D6.5 Business Plan involving social and market aspects

WP6, T6.1 & T6.2

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[1] PU = Public

CO = Confidential

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Versions

No.	Name SURNAME	Partner	Contribution	Date
0.1	Alessio PACCHIANA	RINA_C	Table of Contents	2023/06/09
0.2	Alessio PACCHIANA	RINA_C	First complete draft for review	2024/09/06
0.3	Ana DIEZ Paula RIVAS	GBCe	REVIEW	2024/09/23
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Disclaimer

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Abbreviations and acronyms

Acronym	Description
CA	Consortium Agreement
CAPEX	Capital Expenditure
CO2	Carbon Dioxide
COP	Coefficient of Performance
DHW	Domestic Hot Water
EC	European Commission
EnPC	Energy Performance Contracting
ESCO	Energy Services Company
GA	Grant Agreement or General Assembly
GHG	Greenhouse Gases
JRC	Joint Research Centre
kWp	Kilowatt Peak
NPV	Net Present Value
O&M	Operation and Maintenance
OPEX	Operating Expenditure
PE	Primary Energy
PSC	Project Steering Committee
PV	Photovoltaics
PVGIS	Photovoltaic Geographical Information System
QAP	Quality Assurance Plan
ROI	Return on Investment
WP	Work Package

Abstract of the HAPPENING project

Currently, **buildings are responsible for 40 % of the energy demand and 36% of the CO_2 emissions in Europe**. Decarbonisation of existing buildings plays a key role in order to reach the overall climate protection targets. However, current renovation rates lie in the order of 1%.

Heat pumps are a key technology in bringing renewable shares into heat supply of buildings; especially their combination with onsite renewable electricity production e.g. by PV allows to bring high renewable shares. Their current installation in existing multi-apartment buildings is however still marginal.

The proposed technological solution is based on decentralized heat pumps, in such a way that it results an easy-to-install solution for installers, low-intrusive for the occupants and easily adaptable to a large number of different building situations. This is flanked by developing near-zero planning, implementation and operation processes, in order to facilitate the work during the planning phase, ensure a high-quality installation and effective operation, and reduce the efforts and costs within the whole retrofitting project. The challenge of cost-competitiveness is addressed by developing new financial and business models. Bringing new players (such as financial experts) and financing models to the renovation market is expected to bring the needed paradigm change and boost investments in the residential retrofitting sector. Dissemination of measured performance and system characteristics from HAPPENING will be one of the key results of the project.

Through **3 demo sites (Spain, Italy and Austria)**, the project will demonstrate a highly versatile, scalable and replicable solution package for buildings energy system retrofitting allowing 70-75% of renewable energy fraction, 30-50% of PE and GHG savings, reduction of planning time by 50% and installation/operation time by 30% and payback time for ESCOs and investors of less than 8 years, compared to best available solution existing today.

1 Introduction

1.1 Objectives of the deliverable D6.5

The deliverable D6.5 elaborates conceptual business models described in D6.3 making them more concrete addressing the following issues:

- Suitable contractual arrangements for the demonstrated technological solutions
- Target market (size of potential market in the demo site countries and at the extrapolated EU level.)
- Business model adjustments
- Team required for market introduction of the technology
- Finance (capital requirement for commercialization, Return On Investment, type of investors, etc.)
- Environmental and social aspects (directly linked to task 6.1)

These aspects are assessed on a time scale, considering short, medium- and long-term actions to be planned towards the technology packages deployment. This document takes the shape of a business plan studied also with the integration of social/marketing aspects for the work going forward, to take it into commercial exploitation. This will determine which results do have the potential market exploitation and which results are exclusively limited to in-house exploitation of the partners. It will gain in detail as more project results become available and is as such dependent on progress in the other WPs. It shall notably contain a commercial proposition based on the identification of market needs, a competitor analysis, the establishment of value chains and routes to market, and the assessment of potential revenues and costs.

1.2 Deliverable description

This deliverable, D6.5, is divided into multiple sections, each addressing key components essential for the business and market integration of HAPPENING's technological solutions. The deliverable is structured as follows:

- *Business Models*: Building on the conceptual models developed in D6.3, this section delves into value chains, contractual arrangements, and provides an overview of the technological solutions that are crucial for replicating and scaling the project.
- *Market Analysis*: An assessment of market conditions in the demonstration site countries, alongside an extrapolated view of the EU market, is conducted. This includes analysis of market size, competition, and specific needs that could be met by the HAPPENING solutions.
- *Environmental and Social Aspects*: A detailed exploration of the societal and environmental impacts of implementing HAPPENING solutions, contributing significantly to WP6 and task T6.1, led by Michele Valery.
- *Business Plans*: Comprehensive business plans are developed for the demo sites, including social and marketing aspects. These plans also explore potential routes to market, along with short-, medium-, and long-term actions required to deploy the technology packages.

1.3 Contribution of partners

The development of this deliverable involved contributions from several project partners, each playing a critical role in providing data and insights from their respective demonstration sites and areas of expertise:

- *RINA-C* was responsible for writing the deliverable and coordinating its development. They engaged with other partners to gather the necessary information and data for the business plan.
- *TECNOZENITH* provided essential data specific to the Verzuolo demo site.
- *AEE* contributed data relevant to the Liezen demo site, enabling accurate assessments of this location.
- *TECNALIA* was instrumental in providing data for the Pasaia demo site, ensuring the deliverable accurately reflects the project’s progress there.

1.4 Relations with other activities in the project

This deliverable has a strong connection to previous and concurrent work within the HAPPENING project. Specifically, there is a direct relationship with deliverable “D6.3 Business and ESCO Model”, which laid the groundwork for the definition of business models. In D6.3, key barriers and enablers for the replication and scalability of HAPPENING solutions were identified, providing the foundation for the business models discussed in this deliverable. The analysis of these barriers and enablers continues to inform the strategies outlined in the business plan.

Additionally, the techno-economic assessment provided in deliverables D4.7, D4.8, and D4.9 plays a critical role in shaping the economic considerations of the business models. These deliverables highlight the economic viability of the HAPPENING solutions by evaluating costs, savings, and overall performance in the demo sites. The insights from these assessments, particularly concerning installation, operational costs, and potential savings, are integral to the business planning and market deployment strategies explored in this document.

2 Heat pump systems market analysis

The European heat pump market is experiencing rapid growth, driven by increasing demand for energy-efficient technologies, favourable regulatory environments, and the European Union's ambitious climate goals. This analysis provides a comprehensive overview of the market size, competitive landscape, and key market needs, integrating both qualitative and quantitative data from recent industry reports and research.

2.1 Market size

The European heat pump market has seen significant expansion in recent years, largely due to the need to reduce carbon emissions and enhance energy efficiency in buildings. The shift towards sustainable energy solutions, combined with strong government incentives, has made heat pumps a critical component in achieving the EU's environmental objectives.

The European heat pump market was valued at approximately EUR 7.3 billion in 2020, with projections indicating a compound annual growth rate (CAGR) of around 10% from 2021 to 2027. This growth is fuelled by the increasing adoption of heat pumps across residential, commercial, and industrial sectors. The ongoing transition from fossil fuel-based heating systems to more sustainable alternatives is expected to further drive market expansion.

In 2020, around 1.8 million heat pump units were sold across Europe, representing a 7% increase from the previous year. This growth is consistent with the broader trend of rising demand for energy-efficient technologies in Europe. The most significant markets include France, Germany, Italy, and Sweden, which collectively account for over 60% of total European sales.

The European heat pump market is broadly segmented into three main technology types: air-source, ground-source, and water-source heat pumps. Each of these technologies has unique advantages and limitations, which determine their suitability for different environments and applications.

- *Air-Source Heat Pumps (ASHPs)*: Air-source heat pumps dominate the European market, accounting for approximately 80% of total sales. Their popularity is largely due to their relatively lower installation costs, ease of integration into existing heating systems, and adaptability to a wide range of climates. ASHPs extract heat from the ambient air, making them highly effective in moderate climates. However, their efficiency can decrease in extremely cold environments, which has spurred innovations such as hybrid systems that pair ASHPs with secondary heating sources for better performance in colder regions. Additionally, there is growing potential for interaction with photovoltaic (PV) power generation systems, which can further enhance ASHP performance, particularly during the winter months in temperate climates. The integration of PV systems allows for renewable electricity to power the ASHPs, reducing reliance on grid electricity and improving overall energy efficiency in colder conditions.

- *Ground-Source Heat Pumps (GSHPs)*: Ground-source heat pumps are recognized for their higher efficiency compared to ASHPs, particularly in colder climates where the ground temperature remains relatively constant. These systems, though more expensive to install due to the need for drilling and ground loop systems, offer substantial long-term savings through higher Coefficient of Performance (COP) values. GSHPs are increasingly favoured in regions with severe winters, such as the Nordic countries, where they provide reliable and efficient heating throughout the year.
- *Water-Source Heat Pumps (WSHPs)*: While less common than air and ground-source systems, water-source heat pumps are used in specific settings where a suitable water source is available. These systems can offer even higher efficiencies than GSHPs, but their application is limited by the availability of water bodies and the regulatory requirements governing their use. WSHPs are typically employed in commercial or industrial applications where large bodies of water, such as lakes or rivers, can be used as heat exchange sources.

The application segmentation of the heat pump market is crucial in understanding the diverse demand drivers across different sectors.

- *Residential Sector*: The residential sector remains the largest application segment, driven by the increasing need for energy-efficient heating solutions in homes across Europe. The adoption of heat pumps in residential buildings is propelled by government incentives, rising energy costs, and the growing consumer awareness of environmental benefits. Within this sector, air-source heat pumps are particularly popular due to their affordability and ease of installation. However, in regions with harsher climates, ground-source systems are gaining traction despite their higher initial costs due to their superior long-term efficiency. Additionally, similar to the commercial sector, there is a growing need for cooling in the residential sector, particularly in Southern Europe but increasingly in other regions as well. This trend adds further value to the transition from traditional fossil fuel-based heating systems to heat pumps, which can provide both heating and cooling, making them a more versatile and sustainable solution for modern residential needs.
- *Commercial Sector*: The commercial sector is seeing growing interest in heat pump technology, especially in buildings requiring significant heating and cooling capabilities, such as offices, retail centres, and hotels. The ability of heat pumps to provide both heating and cooling from a single system makes them an attractive option for commercial applications. Additionally, the push towards greener building certifications, such as LEED, is driving the adoption of heat pumps as part of broader energy efficiency strategies in commercial real estate.

- *Industrial Sector*: The industrial application of heat pumps is an emerging market with significant potential, particularly in processes that require low to medium-grade heat. Industries such as food processing, chemicals, and paper manufacturing are exploring the use of high-temperature heat pumps, which can reach temperatures up to 165°C, for various processes. The integration of heat pumps in industrial settings is also seen as a critical step towards reducing carbon emissions and improving overall energy efficiency in line with the European Union's climate goals.

The segmentation of the European heat pump market by technology type and application highlights the diverse needs and opportunities across different regions and sectors. Air-source heat pumps dominate due to their versatility and lower costs, while ground-source systems are preferred in colder climates for their efficiency. The residential sector leads in adoption, but commercial and industrial applications are growing rapidly as the technology advances and the demand for sustainable solutions increases. These segmentation trends underline the ongoing evolution of the heat pump market as it adapts to varying climatic conditions, regulatory environments, and consumer needs across Europe.

2.2 Competitive landscape

The competitive landscape of the European heat pump market is diverse, with a mix of large multinational companies and smaller, specialized firms. The market is characterized by intense competition, with companies continually innovating to enhance efficiency, reduce costs, and integrate renewable energy sources.

Major Players

- *Daikin Europe*: A leading manufacturer with a strong presence across the continent, known for its high-quality air-source heat pumps and significant investments in R&D.
- *Mitsubishi Electric*: Offers a wide range of products, including air-to-water and ground-source models, and is particularly popular in Germany and the UK.
- *Viessmann*: A German company that has gained substantial market share with its integrated heating systems, combining heat pumps with other renewable energy technologies.

Niche Competitors

- *NIBE*: Specializes in ground-source heat pumps, with a strong presence in the Nordic countries.

- *Bosch Thermotechnology*: Focuses on innovative heat pump solutions that are easy to integrate with smart home systems.

Market Differentiation

The differentiation within the European heat pump market is primarily driven by innovation and customization. These factors are essential for companies to maintain a competitive edge and meet the diverse needs of consumers across various regions.

Innovation in the heat pump market has primarily focused on enhancing efficiency, expanding operational capabilities, and improving user convenience. Key areas of innovation include:

- *Hybrid Heat Pumps*: One significant innovation is the development of hybrid heat pumps, which combine air-source technology with a secondary heating source, such as gas or electric boilers. This combination allows these systems to operate efficiently across a wider range of temperatures, particularly in colder climates where traditional air-source heat pumps might struggle. This makes them a popular choice in regions with harsh winters, where maintaining consistent heating efficiency is challenging.

- *High-Temperature Heat Pumps*: The need for heat pumps that can operate at higher temperatures is particularly relevant in industrial applications. Recent advancements have led to the development of heat pumps capable of providing heat at temperatures up to 165°C, with ongoing research pushing these limits even further. These high-temperature pumps are critical for industries that require substantial heating, such as in chemical processing or food production.

- *Integrated Systems*: Companies are also focusing on integrating heat pumps with other renewable energy sources, such as solar PV systems. This integration maximizes the use of renewable energy, reducing overall energy costs and increasing system efficiency. For example, some systems now offer the capability to use solar energy during peak sunlight hours, supplementing heat pump operations and reducing reliance on grid electricity .

Customization is becoming increasingly important as the European heat pump market matures. Companies that can offer tailored solutions to meet specific regional or application needs are likely to gain a competitive advantage. Key areas of customization include:

- *Climate-Specific Solutions*: Different regions in Europe have varying climate conditions, necessitating tailored heat pump solutions. For instance, the Nordic countries require systems that perform well in extremely cold conditions, leading to a higher demand for ground-source heat pumps, which maintain efficiency in such climates. Conversely, in milder climates, air-source heat pumps are more prevalent due to their lower installation costs and sufficient efficiency.

- *Application-Specific Design*: Customization also extends to different application needs, such as residential versus industrial uses. In residential applications, there is a growing demand for compact, easy-to-install systems that can be integrated into existing home energy systems. In contrast, industrial applications require larger, more robust systems capable of handling higher capacities and providing higher temperatures.
- *Smart Home Integration*: As smart home technology becomes more prevalent, there is a rising demand for heat pumps that can be seamlessly integrated with home automation systems. These smart heat pumps allow users to control and monitor their heating and cooling systems remotely, optimizing energy use and improving overall home efficiency.

These innovations and the ability to customize offerings are crucial for companies looking to differentiate themselves in the competitive European heat pump market. As technological advancements continue, the focus on innovation and customization will likely intensify, further driving market growth and adoption across the continent.

2.3 Market needs

The adoption of heat pumps in Europe is driven by several critical market needs that are essential for understanding the future direction of the market. These needs are closely tied to broader environmental and energy policy goals within the European Union, technological advancements, and evolving consumer awareness.

Decarbonization and Energy Efficiency

The push for decarbonization is a significant driver of heat pump adoption across Europe. The European Union has set ambitious climate goals, aiming to become the world's first climate-neutral continent by 2050. This transition requires a dramatic reduction in greenhouse gas emissions, with heating and cooling sectors being pivotal since they account for approximately 50% of the total energy consumption in Europe. Decarbonization roadmaps developed for various EU countries identify heat pumps as a cornerstone technology, essential for achieving these climate goals by utilizing renewable heat from the environment for both heating and cooling needs. Key European initiatives such as the Heat Roadmap Europe (HRE) project highlight the critical role of heat pumps in decarbonizing heating and cooling systems across 14 countries, representing 90% of Europe's heating demand. The roadmaps suggest that achieving an efficient and renewable energy system requires a combination of heat pumps, district heating, and other renewable technologies. These strategies aim for significant reductions in CO_2 emissions, primary energy use, and energy system costs, ultimately making heat pumps a crucial element for decarbonization. Here below a summary of national roadmaps for HAPPENING Involved counties Is shown:

- *Austria*: In Austria, decarbonization of the heating sector is a critical goal. The roadmap outlines significant reductions in the reliance on fossil fuels, shifting towards renewable heating solutions. Austria's focus includes a strong push for electrification using heat pumps, particularly in residential and industrial sectors. By 2050, the target is to reach almost complete reliance on renewable energy for heating through extensive integration of heat pumps with district heating networks and the use of excess industrial heat.
- *Italy*: Italy's decarbonization roadmap emphasizes the transition from gas-based heating to renewable technologies like heat pumps. The Italian roadmap identifies the need to boost energy efficiency measures in both new and existing buildings. By promoting heat pump technologies, Italy aims to decarbonize both its residential and industrial heating sectors, reducing emissions significantly by 2050. The roadmap also highlights the potential role of heat pumps in providing cooling solutions, particularly in southern regions where cooling needs are expected to increase due to rising temperatures.
- *Spain*: Spain's decarbonization efforts, outlined in its national roadmap, place a strong emphasis on the integration of heat pumps alongside district heating systems to meet both heating and cooling demands. Spain's "*Hoja de Ruta para la Calefacción Renovable*" emphasizes the adoption of heat pumps as a key strategy to replace fossil fuel-based heating systems. This roadmap aligns with findings from the HRE Spain project, that demonstrates the technical and economic feasibility of decarbonizing the Spanish heating and cooling sectors through efficient, renewable technologies such as heat pumps. In Spain, cooling demand, especially in the residential sector, is expected to grow significantly, making the adoption of heat pumps essential not only for heating but also for cooling. The roadmap projects a six-fold increase in space cooling by 2050, particularly in Southern Spain. Heat pumps are positioned as the primary solution to meet both heating and cooling needs, leveraging renewable electricity to drive down CO2 emissions and energy costs.

Government Incentives

Government incentives play a crucial role in driving the adoption of heat pumps by making the technology more affordable for consumers and businesses. These incentives vary widely across European countries, including direct subsidies, tax credits, and low-interest loans designed to reduce the upfront cost of installation. For instance, Germany's Federal Office for Economic Affairs and Export Control (BAFA) offers substantial grants for heat pump installations, making it easier for both residential and commercial sectors to transition away from fossil-fuel-based systems. These financial supports are not only crucial for Increasing adoption rates but also for fostering market growth. As more countries introduce or expand their incentive programs, the market is likely to see a sustained increase in heat pump installations, further driving down costs through economies of scale and technological advancements.

Technological Advancements

The growing demand for more efficient and versatile heat pump systems is closely linked to ongoing technological advancements in the industry. Innovations such as hybrid heat pumps, that combine air-source technology with a secondary heating source, are becoming increasingly popular, especially in colder regions where traditional air-source heat pumps may struggle to maintain efficiency. Additionally, the development of high-temperature heat pumps, capable of operating at temperatures up to 165°C, is opening up new possibilities for industrial applications. These advancements are crucial for expanding the use of heat pumps beyond residential and commercial buildings, making them viable for Industrial processes that require substantial heat.

Integration with Renewable Energy

The integration of heat pumps with renewable energy sources, such as solar photovoltaic (PV) systems, is seen as essential for maximizing efficiency and sustainability. This integration allows heat pumps to operate using renewable electricity, further reducing reliance on fossil fuels and lowering energy costs. For example, during periods of peak solar production, solar energy can be used to power heat pumps, providing a highly efficient and sustainable heating solution. Such integration is particularly important in the context of the European Union's broader energy transition strategy, that emphasizes the need for synergy between various renewable technologies to achieve decarbonization goals. As the technology continues to evolve, the market is expected to see more advanced systems that seamlessly combine heat pumps with other renewable energy sources, enhancing overall energy system resilience and sustainability.

Consumer Awareness and Education

As the heat pump market grows, there is an increasing need to educate consumers about the benefits of heat pumps. Despite their advantages, many consumers remain unfamiliar with how heat pumps work and the long-term savings they can offer. Effective consumer outreach and education are critical for overcoming these barriers and driving adoption, particularly in regions where heat pump technology is relatively new. Efforts to raise awareness are likely to focus on highlighting the environmental and economic benefits of heat pumps, such as reduced energy bills and lower carbon footprints. Additionally, as more consumers perceive the benefits firsthand, word-of-mouth and peer influence are expected to play a significant role in further boosting market penetration.

3 Business modelling aspects of HAPPENING solutions

The HAPPENING project demonstrates innovative business models and technological solutions to retrofit existing buildings for improved energy efficiency and reduced greenhouse gas emissions. This chapter explores the technological implementations across the three demo sites—Pasaia (Spain), Verzuolo (Italy), and Liezen (Austria)—and discusses the business models applied, economic considerations, and financing strategies to ensure the project's success.

3.1 Technological Solutions Implemented

This section provides an in-depth overview of the technological solutions implemented at each of the three HAPPENING demo sites: Pasaia (Spain), Verzuolo (Italy), and Liezen (Austria). These solutions are designed to enhance energy efficiency, reduce greenhouse gas emissions, and increase the use of renewable energy, tailored to the specific needs and conditions of each location. The detailed descriptions of these technological solutions are drawn from the following deliverables:

- *Deliverable D4.7: "Techno-economic assessment - Spanish demo site"*, that details the systems implemented at the Pasaia demo site.
- *Deliverable D4.8: "Techno-economic assessment - Italian demo site"*, that provides comprehensive information on the Verzuolo demo site.
- *Deliverable D4.9: "Techno-economic assessment - Austrian demo site"*, that outlines the innovative solutions applied at the Liezen demo site.

Each section below elaborates on the specific technologies, equipment, and layouts used at each site.

Pasaia (Spain)

The Pasaia demo site integrates advanced technologies focused on decentralized heating and domestic hot water (DHW) systems, combined with renewable energy sources.

- *Decentralized Heat Pump System*: the primary technology in Pasaia is a decentralized air-to-water heat pump system, with each apartment equipped with a Mitsubishi Electric PUHZ-SHW112YHA unit. These heat pumps provide heating and DHW with a heating capacity of 11.2 kW (and a cooling capacity of 10.0 kW, not used in Pasaia). The units operate with a high coefficient of performance (COP) of up to 4.0, ensuring energy efficiency. A central tempered water tank of 2000 litres is also installed.

- *Centralized Control and Monitoring*: although the heat pumps are decentralized, a centralized control system manages their operation, optimizing performance based on real-time data. This system is advanced monitoring tools to track energy consumption and system performance, facilitating proactive maintenance and ensuring peak efficiency.
- *Photovoltaic System*: the rooftops of the buildings in Pasaia are equipped with a photovoltaic (PV) system with a capacity of 15 kWp. These panels generate renewable electricity to power the heat pumps and other building systems, reducing reliance on grid electricity and lowering the carbon footprint.
- *Smart Energy Management*: a sophisticated energy management system is implemented to maximize the use of solar energy. This system intelligently balances energy supply and demand, ensuring that the generated renewable energy is used efficiently. A battery storage solution with a capacity of 15 kWh stores excess solar energy for use during periods of low sunlight.

The integration of these technologies has led to significant reductions in energy consumption and CO_2 emissions. The decentralized heat pump system, supported by renewable energy and smart management, offers a model for sustainable building retrofits in similar climatic regions, resulting in increased energy efficiency and reduced operational costs for residents. Energy consumption reductions were quantified through a detailed analysis in chapter 4, showing significant savings in electricity use due to the combined operation of heat pumps and PV power generation. A qualitative assessment suggests that these measures resulted in a reduction in energy consumption of approximately 30-40%, depending on weather conditions and load.

Verzuolo (Italy)

The Verzuolo demo site in Italy focuses on enhancing the building's thermal performance through advanced materials and energy-efficient systems, making it a model of sustainable residential architecture.

- *Advanced Insulation and Building Envelope*: the retrofitting of the Verzuolo buildings began with the application of high-performance insulation materials, thing mineral wool panels with a thermal conductivity of 0.032 W/m·K. This insulation was applied to walls, roofs, and floors, significantly reducing heat loss and improving the building's overall thermal performance.
- *Energy-Efficient HVAC Systems*: the HVAC system at Verzuolo features the Daikin Altherma 3 R, a high-efficiency air-to-water heat pump with a heating capacity of 16 kW and a cooling capacity of 14 kW. Operating with a seasonal coefficient of performance (SCOP) of 4.5, the system is integrated with the building's automation system for precise indoor climate control and optimized energy use.

- *Photovoltaic System*: the rooftop PV system, with a capacity of 30 kWp, is designed to generate approximately 40,000 kWh of electricity annually. The generated energy is used primarily to power the HVAC system and other electrical needs of the building, with any excess energy stored or fed back into the grid.
- *Building Automation and Energy Management*: a KNX-based building automation system manages the HVAC units, lighting, and other electrical systems. This system includes sensors for temperature, humidity, and occupancy, allowing automated adjustments to optimize energy use while maintaining comfort levels.

The technological enhancements in Verzuolo have resulted in substantial energy savings and a lower environmental impact. The combination of advanced insulation, energy-efficient HVAC systems, and renewable energy integration has transformed the building into a sustainable residential model, reducing energy bills for residents and significantly decreasing the building's carbon footprint. As outlined in chapter 4, calculations indicated a reduction in energy consumption of up to 25%, primarily driven by improvements in the performance of heating and cooling systems.

Liezen (Austria)

The Liezen demo site showcases an innovative cascading heat pump system designed to efficiently meet the heating and DHW needs in a cold-climate region.

- *Cascading Heat Pump System*: the Liezen system utilizes INNOVA eHPoca 25T air-to-water heat pumps, each with a nominal heating capacity of 25 kW. These central heat pumps supply a low-temperature distribution loop that operates at 25°C, this is connected to decentralized INNOVA 3in1 GEO WW Incasso 5M heat pumps in each apartment. The decentralized units have a nominal heating capacity of 5.5 kW and a COP of 5.03, ensuring efficient space heating and DHW production.
- *Low-Temperature Distribution Loop*: a key feature of the Liezen system is the low-temperature distribution loop, that minimizes heat losses during energy transfer from the central heat pumps to the decentralized units. This loop operates at around 25°C, balancing the need for efficient heat distribution with reduced thermal losses.
- *Photovoltaic Integration*: the PV system at Liezen, covering 125 m², has a peak capacity of 25 kWp. The panels are installed on the east and west-facing roof slopes, optimizing energy production throughout the day. The generated electricity is used to power the heat pumps, with surplus energy managed by an intelligent control system to maximize self-consumption.
- *Intelligent Control System*: the intelligent control system in Liezen coordinates the operation of the heat pumps with the PV system, optimizing energy use by aligning heat pump operation with periods of high solar energy generation. This system also manages the thermal storage tanks to ensure that excess heat is stored and used efficiently during peak demand.

- *Thermal Storage Tanks*: the system includes four thermal storage tanks, each with a capacity of 800 litres. These tanks store excess heat generated during periods of low demand or high solar availability, allowing the system to operate flexibly and efficiently. This setup reduces the strain on the heat pumps and enhances the overall system efficiency.

The implementation of these advanced technologies in Liezen has significantly improved the building's energy efficiency and reduced its carbon emissions. The cascading heat pump system, supported by thermal storage and photovoltaic energy, demonstrates a cutting-edge solution for retrofitting older buildings in colder climates, making them energy-efficient and sustainable. Chapter 4’s calculations indicated that the interventions at Liezen led to reductions in heating demand by 35%, with further reductions expected through continued optimization of the installed systems.

3.2 Business Models and Stakeholder Perspectives

The business models employed at each HAPPENING demo site were meticulously selected to align with the specific technological and financial conditions of each location. These models were designed to address the needs and expectations of key stakeholders, like Energy Service Companies (ESCOs), building owners, and tenants. Below is a detailed examination of the business models used, their respective Canvas frameworks, and the contractual arrangements applied at each demo site.

Energy Performance Contracting (EnPC) for Pasaia and Verzuolo

Energy Performance Contracting (EnPC) is a financing model in which an Energy Service Company (ESCO) implements energy-saving measures and guarantees the resulting savings. Under this model, the ESCO assumes both financial and operational risks, covering upfront costs and ensuring performance throughout the contract's duration. Establishing a baseline for energy consumption is crucial for accurately calculating savings. Contracts typically include detailed methodologies for measuring and verifying these savings. The ESCO guarantees the agreed-upon savings, and if the savings fall short, the ESCO compensates the customer.

- *Stakeholder Perspective (ESCO):* In both Pasaia and Verzuolo, the ESCO is responsible for financing, installation, and ongoing maintenance. This arrangement is particularly beneficial for public entities or building owners with limited funding, as it allows them to achieve energy savings without requiring significant initial capital. Tenants benefit from reduced energy costs, while the ESCO recoups its investment through a share of the realized energy savings.

- *Application in Pasaia*: in Pasaia, the EnPC model is particularly well-suited to ALOKABIDE, a public housing entity facing budget constraints and serving low-income tenants. The model provides predictable energy costs and allows ALOKABIDE to manage its resources effectively while transferring operational responsibilities to the ESCO. The straightforward nature of the EnPC contract also aligns with the public entity's need for accountability and ease of management.
- *Application in Verzuolo:* in Verzuolo, the EnPC model aligns with the building owner's goal of improving energy efficiency, as energy costs are included in the rental fees. The predictability of cost and energy savings is crucial for maintaining profitability, while the inclusion of operation and maintenance (O&M) responsibilities reduces the owner's involvement in technical decisions. The ESCO's financing provides more favourable conditions compared to traditional financial markets.

Turnkey Contract for Liezen

The Turnkey contract model positions the building owner as the lead for the entire energy efficiency project, overseeing everything from financing to implementation. The owner manages all associated risks and retains full control over the project, enabling them to directly benefit from the resulting energy savings. In this model, the building owner assumes all risks, including financial, technical, and operational. The contract typically includes clauses that clearly define the scope of work, timelines, and quality standards to ensure the project's success.

- *Stakeholder Perspective (Building Owner):* at the Liezen demo site, the building owner, GWS (Gemeinnützige Alpenländische Gesellschaft für Inungsbau und Siedlungswesen), assumes full responsibility for both the financial investment and operational management of the project. This model allows GWS to directly benefit from the energy savings, that help offset the initial investment and ongoing operational costs.
- Application in Liezen: the Turnkey model is particularly well-suited for the Liezen site, managed by GWS, a non-profit social housing company. Given that tenants are involved in the decision-making process and require engagement, the simplicity and transparency of the Turnkey contract are advantageous. Financing support and a streamlined process also align well with GWS's budget constraints and need for efficient project management.

Value Proposition	Guaranteed energy and cost savings with minimized financial risk for the customer. The ESCO manages the entire process, from design to maintenance, ensuring streamlined and efficient operations.
Key Resources	High-efficiency heating systems, smart energy management tools, and renewable energy technologies.

Customer Segments	Public housing entities (Pasaia) and private building owners (Verzuolo) seeking to reduce energy costs without upfront investments.
Key Activities	Energy audits, system design, installation, monitoring, and maintenance.
Key Partners	Technology providers, financial institutions, and local authorities.
Customer Relationships	Performance-based contracts with guaranteed savings, fostering trust and long-term engagement.
Cost Structure	Initial capital investment by the ESCO, O&M costs, and performance monitoring.
Revenue Streams	A share of the energy savings achieved, service fees, and potential government incentives.

Table 3.1: Business Model canvas for EnPC

Value Proposition	A complete, ready-to-use solution with minimal disruption to tenants, managed entirely by the building owner. The owner benefits directly from all energy savings, improving the return on investment.
Key Resources	Central and decentralized heat pumps, thermal storage, and photovoltaic systems.
Customer Segments	Non-profit housing organizations like GWS, focused on long-term sustainability and cost efficiency.
Key Activities	Project planning, procurement, installation, and quality assurance.
Key Partners	Equipment suppliers, contractors, and financial institutions.
Customer Relationships	Direct management by the building owner with straightforward contracts and clear terms.
Cost Structure	Upfront capital expenditure, ongoing O&M costs.

Revenue Streams	Energy savings, increased property value, and potential government grants.

Table 3.2: Business Model Canvas for Turnkey

3.3 Economic Considerations

A thorough economic analysis is essential for understanding the viability of the business models implemented in the HAPPENING demos. This section details the key economic factors, including installation costs, operational expenditure, incomes and incentives, and risk allocation for each business model, with a focus on the demo sites in Pasaia, Verzuolo, and Liezen.

Installation Costs and CAPEX

- *Energy Performance Contracting (EnPC) for Pasaia and Verzuolo:* in the EnPC model, the ESCO typically assumes the burden of installation costs and capital expenditure (CAPEX). This approach ensures that the project is financially viable without requiring significant upfront capital from tenants or building owners. The ability of the ESCO to secure competitive financing and manage CAPEX effectively is crucial for the success of the project. Accurate estimation of these costs is essential for planning and for the financial model to be sustainable over the long term. The CAPEX covered by the ESCO includes all necessary equipment, installation services, and initial project management fees.
- *Turnkey Contract for Liezen*: in contrast, the Turnkey model places the responsibility for all installation costs and CAPEX on the building owner. This requires the building owner to secure financing for the initial investment, which can be substantial. Detailed CAPEX estimates are vital in planning and securing the necessary funds, ensuring the project's financial feasibility. In the Liezen demo, GWS had to ensure that all financial arrangements were in place before project commencement, reflecting the significant role of financial planning in this model.

Operational Expenditure (OPEX)

- *Energy Performance Contracting (EnPC) for Pasaia and Verzuolo*: under the EnPC model, the ESCO also manages the operational expenditure (OPEX), including operation and maintenance (O&M) costs. This encompasses regular maintenance, repairs, and operational management of the energy systems installed. By handling these expenses, the ESCO ensures that the energy-saving measures are maintained efficiently, thereby maximizing performance and savings over the contract duration. This model relieves building owners and tenants of the financial and managerial burden of maintaining energy systems.

- *Turnkey Contract for Liezen*: in the Turnkey model, all OPEX, including O&M costs, are the responsibility of the building owner. This includes ongoing operational management, maintenance, and any necessary repairs. The effectiveness with which the building owner manages these costs is crucial to maximizing the return on investment from the energy savings. The Liezen demo site under GWS management illustrates the importance of efficient OPEX management in maintaining the project's financial viability over time.

Incomes and Incentives

- *Energy Performance Contracting (EnPC) for Pasaia and Verzuolo*: in the EnPC model, the primary source of income for the ESCO is the savings generated from energy efficiency improvements. These savings are typically shared between the ESCO and the tenants, with the ESCO receiving a larger portion to cover costs and profit. Additionally, incentives for energy efficiency, such as government grants, tax rebates, and renewable energy credits, can further enhance financial returns. The potential for income from selling excess energy back to the grid also contributes to the project's financial sustainability.
- *Turnkey Contract for Liezen*: for the Turnkey model, the building owner directly benefits from the energy savings achieved through the efficiency measures. All savings are retained by the building owner, providing a direct financial benefit. Similar to the EnPC model, the building owner can also benefit from incentives for energy efficiency and income from selling excess energy. These additional incomes significantly improve the overall financial performance of the project, making the investment in energy efficiency more attractive.

Risks

- *Energy Performance Contracting (EnPC) for Pasaia and Verzuolo*: in the EnPC model, the ESCO assumes most of the risks associated with the project, including financial risks, installation risks, and performance risks. By covering the upfront costs and managing the operational aspects, the ESCO mitigates the financial burden on the tenants and building owners. This model ensures that tenants benefit from improved energy efficiency and lower energy costs without taking on the associated risks. The ESCO's ability to manage and absorb these risks is critical to the overall success and sustainability of the project.
- *Turnkey Contract for Liezen*: in the Turnkey model, the building owner assumes all financial and operational risks. This includes the initial investment for the installation and the ongoing maintenance costs. The success of the project relies heavily on the building owner’s ability to manage these risks effectively. The retention of energy savings by the building owner serves as a strong incentive to maintain efficient operations and ensure the longevity

of the energy-saving measures. The potential for high returns from energy savings motivates the building owner to invest in high-quality installations and proactive maintenance.

The economic considerations of installation costs, operational expenditure, incomes and incentives, and risk allocation are fundamental to the viability of the business models chosen for the HAPPENING demos. In Pasaia and Verzuolo, the EnPC model leverages the ESCO's capacity to manage and finance the project, minimizing financial risks for tenants while ensuring performance and savings. In Liezen, the Turnkey model places the building owner in control, with all associated risks and rewards, incentivizing efficient management and operation. These models, tailored to the specific needs and constraints of each demo site, are crucial for achieving the consortium's goals of enhanced energy efficiency and sustainability in building renovations.

3.4 Financing

The economic considerations for the HAPPENING project focus on understanding the financial requirements and viability of the various business models proposed for the deployment of high-performing heating, cooling, and domestic hot water (DHW) systems in residential buildings. These systems aim to achieve high shares of renewable energy while remaining affordable for end-users and profitable for ESCOs. The following sections delve into capital requirements, Return on Investment (ROI) analysis, and the types of investors and investment strategies relevant to the commercialization of the HAPPENING solution.

Capital Requirements for Commercialization

The commercialization of the HAPPENING system involves significant capital investment, primarily in the installation of energy-efficient technologies and renewable energy systems. The capital requirements vary depending on the business financing scheme chosen:

- *BF1 (Owner-Financed Model)*: In this model, all investment is made by the dwelling owners, who bear the capital expenditure (CAPEX) for planning, implementing, and maintaining the systems. This model requires the owners to secure substantial financing, which can be a barrier for many potential users.
- *BF2 (ESCO-Financed Model)*: Here, the ESCO is responsible for the majority, if not all, of the capital investment. The ESCO must secure financing through loans, grants, or private investments. The feasibility of this model is highly dependent on the ESCO's ability to access capital at competitive rates and manage these funds effectively.

- *BF3 (Hybrid Model)*: This model splits the capital requirements between the ESCO and the dwelling owners. The initial investment by the ESCO reduces the immediate financial burden on the owners, making the model more accessible while still requiring the ESCO to manage significant capital.
- *BF4 (Third-Party Financing)*: In this scenario, third parties, such as financial institutions or public administrations, play a crucial role in financing the project. This approach can reduce the financial risks assumed by the ESCO or the dwelling owners, particularly in larger-scale implementations.

The ability to meet capital requirements is fundamental to the successful deployment of the HAPPENING system across the different business models. Access to favourable financing options, including loans, grants, and equity investments, is essential for mitigating the financial risks associated with these capital-intensive projects.

Return on Investment (ROI) Analysis

ROI is a critical metric for evaluating the financial viability of the HAPPENING solutions. It measures the profitability of the investment by comparing the net gains from the project to the initial investment costs.

- *BF1 (Owner-Financed Model)*: For owners who finance the entire project, ROI is directly related to the energy savings achieved. The high initial investment is offset by the long-term savings on energy bills, resulting in a gradual payback period and eventual profitability. The ROI in this model is typically lower initially but increases as the energy savings accumulate over time.
- *BF2 (ESCO-Financed Model)*: The ROI for the ESCO in this model depends on the efficiency of the energy systems and the ability to maintain low operational costs while achieving significant energy savings. The ESCO profits from the difference between the cost of energy production and the price at which it is sold to the end-users. A well-managed project can lead to a strong ROI, particularly if government incentives and energy credits are leveraged effectively.
- *BF3 (Hybrid Model)*: The ROI in the hybrid model benefits both the ESCO and the dwelling owners. The initial shared investment reduces the financial burden on both parties, and the gradual transfer of ownership to the dwelling owners after a set period ensures that both parties enjoy the financial benefits. The ROI is spread over a longer time frame, with reduced financial risk.
- *BF4 (Third-Party Financing)*: The ROI for third-party investors, such as banks or public entities, depends on the terms of the financing agreements and the overall success of the energy-saving measures. These investors typically seek a stable and predictable return, often backed by government guarantees or low-risk, long-term contracts.

Types of Investors and Investment Strategies

Different types of investors are involved in the HAPPENING project, each with unique strategies and risk appetites:

- *Private Investors and Venture Capitalists*: These investors are typically involved in BF1 and BF3, where the potential for high returns exists but with significant risks. They are attracted to innovative energy solutions that promise long-term profitability.
- *Institutional Investors*: Large financial institutions, including pension funds and insurance companies, are more likely to invest in BF2 and BF4 models. These investors favour low-risk, stable returns, often secured by long-term contracts and government incentives.
- *Public Sector Entities*: Public administrations may invest in BF4, particularly when there is a policy mandate to promote energy efficiency and sustainability. These entities are often less focused on profit and more on achieving broader social and environmental goals.
- *Impact Investors:* Impact investors focus on generating both financial returns and positive environmental or social outcomes. They aim to support projects that align with values like sustainability and social responsibility. In recent years, this type of investment has grown significantly, driven by demand from individuals and institutions seeking to balance profit with purpose. While some may accept lower returns, many still seek competitive financial gains. Impact investors are particularly interested in initiatives such as renewable energy and energy efficiency. In the HAPPENING project, they play a key role in BF2 and BF4 models, which emphasize long-term sustainability and energy savings.
- *Energy Service Companies (ESCOs)*: ESCOs themselves are key investors in BF2 and BF3, where they finance the installation and operation of energy systems. Their investment strategy revolves around achieving cost savings through efficient energy management and leveraging these savings to ensure profitability.

The economic analysis of the HAPPENING project highlights the importance of aligning capital requirements, ROI expectations, and investment strategies with the chosen business model. Each model presents different financial challenges and opportunities, requiring careful planning and execution to ensure that the projects are both financially viable and attractive to investors. By understanding the dynamics of capital investment, ROI, and investor types, the HAPPENING project can successfully commercialize its innovative energy solutions, driving the transition to sustainable energy in residential buildings.

3.5 Environmental and social aspects

This section addresses the environmental and social aspects associated with the deployment of the HAPPENING project's technologies, with a specific focus on the impact these aspects have on the business plan. The insights from Deliverables D6.1 and D6.2, as well as data and conclusions from relevant studies on economic, environmental, and social impacts, will be integrated into this analysis. The goal is to assess how these environmental and social considerations influence the overall feasibility and attractiveness of the business models proposed earlier in Deliverable D6.5.

Environmental Impacts

The core environmental benefit of the HAPPENING project is its potential to significantly reduce greenhouse gas (GHG) emissions. The decentralized heat pump systems employed in the project are designed to replace or supplement existing fossil fuel-based heating systems, which are a major source of CO2 emissions in residential buildings. According to the findings in Deliverable D6.2, the implementation of these heat pumps across the demo sites in Pasaia, Verzuolo, and Liezen is projected to reduce GHG emissions by 30-50%, depending on site-specific factors such as building insulation and the local climate. These reductions are not only beneficial from an environmental standpoint but also enhance the economic viability of the business models. As EU regulations continue to tighten around carbon emissions, the ability to offer significant reductions in GHG emissions becomes a strong selling point for the HAPPENING technologies. Moreover, the potential to generate carbon credits or benefit from government incentives for low-carbon technologies further improves the financial outlook of these solutions.

The HAPPENING project emphasizes the integration of energy-efficient technologies with renewable energy sources, particularly photovoltaics (PV). The decentralized heat pump systems are paired with PV panels that provide renewable electricity, significantly reducing the reliance on grid electricity, which is often generated from non-renewable sources. This combination not only reduces operational costs but also minimizes the overall environmental impact of the buildings involved. Deliverable D6.2 highlights that the integration of PV systems can cover up to 70-75% of the buildings' energy needs in optimal conditions. This high level of renewable energy integration is critical for meeting the EU’s 2050 climate neutrality goals. Additionally, the project demonstrates the viability of low-temperature distribution loops in the Liezen demo site, which further enhances the energy efficiency of the heat pump systems by minimizing heat loss during distribution.

Beyond the operational phase, the lifecycle environmental impact of the technologies is an essential consideration. This includes the environmental costs associated with the manufacturing, installation, maintenance, and eventual decommissioning of the systems. The project has taken steps to ensure that the materials and processes used are sustainable, with a focus on reducing the embodied energy and carbon footprint of the components used in the heat pumps and PV systems. The choice of materials, such as the use of eco-friendly insulation in Verzuolo, and the emphasis on recyclability and durability of components, contribute to lowering the overall environmental impact. This lifecycle approach not only supports the environmental sustainability of the HAPPENING technologies but also aligns with emerging regulatory requirements in the EU that increasingly demand a full accounting of lifecycle emissions.

Social Implications

Social acceptance is a critical factor in the success of the HAPPENING project, as the technologies are deployed in residential settings where community support is vital. Deliverable D6.1 provides a detailed analysis of the social implications of the project, emphasizing the importance of involving residents in the decision-making process and ensuring that the technologies meet their needs and expectations. The project has implemented a robust community engagement strategy, particularly in the demo sites, to gather feedback and address concerns. This strategy includes regular meetings with residents, educational campaigns about the benefits of the technologies, and the provision of technical support to help residents understand and manage the new systems. In Pasaia, for instance, where the demographic includes a significant proportion of low-income households, the project has taken extra steps to ensure that the installation and operation of the systems do not impose financial or practical burdens on the residents. The feedback collected from these engagement activities has been instrumental in refining the technologies and their deployment strategies, ensuring that they are not only accepted but also embraced by the communities. This proactive approach to social acceptance reduces the risk of opposition or non-cooperation from residents, which can be a significant barrier to the success of energy efficiency projects.

The deployment of HAPPENING technologies is expected to have a positive impact on the quality of life for residents in the demo sites. The improved energy efficiency and enhanced thermal comfort provided by the heat pump systems are significant benefits, particularly in regions where extreme temperatures are common. In Verzuolo, the advanced insulation and building envelope improvements have led to more stable indoor temperatures, reducing the reliance on heating and cooling systems and lowering energy bills for residents. Additionally, the reduction in energy costs is particularly important for residents in social housing, as seen in the Pasaia demo site. Here, the project addresses energy poverty by providing a more affordable and sustainable heating solution, thereby reducing the financial stress associated with high energy bills. This aligns with broader social goals of reducing inequality and improving living conditions for vulnerable populations.

The implementation of the HAPPENING project has also generated local economic benefits, including job creation in the installation, maintenance, and monitoring of the heat pump and PV systems. The project has prioritized the use of local contractors and suppliers wherever possible, contributing to the local economy and supporting small and medium-sized enterprises (SMEs). Furthermore, the skills and knowledge developed through the project can be leveraged for future energy efficiency projects, creating a legacy of expertise that benefits the broader community. The training programs associated with the project, aimed at both installers and end-users, ensure that the local workforce is equipped with the necessary skills to support the ongoing operation and maintenance of the systems.

Impact on Business Plan

The integration of environmental and social aspects into the business plan is essential for ensuring the long-term success and sustainability of the HAPPENING project. These aspects influence the business plan in several key areas:

- *Market Positioning and Competitiveness:* the strong environmental performance of the HAPPENING technologies positions them well in a market that is increasingly driven by sustainability concerns. As consumers and regulators place greater emphasis on carbon reduction and energy efficiency, the ability of these technologies to deliver substantial GHG reductions and energy savings gives them a competitive edge. This is particularly relevant in markets where environmental credentials are a key differentiator, such as in the EU, where green certifications and energy efficiency labels are becoming more prominent in consumer decision-making. Moreover, the social benefits of the project, including improved quality of life and contributions to local economies, enhance the overall value proposition of the HAPPENING solutions. These factors make the technologies more attractive to a broader range of stakeholders, including government agencies, social housing providers, and community organizations, which can support market penetration and scalability.
- *Risk Management:* the environmental and social aspects of the project also play a crucial role in risk management. By proactively addressing potential social resistance through community engagement and ensuring that the technologies are environmentally sustainable, the project mitigates significant operational and reputational risks. This reduces the likelihood of delays, cost overruns, or conflicts with stakeholders, which are common risks in large-scale infrastructure projects. Additionally, the alignment with regulatory trends, such as the EU's focus on lifecycle emissions and social sustainability, reduces the risk of future regulatory challenges. This foresight in environmental and social planning enhances the project's resilience to external pressures, ensuring that it can adapt to changing market conditions and regulatory environments.
- *Financial Viability and Investor Confidence:* the environmental and social credentials of the HAPPENING project are also critical for attracting investment. Investors are increasingly looking for projects that deliver not only financial returns but also positive environmental and social outcomes. The HAPPENING project's strong performance in these areas enhances its appeal to impact investors, green funds, and public sector financiers who prioritize sustainability. Furthermore, the potential for government incentives related to carbon reduction and energy efficiency, as well as the possibility of generating additional revenue through carbon credits, improves the financial viability of the project. These factors contribute to a more robust and attractive business case, supporting the long-term sustainability of the HAPPENING technologies in the market.

4 Demo sites business plans assessment

4.1 Pasaia

The techno-economic assessment for the Pasaia demo site, as detailed in Deliverable D4.7, provides a comprehensive evaluation of the installation and operational costs, as well as the expected savings from the proposed energy refurbishment activities. The project follows an Energy Performance Contracting (EnPC) model, which ensures that the energy savings achieved are shared between the contractor and the building owner. This model helps minimize financial risks while securing long-term savings. The following sections summarize the key aspects of the assessment and explore scenarios relevant to the business plan. For detailed calculations, refer to Annex 1, which includes a breakdown of the costs, savings, and financial projections.

Installation and Operating Costs

The installation costs at the Pasaia demo site primarily include the expenses related to the procurement and installation of decentralized heat pump systems, photovoltaic (PV) panels, and associated energy management systems. These costs are influenced by several factors:

- *Heat Pump Systems*: The decentralized heat pump units are the most significant cost component. These units provide heating, cooling, and domestic hot water (DHW) and are designed to be highly efficient with a Coefficient of Performance (COP) of up to 4.0.
- *Photovoltaic System*: The installation of a 15 kWp PV system on the rooftops contributes significantly to the initial capital expenditure. This system generates renewable electricity to power the heat pumps, reducing reliance on grid electricity and lowering operating costs.
- *Energy Management and Monitoring Systems*: The centralized control and monitoring systems, which optimize the operation of the decentralized heat pumps, also contribute to the overall installation costs. These systems include advanced monitoring tools that track energy consumption and system performance.

Operating costs primarily consist of maintenance, energy consumption from the grid (in cases where PV generation is insufficient), and personnel costs for system monitoring and management. Deliverable D4.7 provides detailed cost figures and a breakdown of these expenses.

It is important to note that these costs reflect a pilot project and, as such, are expected to be higher than those in future, scaled-up installations. Pilot projects typically incur higher costs due to the smaller scale of procurement and the innovative nature of the solutions. Future installations should benefit from cost reductions as the technologies mature and the supply chains stabilize.

Revenues

The techno-economic assessment calculates the potential savings under two scenarios: with and without a bonus for energy savings.

- *No Bonus Scenario*: In this scenario, savings are calculated based on the direct reduction in energy consumption resulting from the installation of the heat pump systems and the PV panels. The reduction in energy costs is primarily due to the decreased reliance on grid electricity and improved efficiency of the heating systems.
- *With Bonus Scenario*: This scenario includes additional incentives or bonuses that might be available through government programs or carbon credits. These bonuses could be based on the amount of CO_2 emissions reduced or other energy efficiency targets achieved. Including such bonuses significantly enhances the financial viability of the project.

Tables from D4.7 illustrate these calculations, showing the differences in net savings between the two scenarios. These tables highlight the impact of potential bonuses on the overall economic sustainability of the project.

The PV self-consumption savings were calculated based on the expected useful production of the PV systems and the specific energy consumption characteristics of the Pasaia demo site. The expected useful production was calculated using the JRC Photovoltaic Geographical Information System (PVGIS) tool, which provides detailed solar radiation data and estimates for PV system performance based on location. For the 15 kWp system, the expected production was 16,410 kWh/year. Assumption of 23% losses was applied to account for system inefficiencies such as shading, temperature effects, and inverter losses. The assessment outcomes are shown in the table below.

Power	***kWp***	15
Expected useful production	*kWh/year*	16.410
Ratio on total consumption	*%*	62%
Average electricity price (without social bonus)	*€/kWh*	0,24

Average yearly savings (without social bonus)	*€/year*	3.881,14
Average electricity price (without social bonus)	*€/kWh*	0,14
Average yearly savings (without social bonus)	*€/year*	2.349,13

Table 4.1: Pasaia energy and economic savings

Business plan assessment

Collecting and analysing all the data mentioned earlier, the following sections highlight the key results of the business plan for the Pasaia demo site under both the No Social Bonus and Social Bonus scenarios. The table below summarizes the yearly energy savings, PV self-consumption savings, total yearly incomes, investment, maintenance costs, total operating expenses (OPEX), Net Present Value (NPV), Internal Rate of Return (IRR), Return on Investment (ROI) over 20 years, and the payback period.

		No Social Bonus	**Social Bonus**
Energy Savings (€/year)	*€/year*	430,00 €	604,00 €
PV self-consumption Savings	*€/year*	3.881,14 €	3.881,14 €
Total Yearly Incomes	*€/year*	4,311.14	2.953,13 €
Total investment	*€/year*	344,740.41	344,740.41
Total OPEX	*€/year*	767.81	767.81
Net Present Value	*€/year*	-298.202,46 €	-316.062,35 €
Internal Rate of Return	*%*	< 0	< 0

Table 4.2: Pasaia business plan economic performance

The provided table clearly indicates that the investment in the Pasaia demo site is not sustainable under the current conditions: Net Present Value (NPV) over 20 years is significantly negative in both scenarios (−€298,202.46 without the social bonus and −€316,062.35 with the social bonus), and the Internal Rate of Return (IRR) is below zero. These metrics indicate that the investment will not generate sufficient returns over the long term, making it financially unviable under the current conditions. Several key factors contribute to this conclusion:

- *Low energy savings*: the household's low thermal load results in minimal energy savings (€430/year in the No Social Bonus scenario and €604/year in the Social Bonus scenario). This low savings potential is insufficient to justify the substantial upfront investment, especially when considering the project's scale and objectives.
- *High installation costs*: the initial investment of €344,740.41 is extremely high. It's important to note that pilot projects typically incur higher costs due to the innovative nature of the technologies being tested, the smaller scale of procurement, and the higher labour costs associated with early-stage deployment. However, these costs are expected to decrease in future applications as the technology matures and economies of scale are achieved.
- *Impact of building characteristics*: the initial conditions of the building significantly affect the overall project viability. For example, the need for a central distribution loop to manage the energy systems can drastically increase installation costs and reduce overall efficiency. Additionally, decisions regarding whether to maintain or replace existing emitters in each dwelling and the type of services required from tenants (e.g., heating, domestic hot water, or cooling) also have significant cost implications. The potential integration of micro heat pumps for cooling further complicates the financial model, as it may require additional infrastructure investments.
- *Social bonus impact*: interestingly, the Social Bonus scenario, while beneficial for tenants, poses challenges for Energy Performance Contracting (EnPC) models aimed at generating revenue. The reason for this is that the Social Bonus reduces the overall savings due to the lower price of the electricity that is not used. This reduction in savings impacts the financial performance of the EnPC, making it less effective in generating the intended revenues. Thus, while tenants benefit from lower energy costs, the contracting entity may see diminished returns.

The current investment in the Pasaia demo site is clearly not sustainable due to low energy savings, high installation costs, and the impact of the social bonus on actual savings. However, by implementing strategic cost reductions, optimizing building characteristics, and adopting a better compensation model, future projects might achieve financial viability.

- *Installation costs*: As mentioned, the high installation costs are partly justified by the pilot nature of the project. However, future projects must focus on reducing these costs through improved installation methods, better procurement strategies, and leveraging economies of scale.
- *Building characteristics*: The specific characteristics of the building, such as the need for a central distribution loop and the decision to maintain or upgrade existing emitters, should be carefully analysed in future projects. Optimizing these elements could significantly reduce costs and improve overall project viability. It is important to

note that the household's actual thermal load, approximately 2000 kWh per year, is significantly lower than the average Spanish household's thermal load, which is around 8000 kWh per year. In section 1.3 "Economic Savings" of D4.7, a linear relationship between annual savings and thermal load is discussed, indicating that higher thermal loads result in greater savings.

- *Photovoltaic compensation model*: The compensation model for surplus energy generated by the PV system is a crucial factor for the financial viability of the Pasaia demo site project. In Spain, surplus energy is compensated under the "*compensación simplificada*" scheme, which offers a rate near the wholesale market price—lower than the retail price but still contributing to the project's income. This compensation is typically credited against electricity bills. For future projects, integrating both residential and commercial users into the same PV system could optimize energy use and enhance compensation income by balancing the generation and consumption profiles.

Here below, a *best-case scenario* is shown to provide a reference, highlighting potential savings and returns with a 50 kWp PV system and reduced costs. This scenario demonstrates how far the business plan is from being sustainable without incentives. Significant revisions are essential to ensure positive returns in the long term. The main assumptions are:

- *Energy Savings*: based on the average Spanish thermal load (8.000 kWh/year) and social bonus.
- *PV self-consumption*: 50 kWp system (as planned at the project start) with a 70% self-consumption ratio.
- *PV Compensation Scheme*: 30% of the produced energy is compensated under the "compensación simplificada" scheme (selling price to the grid: 0,07 €/kWh). Details are highlighted in the table below.
- *Investment Reduction*: 70% of the initial investment cost considered, with future cost reductions anticipated due to economies of scale, process efficiencies and potential incentives.

Power	***kWp***	50
Expected useful production	*kWh/year*	54,699
Ratio self-consumption vs compensation	*%*	70
Self-consumption total	*kWh/year*	38,289.63
Compensation total	*kWh/year*	16,409.84

Table 4.3: Pasaia best case scenario PV production data

Below is the summarizing table of the economic performance of this scenario for the Pasaia demo site.

Energy Savings	*€/year*	2,337.72
PV self-consumption Savings	*€/year*	5,481.30
PV Compensation Savings	*€/year*	1,148.69
Investment	*€*	103,422.12
Maintenance Costs	*€/year*	767.81
Rate	*%*	4
NPV	*€*	4,251.10
Return on Investment	*%*	44
Internal Rate of Return	*%*	0.82

Table 4.4: Pasaia best case scenario business plan economic performance

4.2 Verzuolo

The following section details the economic assessment of the Liezen demo site, similar to the analysis conducted for the Pasaia demo site. This includes a summary of installation and operating costs, as well as the expected savings detailed in D4.8, following the overall economic performance indicators assessment. The project is implemented under the Energy Performance Contracting (EnPC) model, ensuring that the energy savings are shared between the building owner and the contractor, reducing financial risks while securing long-term benefits. For a detailed breakdown of the calculations, please refer to Annex 2, which provides an in-depth analysis of costs, savings, and financial outcomes.

Installation and Operating Costs

The installation costs for the Verzuolo demo site include expenses related to the procurement and installation of the heating, ventilation, and air conditioning (HVAC) systems, photovoltaic (PV) panels, and associated energy management systems. Below is a breakdown of the key installation components:

- *Photovoltaic and Storage System*: the installation of the photovoltaic (PV) system and associated energy storage was a critical component of the Verzuolo demo site. The system includes high-efficiency PV panels designed to capture solar energy, which is then stored in a series of advanced battery modules. These batteries, along with the necessary inverters and smart meters, ensure that the building can utilize solar energy efficiently, optimizing energy use and reducing reliance on grid electricity. The installation also required robust supports and brackets to securely mount the PV panels on the building's roof.
- *Heat Pumps*: the heat pumps installed at Verzuolo are central to the building's new energy system. These include micro heat pumps, which serve as terminals within each apartment, providing both heating and cooling through a decentralized approach. Additionally, centralized air-to-water heat pumps were installed to maintain a consistent temperature within the building's water distribution loop, ensuring efficient operation throughout the year. A specialized water-to-water heat pump was also added for the production of domestic hot water, integrating seamlessly with the neutral temperature water loop.
- *Building Energy Management System (BEMS)*: the Building Energy Management System (BEMS) was implemented to automate and optimize the operation of the newly installed energy systems. The BEMS includes sophisticated main controllers capable of interfacing with various devices and managing the overall energy flow within the building. Numerous sensors, probes, and thermal meters were installed to monitor the performance of the systems in real-time, allowing for precise adjustments and ensuring optimal efficiency. Additional hardware expansions were necessary to accommodate the large number of sensors and meters, enabling comprehensive control and monitoring of the building's energy usage.
- *Hydraulic System*: upgrades to the hydraulic system were essential to support the new energy infrastructure. This involved the installation of new pipes, pumps, and fittings, as well as safety devices and valves to ensure the safe and efficient distribution of heated and cooled water throughout the building. The system also includes thermal storage tanks that help to balance energy demand and supply, allowing the heat pumps to operate more efficiently. Insulation was added to all new hydraulic components to minimize heat loss and enhance overall system performance.
- *Electric System*: the electrical system at Verzuolo was also extensively upgraded to accommodate the new energy systems. This included the installation of new electric panels, wiring, and safety devices to ensure the safe operation of all electrical components. The upgraded system is designed to support the increased electrical

demand of the heat pumps, BEMS, and other newly installed equipment, providing reliable power distribution throughout the building.

Regular maintenance is required to keep the energy systems at Verzuolo running smoothly and efficiently. This includes routine checks and servicing of the heat pumps, PV panels, BEMS, and associated infrastructure. Maintenance activities are essential to ensure that all systems continue to operate at their peak performance levels, minimizing the risk of breakdowns and prolonging the lifespan of the equipment.

While the PV system provides a significant portion of the building's energy needs, there are times when additional electricity must be drawn from the grid, particularly during periods of low solar generation. The operating costs associated with grid electricity are managed carefully to optimize the overall energy efficiency of the building.

Ongoing monitoring and management of the energy systems are crucial for maintaining optimal performance. This involves continuous oversight of the BEMS, analysing data from the sensors and meters to ensure the systems are functioning as intended. Adjustments are made as necessary to improve efficiency and reduce energy consumption, ensuring that the building's energy systems continue to meet the project's goals of sustainability and cost-effectiveness. Operating costs primarily consist of maintenance expenses, energy consumption from the grid (for times when PV generation is insufficient), and personnel costs for system monitoring and management. The table below provides a summary of the expected annual operating costs.

Revenues

The transition from a traditional gas boiler system to advanced heat pumps at the Verzuolo demo site has resulted in significant primary energy savings, primarily due to the enhanced energy efficiency of the heat pumps. This improvement in efficiency was carefully calculated using the KPIs developed in WP3, which allowed for a detailed analysis of the energy performance before and after the intervention.

Historically, the Verzuolo building relied on a gas boiler system for heating and domestic hot water production. By switching to heat pumps, the building's energy system has reduced its reliance on fossil fuels, thus achieving substantial primary energy savings. These savings are quantified as the amount of primary energy (from gas) that is avoided due to the increased efficiency of the heat pumps compared to the gas boiler.

The calculations, which were based on historical consumption data and the efficiency of the original boiler, estimate that the switch to heat pumps has resulted in approximately 74,48% savings in primary energy. This significant reduction highlights the effectiveness of the heat pumps in reducing overall energy demand, contributing to the project's sustainability goals.

For the period from June 2023 to July 2024, the building’s primary energy consumption was measured at 71,247.40 kWh. The annual primary energy savings achieved through the use of heat pumps, compared to the previous gas boiler system, amounts to 53,066,55 kWh. These savings are a direct result of the improved efficiency and reduced energy wastage associated with the heat pumps.

In addition to the savings from the heat pumps, the building's photovoltaic (PV) system has contributed further to the overall energy efficiency. The PV system has provided approximately 13,265 kWh of electricity annually, which has been primarily used for self-consumption within the building. This additional renewable energy generation further reduces the building's reliance on external energy sources, enhancing the overall energy savings.

Looking forward, the economic savings derived from these energy efficiency improvements are expected to be significant. The primary energy savings have been translated into financial terms using EEX future PSV gas price forecasts. These economic savings will be shared with the tenants starting after the 10th year of operation, in line with the Energy Performance Contract (EnPC) formula, which allocates 50% of the savings to the tenants.

Furthermore, the project benefits from significant financial incentives available for the installation of heat pumps and photovoltaic systems. Specifically, the Italian government provides a tax credit deduction of 65% on the cost of the heat pump system and 50% on the PV system, including all related installation costs such as workforce, electric, and hydraulic systems. These deductions are spread over ten years and are being considered as an income after the first-year investment. This incentivization plays a crucial role in enhancing the financial viability of the project, making the upfront costs more manageable and ensuring a quicker return on investment.

This section outlines how the transition to heat pumps, complemented by the integration of renewable energy sources, has not only achieved significant energy savings but also sets the foundation for long-term economic benefits for both the building owners and tenants at the Verzuolo demo site.

Primary energy savings (switch from gas boiler to HPs)	*%*	74,48
Primary energy consumption(Jun-23 to Jul-24)	*kWh/year*	71.247,40
Primary energy annual savings	*kWh/year*	53.066,55
Savings from PV system	*kWh/year*	11.265,88
Savings shared with tenants after 10th year	*%*	50

Table 4.5: Verzuolo primary energy savings

Business plan assessment

The following table presents the key outcomes of the business plan for the Verzuolo demo site.

Gas Boiler to HPs Energy Savings	*€/year*	2.192,54 €
PV self-consumption Savings	*€/year*	1.538,18 €
Incentives	*€*	10.793,17 €
Investment	*€*	92.310,92 €
Maintenance Costs	*€/year*	2.130,00 €
Rate	*%*	4%
NPV	*€*	-5.850,63 €
Return on Investment	*%*	8%
Internal Rate of Return	*%*	2,48%

Table 4.6: Verzuolo business plan economic performance

The economic performance of the Verzuolo demo site, as detailed in the business plan, highlights several key factors that influence the overall financial viability of the project:

- *Impact of incentives*: the role of incentives is crucial at this stage of technology deployment. The substantial incentives provided in the first year, particularly the tax credits covering 65% of the heat pump system and 50% of the photovoltaic (PV) system, significantly enhance the project's economic attractiveness. Without these incentives, the upfront investment would be prohibitively high, making the payback period longer and the return on investment less favourable. As the technology matures and potentially becomes more cost-competitive, the reliance on such incentives might decrease, but at this early stage, they are essential for driving adoption and achieving financial viability.
- *Impact of PV system expansion*: the increase in PV capacity could theoretically enhance the project's economic performance by generating more renewable electricity. However, it is important to consider that as the installed capacity (kWp) increases, the share of auto-consumption typically decreases. This is because the energy produced may exceed the immediate demand of the building, leading to surplus electricity being fed back into the grid under the "Scambio sul Posto" scheme. The revenue from selling this surplus is relatively modest, calculated as the zonal PUN (Prezzo Unico Nazionale) plus a fee, which is currently around €0.18/kWh. Therefore, while expanding the PV

system can increase overall energy savings, the financial returns from excess generation may be limited, especially if the auto-consumption share diminishes.

- *Inclusion of cooling as a new service*: another important consideration is the addition of cooling services to the building, made possible by the heat pumps' ability to function as both heaters and coolers. This represents an added value not previously accounted for when the building was solely heated with a gas boiler. To fully appreciate the economic performance, this added service should be monetized. One approach is to establish a baseline for cooling demand based on regional climatic data for Verzuolo. For example, cooling degree days (CDD) specific to the region could be used to estimate a standard energy consumption for cooling, which would then be valued at the local electricity rate. This baseline could then be compared to the energy efficiency of the heat pumps to quantify the financial benefit of the newly available cooling service. Including this in the economic analysis would give a more comprehensive view of the project's overall value to the tenants and building owners.

In summary, the economic performance of the Verzuolo demo site is heavily influenced by the availability of incentives, the balance between PV generation and auto-consumption, and the added value of providing cooling services. While the project shows modest returns and a long payback period under current conditions, these considerations highlight potential areas for improving financial outcomes, particularly as the technology evolves and market conditions change.

4.3 Liezen

The following section details the economic assessment of the Liezen demo site, similar to the analysis conducted for the Pasaia demo site. This includes a summary of installation and operating costs, as well as the expected savings detailed in D4.9, following the overall economic performance indicators assessment. It is important to note that in this scenario, the Liezen demo site follows a turnkey model, where the complete solution—including design, planning, installation, and commissioning—was managed as a comprehensive package by a single contractor. This turnkey approach simplifies project management, ensuring consistency across all stages of implementation and providing clear financial predictability from the outset. The business model is taken from the building owner's perspective, emphasizing long-term benefits in terms of energy savings and operational efficiency. This approach ensures that the owner has a clear understanding of the investment, costs, and savings, while minimizing risks associated with managing multiple contractors or fragmented responsibilities. For a detailed breakdown of the calculations, including specific cost and savings figures, please refer to Annex 3, which provides an in-depth analysis of the financial projections and economic outcomes.

Installation and Operating Costs

The installation of the energy system at the Liezen demo site involved significant upfront capital expenditures, encompassing a wide range of activities essential for the deployment of the HAPPENING solution. These costs are detailed as follows:

- *Planning and Tendering*: The process of planning and calling for tenders was a significant upfront activity, ensuring the correct specifications and compliance with local standards.
- *Hydraulic Installation*: This included extensive work in the building's basement and apartments, such as installing low-temperature circuits, heating distributors, and radiators, as well as setting up decentralized heat pumps.
- *Electrical Installations*: The electrical work involved setting up distribution circuits, cabling, and integrating a monitoring system essential for the centralized and decentralized heat pumps.
- *PV System Installation*: A photovoltaic system was installed to supply renewable energy, significantly reducing reliance on external electricity sources.
- *Building Modifications*: The building's basement required modifications, including lowering the floor to accommodate the decentralized heat pumps, and various structural changes were needed in the apartments following the installation of the new heating system.
- *Monitoring System*: Extensive monitoring equipment was installed to ensure optimal performance and allow for continuous analysis and improvements.

The total installation costs for the Liezen demo site amounted to €762,834. This includes costs for hydraulic and electric installations, building modifications, the PV system, and the installation of decentralized heat pumps across the 18 apartments.

Post-installation, the system incurs regular operating costs, primarily associated with maintenance and energy consumption. The maintenance costs include routine checks and repairs of the heat pumps and associated infrastructure, amounting to approximately €3,105 annually. Additionally, the operational management, including emergency services and maintenance of non-heat pump components, adds €2,595 per year. Energy costs for electricity supplied from the grid are based on a fixed tariff of €0.335 per kWh, with a projected annual consumption of 49,352 kWh, leading to an annual energy cost of €16,532.92. However, the energy savings generated by the PV system, selling excess energy back to the grid at €0.045 per kWh, offsets these costs slightly, reducing the net energy expense.

Revenues

The Liezen demo site's HAPPENING system has demonstrated substantial energy savings, calculated through a clear and rigorous methodology detailed in D4.9. These savings, considered as a direct income stream, stem from multiple sources:

- *Primary energy savings*: by replacing individual stoves and boilers with centralized and decentralized heat pump systems, the Liezen demo site achieves substantial primary energy savings. Specifically, the site has recorded annual primary energy savings of 72,463 kWh. This shift not only reduces reliance on fossil fuels but also significantly lowers CO2 emissions, contributing to both environmental goals and improved financial outcomes. These savings can be further quantified by considering the avoided use of oil for heating. The previous oil-based heating system had a cost of 1.22 €/L for oil, with each litre containing approximately 9.99 kWh of energy, based on an oil density of 0.84 kg/L and a lower heating value (LHV) of 11.89 kWh/kg. Using these values, the avoided energy consumption from oil translates into considerable cost savings.
- *PV auto-consumption savings*: the installed photovoltaic system generates electricity, a significant portion of which is consumed on-site, reducing the need for grid electricity. With an electricity price of €0.355 per kWh, the annual savings from PV auto-consumption are substantial.
- *Incentives*: The PV system installation was supported by a financial subsidy covering 11.4% of the total PV system cost (€2,608.23). Furthermore, the "Raus aus Öl und Gas" program provides funding for replacing fossil fuel heating systems with renewable technologies. Although this was not claimed for the Liezen site (as the program became available post-installation), the project could have received up to 75% of the eligible installation costs. If this incentive had been applied, the maximum funding would have been €506,000, significantly offsetting the project's capital expenses.
- *Revenue from excess energy*: The excess electricity generated by the PV system is sold back to the grid at a rate of €0.045 per kWh, providing an additional, though modest, revenue stream.

Business Plan Assessment

The financial assessment of the Liezen demo site's business plan reveals a nuanced picture of the project's economic performance:

Energy Savings Due to Increased Efficiency	*€/year*	8.868,15 €
PV self-consumption Savings	*€/year*	4.419,90 €
Investment	€	762.831,00 €
Incentives	€	506.000,00 €

Maintenance Costs	*€/year*	5.700,00 €
Rate	*%*	4%
NPV	*€*	-153.706,94 €
Return on Investment	*%*	-12%
Internal Rate of Return	*%*	-4,56%

Table 4.7: Liezen business model economic performance

- *Impact of incentives*: the available incentives, particularly the financial support for the PV installation, are crucial for making the project economically viable at this stage. These incentives help alleviate the initial capital costs and improve the return on investment. Unfortunately, the unclaimed incentive for replacing fossil fuel heating systems represents a missed opportunity, which could have improved the overall financial outlook of the project. By leveraging this additional support, the project's financial performance could have been substantially enhanced, allowing for a faster payback period and improved cash flow in the early years.
- *PV System Impact*: while expanding the PV system could lead to further energy savings, there is a diminishing return on the share of self-consumption as the PV capacity increases. The surplus energy sold to the grid under the "Scambio sul Posto" scheme at €0.045 per kWh generates relatively small revenues compared to the savings realized from using the energy on-site. As a result, careful planning is needed when considering the expansion of PV capacity, to balance between increasing self-consumption and optimizing financial returns.
- *Additional value from cooling services*: the new heat pump system's ability to provide cooling adds significant value compared to the previous heating-only system. This service should be monetized within the financial assessment. Establishing a baseline for cooling energy demand, based on geographic and climatic data from Liezen, could help quantify the added value of this feature. Comparing the energy efficiency of the new system to standard cooling consumption figures would provide a more accurate economic picture of the cooling service. This inclusion would enhance the overall valuation of the system, contributing further to tenant satisfaction and the attractiveness of the building.
- *Absorbing investment costs through building value and compliance*: For the investment to be truly sustainable, it is essential that the negative financial impact of the upfront capital costs is offset by the increase in the value of the building. As the stakeholder is the building owner, the modernized, energy-efficient systems could significantly raise the property's market value. Additionally, the need for residential buildings to comply with increasingly

stringent European Union energy regulations—such as the EU's Energy Performance of Buildings Directive (EPBD), which mandates higher energy efficiency standards—further enhances the building's long-term sustainability and attractiveness. This compliance with new regulations not only future-proofs the building but also makes it more competitive in the real estate market as energy-efficient properties become a requirement rather than a preference.

In conclusion, the economic performance of the Liezen demo site is complex but shows positive potential, driven by energy savings, effective use of incentives, and the added value provided by modernized energy systems, including cooling. The high upfront investment results in a longer payback period, and negative cash flows in the short term, but the long-term benefits—including increased building value, regulatory compliance, and improved tenant satisfaction—present a compelling case for the project's overall success. For long-term sustainability, it is critical that the investment is not only seen through the lens of energy savings but also in terms of the increased value of the asset and its compliance with future regulatory frameworks.

5 Conclusions

The HAPPENING project's business plans for the demo sites in Pasaia, Verzuolo, and Liezen present comprehensive evaluations of the technical, economic, and environmental feasibility of implementing low-carbon heating and cooling systems. Each demo site has provided valuable insights into the scalability and replicability of the technologies tested, along with highlighting critical barriers and enablers for future deployment.

The Pasaia demo site faced significant challenges in achieving economic viability, primarily due to the high initial investment costs for heat pump and photovoltaic (PV) installations. Despite substantial energy savings from the decentralized heat pump system and a 15 kWp PV installation, the financial analysis revealed that the net present value (NPV) remains negative over a 20-year period, even under optimal conditions. The techno-economic assessments from Deliverable D4.7 highlight that these high upfront costs are partly attributed to the innovative nature of the pilot project and the lack of economies of scale at this stage. However, future projects are expected to benefit from reduced costs through technology maturity and optimized procurement strategies. Additionally, while the PV auto-consumption savings contribute to lowering operational costs, the compensation model for surplus energy requires further refinement to improve financial returns.

The Verzuolo demo site demonstrated significant primary energy savings, particularly through the transition from a traditional gas boiler system to heat pumps. The site's energy savings amounted to approximately 74,48%, while the integration of a PV system added further to the overall energy efficiency. These improvements align closely with the findings in Deliverable D4.8, which underscore the critical role of combining renewable energy sources with high-efficiency systems. Financially, the project benefits from Italian government incentives, including tax credits on the installation of heat pumps and PV systems, which enhance the economic viability of the project. Over time, these incentives, combined with energy savings, should lead to positive returns, particularly when considering the Energy Performance Contract (EnPC) model, which shares savings with tenants after 10 years.

The Liezen demo site, like Verzuolo, followed an EnPC model and achieved long-term energy savings by replacing fossil fuel-based heating systems with heat pumps. However, the techno-economic assessment revealed complexities in balancing high installation costs with future savings. While the installation of the PV system and heat pumps resulted in significant efficiency gains, the high capital expenditures initially limit the project's financial feasibility. Nonetheless, Deliverable D4.9 highlights those leveraging incentives, such as government grants and carbon credits, will play a crucial role in improving the project's financial performance. Additionally, increasing the building's value and ensuring compliance with stringent European Union energy regulations can further enhance long-term returns.

Strategic Recommendations

- *Short-term actions*: Immediate focus should be placed on reducing installation costs through improved procurement strategies and leveraging available incentives.
- *Medium-term actions*: Explore the possibility of expanding PV capacity, optimizing energy compensation models, and integrating cooling services to enhance energy savings.
- *Long-term actions*: Future projects must ensure that building characteristics are optimized for the integration of energy-efficient systems, and efforts should be made to reduce costs through economies of scale.

The successful deployment of these technology packages across the demo sites provides a robust framework for future replication and scaling, offering both environmental and financial benefits. However, careful attention must be paid to the specific market conditions, regulatory environments, and building characteristics to ensure long-term sustainability.

Annexes

Annex 0: Bibliography

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Annex 1: Pasaia Business Plan tables

NO SOCIAL BONUS		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Energy savings (€)		- €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €	430 €
PV autoconsumption savings (€)		- €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €	3.881 €
TOTAL INCOMES		- €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €	4.311 €
Investment		344.740 €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €
Maintenance costs		- €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €
TOTAL OPEX		344.740 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €
CASH FLOWS		- 344.740 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €	3.543 €
ACTUALIZED CASH FLOWS (estimated rate)	4%	- 344.740 €	3.407 €	3.276 €	3.150 €	3.029 €	2.912 €	2.800 €	2.693 €	2.589 €	2.490 €	2.394 €	2.302 €	2.213 €	2.128 €	2.046 €	1.967 €	1.892 €	1.819 €	1.749 €	1.682 €	1.617 €
NPV (years)	20	- 298.202 €																				
Return of Investment (years)	20	-77%																				
Internal Rate of Return		-15,28%																				

Table A1.1: Pasaia business plan (no social bonus scenario)

SOCIAL BONUS		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Energy savings (€)		- €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €	604 €
PV autoconsumption savings (€)		- €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €	2.349 €
TOTAL INCOMES		- €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €	2.953 €
Investment		344.740 €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	1 €	2 €	3 €	4 €	5 €	6 €	7 €	8 €	9 €	10 €
Maintenance costs		- €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €
TOTAL OPEX		344.740 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	769 €	770 €	771 €	772 €	773 €	774 €	775 €	776 €	777 €	778 €
CASH FLOWS		- 344.740 €	2.185 €	2.185 €	2.185 €	2.185 €	2.185 €	2.185 €	2.185 €	2.185 €	2.185 €	2.185 €	2.184 €	2.183 €	2.182 €	2.181 €	2.180 €	2.179 €	2.178 €	2.177 €	2.176 €	2.175 €
ACTUALIZED CASH FLOWS (estimated rate)	4%	- 344.740 €	2.101 €	2.020 €	1.943 €	1.868 €	1.796 €	1.727 €	1.661 €	1.597 €	1.535 €	1.476 €	1.419 €	1.364 €	1.311 €	1.260 €	1.211 €	1.164 €	1.118 €	1.075 €	1.033 €	993 €
NPV (years)	20	- 316.062 €																				
Return of Investment (years)	20	-84%																				
Internal Rate of Return		-18,03%																				

TableA1.2: Pasaia business plan (social bonus scenario)

BEST CASE SCENARIO		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Energy savings (€)	avg spain thermal load	- €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €	2.338 €
PV autoconsumption savings (€)	social bonus, 50 kWp, 70% ratio of total consumption	- €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €	5.481 €
PV compensation savings (€)	30% ratio of total consumption	- €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €	1.149 €
TOTAL INCOMES		- €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €	8.968 €
Investment	**70%**	103.422 €	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €	1 €	2 €	3 €	4 €	5 €	6 €	7 €	8 €	9 €	10 €
Maintenance costs		- €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €
TOTAL OPEX		103.422 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	768 €	769 €	770 €	771 €	772 €	773 €	774 €	775 €	776 €	777 €	778 €
CASH FLOWS		- 103.422 €	8.200 €	8.200 €	8.200 €	8.200 €	8.200 €	8.200 €	8.200 €	8.200 €	8.200 €	8.200 €	8.199 €	8.198 €	8.197 €	8.196 €	8.195 €	8.194 €	8.193 €	8.192 €	8.191 €	8.190 €
ACTUALIZED CASH FLOWS (estimated rate)	4%	- 103.422 €	7.885 €	7.581 €	7.290 €	7.009 €	6.740 €	6.481 €	6.231 €	5.992 €	5.761 €	5.540 €	5.326 €	5.120 €	4.923 €	4.733 €	4.550 €	4.375 €	4.206 €	4.044 €	3.888 €	3.738 €
NPV (years)	20	4.251 €																				
Return of Investment (years)	20	44%																				
Internal Rate of Return		0,82%																				

Table A1.3: Pasaia business plan (best case scenario)

Annex 2: Verzuolo Business Plan tables

		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Gas boiler to HPs energy savings (€)		**- €**	**2.192 €**	**1.913 €**	**1.562 €**	**1.390 €**	**1.377 €**	**1.377 €**	**1.377 €**	**1.377 €**	**1.377 €**	**1.377 €**	**688 €**	**688 €**	**688 €**	**688 €**	**688 €**	**688 €**	**688 €**	**688 €**	**688 €**	**688 €**
PV autoconsumption savings (€)		**- €**	**1.538 €**	**1.388 €**	**1.159 €**	**1.051 €**	**1.003 €**	**975 €**	**961 €**	**941 €**	**926 €**	**913 €**	**456 €**	**456 €**	**456 €**	**456 €**	**456 €**	**456 €**	**456 €**	**456 €**	**456 €**	**456 €**
Incentives (€)		**- €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**10.793 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**
TOTAL INCOMES		**- €**	**14.523 €**	**14.095 €**	**13.514 €**	**13.234 €**	**13.173 €**	**13.145 €**	**13.131 €**	**13.111 €**	**13.095 €**	**13.083 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**	**1.145 €**
Investment		**92.311 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**
Maintenance costs		**- €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**
TOTAL COSTS		**92.311 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**	**2.130 €**
CASH FLOWS		- 92.311 €	12.393 €	11.965 €	11.384 €	11.104 €	11.043 €	11.015 €	11.001 €	10.981 €	10.965 €	10.953 €	- 985 €	- 985 €	- 985 €	- 985 €	- 985 €	- 985 €	- 985 €	- 985 €	- 985 €	- 985 €
ACTUALIZED CASH FLOWS (estimated rate)	4%	- 92.311 €	11.916 €	11.062 €	10.121 €	9.492 €	9.077 €	8.705 €	8.360 €	8.024 €	7.704 €	7.399 €	- 640 €	- 615 €	- 592 €	- 569 €	- 547 €	- 526 €	- 506 €	- 486 €	- 468 €	- 450 €
NPV (years)	20	- 5.849,63 €																				
Return of Investment (ROI)	20	8%																				
Internal Rate of Return (IRR)		2,48%																				

Table A2.4: Verzuolo detailed business plan

Annex 3: Liezen Business Plan tables

		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Energy savings due to increased efficiency		**- €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**	**8.868 €**
PV autoconsumption savings (€)		**- €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**	**4.420 €**
Incentives (€)		**506.000 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**
TOTAL INCOMES		**506.000 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**	**13.288 €**
Investment		**762.831 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**
Maintenance costs		**- €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**
TOTAL COSTS		**762.831 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**	**5.700 €**
CASH FLOWS		- 256.831 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €	7.588 €
ACTUALIZED CASH FLOWS (estimated rate)	4%	- 256.831 €	7.296 €	7.016 €	6.746 €	6.486 €	6.237 €	5.997 €	5.766 €	5.545 €	5.331 €	5.126 €	4.929 €	4.739 €	4.557 €	4.382 €	4.213 €	4.051 €	3.896 €	3.746 €	3.602 €	3.463 €
NPV (years)	20	- 153.707 €																				
Return of Investment (ROI)	20	-12%																				
Internal Rate of Return (IRR)		-4,56%																				

Table A3.5:Liezen detailed business plan