ASCEND

Operational Funding and Financial Mechanisms Supporting Solution Packages

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Abstract

This deliverable outlines the actions carried out by ASCEND partners (WP5 contributors and cities) to support the application of appropriate funding schemes for the deployment and replication of Solution Packages (SPs). It provides cities with a structured approach to leveraging innovative financing mechanisms while ensuring alignment with public business models. The document explores diverse funding options, including green bonds, debt, equity, etc. Additionally, it integrates Environmental, Social and Governance (ESG) factors and EU Taxonomy considerations to translate non-monetisable benefits into investment opportunities.

By linking funding schemes with public business models, this deliverable supports cities in establishing sustainable financial strategies for SP implementation. A key outcome is the inclusion of supportive cost benefits analysis that help municipalities in better assessing the features and performances of their investment projects. The work carried out so far (and reported in this document) is calibrated to the current development stage of the projects undertaken by the cities. The deliverable is first presented at M27 (March 2025), with an updated version at M36 (December 2025) to incorporate refinements based on further insights and stakeholder engagement.

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Project Partners

Partners	Country	Abbreviation
SPL LYON CONFLUENCE	FR	SPL
METROPLE DE LYON	FR	GLY
COMMUNE DE LYON	FR	LYS
HESPUL ASSOCIATION	FR	HES
URBAN PRACTICES	FR	UP
ENERTECH	FR	ETC
LANDESHAUPTSTADT MUNCHEN	DE	LHM
STADTWERKE MUENCHEN GMBH	DE	SWM
MUENCHNER GESELLSCHAFT FUER STADTERNEUERUNG MBH	DE	MGS
MUENCHNER WOHNEN GMBH	DE	MW
UNICCORN GMBH	DE	UNC
TECHNISCHE UNIVERSITAET MUENCHEN	DE	TUM
ISARWATT EG	DE	IW
AVANCIS GMBH	DE	AVC
SPECTRUM MOBIL GMBH	DE	STA
UNTERNEHMERTUM GMBH	DE	UTUM
MUNICIPALITY OF ALBA IULIA	RO	AIM
VILLE DE CHARLEROI	BE	CHA
IGRETEC	BE	IGC
AGÊNCIA DE ENERGIA DO PORTO	PT	PEN
EMPRESA DE AGUAS E ENERGIADO MUNICIPIO DO PORTO EM	PT	AEP
FUNDACAO DE SERRALVES	PT	SRV
ASSOCIACAO PORTO DIGITAL	PT	APD
CESKE VYSOKE UCENI TECHNICKE V PRAZE	CZ	CVUT
OPERATOR ICT AS	CZ	OICT
PRAZSKA DEVELOPERSKA SPOLECNOST	CZ	PDS
BUDAPEST FOVAROS ONKORMANYZATA	HU	BUD
BKK BUDAPESTI KOZLEKEDESI KOZPONT ZARTKORUEN MUKODO RESZVENYTARSASAG	HU	BKK
ENERGY CITIES	BE	ENC
STOCKHOLMS STAD	SE	STK
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH	AT	AIT
FUNDACION CARTIF	ES	CAR
UNIVERSITE DU LUXEMBOURG	LU	UoL
BLUE-SIGHT CONSEIL	FR	BLS
DATEN-KOMPETENZZENTRUM STÄDTE UND REGIONEN GMBH	DE	DKSR
CIVIESCO SRL	IT	CIV
TWENTY COMMUNICATIONS SRO	SK	TWE
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Abbreviations and acronyms

Acronym	Description
AI	Artificial Intelligence
API	Application Programming Interface
BEMS	Building Energy Management Systems
BM	Business Model
CA	Consortium Agreement
CAPEX	Capital Expenditure
CBA	Cost and Benefit Analysis
CEA	City Energy Analyst
CHP	Combined Heat and Power
EC	European Commission
EHS	Environment, Health and Safety
ELTIF	European Long-Term Investment Fund
EPC	Energy Performance Contract
ESCO	Energy Service Company
ESG	Environmental, Social and Governance
EV	Electric Vehicle
GA	Grant Agreement
GHG	Greenhouse Gas
HE	Horizon Europe
ICT	Information and Communication Technologies
IRR	Internal Rate of Return
KPI	Key Performance Indicator
LHC	Lighthouse City
MC	Multiplier City
MVP	Minimum Viable Product
NPV	Net Present Value
NZEB	Nearly Zero Energy building
OPEX	Operational Expenditure
PBT	Payback Time
PC	Project Coordinator
PCED	Positive and Clean Energy District
PPP	Public-Private Partnership

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PRR	Recovery and Resilience Fund
PV	Photovoltaic
RE	Real Estate
REC	Renewable Energy Community
RES	Renewable Energy Sources
SCC	Smart Cities and Communities
SME	Small and Medium-sized Enterprise
SP	Solution Package
SPV	Special Purpose Vehicle
VCE	Value Creation Ecosystem
WP	Work Package
WPL	Work Package Leader

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Executive Summary

The main objective of the ASCEND project is to create relevant conditions for upscaling solutions at the level of each partner city and across Europe. Our core assumption is to "scale up by design" our solutions instead of waiting for the final technical loop to start the process. WP5 oversees the process, providing cities with easy and intuitive tools that will help them correctly frame the problem of upscaling and raise questions that must be solved during the lifespan of the ASCEND project. Those tools aim to enable project owners and cities to make decisions and measure the "market or adoption maturity" of their solutions.

The deliverable D5.3 at hand focuses on the operational funding and financing mechanisms for PCEDs, and is a key component of WP5, which is dedicated to scaling up Solution Packages (SPs) for a large community of cities and investors. This deliverable is crucial for bridging the gap between cities and the financial community.

The deliverable's content is based on the project's overall methodology, which involves developing six SPs through an iterative and agile Minimum Viable Product (MVP) approach. These SPs are tested and validated in Lighthouse Cities (Lyon and Munich, LHCs) and Multiplier Cities (MCs). The SPs are designed to be adaptable to different local contexts and will be monitored using a set of KPIs.

Key aspects of the deliverable include:

- **Developing new public business models** for PCEDs. This involves a holistic approach to demonstrate the ecological and economic benefits of combined solutions packages.
- **Evaluating non-conventional financing** by investors. This includes identifying and addressing barriers to investment and creating a snowball effect towards investors.
- **Sharing successfully validated schemes and models to Multiplier Cities**. This focuses on sharing knowledge and enabling replication of successful organisational schemes for PCED implementations.
- **Providing a dedicated financial decision-making methodology.** The project support cities in assessing their investment projects by using a holistic Cost Benefit Analysis (CBA), designed to support the decision-making process.
- **Deployment of innovative funding strategies** for both LHCs and MCs, with specific targets for public/private investment ratios.
- **Emphasis on making PCEDs** scalable by design. The proposed methodology supports cities in the definition of the key aspects for future scalability since the early phases of development.

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- **Addressing the challenge cities face:** identifying the funding gap and support cities in exploring alternative financing resources to their usual funding instruments.
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The implementation of the T5.3 activities (described in this report), particularly the CBA process, has highlighted significant differences in the development stages of the selected solutions. More broadly, there are also notable variations in city projects regarding the overall development of each ASCEND Positive Clean Energy District (PCED). As such, a certain degree of flexibility and approximation is required to effectively test analytical methodologies, such as the CBA approach. For most cities, **accessing and obtaining relevant data for the CBA remains a major challenge.** This can be attributed to several factors, including the early-stage development of most projects, the misalignment between the public-sector investment mindset and that of private investors, and difficulties in data accessibility.
The limited availability of data and monetisation capabilities by cities significantly impacted the depth of the CBA, making it more of a first step analysis rather than a fully comprehensive assessment ready for discussion with external financiers. However, the positive collaboration demonstrated by the LHCs and MCs, in most cases, enabled the R2M team **to facilitate valuable knowledge transfer, particularly in terms of CBA methodology.**
Based on the developed assessment of city projects, a **preliminary analysis of applicable financial instruments has been conducted**, complemented by a review of compelling use cases where private funding mechanisms have been employed to finance concrete PCED interventions.

Overall, **this deliverable** serves a dual purpose: on the one hand, it **provides a practical framework and a set of tools to help cities secure funding and accelerate the implementation of PCEDs**, contributing to the broader goal of achieving climate neutrality. On the other hand, **it documents the experience of applying the proposed methodology within the ASCEND cities** at this stage of project development. The concepts outlined in this report aim to reduce investment risk, build market confidence, and shape the conditions for large-scale investments. The effectiveness of this deliverable also relies on the successful implementation of other WP5 deliverables, which together form a cohesive package for scaling up the project's solutions.

Keywords:

Positive Clean Energy Districts (PCEDs), Operational funding and financing mechanisms, public business models, non-conventional financing, Investment barriers, Risk reduction, Innovative funding strategies, Funding gap, Market uptake and Large-scale investments.

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1. Introduction

1.1. About the ASCEND project

1.1.1. Horizon Europe project based on the PCED concept

Launched in January 2023 and coordinated by SPL Lyon Confluence (SPL), ASCEND will accelerate the implementation of PCEDs for 60 months. Specifically, it will deliver two inclusive, affordable PCEDs in Lyon and Munich. The project will scale up solution packages for a large community of cities and investors across Europe. By disseminating its results widely to the smart cities community, ASCEND will make cities healthier, inclusive and climate neutral. It will speed up and scale up the deployment of cost-effective PCEDs solutions and bring about a PCEDs replication wave in eight partnering cities.

A PCED is a delimited urban area composed of buildings with different typologies and public spaces where the total annual energy balance must be positive. Therefore, the district will have an extra energy production that can be shared with other urban zones. The total energy balance is the energy taken from outside the district minus the energy delivered inside the district. Even if all energy carriers can be considered as potential energy inputs and/or outputs, only primary energy units make a suitable calculation of energy flows to establish the total energy balance. Finally, achieving PCEDs means that the amount of energy delivered by the district must be higher than the amount of energy supplied from outside.

PCEDs are defined as "energy-efficient and energy-flexible urban areas 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 infrastructure and interaction between buildings, the users and the regional energy, mobility and ICT systems while optimising the liveability of the urban environment in line with social, economic and environmental sustainability" [1].

Derived from the Positive Energy Block (PEB) definition established by the European Innovation Partnership on Smart Cities and Communities (EIP-SCC), PCEDs are typically developed within cities as part of broader climate action plans, often involving public-private partnerships, digital tools for energy management, and inclusive governance structures to maximise their social, economic, and environmental benefits.

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1.1.2. Energy transition towards a City Vision 2050

For a successful PCED implementation, the ASCEND project is considering a series of key sectors and applications which will ensure a long-term vision for energy transition. A structural shift from a system mainly based on finite energy sources such as fossil fuels, towards a system using more clean and renewable energy sources is considered as energy transition. This significant change also leads to a better management of energy demand in addition to an increase of energy efficiency.
Currently, city energy plans for energy transition are designed within a 2030 horizon, which can be considered as a mid-term strategy (part of the 2030 Climate & Energy Framework in Europe). Nevertheless, learning from the past to plan the future of cities for more than the next few years appears to be a real need. In ASCEND, the City Vision 2050 is used as a longer timescale to address the urban energy system transformation towards low-carbon cities, bringing appropriate energy planning tools as well as reconsidering municipal organisation (creation of City Planning Offices for instance).

The implementation and/or replication of the Positive Clean Energy District (PCED) concept developed by the ASCEND partners includes several applications beyond social innovation and citizen engagement activities. These applications can be categorised based on the project’s five pillars:

Zero-Carbon Frugal Buildings:

- Deployment of high-energy performance buildings with self-consumption systems, powered by clean and locally produced renewable energy.
- Integration of renewable energy sources (RES) and storage solutions, including frugal solutions.
- Implementation of energy-efficient building designs.
- Use of Building Energy Management Systems (BEMS).
- New construction adhering to Nearly Zero-Energy Building (NZEB) standards.
- Installation of standard photovoltaic (PV) systems on roofs with self-consumption and storage capabilities.
- Refurbishment of existing buildings to improve energy performance.

Dynamic and Flexible Energy Grids:

- Deployment of smart grids for electricity and heating to enable real-time management, prediction, and anticipation.
- Development of local energy communities.
- Optimisation of energy flows and demand using digital tools.
- Balancing local and regional heating systems for peak shaving and increasing RES share in the overall system.
- Implementation of smart heating grids.

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- Use of local energy storage, including thermal storage and electricity storage.
- Integration of local biomass combined heat and power (CHP).

Decarbonised Public Spaces and Mobility:

- Creation of car-free districts.
- Deployment of alternative mobility options, such as electro and micro-mobility.
- Redesigning public spaces to be greener and more liveable.
- Implementation of smart charging points for electric vehicles (EVs) and other electric mobility options.
- Use of local photovoltaic production to power EVs.
- Establishment of decarbonised logistics hubs.
- Development of new lanes for bikes and cargo bikes.

Digital Tools:

- Development of digital platforms to support the PCED, optimise energy supply and demand, and manage the district.
- Use of digital twins for PCED design and replication planning.
- Implementation of digital monitoring infrastructure.
- Deployment of a KPI (Key Performance Indicator) engine for automatic PCED indicator calculations.
- Standardisation of data collection procedures and use of open-source tools.
- Integration of AI capabilities for prediction and data interoperability.
- Development of Application Programming Interfaces (APIs) to support data collection and use.

Urban Orchestrator

- Establishment of a public entity, the urban orchestrator, to manage, coordinate, and maintain district performance.
- Development of governance models for local governance at the district level.
- Creation of collaborative structures bringing together stakeholders, such as policy-makers, industry/SMEs, property developers, financial actors, R&I organisations, energy service providers, citizen associations, and energy agencies.

These applications are supported by six SPs which are developed in LHCs and tested in MCs:

- **SP1**: Digital infrastructures and ICT tools to support flexible energy systems and PCED.
- **SP2**: Deployment of energy communities and prosumer services.
- **SP3**: Deployment of energy-efficient buildings integrating RES and storage, including frugal solutions.

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- **SP4**: Decarbonised mobility/freight, including frugal solutions.
- **SP5**: Citizen-centered solutions and co-creation along the governance chain.
- **SP6**: Urban orchestrator.

They are applied in two Lighthouse cities, Lyon (FR) and Munich (DE) and 6 Multiplier Cities, Alba Iulia (RO), Budapest (HU), Charleroi (BE), Porto (PO), Prague (CZ) and Stockholm (SE). These technical and infrastructural applications are intended to work together with social innovation and citizen engagement to achieve the project's goals of climate neutrality, energy efficiency, and improved quality of life in urban areas.

1.1.3. Purpose of this deliverable and target group

The current document is about operational funding and financial mechanisms supporting Solution Packages. This deliverable, D5.3, is a key component of WP5, which is dedicated to scaling up SPs for a large community of cities and investors. **This report aims to bridge the gap between cities and the financial community.** It builds upon the state-of-the-art assessment of the 6 SPs done in deliverable D5.1 and works closely with the capacity-building activities for cities for SP implementation found in deliverable D5.2. **D5.3 focuses on developing new public business models for PCEDs while also evaluating non-conventional financing options from investors.** These models have been assessed through cost-benefit analysis based on the current available information, supporting **project promoters and ASCEND partners** to better structure and organise the specific data and information that could attract **investor** interest.

This report contributes to transferring successfully validated schemes and models to MCs via capacity building programs, as well as provide a dedicated financial decision-making methodology to support the decision-making process regarding innovative funding and financing schemes, and public business models. Furthermore, D5.3 emphasises making PCEDs scalable by design, and ensuring the urban orchestrator and PCED platform are easily transferable. This includes the development of Special Purpose Vehicle (SPV) to provide proof of concept for an Urban Orchestrator, which will play a key role in accelerating PCED deployment.

This deliverable aims to address the challenges cities face in **bridging a funding gap while maintaining their decision power and ensuring accelerated spending, all while lowering investment risks.** It will also work to improve the market viability of the SPs. It is an essential element in the overall strategy to move from pilot programs towards mainstreaming PCEDs, and is designed to enable a wider replication by working to increase the attractiveness for investors.

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1.1.4. Contributing partners

The main author of this deliverable is R2M Solution (T5.3 leader). R2M Solution contacted all relevant project partners, mainly LHCs and MCs, and task contributors including SP owners, USG, BLS to collect data and information about the PCED solutions selected by LHCs and MCs.

1.1.5. Relation to other activities and key aspects in the project

D5.3 and T5.3 are closely related to other activities and key concepts within the ASCEND project, particularly those focused on scaling up and implementing PCEDs. D5.3 is a key output of WP5, which focuses on scaling up the six SPs developed in the project.

Here's how D5.3 and T5.3 relate to other project activities:

- **Building upon Previous Work:** D5.3 builds directly on the state-of-the-art assessment of the six SPs done in deliverable D5.1 (led by USG), and the capacity-building activities for cities for SP implementation included in deliverable D5.2 (led by Energy Cities).
- **Development of Business Models:** T5.3 is specifically focused on the co-design of funding schemes and business models. This involves developing new public business models for PCEDs and evaluating non-conventional financing options. The work done in T5.3 directly informs the content of D5.3 and is strongly connected to the periodical in-presence and virtual Business Models Workshops led by USG with LHCs and MCs.
- **Supporting Implementation:** D5.3 aims to transfer successfully validated financial schemes and models to MCs through a capacity-building programme. This ensures that the financial mechanisms developed are practical and can be used by cities to implement PCEDs.
- **Financial Decision-Making** methodology. A key aspect of D5.3 is the provision of a dedicated financial decision-making methodology mainly based on the CBA.
- **Funding and financing schemes and public business models.** This methodology is intended to help cities make informed decisions about financing PCED projects.
- **Market Viability:** D5.3 and T5.3 are concerned with the market viability of the SPs. This focus on practical application and market needs is vital for ensuring the SPs can be widely adopted.
- **Investment Ratios:** The deliverable focuses on the deployment of innovative funding strategies for both LHCs and MCs, with specific targets for public/private investment ratios. This demonstrates the goal of the project to leverage public funding to attract private investment.
- **Inclusivity and Transferability:** D5.3 emphasises making PCEDs inclusive by design and ensures that the urban orchestrator

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and PCED platform are easily transferable. This is done to ensure the project solutions can be applied across different contexts.

- **Special Purpose Vehicle (SPV):** The deliverable also focuses on the development of SPVs to provide proof of concept for an Urban Orchestrator, which will play a crucial role in accelerating PCED deployment.
- **Design of the digital modules for the Multi-Criteria Decision Analysis tool** (T5.4). D5.3 is directly connected to this task. The assessment of potential financial mechanisms proposed in D5.3 is intended to be integrated within the MCDA tool.
- **Market uptake of Solutions Packages:** the deliverable D5.5 focuses on the market uptake of the SPs. D5.3 contributes directly to the successful market uptake of SPs by addressing financial aspects, as well as providing a dedicated financial decision-making tool to improve their market viability.
- **Feedback from Cities:** D5.3 and T5.3 relate to the work in the LHCs and MCs, as they will provide feedback on the practical application and effectiveness of the solutions and business models.

D5.3 and T5.3 work to bridge the gap between the technical solutions developed in the SPs and the financial realities that cities must navigate to implement PCEDs on a large scale. The work done in these areas is crucial for the project's overall goals of scaling up PCEDs and achieving climate neutrality in cities across Europe.

1.1.6. Challenges related to this deliverable

During the implementation of the CBA activity, several challenges related to data accessibility arose due to various factors, including:

- Confidentiality concerns
- Lack of actual offers or contracts to provide accurate benchmarking
- Absence of economic projections
- Limited quantification of benefits
- Constraints arising from the fact that representatives of the city within ASCEND may not have access to or awareness of data from their municipality's finance department.

This data gap was addressed by utilising information from other sources, including R2M desk research and data from similar projects in Europe (where applicable), or by limiting the scope of the analysis and/or calculations in a few cases.

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2. CBA definitions and methodology

2.1. Definitions

The key definitions to understand the ASCEND methodology (developed and implemented via T5.3) are based on three axes and include [2]:

2.1.1. AXE 1: Economic KPIs

Internal Rate of Return (IRR): It is a financial metric used to evaluate the profitability of an investment or project. It represents the discount rate at which the net present value (NPV) of all future cash flows (both inflows and outflows) equals zero. In other words, IRR is the rate at which an investment breaks even in terms of the present value of its costs and benefits. A higher IRR indicates a more attractive investment.

Net Present Value (NPV): It is a financial metric used to evaluate the profitability of an investment or project. It represents the difference between the present value of cash inflows and the present value of cash outflows over a specified period. The NPV is calculated by discounting future cash flows back to the present value using a specified discount rate (often the cost of capital or required rate of return).

Payback time (PBT): it is the length of time required to recover the initial investment in a project or investment through its net cash inflows. It is a simple metric used to evaluate the risk of an investment: the shorter the payback period, the quicker the investment is expected to generate enough cash flows to recover the initial outlay.

Cost-Benefit Analysis (CBA): A method used to evaluate the financial feasibility of a project by comparing its costs with the expected benefits, helping investors and stakeholders determine whether the project is worth pursuing.

2.1.2. AXE 2: Non-monetary benefits

The non-monetary benefits refer to the advantages or positive outcomes of a project or initiative that cannot be directly measured in financial terms. In the context of PCEDs, these benefits include improvements in air quality, public health, social cohesion, and overall quality of life for residents and many others.

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2.1.3. AXE 3: Risks assessment

The risk assessment is the systematic process of identifying, analysing, and evaluating potential hazards or risks that could negatively affect individuals, assets, or the environment.
It involves determining possible mishaps, their likelihood, consequences, and tolerances for such events.

The capability to collect data and information on the above axes define the **Project Maturity**, intended as **the readiness of the project vis-à-vis investors' interest.** Investors (both public and private) looks at the bankability of the proposed investments and the capability to quantify/qualify the non-monetary benefits and related risks. Under ASCEND methodology, **a project is mature if it can present consistent and justified information about these three axes.**

2.2. ASCEND Methodology

The ASCEND project aims to initiate the process for PCED scaling up at an early stage of development. As highlighted by the current work from the Scalable Cities Business Models and Financing Task Group, one of the main challenges remain **the capability to attract the necessary financing to transform pilots projects into replicable ones:**
"Climate challenges and finances stay in the realm of the public sector, representing only 15 or 20% of the funding needed to decarbonise. Accessing private funding to address the much more significant 80-85% of city assets remains a challenge."
ASCEND T5.3 methodology answers to a specific need linked to the above-mentioned challenge: in order to be able to attract investors' interest, **projects should be mature enough in terms of available data and assessed impacts.** Investors are interested in assessing both the economic, non-monetary benefits and risks related to projects.
The proposed **methodology supports ASCEND cities in the understanding and preparation of the relevant set of information to present their investment projects to potential external investors.** This set of information includes a preliminary profitability analysis of operational solutions, the assessment of non-monetary benefits and a study of the main risks associated with the initiatives. The following scheme summarises the maturity model concept of ASCEND, in which the CBA process is represented by the steps of Level 1 and Level 2.

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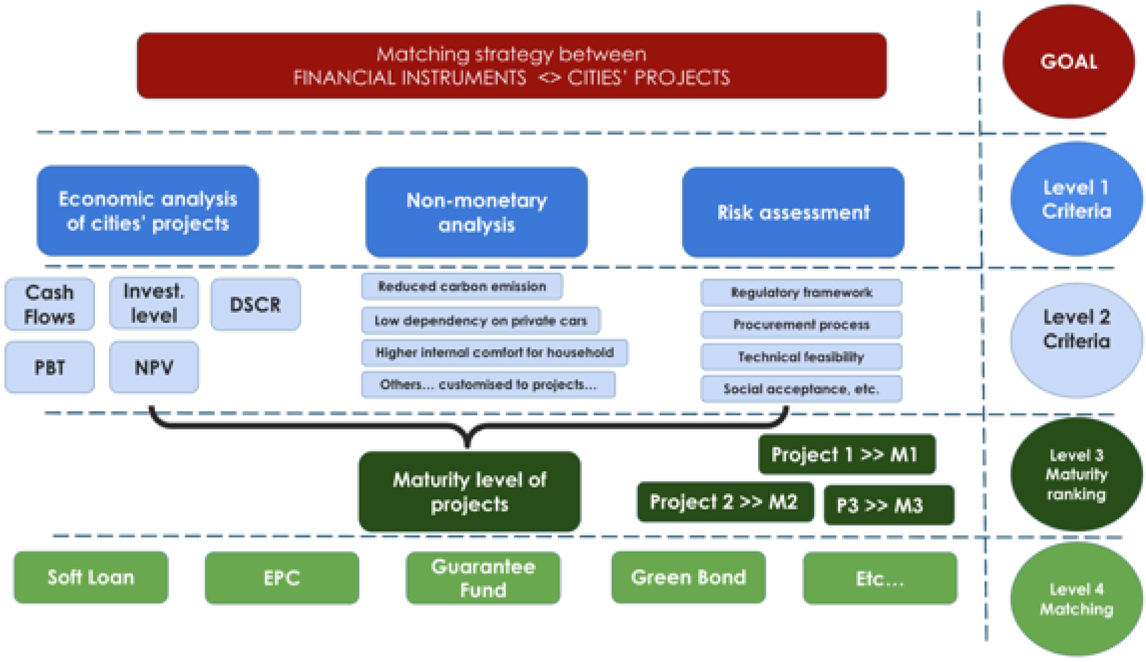

Figure 1 - ASCEND maturity model methodology

For the most mature projects, WP5 aims at suggesting strategies for financing instruments matching and initiate a dialogue with potential investors, helping cities in considering new resources for their PCED development.

Within T5.3 led by R2M, LHCs and MCs were guided in the CBA process, which included the following main phases:

1. Preparation of the **customised templates** to gather i) business model and economic-financial data; ii) information related to non-monetary benefits; iii) preliminary screening of projects' risks and their relevance.

2. Multiple meetings with LHCs and MCs to present the methodology and initiate the process. During the first session, cities were requested **to select the more mature "operational solutions" among the different SP included in cities' Investment Plans.**

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3. R2M developed **a CBA for the selected operational solutions** chosen by the cities. The CBA included the calculation of economic-financial KPIs, identification and quantification (where possible) of non-monetary benefits and analysis of SPs risks.

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Other parallel activities to T5.3 have been beneficial to the CBA process. In particular, the CBA workshop organised by R2M during one of the Experts Training sessions (as reported in paragraph 4.1) and the series of periodic workshops on Business Modelling led by USG have provided valuable insights.

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To complete the calculation of relevant KPIs and describe the project impacts of the seven solutions selected by the cities, **it was necessary in some cases to rely on external assumptions.** These assumptions, not provided by the cities, were based on R2M's desk research on similar EU projects.

D5.3 documents the work carried out to support cities in the CBA process. Although this work was conducted only on one solution per city for the purposes of T5.3, **the developed methodology can serve as a valuable tool for assessing all city investment projects.** It can also be leveraged to evaluate the integration of SPs from a PCED perspective.

The next steps following this report will be implemented through T5.6. Specifically, **the progress of SP development and their integration into PCEDs will be monitored to assess their bankability and contribution to GHG emission reduction.**

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3. Status of the selected operational solutions

3.1. Results from the Expert Training session

3.1.1. Cost Benefit Analysis Workshop at the Expert Training Session in Stockholm

The Cost Benefit Analysis (CBA) workshop, held as part of the Expert Training session in Stockholm, was a key event aimed at equipping representatives from ASCEND cities with the tools necessary to evaluate the financial and non-financial aspects of various urban solutions. **The training specifically targeted those involved in investment decisions at the municipal level,** with a focus on cities at different stages of the ASCEND project. This tailored approach allowed for a deeper understanding of how cities can apply CBA principles to determine the most cost-effective solutions for their needs.

Facilitated by the R2M team, the session was designed to be highly interactive. Local city representatives, decision-makers and external stakeholders were invited to contribute to the workshop, enriching the experience and providing a broader perspective on the challenges and opportunities cities face in evaluating investments.

The CBA workshop also incorporated role-playing exercises and case studies of successfully implemented solutions, which helped participants simulate real-world decision-making based on different CBA scenarios. This practical component not only provided concrete examples but also encouraged discussions on how to adapt these solutions to the unique contexts of the ASCEND cities.

In addition to the CBA training, **the MIRO Board session provided a digital space for cities to interact and assess the maturity of their respective projects.** The cities were tasked with evaluating their solutions in terms of readiness for investment, using a MIRO Board to answer questions about their projects and reflect on their future trajectory. This session encouraged cities to think about the maturity of their projects in six months' time, placing their solutions on a Maturity Board to visually represent their progress and the availability of economic data.

This collaborative exercise provided valuable insights into the maturity of different projects and served as a foundation for the report at hand, which focuses on operational funding and financial mechanisms.

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3.1.2. Solutions Selected by Each City

Below are the solutions selected by each city, which formed the basis of their contributions to the CBA workshop and the MIRO Board session. These solutions reflect the cities' evaluations of their projects' maturity and investment readiness.

Lyon Confluence (FR):

- **Solution LY 4.8 –** Decarbonised logistics hub
- **Solution LY 2.1 -** Energy Communities (only for the MIRO board session)

Munich (DE):

- **Solution MUC 4.2 –** Mobility stations on private land
- **Solution MUC 4.3** – e-Car sharing with a focus on tenants (only for the MIRO board session)

Alba Iulia (RO)

- **Solution ALB 2.1 –** Renewable energy communities

Budapest (HU):

- **Solution BUD 3.2 -** Pilot heat exchange system using drinking water pipeline

Charleroi (BE):

- **Solution CRL 2.2 -** Deploy Energy Community dealing with electricity, heating/cooling and carbon-related topics on the project area

Porto (PO):

- **Solution POR 2.1 -** Plan and develop a PV Energy Community integrating schools, housing and municipal buildings

Prague (CZ):

- **Solution PRA 6.3 -** Investment opportunities for the construction of PCED
-

Since Stockholm's actions within ASCEND are focused on knowledge sharing, it has not participated in this workshop's practice at the request of the Stockholm team.

3.1.3. Actors

To develop standardised models, it is essential to establish a set of actor roles. These roles were initially introduced within the workshop template shared with cities two weeks prior to the session. In addition, these roles and their corresponded terminologies have been further refined within the workshop itself conducted as part of the Expert Training in Stockholm in October 2024 (Table 1).

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Table 1 - List of Actors appearing on the VCE models and Definitions of their roles

Actors	Definition
Citizens	The ultimate recipients of all interventions.
Municipality	Understood in its usual sense. The central coordinating org. in all the Value Creation Ecosystems (VCE) models
Funding body	Any other source of grant-based funding such as the European Commission
Intervention beneficiary	Owners of property that require investment for interventions (e.g. Solar PV) or users of equipment (e.g. buying an e-bus) or a company that is providing a service (e.g. a District Heating System).
Intervention supplier	A Third-Party organisation that provides interventions to private/business owners of property (e.g. Solar PV systems).
Infrastructure provider	The provider of infrastructure that requires capital investment.
Financial institutions	The providers of loans/finance to either i) private or business owners of property, or ii) Special Purpose Vehicles (SPVs), or iii) arrangement of issuing bonds.
Crowdfunding platform	A company that operates a crowdfunding platform and can offer it as a service to a municipality and connect to individuals or groups that will be providing investment.
Monitoring body	Organisation that has an interest in obtaining data about the performance of interventions.
Partner organisation	A partner organisation is being sought through a procurement process to support the municipality in delivering the interventions outlined in the city plan.
Special Purpose Vehicle (SPV)	Organisation that has been created by the municipality either with sole ownership or as a Joint Venture (JV) to enact a role that "circumvents" some of the limitations faced by a municipality e.g. restrictions on borrowing and procurement.

3.1.4. ASCEND cities' business models and monetary schemes

The business models for ASCEND cities focus on long-term urban sustainability by addressing specific city challenges. These models are based on a structured methodology, incorporating a PCED business framework that emphasises collaboration among stakeholders, including political, business, scientific representatives, and citizens, who are considered the central stakeholders. However, challenges in stakeholder collaboration, such as commitment issues and poor communication, have been identified, potentially delaying project implementation and hindering the achievement of shared goals.

Monetary schemes in ASCEND are closely tied to these business models, with funding mechanisms like tax incentives, co-financing, and crowdfunding used to support investments in technologies such as heat exchangers, heat pumps, solar panels, district heating systems, and mobility assets. Despite this, financial barriers like limited human resources and restricted access to funds remain, which could impede the success of PCED projects. This highlights the need for more robust, varied and innovative funding solutions.

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The integration of business models and financial schemes is key to the success of ASCEND. These models ensure the scalability and replicability of PCED frameworks across European cities.

3.1.5. MIRO maturity board

To gather insights on the cities' current situation, we assessed their ability to evaluate the expected financial, environmental, social, and governance impacts of their planned projects. Additionally, we explored the innovative solutions and technologies being implemented and the funding opportunities available for investors. Following this, cities were asked to position their PCED project on the maturity panel, considering its non-monetary impacts and associated risks for the next six months. To facilitate this process, a MIRO maturity board was designed, and its link was shared with the cities for them to complete (Figure 2).

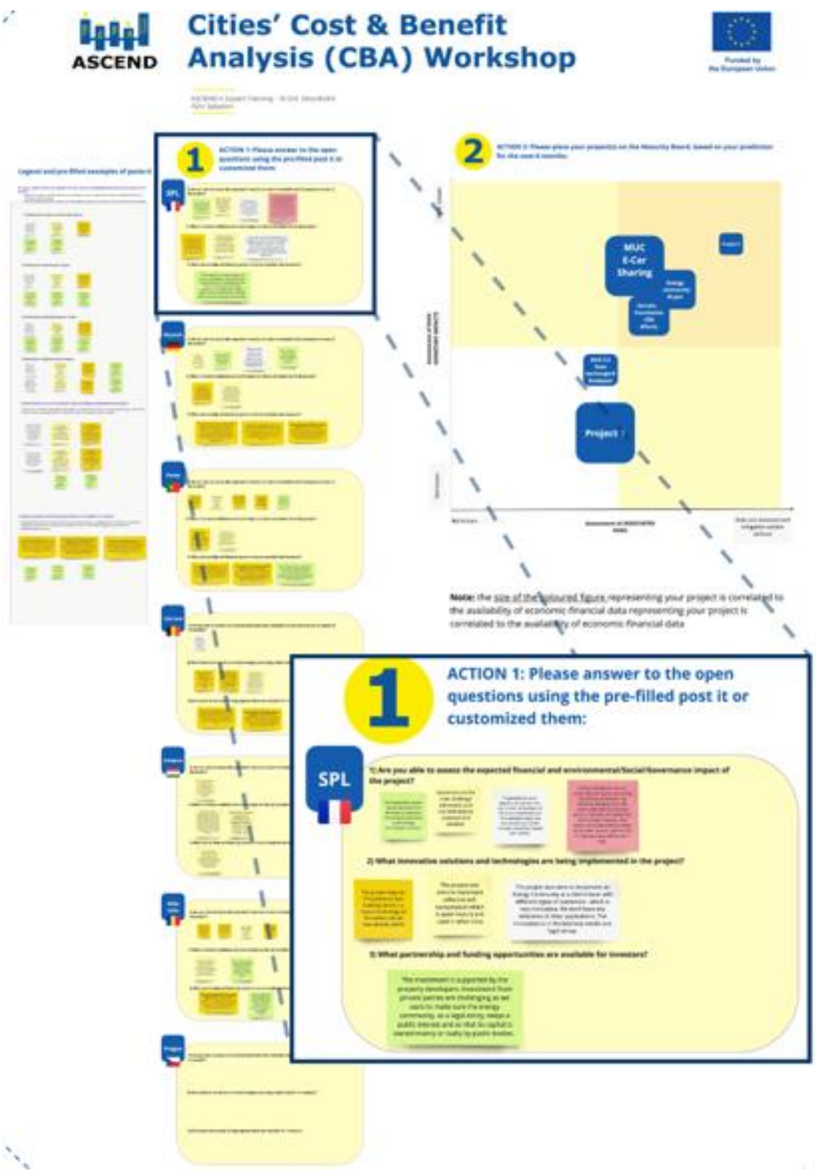

Figure 2 - Interactive MIRO board

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Below the questions asked to each city:

Domain	Question
1) ESG assessment capability	**Are you able to assess the expected financial and environmental/Social/Governance impact of your project?**
2) Technological maturity	**What innovative solutions and technologies are being implemented in your project?**
3) Investor attractiveness	**What partnership and funding opportunities are available for investors?**

3.2. PCED's feasibility, innovation, and sustainability

3.2.1. Lyon

For the MIRO Board session, the Lyon Confluence team decided to participate by considering their solution LY 2.1 Energy Communities. **Regarding the ESG assessment capability aspect** (Question 1, see paragraph 4.1.5), the project's impacts are assessed across financial, environmental, social, and governance dimensions. Environmental impacts are tied to the renewable electricity consumption of community members, while governance challenges are addressed in detail. Social impacts are estimated based on the number of community members, though these estimates may lack precision. Financial impacts can be gauged by comparing the community's electricity selling price to the national market price, though price forecasting carries risks. **In terms of technology maturity** (Question 2, see paragraph 4.1.5), the project integrates well-established PV systems and aims to implement collective self-consumption. A key innovation is the creation of an Energy Community at the district level, with a unique business model and legal framework. **From the investors' perspective** (Question 3, see paragraph 4.1.5), property developers support the investment, but private investment is challenging due to the need for the Energy Community to remain a public interest entity, with its capital mainly owned by public bodies to preserve its social and environmental goals. Lyon's Energy Communities PCED project has reached a significant level of maturity in assessing its non-monetary impacts, with most aspects well understood. Similarly, the project's maturity in evaluating its associated risks is at a comparable stage, demonstrating a strong grasp of potential challenges and mitigation strategies (Figure 3).

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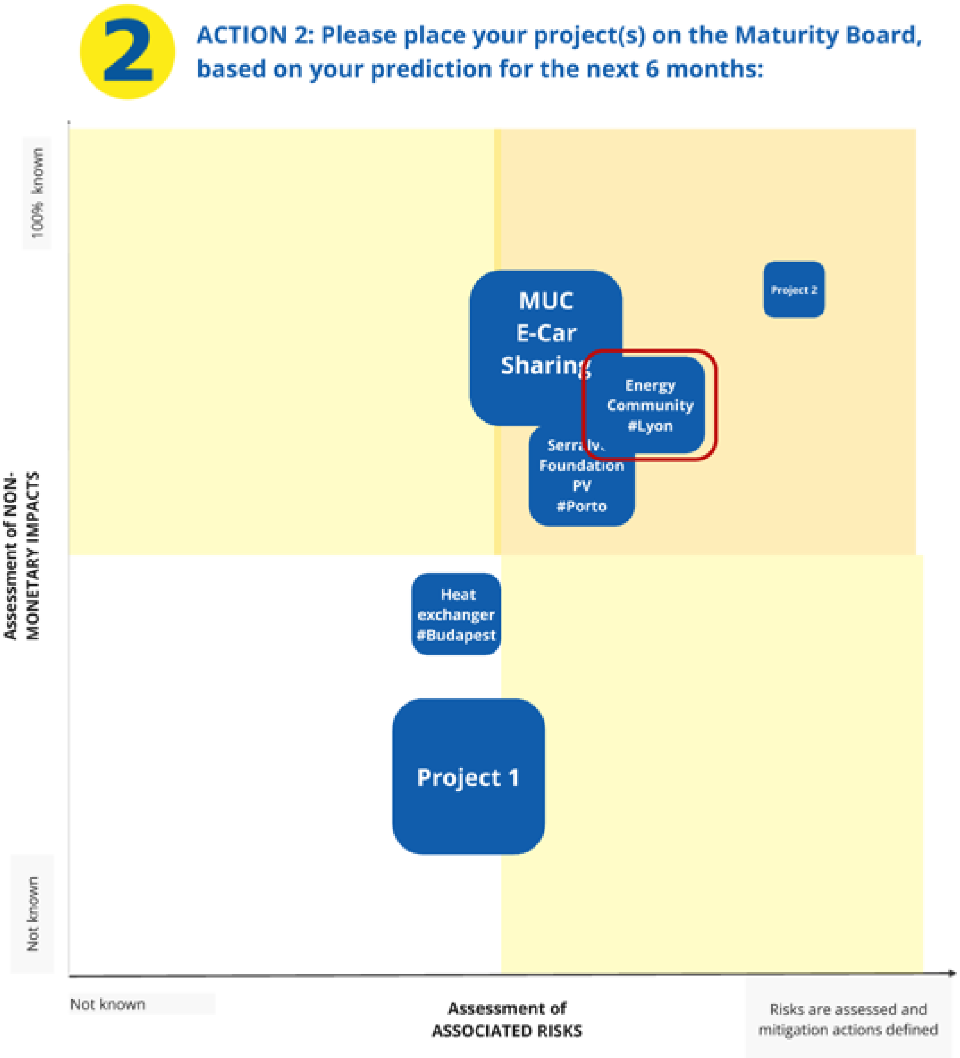

Figure 3 - Placement of the Lyon PCED project on the maturity board

For the purpose of the Cost-Benefit Analysis (see Section 4), an alternative solution to the LY 2.1 Energy Community has been selected (LY 4.8 – Decarbonised logistics hub). This aims to diversify the topics analyzed, in contrast to other cities that are also applying CBAs to the energy community theme.

3.2.2. Munich

For the purpose of the MIRO Board session only, the Munich team selected the solution MUC 4.3 – e-Car sharing with a focus on tenants. **Regarding the ESG assessment capability aspect**, the project's financial, environmental, social, and governance (ESG) impacts are still being assessed, with clearer insights expected after operations begin in Q2 2025. Environmental and social impacts remain uncertain, and governance impacts related to e-carsharing are difficult to define at this stage. **In terms of technology maturity**, the project integrates

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e-carsharing which is a mature application, but replicating this in privately owned buildings may be challenging due to space constraints. The demand for e-carsharing in the district is still to be assessed, and partnerships could involve property owners providing parking with charging facilities. **From the investment perspective**, funding could come from energy upgrading projects, tax incentives, subsidised financing, and European structural funds, as well as local and green investment platforms. Munich's e-carsharing with a focus on tenants PCED project has reached a significant level of maturity in assessing its non-monetary impacts, with most aspects well understood. Similarly, the project's maturity in evaluating its associated risks is at a comparable stage, demonstrating a strong grasp of potential challenges and mitigation strategies.

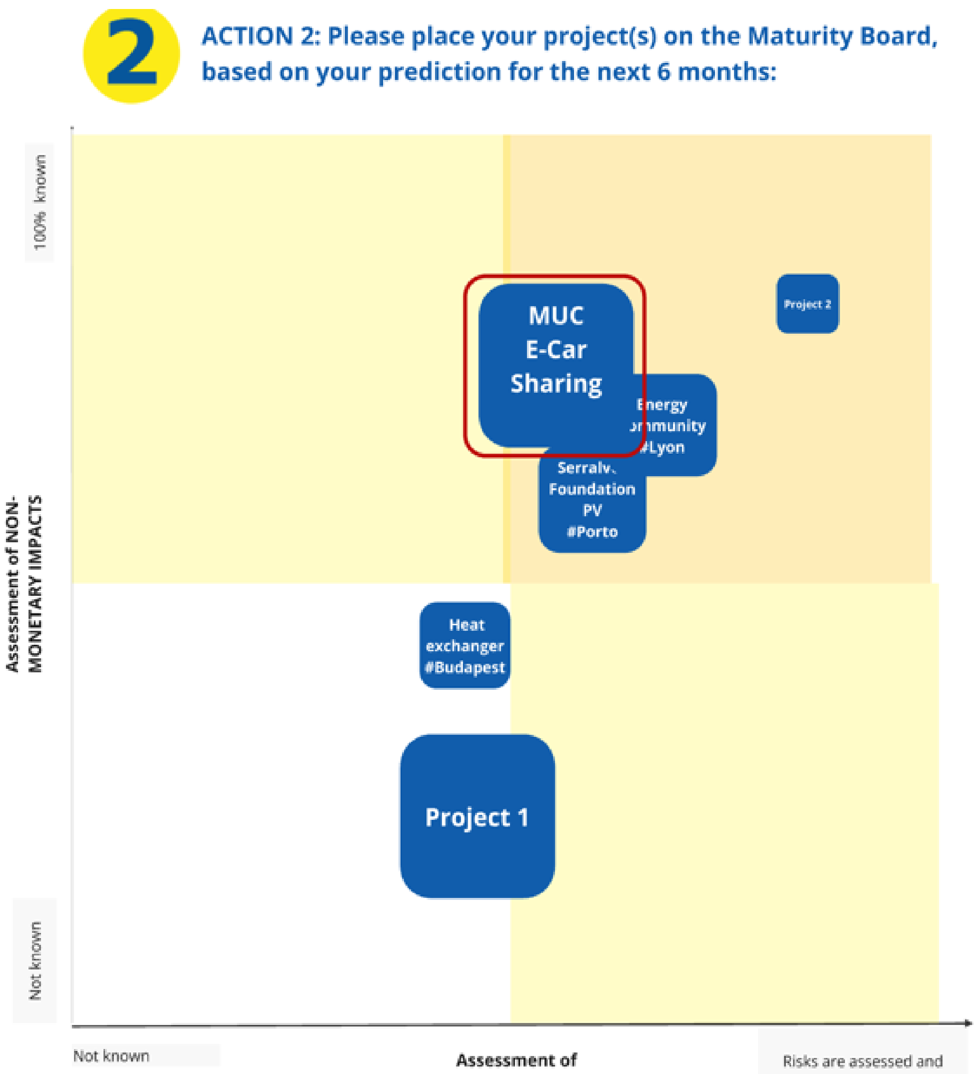

Figure 4 - Placement of the Munich PCED project on the maturity board

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For the purpose of the Cost Benefit Analysis (see Section 4), an alternative solution to the MUC 4.3 e-car sharing with a focus on tenants has been selected (MUC 4.2 – Mobility stations on private land). This is due to the higher availability of data to be used in the CBA at the time of this report.

3.2.3. Alba Iulia

For the purpose of the MIRO Board session, Alba Iulia team took a general view on their large portfolio of projects. **Regarding the ESG assessment capability aspect**, the project's financial and ESG impacts are evaluated using measurable factors like environmental effects, governance involvement, economic viability, and social engagement. **Concerning the technological maturity**, it incorporates advanced technologies such as PV systems, batteries, and heat pumps, though its replication is hindered by legislative and financial barriers. **In terms of investment opportunities**, these include EU structural funds and green investment platforms, but legal limitations on public-private partnerships may restrict investment. Overcoming these barriers could boost investment potential and scalability.

The maturity board diagram maps Alba Iulia's PCED projects by their known non-monetary impacts (vertical axis) and assessed risks (horizontal axis). Projects like "Upgrade public lighting to LED," "Rehabilitation works at Dorin Pavel High School," "Building new lanes for bikes," and "Engage local stakeholders" are in the upper-right quadrant, showing well-known impacts and well-managed risks. The " Smart energy management" project sits centrally, indicating moderate clarity on impacts and risks. "Create new PEB campus" and "Organise a Climathon" are lower but still show good risk assessment. The empty lower-left quadrant highlights the absence of immature projects with unknown impacts and risks.

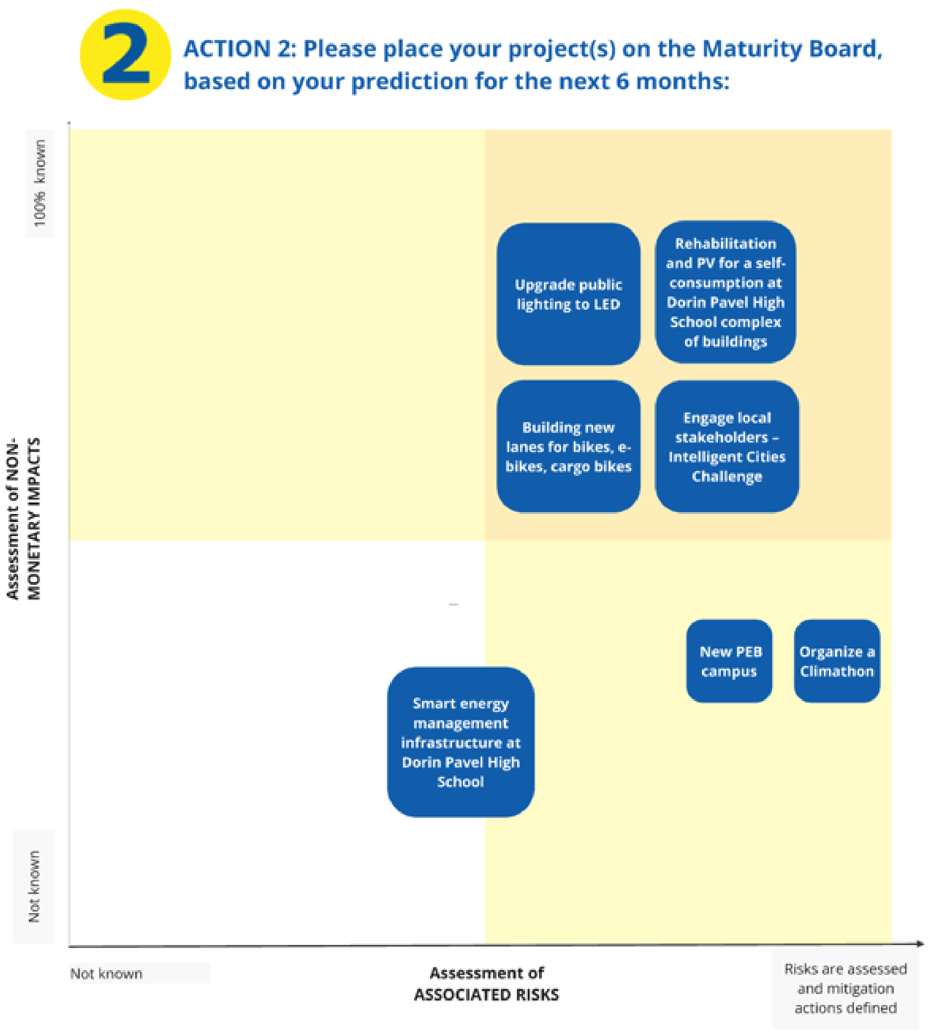

Figure 5 - Placement of the Alba Iulia's PCED projects on the maturity board

3.2.4. Budapest

Budapest team selected the solution BUD 3.2 - Pilot heat exchange system using the drinking water pipeline. **In terms of ESG assessment capability**, the project is in its early stages, so its financial and ESG impacts are not yet fully assessable. Further evaluations will be required as it progresses. **From the technological perspective**, the initiative, led by Budapest Waterworks, introduces an innovative solution that uses the excess heat capacity of potable water by integrating a heat exchanger into standard heat pumps for heating and cooling nearby buildings. The project team is exploring expanding the system to more buildings, enhancing scalability. **Regarding the investment aspects**, Budapest Waterworks will manage the design, financing, and operation, ensuring sustainable deployment.

The Solution BUD 3.2 - Pilot heat exchange system using the drinking water pipeline within the PCED project has reached an early stage of maturity in assessing its non-monetary impacts, with a basic

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understanding of its environmental, social, and governance effects, though further analysis is needed. Similarly, the project's assessment of associated risks is at a slightly more developed stage, with some key risks identified but still requiring a more comprehensive evaluation to ensure effective mitigation strategies.

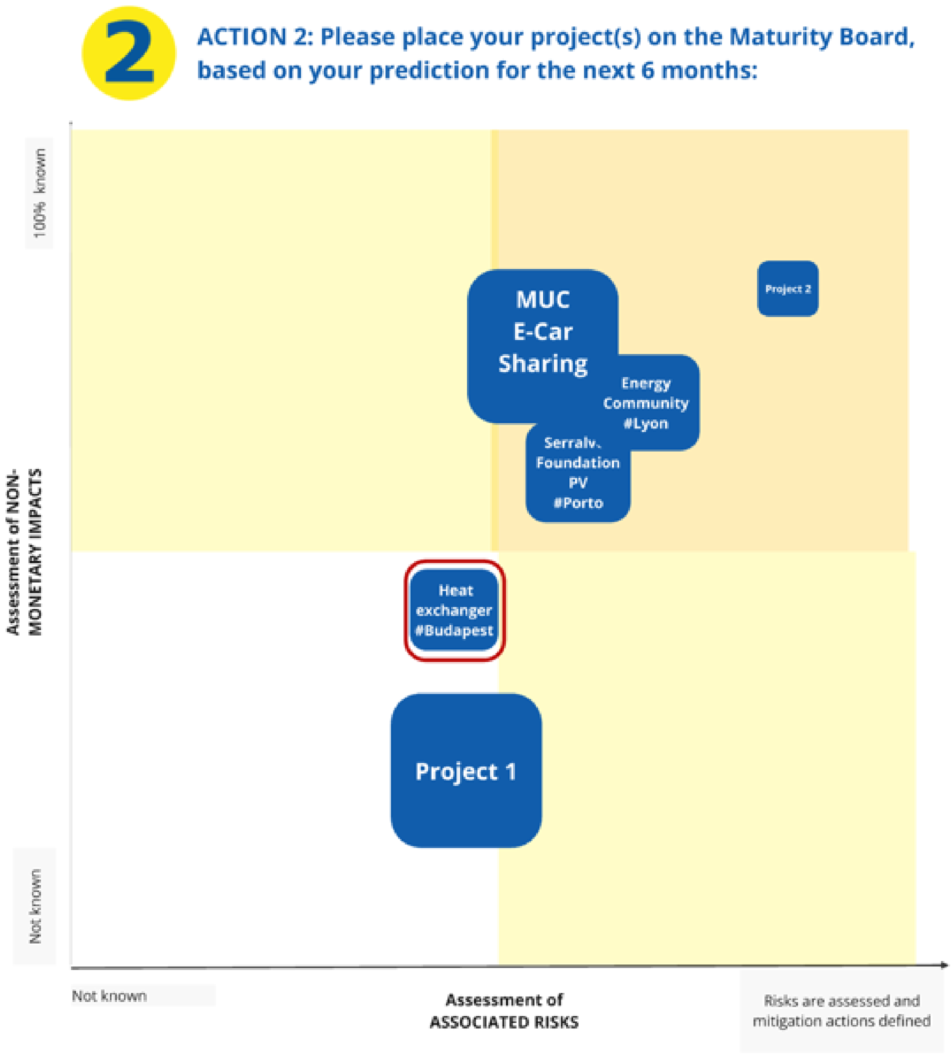

Figure 6 - Placement of the Budapest PCED project on the maturity board

3.2.5. Charleroi

Charleroi team selected their solution CRL 2.2 - Energy Community. **In terms of ESG assessment,** at this early stage, there is limited information on financing and it is difficult to assess the project's financial and ESG impacts. **From a technological maturity perspective,** the initiative will incorporate PV installations and an Energy network Installation, both proven technologies. The project aims to create an Energy Community with public and private entities, but its development is uncertain due to national legal barriers. These challenges will require further analysis. **Regarding the investment perspective,**

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various funding and partnership opportunities are available, including public-private financing, European funds like Horizon Europe, and sustainability-focused financial instruments. Structural funds, local investment programs, and green investment platforms can also support the project's success.

As of February 2025, the municipality of Charleroi was not ready to place their PCED project on the maturity board.

3.2.6. Porto

Concerning the Porto's solution POR 2.1 - Energy Community, the project's financial and ESG impacts can be assessed using quantifiable factors, with environmental impacts measured by established technologies and social impacts estimated through research or assumptions. Governance impacts are determined by data such as local authority involvement. Funding options are clear, with an application submitted to the Recovery and Resilience Fund (PRR) and additional funding sources available. **Concerning the technological aspects**, the project integrates PV installations and aims to establish an Energy Community, though legal barriers may impact scalability. **In terms of investment perspective**, various funding opportunities exist, including public-private financing, European funds like Horizon Europe, and local investment programs. The project's CBA offers potential for innovative funding methods, which could be replicated to enhance financial viability.

The Serralves Foundation project, within the Porto PCED project, has reached a moderate to advanced stage in assessing its non-monetary impact, with approximately two thirds of the evaluation already established. In terms of assessing associated risks, the project's maturity is at a solid but slightly lower level, with around three fifths of the necessary analysis completed.

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Figure 7 - Placement of the Porto's PCED project on the maturity board

3.2.7. Prague

As of February 2025, the municipality of Prague was not ready to provide information on its PCED project's feasibility, innovation, and sustainability as well as placing their PCED project on the maturity board.

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4. Cost Benefit Analysis (CBA)

This section presents a summary of the results of the cost benefits analysis applied to seven selected solutions from ASCEND cities. The full details of the CBA can be found in the annexes.

4.1. CBA applied to Lyon Confluence – Decarbonised Mobility Hub

4.1.1. Overview of the decarbonised mobility hub (Micro Hub)

The Lyon Confluence Micro Hub, developed in alignment **with Solution Package 4 – Mobility & Freight (SP4)** of the ASCEND project, is a strategic infrastructure initiative aimed at advancing decarbonised urban logistics and mobility services within the Lyon Confluence PCED. Located in the underground space of a new real estate complex, the Micro Hub is envisioned as a multi-functional space offering different services:

- Bike storage for residents;
- Car-sharing services for residents and the general public;
- Last-mile logistics services;
- Rental parking.
-

Some of the services will be provided and managed by Lyon Confluence (car-sharing logistics zone), others by the real estate developer.

Figure 8 - Detail of the underground space in which the Micro Hub will be located

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4.1.2. Business model options and selected scenario

The Micro Hub is being developed through a mechanism similar to a **Public-Private Partnership (PPP) between SPL Lyon Confluence (public body and landowner) and a real estate (RE) developer (private entity responsible for construction).** SPL oversees district-level sustainability standards and may become the partial or full owner of the Micro Hub, leasing out spaces to mobility and logistics providers. The users include both future residents of the buildings and the wider community. While external financiers are not currently involved, price compensation mechanisms are employed in the financing strategy.

After exploring different potential ownership and investment models, the following one was selected by Lyon Confluence:

- **Scenario 4:** SPL invests in ~40% of the hub, targeting the logistics area and 10 car-sharing parking slots. This scenario excludes external financing to reflect SPL's strategy to compensate the hub construction costs via a win-win agreement with the RE developer. SPL is allowing them to have parking spaces to exploit and to own spaces on the ground floor that they will rent out.

The selected business model focuses on renting out specific spaces to service providers, balancing initial capital expenditure with income from carsharing and logistics services.

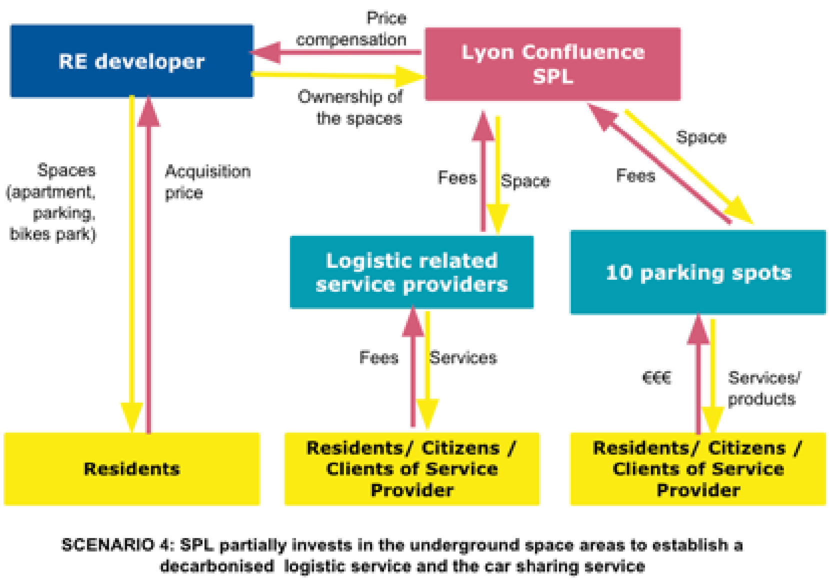

Figure 9 - Business Model of SPL selected scenario

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4.1.3. Economic and financial feasibility analysis

The financial analysis of Scenario 4 highlights key assumptions and investment dynamics:

Monetisation Strategy

It includes the renting of the acquired Micro Hub spaces to different service providers:

- **Car service area:** SPL owns the equivalent area of 10 car spots to be rented to carsharing service providers. Based on the current assumptions, both residents and external citizens could benefit from the service.
- **Logistics service area:** SPL rents the area to logistic service providers able to offer a low-carbon storage area, transfer zones for goods and parcels.

Cost structure of the project

The scenarios for the Micro Hub project considered the following cost items:

- **CAPEX:** the project promoter acquires the spaces from the RE developer who is responsible for the construction of the planned residential real estate. The acquisition price is managed via a compensation mechanism allowing the RE developer to have parkings and private spaces to rent.
- **Operating costs:** maintenance costs for cleaning and small interventions and administrative costs to manage the rental contracts with different counterparts have been considered.

Despite efforts to minimise upfront costs, the analysis shows that Scenario 4 yields a negative Net Present Value (NPV) under current assumptions. Achieving a positive NPV would require revenue increases to around €80k–85k annually, which may be difficult given the service nature and modest rental footprint.

The economic sustainability of the Micro Hub should thus not be judged in isolation but as part of a broader district-level decarbonisation strategy. In this context, non-monetary benefits and replicability potential significantly increase the project's value.

The PPP model based on land ownership leverage offers a blueprint for replication in other cities, enabling low-carbon investments with modest public expenditure. With appropriate policy support, performance monitoring, and scaling strategies, this model can contribute meaningfully to city-level climate goals and social equity objectives.

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4.1.4. Non-Monetary Benefits

Despite its limited immediate financial return, the Micro Hub delivers substantial environmental, social, and public health benefits:

Environmental Impact

- Decreases CO_2 emissions by encouraging electric/light logistics vehicles;
- Improves air quality, reducing pollutants such as NOx and PM2.5, with associated healthcare cost reductions.

Social Benefits

- Provides inclusive mobility services (e.g. bike/car sharing) for all income levels and people with disabilities;
- Fosters community cohesion by offering shared spaces and services.

Public Health Outcomes

- Encourages physical activity via active mobility options;
- Reduces road accidents by shifting from heavy freight to bikes and smaller electric vehicles;
- Minimises noise pollution, positively impacting mental health and sleep.

The long-term social return on investment is strongly positive when considering these co-benefits, especially if the solution is replicated across other urban developments.

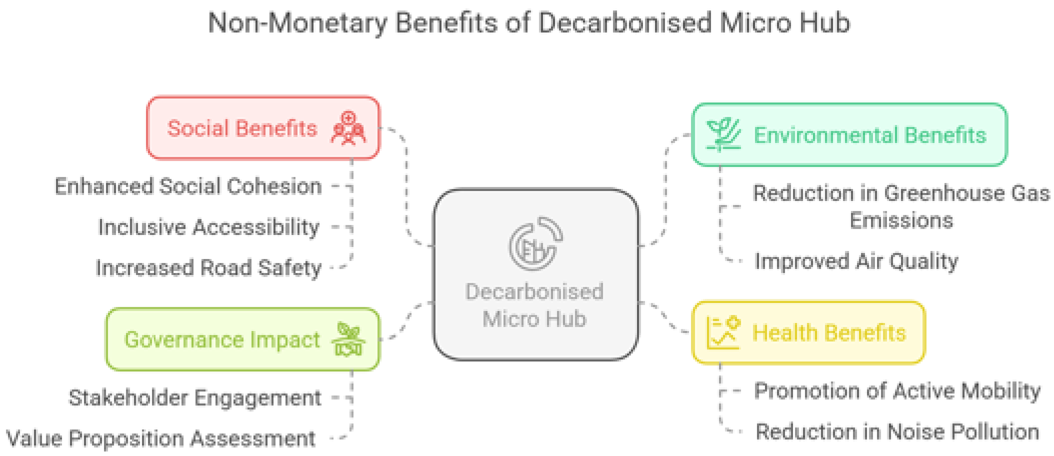

Figure 10 - Non-Monetary Benefits of solution LY 4.8

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4.1.5. Risk Assessment

Several risks have been identified, with mitigation strategies proposed:

Technological Risks
- Integration delays and obsolescence: addressed by modular design and phased implementation (TEC1);
- Risk of technology becoming obsolete (TEC2).

Management and Operational Risks
- Lack of experienced managers to oversee stakeholder relationships (MAN1);
- Complexity in managing multiple contracts (OPE1);
- Construction delays (OPE2);
- Offline assets due to maintenance (OPE3).

Market Risks
- Competition from established mobility services (MKT1);
- Changes in market demand for the involved services (MKT2);
- Increased in taxes affecting profitability (MKT3).

Financial Risks
- Budget overruns and revenue shortfalls: tackled through tight financial control and diverse revenue strategies (FIN1);

Security and Social Risks
- Cybersecurity threats to digital systems (SEC1);
- Risks related to the protection of personal data/privacy (LEG1);
- Resident resistance(SOC1);
- Inadequate engagement with stakeholders (SOC2);

Scalability Risks
- Difficulties in expanding the project as demand grows (SCA1).

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Figure 11 - Risks matrix for solution LY 4.8

4.2. CBA applied to Munich – Mobility stations on private land

4.2.1. Overview of the Mobility Stations concept

In alignment with Solution Package 4 – Mobility and Freight Transport (SP4) of the ASCEND project, Münchner Wohnen (MW), Munich's municipal housing company, is implementing shared mobility stations on private property in the Harthof district, within the PCED lighthouse area of Munich.

The project seeks to integrate:

- Carsharing services for residents at discounted rates;
- Free access to pedelecs and electric cargo bikes.

These services are deployed in connection with new social housing construction. The legal framework allows developers like MW to reduce the number of mandatory underground parking spots per apartment if they offer a qualified mobility concept. Thus, by implementing mobility stations, MW can save significantly on construction costs, while supporting sustainable urban transport.

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Figure 12 - Picture of pedelecs and electric cargo-bikes

4.2.1. Business model

The business model for Solution 4.2 is based on a successful model already implemented in other Munich districts. It leverages municipal budget allocations for social housing while reducing infrastructure costs via legal exemptions on parking requirements.

Key Elements of the Business Model:

- Public financing via the City of Munich;
- Avoidance of expensive underground parking by substituting it with mobility stations;
- Outsourced services: carsharing is managed by an external provider under MW's oversight;
- No external financiers are involved in this case.

MW maintains ownership and responsibility for infrastructure and services. The cost savings from reduced parking construction are partially reinvested into enhanced mobility offerings, increasing value for residents without generating direct revenue.

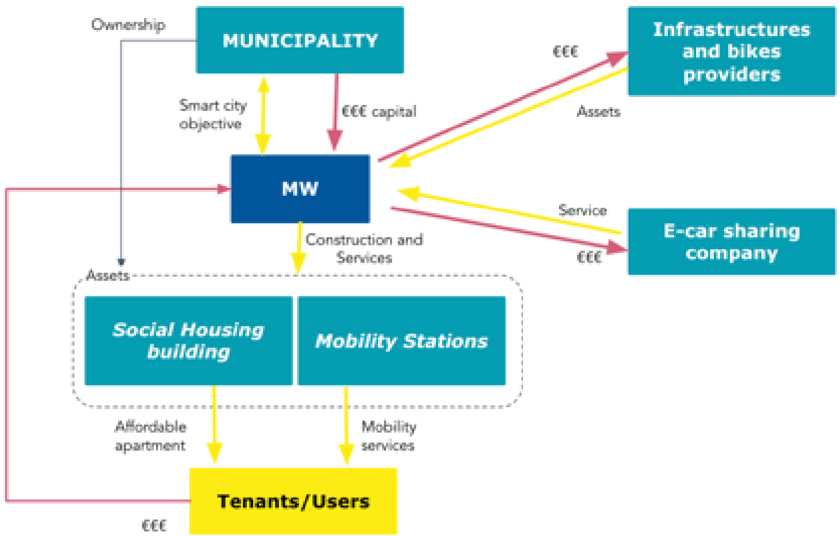

Figure 13 – Business model scheme of solution MUC 4.2

4.2.2. Economic-financial feasibility analysis

The economic analysis conducted for ASCEND Task 5.3 focused on cost efficiency rather than revenue generation, as MW does not profit directly from service use.

Monetisation Strategy

- No income is generated from mobility services themselves;
- The main financial advantage is the avoidance of underground parking costs.

Costs structure

The business model of the solution is characterised by the following cost items:

- **CAPEX:** MW covers the investment costs for the bikes and cargo bikes as well as the installation of the mobility stations to accommodate them and ensure a rental operation.
- **Operating costs:** MW covers the general maintenance/service of the bikes, electric cargo bikes and the infrastructure of the mobility points, including the cost of lighting and space cleaning. OPEX also includes the service fee paid to the car-sharing company for managing its service on public land.

Based on a 15-year horizon, the Net Present Value (NPV) is estimated at €2.71 million. This value is grounded in building regulation savings. The investment model is self-sustaining and cost-efficient, especially when replicated at a city level for new social housing.

This model has limited scalability beyond Munich, as it relies on a specific legal context that permits parking exemptions. However, it can be transferred across the city or to other municipalities with similar legislative frameworks.

The Munich Mobility Station use case demonstrates how smart regulatory levers—such as adjusting parking requirements—can unlock significant cost savings while supporting climate and social policy goals.

4.2.3. Non-Monetary Benefits

The project's real value lies in its social, environmental, and health contributions to the urban ecosystem.

Environmental Sustainability

- Encourages low-emission, shared mobility, reducing GHG emissions and improving air quality;
- Frees up urban space, allowing for green areas and biodiversity through reduced parking infrastructure;
- Decreases noise pollution, enhancing resident quality of life.

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Social Inclusion and Equity

- Ensures equal access to mobility, particularly for low-income residents without cars;
- Benefits underserved areas lacking robust public transport;
- Creates safer, more walkable neighbourhoods by reducing car congestion.

Public Health and Well-being

- Improved air quality translates to lower respiratory illnesses and reduced public health costs;
- Enhances physical activity by promoting active transport like biking;
- Reduces road accidents and improves community safety.

Behavioural and Cultural Change

- Raises awareness of sustainable transportation benefits;
- Promotes collective mobility mindsets, discouraging private car ownership.

Urban Innovation and Leadership

- Incorporates smart digital solutions (apps, booking platforms);
- Aligns with Munich's Mobility Strategy 2035, strengthening the city's role as a leader in sustainable urban transport innovation.

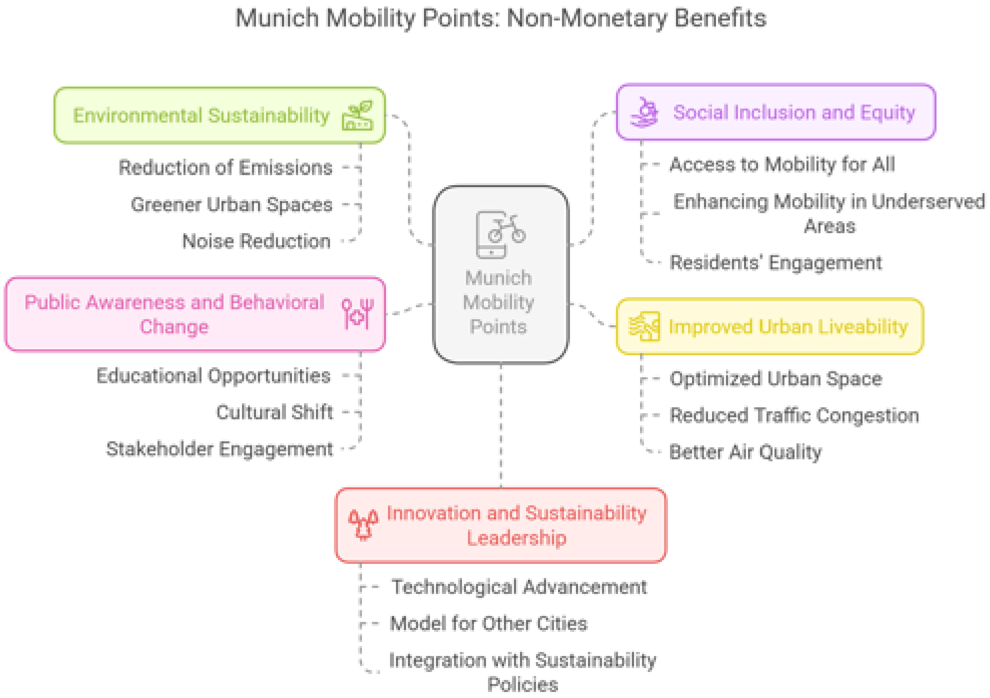

Figure 14 – Non-Monetary Benefits of solution MUC 4.2

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4.2.4. Risk Assessment

The project, while low-risk overall, includes potential challenges across operational, technological, financial, and regulatory dimensions.

Technological Risks

- Uncertainties in planning and siting of charging infrastructure (TEC1).

Financial Risks

- High initial CAPEX for infrastructure and vehicle procurement (FIN1);
- Uncertain adoption rates could affect cost-effectiveness (FIN2);
- Volatile market situation, changing providers (FIN3).

Operational Risks

- Maintenance needs for shared bikes and infrastructure (OPE1);
- Risk of service interruption from outsourced carsharing operations (OPE2);
- Vehicle maintenance and reliability issues (OPE3).

Market and Competitive Risks

- Competing mobility services (e.g. ride-hailing, private rentals) (MKT1);
- Changes in local regulations for urban mobility (MKT2).

Regulatory and Legal Risks

- Shifting environmental policies or building codes could impact planning (LEG1);
- Data protection and GDPR compliance for user data (LEG2).

Social Acceptance Risks

- Stakeholders responsibility (car sharing) (SOC1);
- Insufficient communication/public relations (SOC2);
- Fear of losing parking spaces (SOC3).

Security Risks

- Data breaches, hacking, misuse of data (SEC1).

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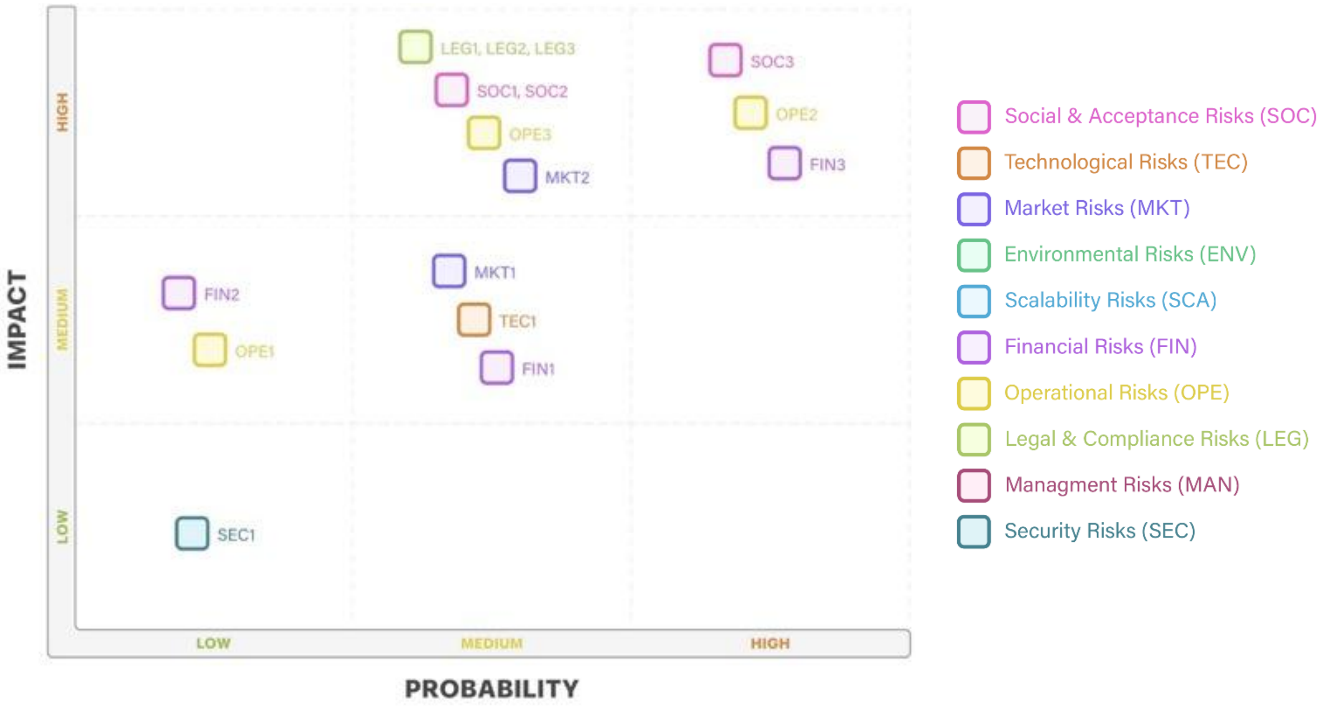

Figure 15 – Risks matrix for solution MUC 4.2

4.3. CBA applied to Porto – Energy community within the PCED

4.3.1. Overview of the photovoltaic project and future scenario for the energy community

As part of **Solution Package 2 – Deployment of Energy Communities and Prosumer Services (SP2)**, the Porto Energy Agency is supporting the creation of energy communities through the installation of photovoltaic (PV) systems across a mix of public and private buildings in the PCED of Porto. These include social housing complexes, schools, municipal police buildings, and notably the Serralves Museum, a private cultural landmark.

While the long-term vision involves shared energy use across a distributed community, this Cost-Benefit Analysis (CBA) focuses on the individual self-consumption PV installation planned at the Serralves Museum, which offers a valuable test case to develop KPIs for future replicable models involving private stakeholders.

The Serralves Foundation, owner of the museum, plays a leading role as the project promoter, facing both technical and legal complexities due to the site's classification as a National Monument, which requires heritage authority approvals for any infrastructural changes.

The Serralves Museum, a large multi-functional facility, consumes nearly 2 million kWh/year of electricity. The site’s high energy

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demand, driven by strict conservation requirements for artworks and visitor comfort, makes it ideal for a PV self-consumption project.

4.3.1. Business model

In the short term, the Foundation aims to install a PV system for exclusive self-consumption, generating cost savings through reduced electricity bills. This standalone model allows for fast implementation while respecting the regulatory constraints of a heritage site. In the long term, the model may evolve into a multi-stakeholder energy community, integrating schools, police buildings, housing blocks, and potentially new partners such as Águas e Energia do Porto (AedP) and Porto Digital. These actors would jointly share renewable energy, strengthening decarbonisation, social inclusion, and urban resilience.

The CBA analysis conducted under ASCEND Task 5.3 is limited to the **short-term scenario** due to data availability.

The two scenarios in the short and long terms are visualised in the following schemes:

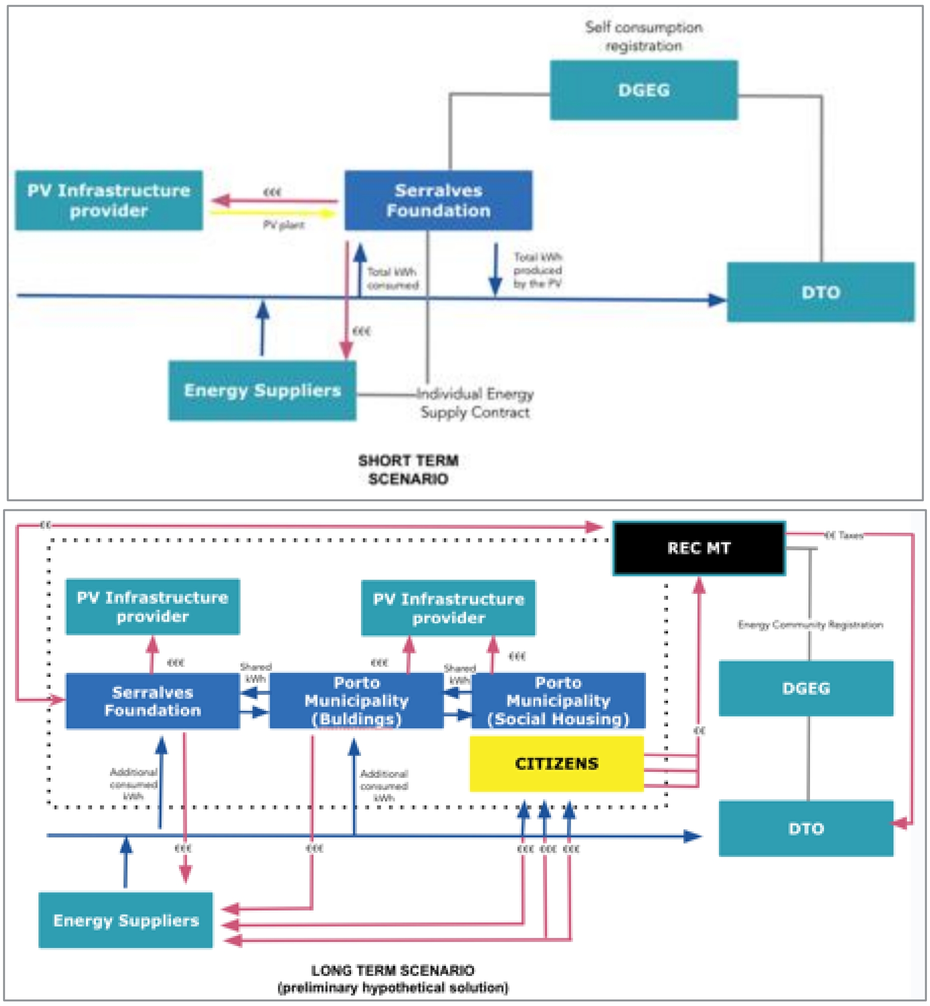

Figure 16 – Business model schemes in the short and long term

4.3.1. Economic-financial feasibility analysis

The economic-financial analysis highlighted the following aspects:

Monetisation strategy

In the considered scenario, the monetisation strategy includes:

- The **energy savings** due to the self-consumption of 100% of the electricity produced by the PV plant.

Cost structure of the project

The scenario analysis considered the following cost items:

- **CAPEX**: the project promoter acquires the PV installation and invests in some additional project-related costs such as structural analysis and construction of new low-voltage branches.
- **Operating costs by the project promoter**: they have been preliminary estimated as a flat fee including maintenance costs for cleaning, small interventions and administrative costs to manage the procedure with the energy authorities (i.e. DGEG, DTO).

A time window of 15 years has been considered for the calculation of the following main KPIs (project IRR and NPV) of the reference scenario, the full calculation of which is provided in Annex 16.3.1:

REFERENCE SCENARIO	**Reference scenario including grant** (including secured grant of 55,000€)	**Reference scenario without grant**
Payback time	5 years	9 years
Project IRR	21.4%	10.0%
Net Present Value	126,772 €	71,772 €

Under the considered assumptions, even without grant funding, the investment remains **financially viable.** Simulations based on **min/max input variations** confirm a robust business case across a range of conditions.

Analysis of potential financial instruments suitable for the investment

With the aim of testing a potential financing instrument applicable to the Porto SP2 project, R2M developed a simulation scenario incorporating a crowdlending mechanism designed to cover 30% of the expected investment. Serralves Foundation has not provided any confirmation or validation regarding the applicability of the proposed scenario to their specific context. This involves:

- Use of a crowdfunding platform (e.g. GoParity);
- 4-year loan term;
- 6% annual return for community investors;

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- Monthly repayments including capital and interest.

From the project promoter's perspective, the impact on KPIs is negligible, but 50% of energy savings would go toward loan repayment in the first 4 years. This model promotes community participation, offering citizens a financial stake in Porto's energy transition and demonstrating how private PV projects can attract socially responsible investment.

4.3.2. Non-monetary benefits

Though focused on financial viability, the project generates significant non-monetary benefits, contributing to environmental, educational, social, and cultural objectives.

Environmental Impact

- Annual CO_2 reduction of 32.5 tons;
- Supports Porto's climate neutrality and European Green Deal targets;
- Enhances energy resilience through local self-generation.

Social and Educational Value

- The Serralves Foundation acts as a cultural ambassador for sustainability;
- Awareness campaigns, exhibitions, and youth education programs promote behavioural change and public engagement;
- Future expansion to social housing will help reduce energy poverty.

Public Health & Heritage Preservation

- Lower reliance on fossil fuels improves air quality;
- PV integration in a heritage site showcases how sustainability and cultural preservation can co-exist.

Governance and Replicability

- Demonstrates multi-actor cooperation involving public institutions, private investors, and citizens;
- Use of digital monitoring tools fosters transparency and active citizen participation;
- Offers a scalable model for similar urban contexts across Europe.

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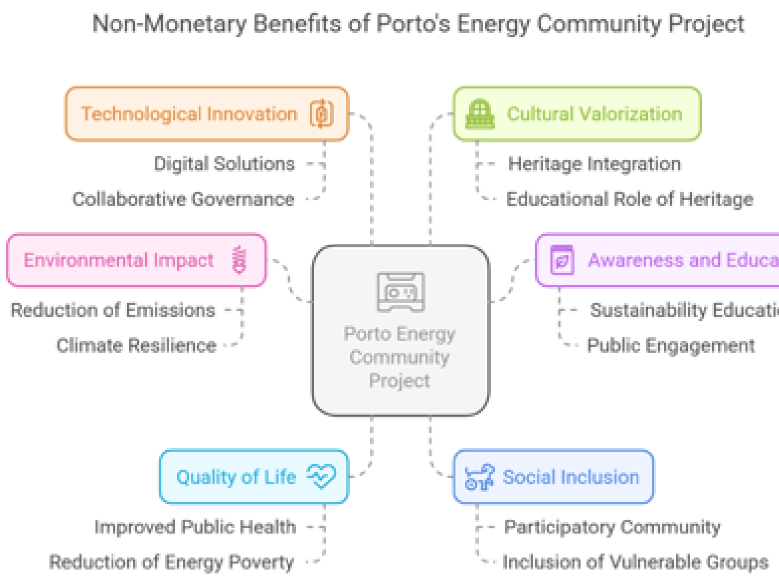

Figure 17 – Non-Monetary Benefits of Solution POR 2.1

4.3.3. Risks and mitigation strategies

The project presents various risks, mostly technical, financial, and regulatory, but they are considered manageable with appropriate safeguards.

Technological Risks

- Integration of PV with existing infrastructure may require upgrades or compatibility checks (TEC1);
- Uncertaint reliability/performance in the long term (TEC2).

Financial Risks

- Cost fluctuations in materials (e.g. silicon)(FIN1);
- Delays in grant disbursement or financing approval (FIN2).

Operational Risks

- Delays in installation and permitting (OPE1);
- Complexity in managing projects with multiple stakeholders (OPE2).

Market and Legal Risks

- Changes in energy tariffs or regulatory frameworks (MKT1);
- Unforeseen fluctuations in energy demand (MKT2);
- Legal/transparency restrictions for integration of public/private REC (LEG1);
- Difficult comply with criteria for integrating new elements into Classified buildings (LEG2).

Social & Environmental Risks

- Concerns regarding the environmental impact of solution (SOC1).

Figure 18 – Risks matrix for solution POR 2.1

4.4. CBA applied to Budapest - Pilot heat exchange system using drinking water pipeline

4.4.1. Overview of Budapest solution package

As part of **Solution Package 3 – Deployment of Energy-Efficient Buildings and RES (SP3)**, the Municipality of Budapest plans to refurbish an abandoned former school in the city's IV District into a Net Zero Energy co-housing facility with approximately 42 affordable apartments for around 100–120 socially disadvantaged people.

To power the heating, cooling, and hot water systems, the city proposes testing an innovative pilot technology developed by Budapest Waterworks that uses drinking water pipelines as a thermal exchange medium. The system takes advantage of the stable year-round temperature of potable water to operate heat pumps efficiently, potentially reducing GHG emissions and improving energy performance.

This pilot is the first real-world deployment of a heat exchanger technology that is custom-designed to comply with the requirements of potable water infrastructure. The project may be expanded to connect other nearby buildings and could serve as a model for replication across the district and city.

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Figure 19 – Pipes sections in Budapest District marked in red where the minimum water speed exceeds 0.2 m/s in the main pipes

4.4.2. Business model

The business model is in an early exploratory phase, with no contracts signed yet. **The partnership between the municipality and Budapest Waterworks is informal but strong, and the project has zoning support from the IV District administration.** The building will be owned and operated by the municipality, with rents collected from tenants that include energy usage.

The pilot is primarily funded through public investment, though future replication may require external grants or subsidies due to high capital expenditure. There is no current public-private partnership arrangement, though private involvement in supply and scaling could be an interesting option to explore.

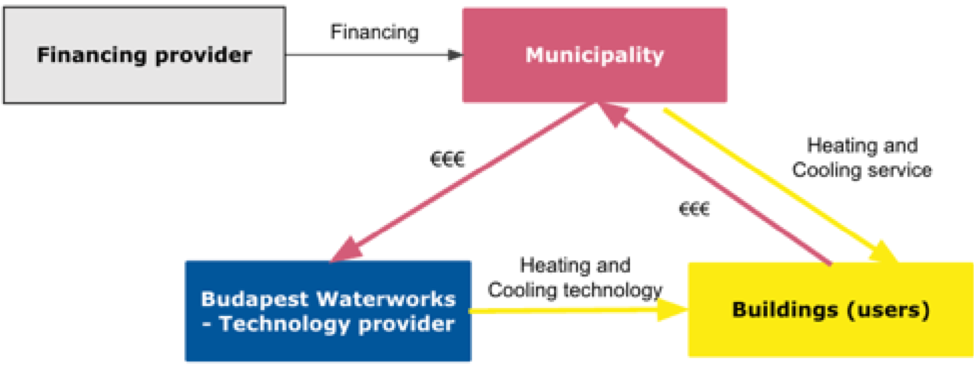

Figure 20 – Preliminary assumption of business model scheme

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4.4.3. Economic-financial feasibility

The CBA relies on preliminary data and assumptions provided by the project promoter and modelled by R2M. It aims to identify the rent and subsidy levels needed to ensure economic viability.

Monetisation strategy

In the considered scenario, the monetisation strategy includes the monthly rents paid by the tenants occupying the renovated building, including the energy costs. Approximately 42 apartments are foreseen in the building.

Cost structure of the project

The analysis considered the following cost items:

- **CAPEX:** the investment includes all costs related to the energy plant equipment and the costs for the building refurbishment.
- **Operating costs by the project promoter:** they mainly include maintenance and administrative costs. The cost of electricity consumed by the heat pump is minimal as the scenario considered the integration of a PV installation.

Three scenarios have been assessed to compare the required monthly rent per square metre and the potential amount of subsidy to secure (as % on total CAPEX) to have positive Net Present Value of the investment. The KPIs of the three scenarios are presented below:

	Scenario 1 No subsidy	Scenario 2 24% of subsidy	Scenario 3 34% of subsidy
Rent cost (€/m2/month)	8	8	7
Rent cost (€/month, 50m2)	400	400	350
NPV (€)	Negative	19,551	52,879
IRR (%)	1,1%	3,0%	3,1%
PBT (years)	More than 30	30	30

Subsidies are key to achieving a positive NPV and keeping rents affordable for low-income tenants. The project remains financially challenging due to high upfront investment, but it can be justified through its social and environmental return.

The Budapest pilot demonstrates how cities can leverage public infrastructure in innovative, low-carbon ways. The project's success will depend on i) securing subsidies or blended finance; ii) proving the viability of the new heat exchanger technology and iii) sustained collaboration between public actors and utilities.

If successful, this model could pave the way for integrated municipal energy systems across Europe—where climate mitigation, social welfare, and infrastructure innovation go hand-in-hand.

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4.4.4. Non-Monetary Benefits

This pilot offers far-reaching non-monetary benefits, including environmental innovation, social inclusion, and urban resilience.

Environmental Impact

- Estimated GHG reduction of ~80 tons/year;
- Improved energy efficiency via smart use of potable water infrastructure;
- Integration with PV systems enhances renewable self-consumption.

Social Value

- Provides affordable, energy-efficient housing for disadvantaged communities;
- Reduces energy poverty by offering lower energy bills and modern comfort;
- Enhances indoor air quality and reduces health risks linked to poor thermal comfort.

Public Engagement & Education

- Encourages citizen awareness of sustainable heating and cooling systems;
- Creates a model project for local authorities and energy utilities.

Governance and Replication

- Promotes cross-sectoral cooperation between utilities, municipalities, and technical actors;
- Demonstrates a scalable solution for net zero buildings in cities with compatible infrastructure (e.g., stable water flow, pipe diameter);
- Sets a technological precedent in integrating potable water and heat exchange safely and efficiently.

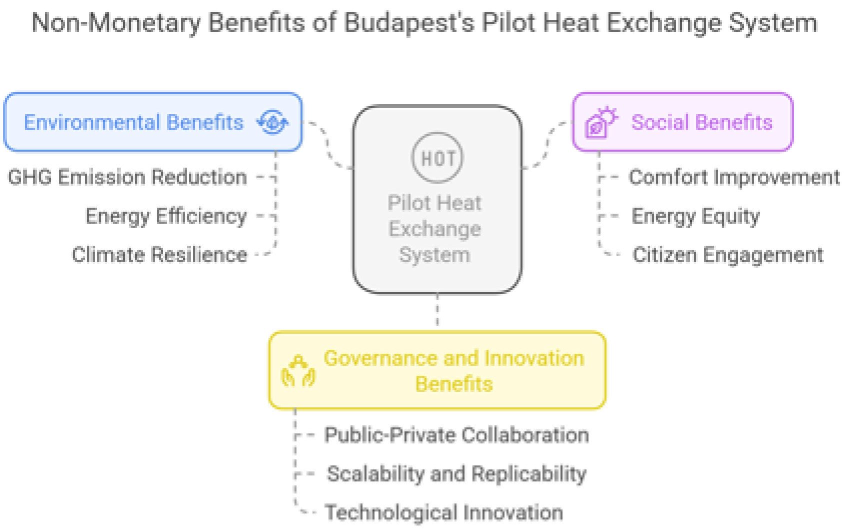

Figure 21 – Non-Monetary Benefits of Solution BUD 3.2

4.4.5. Risk Assessment

This innovative solution carries several technical, financial, and regulatory risks, but they are manageable with proactive planning.

Technological Risks

- System failure or underperformance of the heat exchanger (TEC1);
- Compatibility challenges with building and water systems (TEC2).

Financial Risks

- High CAPEX and cost overruns (FIN1);

Operational and Regulatory Risks

- Permitting delays for new construction and water system integration (OPE1);
- Potential shortage of trained installers (OPE2);

Market and Social Risks

- Fluctuating heating/cooling demand (MKT1);
- Unavailability of the manufacturing company of the heat exchanger (MKT2);
- Risk of tenant dissatisfaction if costs rise or system fails (SOC1).

Environmental, Legal and Security Risks

- Potential contamination or ecological impacts (ENV1);
- Difficulties in adhering to local environmental regulations (LEG1);
- Licensing of solar installation (LEG2).
- Vulnerability to cyberattacks compromising data and supply (SEC1).

Scalability Risks

- Difficulties in expanding the project to accommodate more members.

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Figure 22 – Risks matrix for solution BUD 3.2

4.5. CBA applied to Alba Iulia - Renewable energy communities

4.5.1. Overview of Alba Iulia solution package

As part of **Solution Package 2 – Deployment of Energy Communities and Prosumer Services (SP2)**, the Municipality of Alba Iulia developed a pioneering case study based on existing PV installations across three municipal buildings located within the Dorin Pavel Community District. This includes:

- The headquarters of the Dorin Pavel Technical College (57.75 kWp),
- The sports hall (52.8 kWp),
- The central heating building (23.3 kWp).

These installations currently serve for self-consumption only, as Romanian legislation does not yet permit peer-to-peer energy exchange. However, new legal developments are anticipated, and **Alba Iulia is among the first Romanian municipalities preparing local policy to support and influence future national frameworks for energy communities.**

The district hosts public, educational, and residential buildings, with significant potential for expanding PV capacity and forming a

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full-scale energy community involving public and, eventually, private buildings.

Figure 23 – Pictures of the Dorin Pavel Community

4.5.2. Business Model

The current business model relies solely on self-consumption from municipal PV systems, with the Municipality as both owner and beneficiary of the energy savings. Peer-to-peer sale or energy sharing within communities is not yet legal, limiting monetisation potential. Future expansion into a renewable energy community (REC) framework is planned, contingent on the adoption of enabling legislation. The municipality is actively involved in EU-level projects (e.g., NetZeroCities, Intelligent Cities Challenge) and is lobbying for the legalisation of energy communities in Romania. In the scenario of a more favourable legislation, the Municipality will investigate the setting of a more complex energy community framework potentially

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integrating different types of buildings (residential buildings, schools, commercial properties, etc.).

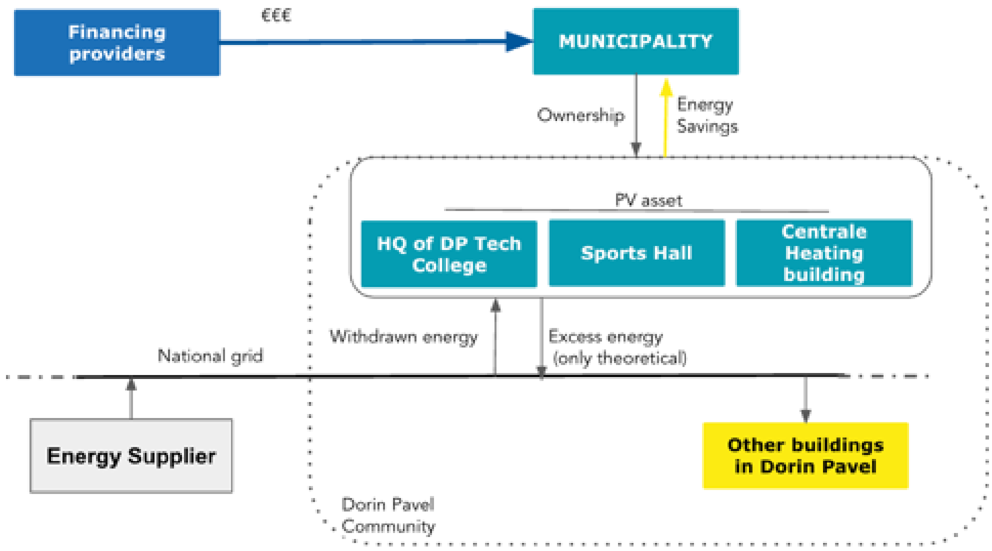

Figure 24 – Business model scheme of Alba Iulia project

4.5.3. Economic-Financial Feasibility

The CBA under ASCEND Task 5.3 analyses two scenarios:

- **Scenario 1:** Energy savings from existing PV plants only, with no excess energy valorisation.
- **Scenario 2:** Adds future PV capacity (22 kWp in 2025) and theoretical income from peer-to-peer sales of surplus energy within an energy community model (at €0.2/kWh).

Monetisation strategy

- For Scenario 1 and Scenario 2, the energy savings are due to the self-consumption of approx. 45% of the electricity produced by the PV plant. The self-consumed energy is valorised as the avoided costs of energy withdrawn from the grid at a price of 0.2 €/kWh, based on the information provided by the project promoter. The beneficiaries of these energy savings are the Municipal buildings integrating the PV installations.
- Only for Scenario 2, the theoretical sale of excess energy to the other municipal building involved in an energy community is valorised at the price of 0.2 €/kWh as well.

Cost structure of the use case

The scenario analysis considered the following cost items:

- **CAPEX:** the project promoter acquires the PV installation and invests in some additional project-related costs such as the distribution network and monitoring/billing equipment.

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- **Operating costs:** they have been preliminary estimated by R2M in line with other similar projects. They include ordinary maintenance, administrative and insurance costs.

Under the considered assumptions, Scenario 1 shows positive KPIs and demonstrates the economic benefits of Alba Iulia's intervention that could be replicated for other municipal buildings in the same district. Scenario 2 shows the combined impact of the additional PV installation expected to happen in 2025 (22 kWp) and of a potential change in the regulatory framework allowing creating an energy community among the Municipal buildings of the district able to exchange the excess energy among them:

	Scenario 1 – Existing PV plant	**Scenario 2 – Additional PV and valorisation of excess energy**
Payback time	13	6
Project IRR	4.9%	16.8%
Net Present Value	9,191 €	87,731 €

Analysis of potential financial instruments suitable for the investment

Alba Iulia has demonstrated strong capacity in securing public funding for sustainable energy and urban development projects. Instruments already used include: EU grants (Intelligent Cities Challenge, Horizon Europe); European City Facility lump sums; ELENA assistance and loans from European Bank for Reconstruction and Development (EBRD). However, barriers remain, in particular:

- PPP models are legally constrained and discouraged;
- ESCO contracts are not yet established in Romania;
- Crowdfunding/crowdlending is mostly limited to private sector;
- Green bonds have been explored but face legal limitations.

In this context, public grants, municipal loans, and corporate sponsorships appear most suitable for future REC expansion in Alba Iulia.

4.5.4. Non-Monetary Benefits

Beyond the financial KPIs, the project delivers wide-ranging co-benefits aligned with EU climate and energy goals:

Environmental Impact

- Current CO_2 emissions for six buildings: ~212 tons/year;

- Expected reduction: ~84 tons/year (via PV, heat pumps, BEMS, storage);
- Local renewable production reduces transmission losses by 5–10%.

Social Benefits

- Energy cost reduction for public services and low-income households;
- Contribution to alleviating energy poverty (~13% of Romanian households);
- Improves energy security and resilience during supply crises.

Educational and Civic Engagement

- ~700 pupils and teachers engaged through awareness campaigns;
- REC serves as a model for replication in private households;
- Fosters public participation, ownership, and technology adoption.

Economic Development

- Job creation in construction, monitoring, and maintenance;
- International Renewable Energy Agency (IRENA) estimates 4–6 jobs per MWp installed PV capacity;
- Boosts the local green economy.

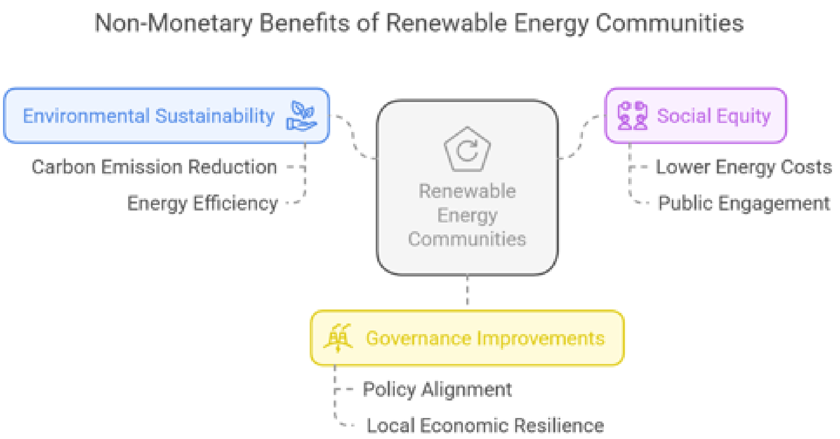

Figure 25 – Non-Monetary Benefits of solution ALB 2.1

4.5.5. Risk Assessment

The deployment of RECs in Alba Iulia faces several risks that must be mitigated through effective planning:

Financial Risks

- Cost volatility of raw materials can trigger overruns (FIN1);
- Uncertain availability of funding on favorable terms (FIN2);

- High upfront CAPEX for PV, batteries, and smart systems (FIN3);

Technological and Management Risks

- Grid integration challenges (voltage, balance, interoperability) (TEC1);
- Uncertain long term reliability/performance of technology (TEC2);
- Lack of interoperability among different systems (TEC3);
- Risk of technological obsolescence if innovations outpace adoption (TEC4);
- Difficulty in finding skilled personnel (MAN1).

Operational Risks

- Delays in the delivery/installation of the infrastructure. (OPE1);
- Complex project management involving multiple stakeholders (OPE2);
- Accidents or safety issues during construction/operation (OPE3);
- Unexpected costs for maintenance and repair (OPE4);
- Offline energy systems due to maintenance or failures (OPE5).

Market and Regulatory Risks

- Risks related to non-compliance with regulations. Romania lacks clear legal frameworks for RECs and peer-to-peer sale (LEG1);
- Risks related to future legislative or regulatory changes (LEG2);
- Risks related to the protection of personal data/privacy (LEG3);
- Potential changes in energy policies influencing market. Uncertainty over net metering and future tariffs complicates business planning (MKT1);
- Unforeseen fluctuations in energy demand (MKT2).

Social Risks

- Public scepticism about cost-sharing and governance models (SOC1);
- Concerns regarding the environmental impact (SOC2);
- Risk of low community engagement unless trust and awareness are built. Opposition or protests from community groups (SOC3).

Environmental and Cybersecurity Risks

- Minimal ecological impact, but weather events (storms, heatwaves) may disrupt operations (ENV1);

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- Cybersecurity threats to digital grid systems require robust protection (SEC1);

Scalability Risks

- Difficulties in expanding to accommodate more members (SCA1).

Figure 26 – Risk Assessment of solution ALB 2.1

4.6. CBA applied to Charleroi – Deployment of energy communities

4.6.1. Overview of Charleroi's solution package

In line with **Solution Package 2 – Deployment of Energy Communities and Prosumer Services (SP2)**, the City of Charleroi, supported by Igretec (the urban planner), is planning the implementation of a renewable energy community within the Porte Ouest District—a 100-hectare brownfield undergoing transformation into a clean energy-driven innovation hub.
This new District CleanTech will include office spaces, renovated industrial heritage buildings, and research and innovation facilities. The energy community aims to power local SMEs and business park tenants with solar energy, potentially supported by battery storage and smart energy management solutions.
The project forms part of a wider territorial revitalisation strategy, involving key players like the Walloon government, Wallonie

Entreprendre, and District CleanTech. Charleroi is aiming to become a regional leader in green industrial renewal and low-carbon innovation ecosystems.


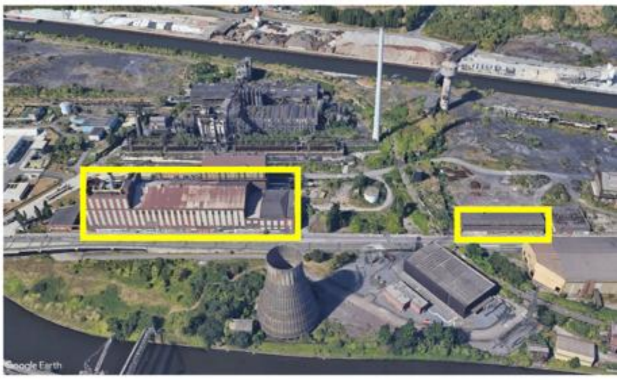

Figure 27 – CleanTech District (masterplan and picture with The Centrale and Vestiaires buildings in yellow - heart of the new ecosystem)

4.6.2. Business model

The project is currently in the planning phase, with legal and ownership structures still under development. The business model foresees the creation of a renewable energy community, supplying locally generated PV electricity to CleanTech district SMEs, potentially via ESCO-based partnerships.
A future-oriented strategy includes:

- Self-consumption of PV energy within the community;
- Potential sale of excess energy to grid or within the community;
- Integration of battery systems to enhance energy autonomy.

Multiple financing options and governance models are under consideration, including Energy-as-a-Service, Shared Savings Contracts, and performance-based Energy Performance Contracts (EPCs).

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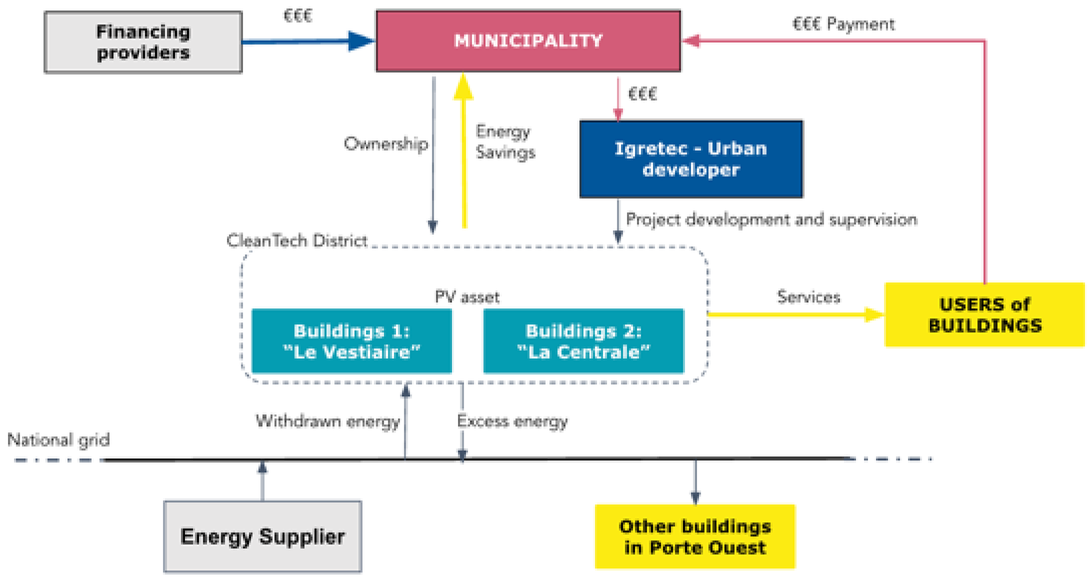

Figure 28 - Preliminary assumption of the business model for the CleanTech District

4.6.1. Economic-financial feasibility

The CBA developed under ASCEND Task 5.3 includes two scenarios that vary based on PV self-consumption rates and performance levels.

Monetisation strategy

In the considered scenario, the monetisation strategy includes:

- The revenues from the sales of energy to the members of the energy community;
- The energy savings due to the avoided withdrawal from the grid.

Cost structure of the project

The scenario considered the following cost items:

- **CAPEX:** the investment costs for the PV installations.
- **Operating costs:** they include administrative costs, Environmental Health and Safety (EHS) management, maintenance, injection and network costs. The costs for plant insurance have been also considered.

A time window of 20 years has been considered for the calculation of the following main KPIs of the two scenarios:

	Scenario Max (900 kWh/kWp; 100% self consumption)	**Scenario Min** (800 kWh/kWp; 50% self consumption)
Payback time	11 years	> 20 years
Project IRR	8.4%	N.a.
Net Present Value	7,177,293 €	Negative value

The Max Scenario is economically viable, while the Min Scenario shows insufficient return due to limited self-consumption and higher reliance on grid electricity. This highlights the critical importance of load matching and smart energy management.

Analysis of potential financial instruments suitable for the investment

A promising financing strategy involves the integration of an ESCO model to:

- Finance, install, and operate PV and battery systems;
- Offer performance-based returns via Energy Performance Contracts (EPCs) or shared savings contracts;
- Deploy smart grid technologies for energy flow optimisation;
- Access EU funding, crowdlending, or operational leasing.

ESCOs can assume different roles depending on ownership preferences:

- Full asset ownership with Energy-as-a-Service contracts;
- Co-investment with shared governance (Shared Savings);
- Operational partner with fixed performance targets (EPC).

This approach would allow the Municipality and Igretec to:

- Reduce up-front investment,
- Share technical and financial risk,
- Leverage private sector expertise.

Smart energy management by an ESCO could also enhance the project's financial KPIs, improve self-consumption, and shorten the payback period of the overall investment.
The project is financially viable under high self-consumption conditions. Success will depend on optimising local energy use and potentially integrating an ESCO model.

4.6.2. Non-Monetary Benefits

The Charleroi energy community brings substantial environmental, social, and technological benefits.

Environmental Impact

- GHG emissions reduced by 1,856 tons/year, compared to baseline emissions of 2,882 tons;
- Accelerates decarbonisation and aligns with Belgium's climate targets.

Social Value

- Fosters community participation and stakeholder engagement;
- Supports energy democracy and local empowerment;
- Encourages energy-conscious behaviours among SMEs and public institutions;

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- ~20 stakeholders, including city departments and private energy actors, already engaged.

Technological Advancements

- Promotes decentralised energy production and storage;
- Enhances grid stability and energy efficiency through smart energy systems;
- Reduces transmission losses and improves energy autonomy;
- Strengthens the long-term resilience and innovation capacity of the regional energy sector;
- The project serves as a blueprint for industrial decarbonisation and collaborative innovation ecosystems.

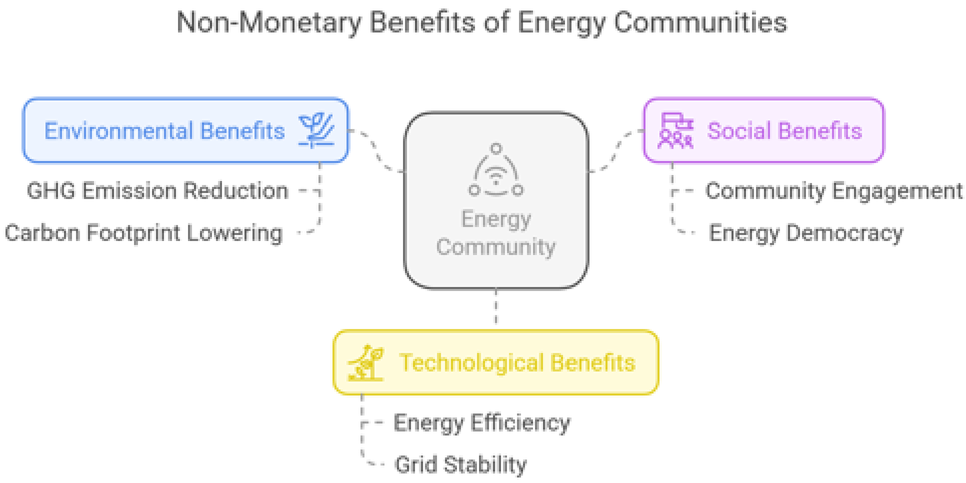

Figure 29 - Non-Monetary Benefits of solution CRL 2.2

4.6.3. Risk Assessment

Despite its strong potential, the project must navigate a series of risks.

Technological Risks

- Integration of PV, battery, and heat/cooling networks can be complex (TEC1 in Fig 30);
- Obsolescence is not a major concern, but long-term reliability is essential (TEC2 in Fig 30)
- Interoperability and smart grid compatibility must be carefully managed (TEC3 in Fig 30).

Financial Risks

- Material cost fluctuations (e.g. solar panels) may raise CAPEX (FIN1);
- Uncertainty in funding availability (grants, incentives) could delay implementation (FIN2);
- Over-indebtedness risk due to large upfront investment (FIN3).

Operational & Management Risks

- Delays in the delivery of the infrastructure (OPE1);

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- Multi-stakeholder coordination is complex and time-consuming (OPE2);
- Need for skilled personnel to manage new systems and stakeholder interests (MAN1);
- Accidents or safety issues during construction/operations (OPE3);
- Unexpected costs for maintenance or failures (OPE4);
- Offline energy systems due to maintenance and repair (OPE5).

Market and Regulatory Risks

- Changing energy policies or grid tariffs could affect business models (MKT1);
- Unforeseen fluctuations in energy demand (MKT2);
- Cybersecurity risks arise from digital energy platforms and require strict protocols (SEC1);
- Social acceptance hinges on transparent communication and inclusive design (SOC1);
- Concerns regarding the environmental impact (SOC2);
- Opposition of protests from community groups (SOC3);
- Incidence of extreme weather conditions (ENV1);
- Difficulties in expanding to accommodate more members(SCA1);
- Risks related to non-compliance with regulations (LEG1);
- Risks related to future legislative or regulatory changes (LEG2);
- Risks related to the protection of personal data/privacy (LEG3).

Figure 30 - Risk matrix for solution CRL 2.2

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4.7. CBA applied to Prague – Construction of a new PCED

4.7.1. Overview of Prague’s PCED project

As part of **Solution Package 3 – Deployment of Energy-Efficient Buildings Integrating RES and Storage (SP3)**, the Municipality of Prague, through its municipal organisation Prague Development Company (PDS), is developing a Public Community Energy District in Dolní Počernice. The initiative addresses the pressing need for affordable, energy-efficient housing for key public employees such as police officers, teachers, and healthcare workers.

The new district will be constructed on 129,000 m² of municipal land and will feature 650 affordable rental units, powered and heated through a combined heat and power (CHP) plant and district heating system.

The project aligns with Prague’s long-term urban development strategy, which focuses on optimising the city’s land assets and expanding the public rental housing stock.

Figure 31 - Design of Prague PCED project

4.7.2. Business model

PDS serves as the central coordinator of the project, managing a portfolio of public housing developments. The Dolní Počernice PCED is part of a broader pipeline to deliver 6,000–8,000 units across multiple sites over 10–15 years. The business model follows four phases: 1) Design, 2) Preparation, 3) Construction, 4) Closing up / Operation. While the City’s budget typically covers phases 1 and 2, phase 3 (construction) poses greater financial challenges, requiring alternative financing instruments to bridge the investment gap.

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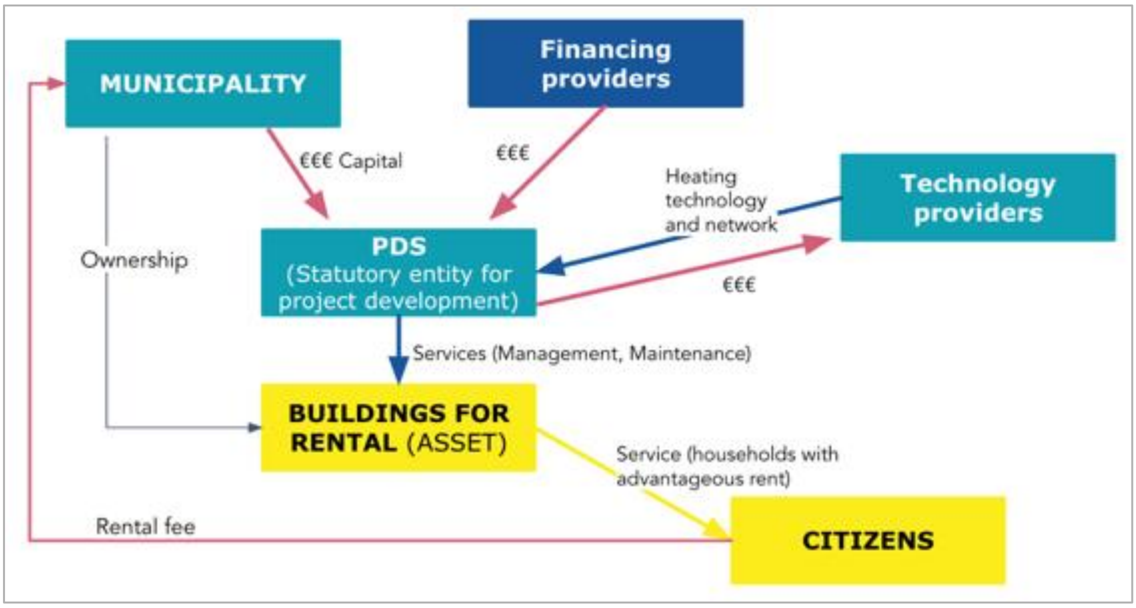

Figure 32 - Preliminary business model scheme for Prague project

4.7.3. Economic-financial feasibility

PDS project management team is used to assess the economic profitability of their development projects. Projects are approved only on certain parameters by an internal Investment Committee monitoring their cash flow generation potential.

Monetisation strategy

The revenue items incorporate the rental income and the portion of the operating costs covered by the tenants for energy and utilities supply.

Cost structure of the project

The main cost items are the following:

- **CAPEX:** the investment costs for all the four phases of development (design, preparation, construction and closing up) are spread over a 10-year period (due to development and permitting timeline).
- **Operating costs paid by the project promoter:** while a portion of the costs is transferred to tenants, the remaining part is paid by PDS due to the maintenance and utilities service supply. The unrealised lease is also considered among the operating costs.

The project shows long-term financial viability, with slow cash flow in early years due to delayed revenue generation. While the payback period is extended, the project holds strategic urban and social value. To mitigate financial risk, PDS adopts a portfolio approach, balancing mature and early-phase projects to maintain fiscal stability.

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Analysis of potential financial instruments suitable for the investment

The project's large-scale nature and strategic importance make it suitable for a hybrid financing approach, combining public and private resources.
Possible financing instruments include:

- European Long-Term Investment Funds (ELTIFs): Secure long-term institutional capital with social impact focus;
- Municipal Green Bonds: Raise funds specifically for sustainable housing and energy infrastructure;
- EU Funds: ERDF or EIB loans could support ecological building standards;
- Public-Private Partnerships (PPPs): Engage private developers for construction under long-term leasing contracts;
- Asset-backed lending: Leverage Prague's real estate assets (valued at CZK 7.1 billion) to secure debt or attract private capital.

Amongst the comparable models there are Aspern Seestadt (Vienna)with green infrastructure and rental affordability through public-private mix; Hammarby Sjöstad (Stockholm), a PPP-funded eco-district with district heating and integrated energy services; Lyon Confluence including sustainable urban regeneration leveraging strategic land ownership and partnerships.
These precedents confirm that green finance, municipal control, and strategic partnerships can co-exist in complex public housing investments.

4.7.4. Non-Monetary Benefits

The project delivers extensive non-monetary value, contributing to Prague's long-term urban and social goals.

Environmental Sustainability

- CHP plant and district heating network reduce energy waste and reliance on gas boilers;
- Centralised system offers stable, low-emission heating;
- Aligns with climate neutrality objectives and Prague's 2030 and 2050 strategies.

Social Benefits

- Provides affordable housing for essential workers, improving job retention;
- Predictable utility costs enhance energy equity and protect low-income tenants;
- Supports urban densification without environmental compromise.

Governance

- The project is publicly managed, ensuring transparency, accountability, and long-term planning.
- Promotes cross-departmental coordination between housing, energy, and finance.

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- Sets a replicable framework for future housing developments.

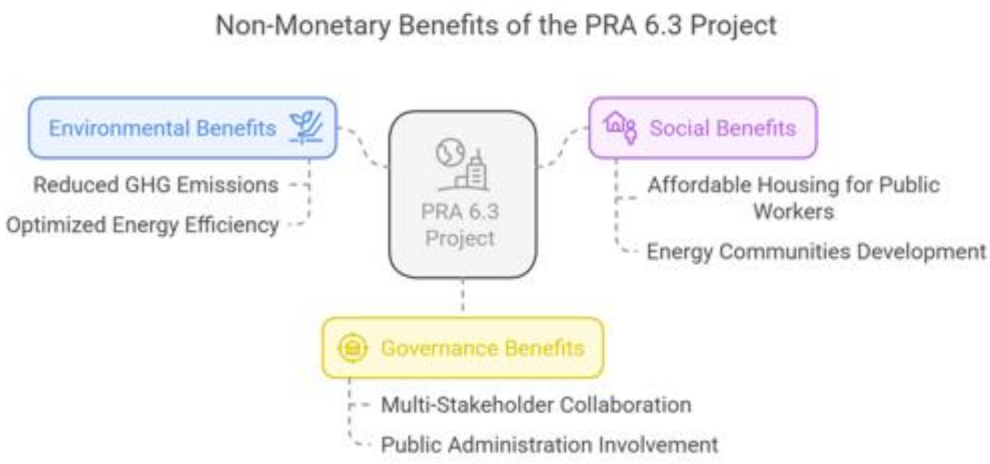

Figure 33 - Non-Monetary Benefits of solution PRA 6.3

4.7.5. Risk Assessment

The project faces several multi-dimensional risks across technical, financial, operational, and regulatory domains.

Technological Risks

- Complex integration of CHP and district heating;
- Delays due to equipment procurement or system compatibility;
- Mitigated by selecting experienced providers and ensuring continuous monitoring.

Financial Risks

- High CAPEX over 10 years strains municipal budgets;
- Funding gaps during the construction phase may threaten delivery;
- Mitigation via green bonds, ELTIFs, and blended finance.

Operational Risks

- Complex coordination across four project phases;
- Poor resource allocation may increase costs and extend timelines;
- Risk reduced through robust project management tools and experienced teams.
-

Market Risks

- Real estate competition and shifting demand may reduce occupancy rates;
- Resolved through targeted tenant engagement and below-market rents.

Regulatory & Compliance Risks

- Permitting delays or changes to planning laws could create setbacks;
- Active collaboration with authorities and proactive permitting strategies are essential.

Social Acceptance

- New district heating infrastructure may face opposition;
- Requires transparent communication, public consultation, and early engagement.

Scalability

- Future expansions may face land, infrastructure, or financing constraints;
- Modular planning allows phased expansion without reworking the entire model.

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5. Analysis on the expected CO_2 reduction linked to SPs – Current challenges

The transition to sustainable urban energy systems and the development of Positive Clean Energy Districts aim to significantly reduce CO_2 emissions, improve energy efficiency, and integrate renewable energy solutions across European cities. However, a key aspect that requires further attention is the quantification and economic assessment of CO_2 reduction achieved through these initiatives.

While ASCEND, via WP6, plans to track and measure the environmental impact of implemented solutions, the availability of data provided by participating cities remains limited and inconsistent so far. This lack of structured information makes it difficult to compare the environmental and economic performance of different solutions and assess their effectiveness against alternative decarbonisation strategies.

Inconsistencies in data collection methodologies adopted by cities exist, as many of them lack detailed estimates of avoided emissions or associated costs.

This data gap has significant implications for resource allocation efficiency. Without a clear correlation between investment and emission reductions, funding decisions might not be optimised for maximum environmental and economic impacts. Moreover, the absence of a standardised cost-per-ton of CO_2 avoided metric makes it challenging for private investors to assess the financial viability of PCEDs compared to other decarbonisation initiatives.

The table below presents the available estimates of CO_2 reduction achieved through various solutions implemented in ASCEND cities:

Project promoter	Specific Solution	Estimate Co2 saved	Comments
Lyon Confluence	LY4.6 Decarbonised logistic hub	N.a.	
Munich	MUC4.2 Mobility Stations	c. **800 tons**	CO_2 grey energy saved per unbuilt vehicle parking space.
Porto	POR 2.1 - Plan and develop a PV Energy Community.	c. **32.46 tons/y**	Only the PV installation on Serralves Museum is considered.
Budapest	BUD 3.2 -Pilot heat exchange system using drinking water pipeline	c. **80 tons/y**	Under the scenario of PV installations covering 100% of demand.

Alba Iulia	ALB2.1 - Renewable energy communities	c. **84 tons/y**	
Charleroi	CRL 2.2 - Deploy Energy Community	c.1,856 tons/y	
Prague	PRA 6.3 - Investment opportunities for the construction of PCED	N.a.	

The gathered data highlighted a critical challenge: a lack of standardised and consistent reporting across participating cities. The main issues identified include:

1. Incomplete or inconsistent data – Some cities have not provided any estimates, while others have reported figures using different units or considering only a portion of the considered perimeter.
2. No common methodology for calculation – Emission reductions are estimated based on varying criteria, including renewable energy production, indirect benefits (e.g. sustainable mobility), and efficiency improvements, making comparisons difficult.
3. Based on discussions with cities so far, the economic valuation of CO_2 reductions does not appear to be a prioritised consideration. However, without a cost-per-ton CO_2 avoided metric, it is impossible to benchmark the financial effectiveness of PCED investments, which is crucial for both public decision-making and private sector engagement.

To address these challenges and improve the economic assessment of PCEDs, different actions could be recommended, including:

- to enhance data collection from cities;
- to develop an ad hoc methodology and comparative analysis of CO_2 abatement costs;
- To incorporate this metric into financial models;
- To create a centralised database for CO_2 performance tracking.

The lack of structured data from cities remains a significant barrier to assessing the true economic and environmental impact of PCEDs. ASCEND is contributing to tackling this barrier via a specific task in WP6 (T6.1) and via WP5 (T5.5), providing a methodological framework and digital tools to support the monitoring and evaluation of the impact of the implemented SP, including avoided CO_2.

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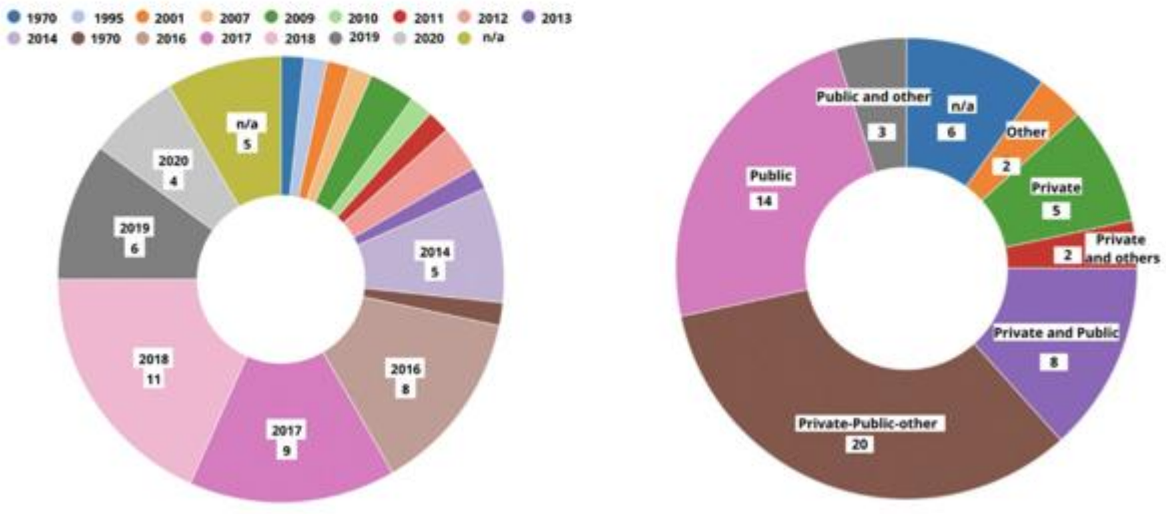
6. Examples of financial instruments applied to PCED projects in the EU

The development and replication of PCEDs across Europe require a mix of public, private, and hybrid financing mechanisms. The European Union, through Horizon 2020 and Horizon Europe, has played a pivotal role in enabling cities to transition towards climate-neutral, energy-positive urban districts.

This section provides an overview of financial instruments applied to PCED projects, categorising them by funding type and highlighting key sources such as EU grants, green bonds, private investments, and cooperative models. A table summarising the financing mechanisms used in various PCED projects follows.

A recent study by Zhang et al.(2021) analysed 60 PCED projects across Europe, highlighting their key financing models, implementation timelines, and technological integration strategies. The study found that the number of PED initiatives has increased significantly since 2014, with a peak in 2018-2019.

The following graphs from this study illustrate i) the distribution of 60 PED projects based on their initiation year, demonstrating the acceleration of energy-positive urban initiatives over time; ii) the commonly used type of finance models.



Distribution of 60 PED projects based on their initiation year

Commonly used type of finance models amongst the 60 PED projects.

Figure 34 - Characterisation of 60 analysed PED (Zhang et al., 2021)

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The analysis highlights that the financial models used in PCED projects are varied and often combined. The 33% of models is a combination of public, private, and other funding sources. These findings indicate that the private sector is actively involved in PED projects, often in collaboration with the public sector.

The implementation of PCED projects involves diverse financial approaches, including:

1. EU Public Funding (Grants & Loans).

- Horizon 2020 & Horizon Europe Grants: Direct non-repayable funding for research, demonstration, and implementation of energy-efficient technologies in urban districts.
- European Investment Bank (EIB) Soft Loans: Low-interest loans supporting green infrastructure and urban energy transition.
- European Regional Development Fund (ERDF) & Recovery and Resilience Facility (RRF): Funds allocated to local governments for decarbonisation projects.

2. Private and Hybrid Investment Models.

- Public-Private Partnerships (PPP): Shared investment between municipalities and private entities to co-develop energy infrastructure.
- Green Bonds & Sustainability-Linked Bonds: Municipalities and organisations issue bonds to attract institutional investors for clean energy projects.
- ESCO (Energy Service Company) Models: Private firms invest in energy-efficient solutions, with repayment based on cost savings from energy reductions.
- Cooperative & Citizen-Driven Financing: Energy communities raise funds through crowdfunding, local cooperatives, and shared ownership models.

The following table summarises key financial instruments applied in Horizon-funded and non-EU-funded PCEDs. The table includes a mix of EU grants, national subsidies, green bonds, and private investments, highlighting the diversity of funding strategies (all sources are included in section 15).

Table 2 - List of PCEDs and their financial instruments

No.	City (Country) Type of investment	Amount (€)	Type of Financing
1.	**Turku (Finland) & Dijon (France)** RESPONSE Project (smart district)	~€15M	Horizon 2020 grant + Green Bonds + Private investments
2.	**Rouen (France)** Renewal of the bus fleet with low-emission vehicles	€50M (EIB loan) + €64M city investment + €8.7M government subsidy	Public-private mix: EIB loan (€50M) + Government subsidy (€8.7M) + Municipal investment (€64M)

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3.	**Provence-Alpes-Côte d'Azur (France)** Energy Community (Enercoop PACA)	€125,000 capital raised + public subsidies	Cooperative model: Crowdfunding from cooperative members (€125K) + Regional public subsidies + Institutional support
4.	**Castilfrío de la Sierra (Spain)** First Rural Energy Community	€29,990	Public and local financing: Red Eléctrica de España (REE) + Local bank (Caja Rural de Soria) + Revenues from energy sales
5.	**Padova (IT), Pordenone(IT), Verona (IT)** SUPERHEERO project	<€2M	H2020+ Crowdlending + private investments
6.	**Vesterbro (Denmark)** Large-scale district renovation	~€72M	Public-private mix: Danish Ministry of Planning and Housing + Copenhagen Municipality + EU Thermie funding
7.	**Barcelona (Spain)** Large-scale Bike Sharing system	Not specified	Public-private mix: Private investment (Clear Channel) + Strategic cycling plan budget from the City Council
8.	**Villerouge-Termenès (France)** Electric car-sharing service in a rural area	80% of costs covered	EU and regional subsidies: LEADER program (80%) + Regional & municipal funding
9.	**Vienna (Austria)** Energy-efficient social housing	€2M	Municipal loan: Loan from Vienna City Council (€2M) + Resident contributions through rental payments
10.	**Zurich (Switzerland)** Sustainable neighbourhood Hunziker Areal	~€40M	Green loans and cooperative model: Government incentives + Bank loans for sustainable housing
11.	**Borlänge (Sweden)** Residential energy efficiency improvement	~€10M	Green Bonds and local funding: EU Sustainable Finance Taxonomy-aligned Green Bonds + Local government funding
12.	**Stor-Elvdal (Norway)** Smart Energy Municipality	Not specified	Public-Private Partnership (PPP)
13.	**Drammen (Norway)** Large-scale Heat Pump District	Not specified	Public funding and municipal investment
14.	**Oulu (Finland)** Smart City Energy System	Not specified	Horizon 2020 grant
15.	**Amsterdam (Netherlands) & Bilbao (Spain)** ATELIER Project (Positive Energy Districts)	Not specified	Horizon 2020 grant + Public-private funding
16.	**Évora (Portugal) & Alkmaar (Netherlands)** POCITYF Project	Not specified	Horizon 2020 grant + Utility investment + Government incentives
17.	**Espoo (Finland) & Leipzig (Germany)** SPARCS Project	Not specified	Horizon 2020 grant + Municipality funding + Private investments

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18.	**Pamplona (Spain), Tampere (Finland), Trento (Italy)** STARDUST Project	Not specified	Horizon 2020 grant + Local government + EU Green Bonds
19.	**Valencia (Spain), Dresden (Germany), Antalya (Turkey)** MATCHUP Project	Not specified	Horizon 2020 grant + City funding + Private co-investments
20.	**Trondheim (Norway) & Limerick (Ireland)** CITYxCHANGE Project	Not specified	Horizon 2020 grant + PPP + Public funds
21.	**Groningen (Netherlands) & Oulu (Finland)** Making-City Project	Not specified	Horizon 2020 grant + Municipality funding
22.	**León (Spain), Bassano del Grappa (Italy), Kadiköy (Turkey), Lublin (Poland), Poprad (Slovakia), Vidin (Bulgaria)** Making-City Follower Cities	Not specified	Horizon 2020 grant

The provided list of examples can be of inspiration to ASCEND cities for the development of their financial strategies related to their PCED projects. The following key lessons can be drawn:

- Blended financing is essential: no single funding mechanism is sufficient. Cities that successfully implement PCEDs use a combination of grants, green bonds, PPPs, and cooperative funding.
- Municipal green bonds are gaining popularity: cities like Turku, Amsterdam, and Porto are issuing green municipal bonds to attract sustainable investors.
- Public-Private Partnerships (PPP) accelerate deployment: Projects like Making-City (Groningen & Oulu) and +CityxChange (Trondheim & Limerick) have leveraged PPP models to develop large-scale PED infrastructure.
- Horizon Europe and other EU and national funding programmes will still play a key role in scaling cities' projects.

By integrating financial innovation with policy frameworks and stakeholder engagement, cities can replicate and scale PCED models across Europe, ensuring a just and sustainable energy transition.

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7. Conclusions

This deliverable, developed as part of WP5 of the ASCEND project (T5.3), has explored financial mechanisms and instruments designed to facilitate the implementation and scalability of Positive Clean Energy Districts (PCEDs) across European cities. The overarching objective has been to establish a structured framework that enables municipalities and other project promoters to adopt sustainable, replicable, and investment-ready business models while addressing key financial barriers.

A key finding of this analysis is that PCED deployment is predominantly driven by public entities. Across the participating cities, the primary stakeholders include municipal authorities (Cities of Munich, Budapest, Alba Iulia), municipal housing corporations (PDS, Münchner Wohnen), dedicated Special Purpose Vehicle established by the local policy makers (SPL), urban planner (IGRETEC), and municipal utility provider (Budapest Waterworks). **The public sector's central role in PCED development has substantial financial implications, particularly in shaping the financing mix.** The mapping of the existing European PCEDs highlights that PCED implementation relies on a combination of public funding sources—municipal budgets, subsidies, and grants—complemented by private sector contributions, including investments from building owners, tenants, and businesses. However, the underlying financing models vary significantly depending on asset ownership structures. In cases where publicly-owned entities such as SPL and PDS own the land or operate within a near-monopoly framework (as in Budapest), financing structures differ, often necessitating distinct forms of public-private co-financing. A comparative analysis of these models could further clarify their respective advantages and limitations, providing a more structured basis for future PCED financial planning.

Beyond financing considerations, **the scalability and integration of PCED solutions emerge as the most pressing challenges for achieving meaningful decarbonisation.** Individually, the solutions implemented within ASCEND cities contribute only marginally to emission reductions. Their transformative potential can only be realised if they are effectively upscaled at the municipal level or integrated within broader district-wide strategies, ensuring systemic impact rather than isolated interventions. The absence of a clear coordinating mechanism further complicates this process, making it essential to define governance structures capable of guiding and managing the large-scale implementation of PCEDs.

From a financial perspective, several instruments could facilitate this process, including blended finance models, municipal green bonds, revolving funds, Special Purpose Vehicles (SPVs), and ESG-aligned private sector investments. **However, it is not sufficient for cities**

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to merely explore the availability of these instruments; they must also develop a strategic, structured approach to financial planning, ensuring that each PCED intervention is evaluated in terms of economic viability and long-term sustainability.

In response to this need, LHCs and MCs, guided by R2M, collaborated on developing cost-benefit analyses (CBA) applied to individual case studies. This process provided valuable insights into the diverse strategies and challenges each city faces in deploying PCEDs. The work carried out enabled cities to leverage the ASCEND methodology to enhance the maturity of their projects, improving their readiness for investors' due diligence. However, due to the lack of comprehensive data in most cases, the analytical models had to be adapted, requiring further validation and localised refinements. These analyses represent only a starting point for a more in-depth economic and holistic assessment (including non-monetary benefits and risks), which will be feasible at a more advanced stage of the projects if complementary data and information are shared.

Moreover, a particularly critical issue that has emerged is **the lack of economic consideration regarding CO_2 abatement costs.** Municipal investment decisions are often made without a systematic assessment of the cost effectiveness of individual measures in reducing emissions. **This absence of financial analysis limits the ability to compare different strategies and allocate resources efficiently.** A more structured approach to evaluating CO_2 abatement costs would enable cities to prioritise interventions that deliver the highest environmental impact per unit of investment, improving the overall effectiveness of decarbonisation efforts.

In conclusion, the large-scale implementation of PCEDs necessitates **a shift in focus from individual solution deployment to scalability, financial structuring, and economic impact assessment.** While this deliverable provides an initial foundation for addressing these challenges, success will ultimately depend on cities' ability, readiness and willingness to develop holistic investment strategies, establish robust governance frameworks, and integrate CO_2 abatement cost analyses into their decision-making processes. Moving forward, further development of financial models, enhanced capabilities to quantify the associated non-monetary benefits, enhanced engagement with private sector stakeholders, and the incorporation of rigorous economic evaluation methodologies will be essential to positioning PCEDs as a scalable, financially viable, and impactful decarbonisation strategy for European cities, capable of attracting the interest of external investors.

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9. Annexes

9.1. CBA applied to Lyon Confluence – Decarbonised Mobility Hub

In conjunction with the **Solution Package 4 – Mobility & Freight (SP4)**, SPL Lyon Confluence is working on the development of a decarbonised mobility hub, the Micro Hub (as preliminarily described in D5.1) located in the Lyon Confluence PCED area. The current project is under development in collaboration with a real estate developer and will consist in a newly built space located at the basement of four new buildings offering, among other services, bike deposits for residents, carsharing for residents and external users, parcel station to residents and external people, logistic area available for selected logistic companies, parking spots available for renting; and potentially other activities non-related to mobility services (e.g. commercial activities).
The Micro Hub provides a low-carbon storage space and a transfer point for goods and parcels in Lyon. It promotes the transition from heavy, polluting vehicles to lighter, low-carbon transportation methods, significantly decreasing the carbon footprint of urban logistics.

The **main stakeholders** involved in this SP4 use case are the following:

Stakeholder	Role
Lyon Confluence SPL (SPL)	• SPL is the **owner of the land** on which the real estate project will be located. • SPL is the **project promoter** for the Micro Hub. • SPL ensures the respect of specific PCED requirements by all new real estate constructions and initiatives located in Lyon Confluence District. • SPL explores the option to become the owner of the Micro Hub (partial or full ownership) after construction by the RE developer and to rent spaces to service providers. • SPL monitors that all projects located in the district bring positive environmental, social and economic impacts on the users (i.e. residents and citizens.
Real Estate (RE) developer	• RE is the contractor identified by SPL for the construction of the new buildings located in Lyon Confluence PCED, at the basement of which the Micro Hub will be located.

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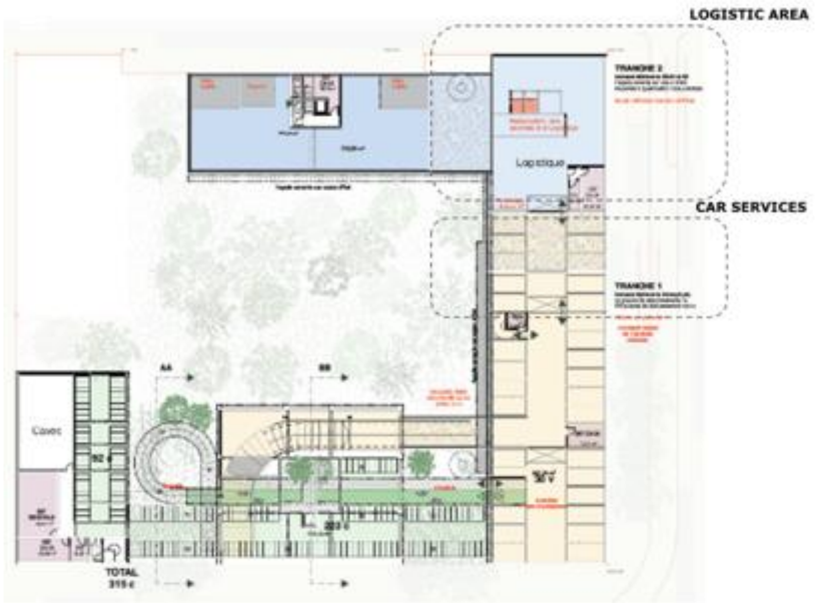
	• RE will be the owner of the newly built real estate property (including the Micro Hub space), before a potential sale to SPL or other investors.
Service providers	• SPL will outsource the management of the spaces to third party service suppliers: car or and/or bike sharing providers, logistic companies, etc.
Users	• Users are the future residents of the new buildings and the citizens using the services provided inside the Micro Hub.
Financing provider	• SPL would not consider external financiers as they would use a compensation mechanism on the initial price of land sales. • Another option is represented by banks or other financial institutions interested in financing the project promoter (SPL) and/or the RE for the purpose of the Micro Hub investment.

The **main assets** considered in this use case are the spaces on which the different services of the Micro Hub will be located. The following picture shows the whole area of the Micro Hub and the spaces dedicated to the combination of different services managed by SPL and/or by the real estate developer:



Detail of the underground space in which the Micro Hub will be located

The development of the Micro hub is the result of an extended negotiation between SPL and the real estate developer to reach a win-win agreement. In the current stage of development, the agreement has the characteristics of a Public-Private Partnership (PPP), a long-term collaboration where risks, investments, and responsibilities are shared between the public authority and a private company to co-develop the underground space.

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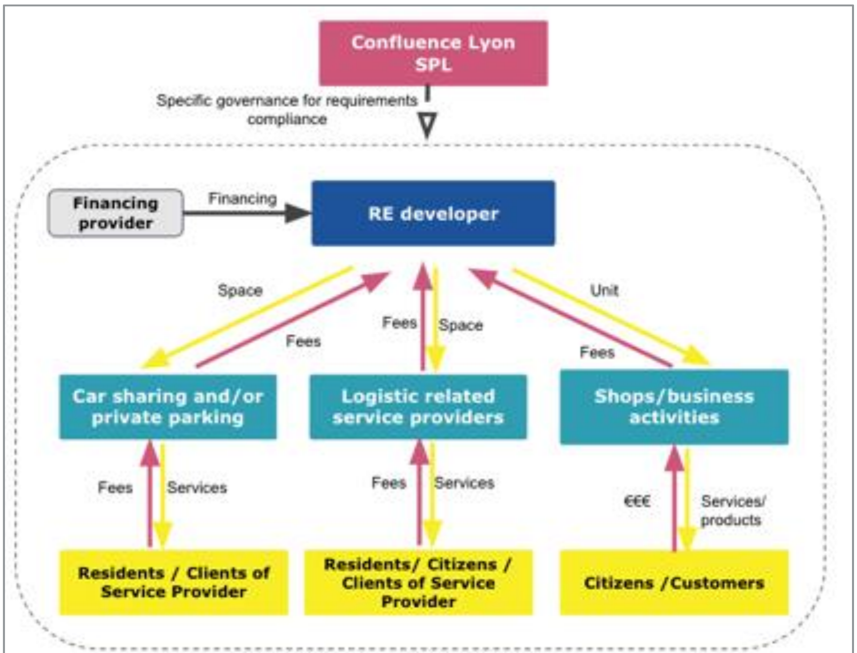
9.1.1. Business Model

SPL assessed four options for business models to assess the economic sustainability, the environmental and social impacts of the Micro Hub in the district. All of them have been assessed using the ASCEND Cost-Benefit Analysis approach.

The four scenarios differ to each other depending on the ownership of the assets (the spaces of the Micro Hub) split between SPL and the RE developer:

Scenario 1: SPL does not invest in the Micro Hub directly and acts as an external monitoring entity for the respect of the contractual requirements for the construction and management of the Micro Hub.

Business model scheme:



SCENARIO 1: The RE developer retains ownership of the 3 AREAS of the Micro Hub.

Investment evaluation:

No evaluation has been done in this scenario as SPL is not investing in the asset.

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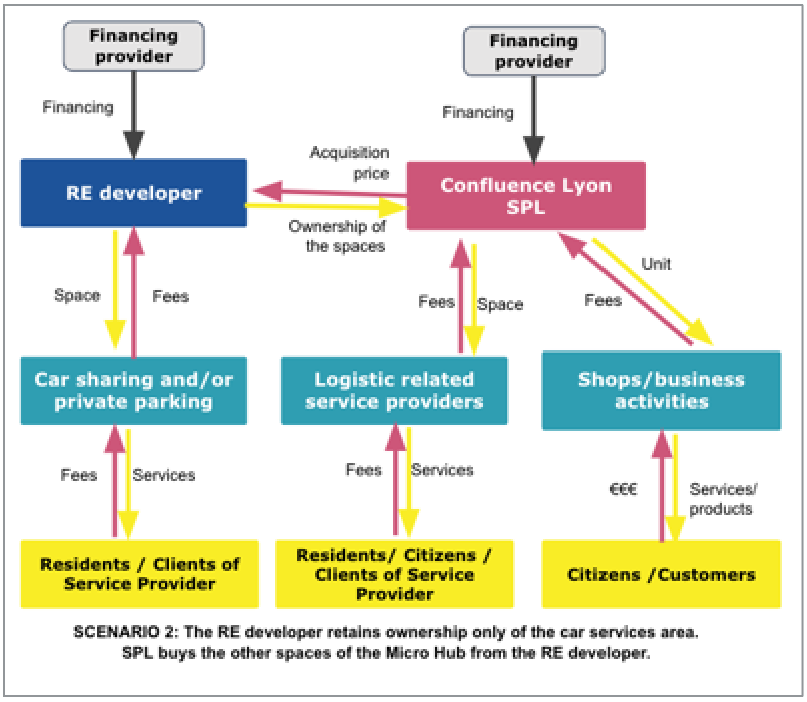
Scenario 2: SPL invests in approx. 47% of the underground space including areas for logistic services and potential commercial activities, paying the related acquisition price to the RE developer.

Business model scheme:



Investment evaluation:

Investment evaluation																
Year	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Y0	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Y11**	**Y12**	**Y13**	**Y14**	**Y15**
Investment cost	-1 221 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating Cash flow	0	275 062	77 996	79 676	81 396	83 158	84 962	86 809	88 700	90 637	92 620	94 650	96 728	98 856	101 034	103 265
	-1 221 200	**275 062**	**77 996**	**79 676**	**81 396**	**83 158**	**84 962**	**86 809**	**88 700**	**90 637**	**92 620**	**94 650**	**96 728**	**98 856**	**101 034**	**103 265**
Discount rate	1,000	0,971	0,943	0,915	0,888	0,863	0,837	0,813	0,789	0,766	0,744	0,722	0,701	0,681	0,661	0,642
Discounted cash flow	**-1 221 200**	**267 051**	**73 518**	**72 915**	**72 320**	**71 733**	**71 154**	**70 584**	**70 021**	**69 466**	**68 918**	**68 377**	**67 843**	**67 316**	**66 796**	**66 282**
Cumulated cash flow	**-1 221 200**	**-954 149**	**-880 631**	**-807 716**	**-735 397**	**-663 664**	**-592 510**	**-521 926**	**-451 905**	**-382 439**	**-313 521**	**-245 144**	**-177 301**	**-109 985**	**-43 190**	**23 092**
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
DSCR		5,01	1,43	1,46	1,50	1,54	1,58	1,62	1,67	1,71	1,76	1,80	1,85	1,90	1,95	2,00

Payback time	15
Project IRR	3,3%
NPV	23 092

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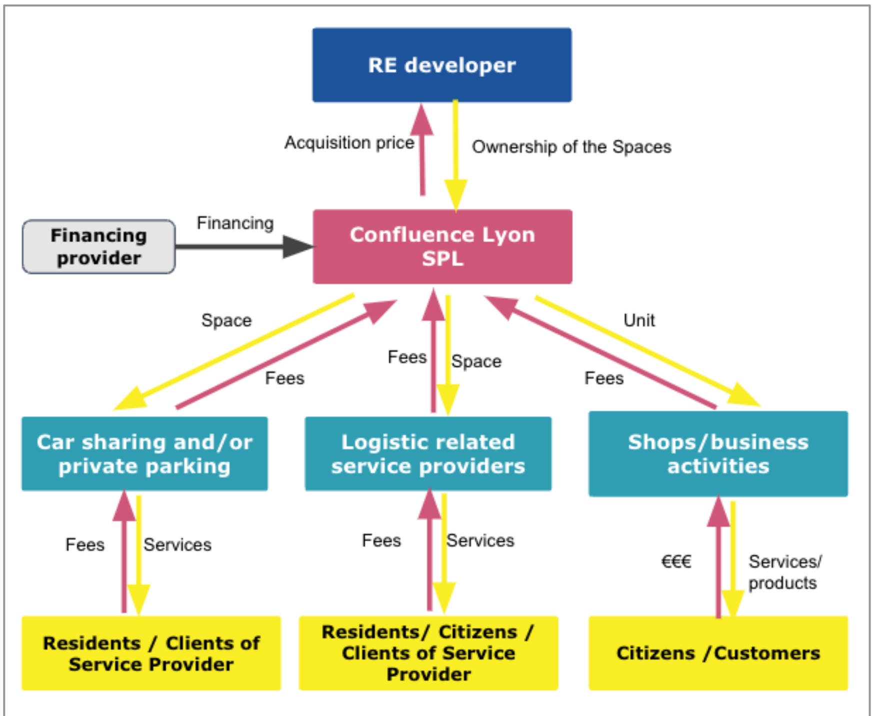
Scenario 3: SPL becomes the owner of the whole Micro Hub space (paying the related acquisition price to the RE developer) and manages the relationship with all the service providers.

Business model scheme:



SCENARIO 3: SPL buys the 3 AREAS of the Micro Hub from the RE developer.

Investment evaluation:

Investment evaluation

Year	-	1	2	3	4	5	6	7
	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Investment cost	-2 581 200	0	0	0	0	0	0	0
Operating Cash flow	0	525 303	107 565	109 885	110 454	109 139	107 700	106 130
	-2 581 200	525 303	107 565	109 885	110 454	109 139	107 700	106 130
Discount rate	1,000	0,971	0,943	0,915	0,888	0,863	0,837	0,813
Discounted cash flow	-2 581 200	510 003	101 390	100 560	98 137	94 144	90 197	86 294
Cumulated cash flow	-2 581 200	-2 071 197	-1 969 807	-1 869 247	-1 771 110	-1 676 966	-1 586 769	-1 500 475
	1	1	1	1	1	1	1	1
DSCR		4,52	0,93	0,95	0,96	0,96	0,95	0,94

Year	8	9	10	11	12	13	14	15
	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
Investment cost	0	0	0	0	0	0	0	0
Operating Cash flow	104 425	102 578	100 583	98 434	96 124	93 646	90 994	88 160
	104 425	102 578	100 583	98 434	96 124	93 646	90 994	88 160
Discount rate	0,789	0,766	0,744	0,722	0,701	0,681	0,661	0,642
Discounted cash flow	82 434	78 617	74 843	71 110	67 419	63 768	60 158	56 587
Cumulated cash flow	-1 418 041	-1 339 424	-1 264 581	-1 193 470	-1 126 051	-1 062 283	-1 002 125	-945 538
	1	1	1	1	1	1	1	1
DSCR	0,93	0,92	0,90	0,89	0,87	0,85	0,83	0,81

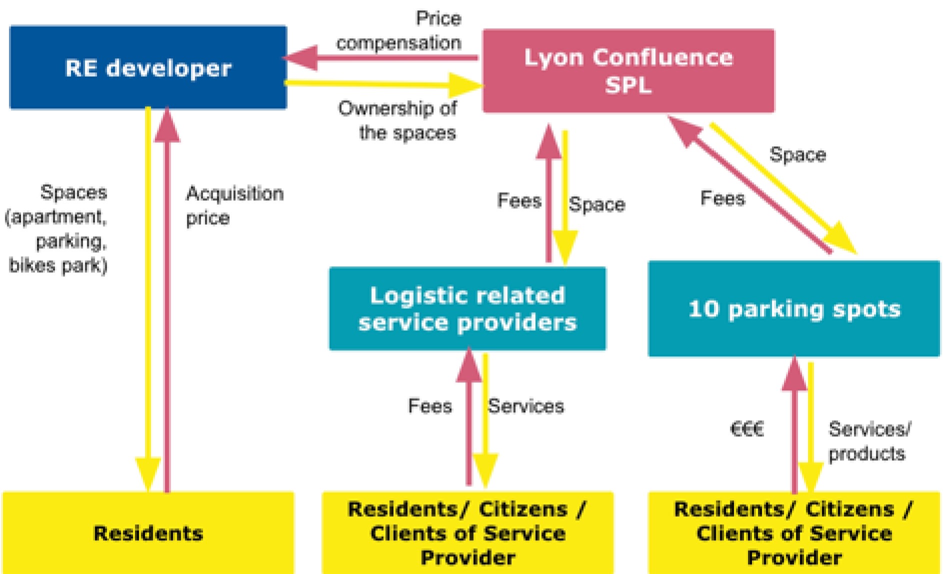
Payback time	>15 years
Project IRR	-4,1%
NPV	-945 538

Funded by the European Union

<u>Scenario 4 (selected one):</u> SPL invests in approx. 40% of the underground space (paying the related acquisition price to the RE developer) including areas for logistic service and ten parking slots able to host the car-sharing service (business model scheme and scenarios KPIs provided in the following paragraph). The business unit is not built in order to reduce investment.

In scenarios from 1 to 3, the presence of an external financing provider has been assumed to complement the funds received via ASCEND grant. In scenario 4 the use of external financiers has not been included to better reflect SPL current strategy.

The business model scheme of scenario 4 is provided as follows:



SCENARIO 4: SPL partially invests in the underground space areas to establish a decarbonised logistic service and the car sharing service

Business Model of SPL selected scenario

9.1.2. Economic-financial analysis (Scenario 4)

For the purpose of T5.3 aiming at testing specific financing instruments applied to SPs, an economic-financial analysis comparing the economic KPIs of different scenarios has been developed to investigate the economic feasibility of the investment from SPL perspective in both cases. In the following paragraph, only the selected scenario (n. 4) is presented (details of other scenarios are provided in the Annex from 16.1.1 to 16.1.3).

<u>Monetisation strategy</u>

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Scenarios of monetisation strategy have been explored by the project promoter in order to ensure the sustainability of the investment and the coverage of operating costs over time and minimise the dependency from public subsidies.
In Scenario 4, the monetisation strategy includes the renting of the acquired Micro Hub spaces to different service providers:

- **Car service area:** SPL owns the equivalent area of 10 car spots to be rented to carsharing service providers. Based on the current assumptions, both residents and external citizens could benefit from the service. The details of the contracts will be set once the procedure of public tender to find the adequate supplier is completed.
- **Logistic service area:** SPL rents the area to logistic service providers able to offer a low-carbon storage area, transfer zones for goods and parcels.

Cost structure of the project

The scenarios for the Micro Hub project considered the following cost items:

- **CAPEX:** the project promoter acquires the spaces from the RE developer who is responsible for the construction of the planned residential real estate, including both residential buildings (apartments) and the Micro Hub spaces located in the basement of the entire property. The acquisition price is managed via a price compensation mechanism on the previous contract to acquire the land from SPL.
- **Operating costs:** maintenance costs for cleaning and small interventions and administrative costs to manage the rental contracts with different counterparts have been considered.

Based on the current available information provided by the project promoter, the following main assumptions have been considered for the CBA and for the calculation of the main economic-financial KPIs:

Revenues	Value	Unit	Notes
Car services revenues	75	€/spot /month	The value considered is based on the amount paid by the major car-sharing player in Lyon (LPA) in the other car parks. Final price is still to be defined.
Logistic services revenues	c. 80	€/m2/y	The space is rented out for logistic service providers. Final price is still to be defined.
Received subsidy	Max: 542,500	€	ASCEND grant

Operating Costs (OPEX)	c. 22,000	€/y	Maintenance and administrative costs based on market prices[1]
Capital Expenditure (CAPEX) by SPL to buy the spaces from the RE developer	990,000	€	Estimated acquisition price – still under negotiation between parties.
Tax rate (not applicable on received grant)	30%	%	Internal assumption
Inflation rate	2.3%	%	Source: ECB data portal[2] - Nov 2024 value
WACC	3%	%	Internal assumption

The figures reported in the table above are still very preliminary, as they are not yet supported by any offers from service providers. This means that both the revenue and cost structures may change in value. From a purely economic perspective, the scenario presents a negative Net Present Value for SPL (see summary below). In fact, based on the considered assumptions, a revenue profile generating approximately €80k-85k would be necessary to achieve a positive NPV, which could be difficult to attain due to the nature of the provided activities.

Investment evaluation

Year	-	1	2	3	4	5	6	7
	Y0	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**
Investment cost	-990 000	0	0	0	0	0	0	0
Operating Cash flow	0	554 903	12 688	12 980	13 278	13 584	13 896	14 216
	-990 000	**554 903**	**12 688**	**12 980**	**13 278**	**13 584**	**13 896**	**14 216**
Discount rate	1,000	0,971	0,943	0,915	0,888	0,863	0,837	0,813
Discounted cash flow	**-990 000**	**538 741**	**11 960**	**11 878**	**11 798**	**11 718**	**11 638**	**11 559**
Cumulated cash flow	**-990 000**	**-451 259**	**-439 300**	**-427 421**	**-415 623**	**-403 906**	**-392 268**	**-380 709**
	1	1	1	1	1	1	1	1

Year	8	9	10	11	12	13	14	15
	Y8	**Y9**	**Y10**	**Y11**	**Y12**	**Y13**	**Y14**	**Y15**
Investment cost	0	0	0	0	0	0	0	0
Operating Cash flow	14 543	14 877	15 220	15 570	15 928	16 294	16 669	17 052
	14 543	**14 877**	**15 220**	**15 570**	**15 928**	**16 294**	**16 669**	**17 052**
Discount rate	0,789	0,766	0,744	0,722	0,701	0,681	0,661	0,642
Discounted cash flow	**11 480**	**11 402**	**11 325**	**11 248**	**11 171**	**11 095**	**11 020**	**10 945**
Cumulated cash flow	**-369 229**	**-357 826**	**-346 502**	**-335 254**	**-324 083**	**-312 987**	**-301 967**	**-291 022**
	1	1	1	1	1	1	1	1

Payback time	>15 years
Project IRR	-6,7%
NPV	-291 022

The SP4 use case should not be evaluated solely from a purely economic perspective or in isolation (without scaling up to the city or district level). During the project's exploitation phase of the use case, non-monetary benefits should be carefully monitored to be able to assess their impact in a scaling-up scenario. In fact, while the environmental and social benefits of the individual initiative are limited for the individual use case, they become significant in scenarios involving replication and/or scaling up at the city or

[1] Source of commercial prices: https://www.fnaut.fr/uploads/2023/03/Le-cout-du-stationnement-automobile-pour-les-finances-publiques-rapport-ADETEC.pdf https://www.entreprisenettoyage.pro/tarif-entreprise-de-nettoyage/

[2] https://data.ecb.europa.eu/main-figures/inflation

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district level. The proposed business model, which involves collaboration between a public entity (the landowner) and a private entity (responsible for project development), is particularly interesting for replication purposes, as it is based on mutual benefits—lower investment costs offset by the provision of decarbonised services for citizens. This mechanism is possible due to SPL specific business model in which Lyon Metropole owns the land and can negotiate specific conditions through SPL with real estate developers.

Analysis of potential financial instruments suitable for the investment

From a financial perspective, SPL strategy is to use a price compensation mechanism to finance the investment. Part of the CAPEX are offset thanks to a price reduction applied in the transaction for the sale of the land from SPL to the real-estate developer.
Thanks to this compensation mechanism, the investment is more affordable for the project promoter. Operational costs are partly covered by the revenues generated by the activities and by the upfront payment of the ASCEND grant.

9.1.3. Non-Monetary benefits

The implementation of the decarbonised Micro Hub in Confluence Lyon generates a range of non-monetary benefits that significantly contribute to environmental sustainability, social cohesion, and the collective well-being of the district. Although these benefits are not directly quantifiable in financial terms, their positive impact is substantial and can be analysed through qualitative and quantitative indicators. Below, the main non-monetary benefits are examined, supported by scientific evidence and bibliographic references.

Environmental Benefits

Reduction in greenhouse gas emissions: The Micro Hub promotes the adoption of low-carbon transportation methods, such as cargo bikes and car-sharing services, which significantly reduce CO_2 emissions compared to traditional urban logistics methods. According to a study by Baptista et al. (2014), the use of electric vehicles and cargo bikes can reduce CO_2 emissions by up to 50% compared to conventional diesel or petrol-powered vehicles.
This solution aims mainly not to increase the mobility-related GHG emissions despite new buildings being constructed in the PCED.

Improved Air Quality: The transition to low-emission vehicles contributes to a reduction in air pollutants, such as nitrogen

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oxides (NOx) and particulate matter (PM2.5), which are associated with respiratory and cardiovascular problems (WHO, 2021). This improvement in air quality has a direct impact on public health, reducing healthcare costs associated with pollution.

Social Benefits

Enhanced social cohesion: The Micro Hub serves as a community hub, offering shared spaces and accessible services to all residents. This fosters social interaction and reduces isolation, particularly among vulnerable groups. According to Putnam (2000), the creation of shared public spaces is crucial for strengthening social capital and promoting community cohesion. The project increases the residents' engagement: for instance, considering the car-sharing service, the project promoter aims at offering from 10 vehicles at the commissioning to 30 at the end of the construction of the PCED. Based on a ratio of 5 households/vehicle, the project would get around 300 residents engaged. However, it is more difficult to estimate the number of residents able to benefit from the new logistics solutions.

Inclusive accessibility: The Micro Hub ensures access to sustainable mobility services for people with disabilities or economic limitations, promoting social inclusion. This aspect aligns with the objectives of the 2030 Agenda for Sustainable Development, particularly Goal 11 (Sustainable Cities and Communities) (UN, 2015).
Increased road safety: The reduction in heavy vehicle traffic and the increase in light transportation modes, such as bicycles, contribute to a decrease in road accidents. It is well documented that cycling infrastructure and the promotion of active mobility are associated with a significant reduction in fatal accidents.

Health Benefits

Promotion of active mobility: The use of cargo bikes and other sustainable transport modes encourages physical activity among residents, with demonstrated benefits for cardiovascular health and a reduced risk of chronic diseases, such as diabetes and obesity (Sallis et al., 2016).
Reduction in noise pollution: The shift to electric and low-noise vehicles reduces exposure to noise, which is associated with sleep disturbances, stress, and mental health issues (WHO, 2018). This improvement contributes to a healthier and more liveable urban environment.

Governance impact

The project engages with several key stakeholders including Lyon Metropole (as a member in Lyon Confluence's Board of Directors), real estate developers, residents, (potentially) businesses, providers of mobility services and logistics operators. The value proposition for

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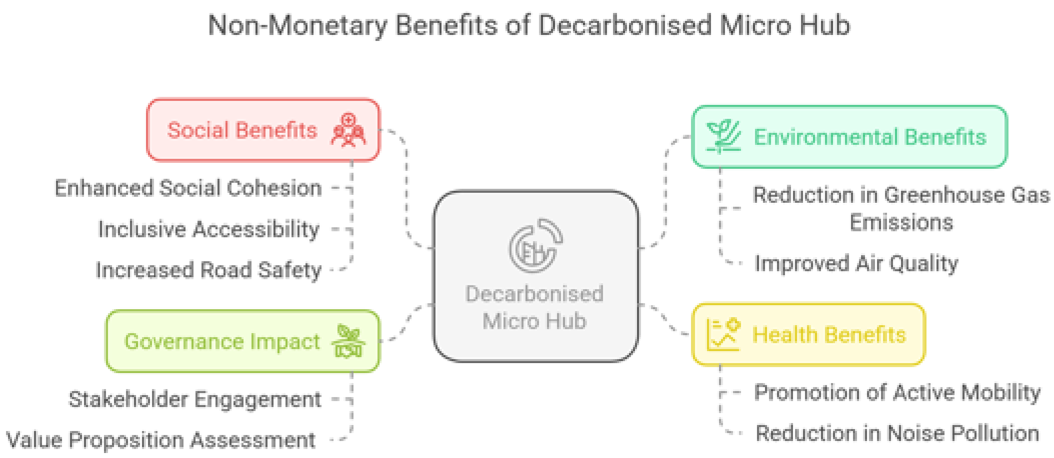
each of them needs to be assessed to achieve a successful and sustainable initiative on the long term.

The non-monetary benefits of the decarbonised Micro Hub in Confluence Lyon are multifaceted and interconnected, with positive impacts on the environment, society, and public health. Although these benefits are not directly measurable in economic terms, they substantially contribute to the creation of a more sustainable, inclusive, and resilient district.



Non-Monetary Benefits of solution LY 4.8

9.1.4. Risks Assessment

The transformation of an underground space into a mobility hub, as envisioned in the Micro-Hub project in Lyon, presents various challenges and risks. SPL, responsible for the urban development of the Lyon Confluence district, has already identified some of these risks and is working proactively to address them.

One of the key **technological risks** is integration delays, where the implementation of infrastructure for EVs and cargo bikes may face setbacks due to supply chain issues or compatibility challenges. This medium-risk factor can be mitigated by selecting reliable suppliers and planning integration phases carefully. Additionally, rapid advancements in energy technologies could render certain components obsolete, necessitating costly upgrades. To address this, SPL should prioritise modular and flexible solutions while considering leasing options to maintain access to cutting-edge technology without significant upfront costs. Scalability is another concern, as the fixed nature of the underground space limits future expansion. While the Micro-Hub model is replicable in other urban centres, space constraints pose challenges to widespread adoption.

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Operational risks include a lack of qualified personnel due to the novelty of the concept, making it crucial for SPL to invest in training programs and collaborate with technical institutes. Another major risk is complex contract management, where multiple stakeholders, including real estate developers and service providers, could lead to delays and increased costs. Establishing clear procedures and strong project management practices is essential. Additionally, delivery and installation delays, highly probable in construction projects, could significantly impact the timeline. Close monitoring of deliveries and collaboration with suppliers and contractors are necessary to mitigate this risk.

Market risks include uncertainty regarding demand, which could lead to underutilisation of the hub. Conducting market research and analysing mobility trends in the La Confluence district are critical for assessing demand and adapting services accordingly. Competition from existing mobility services also poses a threat, although SPL considers this a lower probability risk. Developing a strong marketing strategy that highlights the Micro-Hub's unique advantages will be essential in securing market share.

Financial risks such as cost overruns present a significant challenge. SPL has set a maximum purchase price for "Volume Capable" at €1,600/m² from the real estate developer. Strict financial planning and cost management are necessary to prevent budget overruns. Over-indebtedness, though considered a low to medium probability risk, could still have a high impact on operations, while potential tax increases could further affect business profitability. To counter revenue shortfalls, SPL should develop flexible business models and explore alternative revenue streams, such as space leasing and partnerships with commercial entities.

Security risks include potential cyberattacks on the increasingly digitalised mobility hub management systems. While SPL considers this a medium-probability, low-impact risk, strengthening cybersecurity measures is advisable to protect infrastructure and sensitive data.

Other practical considerations include site access, as construction in a well-established urban area like Lyon Confluence requires careful planning to minimise disruption to residents and businesses. SPL must coordinate with local authorities and inform the community about construction phases. Additionally, the impact on residents from noise and traffic congestion should be addressed through mitigation measures such as limited working hours and low-impact technologies. **Social acceptance** risks are also significant, with potential resistance from building residents. Early engagement and effective communication strategies will be key to ensuring project success.

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Risks matrix for solution LY 4.8

9.2. CBA applied to Munich – Mobility Stations solution

In conjunction with **Solution Package 4 - Mobility and Freight Transport (SP4)**, the City of Munich's housing association, Münchner Wohnen (MW), is working on the development of its own mobility stations on private property (Sol 4.2 of the ASCEND Roadmap). This solution includes the installation of carsharing, pedelec and electric cargo bike services in the Harthofviertel, part of the PCED in the lighthouse city of Munich. These installations have already been successfully implemented and tested in other districts outside the PCED and are now being replicated in the PCED Harthof district. The project sponsor MW is building new social housing in the Harthof district and must fulfil various legal requirements, including the obligation to provide between 0.6 and 0.8 parking spaces per apartment built and to arrange them underground in accordance with the development plan. At the municipal level, the legislation allows a reduction in the ratio of required parking spaces per built apartment (up to approx. 0.4x) if MW provides the necessary infrastructure for an appropriate number of sharing infrastructure/mobility stations (submission of a qualified mobility concept). The first mobility station in the PCED Harthof district will be in operation from the end of 2027 and will offer the following services:

- carsharing for residents at a preferential rate;
- Free access to electric bicycles and electric cargo bikes for residents.

The main stakeholders involved in this SP4 are:

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Stakeholder	Role
Münchner Wohnen (MW)	MW is the municipal housing company responsible for the construction of new (social) housing in the city of Munich. It is the project sponsor.
Munich City Council (LHC)	The city administration is involved as the controlling body and financier of the investment. The construction of social housing is financed from the municipal budget, among other sources. The municipality also manages the allocation of housing to residents.
Assets providers	This category includes the providers of bicycles, electric cargo bikes, bicycle infrastructure and car-sharing vehicle providers, as well as other providers of the equipment required for the installation and use of the mobility stations.
carsharing service provider	A car-sharing service provider is selected and contracted by the MW. The MW provides private parking spaces, the carsharing company is responsible for providing the vehicles and operating the e-cars.
Legislators	National and local authorities who set the requirements in terms of parking to residential ratios, parking and building permits, and compliance with all other local legal obligations.
Residents	Residents are the users of the mobility stations; they receive social housing rents and can use the alternative mobility services at preferential rates.

The **key assets** considered in this use case include:

- the space on private land available for the mobility stations;
- the associated infrastructure, the pedelecs and electric cargo bikes as well as the vehicles for the carsharing service.

The promoter owns all assets, except for the car units, as the service is outsourced to external private companies specialised in this business.

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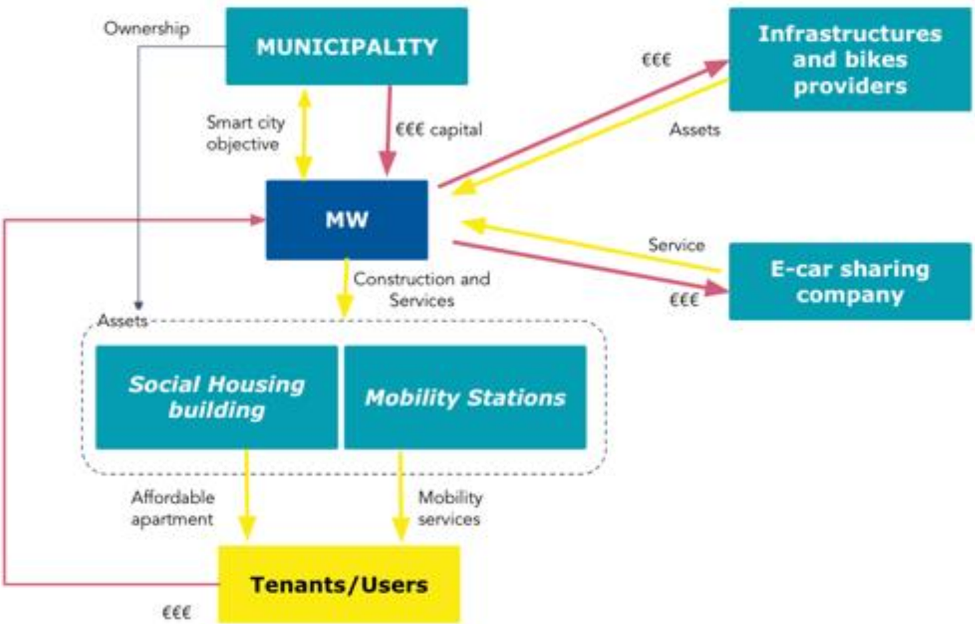
Picture of pedelecs and electric cargo-bikes

9.2.1. Business Model

The project sponsor MW is using the same business model for setting up mobility stations that has been successfully tested in two other districts near Harthof.
The financier of solution 4.2 is the City of Munich: The construction of the mobility stations is linked to the development of new (social) housing, which is primarily financed from the municipal budget.
By saving on cost-intensive underground parking spaces, there is an opportunity to reduce construction costs and to realise some of these savings in sharing offers for the tenants. MW remains responsible for carrying out the work and providing services for the tenants.
The most important business relationships are with the providers of bicycle-based cargo bike services and the associated infrastructure, as well as with the car-sharing company contracted by MW. No external funding body is required for this business model.



Business model scheme of solution MUC 4.2

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9.2.2. Economic-financial planning

For T5.3, which aims to test specific financing instruments for SPs, an economic-financial analysis was developed to assess the economic feasibility of the investment from a MW perspective.

Monetisation strategy

MW's monetisation strategy for the proposed solution is based on the cost savings from not building underground car parks. The development of mobility stations allows the real estate developer to reduce the number of mandatory parking spaces for each newly built apartment in accordance with municipal legislation. This approach results in significant savings for the developer and therefore also for the City of Munich's budget. MW does not generate any income from the mobility services, as the use of bicycles is free of charge for residents and carsharing is outsourced to an external operator. The external operator is selected by MW on the basis of its proposed revenue model. This model can vary in its fee structure in terms of fixed monthly and annual fees or a pure usage fee, depending on the operator.

Cost structure of the project

The business model of the solution is characterised by the following cost items:

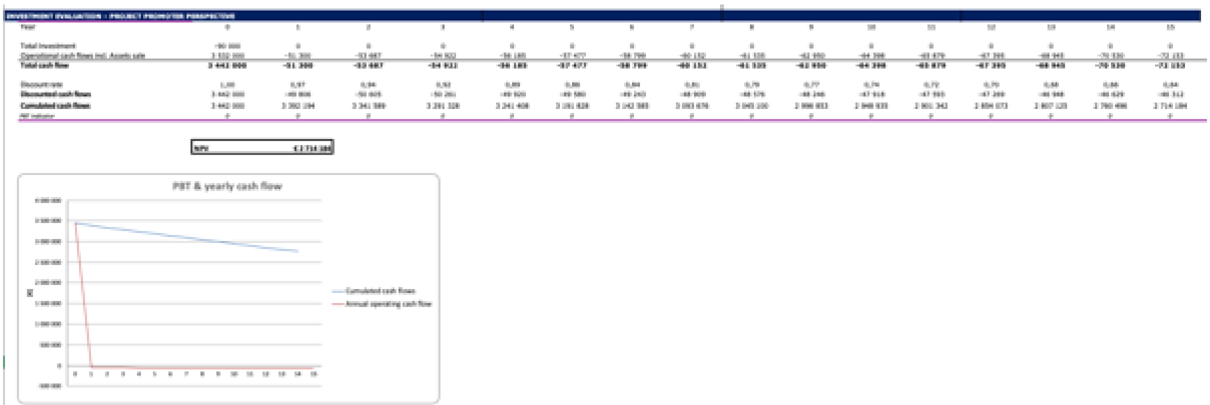
- **Investment costs (CAPEX):** MW covers the investment costs for the bikes and cargo bikes as well as the installation of the mobility stations to accommodate them and ensure a rental operation.
- **Operating costs (OPEX):** MW covers the general maintenance/service of the bikes, electric cargo bikes and the infrastructure of the mobility points, including the cost of lighting and space cleaning. OPEX also includes the service fee paid to the car-sharing company for managing its service on public land.

Based on the currently available information from the promoter, the following main assumptions have been taken into account for the CBA and the calculation of the key economic-financial indicators:

Revenues	Value	Unit	Notes
Avoided cost of construction for the underground parking (63 parking spaces)	56,000	€/parking space	Unit saving for one unbuilt underground parking (pure construction costs)
Received subsidy	4,000	€	Public subsidy for cargo bikes

Operating Costs (OPEX)	51,300	€/y	This includes maintenance, service fees for carsharing companies, communication, etc.
Capital Expenditure (CAPEX)	90,000	€	Average value for the planned size of the mobility station with approx. 10 mobility modules (pedelecs, bike trailers, electric cargo bikes, etc.) in the ASCEND area including the charging infrastructure for the 3 car-sharing vehicles

The "Mobility Station" project in Harthof offers significant benefits to the residents of the newly built social housing and at the same time contributes to the goals of low-carbon mobility and the upgrading of urban spaces. In addition to the non-monetary benefits, the project represents a financially viable and replicable model. By avoiding the cost of building costly underground parking spaces, there are significant savings for the municipality so that the redistributed funds can be invested in the construction of additional rental apartments. These subsidised apartments offer affordable housing options (e.g. €10/sqm compared to the market average of €22/sqm).
For the ASCEND solution 4.2, the estimated net present value (NPV) over a 15-year period is €2,714,184, based on the above assumptions (from a purely building law perspective, the mobility station and the car-sharing service must be maintained "over the lifetime of the building", but even here the economic benefits are evident in residential construction).



This model has great potential for local applications to other social housing projects. The underlying financing mechanism is to optimise the municipal budget allocation based on legal measures for urban decarbonisation and sustainable development.

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In this type of investment, it is crucial to monitor the evolution of the adoption rate among residents and potential fluctuations in operating costs, such as infrastructure maintenance or technological upgrades for mobility points, as they could affect the economic balance of the project. It is important to emphasise that the scalability of the model is limited to the local context, as the possibility to reduce the number of mandatory underground parking spaces is enabled by a specific legislation in Munich. This means that while the project can be transferred to other parts of the city, scaling up on a national or international level would require similar local regulatory framework.

9.2.3. Non-Monetary benefits

The Munich Mobility Points solution brings a variety of non-monetary benefits and contributes to environmental sustainability, social inclusion, urban optimisation and public awareness. These benefits illustrate how the project goes far beyond financial considerations and creates added value for the community and the environment.

Environmental sustainability

Reduction of emissions: By promoting shared mobility solutions such as carsharing and bike sharing, the mobility stations on private land reduce dependence on private vehicles, leading to a reduction in greenhouse gas emissions and an improvement in air quality in the neighbourhoods. This is in line with Munich's goal of becoming climate neutral by 2035.

More green space in the city: The rededication of parking spaces or other uses reduces the urban heat island effect and promotes biodiversity by increasing green spaces in the city.

Noise reduction: Fewer private vehicles on the roads means less traffic noise, which improves the overall quality of life in Munich's urban areas.

Social Inclusion and Equity

Access to mobility for all: Mobility stations ensure equal access to transportation for different groups, including low-income residents and people without access to a private vehicle. They offer alternatives for those who cannot afford or operate a private car.

Improving mobility in underserved areas: Through the strategic placement of mobility stations, the initiative expands mobility options in areas with limited access to public transportation, promoting greater inclusion and social equity.

Improved urban quality of life

Optimised urban space: Mobility stations on private land help to reduce car dependency by freeing up space that was previously used for parking or parking vehicles in underground garages. This measure creates space for more large trees and rainwater infiltration areas.

Less traffic congestion: Shared mobility solutions reduce the number of vehicles on the road, relieving traffic congestion and creating

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safer, more walkable neighbourhoods.
Better air quality: Reduced emissions from private vehicles improve air quality in densely populated areas, which has a positive impact on public health and reduces respiratory problems.

Increased Public Awareness and Behavioural Change.
Educational Opportunities: The initiative raises awareness of sustainable mobility's benefits through public campaigns, encouraging behavioural changes that prioritise shared and eco-friendly transportation modes.

Cultural Shift: By offering easy-to-access shared mobility options, the project promotes a shift away from car ownership, fostering a culture that values sustainability and communal resources.

Support for Innovation and Sustainability Leadership.
Technological Advancement: The implementation of digital solutions, such as mobility apps and booking platforms, modernises Munich's urban infrastructure, making it more efficient and user-friendly.
Model for Other Cities: Munich's initiative serves as an exemplary model for cities worldwide, demonstrating how shared mobility can address urban challenges sustainably and inclusively.
Integration with Sustainability Policies: Mobility Points are a central component of Munich's Mobility Strategy 2035, demonstrating the city's leadership in prioritising innovative and sustainable urban mobility solutions.

The "Mobility Stations on Private Land" project illustrates how municipal legislation and urban initiatives can deliver transformative non-monetary benefits. By improving environmental quality, promoting social inclusion, enhancing urban space and fostering mobility culture change, the initiative goes beyond financial gains to have a lasting positive impact on the city's quality of life and sustainability goals. This pioneering approach underlines Munich's role as a pioneer in sustainable urban development.

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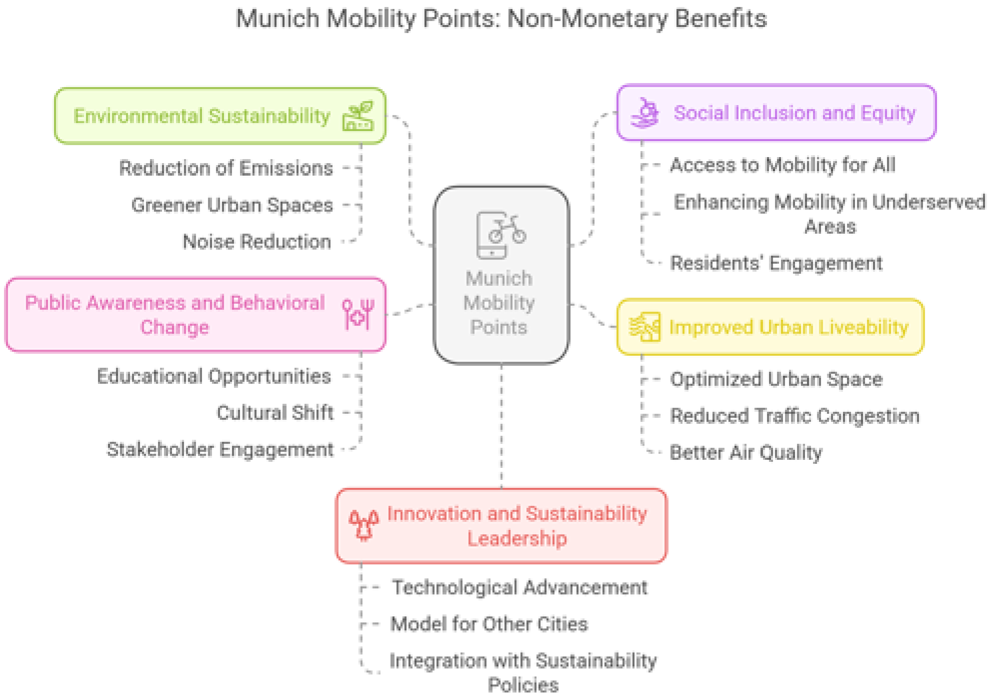

Non-Monetary Benefits of solution MUC 4.2

9.2.4. Risks Assessment

The project aims to enhance shared electric vehicle use through urban charging infrastructure and introduce bike- and cargo-bike-sharing for local residents.

Technological risks include uncertainties in planning the charging infrastructure, such as location selection, scheduling and battery capacity. Clear stakeholder responsibilities and coordination with outsourcing companies are essential for both offered services. **Financial risks** include high initial CAPEX for purchasing bikes, infrastructure, and car-sharing services. A phased rollout strategy, supported by public-private partnerships (PPPs), can help manage costs. Uncertain revenue streams, influenced by adoption rates and competition, pose another risk, mitigated through market research, flexible pricing, and promotions. **Operational risks** include maintenance and reliability concerns for the bike-sharing service. Regular monitoring and scheduled maintenance can prevent costly repairs and interruptions. Outsourced car-sharing services also pose risks due to initial costs for electric vehicle operators. Financing options such as grants, leasing, and concessional loans should be explored. **Market risks** include competition from car rentals, ride-hailing services, and other mobility providers. Differentiation through superior service, technology, and partnerships can mitigate this. **Regulatory changes** in urban mobility and environmental standards

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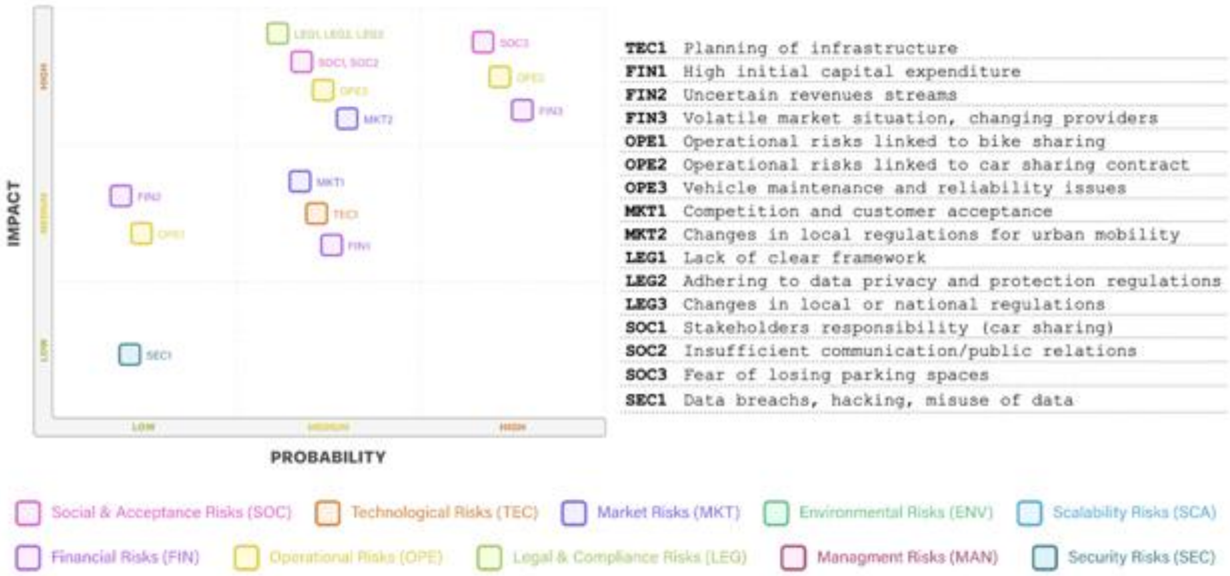
can be a risk, requiring proactive engagement and adaptable business models. **Legal and compliance risks** include the lack of a clear regulatory framework for clean transport, mitigated through policy development and public engagement. Data privacy regulations, such as GDPR, require strict adherence to data protection policies and audits. **Social and acceptance risks** include complex stakeholder coordination, mitigated through early engagement, good communication and role definition. User resistance due to cultural concerns and fear of losing parking space fears are impacting risks. Educational campaigns, public presentations, and awareness efforts are essential for community buy-in.



Risks matrix for solution MUC 4.2

9.3. CBA applied to Porto – Energy community within the PCED

In conjunction with the **Solution Package 2 – Deployment of energy communities and prosumer services (SP2)**, the Porto Energy Agency is working on the development of different PV systems installations located inside their targeted PCED, involving several public and private buildings: Social Housing Neighbourhood (Pasteleira & Pasteleira Nova Neighborhood, Lordelo Neighbourhood, Pinheiro Torres Neighbourhood, Mouteira Neighbourhood, Condominhas Neighbourhood and Rainha D. Leonor Neighborhood & Houses), 4 schools (Pasteleira School, Paulo da Gama School, Condominhas School and Leonardo Coimbra School), the municipal police building and other public buildings, as well as the private building of the museum owned by Serralves Foundation.

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The future goal of the Porto Energy Agency consists in creating a system of energy communities based on the above-mentioned PV installations, that will be able to share the produced energy between the different entities. A collective self-consumption solution is already licensed between 3 of the schools mentioned and the municipal police building.

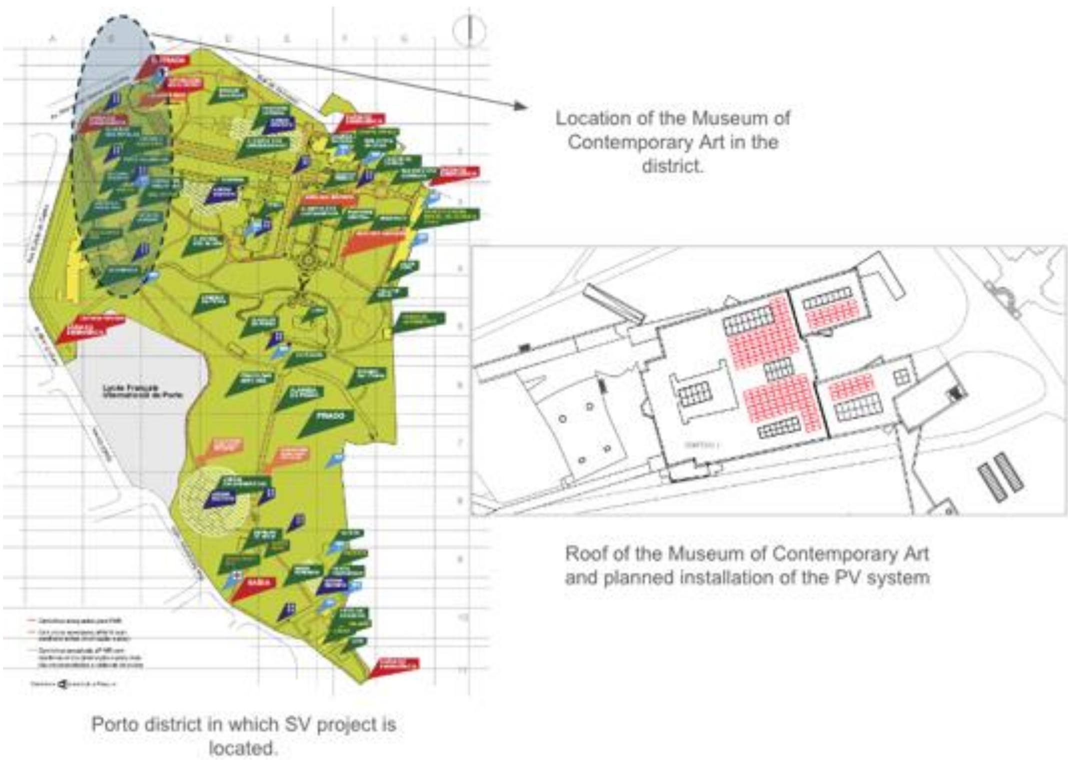
For the purpose of the CBA and based on the current availability of data, the Porto Energy Agency and Serralves Foundation decided to focus on the analysis of the PV installation on the private building of the Serralves Museum for self-consumption only, with the view to gather useful KPIs to promote incentives for PV installation on private property in the PCED and to test the CBA approach that could be applied to the future energy community initiatives involving both private and public buildings.

The **main stakeholders** involved in this SP2 are the following:

Stakeholder	Role
Serralves Foundation (SV)	• **SV is the project promoter.** The Foundation has a valuable historical and cultural heritage, including the Serralves Museum, a project by architect Álvaro Siza, winner of the Pritzker Prize in 1992, the Casa de Serralves, a unique example of Art Deco architecture, and the park, designed by French architect Jacques Gréber and awarded the "Henry Ford Prize for the Preservation of the Environment" in 1997. • SV is considering the installation of PV systems on the Serralves Museum for self-consumption first and can investigate the interest in joining energy communities within the PCED in the future. • SV is subject to many restrictions on the implementation of PV in their infrastructure as Serralves area is classified as a National Monument so any installation requires the consent of specific permitting authorities including the Architects' Register.
Porto Energy Agency	The Porto Energy Agency or the Municipality of Porto don't have any legal connection with the SV. They have an indirect involvement in the project as the Foundation is located within the targeted PCED in which other energy communities on public buildings are planned. Furthermore, the **Porto Energy Agency collaborates with SV to promote incentives for PV installation** on private property.
Permitting Authorities	Serralves heritage site was classified as a "National Monument" in 2012. National authorities including the Architects' Register must provide the **necessary**

	permits to implement PV installations on Serralves buildings.
DTO and energy supplier	**Energy Distribution operator and energy suppliers.**
DGEG	**Direção-Geral de Energia e Geologia (DGEG)** is the Portuguese Directorate responsible for the energy and geology sectors in Portugal. All project promoters for PV installation and connection to the grid are required to comply with DGEG regulation and licensing process.
Financing providers	• Among the potential financiers of this project, there are the **Serralves Foundation** with their own budget potentially financing up to c. 60%; the National authority distributing resources from the **Portuguese Recovery and Resilience Plan** (PRR) for potentially c. 40% of the investment. • A grant request for the PRR funds is ongoing but no certainty on the amount secured is confirmed.

The **main asset** considered in this use case is the Serralves Museum which is located in the perimeter of Serralves Foundation which also includes other relevant historical buildings such as the Serralves Villa, House of Cinema Manoel de Oliveira and the Treetop Walk (buildings highlighted in yellow in the map below):



Location of Serralves Museum project

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The Museum area includes spaces with various functions, including galleries, offices, libraries, auditoriums, cafeterias and restaurants. It also has complementary spaces such as a car park, warehouses, technical areas and kitchens.
The Museum building has specific requirements for its activity – particularly regarding temperature and humidity conditions for the conservation of works of art as well as the well-being of users, which results in a high level of energy consumption. Based on 2021 measurements, the annual energy use of the Museum was 1,988,249 kWh for electricity and 726,627 kWh equivalent for Natural Gas.

9.3.1. Business Model

In the short term, the Serralves Foundation is investigating the feasibility and economic interest of installing a PV system for their own self-consumption. Their general goal is also to become a reference example in their district to promote the installation of PV on private buildings also leveraging on the collaboration with the Porto Energy Agency.
In the short term, both stakeholders aim at investigating the setting of a more complex energy community framework potentially integrate different types of organisations (public and private). This will allow private and public buildings to mutually share the produced energy, reduce CO_2 emissions and improve energy efficiency in Porto. In the long-term scenarios, other stakeholders could be involved, among others: **Águas e Energia do Porto** (AedP), a public company responsible for renewable energy production, water services, and energy efficiency in public infrastructure and **Porto Digital**, an organisation integrating digital technologies to encourage active community participation in the energy transition. This type of involvement is already foreseen in the implementation of the PCED but could be extended to key partners in the area of intervention.

The two scenarios in the short and long terms are visualised in the following schemes:

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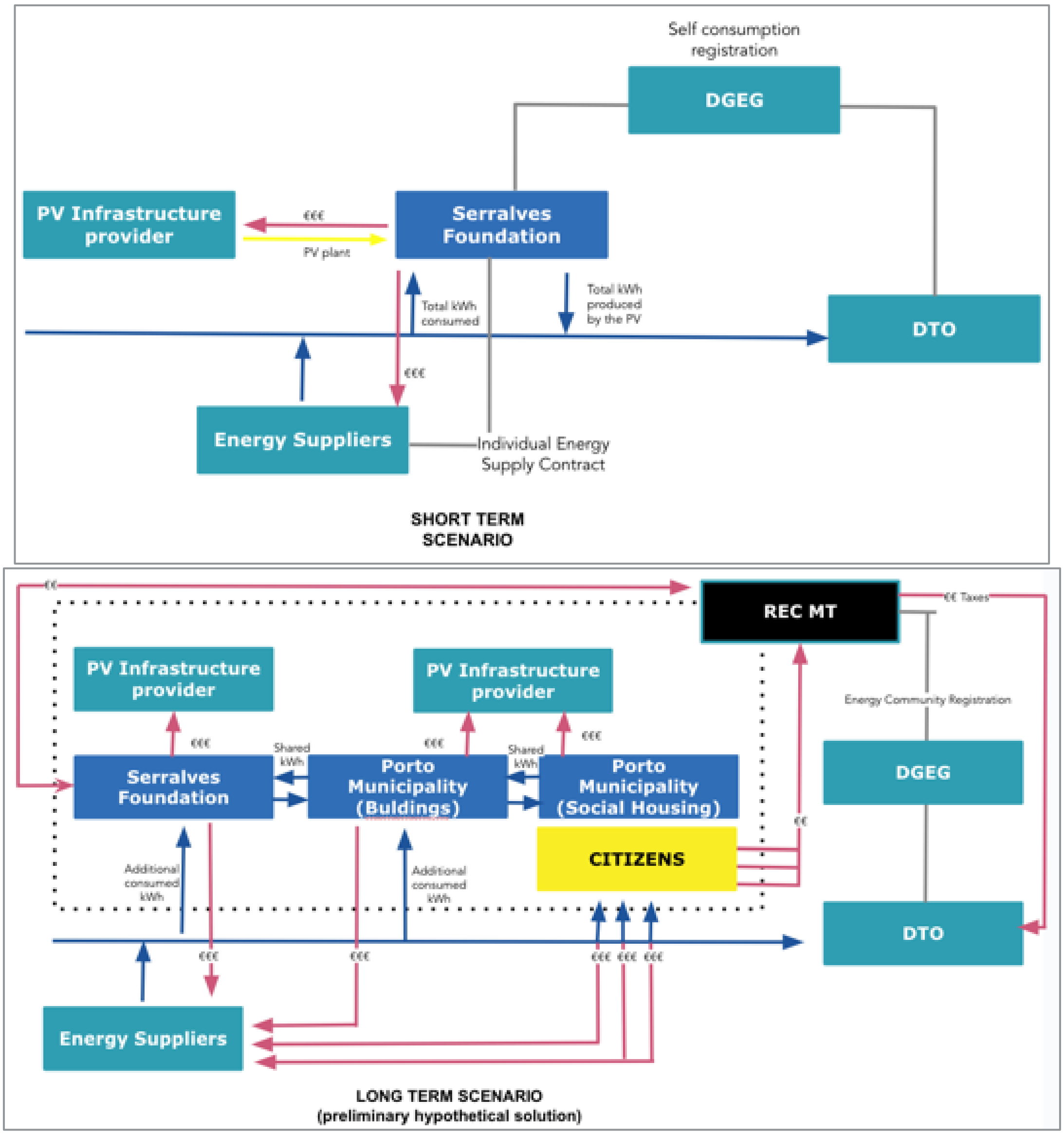

Business model schemes in the short and long term

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9.3.2. Economic-financial analysis

For the purpose of T5.3 aiming at testing specific financing instruments applied to SPs, an economic-financial analysis has been developed on the short-term scenario only due to the current availability of data. The purpose of this analysis is to assess the economic impact of the investment from Serralves Foundation perspective.

Monetisation strategy

In the considered scenario, the monetisation strategy includes:

- The **energy savings** due to the self-consumption of 100% of the electricity produced by the PV plant. The self-consumed energy is valorised as the avoided costs of energy withdrawn from the grid at a price of around 0.12 €/kWh(plus taxes), based on the information provided by the project promoter.

Cost structure of the project

The scenario analysis considered the following cost items:

- **CAPEX:** the project promoter acquires the PV installation and invests in some additional project-related costs such as structural analysis and construction of new low-voltage branches.
- **Operating costs by the project promoter:** they have been preliminary estimated as a flat fee including maintenance costs for cleaning, small interventions and administrative costs to manage the procedure with the energy authorities (i.e. DGEG, DTO).

Based on the current available information provided by the project promoter and complementary assumptions provided by R2M, the following main items have been considered for the CBA and for the calculation of the main economic-financial KPIs:

Revenues	Value	Unit	Notes
Energy savings	Ref :25,311(Y1) Max :28,466(Y1) Min :21,572(Y1)	€/y	Considered electricity price of 0.12 €/kWh
Received subsidy	Ref: 55,000 Max: 60,000 Min: 46,000	€	Amount granted by the PRR calculated as 40% of the total investment. The grant is not confirmed yet.
Operating Costs (OPEX)	Ref : 10 Max : 23 (Y1) Min : 8 (Y1)	€/kW/y	Maintenance, Cleaning and administrative costs
Main Capital Expenditure (CAPEX) for the PV installation	Ref: 127,500 Max: 135,000 Min: 105,000	€	PV installation costs

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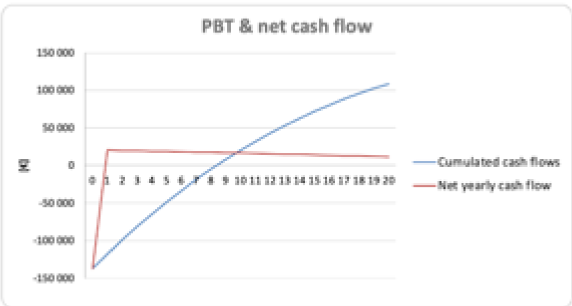
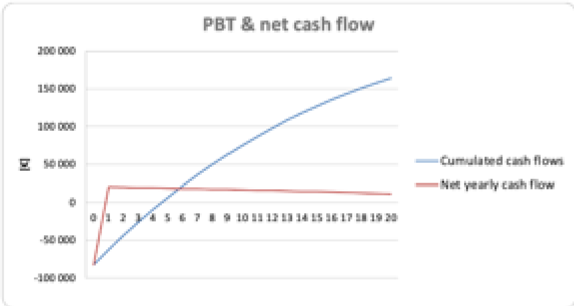
Other Capital Expenditure (CAPEX)	Ref: 10,000 Max: 15,000 Min: 10,000	€	Structural analysis and new low-voltage branches
Inflation rate	2.3%	%	Source: ECB data portal – Nov 2024 value
WACC	3%	%	Internal assumption

A time window of 15 years has been considered for the calculation of the following main KPIs (project IRR and NPV) of the reference scenario, the full calculation of which is provided in Annex 16.3.1:

REFERENCE SCENARIO	**Reference scenario including grant** (including secured grant of 55,000€)	**Reference scenario without grant**
Payback time	5 years	9 years
Project IRR	21.4%	10.0%
Net Present Value	126,772 €	71,772 €



SCENARIO without PRR grant



SCENARIO including PRR grant

Under the considered assumptions, the Reference scenario shows positive KPIs independently on the secure of the PRR grant.

Investment evaluation, scenario including the grant:

INVESTMENT EVALUATION – PROJECT PROMOTER PERSPECTIVE																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-137 500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	55 000	20 553	19 639	19 292	18 933	18 563	18 180	17 785	17 377	16 956	16 521	16 073	15 611	15 135	14 644	14 138
Total cash flow	**-82 500**	**20 553**	**19 639**	**19 292**	**18 933**	**18 563**	**18 180**	**17 785**	**17 377**	**16 956**	**16 521**	**16 073**	**15 611**	**15 135**	**14 644**	**14 138**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-82 500	19 954	18 512	17 655	16 822	16 012	15 226	14 461	13 717	12 995	12 294	11 612	10 950	10 306	9 682	9 075
Cumulated cash flows	-82 500	-62 546	-44 034	-26 379	-9 557	6 455	21 681	36 141	49 859	62 854	75 148	86 759	97 709	108 015	117 697	126 772
PBT indicator	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

NPV	**€ 126 772**
IRR	21,4%
PBT	5

Investment evaluation, scenario excluding the grant:

Funded by the European Union

INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-137 500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	0	20 553	19 639	19 292	18 933	18 563	18 180	17 785	17 377	16 956	16 521	16 073	15 611	15 135	14 644	14 138
Total cash flow	**-137 500**	**20 553**	**19 639**	**19 292**	**18 933**	**18 563**	**18 180**	**17 785**	**17 377**	**16 956**	**16 521**	**16 073**	**15 611**	**15 135**	**14 644**	**14 138**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-137 500	19 954	18 512	17 655	16 822	16 012	15 226	14 461	13 717	12 995	12 294	11 612	10 950	10 306	9 682	9 075
Cumulated cash flows	-137 500	-117 546	-99 034	-81 379	-64 557	-48 545	-33 319	-18 859	-5 141	7 854	20 148	31 759	42 709	53 015	62 697	71 772
PBT indicator	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

NPV	**€ 71 772**
IRR	10,0%
PBT	9

The CBA was also run by using the minimum and maximum values of the most relevant items (energy savings, operating costs flat fee, CAPEX) based on the project promoter's information. KPIs under these scenarios don't differ too much from the reference scenario as summarised in the following tables:

MINIMUM SCENARIO	**Reference scenario including grant** (including secured grant of 46,000€)	**Reference scenario without grant**
Payback time	5 years	9 years
Project IRR	21.7%	10.1 %
Net Present Value	107,728 €	61,728 €

MAXIMUM SCENARIO	**Reference scenario including grant** (including secured grant of 60,000€)	**Reference scenario without grant**
Payback time	5 years	10 years
Project IRR	19.7%	8.6 %
Net Present Value	121,452 €	61,452 €

Analysis of potential financial instruments suitable for the investment

With the aim of testing a potential financing instrument applicable to the Porto SP2 project, R2M developed a simulation scenario incorporating a crowdlending mechanism designed to cover 30% of the expected investment. The remaining investment is assumed to be funded by the Foundation's own resources (30%) and the PRR grant (40%).
The crowdlending scenario involves leveraging a crowdfunding platform to manage the fundraising campaign, attract local and international small to medium-sized investors, and facilitate the payment of returns to registered investors.

This scenario is based solely on R2M's assumptions, considering the current market conditions of crowdfunding platforms and drawing inspiration from European energy communities and private PV installation projects that have adopted this financing mechanism. The

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Serralves Foundation has not provided any confirmation or validation regarding the applicability of the proposed scenario to their specific context.

From the project promoter's perspective, the scenario includes the same assumptions as the Reference use case described in the previous paragraph and add the following assumptions:

Other operating costs linked to the crowdlending scenario	Insurance: 1,042 Admin costs: 2,847 Crowdlending fee: 675	€/y	-Based on similar project on energy community -Crowdlending fee equal to 4.5% of raised capital based on GOPARITY pricing.

The KPIs calculation is not impacted by the chosen financing instruments; however, an impact is expected on the cash flow of the project promoter during the reimbursement period to lenders: under the considered assumptions, c. 50% of the obtained energy savings would be used to cover the reimbursement of the debt, interests and platform fees in the first 4 years after the investment[3].

From the perspective of an individual stakeholder aiming at participating as an investor in the Serralves Foundation project, the main investment assumptions have been considered:

- Average initial loan term: 4 years;
- Average annual borrowing interest rate: 6%;
- Other general conditions: the investors receive monthly payments from the project promoter including the reimbursement instalment and the interests;
- No other fees are requested to the investor.

These assumptions are in line with the average conditions applied in the platform considered as reference[4]. The structuring of the investment is in line with other EU examples of crowdlending applied to private PV installations.

The KPIs of the investment from the perspective of the aggregated community investing in the project are as follows:

[3] For the purpose of the CBA, the pricing conditions and investments statistics of the portuguese GOPARITY crowdlending platform have been considered: https://goparity.com/

[4] Source: https://www.statistics.goparity.com/

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Investor's perspective	Economic-financial KPIs
Total aggregated investment (reference scenario)	41,250 €
Cumulative remuneration in 5-year period	49,913 €
NPV	5,392
IRR	8.8%
PBT	4

9.3.3. Non-Monetary benefits

The future goal of the project promoter is to build a wider energy community in Porto district, also involving public schools, police buildings and other public properties, in addition to the installation of Serralves Museum. The future project of extended energy community goes beyond renewable energy production; it represents a cultural, social, and environmental transformation, demonstrating how the energy transition can be a driver of sustainable development and social cohesion. Below are the main non-monetary benefits that can be triggered by the foreseen extended project.

Reduction of Environmental Impact and Climate Resilience:

Reduction in greenhouse gas emissions (CO_2 and others): The installation of solar panels at the Serralves Museum is estimated to reduce annual CO_2 emissions by 32.46 tons/y. Since district-level emission data is not yet available, this estimate is based on the Serralves Museum's contribution alone. In addition to CO_2, the project also aims to lower other indirect emissions linked to energy consumption (methane, nitrous oxide), positively impacting climate change mitigation. The current annual GHG emissions related to the Serralves Museum only are c. 659.71 tons/y.

Contribution to the European Union's climate goals: The project aligns with the European Green Deal and the 2050 climate neutrality objectives, showcasing how cities can lead the decarbonisation process.

Promotion of a resilient energy model: By reducing dependence on fossil fuels and the volatility of international energy markets, the project enhances Porto's resilience to external shocks, fostering greater local energy self-sufficiency.

Environmental Awareness and Education:

Serralves Foundation as a hub for sustainability education: As a cultural and social reference point in the city, the Serralves Foundation plays a key role in raising public awareness about renewable energy. Through events, exhibitions, workshops, and educational programs, the institution can foster dialogue on

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sustainability, reaching diverse audiences, from schools to professionals. Despite the private nature of the project, the Porto Municipality and AdEPorto are highly involved as key stakeholders due to their joint participation in ASCEND.

Engagement with schools and young people: The project promoter can involve public schools in the energy community to educate students about the benefits of energy efficiency and self-consumption, shaping a new generation of conscious and responsible citizens.

Awareness campaigns for families: Education extends beyond schools. By potentially engaging with residents, also families with limited access to advanced technologies are made aware of the benefits of sustainability, helping them learn how to reduce energy consumption at home.

Improved Quality of Life:

Enhanced comfort in public and social buildings: Interventions in facilities like schools, public pools, and social housing not only reduce energy consumption but also improve the quality of the spaces. For example, public pools will benefit from advanced technologies for water heating, increasing user comfort.

Public health improvements: A reduced reliance on fossil fuels lowers air pollution, improving air quality. This can have significant health benefits for residents, especially in densely populated urban areas.

Reduction of energy poverty: While not a direct monetary benefit, interventions that enhance energy efficiency in social housing indirectly reduce the energy burden on low-income families, ensuring equitable access to high-quality energy.

Social Inclusion and Cohesion:

Building a participatory energy community: The wider project can foster collaboration between citizens, public entities, and private organisations, encouraging residents to actively participate in managing energy resources. This approach strengthens the sense of belonging and social cohesion.

Inclusion of vulnerable communities: Interventions in social housing and public schools, which are also foreseen in the extended energy community project, ensure that economically disadvantaged communities also benefit from advanced technologies and equitable access to sustainable energy.

Increased civic engagement: The project promoter could choose to actively involve the community in decision-making and solution implementation. In doing so, the project promotes a shared sense of responsibility, transforming citizens into key actors in the energy transition.

Technological Innovation and Advanced Governance:

Digitalisation for energy management: Porto Digital integrates advanced digital solutions to monitor, analyse, and optimise energy consumption. This system enables more transparent and efficient management, allowing for the optimal use of resources.

Multi-stakeholder collaboration: Referring to the future vision of an extended energy community, the governance of the project, which could involve public entities, cultural institutions, and private organisations, would serve as a reference model for the participatory management of energy communities.

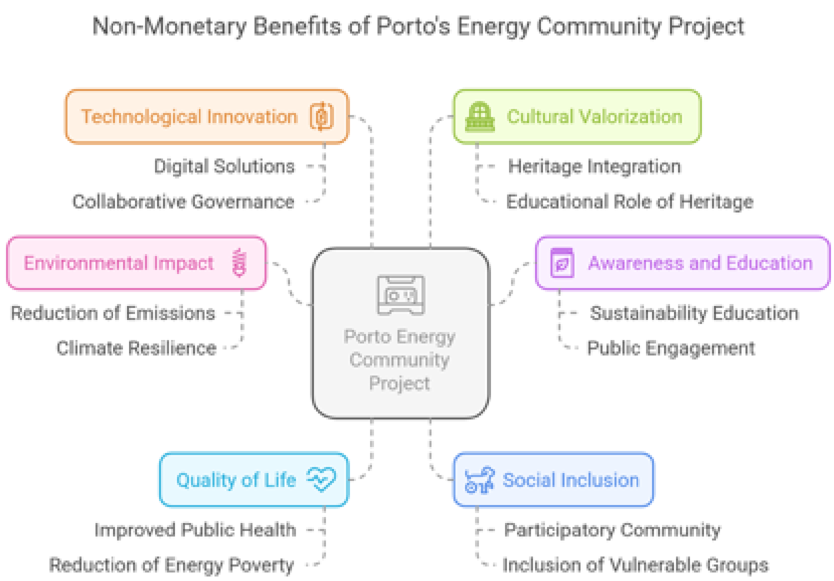
Replicability and scalability: The solutions implemented in Porto are not confined to the local context. The project becomes an innovation laboratory, whose practices can be replicated in other European cities with similar characteristics.

Cultural valorisation:

Compatibility between historical heritage and innovation: The project demonstrates how advanced renewable energy technologies can be integrated into historical buildings without compromising their architectural integrity. The Serralves Foundation, as a national monument, represents an example of how sustainability and preservation can coexist harmoniously.

Promoting the educational role of heritage: Through its symbolic value and cultural role, the Foundation becomes a vehicle for conveying values related to sustainability and environmental respect.

The Porto Energy Community project can become much more than a technological or environmental initiative: it would be a catalyst for social, educational, and cultural change. Through an integrated approach, the project promotes sustainability, strengthens social cohesion, and demonstrates how innovation can serve the goal of improving quality of life while preserving cultural heritage. This model not only addresses local challenges but also becomes a replicable example on a European scale, inspiring other cities to follow a similar path.



Non-Monetary Benefits of Solution POR 2.1

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9.3.4. Risks Assessment

The Porto project, led by the Serralves Foundation, aims to install a PV system on the Foundation's roof to enable self-consumption of energy and, in the future, potentially share electricity with nearby schools, housing and municipal buildings. While this initiative advances renewable energy adoption and local sustainability, it also presents various risks that must be managed effectively.

Technological risks include the integration of PV systems into existing energy networks, which, while having a low probability, could cause medium impact issues such as compatibility challenges, delays, or additional costs. Conducting compatibility assessments and working with experienced energy system integrators can mitigate these risks. Another concern is the reliability of innovative energy generation technologies. If these technologies underperform or require frequent maintenance, operations could be disrupted. To address this, the project should prioritise proven technologies and establish performance guarantees with suppliers.

Financial risks include fluctuations in raw material costs, particularly silicon for PV panels. Although the probability of significant price increases is low, their impact could be substantial. Long-term supply contracts and contingency budgeting can help manage this uncertainty. More critically, the availability of funding poses a high probability and medium impact risk, as securing financing delays could affect project timelines. Exploring diverse funding sources, including public-private partnerships and green financing, is essential.

Operational risks involve potential delays in the delivery and installation of energy infrastructure, which could slow progress and affect stakeholder confidence. A well-structured timeline with buffer periods and close collaboration with suppliers can help prevent setbacks. Additionally, managing multiple stakeholders and development phases introduces complexity, making effective coordination crucial. Clear governance structures, advanced project management tools, and regular stakeholder meetings are necessary to ensure efficiency.

Market risks include changes in energy policies, which, while unlikely, could have a high impact on the project's feasibility. Monitoring policy developments and maintaining flexibility in planning will help mitigate regulatory uncertainties. Variations in energy demand could also affect the project's economic performance. Implementing accurate demand forecasting and adaptable energy storage solutions can reduce these risks.

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Legal and compliance risks include potential challenges in integrating public and private renewable energy communities (RECs), requiring clear legal frameworks to ensure transparency. Architectural and licensing risks are also present, given that the project involves modifying a National Monument. Collaboration with heritage authorities and adherence to preservation guidelines are critical for regulatory approval.

Social and environmental risks appear minimal, as the project aligns well with community interests and has a low environmental impact. Nonetheless, comprehensive environmental assessments and sustainable construction practices should be employed.

Risks matrix for solution POR 2.1

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9.4. CBA applied to Budapest – Pilot heat exchange system using drinking water pipeline

In conjunction with the **Solution Package 3 – Deployment of energy-efficient buildings integrating RES and storage including frugal solutions (SP3)**, Budapest Municipality is planning a refurbishment of an abandoned institution previously used as a school to turn it into a Net Zero Energy co-housing facility. The construction of 116pprox.. 42 apartments is planned in the building, which would provide affordable housing for socially disadvantaged people and families (116pprox.. 100-120persons). The Municipality is investigating the application of an innovative pilot technology developed by Budapest Waterworks to supply energy (heating, cooling and domestic hot water) to the future residential building.

The innovative technology explores the use of potable water pipelines for heat exchange. This system is designed to utilise the water flowing through the city's drinking water infrastructure as a medium for thermal energy exchange. The primary objective is to reduce the environmental impact and increase energy efficiency by harnessing the relatively stable temperature of the water in these pipelines to either absorb heat or release it, depending on the season and specific heating or cooling needs.

The main components of the innovative solution are the unique drinking water heat exchanger, the connection to the underground drinking water pipe system and a heat pump. The heat pump is located in the destination building, where the heating/cooling is needed.
The installation can be coupled with PV production to cover the electricity demand for the heat pump.

There is a potential in the heat exchanger's capacity; other buildings next to the former school can be connected at a later stage.
The technology involved is highly innovative: the heat exchanger designed and tested by Budapest Waterworks is unique, as it differs from those currently available on the market, meeting all the specific requirements necessary for use in drinking water networks.

The **main stakeholders** are:

Stakeholder	Role
Municipality of Budapest	They are the **project promoter** and will be the **joint operator** of the energy plant together with Budapest Waterworks.
Budapest Waterworks	Publicly owned water utility service provider, they are the **technology provider and technical operator** of the energy asset (installation, monitoring and maintenance).

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Municipality of the IV District	**Local governance body** for the District in which the PCED is located, in the northern part of Pest. The district's chief architect's office is involved to ensure that the concept plan is accepted. Moreover, a district zoning plan (KÉSZ) modification was initiated, that is necessary for the functional change of the property from an institutional to a residential zone.
Subcontractors	All **other technology and service providers** to supply the technological components and works.
Tenants	**Residents of the affordable housing building,** benefitting from a rental price which is lower than the market average.
Financing providers	**Finance providers** which are likely to be a mix of City's budget, grants and potentially external investors.

The **main assets** involved in this solution are:

- **the building to be renovated** in order to become a Net Zero Energy property that will be characterised by 3 levels, 4000 m2, 42 apartments, c. 100 tenants. The building is owned by the Municipality of Budapest.
- **the technologies involved in the energy supply system** (unique heat exchanger, heat pumps, main networks to the main potable water pipes).
- the **PV installation** to cover the energy demand of heat pumps.
  -
  -
  - The ownership structure of the technologies involved in the installation is still to be defined.
  -

The Budapest PCED includes institutional, residential, industrial properties and several municipal properties, including the site of Budapest Waterworks, where the solution is planned to be established. There is potential to create heat centres for energy distribution in the PCED in the future. Potentially the system is replicable in other sites of the district and/or city, provided that some specific technical requirements are met in terms of water pipes dimension and water velocity.

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Pipes sections in Budapest District marked in red where the minimum water speed exceeds 0.2 m/s in the main pipes

9.4.1. Business Model

The status of the project is relatively at an early stage: so far only in-house tests were conducted with the technology. This project will be the first unscaled testing of the technology involving multiple stakeholders. No contracts exist between the parties yet. There is no public-private-partnership in this specific case, but collaboration between the Municipality and the technology provider is strong. A simplified scheme to summarise a potential business model configuration is provided in the figure below:

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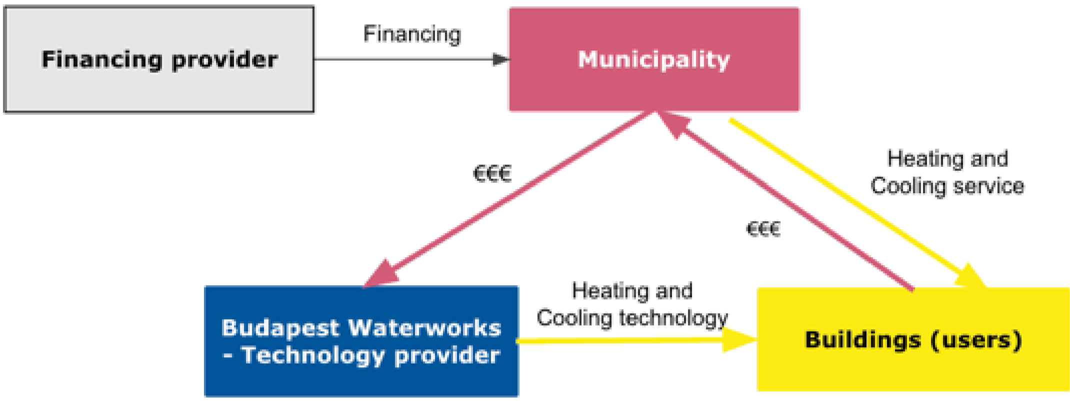

Preliminary assumption of business model scheme

9.4.2. Economic-financial analysis

An economic-financial analysis has been developed based on the limited and very preliminary economic figures estimated by the project promoter. The purpose of this analysis is to assess the needed remuneration able to ensure meaningful economic financial KPIs for the investment.
Given that the business model of the solution is at an early stage of development, the project promoter could only provide estimated figures for the costs structure. All the assumptions related to the monetisation strategy have been assumed by R2M.

Monetisation strategy

In the considered scenario, the monetisation strategy includes the monthly rents paid by the tenants occupying the renovated building, including the energy costs. Approximately 42 apartments are foreseen in the building.

Cost structure of the project

The analysis considered the following cost items:

- **CAPEX:** the investment includes all costs related to the energy plant equipment and the costs for the building refurbishment.
- **Operating costs by the project promoter:** they mainly include maintenance and administrative costs. The cost of electricity consumed by the heat pump is minimal as the scenario considered the integration of a PV installation.

Based on the current available information provided by the project promoter and complementary assumptions provided by R2M, the following main items have been considered for the CBA and for the calculation of the main economic-financial KPIs:

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Revenues	Value	Unit	Notes
Monthly rents	From 7 to 8	€/m2/ month	Estimated rental price lower than mkt
Received subsidy	From 0% to 35%	% on total CAPEX	R2M assumptions for sensitivities purpose
Operating Costs (OPEX)	519 250	€/y	-small maintenance -administrative costs
Main Capital Expenditure (CAPEX) for the refurbishment	7,039,000	€	Building renovation and insulation
Other Capital Expenditure (CAPEX)	789,200	€	All equipment and planning for the installation of the potable water heat exchanger plant
PV installation (CAPEX)	52,500	€	80 kW of PV systems
Total m2 to be rented	c. 75%	% of total m2	R2M assumptions (total m2 of the building=4,000m2)
Inflation rate	2.3%	%	Source: ECB data portal – Nov 2024 value
WACC	3%	%	Internal assumption

Based on the above presented cost structure, three scenarios have been assessed to compare the required monthly rent per square metre and the potential amount of subsidy to secure (as % on total CAPEX) to have positive Net Present Value of the investment. The KPIs of the three scenarios are presented below:

	Scenario 1 No subsidy	Scenario 2 24% of subsidy	Scenario 3 34% of subsidy
Rent cost (€/m2/month)	8	8	7
Rent cost (€/month, 50m2)	400	400	350
NPV (€)	Negative	19,551	52,879
IRR (%)	1,1%	3,0%	3,1%
PBT (years)	More than 30	30	30

Given the highly innovative character of the technology involved, it is reasonable to assume that the project could apply for appropriate subsidised funding able to increase the maturity level of the application and facilitate the scale up potential. Depending on the capability of the project promoter to secure subsidy, the rent costs applied to the tenants can vary consequently between affordable levels

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of price which remain below the average costs/m2 in the specific district.

Investment evaluation, Scenario 1 (view on the first 15 years):

INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-7 880 700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	0	288 626	290 027	291 435	292 849	294 269	295 696	297 129	298 569	300 016	301 468	302 928	304 394	305 866	307 345	308 831
Total cash flow	**-7 880 700**	**288 626**	**290 027**	**291 435**	**292 849**	**294 269**	**295 696**	**297 129**	**298 569**	**300 016**	**301 468**	**302 928**	**304 394**	**305 866**	**307 345**	**308 831**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-7 880 700	280 219	273 378	266 704	260 192	253 839	247 641	241 593	235 693	229 937	224 321	218 841	213 496	208 280	203 191	198 227
Cumulated cash flows	-7 880 700	-7 600 481	-7 327 102	-7 060 398	-6 800 206	-6 546 367	-6 298 726	-6 057 133	-5 821 439	-5 591 502	-5 367 182	-5 148 340	-4 934 845	-4 726 565	-4 523 373	-4 325 146
PBT indicator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

NPV	-€ 1 871 857
IRR	1,1%
PBT more than	31

Investment evaluation, Scenario 2 (view on the first 15 years):

INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-7 880 700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	1 891 368	288 626	290 027	291 435	292 849	294 269	295 696	297 129	298 569	300 016	301 468	302 928	304 394	305 866	307 345	308 831
Total cash flow	**-5 989 332**	**288 626**	**290 027**	**291 435**	**292 849**	**294 269**	**295 696**	**297 129**	**298 569**	**300 016**	**301 468**	**302 928**	**304 394**	**305 866**	**307 345**	**308 831**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-5 989 332	280 219	273 378	266 704	260 192	253 839	247 641	241 593	235 693	229 937	224 321	218 841	213 496	208 280	203 191	198 227
Cumulated cash flows	-5 989 332	-5 709 113	-5 435 734	-5 169 030	-4 908 838	-4 654 999	-4 407 358	-4 165 765	-3 930 071	-3 700 134	-3 475 814	-3 256 972	-3 043 477	-2 835 197	-2 632 005	-2 433 778
PBT indicator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

NPV	€ 19 151
IRR	3,0%
PBT	30

Investment evaluation, Scenario 3 (view on the first 15 years):

INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-7 880 700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	2 679 438	252 446	253 666	254 892	256 123	257 360	258 602	259 850	261 104	262 363	263 627	264 897	266 173	267 455	268 742	270 035
Total cash flow	**-5 201 262**	**252 446**	**253 666**	**254 892**	**256 123**	**257 360**	**258 602**	**259 850**	**261 104**	**262 363**	**263 627**	**264 897**	**266 173**	**267 455**	**268 742**	**270 035**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-5 201 262	245 093	239 105	233 262	227 562	222 001	216 575	211 282	206 118	201 079	196 163	191 368	186 689	182 124	177 670	173 325
Cumulated cash flows	-5 201 262	-4 956 169	-4 717 064	-4 483 802	-4 256 240	-4 034 238	-3 817 663	-3 606 381	-3 400 263	-3 199 184	-3 003 021	-2 811 653	-2 624 964	-2 442 841	-2 265 171	-2 091 846
PBT indicator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

NPV	€ 52 879
IRR	3,1%
PBT	30

9.4.3. Non-Monetary Benefits

The Pilot Heat Exchange System Using Drinking Water Pipeline in Budapest offers significant non-monetary benefits across environmental, social, governance, and technological dimensions.

Environmental benefits

From an environmental perspective, the system contributes to the reduction of greenhouse gas emissions by decreasing reliance on fossil fuels and optimising energy efficiency. By utilising potable water pipelines as a stable heat exchange medium, the project minimises energy waste and enhances heating and cooling efficiency. Additionally, it supports climate resilience by reducing dependence on external energy sources and maximising the use of existing infrastructure, leading to a more sustainable and resource-efficient urban energy model. The estimated amount of annual GHG emission related to the building energy use before intervention is approx. 83 tons/y based on the amount of consumed gas[1]; the annual GHG emission estimated after intervention is approx. 3.5 tons/y in the scenario in which PV fully cover the energy demand of heat pumps.

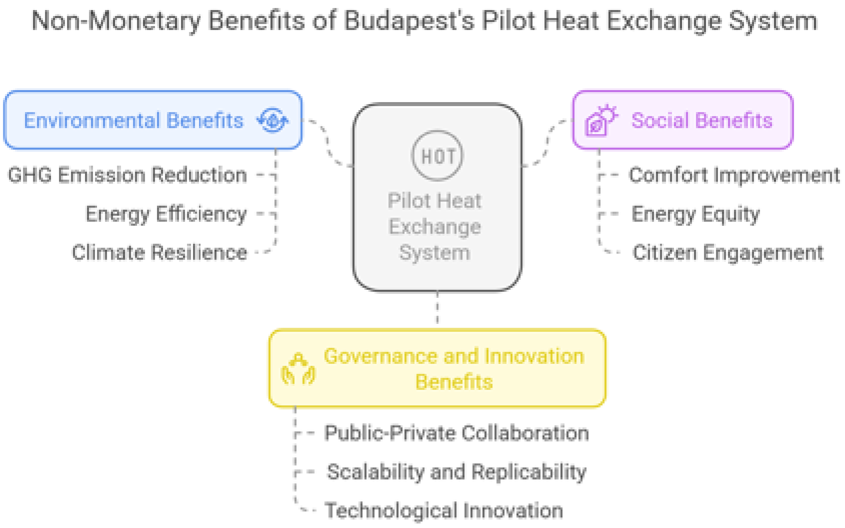
Social Benefits

In terms of social benefits, the project improves comfort and energy equity by providing efficient heating and cooling solutions to a newly refurbished residential building. In case of future scaling up, this benefit would also be transferred to schools, other residential areas, and institutional buildings. This initiative enhances indoor air quality and overall living conditions while also potentially addressing energy poverty by reducing heating costs for vulnerable communities. Furthermore, it fosters citizen engagement and awareness, educating the public on sustainable energy solutions and encouraging participation in energy-sharing initiatives.

Governance and innovation-related Benefits

Governance and policy development play a crucial role in the project's implementation. Through public-private collaboration, the initiative strengthens cooperation between Budapest Waterworks, the municipality, and district authorities, serving as a model for future integrated urban energy projects. The system also demonstrates strong scalability and replicability, offering potential applications in other districts and cities while contributing to climate-adaptive urban planning strategies.

A key component of the project is technological innovation and research development. The development of a custom-designed heat exchanger sets a new benchmark for integrating drinking water networks with heating systems while maintaining drinking water safety standards. Moreover, the project encourages future research and development in urban energy solutions, highlighting the potential of potable water infrastructure in sustainable heating applications.



Non-Monetary Benefits of Solution BUD 3.2

9.4.4. Risks Assessment

The Pilot Heat Exchange System Using Drinking Water Pipeline presents various risks across technological, financial, operational, environmental, social, and scalability domains, requiring careful assessment and mitigation to ensure its successful implementation. Technological risks include potential malfunctions of the heat exchanger, which could disrupt system performance. Although the probability is low, the impact is high, making regular maintenance and monitoring essential. Additionally, system integration issues may arise when connecting the heat exchanger to existing water networks and building systems, posing a medium probability and high impact risk. Comprehensive technical feasibility studies should be conducted before full-scale deployment to minimise these risks.

Financial risks involve possible cost overruns during installation and maintenance, though this is considered a low probability risk. Strict financial controls and contingency planning will help mitigate unexpected budget increases. A more significant challenge is the risk of inadequate funding, which could delay project completion. Securing long-term investments and grants is essential to maintain project momentum and avoid delays. **Operational risks** include potential delays in obtaining necessary permits and regulatory approvals, which could extend project timelines. Early engagement with local authorities will expedite the permitting process. Additionally, the lack of skilled personnel for installation and maintenance, while a low probability risk, can be mitigated by partnering with technical training institutions.

Market risks include variations in heating and cooling demand among consumers, which could affect system utilisation. Developing flexible configurations that adjust to changing energy needs will enhance resilience. Another key risk is the possible unavailability of heat exchanger manufacturers, categorised as medium in both probability and impact. Establishing alternative suppliers and backup procurement plans will help prevent supply chain disruptions. Environmental risks, while minimal, include the potential for potable water contamination or ecological disturbances. Strict compliance with water safety regulations and continuous environmental monitoring are necessary to address these concerns.

Legal and compliance risks may arise from meeting environmental regulations and licensing requirements for integrating solar PV systems with the heat exchanger. Collaboration with regulatory agencies and thorough impact assessments will help ensure compliance. Community acceptance is also crucial, with public engagement campaigns recommended to foster support. Cybersecurity threats related to digital system controls are considered low but require robust data protection protocols. Scalability presents a medium probability and high impact risk, as technical and financial constraints may hinder

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expansion. Developing a scalable business model will ensure the system can adapt to serve larger networks.

Risks matrix for solution BUD 3.2

9.5. CBA applied to Alba Iulia – Energy community

In conjunction with the **Solution Package 2 – Deployment of energy communities and prosumer services (SP2)**, Alba Iulia selected an already existing case study in their Municipality: the installed PV installations on three buildings within the Pavel Dorin Community. The analysis aims at showing the economic benefits of the achieved energy savings thanks to self-consumption and assess the impact of a potential future valorisation of the excess energy sold to the surrounding energy community members located in the same district. The peer-to-peer sale is currently not allowed: there is no law that permits the creation of energy communities, only discussions and debates, but there are many signs that a law for supporting energy communities creation will be drafted soon. Alba Iulia is among the first cities in Romania preparing a local policy in order to influence and support the national legal framework for enabling the energy communities.

The considered district is the Dorin Pavel Community, which includes school, public buildings owned by the Municipality and residential buildings. The Dorin Pavel Technical College headquarter is situated in the central area of the city on one of the main boulevards, being well connected to all transport routes in the city. The Tech College

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headquarter is part of a site composed of a number of buildings which are also interconnected in a basic way in terms of energy consumption.

The main building of the College was endowed in the last years with a relatively high number of PVs aimed to cover part of its energy needs from green sources. Along with the main HQ building, a number of other buildings (belonging to the college) were equipped with PVs in order to cover part of their energy needs. Within the College's site, there are also other educational facilities and buildings which belong to Alba County Council that could potentially host an extension of the existing plant.

A view of the Pavel Dorin Community is provided below in Figure 24. The PV installations considered in the CBA use case are located on the following buildings:

- **Building # 1 (HQ of DP Tech College):** 57.75 kWp of PV installed capacity.
- **Building #2 (Sports Hall):** 52.8 kWp of PV installed capacity.
- Building #3 (Central Heating building): 23.3 kWp of PV installed capacity.
-

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Pictures of the Dorin Pavel Community

The **main stakeholders** involved in the district are:

Stakeholder	Role
Municipality of Alba Iulia	The Municipality is **the project promoter** that installed PV for self-consumption since 2010 in this district. Alba Iulia has a long-term commitment to the sustainable development of the City and already received international recognition for their actions involving above all town hall buildings and infrastructure.
Dorin Pavel Tech College	**Owner** of the buildings hosting the PV installation and **user** of the produced energy.
Alba County Council, Alba local Energy Agency, Regional Development Agency – Centru	Public Authorities providing **permits and influencing local regulations.** Active stakeholders in the ongoing discussion for the energy community's debate.
Technology providers	PV Installation companies

The **main assets** considered in the use case are the Tech College buildings and the already existing PV installations on top of them which are all owned by the Municipality.

As the current installations is surrounded by other Municipality owned buildings that could contribute to further decarbonisation of the local energy production, Alba Iulia is planning the installation of further PV plants on Building called "Workshops" at the "D.P. Tech College", amounting to 22kWh through the National Resilience and Recovery Plan, and another 20 kWh will be installed on the Heating

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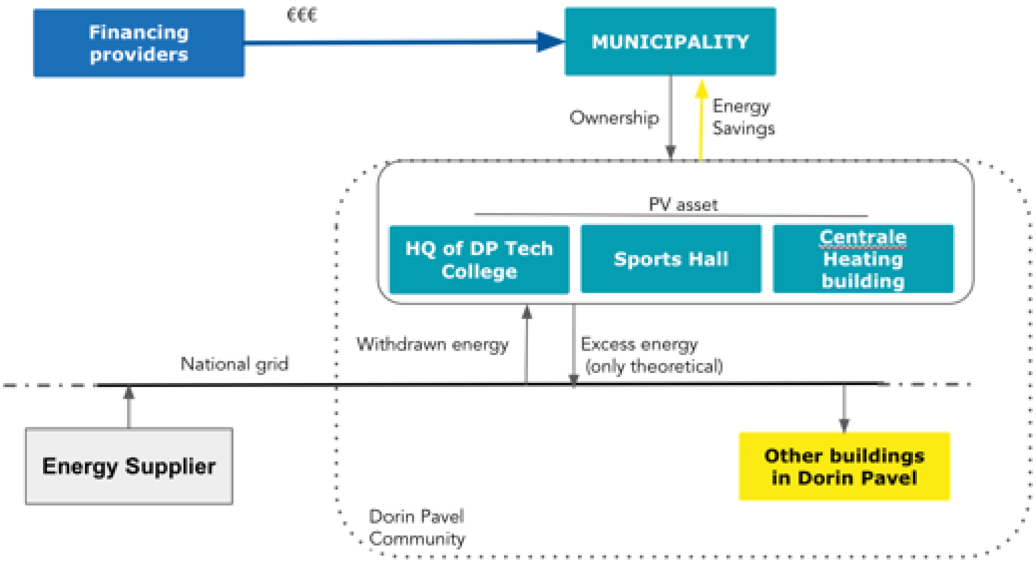
Plant through the "InterPed" Project. The estimated consumption profile of the Municipal Building involved in the Community is around 92,682 kWh/y based on 2023 data.

9.5.1. Business Model

Under the current legislation in Romania, the establishment of energy communities is not allowed yet. The current business model scheme (see Figure 25) includes the Municipality of Alba Iulia as owner and promoter of PV installations on several buildings in the Dorin Pavel Community benefitting from self-consumption only.
The projects implemented by the Municipality represent a reference example in the district to promote the installation of PV both on public and private buildings, also leveraging on the collaboration with Regional Agencies and Energy Agencies.
In the scenario of a more favourable legislation, the Municipality will investigate the setting of a more complex energy community framework potentially integrating different types of buildings (residential buildings, schools, commercial properties, etc.).



Business model scheme of Alba Iulia project

9.5.2. Economic-financial analysis

An economic-financial analysis has been done to assess the profitability of a reference use case corresponding to the Dorin Pavel installation. The input data for energy production and consumption corresponds to the measured 2023 data provided by Alba Iulia team; other data related to the costs structure has been assumed based on R2M assumptions to be able to build a complete use case. Two scenarios have been studied: i) Scenario 1: one use case takes as reference the existing installed capacity and only the benefits brought by the

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energy savings linked to self-consumption; ii) Scenario 2: a second use case considers the additional PV installation foreseen in 2025 (22 kWp of additional capacity) and the theoretical remuneration for the sale of excess energy to other participants of the energy community. The current local legislation does not allow the sale of excess energy to the grid. However, the project promoter believes there is a chance that future regulations may change to permit sales within a local energy community encompassing all public buildings in the municipality.

Monetisation strategy

- For Scenario 1 and Scenario 2, the **energy savings** are due to the self-consumption of approx. 45% of the electricity produced by the PV plant. The self-consumed energy is valorised as the avoided costs of energy withdrawn from the grid at a price of 0.2 €/kWh, based on the information provided by the project promoter. The beneficiaries of these energy savings are the Municipal buildings integrating the PV installations.
- Only for Scenario 2, the **theoretical sale of excess energy to the other municipal building** involved in an energy community is valorised at the price of 0.2 €/kWh as well.

Cost structure of the use case

The scenario analysis considered the following cost items:

- **CAPEX:** the project promoter acquires the PV installation and invests in some additional project-related costs such as the distribution network and monitoring/billing equipment.
- **Operating costs:** they have been preliminary estimated by R2M in line with other similar projects. They include ordinary maintenance, administrative and insurance costs.
  -

Based on the current available information provided by the project promoter and complementary assumptions provided by R2M, the following main items have been considered for the CBA and for the calculation of the main economic-financial KPIs:

Revenues	Value	Unit	Notes
Energy savings	Scen1: 10,102 (Y1) Scen2: 11,714 (Y1)	€/y	Considered electricity price of 0.2 €/kWh
Theoretical sale of excess energy	Scen2: 7,746 (Y1)	€	Valorised at 0.2 €/kWh
Operating Costs (OPEX)	10 10% of revenues 7.5	€/kW/y % €/kWp	Maintenance and administrative and insurance costs
Main Capital Expenditure (CAPEX) for the PV installation	40,000	€	PV installation costs

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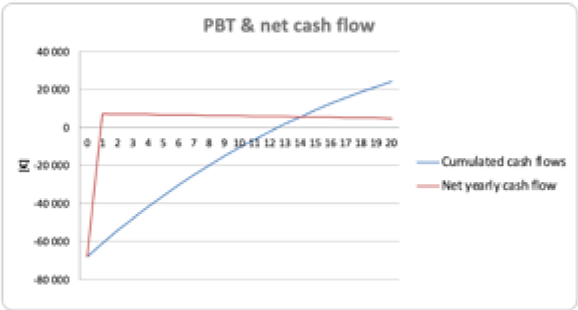
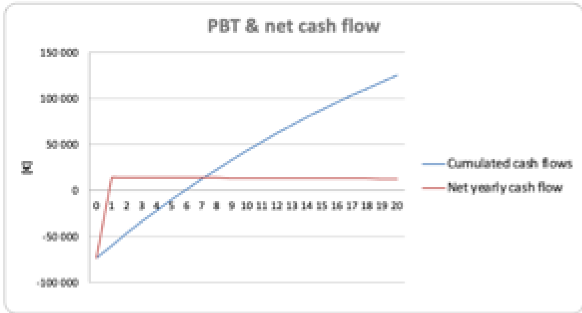
Other Capital Expenditure (CAPEX)	15,000 20,000	€ €	Monitoring/billing system Distribution network
Inflation rate	2.3%	%	Source: ECB data portal – Nov 2024 value
WACC	3%	%	Internal assumption

A time window of 15 years has been considered for the calculation of the following main KPIs of the two scenarios:



SCENARIO 1
Same PV installation as the current Pavel Dorin district



SCENARIO 2
Additional 20kWp of PV installed and valorisation of excess energy

Under the considered assumptions, Scenario 1 shows positive KPIs and demonstrates the economic benefits of Alba Iulia's intervention that could be replicated for other municipal buildings in the same district. Scenario 2 shows the combined impact of the additional PV installation expected to happen in 2025 (22 kWp) and of a potential change in the regulatory framework allowing creating an energy community among the Municipal buildings of the district able to exchange the excess energy among them:

	Scenario 1 – Existing PV plant	**Scenario 2 – Additional PV and valorisation of excess energy**
Payback time	13	6
Project IRR	4.9%	16.8%
Net Present Value	9,191 €	87,731 €

Investment evaluation, Scenario 1:

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INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-75 000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	7 276	7 171	7 064	6 956	6 847	6 736	6 623	6 509	6 394	6 277	6 158	6 038	5 916	5 792	5 666	5 538
Total cash flow	**-67 724**	**7 171**	**7 064**	**6 956**	**6 847**	**6 736**	**6 623**	**6 509**	**6 394**	**6 277**	**6 158**	**6 038**	**5 916**	**5 792**	**5 666**	**5 538**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-67 724	6 962	6 659	6 366	6 083	5 810	5 547	5 293	5 047	4 811	4 582	4 362	4 149	3 944	3 746	3 555
Cumulated cash flows	-67 724	-60 762	-54 103	-47 737	-41 654	-35 844	-30 297	-25 004	-19 957	-15 146	-10 564	-6 202	-2 053	1 891	5 637	9 191
PBT indicator	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0

NPV	€ 9 191
IRR	4,9%
PBT	13

Investment evaluation, Scenario 2:

INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment	-86 970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational cash flows	13 903	13 854	13 803	13 750	13 696	13 639	13 580	13 519	13 456	13 391	13 323	13 252	13 179	13 103	13 024	12 942
Total cash flow	**-73 067**	**13 854**	**13 803**	**13 750**	**13 696**	**13 639**	**13 580**	**13 519**	**13 456**	**13 391**	**13 323**	**13 252**	**13 179**	**13 103**	**13 024**	**12 942**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-73 067	13 450	13 010	12 583	12 168	11 765	11 373	10 992	10 622	10 263	9 913	9 574	9 243	8 922	8 610	8 307
Cumulated cash flows	-73 067	-59 617	-46 606	-34 023	-21 855	-10 089	1 284	12 276	22 899	33 161	43 075	52 648	61 892	70 814	79 424	87 731
PBT indicator	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0

NPV	€ 87 731
IRR	16,8%
PBT	6

Analysis of potential financial instruments suitable for the investment

The Alba Iulia team has a strong expertise in successfully secure public funds to cover their sustainable development and urban regeneration projects. This is proven by their current involvement in very important EU funded initiatives including: Intelligent Cities Challenge, NetZeroCities/Twin Cities and 100 neutral cities.

The team has been mainly using European and National public funds, instruments like ELENA assistance, lump sum funding from the European City Facility and loans from banks, i.e. the European Bank for Reconstruction and Development to finance their projects.

Relevant barriers have been highlighted by Alba Iulia team in regards of the potential application of other kinds of financial instruments to finance the development of solutions for PCED. These barriers include, among others: difficulties in applying the public-private business model which is not encouraged by the public bodies (previously regulated by Law 233/2026 which is no longer active); lack of a mature market for ESCO-related contracts which are not used in Romania yet; applicability of crowdfunding and crowdlending schemes already tested only on private projects. Alba Iulia team already investigated the use of green bonds for various energy efficiency projects, but its application could not be successful due to various legal reasons at the time.

The application of commercial loans and corporate sponsorships seem the most suitable financial instruments for Alba Iulia PCED projects in addition to public grants.

9.5.3. Non-Monetary benefits

The implementation of Renewable Energy Communities (RECs) in Alba Iulia presents significant non-monetary benefits spanning environmental sustainability, social equity, and governance

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improvements. These advantages align with European Union energy policies, promote local economic resilience, and contribute to the city's decarbonisation goals.

By integrating PV installations, potentially energy storage systems, and smart grid technologies, these communities **reduce GHG emissions**, supporting Romania's commitment to EU climate neutrality by 2050. In relation to solution ALB 2.1, the project promoter estimates that the current CO_2 emissions for the six municipal buildings involved in the Pavel Dorin community is approx. 212 Tones of CO_2. The solution implemented at the Alba Iulia in the DPED area proposes the installation of heat pumps and new heating boilers, replacing gas-based units with electric-based ones, BEMS optimisation of all buildings, retrofitting of PVs and installation of energy storage units (through 2 projects financed through the National Recovery and Resilience Plan and 1 project financed through Horizon Europe program). All these installations can bring approx. 84 Tones of CO_2 emission reduction per year.

The localised production and consumption of renewable energy **reduce transmission losses, improving energy efficiency by 5–10%** compared to centralised grids. The decentralised nature of RECs enhances energy security by reducing dependence on the national grid and imported energy, which is crucial for Alba Iulia due to fluctuations in energy prices. By promoting local self-sufficiency, RECs create a more resilient energy system capable of withstanding supply disruptions and external shocks, such as geopolitical crises or extreme weather events.

A major advantage of RECs is their potential to lower energy costs for participating users. Community-based renewable energy projects allow collective purchasing power, reducing the cost per kilowatt-hour (kWh) for members. This is particularly beneficial in Romania, where energy poverty affects approximately 13% of households, according to Eurostat data. The ability to generate and share locally produced solar energy ensures that even low-income households can access affordable and sustainable electricity. The Solution ALB 2.1 in Pavel Dorin District is a reference for the local communities: the local municipal body is the promoter and beneficiary of the developed energy community: the expertise gained in the development and monitoring of energy communities will be useful for future scale up (potentially extending to private households) once the regulatory framework will be more favourable also for further energy sharing and sale.

Additionally, RECs foster public engagement by allowing members to actively participate in the energy transition. Studies on community-led energy models in the EU have shown that such engagement increases public awareness and support for renewable initiatives, leading to higher adoption rates of energy-efficient technologies. In particular, **for the solution ALB 2.1 approx. 700 pupils and teachers have been reached through engagement** dissemination activities organised in the

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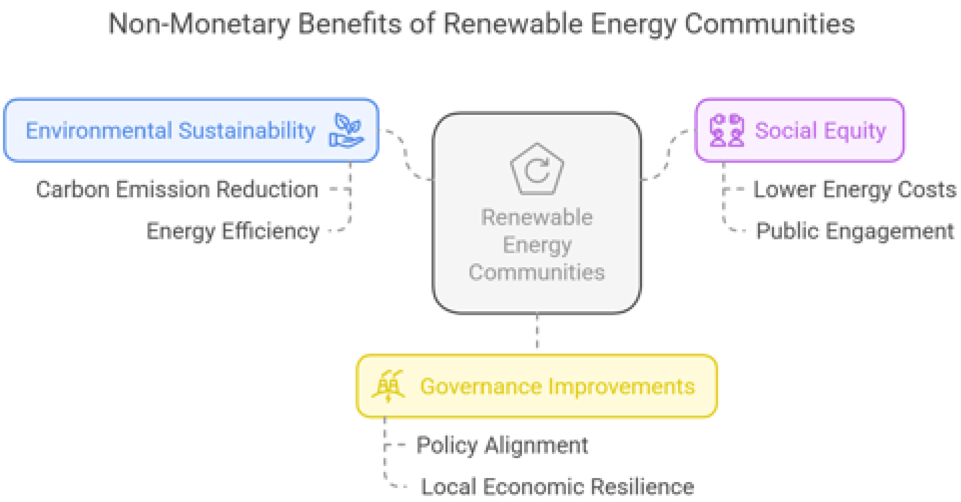
district. **A high degree of satisfaction of different groups of stakeholders has been already assessed** via survey by local partners.

RECs contribute to local job creation and economic growth. The installation, operation, and maintenance of solar panels, battery storage, and grid infrastructure generate employment opportunities in engineering, construction, and energy management. A study by the International Renewable Energy Agency (IRENA) estimates that every megawatt (MW) of solar PV capacity installed can create 4–6 full-time jobs, which could be significant for urban economies like Alba Iulia.

The establishment of RECs aligns with both Romania's National Energy and Climate Plan (NECP) and the EU Renewable Energy Directive (RED II), which require member states to support citizen-led energy initiatives. By integrating RECs into local energy governance, municipalities like Alba Iulia can reduce bureaucratic barriers and streamline policy frameworks that encourage decentralised energy production.



Non-Monetary Benefits of solution ALB 2.1

9.5.4. Risk Assessment

The implementation of RECs in Alba Iulia faces various risks. One of the primary **financial challenges** is the high initial investment required for solar panels, battery storage and smart grid infrastructure. Although EU and national grants can offer partial support, long payback periods and market fluctuations may discourage private investors. The volatility of raw material prices could further increase costs, potentially leading to budget overruns. Additionally, uncertainty about the availability of favourable funding conditions may delay the project implementation, while over-indebtedness due to cost overruns poses a critical risk to the project's financial stability.

Technological and operational risks are also significant. Integrating community-generated energy into the existing grid presents challenges

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such as voltage fluctuations, grid balancing issues, and system interoperability problems. Real-time energy distribution requires advanced grid management and smart metering systems, which are still underdeveloped in the region. The risk of technological obsolescence is high, as rapid innovations in the sector could make current solutions outdated. Technical expertise for maintenance and repair is essential to prevent unexpected failures that could disrupt energy supply. Additionally, delays in infrastructure delivery and installation could impact both project timelines and budgets.

Regulatory and compliance risks stem from Romania's evolving energy regulations, which currently lack a clear legal framework for energy-sharing models and community-owned energy distribution. Uncertain net metering policies and legal ambiguities could complicate the long-term financial sustainability of RECs. Future legislative changes may introduce new requirements, affecting operational conditions and incentives. Data protection and privacy concerns related to managing community members' information further add complexity, requiring robust cybersecurity measures.

Social acceptance plays a crucial role in the project's success. Due to historical memories of collectivisation and low institutional trust, some residents may be reluctant to participate or invest. Scepticism about governance models and concerns over energy price volatility could further hinder engagement. While the risk of social contestation is low, opposition from local groups could delay implementation. To foster participation, a community engagement strategy—including public workshops, information campaigns, and incentive programs—will be deployed to build trust and encourage involvement.

Environmental risks are minimal, but extreme weather events such as storms and heatwaves could affect system performance. Concerns about land use or the visual impact of infrastructure may also arise. Cybersecurity risks linked to digital energy management systems could lead to data breaches or service disruptions, requiring strict security protocols. The scalability of the REC model remains a critical challenge, as expanding the community to include more members or increase generation capacity may face financial, technological, and regulatory barriers. Developing modular, adaptable system designs and maintaining dialogue with policy-makers will be essential to ensure future growth.

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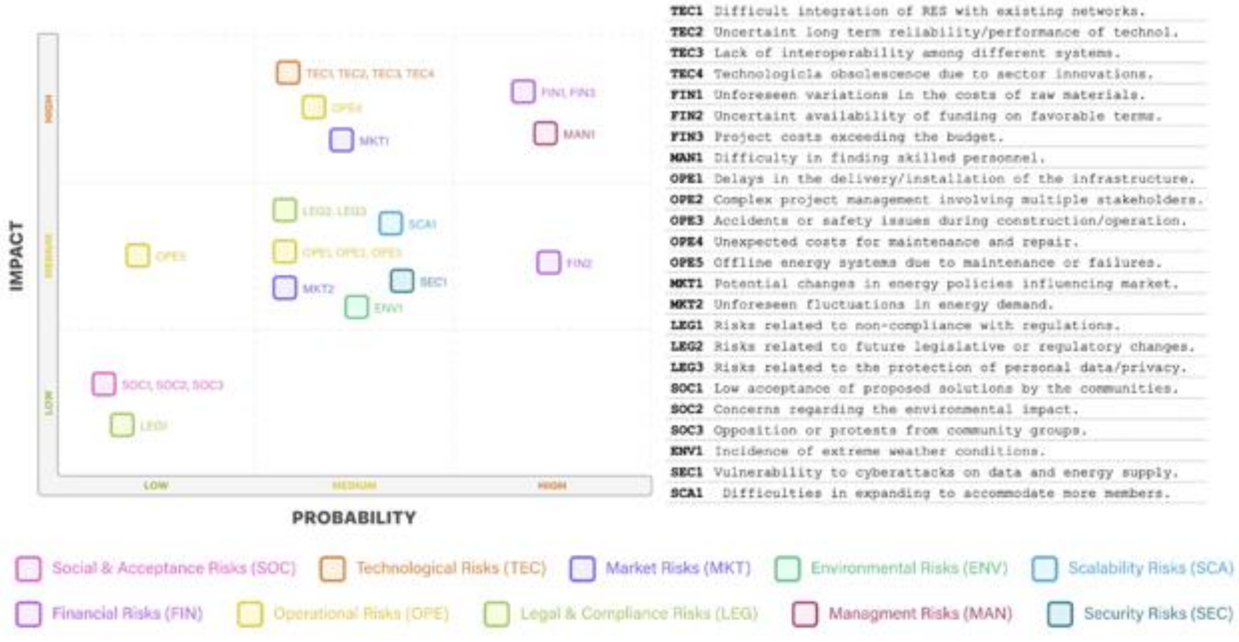

Risk Assessment of solution ALB 2.1

9.6. CBA applied to Charleroi – Energy community within the PCED

In conjunction with the **Solution Package 2 – Deployment of energy communities and prosumer services (SP2)**, Igretec, as Urban Planner appointed by the Municipality of Charleroi, aims at planning and implementing an energy community in the new business park which will be built on a brownfield.

This project is included in a wider rehabilitation project of the Porte Ouest District, previously occupied by steel industries on more than 100 ha. The main goal is to rehabilitate and enhance the energy value of the territory, involving a multidisciplinary collaboration among the Walloon government, Wallonie Entreprendre (WE), Igretec, and other key stakeholders.

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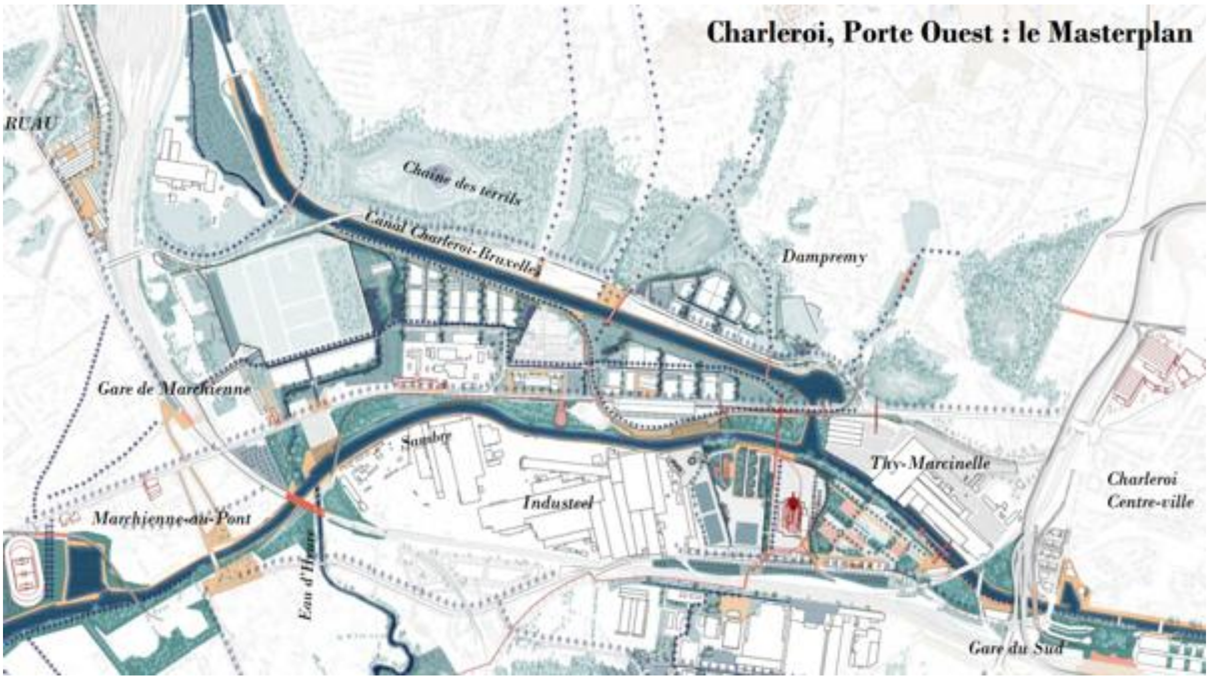

Master plan: press release[5]

In addition to the creation of thermal network connection for the local energy demand, the City of Charleroi and Igretec intend to decarbonise the local electricity demand using photovoltaic installations. The planned energy community will first address at least the electricity needs and production of the buildings located in the CleanTech district.

For the purpose of the CBA and based on the current availability of data, Igretec decided to focus on PV installations on the Business Park (Clean Tech District) which are not built yet.

The preliminary idea is to establish an energy community including SMEs in the business parks and neighbourhood. The energy community could also include a battery park in the future.

The **main stakeholders** of this SP2 are the following:

Stakeholder	Role
City of Charleroi	The City of Charleroi is the **project promoter** to transform the brownfield area into a territorial and economic development park
Igretec	Igretec is the **urban planner mandated by the city to supervise the rehabilitation of the brownfield.**

[5]https://static1.squarespace.com/static/52dbef69e4b09473684733c7/t/61437125ac452663647be4e3/1631809855145/COMMUNIQUE-DE-PRESSE.pdf

District CleanTech	District CleanTech is the **urban orchestrator** and brings together multiple actors, such as companies, startups, research centres, academics and education stakeholders, around an innovation, incubation and education platform to accelerate the development of cleantech solutions.
Users	Users are the future tenants of the renovated buildings and future SMs in the District

The **main assets** involved in the project are the future buildings of Parc of the economic activities called "District CleanTech" including two heritage buildings "*Le Vestiaire*" and "*La Centrale*", potentially hosting and potentially those of the District of the Future, with a global estimated 10 MWp.

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CleanTech District (masterplan and picture with The Centrale and Vestiaires buildings - in yellow - that will be renovated as the heart of the new ecosystem)

District Cleantech is currently in contact with more than 50 organisations that have expressed their interest in participating in this new dynamic. In concrete terms, more than 18 projects have already been identified to feed this brand-new ecosystem and set up their future activities on District Cleantech grounds. On top, several projects are being discussed to facilitate the transition towards decarbonisation of industrial companies active in Charleroi.

9.6.1. Business Model

Igretec will be investigating the feasibility and economic interest of establishing an energy community in the framework of the rehabilitation project of Porte Ouest District. The produced local energy would be provided to SMEs in the business parks, industries and neighbourhood. Given the early stage of development, the most suitable legal and ownership structure still has to be defined as well as the financing instruments to finance the investment. A very preliminary scheme of the potential business model is presented below based on the information available at the time of this report.

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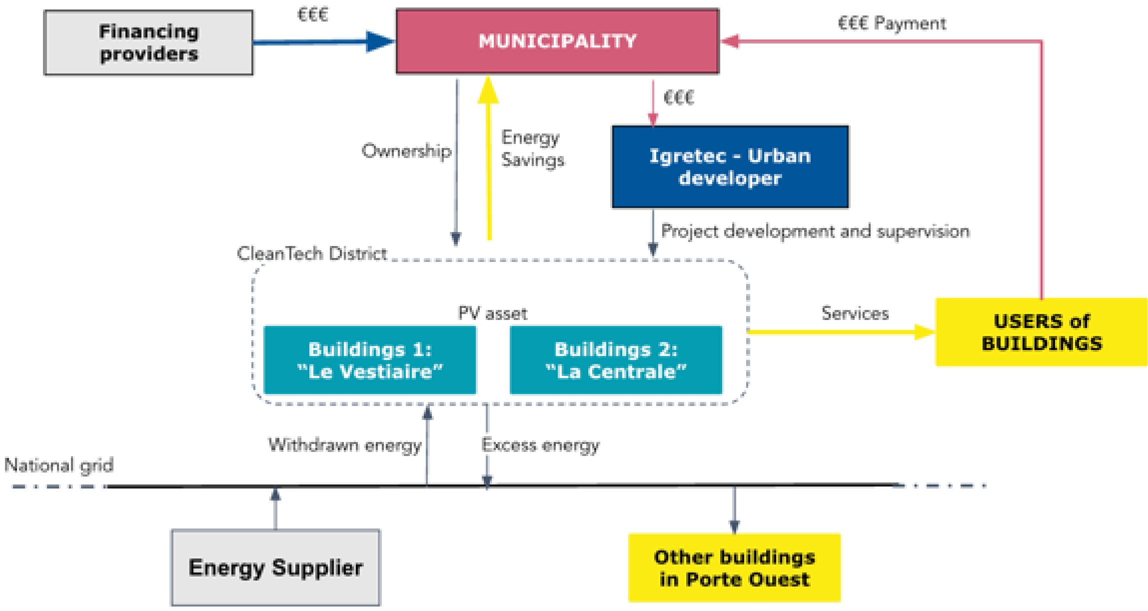

Preliminary assumption of the business model for the CleanTech District

9.6.2. Economic-financial analysis

- For the purpose of T5.3 aiming at testing specific financing instruments applied to SPs, an economic-financial analysis has been developed on two scenarios built on the preliminary assumptions provided by Igretec. The purpose of this analysis is to assess the economic feasibility of the investment from the perspective of the Municipality, supported by Igretec in the project development. The considered scenarios differ based on the following elements:

Assumptions	Scenario 1 - Max	Scenario 2 - Min
Estimated energy production per kWp	900 kWh/kWp	800 kWh/kWp
Self-consumption of PV production	100%	50%

The electricity demand for future buildings is estimated to be approx. 11,000 MWh/y.

Monetisation strategy

In the considered scenario, the monetisation strategy includes:

- The revenues from the sales of energy to the members of the energy community;
- The energy savings due to the avoided withdraw from the grid.

Cost structure of the project

The scenario considered the following cost items:

- **CAPEX**: the investment costs for the PV installation;

- **Operating costs:** they include administrative costs, Environmental Health and Safety (EHS) management, maintenance, injection and network costs. The costs for plant insurance have been also considered.

Based on the current available information provided by the project promoter and complementary assumptions provided by R2M, the following main items have been considered for the CBA and for the calculation of the main economic-financial KPIs:

Revenues	Value	Unit	Notes
Energy sale to surrounding energy community	Max:877,500 (Y1) Min:390,000 (Y1)	€/y	Considered electricity price of 0.1 €/kWh[6]
Energy savings	Max:1,755,000 (Y1) Min: 780,000 (Y1)	€/y	Considered electricity price of 0.2 €/kWh[9]
Operating Costs (OPEX)	Max: 292,500 (Y1) Min: 195,000 (Y1)	€/y	Based on respectively 30 (Max) and 20 (Min) €/kWp/y[7]
Other operating costs	Energy from the grid: -667,500 (Max) -2,130,000 (Min) Insurance costs: 73,125	€/y	Considered electricity price of 0.3 €/kWh[8] For insurance: value of 7.5 €/kWp in line with other EU projects.
Main Capital Expenditure (CAPEX) for the PV installations	Max: 13,650,000 Min: 11,700,000	€	PV installation costs based on respectively 1.4 (Max) and 1.2 (min) €/Wp[9]

[6]Source:https://www.lecho.be/dossiers/crise-energetique/evolution-des-prix-de-l-energie-en-belgique-jour-par-jour-gaz-electricite-mazout/10410704.html

[7]Source: https://www.cre.fr/fileadmin/Documents/Rapports_et_etudes/import/Rapport_couts_PV_2019.pdf p.29

[8]Source: https://www.lecho.be/dossiers/crise-energetique/evolution-des-prix-de-l-energie-en-belgique-jour-par-jour-gaz-electricite-mazout/10410704.html

[9]Source:https://www.cre.fr/fileadmin/Documents/Rapports_et_etudes/import/Rapport_couts_PV_2019.pdf p.17

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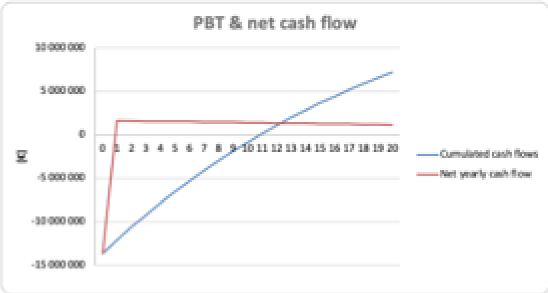
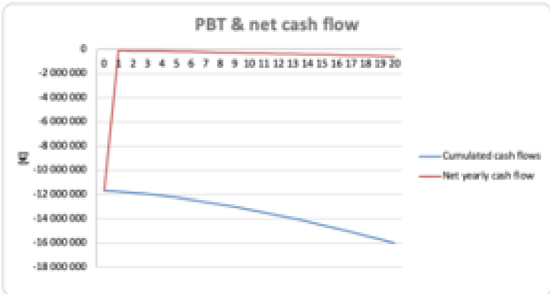
Inflation rate	2.3%	%	Source: ECB data portal[10] - Nov 2024 value
Tax	-	-	Not considered
WACC	3%	%	Internal assumption

A time window of 20 years has been considered for the calculation of the following main KPIs of the two scenarios:

	Scenario Max	Scenario Min
Payback time	11 years	> 20 years
Project IRR	8.4%	N.a.
Net Present Value	7,177,293 €	Negative value



SCENARIO MAX
900 kWh/kWp and 100%
self-consumption



SCENARIO Min
800 kWh/kWp and 50%
self-consumption

Under the considered assumptions, the scenario Max shows positive KPIs while the scenario Min is not economically feasible. This is mainly due to the assumed use case in which only 50% of locally produced energy is self-consumed and there is a disconnection between production and consumption.

Investment evaluation, Scenario MAX:

INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7
Total investment	-13 650 000	0	0	0	0	0	0	0
Operational cash flows	0	1 599 375	1 561 482	1 541 998	1 522 147	1 501 921	1 481 313	1 460 317
Subsidies	0	0	0	0	0	0	0	0
Total cash flow	**-13 650 000**	**1 599 375**	**1 561 482**	**1 541 998**	**1 522 147**	**1 501 921**	**1 481 313**	**1 460 317**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81
Discounted cash flows	-13 650 000	1 552 791	1 471 846	1 411 147	1 352 408	1 295 570	1 240 577	1 187 371
Cumulated cash flows	-13 650 000	-12 097 209	-10 625 362	-9 214 216	-7 861 808	-6 566 238	-5 325 661	-4 138 290
PBT indicator	1	1	1	1	1	1	1	1

Year	8	9	10	11	12	13	14	15
Total investment	0	0	0	0	0	0	0	0
Operational cash flows	1 438 923	1 417 125	1 394 915	1 372 284	1 349 225	1 325 729	1 301 788	1 277 393
Subsidies	0	0	0	0	0	0	0	0
Total cash flow	**1 438 923**	**1 417 125**	**1 394 915**	**1 372 284**	**1 349 225**	**1 325 729**	**1 301 788**	**1 277 393**
Discount rate	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	1 135 899	1 086 108	1 037 948	991 367	946 319	902 757	860 635	819 910
Cumulated cash flows	-3 002 391	-1 916 283	-878 335	113 032	1 059 351	1 962 108	2 822 743	3 642 653
PBT indicator	1	1	1	0	0	0	0	0

NPV	€ 7 177 293
IRR	8,4%
PBT	11

Investment evaluation, Scenario min:

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[10] https://data.ecb.europa.eu/main-figures/inflation

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INVESTMENT EVALUATION - PROJECT PROMOTER PERSPECTIVE

Year	0	1	2	3	4	5	6	7
Total investment	-11 700 000	0	0	0	0	0	0	0
Operational cash flows	0	-58 125	-102 743	-125 590	-148 804	-172 391	-196 357	-220 708
Subsidies	0	0	0	0	0	0	0	0
Total cash flow	**-11 700 000**	**-58 125**	**-102 743**	**-125 590**	**-148 804**	**-172 391**	**-196 357**	**-220 708**
Discount rate	1,00	0,97	0,94	0,92	0,89	0,86	0,84	0,81
Discounted cash flows	-11 700 000	-56 432	-96 845	-114 933	-132 211	-148 706	-164 446	-179 456
Cumulated cash flows	-11 700 000	-11 756 432	-11 853 277	-11 968 210	-12 100 421	-12 249 127	-12 413 572	-12 593 028
PBT indicator	1	1	1	1	1	1	1	1

Year	8	9	10	11	12	13	14	15
Total investment	0	0	0	0	0	0	0	0
Operational cash flows	-245 451	-270 593	-296 140	-322 099	-348 477	-375 281	-402 518	-430 196
Subsidies	0	0	0	0	0	0	0	0
Total cash flow	**-245 451**	**-270 593**	**-296 140**	**-322 099**	**-348 477**	**-375 281**	**-402 518**	**-430 196**
Discount rate	0,79	0,77	0,74	0,72	0,70	0,68	0,66	0,64
Discounted cash flows	-193 761	-207 387	-220 356	-232 691	-244 415	-255 548	-266 112	-276 126
Cumulated cash flows	-12 786 790	-12 994 177	-13 214 533	-13 447 224	-13 691 638	-13 947 187	-14 213 299	-14 489 425
PBT indicator	1	1	1	1	1	1	1	1

NPV	**-€ 16 002 573**
IRR	N.A.
PBT	21

Analysis of potential financial instruments suitable for the investment

The integration of an ESCO (Energy Service Company) business model into the Charleroi project represents a strategic opportunity to ensure the economic sustainability of the planned energy community while simultaneously improving the system's operational and financial efficiency. The project envisions the development of photovoltaic plants in new District, with a projected energy production potential. The ESCO business model could be applied in various ways, depending on the level of operator involvement and the community's needs.

ESCOs operate through performance-based energy contracts, where their revenues derive from the savings achieved for the client. In the context of the Charleroi project, the ESCO could take on several key roles. The first concerns the investment and management of photovoltaic infrastructure and (potentially) battery storage, financing, installing, and operating the plants through an Energy Performance Contract (EPC), in which the ESCO recoups its investment through the savings generated from selling energy to the community. Under this model, generally no initial costs would be incurred by the community, while the ESCO would be responsible for long-term operation and maintenance, with compensation linked to the plant's actual performance. Another possibility is a partnership between the ESCO and the energy community, based on a Shared Savings Contract, where investments and revenues are shared among the parties, ensuring greater local involvement in managing the system. This approach would allow the community to directly benefit from energy savings and electricity sales while sharing the risk with the ESCO. A further option is the Energy-as-a-Service model, where the ESCO provides only energy management services, while ownership of the assets remains with the community or the municipality. This would allow the community to maintain control over the infrastructure while delegating the optimisation of energy flows and operational management to the ESCO.

Another crucial aspect is the optimisation of energy demand and supply management through smart grid solutions, ensuring better balancing between production and consumption and reducing dependence on the national grid. The ESCO could also integrate a battery storage system,

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maximising self-consumption and ensuring a stable energy supply for SMEs and industries within the Business Park. Another key factor involves financing and access to incentives, as the ESCO could leverage innovative financial instruments, such as operational leasing, Shared Savings Contracts, crowdfunding, or crowdlending, thereby reducing financial risk for Igretec and the municipality of Charleroi. Furthermore, its expertise could facilitate access to European funding programs and other transition energy funds.

From an economic-financial perspective, the Cost-Benefit Analysis (CBA) of the Charleroi project presents two scenarios based on different levels of self-consumption of locally produced energy. The maximum scenario, with 100% self-consumption, ensures a payback time of 11 years and an IRR of 8.4%, while the minimum scenario, with only 50% self-consumption, results in a payback period exceeding 20 years, making the project less economically viable. An experienced ESCO could enhance the project's profitability by implementing a more efficient energy management strategy, deploying demand-response mechanisms, reducing operational costs, and increasing the value of produced energy.

Integrating an ESCO into the project would offer several advantages: reducing initial investment costs through private financing, optimising self-consumption and local grid management, enhancing the economic sustainability of the energy community, and facilitating access to European financial instruments. The choice of the most suitable implementation model will depend on the objectives of Igretec and other stakeholders, as well as on the willingness to involve private investments in the management of renewable energy.

9.6.3. Non-Monetary Benefits

The deployment of an energy community dealing with electricity, heating/cooling, and carbon-related topics presents several non-monetary benefits across environmental, social, and technological dimensions.

From an environmental perspective, the initiative contributes to significant reductions in GHG emissions and overall carbon footprint. By leveraging renewable energy sources such as solar photovoltaics and optimising energy consumption, the project supports a more sustainable and cleaner energy system. The community-driven approach enables better energy management, reducing dependency on fossil fuels and lowering annual CO_2 emissions, aligning with broader climate action goals. The project promoter estimates that the district annual GHG emissions amount to 2,882 tons/y[1]; the total annual energy-related Co2 emission reduction foreseen thanks to the energy community installation is estimated at 1,856 tons/y[2].

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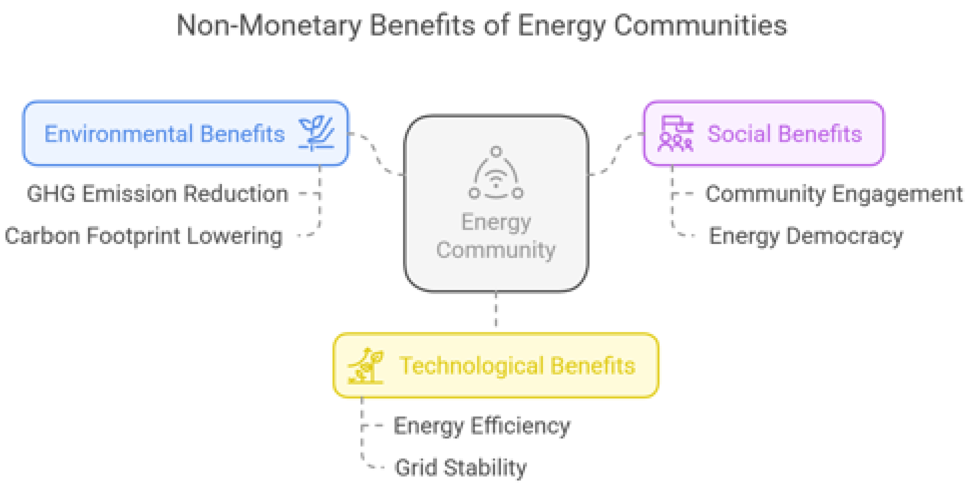
On a social level, the project fosters community engagement and strengthens local participation in sustainable energy practices. Increased awareness and involvement among citizens and SMEs enhance energy-conscious behaviour, leading to more efficient energy use at the building level. The establishment of an energy community also empowers local stakeholders by giving them a role in energy production and consumption decisions, promoting energy democracy and self-sufficiency. The project promoter estimates that approx. 20 key external stakeholders will be involved in the initiatives including local and regional authorities, energy suppliers, etc. The involvement of City administration bodies is high.

From a technological and operational standpoint, the energy community supports advancements in energy efficiency and grid stability. By decentralising energy production and consumption, the project reduces transmission losses and enhances energy security. The integration of smart energy management systems and innovative solutions could further improve grid resilience, ensuring a more reliable and optimised energy network. Additionally, by supporting local renewable energy production, the initiative contributes to the long-term sustainability of the energy sector while fostering innovation in clean energy technologies.



Non-Monetary Benefits of solution CRL 2.2

9.6.4. Risk Assessment

The deployment of an energy community in Charleroi, addressing electricity, heating, cooling, and carbon-related topics, involves several risks. **Technological risks** primarily relate to the integration of renewable technologies into the existing energy infrastructure. The complexity of combining PV systems, battery storage and heating/cooling networks within a smart energy system could lead to inefficiencies or compatibility issues. This risk is considered low in probability but could have a medium impact if not properly managed. **System interoperability** poses a more significant challenge, with a medium probability and high impact, especially when integrating different energy management platforms. However, technological obsolescence and the reliability of innovative technologies are not perceived as major concerns by the project promoter.

Financial risks include potential fluctuations in raw material costs, which could affect the affordability of essential components like solar panels and inverters. The availability of funding remains a key challenge, as community-based energy projects often rely on government incentives, grants, or private investments. Although these risks are considered unlikely, they could moderately impact the project's timeline and profitability. Over-indebtedness, due to high initial capital investment, represents another financial risk that requires careful budgeting and financial planning to avoid long-term strain on stakeholders.

Management risks stem from the need for skilled governance and operational expertise. The lack of experienced personnel could result in suboptimal decision-making and inefficiencies, especially when navigating regulatory frameworks and energy markets. This risk is rated as having a medium probability but a low impact on overall project success. **Operational risks**, however, pose more significant challenges. The coordination of multiple stakeholders, including local authorities, residents, and private companies, presents a high probability and high impact risk. Unexpected maintenance and repair costs are also anticipated as a medium probability, medium impact factor, requiring robust project management and contingency plans.

Market risks include potential changes in energy policies and fluctuations in energy demand from community members. While policy changes are deemed likely but with low impact, unforeseen variations in energy consumption are considered high probability and high impact risks. **Legal and compliance risks** involve future regulatory changes that could alter operational conditions or economic benefits. Data protection and cybersecurity vulnerabilities pose a high impact risk, necessitating strong privacy protocols and cybersecurity measures. **Social acceptance** remains a critical factor for the project's success. Although environmental concerns and political contestation are considered low-risk, community resistance to the proposed solutions is rated as a medium-probability, medium-impact risk. Engaging stakeholders from the early stages through public consultations, workshops, and transparent communication will be essential to foster acceptance and trust.

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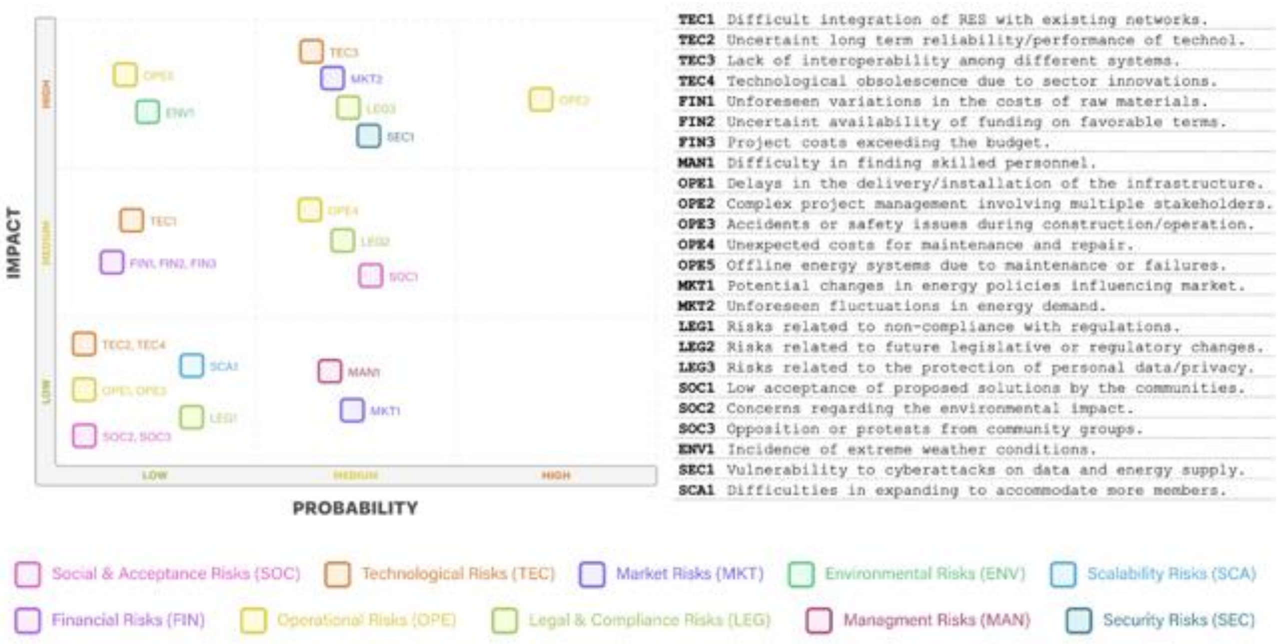
ASCEND



Risk matrix for solution CRL 2.2

9.7. CBA applied to Prague – Investment opportunities for the construction of PCED

In conjunction with the **Solution Package 3 - Deployment of energy-efficient buildings integrating RES and storage including frugal solutions (SP3)**, Prague Municipality, via its municipal statutory organisation PDS, is developing a Municipal Rental Housing aimed at meeting the demand for affordable housing. The planned buildings will be built with the purpose to rent the apartments (the estimated number is 650) to specific public hired professionals (including police employees, teachers and health professionals) and provide housing with the lowest possible costs in terms of heating for the tenants. The project starts from a green field.

This project is included in the real estate assets development strategy led by the city, especially focused on rental housing and other buildings in the public interest, on land that has been handed over to it for management[11].

The **main stakeholders** involved in the project are:

Stakeholder	Role
Municipality of Prague	They are the **project promoter** investing in the valorisation of municipal lands for the

[11] Source: PDS Annual Report 2023

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	development of housing projects for the public interest.
Prague Development Company (PDS)	PDS is a statutory organisation which is 100% owned by the Municipality of Prague. PDS develops projects mainly using the City's budget, but they don't keep the ownership of the projects. Their primary long-term objective is to **increase the value of municipal land** through expert integrated project management and an expanded housing stock.
Permitting Authorities	Local governmental authorities at district level responsible for the concession of **planning and building permits.**
Technology providers	All **other technology and service providers** to supply the technological components and works.
Tenants	**Specific categories of public hired professionals** including police employees, teachers and health professionals are entitled to rent the municipal housing built by the project at an affordable price.
Financing providers	ASCEND project **grant** contribute to the financing of this project. Other funding should be secured via **City's budget** and **external financiers** to be defined.

The **main assets** involved in the project are owned by the Municipality and include:

- The **land** which is approx. 129,000 m2;
- The **newly developed buildings** that will be characterised by a rentable surface of 35,921 m2 for municipal housing;
- The CHP plant and heating network.

The project promoter plans to have the necessary building permit by 2026.

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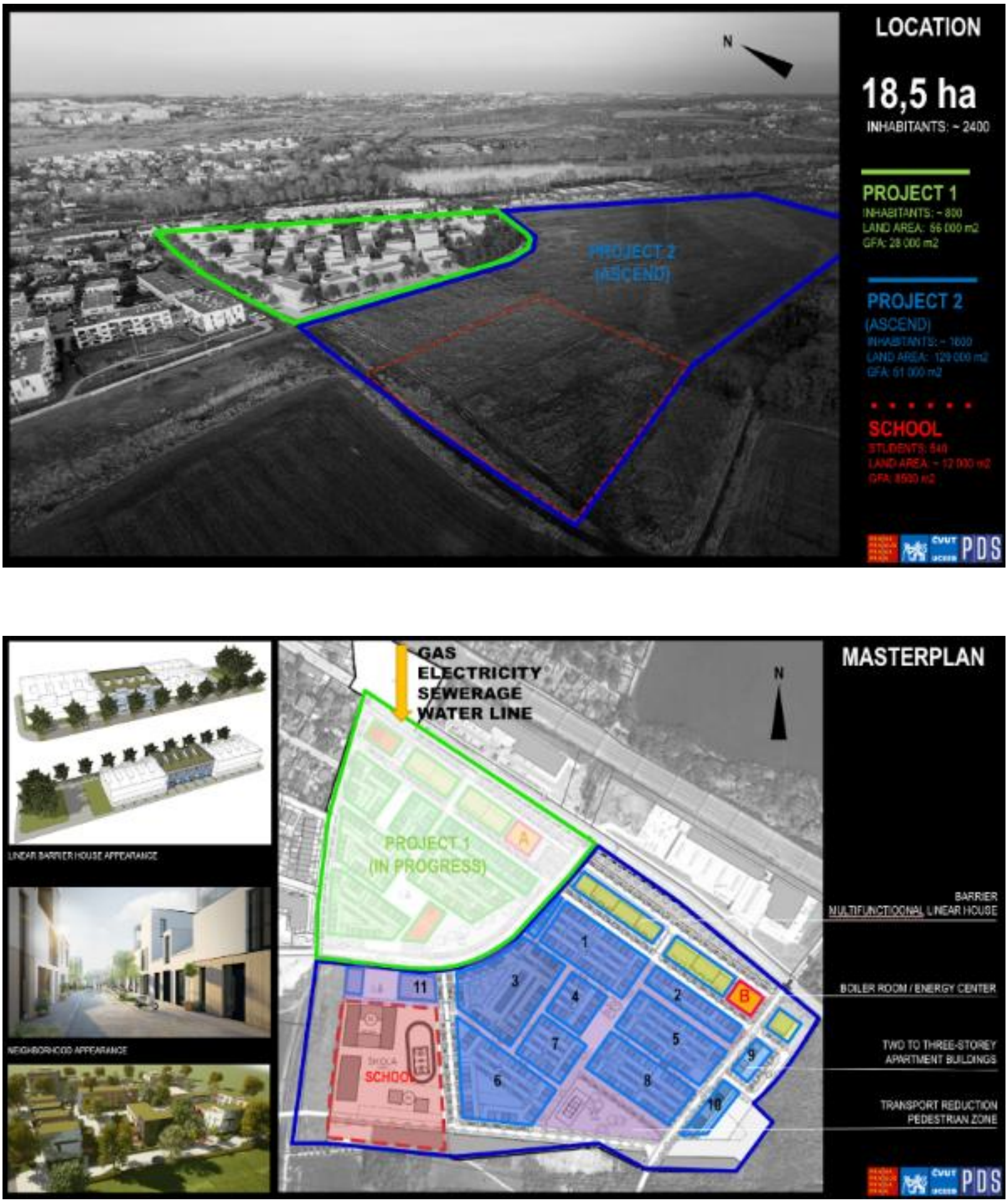

Design of Prague PCED project

9.7.1. Business Model

The role of PDS is central in the overall business model of the solution. In the past years, Prague Municipality handed over lands to PDS for management with a total of 40 hectares suitable for the construction of 6,000 to 8,000 flats within a 10- to 15-year horizon. At the same time, an expert team was created in 2020 to ensure the appropriate governance of operations. The ASCEND project

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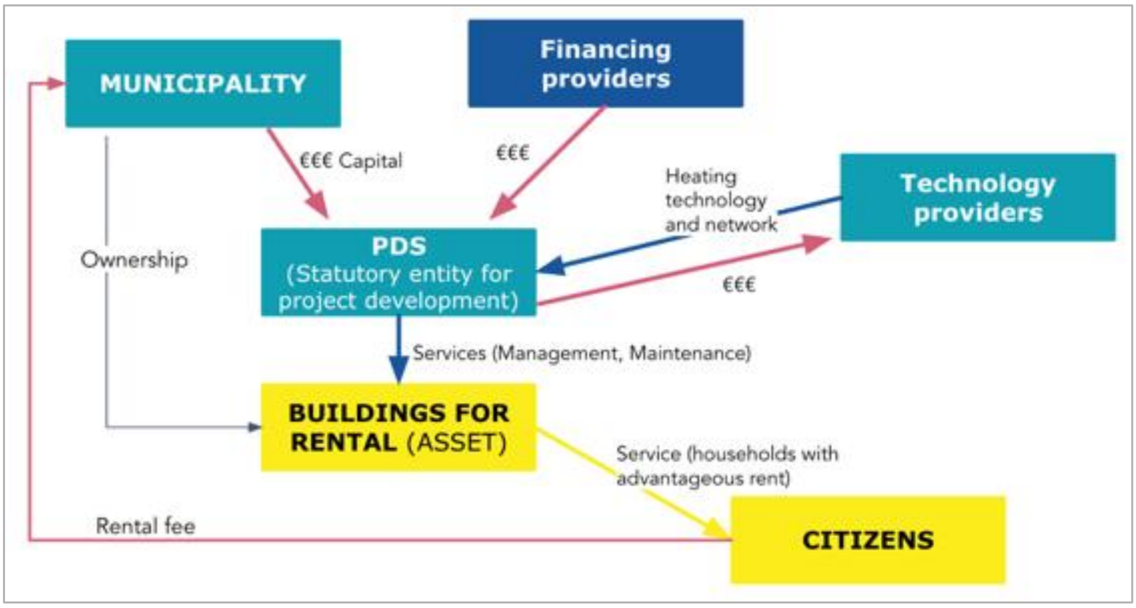
contributes to the development of one of the foreseen projects which is a completely new PCED in Dolní Počernice.

Among the phases of the project, including Design, Preparation, Construction and Closing up, the first two are usually easily funded by the City's budget, while phase 3 can be an issue in terms of financing.

The main business model structure of the project is summarised in the scheme below:



Preliminary business model scheme for Prague project

9.7.2. Economic-financial analysis

PDS project management team is used to assess the economic profitability of their development projects. Projects are approved only on certain parameters by an internal Investment Committee monitoring their cash flow generation potential.

The reported economic-financial analysis has been fully provided by PDS and shows the economic rationale behind the Dolní Počernice PCED business model.

Monetisation strategy

The revenue items incorporate the **rental income** and the portion of the **operating costs covered by the tenants** for energy and utilities supply.

Cost structure of the project

The main cost items are the following:

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- **CAPEX:** the investment costs for all the four phases of development (design, preparation, construction and closing up) are spread over a 10-year period (due to development and permitting timeline).

- **Operating costs paid by the project promoter:** while a portion of the costs is transferred to tenants, the remaining part is paid by PDS due to the maintenance and utilities service supply. The unrealised lease is also considered among the operating costs.

Based on the current available information provided by the project promoter, the following main items have been considered for the CBA and for the calculation of the main economic-financial KPIs:

Revenues	Value	Unit	Notes
Monthly rents	Approx. 11	€/m2/month	Price which is more affordable than the 2023 average in Prague[12]
Total operating Costs (OPEX)	15% of rental income	€/y	Including maintenance and all utility services
Portion of operating costs covered by PDS	5% of total OPEX	%	The remaining costs are paid by tenants
Main Capital Expenditure (CAPEX) for the PCED development	Approx. 111,500,000	€	Over 10 years, including all phases of development and construction

The described PCED construction is an ambitious project characterised by **a high initial investment, with related monetisation income delayed compared to the timeline of investment cash outflows.** The profitability of the investment also depends on the timing of the occupancy rate. Once fully operational, PDS estimates annual EBITDA to be around 4 M€, which results in a long payback period for the project. **This investment prioritises high social and environmental benefits over economic profitability,** addressing the need for more affordable housing in Prague and the demand for energy-efficient and sustainable buildings.

PDS's strategy to manage a portfolio of multiple real estate projects at various stages of development and operation helps mitigate the financial risks associated with individual projects, which can be capital-intensive. **The PCED construction holds economic and financial value from PDS's perspective over the long term (more than 10 years),**

[12] 2023 PDS Annual Report

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with an exit strategy that could involve selling individual apartments to tenants or other interested parties.

Analysis of potential financial instruments suitable for the investment

The PDS PCED project intended for Prague's public sector employees represents a strategic initiative for the municipal administration, aimed at addressing the growing demand for affordable housing with high energy efficiency standards. Given the local authorities' potential interest in involving external investors and assessing the applicability of innovative financing instruments, there is a clear need for a sustainable financial structure that integrates various sources of public and private capital.

According to the PDS Annual Report 2023, the city of Prague, through PDS, has already investigated advanced financial strategies for public housing. Among the most suitable funding options for the project is the issuance of European Long-Term Investment Funds (ELTIFs), an investment vehicle regulated by the European Union, designed to finance long-term projects with positive social and economic impacts. The report highlights how ELTIFs serve as an ideal tool to attract institutional and private capital, specifically for the construction of housing designated for strategic professional categories, such as teachers, healthcare workers, and law enforcement personnel.

A comparable example to this approach is Aspern Seestadt in Vienna, Austria, one of Europe's largest sustainable urban development projects. The district integrates green infrastructure, renewable energy, and high-efficiency buildings, ensuring long-term rental affordability through a mix of municipal funds, tax-based housing subsidies, and PPPs. Similarly, Prague could leverage municipal investment in partnership with private investors and EU funds to ensure affordability and sustainability.

Another potentially applicable funding source is municipal green bonds, which would enable the city to raise funds specifically allocated for the construction of low-impact, environmentally sustainable buildings. The city of Prague has previously explored the possibility of using green bonds and alternative financial instruments to finance sustainable projects, as highlighted in the PDS report.

A successful precedent for green finance and public-private collaboration is Hammarby Sjöstad in Stockholm, which was visited by ASCEND partners in October 2024. The city transformed a former industrial zone into a high-density, eco-friendly urban district. The project was financed through municipal financing instruments, green finance instruments, and direct subsidies, with a strong public-private partnership model. Prague could replicate this structure by using green bonds to attract institutional investors while ensuring public sector guarantees to maintain long-term affordability.

Alternatively, the project could be supported by preferential loans from the European Investment Bank (EIB) or the European Regional

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Development Fund (ERDF), both of which promote the ecological transition and carbon footprint reduction in the construction sector.

The Public-Private Partnership (PPP) approach represents another valuable tool for ensuring a balanced distribution of public and private investment. PDS has already considered adopting PPP models for municipal infrastructure development, suggesting that a setup in which a private entity finances and constructs the building, backed by a long-term lease agreement with the municipality, could be a cost-effective solution to mitigate the financial impact on the public budget.

Another key aspect is the strategic asset enhancement of municipal properties. The PDS Annual Report 2023 states that the value of the real estate portfolio managed by the entity reached 7.1 billion CZK, thanks to a careful strategy of urban land development and optimisation for public housing. This asset growth could be leveraged to secure bank loans, issue debt instruments backed by real estate assets, or attract institutional investors interested in long-term projects with stable returns.

The Aspern Seestadt, Hammarby Sjöstad and Lyon Confluence models confirm the feasibility of Prague's hybrid financing approach, demonstrating how cities can integrate municipal investment, PPPs, green finance instruments, and EU funds to develop long-term, high-efficiency housing for essential workers.

Therefore, the optimal financing strategy for the residential project for Prague's public sector employees should be based on a hybrid approach, combining green bonds, ELTIFs, PPPs, and EU funds. This financial structure would help reduce the direct financial burden on the municipal budget while ensuring high economic, social, and energy sustainability.

The integration of these instruments, already considered in PDS's financial planning, would position the project as a model of innovative public housing in Europe, effectively addressing the housing needs of the city's essential workforce.

9.7.3. Non-Monetary benefits

The solution delivers significant non-monetary benefits, particularly in the areas of environmental sustainability, social well-being, and governance.

Environmental Benefits

The project incorporates Combined Heat and Power (CHP) generation units and a district heating network, significantly reducing energy waste and improving efficiency.

<u>Reduced GHG Emissions</u>: The transition from conventional heating systems to efficient CHP-powered heating minimises the district's CO_2 emissions, contributing to Prague's climate goals.

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Annual Energy-Related CO_2 Reduction: The project replaces carbon-intensive heating systems with low-emission technologies, ensuring a measurable reduction in energy consumption across residential units.

Optimised Energy Efficiency: Centralised heating infrastructure reduces energy loss, ensuring stable and cost-effective heating for residents.

By integrating sustainable heating solutions, the project aligns with Prague's climate action strategy, promoting long-term urban energy sustainability.

Social Benefits

The municipal rental housing project aims to address the city's housing affordability crisis while ensuring access to sustainable and cost-efficient living conditions.

Affordable Housing for Key Public Workers: The project prioritises housing for public employees, including police officers, teachers, and healthcare professionals, ensuring they can live close to their workplaces.

Development of Energy Communities: The initiative promotes local energy sharing, allowing residents to benefit from stable, predictable energy costs while supporting the growth of energy communities.

Resident Satisfaction and Well-Being: The project ensures that housing quality, comfort, and energy affordability remain high, contributing to improving social stability and resident satisfaction.

By creating inclusive housing opportunities, the project supports workforce retention, social cohesion, and economic resilience.

Governance and Institutional Strengthening

The PRA 6.3 project is a publicly managed initiative, reinforcing municipal governance through structured decision-making and strategic planning.

Multi-Stakeholder Collaboration: The initiative engages city administration, energy utility companies, and institutional stakeholders, ensuring an integrated and efficient urban development process.

Public Administration Involvement: The project benefits from strong municipal oversight, ensuring that decisions align with long-term urban development goals and financial sustainability.

This governance model ensures transparency, efficient public resource allocation, and a replicable framework for future housing initiatives.

The PRA 6.3 project delivers substantial non-monetary benefits, reinforcing Prague's commitment to sustainable urban development. By integrating affordable housing with energy-efficient infrastructure, the initiative ensures:

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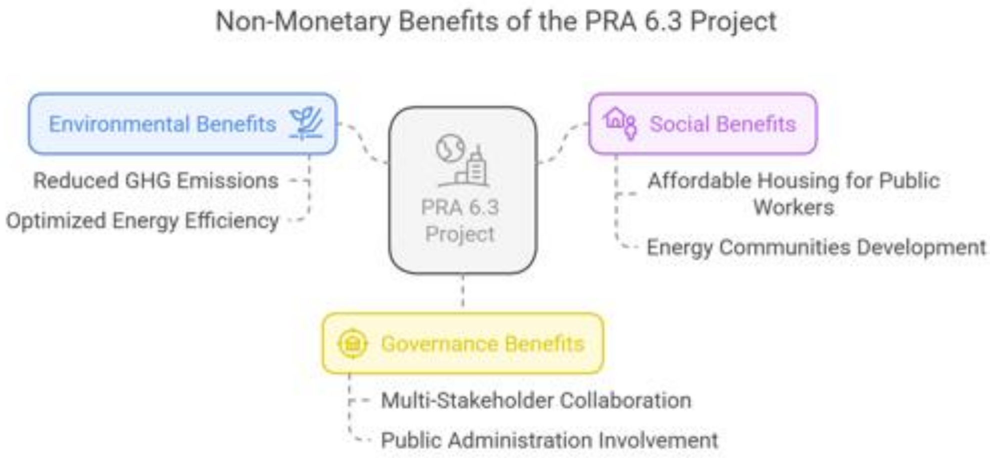
- Lower carbon emissions and improved energy efficiency.
- Affordable housing solutions for key public sector employees.
- A well-managed governance framework for long-term urban planning.

By addressing housing affordability, energy sustainability, and social inclusion, the municipal rental housing initiative serves as a scalable and replicable model for other European cities aiming to implement publicly led, sustainable housing projects.



Non-Monetary Benefits of solution PRA 6.3

9.7.4. Risk Assessment

Similar to above SPs, the implementation of the PRA 6.3 project involves several risks that must be carefully assessed.

Technological risks stem from integrating Combined Heat and Power (CHP) technology and district heating systems into the existing infrastructure. The complexity of installation and potential supply chain issues could cause delays in deployment, while system malfunctions may lead to increased maintenance costs and operational downtime. Continuous monitoring, preventive maintenance, and collaboration with experienced technology providers are essential to mitigate these risks.

Financial risks pose a significant challenge, particularly due to the high project costs. The city's budget must be tripled to cover all project phases, making insufficient funding one of the most critical risks. Exploring alternative financing instruments, such as municipal bonds, public-private partnerships, and EU grants, can help secure the necessary funds and improve the project's financial resilience. **Operational risks** arise from the project's complexity and the need for effective resource management. Coordinating design, preparation, construction, and closing phases may lead to inefficiencies and delays if not properly managed. Poor resource allocation could also extend

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the project timeline and increase overall costs. Implementing data-driven project management systems and appointing experienced project coordinators will be key to addressing these risks and improving efficiency.

Market risks are linked to demand fluctuations and competition in the real estate sector. Changes in demand for affordable housing or competing projects offering alternative rental solutions could reduce occupancy rates and affect financial returns. Developing a targeted marketing strategy, setting competitive rental prices, and aligning the project with local housing needs will help maintain demand and attract tenants. **Regulatory and compliance** risks are critical, as delays in obtaining permits or new legislative requirements could affect the project timeline and increase operational costs. Close collaboration with local authorities and proactive monitoring of regulatory changes will ensure compliance and minimise legal obstacles. Social acceptance is another key factor, as community opposition to new energy infrastructure or lack of stakeholder engagement could hinder project implementation. Transparent communication, public consultations, and active community involvement will help foster trust and broader acceptance of the project.

Scalability challenges may arise if housing demand increases, requiring additional resources and infrastructure expansion. Adopting a modular design and flexible planning approach will facilitate future project growth.

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