data on building characteristics (i.e., data on physical properties of buildings).
INT-4	Interoperability on PED data concerning various aspects (e.g., social, business models, economic, etc.)	Compliance with common data models that will be utilised by all the relevant PEDvolution solutions.
SEC-1	Security of data	A proper mechanism should be established for safeguarding the security of stored and transmitted data.
SEC-2	Confidentiality of sensitive data	A proper mechanism should be established for keeping confidentiality of sensitive data.