ARV

CLIMATE POSITIVE CIRCULAR COMMUNITIES

D9.3 DESIGN BUSINESS MODEL BLUEPRINTS FOR ENERGY POSITIVE RETROFITS FOR DIFFERENT ASSET CLASSES AS MODULES FOR REPLICATION ACROSS THE EU

WP9 BUSINESS MODELS, FINANCIAL INSTRUMENTS, POLICY, AND EXPLOITATION

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[1] *ARV is a Norwegian word meaning "heritage" or "legacy". It reflects the emphasis on circularity, a key aspect in reaching the project's main goal of boosting the building renovation rate in Europe.*

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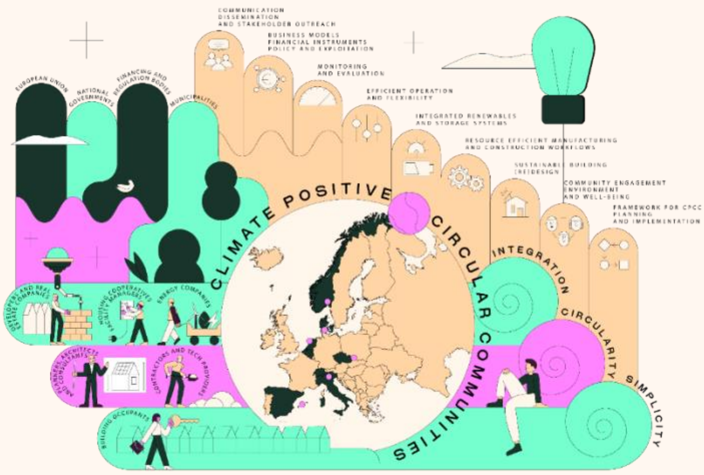
ABOUT THE ARV PROJECT

The vision of the ARV project is to contribute to speedy and wide scale implementation of Climate Positive Circular Communities (CPCC) where people can thrive and prosper for generations to come. The overall aim is to demonstrate and validate attractive, resilient, and affordable solutions for CPCC that will significantly speed up the deep energy renovations and the deployment of energy and climate measures in the construction and energy industries. To achieve this, the ARV project will employ a novel concept relying on a combination of 3 conceptual pillars, 6 demonstration projects, and 9 thematic focus areas.

The 3 conceptual pillars are integration, circularity, and simplicity. **Integration** in ARV means the coupling of people, buildings, and energy systems, through multi-stakeholder co-creation and use of innovative digital tools. **Circularity** in ARV means a systematic way of addressing circular economy through integrated use of Life Cycle Assessment, digital logbooks, and material banks. **Simplicity** in ARV means to make the solutions easy to understand and use for all stakeholders, from manufacturers to end-users.

The 6 demonstration projects are urban regeneration projects in 6 locations around Europe. They have been carefully selected to represent the different European climates and contexts, and due to their high ambitions in environmental, social, and economic sustainability. Renovation of social housing and public buildings are specifically focused. Together, they will demonstrate more than 50 innovations in more than 150,000 m^2 of buildings.

The 9 thematic focus areas are 1) Effective planning and implementation of CPCCs, 2) Enhancing citizen engagement, environment, and well-being, 3) Sustainable building re(design) 4) Resource efficient manufacturing and construction workflows, 5) Smart integration of renewables and storage systems, 6) Effective management of energy and flexibility, 7) Continuous monitoring and evaluation, 8) New business models and financial mechanisms, policy instruments and exploitation, and 9) Effective communication, dissemination, and stakeholder outreach.



The ARV project is an Innovation Action that has received funding under the Green Deal Call LC-GD-4-1-2020 - Building and renovating in an energy and resource efficient way. The project started in January 2022 and has a project period of 4 years, until December 2025. The project is coordinated by the Norwegian University of Science and Technology and involves 35 partners from 8 different European Countries.

EXECUTIVE SUMMARY

The building sector in the EU remains one of the key contributors to greenhouse gas (GHG) emissions, and new business models are urgently needed to support the sector's transition towards a climate positive, circular and liveable future.

Business model innovation is driven by the growing awareness of the environmental and social impacts caused by businesses, as well as economic factors and, increasingly, regulation. Data, digital tools and data driven insights to determine and prioritise renovation needs are important enablers, as is taking a people and place-specific approach to designing and commercialising new products and services.

This report presents seven blueprints for climate positive business models for retrofitting and energy operation value chain that are co-designed and developed with the ARV project demo sites. The models are for different real-estate ownership structures (social housing, rental and privately owned or mixed as well as public buildings). The business models include companies offering energy services and implementing energy-efficiency projects (Energy Service Companies, ESCOs or Energy-as-a-service models), a PV forecasting solution, one-stop shop solutions and large-scale retrofitting enabling services, district heating product solutions and publicly funded energy communities. The business models have been developed in five project demonstration communities: Palma de Mallorca, Spain; Trento, Italy; Utrecht, the Netherlands; Karviná, Czech Republic and Sønderborg, Denmark.

Beyond documenting the models, the report also identifies and analyses conditions and levers for deployment and scalability as well barriers. The diversity of innovations and developed business models in the ARV project is significant. Therefore, all business models benefitted from stakeholder and beneficiary mapping and mapping of respective benefits and costs as well as risks to be able to assess attractiveness per stakeholder group. Economic analyses for five business models are also provided. Chapter 6 describes both the value proposition for each stakeholder as well as quantified economic costs and benefits for the business models. With that, the blueprints aim for sufficient level of detail to allow the replication of these models across other regions in the EU by local actors.

The economic analyses of ARV's business models demonstrate some potential for delivering revenues, and acceptable returns on investment (up to 10-15 years). Strong financial benefits from self-consumption are identified for electricity related business models, however these face risks from fluctuating energy prices. In the case of retrofitting related business models, cost of renovation for households remains high, and these models leverage significant public funding or subsidies. Better quantification and measurement of impacts and strengthening the understanding of multiple benefits as part of the value proposition as well as added business expertise through collaboration with accelerators and commercialisation experts will further support the transition from pilots to market-ready solutions.

Barriers such as low engagement, limited trust, governance challenges and permitting delays restrict adoption. Targeted communication campaigns, fiscal incentives, and municipality-led, human to human facilitation can address these issues. Scalable digital tools, prefabrication, and data-driven renovation prioritisation are opportunities that can enhance adoption. Regulatory incentives and highlighting broader societal benefits like quality-of-life improvements can further strengthen the business case.

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1. INTRODUCTION

The aim of the ARV project is to demonstrate and validate attractive, resilient, and affordable solutions to speed up deep energy renovations and the deployment of energy and climate measures in the built environment. Developing and deploying innovative business models to take these solutions to market is one of the key challenges to overcome to facilitate their speedy uptake. This requires business model innovation and devising new business and value capture models.

At their core, the solutions and innovations are designed to deliver various climate and environmental benefits related to energy, emissions, circularity, and social benefits. These new value streams can be increasingly visualised and exploited thanks to smart urban infrastructure and underlying data. That is also one of the core concepts of the Climate Positive Circular Community (CPCC), which focuses strongly on the interaction and integration between the buildings, the users, and the regional energy, mobility and ICT systems. Therefore, impacts and data and digitalisation are the two key drivers and enablers behind the innovative business models described in this report, and business model innovation more generally.

This report describes how various innovative and climate positive business models were co-designed, developed, and tested with the ARV project demo sites. The report presents seven business model blueprints for retrofitting and energy operation value chain and for different real-estate ownership structures, including social housing, rental and privately owned, and public buildings. The business models developed and described include companies offering energy services and implementing energy-efficiency projects (Energy Service Companies, ESCOs or Energy-as-a-service models), a PV forecasting solution, one-stop shop solutions and large-scale retrofitting enabling services, district heating product solutions and publicly funded energy communities.

These business models have been co-developed in the five large-scale demonstration communities in the ARV project: Palma de Mallorca (Spain), Trento (Italy), Utrecht (the Netherlands), Sønderborg (Denmark) and Karviná (Czech Republic). These communities represent different social, political, regulatory and economic contexts within the wider pan-European regulatory framework and climate targets. This means each place will operate in its unique constellation of financial schemes, business and industry ecosystems, supportive or inhibitive local or national regulations as well as political priorities and characteristics of the local communities. With this in mind, a place-specific approach was chosen so the business models can be tailored from and to the local context and to leverage and address region-specific challenges and opportunities.

Each business model is described and discussed systematically in a written format together with a graphic blueprint. The written discussion captures details and provides in-depth analysis. The graphic blueprint, in turn, is designed to give an accessible overview of the business model and its dynamics and support its dissemination. The visual approach is aligned with the project's visual identity and other graphics to ensure visual cohesion. Economic analysis of five business models have also been included to provide insights and details about the financial and economic factors of these business models.

2. OBJECTIVES

Impact driven, Replicable, Scalable

This report presents blueprints for climate positive business models for retrofitting and energy operation value chain. It describes how positive environmental and social impacts (described in detail in chapter 4) were leveraged to design the value propositions. The report also discusses how data and digitalisation enable and drive business model innovation in these cases, and the financial costs, revenues and other considerations through economic analyses. Describing this innovation process led by the ARV demo sites provides a replicable approach for developing climate positive businesses for the built environment.

Beyond blueprint design, the report identifies and analyses conditions and levers for deployment and scalability as well as most relevant barriers and bankability challenges for the different business models. This analysis, together with the business model blueprints, aim to provide sufficient level of detail to allow the replication of these models across other regions in the EU by local actors under supportive local conditions. Ultimately, these new kind of business models are key to transform the construction industry towards sustainable and efficient renovation and construction paradigm, which is crucial for the shift towards liveable cities and the built environment's net zero targets.

3. ARV DEMO CONTEXTS

From the diversity of real-estate ownership structures and target groups in each ARV demo site, there is a diversity of demo contexts within the six demo sites. (See figure 1)

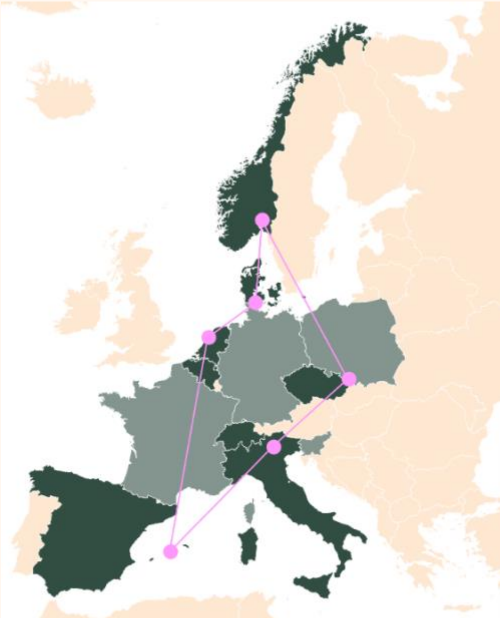

Figure 1. *Map of the ARV demo projects.*

PALMA DE MALLORCA, SPAIN

The Spanish demo case is in the Llevant Innovation District in Palma de Mallorca, the largest of the Balearic Islands in the Mediterranean, more specifically in the districts Nou Llevant and La Soledad, an area in the east of the city of Palma. The area of the neighbourhood is about 90 hectares. The neighbourhood has approximately 9000 inhabitants and is a mixed-used development area including residential, tertiary, and educational buildings that are either newly constructed or buildings that require renovation/retrofitting interventions.

The two areas of the neighbourhood are today characterised by an ageing population. More than 17% are over 65 years old. The demographic profile reflects the migration history of the area. The origin of La Soledat Sud was the result of a rural exodus from agrarian Mallorca to the city and its industrial and/or craft spaces. The expansion of the Nou Llevant is due to the migratory avalanches; first of origin of other Spanish areas in the 1960, and later, already from 1990 until today with the arrival of newcomers of foreign origin.

La Soledat Sud is mainly a mono-functional housing area, with only a small number of businesses.
Within the La Soledat neighbourhood, the energy standards are low, documented by mandatory Energy Certificates issued for each house when sold. Since there is a high turnover of houses in La Soledat, the number of Energy Certificates available is high. The certificates reveal information on poor energy performance, with poor air conditioning and poorly insulated windows and doors. Only in specific cases where the owners have been able to renovate the energy and indoor environmental standards have been improved.

The inhabitants of Nou Llevant live mainly in buildings older than 50 years. The buildings are typically poorly insulated and energy inefficient, unless they have been renovated. There are multi-family estates with crowed living conditions. The ground floors of the estates are either apartments or community spaces. They are occupied by shops or restaurants to a very low extent. However, the neighbourhood has also been experiencing a boom of construction of new luxury residential building block with high energy efficiency standards. And there are still many urban lots pending execution. Due to this development, the social profile is changing due to the new residents.

Overall, the Nou Llevant neighbourhood is better equipped than the La Soledat neighbourhood. It has facilities that serve the population beyond the neighbourhood. There are three public secondary schools, three public kindergartens and/or primary schools, a health centre, and a network of social care services for citizens that serves all public, private and/or NGO initiatives that are active in the neighbourhood.

The demographic profile of the neighbourhood consists mostly of inhabitants of working age (from 16 to 67) and the gender distribution is balanced. 17% of the population are minors and 18% are retired. 25% of the households consist of adults with dependent minors, and 10% are single-parent families, typically comprising a mother and children. The nationality of the inhabitants is primarily Spanish, with some African foreign representation. The construction of new luxury residential blocks in recent years has created two segments in the population within the same neighbourhood, characterized by significant differences in purchasing power.

The main project activities described in this report are establishing Citizen Energy Communities (CEC) and large-scale retrofitting of multi-family apartment buildings.

The building stock of the Nou Llevant and La Soledad district comprise residential and educational buildings where the retrofitting interventions are carried out. The target groups encompass:

- Building neighbors: neighbors inhabiting the existing buildings, including vulnerable segments and new owners and/or tenants of the new buildings. These target groups are particularly relevant for residential buildings.
- School users: including both school employees and school students. This target group is not only relevant for educational buildings, but also to start awareness sessions in young generations to increase the acceptance of the CPCC concept.
- Experts: Including architects, engineers and academic communities, who can contribute with their expertise and at the same time, learn from both retrofitting actions and innovative social engagement methods.

TRENTO, ITALY

The Italian demo case is a large area in Destra Adige in the Piedicastello district in Trento, a city in northern Italy. It is one of the oldest districts in Trento and lies surrounded by the right bank of the Adige River and at the foot of the hill called "Doss Trento", which represents the main landmark of the area. The administrative district comprises 859,95 hectares and includes **20,696 residents** out of 118,288 at the city level. Female residents are equal to 51%; the total number of foreign residents is 18.6%. Piedicastello demo is complemented by an existing '70s residential building in the uphill Povo District, which is used as a testing site for hybrid renovation works (private building with 8 apartments, hybrid renovation comparing ETICS to innovative prefabricated facades).

The main business model developed and tested in the Trento demo is establishing an industry led one-stop-shop supporting large-scale district renovation. The main goals of this initiative are to:

- Establish a multi-stakeholder approach from the very beginning of the ARV project, by addressing Piedicastello residents, the community, and the local authorities, and involving them in the deployment of the demo activities.
- Develop a One-Stop-Shop approach for energy refurbishment of buildings, bringing together aggregated demand and supply of renovation works on the existing buildings of the district.
- Familiarize the residents with the available circular and sustainable technologies for the construction and renovation of buildings (i.e., wood value chain) and on the multiple advantages of these solutions.

- Expose the residents and the community to be an active part of energy transition through the deployment and installation of renewable energies facilities (i.e., geothermal energy).

The target groups of the Trento LL activities are mainly **the suppliers, citizens and the community** who live in Piedicastello, but also in other areas of Trento (such as the Povo district). Some of the citizens joined in a local association called Piedicastello Committee that deals with long lasting urban regeneration concerns and issues on the district level. Others are organised in a District Board/Council consisting of citizens of Piedicastello often interested in the political level of the city. They collect concerns of the district's citizens and deliver them to the municipality.

Other important stakeholders include the municipality of Trento, namely the administrative (municipal officers, e.g., Department of Mobility and Urban Renovation Service) and political persons (city councillors in charge of green transition, territorial planning and social housing). Additional important groups consist of the director and managerial staff from the art gallery and representatives of building managers in Trento (i.e. people in charge of condominium administration and residential building management).

UTRECHT, THE NETHERLANDS

The ARV Living Lab in Utrecht in the Netherlands focuses on two districts: the Overvecht-Noord district in the north and the Kanaleneiland-Zuid district in the south of Utrecht. Both districts were built in the 1960s and 1970s to account for the quick rise in urban population and are in general of low-quality. Both districts share the characteristics of lively multi-cultural districts, with high share of social housing, schools and shops, and a majority of low-income households.

Overvecht is a typical example of what Dutch media refer to as a "vulnerable" neighbourhood. Many residents struggle to make ends meet, find a job, stay healthy or feel at home in the neighbourhood. Compared to the average of the city of Utrecht, the percentage of inhabitants in Overvecht with very low income is almost double. Both districts have a triple energy infrastructure: a district heating network, gas infrastructure for home-boilers and an electricity grid.

There are multiple issues and trends that need to be tackled when working towards climate positive circular communities in the area. This requires a multi-faceted and integrated solution approach. In the Overvecht district, a large governmental program is being implemented with coordinated investments in the social domain, schools and education, health and welfare and improvement of the public space. This program is complemented by investments from the social housing corporations in the physical renovation of the district. However, physical renovation alone is not enough; there needs to be a better mix of income groups, education groups and age groups to improve the district. The intention of creating a greater variety of the population ("mix") in the area in the long run is part of the renovation programs the social housing corporations are implementing. In the district of Kanaleneiland, a similar program is currently being developed.

- The housing corporations (Woonin and Bo-Ex) are approaching and engaging the tenants, involving the "Social renovation team" where needed.
- Close cooperation between the housing corporation (Woonin) and respective support teams at Utrecht municipality (Social development department, Social Team)
- Socio-cultural actors are also at work on a local level to visit tenants before renovation to increase cohesion and identification of welfare issues.

Dutch housing associations own 30% of all Dutch homes. Therefore, they are often mentioned as the starter engine for the Dutch heating transition. Additionally, the Dutch government put the ambition forward to be 100% circular in 2050. By renovating as circular as possible, housing associations can play a major role in the transition to a circular housing stock.

Most Dutch buildings are heated with natural gas. As part of the Dutch climate agreement, all buildings must be heated emission free by 2050[2]. This demands renovation for most of the built environment. At the same time, the Netherlands experiences net congestion on all voltage levels of the electricity grid. Therefore, getting an enlarged grid connection is often a challenge.

SØNDERBORG, DENMARK

The Danish demo case is located in the central part of Sønderborg. Sønderborg has 76 000 inhabitants and is the southernmost municipality in Denmark. The ARV demo area is called SAB Department 22 Kløvermarken/Hvedemarken, and consists of 19 low-rise, social housing apartment blocks of 3 floors, in total **432 rented apartments** with a floor area of 32,000 m². The apartment blocks were constructed in 1970-1973.

The buildings were constructed in 1970 and renovated in 2010. In 2010, the buildings were renovated with more insulation, new energy efficient windows, new radiator systems and new district heating substations with heating controls connected to Danfoss Portal. There are 9 sub-stations covering the 19 apartment blocks.

In 2017, more than 3,000m² solar PV panels were integrated in the roofs of all 19 apartment buildings. The solar PV system can produce 460 kW solar electricity corresponding to 408,000 kWh per year covering 37 % of the total electricity consumption in the 432 apartments. At the same time, new LED outdoor lamps were implemented around the apartment blocks and in the corridors and basement.

In 2021, storage batteries were added to the solar panels in the 19 blocks, each with a storage capacity between 10 and 30 kWh depending on the number of apartments in each block. In 2021, Danfoss Lean Heat system was implemented in all buildings using artificial intelligence to control and monitor the centrally heated buildings.

833 residents live in Kløver/Hvedemarken SAB dept. 22 (data from 2021). The share of immigrants/descendants from non-Western countries is 48.38 %, seen in relation to Sønderborg Municipality and the national average. There is an average of 2.0 people per apartment.

Sønderborg's demo site is also focused on reducing the return temperature from the buildings to the district heating network, as this can provide a financial gain for the housing association and tenants. This is done via two parallel efforts:

- The first: a technical aftercooling solution implemented by demo partner, Danfoss. This takes place in the basement of the buildings.
- The second (also the Living Lab): a behaviour-driven solution aimed at residents, which is about getting residents to optimize their energy consumption, including their heat consumption. Here digital tools (Brunata app) and behavioural learning tools are used to reach the residents and to influence their behaviour.

The main areas for business model development at Sønderborg's demo are developing an Energy Service Company (ESCO) for solar energy production and improving the efficiency of district heating through a combination of technological developments and resident engagement.

[2] *Delft, CE Delft (2022) "The natural gas phase-out in the Netherlands".* https://ce.nl/wp-content/uploads/2022/04/CE_Delft_210381_The_natural_gas_phase-out_in_the_Netherlands_DEF.pdf

KARVINÁ, CZECH REPUBLIC

The Czech demo case surrounds the Karviná Mizerov Health Centre in the city of Karviná. The building was constructed in 1993 and has been renovated. It is partly rented to private specialist practices, and the current occupancy of the building is approximately 50%. The city of Karviná is characterized by two main demographic trends – decrease in the number of inhabitants and ageing of the population, which is the common trend of the region as a whole.

One of the main projects championed by the municipality is the positive energy district (PED) concept that has been already introduced in Karviná. The Karviná Mizerov Health Centre is part of 9 municipality buildings (others being schools, sports facilities, nursing home) located within a radius of 500 meters that is part of the first phase of PED development in Karviná. Based on the municipality strategies and plans, the PV forecasting solution piloted in the demo building will have a great potential to be replicated in other buildings, as well as scaled up to a larger scale (district level).

Main groups are the building owners as well as the private doctors and medical staff and the medical patients. The health centre consists of dental, allergy and other outpatient clinics. The patients are of mixed age groups, not just the elderly.

One of the stakeholders (The Veolia division - Veolia Energie CR) will contribute to the demo building by providing technology for BAPV and car charging stations. Included in the category are:

- Big energy companies such as Veolia, OKD or Diamo.
- Housing companies such as Heimstaden or SBD Drubyd.
- Real estate group, owner of land and leasing office buildings Asental.
- Public administrative office of the Moravian-Silesian Region.
- Local companies, hospitals, spa, retail, culture, sport etc.
- Schools, university, local communities, and NGOs

The groups that the demo does not directly affect, but which will be involved through the planned Living Lab activities, are students of secondary and high schools, and selected institutional stakeholders.

4. DRIVERS AND ENABLERS OF BUSINESS MODEL INNOVATION

The building sector in the EU remains one of the key contributors to greenhouse gas (GHG) emissions, coming mainly from fossil fuel heating systems and electricity and heat production and representing 35% of energy-related EU emissions in 2021[3]. Beyond energy, the new EU Circular Economy Action Plan[4] states that the construction sector requires vast amounts of resources and accounts for about 50% of all extracted materials. The sector is also responsible for over 35% of the EU's total waste.

A paradigm shift is needed to create business models that can support the speedy scale up of net zero-emission buildings and neighbourhoods through energy-efficient, circular, and digital solutions in the construction and building renovation industry. It is imperative to move away from the current, linear business models and towards circular and climate positive models that create value beyond the financial and consider the distribution of burdens and costs in a more fair and sustainable way. The project takes on this challenge and through co-creation and business model innovation has developed blueprints for climate positive business models, presented in detail in chapter 6.

WHAT IS BUSINESS MODEL INNOVATION?

A business model can be defined as something that "**defines how firms create, deliver, and capture value in a market"** [5]. Business model innovation, therefore, refers to the process of modifying or developing those elements to create new value propositions or capture new market opportunities. Value can refer to economic or financial value, but also to other factors such as regulatory compliance, health benefits, social inclusion or improvements in the quality of life of citizens. The key is to find and articulate the right combination of values for each stakeholder group.

DRIVERS

IMPACTS

The need for business model innovation is increasingly driven by a growing awareness of the environmental and social impacts caused by businesses. According to a 2023 Eurobarometer survey [6], 53% of Europeans think that business and industry are responsible for tackling climate change and three quarters of respondents agree that addressing climate change will lead to innovation that will make EU companies more competitive. Consciousness of how business operations affect ecosystems and communities can prompt companies to rethink and redesign their strategies to mitigate negative impacts and enhance positive contributions.

Environmental and social impacts are indeed seen as a business opportunity. As stated in the European Council conclusions,

> *"The transition to climate neutrality will bring significant opportunities, such as potential for economic growth, for new business models and markets, for new jobs and technological development. Forward-looking research, development and innovation policies will have a key role."* [7]

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[3] *EEA, 2023. https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-energy*
[4] *COM (2020), A New Circular Economy Action Plan. For a cleaner and more competitive Europe.*
[5] *Teece, 2010. "Business Models, Business Strategy and Innovation" https://doi.org/10.1016/j.lrp.2009.07.003*
[6] *Eurobarometer, July 2023 https://europa.eu/eurobarometer/surveys/detail/2954*
[7] *European Council meeting (12 December 2019) – Conclusions https://www.consilium.europa.eu/media/41768/12-euco-final-conclusions-en.pdf*

The ARV project is developed within the framework of the EU's Horizon funding programme in support of the European Green Deal and its ambition for the block's climate neutrality by 2050. Therefore, a set of expected environmental, social and economic impacts are at the core of the project. Figure 2 shows an overview of ARV's impacts and the associated Key Performance Indicators (KPIs). These indicators have also guided the development of climate positive business models described later in this report.

Figure 2. *ARV expected impacts and KPIs*

ECONOMIC FACTORS

Economic factors are another important driver for business model innovation. Public subsidies and financial support provided by the EU through NextGenerationEU[8] investments, and the Recovery and Resilience Facility[9] have boosted the sustainable construction and energy renovation industries, which has supported industry growth and improved solution accessibility for the end users. For instance, Italy's 110% "Superbonus"[10] scheme for building renovations, which was introduced in 2020, allowed homeowners, non-profit, social and voluntary organisations, and public social housing bodies (IACPs) to commission energy efficient and structural improvements to their properties, with the 100% of the costs covered by the Italian state. The implementation of the scheme has not been without its problems, but it has played an important role in developing timber-based and circular retrofitting solutions and an associated, industry driven one-stop-shop in the Trento demonstration community.

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[8] https://next-generation-eu.europa.eu/index_en
[9] https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en
[10] https://commission.europa.eu/projects/superbonus-strengthening-ecobonus-and-sismabonus-energy-efficiency-and-building-safety_en

Though public subsidies and support provided by EU governments have created an early economic stimulus toward energy renovation projects, public money alone is not enough. For energy efficiency alone, the estimated annual investment needed to retrofit EU's building stock by 2030 is **€275bn** [11]**.** Unlocking necessary private finance requires, among many other things, new business and value capture models[12]. To do that, business model innovation across the entire retrofitting and energy operation value chain and for different real-estate ownership structures (social housing, rental and privately owned) and customer types is needed. To that effect, the ARV project has developed ESCO-like business models and retrofitting management services that effectively enable or sell energy efficiency through offering cost or bill savings for the end customer. In all cases, these economic gains were identified as key to the value proposition for the end customer to carry out and finance energy retrofits.

On the macroeconomic scale, $44 trillion of economic value generation, representing over half the world's total GDP, is moderately or highly dependent on nature and its services according to the World Economic Forum's estimation in 2020. At $4 trillion, the construction industry is the most dependent of all economic sectors[13]. This strong dependence on the natural world means that environmental degradation and climate shocks can lead to higher costs for raw materials and disruptions in production, which prompts businesses to innovate in ways that reduce their environmental footprint and increase resilience. Additionally, rising construction costs and high interest rates are pushing companies to find more efficient and sustainable ways to operate, leading to innovative approaches that balance economic and environmental considerations.

REGULATION

Thirdly, increasingly strict regulations put pressure on businesses to innovate and can create new market opportunities. The EU has implemented a range of stringent environmental and social regulations to address climate change and promote sustainability, from the spring 2024 recast of the Energy Performance of Buildings Directive (EPBD)[14] to the amended Renewable Energy Directive (RED III)[15] or the Energy Efficiency Directive[16]. These regulations change the landscape in which businesses in the built environment and the construction sector operate by introducing targets and restrictions but also setting a direction of travel for the industry for the future.

In addition to the EU level regulation, the ARV demonstration communities also work in the context of national and local regulations. For instance, in Denmark, the local district heating companies typically have targets of reducing energy delivery per m2 and GHG emissions, and a bonus tariff system is in place for users who comply. This has created financial incentives for products and services that enable those reductions. Spain introduced energy savings certificates (certificado de ahorro energético, CAE) at the start of 2023[17], which emerge from the legal obligation of energy companies to contribute to the

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[11] *EEA, 2023. "Investments in the sustainability transition: leveraging green industrial policy against emerging constraints"* https://www.eea.europa.eu/publications/investments-into-the-sustainability-transition
[12] *EEA, 2024. Accelerating the circular economy in Europe.* https://www.eea.europa.eu/publications/accelerating-the-circular-economy
[13] *World Economy Forum, 2020. Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy.* https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf
[14] *Energy Performance of Buildings Directive* https://eur-lex.europa.eu/legal-content/EN/TXT/uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive
[15] *Renewable Energy Directive III* https://eur-lex.europa.eu/eli/dir/2023/2413/oj
[16] *Energy Efficiency Directive* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_231_R_0001&qid=1695186598766
[17] *Sistema de Certificados de Ahorro Energético (CAE)* https://www.miteco.gob.es/es/energia/eficiencia/cae.html

National Energy Efficiency Fund both directly and through financing energy efficiency projects resulting in energy efficiency certificates. This creates a new finance stream for energy efficiency works and improvements, either for homeowners or residents or another party financing the works.

ENABLERS

DATA AND DIGITALISATION

Data from and digitalisation of the built environment create and visualise new value streams and multiple benefits of climate positive and circular communities as data-driven insights. It also enables increases in efficiency and optimisation, scalability and replication.

In the context of climate positive models, data is crucial for understanding the current state of the environment, energy usage, and other building related factors. Accurate and real-time data enables a more precise understanding of the environmental impact and the potential for improvement. Continuous monitoring of buildings provides valuable data about building energy performance and reductions in energy consumption and/or emissions intensity of that energy consumption. These can create and visualise new value streams and financeable metrics. Tracking energy, emissions, materials, comfort, pollution, user behaviour, and micro-climate related data from the demonstration buildings allows improved energy management. It can unlock the flexibility potential of CPCC, which can later be commoditised and traded through energy trading or P2P platforms. Impact investors and financial institutions can also use data-driven metrics to assess the impact and viability of climate-positive models, making them more attractive for investment. This, in turn, can accelerate their development.

DATA DRIVEN INSIGHTS TO DETERMINE AND PRIORITISE RENOVATION NEEDS

Aside from the impact of real-time impact monitoring, data can improve the speed and effectiveness of decision-making processes towards climate positive buildings, as further described in D5.1. Open data can aid in multi-criteria analyses for project selection by building owners and policymakers in a process called the 'pre-recognition workflow'. Technical, social, economic and environmental criteria assessed by data acquisition dictate the prioritisation of product systems toward particular building types. The acquired data then also aids in developing simplified parametric models that may be used for fast design visualisations, material passports and quotations in the 'pre-manufacturing workflow'. Once project development has been boiled down to particular buildings, on-site inspections deliver enough information to make digital designs down to mm-resolution. Developed designs of products like prefabricated façade panels can be immediately translated to factory processes such as precision-cutting of window frames ('File2Factory').

DIGITAL TOOLS

One of the innovative ways of leveraging digital tools in the project is their use to enable multi-stakeholder co-creation and new forms of engagement. Different 3D and/or visualisation techniques of Virtual Reality (VR) and/or Augmented Reality (AR) are developed and used in the project during the development of the Oslo and Palma demos to better communicate results of different scenario analyses to different types of stakeholders, to facilitate citizen engagement, and to promote education and training for sustainability. AR and VR tools are promising to better communicate and evaluate different solutions to specific problems, as well as to channel users' input and experiences, facilitating their active engagement and are a demonstration of community engagement platforms for awareness raising, occupant insight and well-being, and co-creation.

PEOPLE AND PLACE-SPECIFIC APPROACH

Integration in the ARV project is defined as the coupling of people, buildings, and energy systems through multi-stakeholder co-creation and the use of innovative digital tools. The planning and development of a CPCC is complex and must involve a diversity of stakeholders and actively work with community engagement methods and tools to include end users in the process to utilize their competences, experiences and to address their needs. This is reflected especially through the work of WP3, whose approach is centred around the idea that sustainable neighbourhood transformation arises from building and renovating in an energy and resource efficient way, along with promoting active community engagement to increase the awareness and acceptability of the solutions.

By focusing on people, we address the multitude of needs and values of different stakeholders in the value chain, from end-users to manufacturers and solution providers, and to policy makers and financing institutions. This way, the solutions can be tailored to the local context and addresses region-specific challenges and opportunities. Conversely, it is also looking at the solutions to consider systemic impacts and interactions within the region or across projects and align with regional strategies and policies for scalability.

5. BUSINESS MODEL BLUEPRINT DEVELOPMENT IN ARV

ARV COOKBOOK APPROACH

The approach to the business model blueprint development and testing in ARV builds on work done by the UN Climate Change Global Innovation Hub's Cities Working Group and developed together with GDFA, KPMG, Global Covenant of Mayors and ICLEI, and other partners.

The cookbook approach empowers cities to design and engage in local, needs-driven, and dynamic solution development cycles - through the culinary analogy of crafting exciting dishes that meet need, follow a flexible structure, and invite innovation. This is not a static nor prescriptive process but a feedback loop. The intention is that the cookbook framework informs the project work, and vice versa.

This methodological lens was applied to the ARV project, transitioning from the methodology to a process, as shown in the figure 3 below.

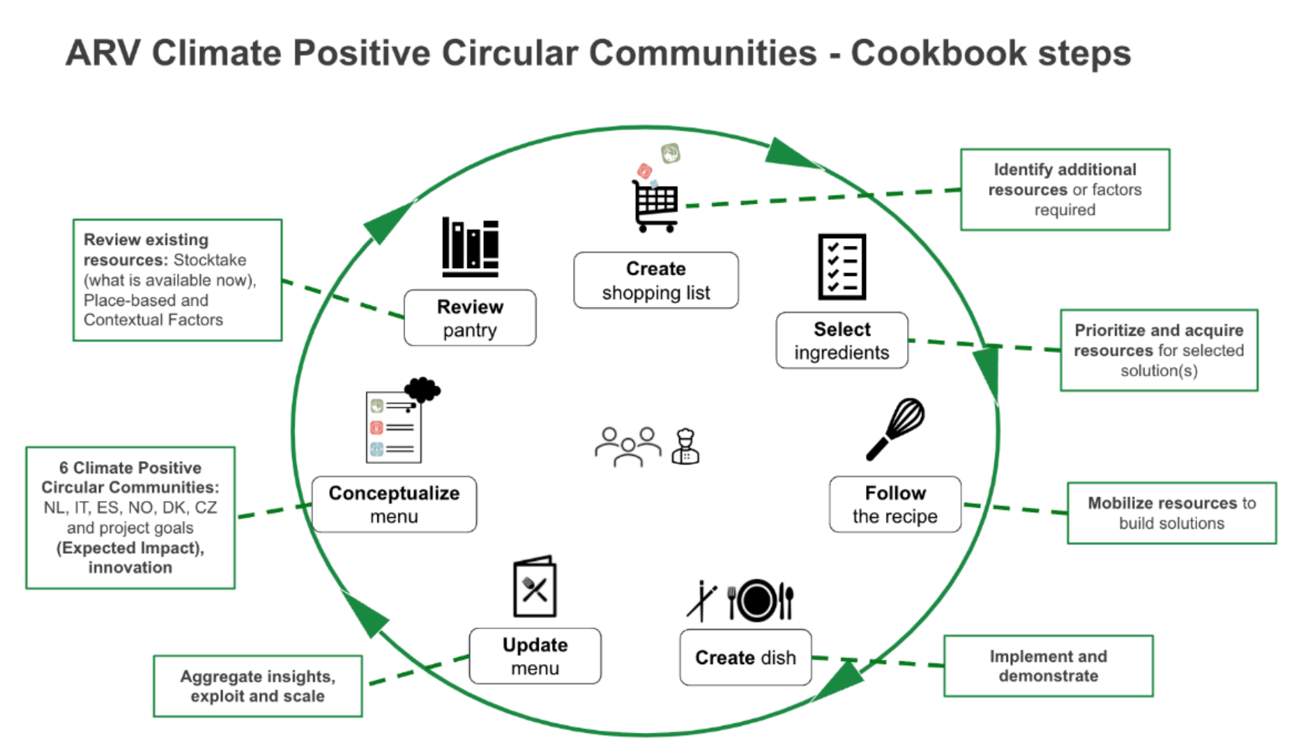


Figure 3. *Cookbook approach applied to ARV (figure: UN Climate Change Global Innovation Hub)*

APPLICATION IN THE ARV PROJECT

Contextualising the approach started by mapping the landscape of existing and scalable business models and financial instruments for energy efficiency and retrofitting adaptable to EU. This led to the creation of a crowd-open-sourced encyclopedia and online catalogue of energy efficiency enablers for buildings renovation and construction, **Encyclopenergy**[18]. From this, the context within which each demonstration community started developing.

The business model development in the ARV project is led by business model teams within each project demonstration site. This means they emerge from the local stakeholder and innovation ecosystem and

[18] *Encyclopenergy, https://encyclopenergy.org/*

partnership and respond to local climate conditions, sustainable and human development priorities and locally relevant impact KPIs.

Regular bilateral and small group meetings with each business model development team were held throughout the first three years of the project in constant iteration to review existing and identify additional resources and future development steps. This process was iteratively captured in collaborative, dedicated online whiteboards, which also formed the basis of the business model blueprints. More detailed and quantitative inputs were collected in an excel format to allow for standardised input collection and comparison of across the key categories: business model context, stakeholders, non-financial data, financial model and data, policy and regulation and place-based and contextual knowledge.

This report presents business model blueprints generated from this process. The aim of the blueprints is to provide a design, that allows the replication of these models, both locally and across other regions in the EU under supportive local conditions. At the time of writing, most business models are implemented in the demonstration communities in line with the overall project timeline. The results and learnings, where available, will be integrated to the exploitation activities through the workstreams of the ARV Exploitation Board and Scaling the innovations through local innovation clusters. This way, the methodology emphasises a continuous cycle of review, adaptation, and scaling, ensuring that the development of climate positive circular communities is both responsive to local conditions and capable of broader application across Europe.

6. ARV PROJECT BUSINESS MODEL BLUEPRINTS

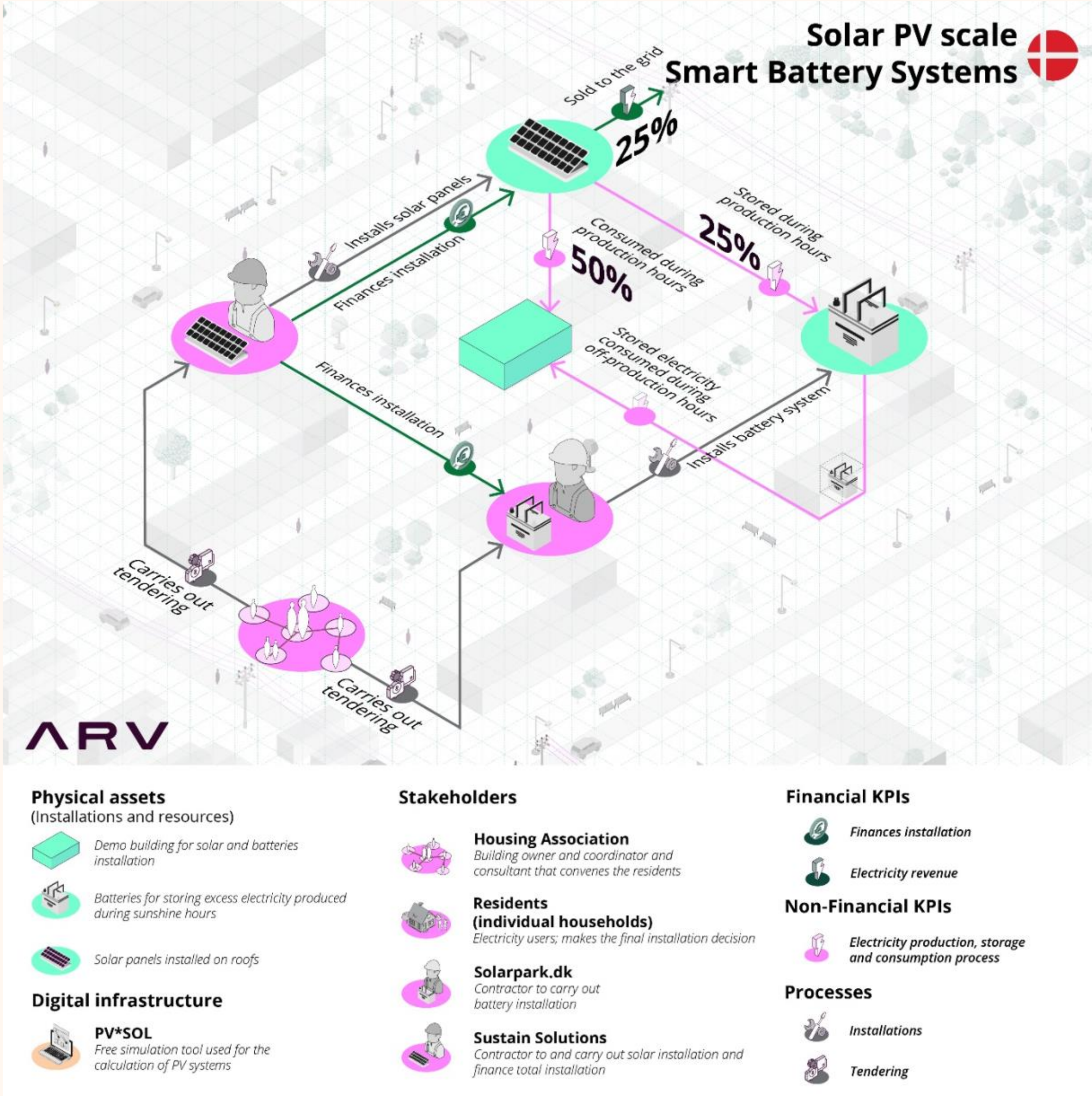
OVERVIEW OF BUSINESS MODELS IN ARV

Seven blueprints for climate positive business models retrofitting and energy operation value chain were co-designed and developed with the following ARV project demonstration communities: Palma de Mallorca, Spain; Trento, Italy; Utrecht, the Netherlands; Karviná, Czech Republic and Sønderborg, Denmark.

Solar PV scale Smart Battery Systems	**Retrofitting Management Entity**	**One-stop-shop for building renovation**	**Forecasting as a Service: PV Forecasting**	**Inside Out - heating as a service**
Aftercooling	**Publicly funded energy shared self-consumption**			

The business models are designed for various real-estate ownership structures: social housing, rental and privately owned or mixed and public buildings. This chapter presents the blueprints one by one, aiming for a sufficient level of detail to allow the replication of these models across other regions in the EU by local actors. Each business model is presented in a standard format to allow a smooth reading and accessible insights and hopefully sparking the interest of the reader to dive deeper into the subject matter. Along with the presentation of the blueprints, an economic analysis for five of the seven business model is presented, detailing the costs and earnings of each main stakeholder.

ESCO: SOLAR PV SCALE SMART BATTERY SYSTEMS



BUSINESS CHALLENGE

The electricity consumption of buildings and households requires decarbonisation, and one of the methods is installing solar panels on the roofs of buildings. This, however, comes at a high initial cost, making it cost prohibitive for many households. Furthermore, electricity consumption from solar panels alone is not sufficient to cover the electricity demands of the households due to the nature of solar energy. Therefore, a solution combining solar PV panels and batteries was required.

The most common method of financing solar systems would be to arrange a mortgage, guaranteed by the municipality in the case of social housing associations. In usual circumstances, the building is considered sufficient collateral. However, the association had carried out various renovation projects in recent years, financed with a mortgage, so there was not enough financial room to provide security for a new mortgage. Therefore, an alternative financing method was required.
The table 1 below describes in more detail the challenges of each key stakeholder.

Table 1. *Roles and challenges of key stakeholders in relation to the ESCO: Solar PV Scale Smart Battery Systems business model*

Stakeholders and roles	Stakeholder challenge(s)
SAB-Sonderborg Housing Association: Building owner that coordinates and convenes the residents and carries out project tendering	Should contribute to the municipality's carbon neutrality plan, rising energy costs put financial pressure on residents, not enough financial room to take out a loan for installations
Contractor: Carries out solar installations and finances total project installation	Need for predictable revenue and growth
Social housing tenants: Electricity users and customers, who make the final installation decision by a vote at the housing department meeting (majority decision)	Electricity is expensive and pricing is hard to understand; some households are environmentally conscious and want to use renewable energy but lack financial means to pay the installation costs upfront

VALUE PROPOSITION

An Energy Services Company (ESCO) helps households reduce energy costs, improve efficiency and switch to renewable energy by offering energy solutions, such as infrastructure upgrades and energy management systems. They address the challenge of high energy expenses, often providing financing options or performance-based contracts that eliminate upfront capital costs for clients. This model was utilised in the case for the Sønderborg demo as an alternative to a mortgage.

At the tendering phase, the contractor was asked to provide financing in addition to the delivery and installation of the solar PV and battery systems. As a result, a private company offered project delivery and financing for a rooftop solar and battery installation for 19 social housing apartment buildings. Customers (individual households in each housing association) obtain bill savings from the self-consumed electricity and pay the company back through these savings. After the installation is fully paid, it is owned by the housing department and continues to provide bill reductions for tenants.

The table 2 below describes the value proposition in detail for each key stakeholder.

Table 2. *Benefits for key stakeholders in relation to the ESCO: Solar PV Scale Smart Battery Systems business model*

Stakeholders	Stakeholder benefit(s)
SAB-Sønderborg Housing Association	Renewable energy installation to its buildings, improved payment capacity of tenants
Contractor	Steady and long-term revenue from electricity sales, access to a wider customer base
Private tenants, privately owned apartments	Significant energy bill reductions once investment is paid back without an increase in rent increase, access to clean energy
Social housing tenants	Significant energy bill reductions once investment is paid back without an increase in rent increase, access to clean energy
Sønderborg Municipality	Progress towards city's carbon neutrality plan and commitment through reduced GHG emissions from electricity generation

UNIQUE SELLING POINT (USP)

Roof-integrated solar panels aren't new but combining them with battery storage in buildings is. Instead of individual main electricity meters, apartments now use internal meters. The solar panels send electricity to the building's main meter, and any excess is stored in batteries for later use, reducing the need to sell surplus energy to the grid at a low price. With batteries, 75% of solar energy is used on-site, compared to 50% without them. This is economically favourable, since solar energy consumed in the building is valued at €0.40/kWh, while grid-sold energy is worth only €0.07/kWh.

ECONOMIC ANALYSIS

The reference case for the economic analysis of this business model involves 19 housing blocks, each equipped with its own solar PV system and battery storage, serving a total of 432 apartments. The solar PV installation spans a surface area of 2,870 m^2, with a combined battery capacity of 270 kWh distributed across all buildings. The system is expected to generate an average of 447,000 kWh of electricity per year. The financing, installation, and operation of the system are coordinated among three key stakeholders: Sønderborg Housing Association, the contractor, who handles both installation and financing, and the social housing tenants, who ultimately benefit from the energy savings.

Contractor 's perspective

The contractor plays a pivotal role by bearing the initial costs of installing the solar PV and battery systems across the 19 housing blocks, with a total investment of €1.8-1.9 million. This includes the solar PV installation, battery storage, cabling, roof construction for adapting the PV system, and other electrical work. In addition to these direct costs, the contractor charges a 3% financing fee over the payback period, which is estimated to last 8-10 years. During this period, the contractor's revenue stream is derived from the energy savings tenants achieve through self-consumption of solar energy, expected to cover 75% of total PV production. Tenants repay the contractor through their utility bills. Additionally, the first simulation shows that about 25% of the solar electricity is in excess and therefore sold to the grid, and the housing association receives payments for this energy. The combination of self-consumption and grid sales ensures the contractor secures a stable revenue stream, while also gaining access to a broader customer base for future energy projects. After the payback period, the contractor's involvement concludes, and ownership of the system transfers to the housing association.

Sønderborg Housing Association (SAB) and tenants' perspective

SAB serves as the building owner and plays a critical role in coordinating the project. It is responsible for project tendering, selecting contractors, and convening the residents for key decisions. While the contractor finances and installs the solar PV and battery systems, SAB does not bear any upfront costs. Instead, it oversees the project and facilitates the tenants' involvement in the decision-making process. The tenants of the 432 social housing apartments are the electricity users, who ultimately decide on the installation through a majority vote at the annual housing department meeting.

During the payback period, both SAB and the tenants do not see immediate financial benefits from reduced electricity bills, but also not incur any additional costs during this time, as the savings from self-consumed solar energy are redirected to repay the contractor. After the payback period, ownership of the solar PV and battery systems transfers to SAB, and both SAB and the tenants begin to benefit from the system. Tenants will see direct bill reductions as the consumption of self-generated solar energy—which covers around 30% of total energy consumption—replaces more expensive grid electricity (valued at €0.40/kWh), providing long-term savings without increasing rent. Additionally, the surplus electricity (not self-consumed) is sold to the public grid, generating additional revenue for SAB at a rate of €0.07/kWh. This revenue is used by SAB to further reduce tenants' electricity costs, providing a dual financial benefit for tenants. SAB will be also responsible for operational and maintenance costs post-repayment, ensuring the continued functionality of the system. By managing the coordination of the project and ensuring long-term operational efficiency, SAB facilitates both immediate environmental benefits and long-term financial savings for its tenants.

Table 3. *Stakeholder disaggregated costs and returns of ESCO: Solar PV Scale Smart Battery Systems business model*

	Contractor			Housing Association and Tenants		
	Unit	Value	Notes	Unit	Value	Notes
Costs	€/m2	367	Total cost for PV installation (570kWp), including VAT, for 19 buildings (432 apartments)	**During the payback period**, tenants do not face additional costs but do not benefit from bill reductions, as the savings from self-consumed solar energy are used to repay the contractor.		
	€/apartment	926	Roof construction costs for adapting the PV installation			
	€/kWh	926	Total cost for batteries (270 kWh), including VAT			
	€/apartment	93	Costs for cabling	€/year	15,800	Operational and maintenance costs post-installation
	€/apartment	116	Costs for blackboards (electrical work)			
Revenues/ Savings	%	3	Financing fee over the payback period calculated on the total investment	€/apartment per year	310	Yearly savings due to the electricity produced by PV and self-consumed **after the payback period****
	€/apartment per year	310	Yearly revenues from the electricity produced by PV and sold to tenants **during the payback period****	€/year	7822	Total yearly revenues from the surplus of electricity produced by PV and sold to the grid **during and after the payback period****

** Calculated assuming a total average solar production of 447,000 kWh per year (for 432 apartments), 75% of self-consumption share (including batteries), 25% of electricity sold to the grid, 0,4 euro/kwh for electricity sold to tenants, 0,07 euro/kwh for electricity sold to grid.

Table 4. *Investment / Return Contribution calculation for ESCO: Solar PV Scale Smart Battery Systems business model*

		Project				Per apartment			
		unit	value	EUR one-off	EUR p.a.	unit	value	EUR one-off	EUR p.a.
Cost / Investment	Apartments	#	432						
	PV Size	sqm	2,870			sqm/apart	6.64		
		EUR/sqm	367.00	1,053,290.00		EUR/apart		2,438.17	
	Rooftop construction	EUR		400,032.00		EUR/apart		926.00	
	Batteries Size	kWh	270			kWh/apart	0.63		
		EUR/kWh	926.00	250,020.00		EUR/kWh		578.75	
	Cabling	EUR		40,176.00		EUR/apart		93	
	Blackboard	EUR		50,112.00		EUR/apart		116	
	O&M costs	EUR			15,800.00	% of the total			36.57
	Financing fee	% p.a.	3%			% p. a.			
	Total	EUR		1,793,630.00	15,800.00	EUR/apart		4,151.92	36.57
Return	Electricity sold	EUR			7,822.00	EUR/apart			18.11
	Energy Savings	EUR			133,920.00	EUR/apart			310.00
	Residual value of PV	EUR	0.00			EUR/apart		0	
	Residual value of Batteries	EUR	0.00			EUR/apart		0	
	Total	EUR		0	141,742.00	EUR/apart		0.00	328.11
	Investment / Return Contribution	EUR		-1,793,630.00	125,942.00	EUR/apart		-4151.92	291.53
	Payback Period	Years	14.24						

Color Legend	
(green)	Value referenced in D9.3
(orange)	Assumption
(purple)	Key Indicator

Electricity Purchase Price	0.4	EUR/kWh
Electricity Sold Tariff	0.07	EUR/kWh
Energy Surplus	111,742.86	kWh p.a.
	258.66	kWh/apart p.a.
Average solar Radiation	1000.00	kWh/sqm
Efficiency	15%	%
Total Energy Produced	996.53	kWh/apart
Self Consumption	74%	
Sold to grid	26%	

MAIN CHALLENGES OR RISKS AND THEIR MITIGATION

Governance

The installation proposal must be discussed with all the tenants in the department, who have to approve the proposal and the financial consequences at a general tenant meeting of the department. In Danish Social Housing Associations with rental apartments, proposals can be approved by a simple majority among tenants present at the annual meetings.

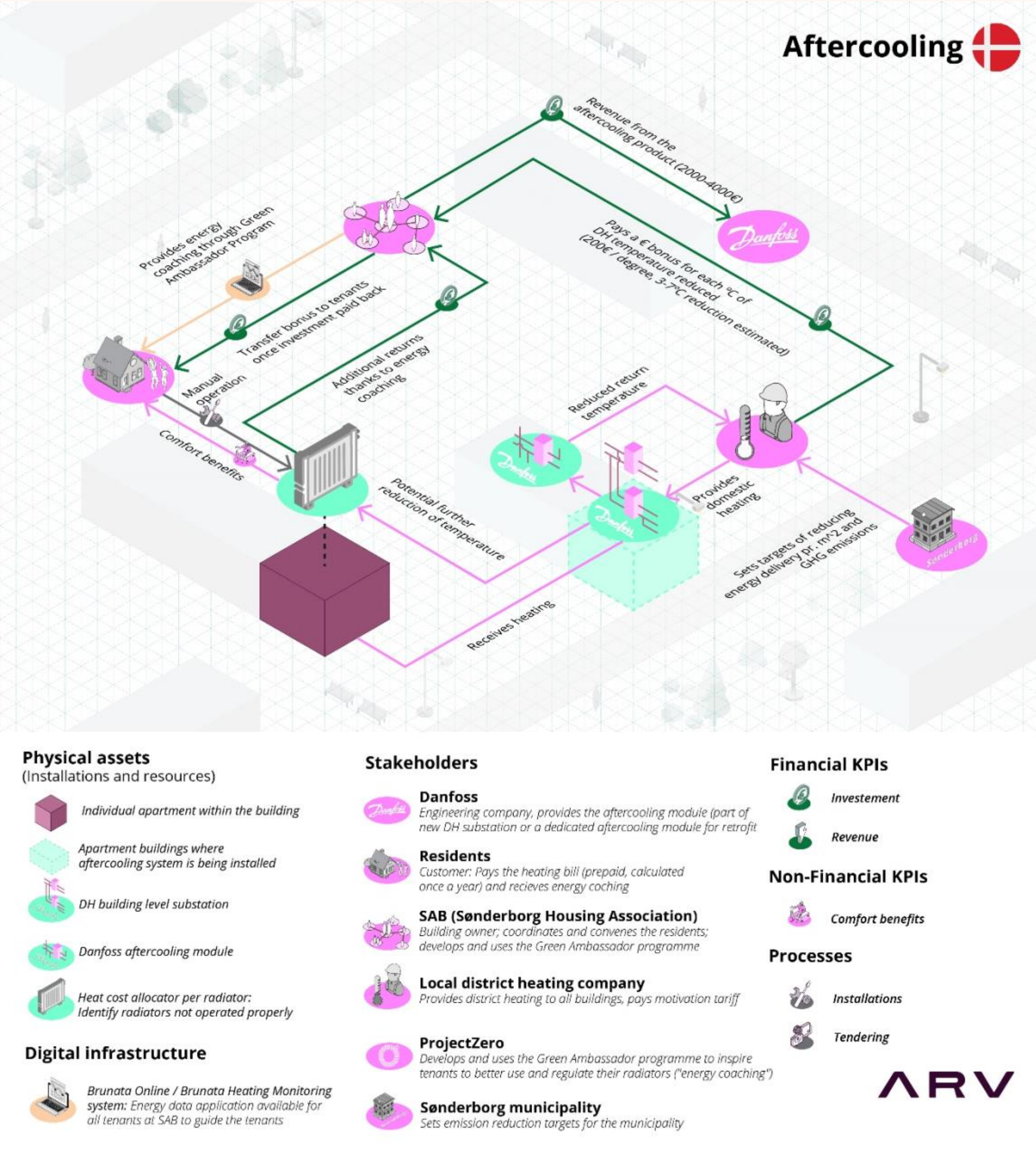
At the time for approval, the electricity prices were close to a mid-range level compared to the yearly average, and reaching a simple majority was not difficult. Generally, if it is possible to show that the annual reduction in electricity costs is higher than the annual increase in costs for renting the apartment, an installation proposal will normally get through.

Electricity pricing

The energy price is a crucial factor in assessing the economic feasibility of energy projects. The primary revenues typically come from savings through self-consumption and from selling surplus energy, both of which are directly influenced by electricity market prices. Given the typical 20-year lifespan of energy projects, relying on current market prices to predict future revenues can be a risky assumption. Such an approach may lead to inaccurate evaluations of key financial metrics, such as Net Present Value or Payback Time. To address this uncertainty, a sensitivity analysis is strongly recommended.

A sensitivity analysis can be conducted in various ways. One straightforward method is to create scenarios with different price trends, analysing how increases or decreases in energy prices affect the results. Alternatively, more advanced techniques involve modelling market dynamics to predict future energy prices, providing a deeper and more robust understanding of potential outcomes. A possible strategy for advanced market modelling is described later in this chapter, i.e. for Publicly Funded Energy Community, where it is applied to the Spanish energy market.

AFTERCOOLING



BUSINESS CHALLENGE

District heating (DH) is a common way to heat homes and buildings in Denmark. Despite the technology being widely used, the temperature in the local district heating network is often unnecessarily high, resulting in a high heat loss as well as an increase in costs. DH companies in Denmark typically have targets to reduce GHG emissions and energy delivery per m^2 of floor area from the energy they deliver, and a bonus tariff structure is in place in Denmark and South Sweden to incentivise this. A reduced district heating return temperature leads to a yearly bonus or income, but methods and solutions for achieving this are still emerging.

The table 5 below describes the challenges of each key stakeholder.

Table 5. Stakeholders and roles and their challenges related to the Aftercooling business model

Stakeholders and roles	Stakeholder challenge(s)
SAB-Sønderborg Housing Association: Building owner; coordinates and convenes the residents. Purchases the aftercooling system; develops and uses the Green Ambassador programme to inspire tenants to better use and regulate their radiators ("energy coaching")	Should contribute to the municipalities carbon neutrality plan, rising energy costs put financial pressure on residents
ProjectZero: Develops and uses the Green Ambassador programme to inspire tenants to better use and regulate their radiators ("energy coaching")	Reaching project energy efficiency goals, low level of tenant engagement in energy related topics
Social housing tenants: Pays the heating bill (prepaid, calculated once a year). Not directly responsible for paying the costs of the aftercooling system, but thanks to energy coaching can optimise radiator operation via heat cost allocators and general energy-saving practices, helping to reduce return temperatures.	Heating bills may be high, lower income households may have to cut down on energy spend to afford cost of living (leads to reduced indoor comfort), disconnect from own heating bills
Private industry company (Danfoss): Sells system and sells software license to building owner for improved operation (Leanheat part) that enables optimal operation of radiators and associated devices for maximum energy efficiency	Need for product innovation and revenue growth
A local district heating company: Provides district heating to all apartments; offers incentives for those who install the aftercooling unit but incurs no direct costs	District heating companies in Denmark typically have targets of reducing energy delivery per m^2 and GHG emissions.
Sønderborg Municipality: Sets emission reduction targets for the municipality	Achieving carbon neutrality, need for more efficient energy infrastructure

VALUE PROPOSITION

Lowering district heating return temperatures result in higher efficiency of the system, by reduced thermal loss in the distribution and by increased efficiency of the heat plant. Danfoss, a private industry company, has developed a solution to reduce the return temperature from the domestic hot water systems in the buildings. The concept is twofold: the aftercooling module and the optimisation of flat level radiator operation through tenant engagement and energy coaching.

The aftercooling module is a physical equipment, that can either be sold as part of a new district heating substation (new building or general retrofitting) or as a dedicated aftercooling module for retrofit. It is purchased as a one-time purchase by the housing association and is designed to lower the district heating return temperature from the building. The typical bonus tariff structure applied to local district heating companies is 1% of the variable energy costs for each °C reduced district heating return temperature. For a typical multifamily building such as the Sønderborg demonstration case, this represents 600-1400 EUR/year for the estimated potential of 3-7°C reduction. This bonus is the "income" to the building the owner.

Regarding the radiator operation, then efforts are made towards the tenants with the aim to motivate operation of the radiators in a more efficient way through energy coaching, leading to further reduction in district heating return temperatures. Input data is based on radiator level heat cost allocators.

The table 6 below describes the value proposition in detail for each key stakeholder.

Table 6. Aftercooling value proposition for each key stakeholder

Stakeholders	Stakeholder benefit
SAB-Sønderborg Housing Association	Increased resident satisfaction and energy security, benefits financially from the bonus tariff offered by the district heating utility.
ProjectZero	A relevant show case, and a contribution to reach the target of zero CO2 emissions by 2029 for Sønderborg.
Social housing tenants	They can achieve energy and monetary savings by practicing more energy-efficient behaviour in the apartment for their own benefit (comfort and economy), as well as for the larger community of the housing association.
Private industry company (Danfoss)	Steady & long-term revenue, access to a wider customer base as well as positioning and developing the concept of district heating
A local district heating company / DH utility	Reduced network thermal losses and improved efficiency due to the lower return temperatures, which are crucial for integrating low-temperature renewable energy sources. A greener and energy efficient district heating system, meet GHG reduction targets, give buildings the ability to operate with low temperature district heating, cost savings, longer lifetime of DH infrastructure.
Sønderborg Municipality	District heating creates local jobs and is the most cost efficient and green solution for providing heat based on socio-economic perspective.

UNIQUE SELLING POINT (USP)

The aftercooling concept is an innovative district heating (DH) substation for large multi-apartment buildings, where the domestic hot water preparation and reheating of the circulation flows are decoupled and obtained in two separate heat exchangers operating in parallel. The primary return temperature flow from the circulation heat exchanger is further cooled by the space heating system before returning to the DH network. The originality of the aftercooling substation lies in the potential to safely deliver sanitary water with DH flow temperatures as low as 55–60°C, fulfilling the Legionella control requirements and achieving low DH return temperatures at the same time. This complies with 4th generation district heating (4GDH) requirements, meaning operating at lower temperatures, facilitating a more cost-effective shift from fossil fuels to renewable or secondary heat sources. Furthermore, unlike previous studies, does not involve the integration of any electrical boosting units[19].

Furthermore, the aftercooling technical product and provided benefits can be complemented with tenants' involvement and encouraging them to optimise their operation of the heating system by better utilisation of the available radiator area in the apartments. This integration of engineering and social engagement (energy coaching with an energy data application called Brunata Online/Brunata) is an innovative approach, that could provide additional benefits and energy & cost savings for the building.

ECONOMIC ANALYSIS

The reference case for the economic analysis of the business model is a multi-family building with 45 apartments (SAB Dept. 22 demo building), with ownership and financial responsibilities structured

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[19] *Jan Eric Thorsen, Oddgeir Gudmundsson, Michele Tunzi, Torben Esbensen, 2024. Aftercooling concept: An innovative substation ready for 4th generation district heating networks, Energy, Volume 293.* https://doi.org/10.1016/j.energy.2024.130750

across three key stakeholders: Social housing tenants, local district heating company, and SAB (Sønderborg Housing Association). The main costs and gains associated with each major stakeholder in the business model are presented in table 8.

Social housing tenants' perspective

In the initial phase, tenants do not contribute to the upfront investment for the new system and, as a result, do not directly benefit from the energy savings and economic gains during this period. However, once the investment in the aftercooling module is repaid, ownership of the system transfers to the tenants, along with the associated financial benefits. According to preliminary estimates by the partners involved in the demonstration site, this transition is expected to occur within 2 to 5 years.

Tenants can play a role in increasing savings by optimizing radiator usage through the heat cost allocators. By doing so, a reduction of 3.5°C in return temperature can be achieved, leading to an estimated 2°C reduction at the building level and potential savings of €400 per year. The aftercooling concept further reduces the return temperature by an additional 1°C, adding another €200 per year in savings. Together, these measures create a 50% synergy increase in energy savings.

Social Housing's perspective

SAB is responsible for the initial investment in the aftercooling module. The cost of the module is €2,000 if integrated into a new substation design, or €4,000 in the case of retrofitting an existing substation. The higher retrofitting cost is due to additional labour required to modify the substation and reconfigure the pipes. These prices include the heat exchanger, control valves, temperature sensors, cabling, piping, and the assembly of these components.

The primary revenue source for SAB to repay this investment is a bonus tariff received from the District Heating company. This bonus is typically 1% of variable energy costs per 1°C reduction in DH return temperature, equating to €200 per year for a 1°C reduction in a building with 45 apartments. With estimated return temperature reductions of 3-7°C, SAB can generate annual savings between €600 and €1,400, with a mean value of €1,000. Additionally, SAB benefits from the synergy described in the tenants' section, which involves optimizing radiator operations and utilizing the aftercooling module to further increase savings. SAB will continue to receive these revenues until the initial investment is fully repaid. The heat cost allocation system is often already in place, and minimal additional costs are required for material and installation.

Local district heating company's perspective

The district heating company provides a bonus tariff to buildings, that install the aftercooling module providing a lower DH return temperature, and in return it gains several significant benefits. One of the main advantages is the reduction in thermal losses. A 5°C reduction in DH return temperature leads to a 5% reduction in thermal losses, which typically account for 10-15% of the total energy supplied. This translates into an overall energy savings of approximately 0.6% for the utility.

In addition to reducing thermal losses, lower return temperatures enable the utility to more easily integrate low-temperature renewable energy sources, such as solar thermal energy and industrial surplus energy. This expands the company's ability to diversify energy sources and support sustainability efforts.

Moreover, there is an energy efficiency gain for the utility. By operating with a temperature differential between supply and return temperatures, reducing the return temperature enhances the overall energy efficiency leading to lower operating costs. While these benefits are clear, they are more complex to quantify, as they depend on scale effects and the specific market strategies of the utility.

Table 7. *Stakeholder disaggregated costs and returns of Aftercooling business model*

		SAB (Sønderborg housing association)			Local district heating utility			Social housing tenants		
		Unit	Value	Notes	Unit	Value	Notes	Unit	Value	Notes
Costs	**Fixed**	€/ building	2000 or 4000	Inv. costs: components, assembly and installation						
	Variable				€/year* building	800	Bonus tariff: expected reduction of 5°C			
Revenues / Savings	**Direct/ Indirect**	€/year * building	1000	Bonus tariff: expected reduction of 5°C	%	0.6	Energy savings from reduction of heating losses	€/year * building	1000	Bonus tariff: expected reduction of 5°C
		€/year * building	600	Synergy: optimizing additional decrease of 4.5 °C				€/year * building	600	Synergy: optimizing additional decrease of 4.5 °C
	Net yearly	€/year * building	800	**Before PayBackTime**, assuming the average reduction of DH return temperature of 5°C (no synergy)				€/year * building	800	**After PayBackTime**, assuming the average reduction of DH return temperature of 5°C (no synergy)
	Net in the lifespan	€/ building	0	After paying back the investment the earnings go to the tenants				€/ building	1000 0 or 8000	**After PayBackTime** depending on the CAPEX

Table 8. Investment / Return contribution calculation of Aftercooling business model

		Project					Per apartment			
		unit	value	EUR one-off	EUR p.a.		unit	value	EUR one-off	EUR p.a.
Costs	Apartments	#	45							
	Building	#	1							
	Investment & Installation	EUR/building		3,000.00			EUR/apart		66.67	
	Bonus Tariff for 5°C reduction	EUR/building			800.00		EUR/apart			17.78
	Total	EUR		3000	800		EUR/apart		66.67	17.78
Return	Energy savings	EUR/building			1,000.00		EUR/apart			22.22
	Synergies (decrease of 4.5°C)	EUR/building			600.00		EUR/apart			13.33
	Heating losses energy savings	%	0.60%		451.98					10.044
	Total	EUR		0	2,051.98		EUR/apart		0.00	45.60
	Investment / Return Contribution	EUR		-3000.00	1251.98		EUR/apart		-66.67	27.82
	Payback Period	Years	2.40							

Color Legend	
(green)	Value referenced in D9.3
(orange)	Assumption
(purple)	Key Indicator

Average Energy Consumption per apartment in Denmark	18	MWh/year per apart
Average Energy Price	93	EUR/MWh
Total	75330	EUR/building
Energy Reduction	0.12%	per 1 °C reduction
Average Temperature Reduction	5.00	°C
Energy Savings	4,860	kWh p.a.
	108.00	kWh/apart p.a.

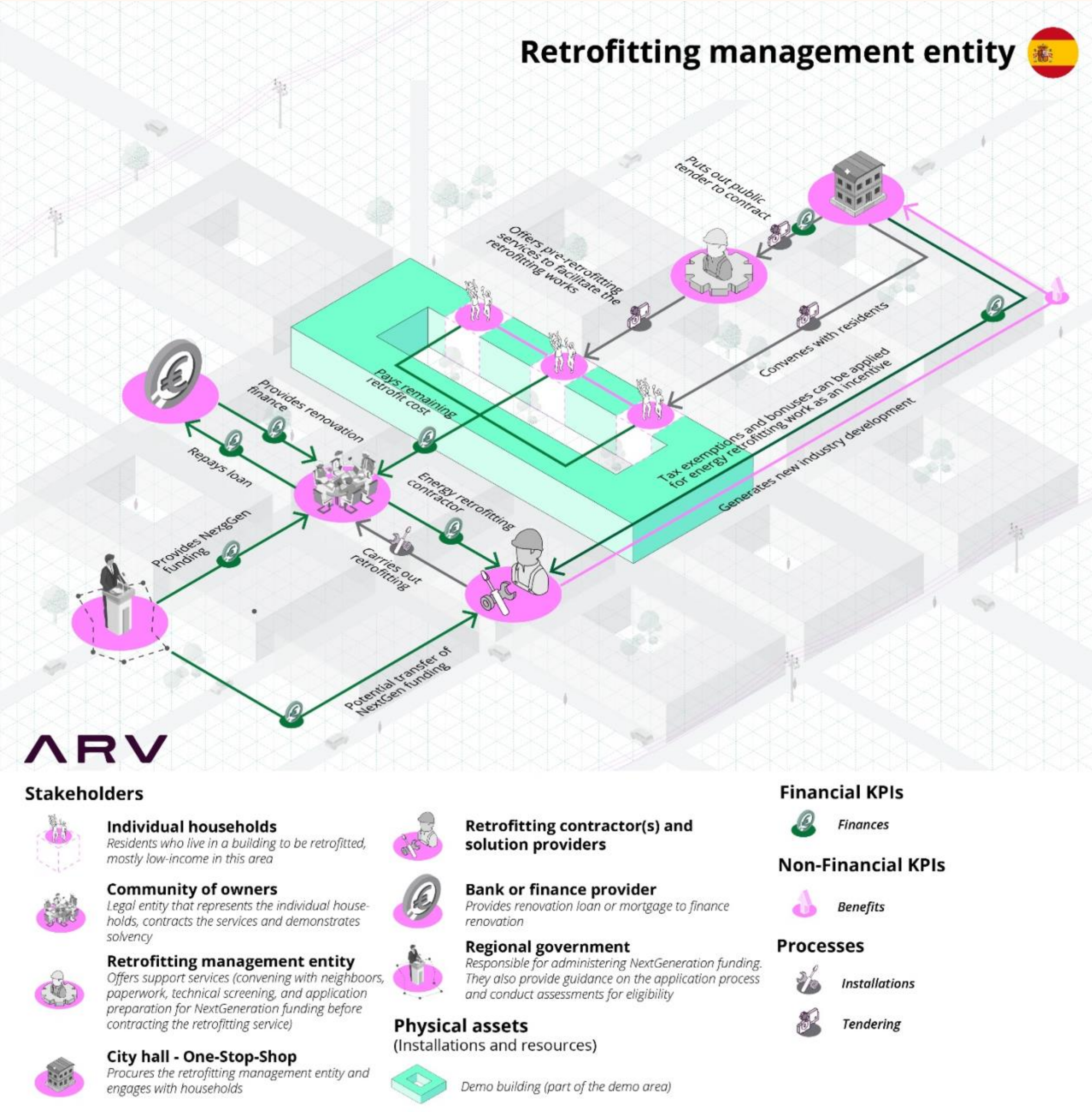
MAIN CHALLENGES OR RISKS AND THEIR MITIGATION

The "human factor"

The low level of engagement in energy related topics is a challenge in the housing association, especially because the housing association already produces its own electricity from solar cells and has cheap district heating from the nearest district heating company. Therefore, the motivation for further energy efficiency gains is not great. In addition, all residents pay for their energy in advance and thereby prepay for their heat. It is calculated once a year in April. This combination makes many residents doubtful as to whether their efforts are having an effect as they don't see the link between the two. This challenge relates predominantly to the complimentary tenant engagement to optimise the flat level radiator operation, where efforts are made to motivate tenants to operate their radiators in a more efficient way.

The Aftercooling technical module and associated savings and benefits are not impacted by the challenges in tenant engagement, however improved tenant motivation could generate additional savings of 600€. This could provide added income or budget for the housing association and is currently underutilised.

RETROFITTING MANAGEMENT ENTITY



BUSINESS CHALLENGE

Retrofitting is a complex topic for many residents, with high costs and complex procedures both for contracting the renovation as well as the administrative procedures that proceed it (subsidy/grant applications, sourcing financing etc.). Large-scale retrofitting of multi-family buildings adds complexity, when all neighbours in the building must agree to renovate, as well as the renovation ambition.

Cities and municipalities can play an important role in catalysing residential retrofit projects, but they often lack the resources or expertise to do so. This was one of the main reasons to establish the public-private-partnership, which enables the public administration to better support the acceleration of energy retrofitting in specific areas.

The table 9 below describes the challenges of each key stakeholder.

Table 9. *Stakeholders and roles and their challenges related to the Retrofitting management entity*

Stakeholders and roles	Stakeholder challenge(s)
Retrofitting management entity: Private company that offers support services (paperwork, technical screening and application preparation needed to contract the retrofitting service)	Need for product / service innovation, new customer acquisition and revenue growth. Today, there is a significant reliance and dependency on NextGeneration funding, as it covers big part of the retrofitting management service. This is especially important in low-income neighbourhoods, where residents may struggle to pay upfront for these services.
Individual homeowners in the building: Residents who live in a building to be retrofitted, mostly low-income in this area	Living in housing that is either too hot or too cold for a significant part of the year, high cost of energy for heating and cooling, contracting a renovation is confusing and expensive. Hard to access bank finance for renovation due to having low income.
Community of owners: Legal entity that represents the individual households, contracts the services and demonstrates solvency	Achieving consensus and agreeing with all neighbours on the renovation decision and the level of ambition for the renovation.
Retrofitting contractors and solution providers: Carry out renovation works and provide solutions that can be utilised	Limited access to finance, a shortage of skilled labour, and fluctuating or hard to activate demand
Bank or finance provider: Provides renovation loan or mortgage to finance renovation	Need for new customer acquisition and revenue growth, lowering risk of lending and maximising loan repayment certainty.
City council: Procures the retrofitting management entity and engages with households. Promote energy retrofitting in the city	High levels of energy poverty in the neighbourhood, high quantity of buildings in need of renovation, need to comply with the municipal climate plan. Limited own resources to support the acceleration of energy retrofitting
Regional government: Responsible for administering NextGeneration funding (up to 80% of the total retrofitting costs). They also provide guidance on the application process and conduct assessments for eligibility.	Offices set up to provide guidance to potentially interested citizens. Need to streamline and improve the delivery of NextGeneration funding to prevent long waiting lists that might disincentivize energy retrofits.

VALUE PROPOSITION

The retrofitting management entity aims to assess building owners in the first steps of the energy retrofitting process, such as convening with neighbours, explaining the subsidies available or informing neighbours about the documentation that needs to be prepared to advance with the retrofitting process. This has the potential to greatly facilitate the contracting of the works and start of the renovation.

The retrofitting management entity organises informative meetings in the neighbourhood for the broad public, but also specific meetings for the most interested or priority communities of owners. It also helps in the process of legally constituting communities of owners, assessing families in the process of applying to validate vulnerability criteria, supporting building communities to elaborate in the energy certificate and the energy retrofitting project as well as in the process of applying to Next Generation subsidies that cover part of the costs of the energy retrofitting project. Finally, it supports buildings in the process of the actual energy retrofitting.

This personal engagement approach is particularly important in countries such as Spain, where residents live in multifamily buildings governed by a community of owners, where mediation between neighbours is a crucial step in facilitating decision-making. This is especially key to advancing energy retrofits in buildings.

The table 10 below describes the value proposition in detail for each key stakeholder.

Table 10. *Retrofitting Management Entity value proposition for key stakeholders*

Stakeholders	Stakeholder benefit
Retrofitting management entity	Increased revenue by providing a service that is tendered by a municipality and expanding the contact list with potential clients such as communities of owners. They also lower the investment risk in the process of advertising their services in the neighbourhood.
Individual homeowners in the building	Easy and free access to clear and transparent information to facilitate the decision-making process before energy retrofitting
Retrofitting contractors and solution providers	Growth in potential customer base, increased demand of services leading to business growth
Community of owners	Receiving strong support throughout the process, including handling all administrative procedures for applying for NextGeneration funding, hiring a construction company, and securing financial support from a bank.
Bank or finance provider	A new business opportunity in financing the expected growth of the energy retrofitting sector in the coming years.
City council	Help achieving energy efficiency goals set in the climate policy; local industry and job creation through the growth of the retrofitting industry (diversification of local economy). Improving urban quality in the neighbourhood.
Regional government	Supporting the Renovation Wave strategy by promoting renovation policies through NextGeneration funding to reduce the carbon footprint of the building stock.

UNIQUE SELLING POINT (USP)

The external support of the retrofitting management entity is a public-private cooperation model based on a single public tender where a private company is selected to promote and support citizens in the retrofitting journey of their buildings.

The approach itself is novel and is enabled both by the public-private-partnership with the Palma City Council (initial tender) and the NextGeneration funding delivered by the regional government that covers up to 80% of the total energy retrofitting costs. Additionally, the Program 5 from Next Generation funding covers almost the total costs of the energy retrofitting project, such as personnel costs and administrative and technical documentation preparation. The management entity plays a key role in enabling this initial works. As a complement, the Spanish Energy Savings Certificates (CAE in Spanish) can generate revenue that helps lowering the financing costs. These certificates must be certified by an official entity.

All in all, the sum of all the reachable economic amounts acts as an incentive for energy retrofits leaving just a portion of the total costs' payable to the residents. This becomes specifically relevant given the neighbourhood's characteristics (low-income neighbourhood, high degree of financially vulnerable families), the entity makes a valuable contribution to addressing energy poverty.

In addition to reducing investment costs and enabling the retrofitting process, the management entity plays a crucial role in facilitating communication and cooperation among neighbours within a community of owners. They simplify complex administrative procedures, translating them into accessible, understandable materials so that everyone can grasp the intricacies of the process. By providing transparency and fostering trust, the entity acts as a neutral mediator within the community, helping to navigate diverse personalities and interests. Furthermore, this entity is instrumental in representing the community of owners when negotiating with banks to secure financing for the portion of the project not covered by subsidies.

ECONOMIC ANALYSIS

The following analysis is based on a large multifamily building (>20 apartments) as the reference case study for energy and economic evaluation, selected for its significance in assessing large-scale retrofitting interventions. It examines various intervention packages that combine passive and active energy measures, assessing both costs and benefits over the project's 50-year lifespan. Passive measures might include improvements such as 6 cm of wall insulation, 8 cm of roof insulation, and energy-efficient windows. These measures are primarily evaluated based on their initial investment costs because they generally require minimal maintenance and do not directly consume energy over time. Once installed, their impact is more static, leading to predictable energy savings with little variation in future costs. Active measures, such as a multi-split heating and cooling system, a heat pump, and a photovoltaic system for electricity generation, are assessed based on both upfront investment costs and long-term operational expenses. This is because active systems involve ongoing energy use, maintenance, and replacement costs throughout their operational life. This cost evaluation approach helps balance initial expenditures with ongoing energy savings, ensuring cost efficiency over the project's lifespan.

Execution works company's perspective (contractor)

The contractor responsible for executing retrofitting works incurs various costs, categorized into fixed, direct, and variable expenses. Fixed costs include general administrative expenses, Value-Added Tax (VAT), technical direction fees, and project management.

Direct costs associated with the retrofitting interventions typically cover expenses for walls, floors, roofs (External Thermal Insulation Composite Systems), and window replacements. Furthermore, €5,070 for the multi-split HVAC system, and €3,531 for the heat pump system. Variable costs over the project's 50-year lifespan, which include operational and maintenance expenses for the installed systems, are estimated at €250 per dwelling per year. These costs could involve, domestic hot water (DHW) heating, and operation and maintenance for the multi-split heating and cooling system.

It is important to note that the reported costs are comprehensive and include a variety of measures—both passive and active—which in some cases may not represent the most optimal solution for every scenario. Costs will vary and detailed evaluations must be conducted on a case-by-case basis to identify the most cost-effective and suitable interventions for each building. Overall, based on an existing pilot project and a case study, the total cost for this retrofitting intervention is estimated at around €500,000 per building (approximately €30,000 per household). In addition, an estimated cost of €20,000 per building (around €950 per household) should be allocated for the preparation of the book of building specifications and project planning.

The comprehensive costs are offset by financial support from grants and subsidies (basically NextGeneration funding) channelled through the Retrofitting Management Entity, ensuring the project's overall financial viability and reducing the financial burden on the stakeholders involved. In this specific case, if the intervention achieves the target of reducing non-renewable energy demand by 60% or more, Next Generation funding will cover approximately 77% of administrative costs for project planning. For the execution of retrofitting works, 50% of the costs for non-vulnerable households are expected to be covered by subsidies, with an additional €4,700 per household for vulnerable households that can increase the coverage up to 70% for the share of the total costs of these vulnerable households. Any remaining costs will be covered by loans from financial entities, enhancing the project's bankability.

Building owners and end-users' perspective

Households contribute to the retrofitting costs primarily through monthly loan repayments (end-users quotes) structured over a 15-year period (180 months). The financing conditions include 0€ in opening costs and 0€ for advanced repayment. The loan carries an annual interest rate of 4.95%, corresponding to a monthly interest rate of 0.40%.

It is important to note that before securing bank financing, the community of owners will receive 50% of the total grant allocated to the building through the NextGeneration EU funding program. For the building presented here as an example, this initial payment amounts to €150,400. This first payment will help cover tax costs and the first four months of retrofitting work. After this, bank financing will be necessary to continue funding the renovation. However, the loan repayment will begin 12 months after the first bank payment, which is approximately 16 months after the retrofitting work starts, giving the community a grace period before repayments begins. During this grace period, the community will only need to pay the interest on the loan. Once the retrofitting is complete, the regional government will release the remaining 50% of the NextGeneration EU funding, another €150,400, which will be used to make an advanced repayment on the bank loan.

The exact amount of the repayments will depend on the specific financial terms, but these costs will likely be partially offset by reductions in primary energy consumption following the retrofitting. Property owners will benefit from long-term energy savings, significantly reducing their energy bills. The reference model predicts a reduction of over 60% in non-renewable primary energy consumption. Additionally, vulnerable end-users may qualify for further subsidies from the NextGeneration EU funding, which will help reduce their financial burden even more.

Retrofitting management entity's perspective

The retrofitting management entity incurs various administrative and coordination costs to ensure the smooth execution of the project. These include organizing meetings, establishing building communities, supporting families in validating their vulnerability criteria. The entity plays a key role in facilitating the retrofitting process by managing the necessary paperwork and providing technical screenings and financing options. These administrative and coordination costs are covered through the PPP mechanism where the local retrofitting management entity called Tramiteco is offering their services. This service has been contracted through a public tender up to €100,000 from Palma City Hall and is estimated to serve 13 buildings and communities of owners in the area.

In addition to administrative tasks, the retrofitting entity is responsible for overseeing payments to the contractor companies for executing the retrofitting works. The entity handles the disbursement of funds provided by the Regional Government, which includes basic payments to cover retrofitting costs. Furthermore, the retrofitting management entity is allocated a portion of the grant to cover its own operational and personnel costs.

City Council's perspective

The project operates under a Public-Private Partnership (PPP) model, led by the City Council. The city council worked on the innovative tender that allowed to contract the retrofitting management entity as a public service to offer the administrative and coordination works needed before energy retrofits. The municipality also convenes and mediates between neighbours, community of owners, and the retrofitting management entity. It also acts as a link between the neighbours and the regional government, which distributes the NextGeneration funding. A significant portion of the project's funding comes from the Next Generation funds, with the Regional Government responsible for managing and disbursing these grants. Up to 80% of the total retrofitting costs can be covered by the Next Generation funds, with maximum grant allocated for housing retrofitting equal to 18,800 €/dwelling and 23,500 €/dwelling for vulnerable households.

Table 11 provides a high-level overview of the business model and the relevant cost and revenue categories for key stakeholders. The multitude of renovation scenarios and other variables make presenting an economic overview challenging. Instead, table 13 offers specific values for a case study.

Table 11. *Stakeholder disaggregated costs and returns of Retrofitting Management Entity (estimated at the end of 2024)*

		Retrofitting Company (Contractor)			Community of owners			Retrofitting Management Entity			City Council		
		Unit	Value	Notes	Unit	Value	Notes	Unit	Value	Notes	Unit	Value	Notes
Costs	Fixed	%		VAT and project taxes	€/year		Payments for execution work to the contractor company (payback period of 15 years)	€		Administrative and coordination costs for meetings and community support	€		Public Service Contract with Retrofitting Management Entity for administrative costs, community support and coordination. (up to 100000 €)
	Variable	€/year		Personnel and administrative costs							€/year		Personnel costs for tendering, validation, and legal services and legal work.
	Direct	€		Direct costs related to retrofitting intervention (building insulation, heat pump and HVAC installation)									
Revenues/ Savings	Direct/ Indirect	€		Payments by the Community of owners to cover costs	€/year		Individual owners' fees to cover retrofitting costs	€		Public Service Contract with City Council for administrative costs, community support and coordination. (up to 100000 €)			
					€/m2 per year		Potential annual cost savings (range: 13-20) * for individual owners						
	Grants/ Subsidies				€/year		Loans from financial entities in case of remaining costs to be covered						
					%	80	Maximum amount of housing grant from Next Generation funds (up to 1880 – 23500 €/dwelling)						

* The calculation assumes a 60.5% reduction in final energy consumption after the retrofitting intervention. The post-retrofit energy mix is projected to consist of 70% electricity, priced at €0.23/kWh, and 30% natural gas, priced at €0.10/kWh. These energy indicators are based on standard operating conditions and apply specifically to energy certification. The energy prices are sourced from Deliverable D4.3.

Table 12. Investment / Return contribution calculation of Retrofitting Management Entity

		Project			
		unit	value	EUR one-off	EUR p.a.
Costs	VAT for General Construction	%	10		
	VAT for Specialized Services	%	21		
	Specialized Carpentry Work	EUR		101.100	
	Preliminary work and Maintenance	EUR	19.800	19.800	
	Cost for Roof insulation	EUR/dwelling	3.100	49.600	
	Façade insulation and plastering	EUR/dwelling	6.600	105.600	
	Heat Pumps Installation	EUR/dwelling	4.800	76.800	
	Demolition, Waste Management and Other	EUR		65.500	
	Asbestos removal	EUR		3.604	
	Project and management	EUR		24.302	-
	Total	EUR		502.058	-
					502.058
Return	Foundings for dwellings	%	80	300800	
	Foundings for vulnerable dwellings			0	
	Foundings for asbestos removal			9.123	
	Energy Savings	EUR/sqm	16,5		21120
	Total	EUR		309.923	21.120
	Annual Loan Repayment	EUR p.a.		277.660	18510,7
	Payback Period	Years	15		
	Total Number of Dwellings	16			
	Number of Vulnerable Dwellings	0			
	Annual Interest Rate	5,00%	%		
	Average Apartment size	80	sqm		
	Color Legend				
	Value referenced in D9.3				
	Assumption				
	Key Indicator				

MAIN CHALLENGES OR RISKS AND THEIR MITIGATION

The “human factor”

Apart from the retrofitting management entity, it is important to have a motivated resident or building owner to lead the process in targeted buildings. Furthermore, given the complexity of the topic for most residents, it is important to have impartial persons such as public employees to convene between retrofitting management entities and building owners in the process of negotiating the energy retrofitting process.

Coming to an agreement about renovation with the neighbours is challenging. Once agreement has been reached, the renovation ambition needs to be negotiated separately, which is often another challenge.

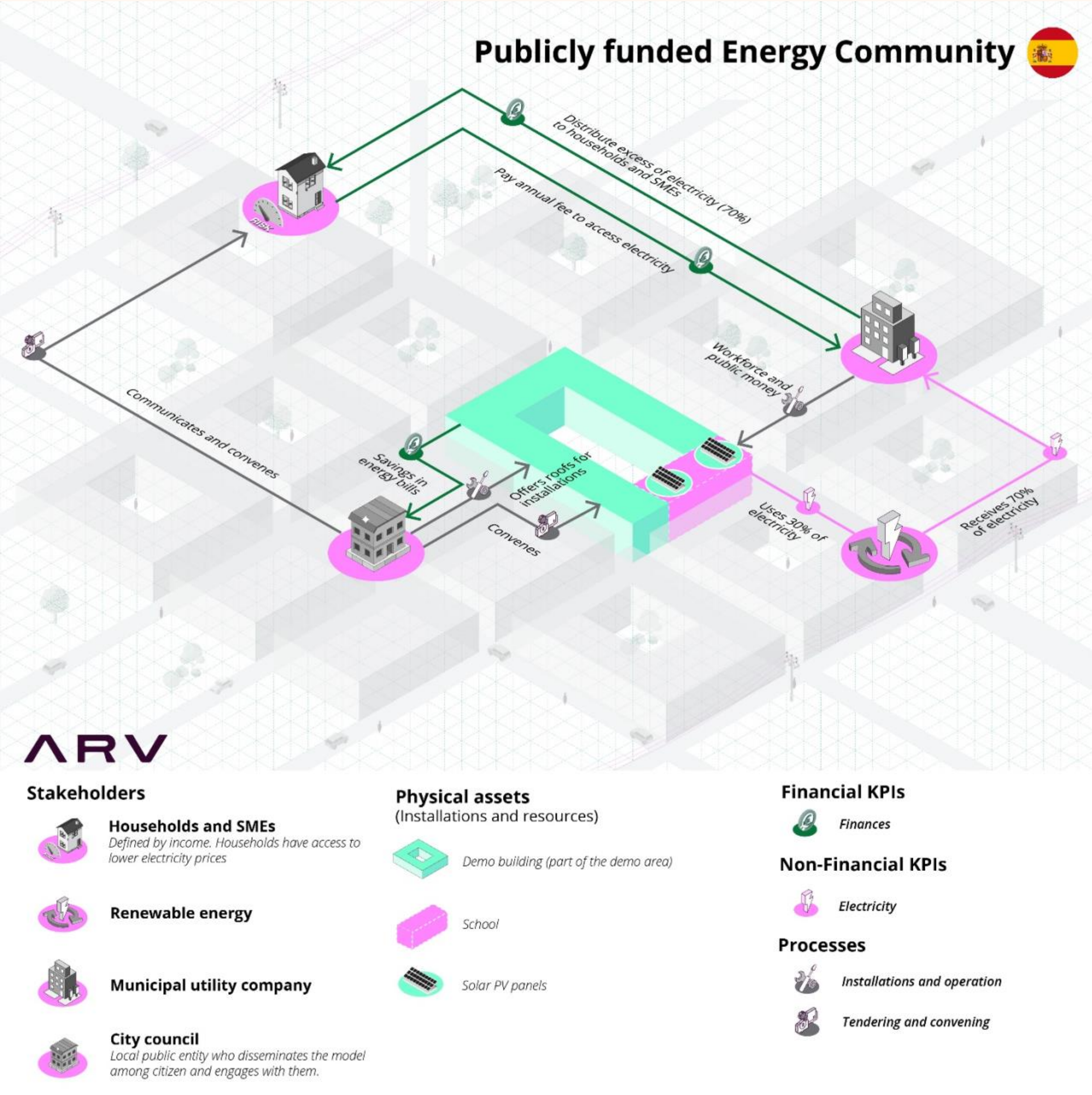
Lack of financial capacity
Many households lack the economic capacity to face the necessary investment for retrofitting. This is specially challenging in low-income neighbourhoods, where it is more necessary to renovate due to the degraded current state of the buildings. However, before spending resources, time and energy in engaging with community of owners, it is important to have a deep understanding of the economic capacity and willingness to energy retrofits of the building owners. This will allow to find a balance between the ones that need it the most, but also to these ones that show more possibilities and willingness to face the investment. To address this issue, we conducted interviews with several members of the community of owners. These analyses were carried out through personal interviews with individual owners within entire buildings.

In parallel, research in financing options available for communities of owners was carried out. This was done by directly engaging with banks and financial institutions. The key findings from this research indicated that banks require several conditions to be met: an evaluation of the retrofitting project, the NextGeneration EU funding allocated to the building, the remaining portion to be paid by the community of owners, and the bank statements of the community of owners to demonstrate that the level of default of community fees is below 10%. This research also provided insights into the financing conditions for energy retrofitting projects, including the associated financing costs and how they would impact the project's cash flow over its lifetime.

All in all, enables to understand further the actual capacity of specific community of owners to face energy retrofitting projects.

Permitting
An inhibiting factor is the slow pace for getting a license to start retrofitting works and the often-extended periods in which NextGeneration funding is liquidated. To mitigate these delays on getting a license for energy retrofitting, Palma City Council worked on a fast permit for energy retrofitting based on the regional regulatory framework, where they can start the work 15 days after the summit of the permit at the municipality. The previous situation meant waiting from 6 months to 1 year.

PUBLICLY FUNDED ENERGY COMMUNITY



BUSINESS CHALLENGE

Urban areas face growing energy demands, increasing dependence on centralised grids, and challenges in meeting sustainability targets. Residents, public administration and businesses and services struggle with fluctuating electricity costs and limited access to renewable energy solutions at the community level. Despite ambitious national and EU goals for decarbonising urban electricity consumption, the lack of localised energy systems hampers progress. Energy poverty is another pressing challenge across the EU, as well as in the Spanish demonstration site. There is a pressing need for localised and community level energy production models that are collaborative and can achieve the dual goals of energy transition and social justice.

The table 13 below describes the challenges of each key stakeholder.

Table 13. *Stakeholders and roles and their challenges related to the Publicly Funded Energy Community*

Stakeholders and roles	Stakeholder challenge(s)
Households and SME Participate with a yearly fee, get access to electricity produced	High electricity costs, reduced ability to pay. Since most of residents live in multifamily buildings, energy self-consumption is not an easy option, so this model provides a good alternative to locally sourced renewable energy.
Municipal utility company: Invests and manages the energy distribution, own the PV installation	Developing their business as an energy retailer and providing energy at low-fare prices for citizen, expanding their business strategy towards a more social and just economy, managing the process of distributing energy among households, design an administrative procedure to charge fees in an efficient way
City council: Provides the roof of public buildings, convenes and communicates the initiative within the neighbourhood	Need to lower the carbon footprint of energy consumption of public buildings to comply with municipal climate change mitigation goals and to lower the dependency on fossil fuels to power their buildings.

VALUE PROPOSITION

The publicly funded energy self-consumption is a business model where a public administration makes the initial investment, and the energy is distributed between public buildings, neighbours, and SMEs located within a 2 km radius for a low-fare rate.

The table 14below describes the value proposition in detail for each key stakeholder.

Table 14. *Publicly Funded Energy Community value proposition for key stakeholders*

Stakeholders	Stakeholder benefit
Households and SMEs	Improved indoor comfort, electricity bill savings
Municipal utility company	Increase the ratio of renewable energy they provide as an energy retailer, expansion of business activities since they can consolidate a new business model within their already existing business structure. Advance in the goals of the Palma climate mitigation plan.
City of Palma	Reduced energy poverty among citizens, lowered carbon footprint of own energy consumption, electricity bill savings

UNIQUE SELLING POINT (USP)

The Palma demonstration site has a particular focus on addressing energy poverty, a pressing issue both locally and more widely in the EU. With a publicly funded energy community, economically vulnerable households get access to renewable electricity through municipality owned energy company.

ECONOMIC ANALYSIS

The following analysis refers to an energy community based on solar energy production, featuring a power plant with a lifespan of 20 years. The values reported are presented in relative terms, meaning they are calculated per kW installed, rather than in absolute terms for the entire energy community project in Palma.

Individual residents' perspective
Residents can rent 1 kWp of solar-installed power on public buildings' roofs from the utility company (around two PV panels production), paying an annual fee of 100€/year per kWp. This allows them to benefit as if they had their own solar panels installed on their rooftops without having to go through the whole investment process. The 100 €/year is intended to cover the investment costs of the installation over the lifespan.

When residents use energy during the hours when the solar panels are producing electricity, they can directly self-consume this energy, reducing their energy bills. Individual participants will keep any energy retailer they prefer, and any surplus energy that is not self-consumed can be compensated economically through the energy retailer. The amount of this compensation is upon agreement with each individual retailer. However, it's important to note that generally monetary compensations for the electricity transferred to the grid offers lower returns than the savings achieved through self-consumption. This is because the price at which electricity is compensated is always lower than the price residents pay for the energy they consume from the grid.

If all the energy produced by the rented solar capacity is self-consumed, a resident can expect to save approximately 178€/kW per year, considering the cost of energy and the additional variable taxes related to the consumption. This estimate is based on the solar energy production profile of a photovoltaic plant in Palma and energy prices from the "Esios red electrica" website for 2023.

Utility company's perspective
The municipality will provide the initial capital for the investment and will own the solar plant. The investment costs include the installation of the solar panels, inverters, and other essential materials needed for the plant. In addition to these, monitoring systems will be implemented to track both energy generation and consumption. Furthermore, a maintenance service will be developed to help participants manage their administrative information, track their energy usage, and gain insights into their energy bills.

Some of the project-related expenses, particularly those connected to the monitoring systems, are still being developed, with final values to be determined as the project progresses. In terms of ongoing operational costs, the utility company will be responsible for maintaining the PV installation. There will also be ongoing costs related to administrative procedures, including managing legal and regulatory requirements.

Additionally, the project will receive financial support through regional subsidies, such as the PITEIB funding provided by the Balearic Islands. These subsidies vary depending on the entity, with large public or private companies receiving up to 11% of the total installation cost.

City of Palma 's perspective
The City of Palma plays a key role in the publicly funded energy community project by providing the rooftops of public buildings for the installation of solar panels. In addition to this logistical support, it acts as an intermediary between the publicly owned utility company and the residents participating in the energy community. This intermediary role comes with various responsibilities, including informing citizens about the initiative, managing administrative tasks, and organizing the model for shared self-consumption among participants. These responsibilities entail costs, such as those related to the

workforce needed to oversee communication with the public and the administrative processes that ensure the smooth operation of the project.

The City of Palma will also benefit directly from the solar installations on its buildings by using 30% of the total installed solar capacity for its own energy consumption. On the revenue side, the utility company will collect an annual participation fee from the residents who rent solar power (100€/kW). The savings generated for the municipality from this self-consumption are estimated to be around 6599-6715 €/year. This estimate is based on the current total installed capacity of 111.2 kW and the average energy price the City of Palma incurred in the previous year, which was €41.325 per MWh. This corresponds to approximately 200 €/kW*year. The revenues would rise to an estimated amount of 12759 - 14460 €/year if we include the users' annual fees.

Table 15. *Stakeholder disaggregated costs and returns of Publicly Funded Energy Community (estimated at the end of 2024)*

		Municipality-owned utility company			Individual residents			City of Palma		
		Unit	Value	Notes	Unit	Value	Notes	Unit	Value	Notes
Costs	Fixed	€/kWp	2000	Estimated values based on previous projects				€/installation	Unknown	Cost of the workforce to inform citizens, administrative work and organize the self-shared consumption model
		€	Unknown	Monitoring acquisition						
		€	Unknown	App/Web Management acquisition						
	Variable	%	1	PV installation maintenance respect to the investment cost	€/kWp/year	100	Annual fee per each kW contracted per year			
		€/month	Unknown	Maintenance services						
		€/installation/year	1000	Administrative procedure maintenance (100 kW)						
Revenues / Savings	Direct/ Indirect				€/kWp/year	178	Savings from self-consumption	€/kWp/year	200	Savings from self-consumption in the public buildings
								€/kWp/year	100	Annual fee per each kW contracted per year
	Grants/ Subsidies	% of total cost	11%	PITEIB funding (Balearic Islands regional funding)						

Table 16. Investment / Return contribution calculation of Publicly Funded Energy Community for City of Palma

		Project			
		unit	value	EUR one-off	EUR p.a.
Costs	PV Size	kW	111		
	Costs of PV installation	EUR/kW	2,000	222,400	
	Cost of montoring acquisition	EUR			
	Cost of Web Management	EUR			
	Cost for dissemination	EUR			
	O&M Costs	% of the total	1.00%		2,224
	Cost for administrative procedures	EUR			1,000
	Total	EUR		222,400	3,224
Return	Annual Membership fee	EUR/kW/year	100		7,784
	Energy Savings from self-consumption	EUR/kW/year	200		6,672
	Grants (PITEIB funding)	% of the total	11.00%	24,464	-
	Total	EUR		24,464	14,456
	Investment / Return Contribution	EUR		-197,936	11,232
	Payback Period	Years	17.62		

Color Legend

(green)	Value referenced in D9.3
(orange)	Assumption
(purple)	Key Indicator

Municipality's average annual savings	13,609	EUR p.a.
Share of Capacity	30%	Municipality
	70%	Members

MAIN CHALLENGES OR RISKS AND THEIR MITIGATION

Disruption to business as usual and stakeholder conflict of interest

In Spain, despite having comprehensive legal frameworks for shared-self-consumption models, some stakeholders can hinder project implementation significantly. The energy distributors have a market monopoly, which means they are often not willing to collaborate, or collaboration is difficult, since it is not in their economic interest to enable self-shared consumption. They are making the process slow and very tedious. Sometimes it takes up to 6 months to start energy sharing after the installation is in place. As there are every time more installations following this business model, it will pressure the distributor to make the activation procedures more agile. Beyond that, defining mitigation strategies is challenging as that is beyond the range of influence of the business model actors, but in the whole process of activating the shared self-consumption model it will be important to set realistic expectations on the timeline considering this potential delays due to the energy distributor.

On the other hand, once the PV installation is in place, it may become difficult to target and engage citizens with a vulnerability profile. This could lead to a situation where those who benefit from the energy are the ones who need it the least. To mitigate this risk, prioritizing households that meet vulnerability criteria and conducting targeted outreach within communities of owners where there are more households in need, will help ensure that the system supports those who need it most.

Electricity prices and their impact on profitability

Energy communities are a recent initiative adopted in Spain, and their economic success relies on balancing supply and demand, much like an electricity market. The design phase of the community—specifically the selection of installed capacity and the number of participants—is a crucial factor in assessing the project's economic feasibility. This is particularly important as the energy community currently lacks long-lasting funding strategy and is highly dependent on political will.

This phase is further complicated by various other factors that may fluctuate over the lifespan of the plant and community, potentially impacting the project's success positively or negatively. Among these factors, two stand out: the price of electricity and the number of participants in the community. These two elements are interconnected; the electricity price directly influences the savings achieved through leasing part of the plant. The higher the price, the greater the savings from using the photovoltaic system, thus increasing the incentive for members to stay or for new participants to join the community.

Since electricity prices are a key factor and have fluctuated significantly in recent years, a thorough analysis of future price trends in Spain is essential. The following analysis, therefore, aims to assess future earnings over the plant's useful life by constructing three possible scenarios for an individual choosing to secure 1 kW of power from the energy community.

Electricity pricing scheme in Spain and PV production

The electricity bill for end-users in Spain can follow two main types of tariffs: a traditional one and a variable-price one, introduced only recently in 2021. The end-user can choose which type of tariff to adopt. The traditional tariff is a fixed-rate, time-of-use tariff where the price of energy is set for specific time intervals and multiplied by the actual consumption in those windows. Taxes and network costs, which tend to be fixed, are then added to this price; for network costs, part may be proportional to consumption.

The variable tariff introduced in 2021 is called PVPC (Precio Voluntario para el Pequeño Consumidor). With this tariff, consumers can opt for a variable rate, updated on an hourly basis and tied to the wholesale cost of electricity. For consumers who choose this option, the cost may change day by day and hour by hour, allowing those who can adapt their usage to save by concentrating their electricity use during hours when prices are lower. In the following analysis, it is assumed that the community energy users have chosen the variable tariff and that their bill thus follows the PVPC.

The PVPC price is composed of various components that together determine the final cost of electricity for consumers. The main basic component is the Day-Ahead Price, the daily wholesale price of electricity set on the Iberian energy market. The second component is represented by balancing costs, or Adjustment Services, used to ensure the balance between supply and demand in real time, maintaining the stability of frequency and voltage in the network. In energy markets with many renewable plants, it is often challenging to have precise production estimates; for this reason, balancing is needed to compensate for potential production surpluses or deficits.

The PVPC also includes capacity costs, which ensure a sufficient reserve to meet demand at peak times, and tolls and charges, which cover the costs of transporting and distributing energy across the national grid. These charges also include contributions for supporting infrastructure and energy policies, such as incentives for renewable energy sources. In addition to these primary components, the PVPC includes other items: term of adjustment of futures markets, OS Financing (funding for the System Operator, REE), OM Financing (market management costs of the Market Operator, OMIE), variable marketing cost, surplus or deficit in renewable auctions (due to incentives resulting from renewable auctions), and the interruptibility service, which covers the cost for large consumers to temporarily reduce their consumption to ensure network stability. These additional costs, relative to the Day-Ahead Price, are collectively referred to as extra charges. A sample daily profile taken directly from Esios Red Eléctrica is shown in figure 4, for the 9th and 11th of November 2024.

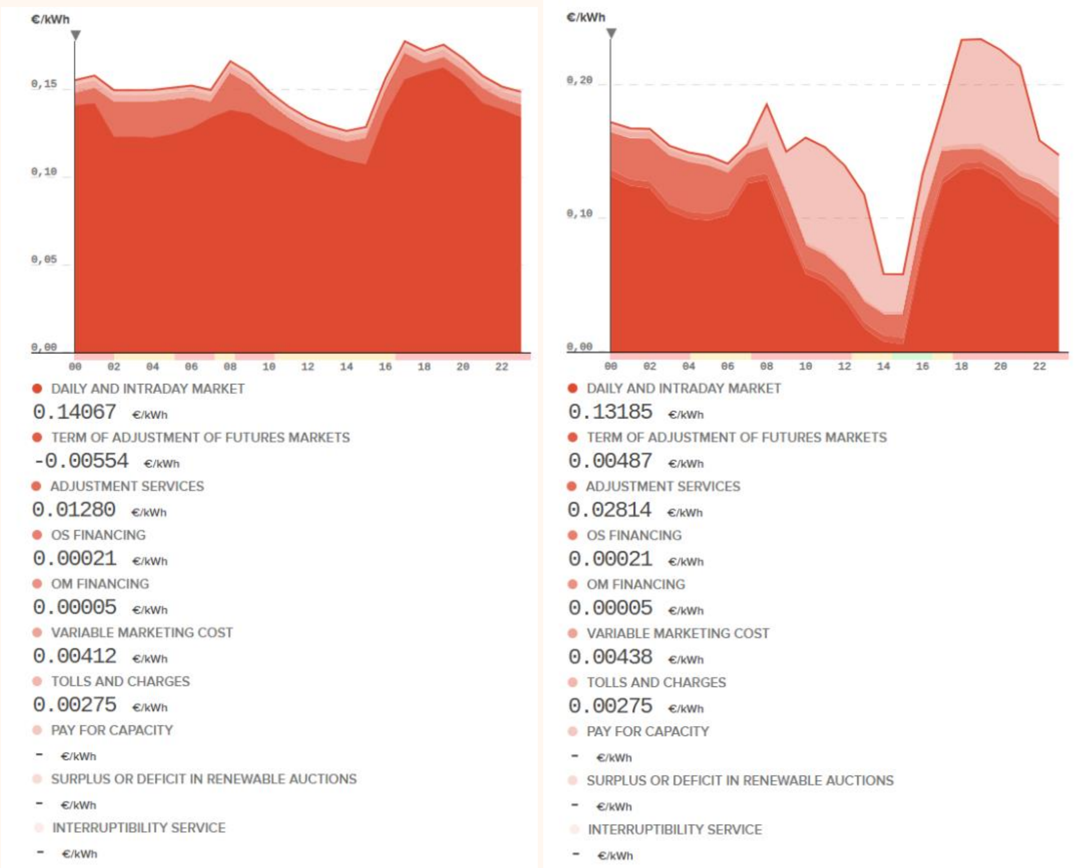


Figure 4. *A sample daily profile for 9th and 11th of November 2024. (Source: Esios Red Eléctrica)*

The final bill for users also includes taxes and charges that are not part of the PVPC calculation, such as the Electricity Tax (Impuesto sobre la Electricidad) and VAT (Impuesto sobre el Valor Añadido). These amounts are set by the government and are included in the PVPC analysis, and set them to their historical values, 21% and 5%.

Most of the extra charges are not fixed but vary hourly and seasonally, as shown in figure 4. The main factors affecting the PVPC include supply and demand for electricity, the price of natural gas, the intermittency of renewables, and network interruptibility services. Demand increases, shortages from cost-effective energy sources, the intermittent availability of renewables, backup power costs, and emergency situations can significantly alter the final price of electricity for consumers who use PVPC.

Future Day-Ahead prices and extra charges distributions

To evaluate future PVPC prices and conduct a detailed scenario analysis using Monte Carlo simulations, two main approaches have been employed:

- First, energy modelling is used to project day-ahead electricity prices, capturing how market conditions and energy policies may evolve.
- Second, a statistical analysis is performed to understand variations in extra charges throughout the year, providing a comprehensive view of how price components fluctuate over time.

EMPIRE

Day-Ahead price projections have been obtained using *The European Model for Power System Investment with Renewable Energy* (EMPIRE)[20]. EMPIRE is a sophisticated modelling tool that helps plan future investments and operations in the European energy system, looking ahead 40 to 50 years. The model's primary goal is to minimize overall system costs, which include both investment costs (such as building new power plants or expanding the electricity grid) and the expected operational costs of running the energy system over time. EMPIRE uses a combination of strategic, long-term investment decisions and short-term operational choices to ensure that the energy system remains efficient and reliable, even under uncertain conditions. For instance, it takes into account unpredictable factors like fluctuating energy demand, variations in wind and solar generation, and changing fuel prices. By optimizing across a wide range of possible *future scenarios*, EMPIRE identifies cost-effective strategies that are robust to these uncertainties.

The model covers 31 European countries, interconnected to simulate a realistic energy market. It simplifies the complexity of the European energy market by representing each country, including Spain, as a single *node*, a simplified representation of a country's entire electricity network summarizing all the energy production and demand within that country. By doing this, EMPIRE can efficiently analyse energy flows between countries while still capturing the main characteristics of each nation's energy system. In terms of time resolution, EMPIRE groups years into five-year investment periods and using selected representative hours for annual operations. This allows for a more manageable and efficient analysis with hourly time resolution without sacrificing the quality of the results.

As a result, EMPIRE can provide useful insights into how different energy policies, technological advancements, and market conditions could impact future electricity prices. Typical results include the total minimized system cost as well as the expected curtailed energy from renewable sources due to grid constraints. It provides details on the installed capacity of generation and storage technologies across Europe and their anticipated annual energy output. The model also reports Europe-wide annual CO2 emissions, carbon pricing, and average electricity prices, alongside comprehensive data on the hourly generation, storage, and transmission of electricity across various scenarios.

The EMPIRE model is available in the Python-based, open-source optimization modelling language Pyomo. All scripts and data can be downloaded from the Git repository OpenEMPIRE and online documentation is available here.

Day-Ahead Price Projections

The European electricity market has been modelled and optimized using EMPIRE as introduced before, allowing to extract day-ahead price projections for Spain. The plots highlight a clear expected downtrend in average day-ahead prices over the years, alongside notable daily fluctuations that reflect evolving market dynamics and the impact of renewable energy integration.

[20] *https://www.sciencedirect.com/science/article/pii/S2352711021001424*

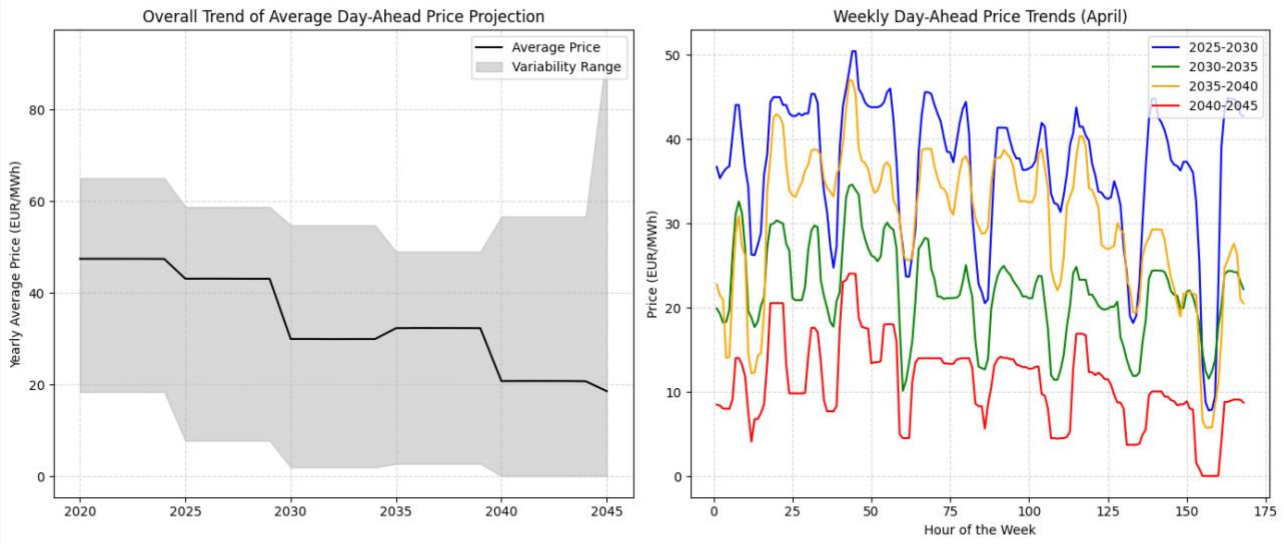


Figure 5. *Day-ahead price projections for Spanish electricity prices*

This trend might have significant implications for the economic viability of the energy community business in Palma, where customers may pay an annual fee to benefit from savings through self-consumption of electricity rather than purchasing from the grid. Since day-ahead prices are a key component of the final PVPC price in Spain, a downtrend in these prices could result in reduced future savings, emphasizing the need for further investigation.

Extra Charges Distributions

The second important component of the PVPC price that adds uncertainty is the extra-charges analyzed in previous sections, because they fluctuate significantly throughout the day and vary across seasons. As shown in the following plots, extra charges tend to increase during periods of high solar PV production and this correlation reflects the additional intra-day adjustments needed in a renewable-rich energy system to balance supply and demand. In winter, when solar production is lower, the spread between day-ahead prices and PVPC narrows, indicating reduced reliance on intra-day adjustments. This seasonal and intra-day variability reflects the complexity of managing grid stability and energy supply in Spain, especially as renewable integration deepens.

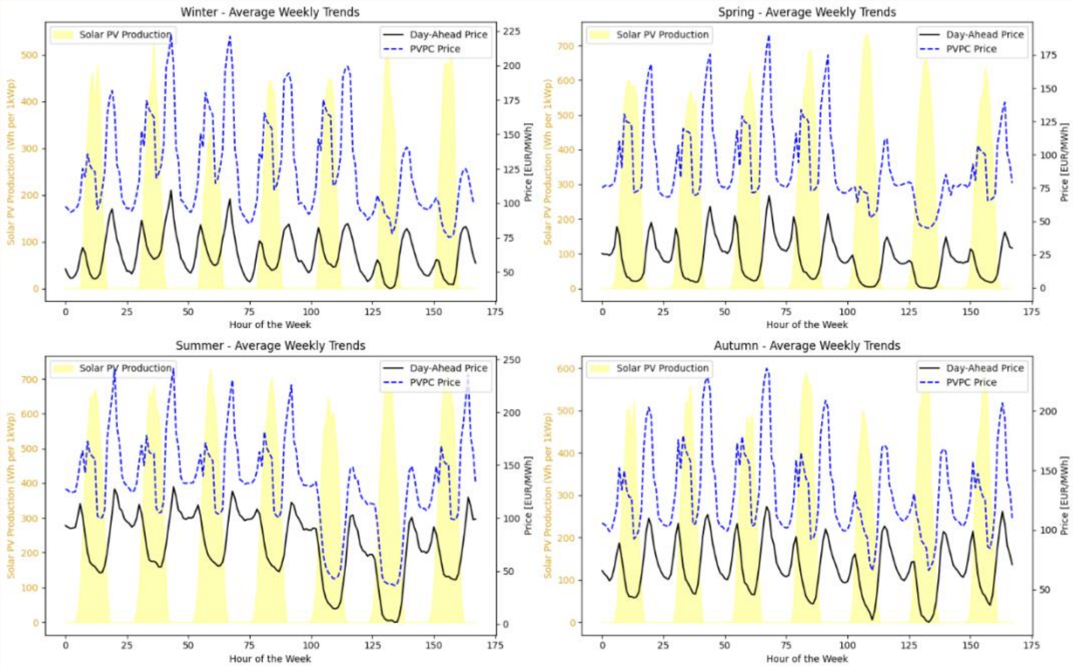


***Figure 6**. Variation in distribution of extra charges*

As mentioned before, the customers can decide to adopt a fixed-based tariff for specific time intervals. This tariff reflexes the typical daily demand patterns, with specific time bands for weekdays and weekends:

- Weekdays (lunes a viernes días laborables):
  i) Peak Hours: 10:00 AM to 1:00 PM and 6:00 PM to 9:00 PM, representing the highest demand.
  ii) Mid-Peak Hours: 8:00 AM to 9:00 AM, 2:00 PM to 5:00 PM, and 10:00 PM to 11:00 PM, indicating moderate demand periods.
  iii) Off-Peak Hours: Midnight to 7:00 AM, and all hours during weekends and holidays, when demand is generally lower.
- Weekends and Holidays (Sábados, domingos y festivos): The entire day is considered Off-Peak, reflecting reduced electricity demand.

To capture the variability in extra charges across different times of day, weeks, and seasons, 2024 extra charges data (supplemented with 2023 values where data is missing) have been segmented into 16 distinct categories. These categories are based on four seasons (winter, spring, summer, autumn) and the three daily bands described above (peak, mid-peak, and off-peak hours). For weekdays, peak hours include periods of highest demand, mid-peak covers transitional periods of moderate demand, and off-peak represents times of lower demand, with weekends and holidays classified entirely as off-peak. From these 16 categories, individual statistical distributions have been derived, each capturing the specific characteristics of extra charges within its specific season and daily band. Each distribution reflects how factors such as solar PV production forecasts, grid balancing needs, and demand patterns influence the extra charges, providing a comprehensive basis for the scenario analysis.

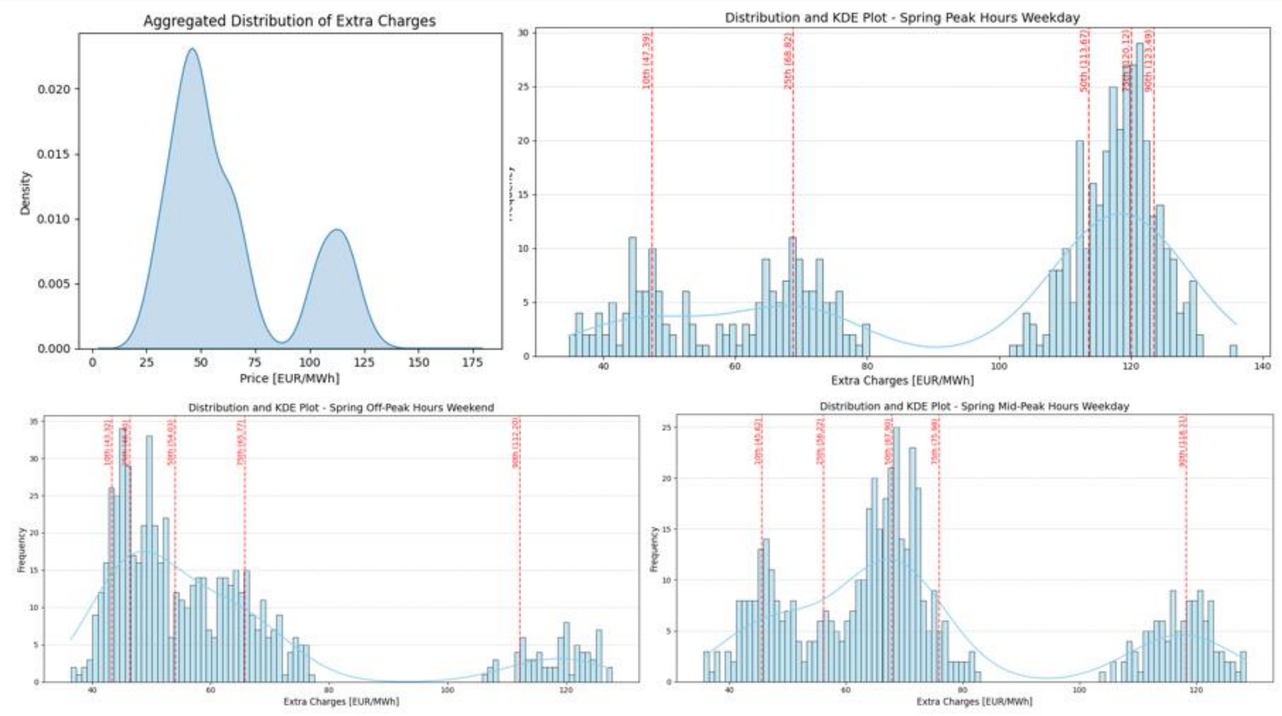


Figure 7. *Distribution of extra charges in Spain's electricity market across different scenarios.*

Figure 7 shows the distribution of extra charges in Spain's electricity market across different scenarios, highlighting their variability. The aggregated distribution (top left) captures overall fluctuations, while the specific examples for spring—weekday peak hours (top right), weekend off-peak (bottom left), and weekday mid-peak (bottom right)—illustrate distinct patterns for each time category. This variability in shapes is further evident in the average values for extra charges, which range from a high of €96.67/MWh during Spring Peak Hours Weekday to a low of €38.55/MWh during Summer Off-Peak Hours Weekday. Such differences justify using 16 categories to accurately model extra charges, capturing the nuances in demand and grid requirements based on season and time of the day.

Monte Carlo Analysis

To evaluate the potential impact of future PVPC scenarios on the economic viability of the energy community business model and the expected energy savings, a Monte Carlo analysis was conducted. This methodology combines long-term day-ahead price projections up to 2045, generated using the EMPIRE model, with stochastic values for extra charges derived from segmented statistical distributions capturing seasonal and intra-day variability as shown before. The aim is to simulate a wide range of possible PVPC price scenarios to capture the inherent uncertainty in future electricity costs. The approach involves running 1,000 simulations, where each simulation represents a potential future realization of PVPC prices. Each simulation draws a random sample from the appropriate distribution, which is then added to the baseline day-ahead price projection to produce a PVPC price for each time step. Specifically, three scenarios have been selected:

- Average Scenario: this scenario provides an expected baseline by using the mean values of extra charges across the simulations, representing typical future price behaviour.
- High-Price Scenario: by considering the 90th percentile of extra charges, this scenario represents a more optimistic outlook from the community members` perspective, with higher extra charges, reflecting favourable conditions where the community could benefit from increased energy savings.

- Low-Price Scenario: using the 10th percentile of extra charges, this scenario represents a more conservative outlook, capturing periods when additional costs are low due to market adjustments and grid balancing needs.

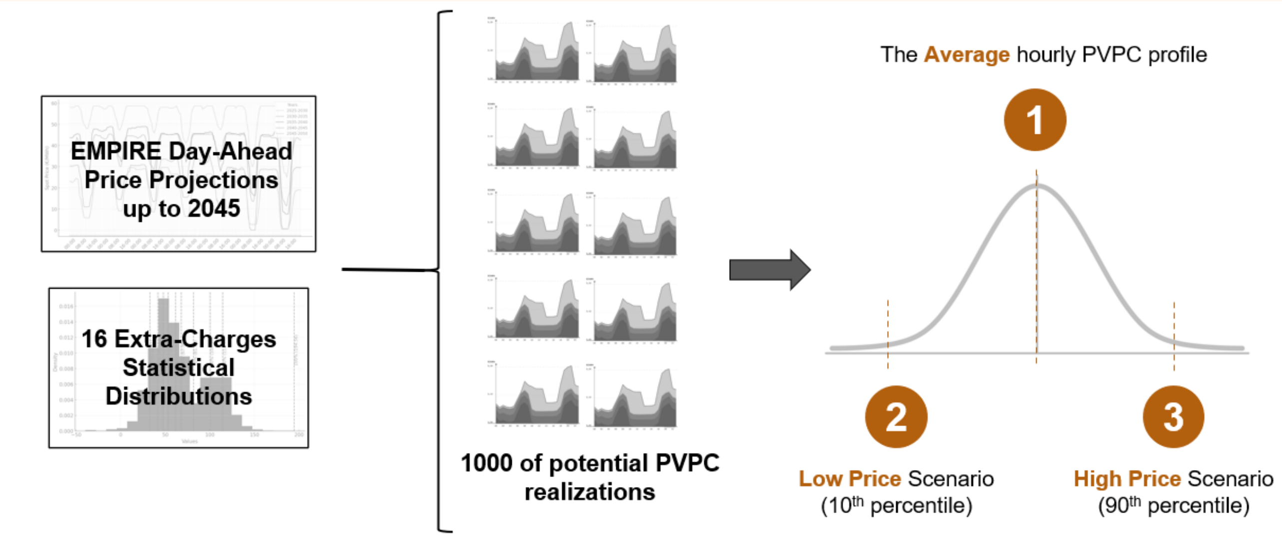


Figure 8. *The methodological approach of the analysis in this report*

The Monte Carlo simulation approach has been chosen in this analysis as it allows to account for the inherent uncertainty in future PVPC prices, especially given the high volatility in electricity markets and extra charges. By simulating a wide range of possible outcomes (1000 simulations), it's possible to achieve a statistically robust distribution, better estimating likely outcomes and extreme cases, which might be relevant for understanding the economic viability of the energy community model.

However, this approach has limitations. Monte Carlo simulations rely on the assumption that past and projected statistical patterns will hold in the future, which may not fully capture unexpected structural changes in the energy market, such as new regulatory policies, technological disruptions, or drastic shifts in demand and supply. Furthermore, the scenarios considered—average, high-price (90th percentile), and low-price (10th percentile)—represent typical patterns within the expected range but are not exact realizations. This approximation can lead to less variability in the results, particularly in the average scenario, where potential fluctuations are smoothed out. Thus, while these percentiles provide useful bounds for assessing risks, they may understate certain dynamic market behaviors.

Results

The following plot, figure 9 illustrates the projected electricity price scenarios over the short-term (2025-2030), focusing on an exemplary week in spring (April 1st to April 7th). It displays the average price profile, along with the 10th and 90th percentile scenarios and, to provide additional context, the benchmark 2024 PVPC price profile along with a shaded area representing the variability range (min-max across simulations).

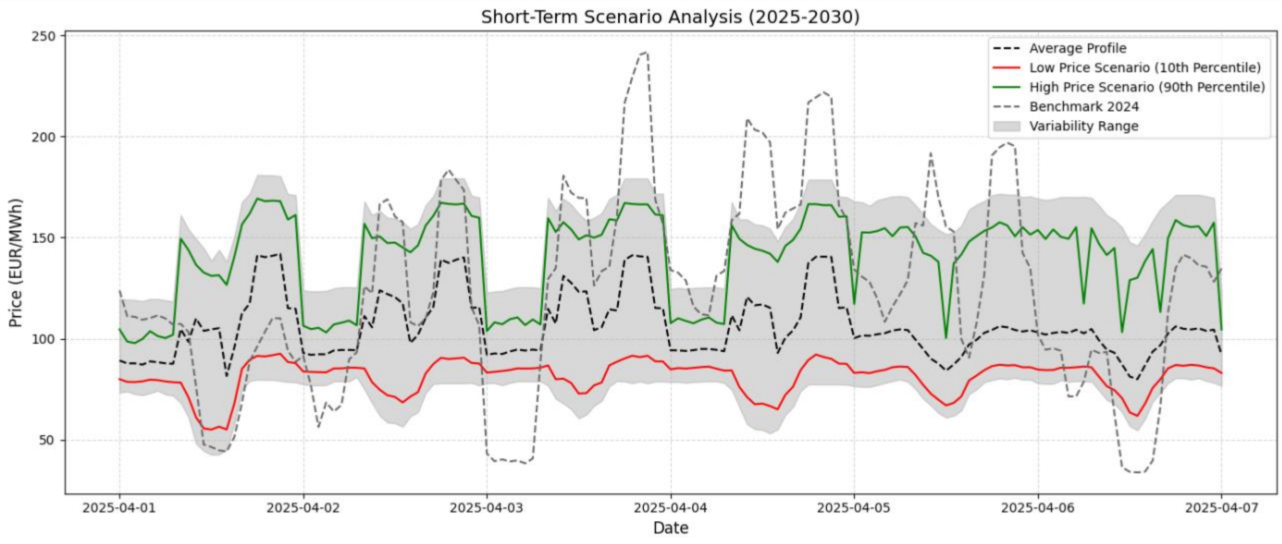


Figure 9*. Projected electricity price scenarios over the short-term (2025-2030)*

The average profile (black dashed line) represents the expected price trend, while the low (red) and high (green) scenarios show the variability bounds. The colour coding reflects the economic implications for the energy community business model: the high-price scenario indicates a more favourable outlook, as higher electricity prices lead to greater savings for community members, while the low-price scenario represents a less favourable condition with reduced savings. This spread between the 10th and 90th percentiles highlight potential fluctuations, and the uncertainty captured by the Monte Carlo simulations.

If the yearly energy savings is then calculated by multiplying the projected electricity price by the energy self-consumed, it provides a benchmark for understanding the economic value of the energy community membership. The plot below, figure 10, compares the three projected scenarios for yearly energy savings while the red horizontal line offers a reference point; scenarios above this line indicate positive net savings for members, highlighting favorable conditions for the community's economic viability.

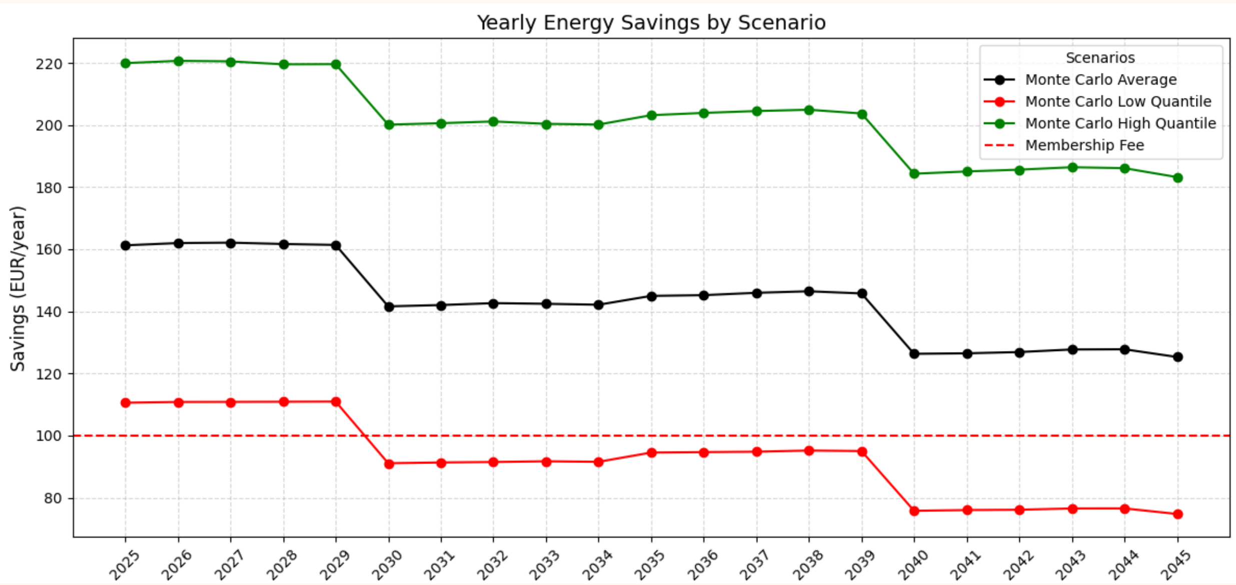


Figure 10*. Comparison of three projected scenarios for annual energy savings*

Figures 10 and 11 show that except for the low-price scenario starting from 2030, all other scenarios provide a positive net profit for energy community members, with yearly savings consistently above the

€100 membership fee. Although savings decline gradually over time due to projected price trends, they remain above the membership fee threshold, indicating sustained economic benefits for members in both the average and high-price scenarios.

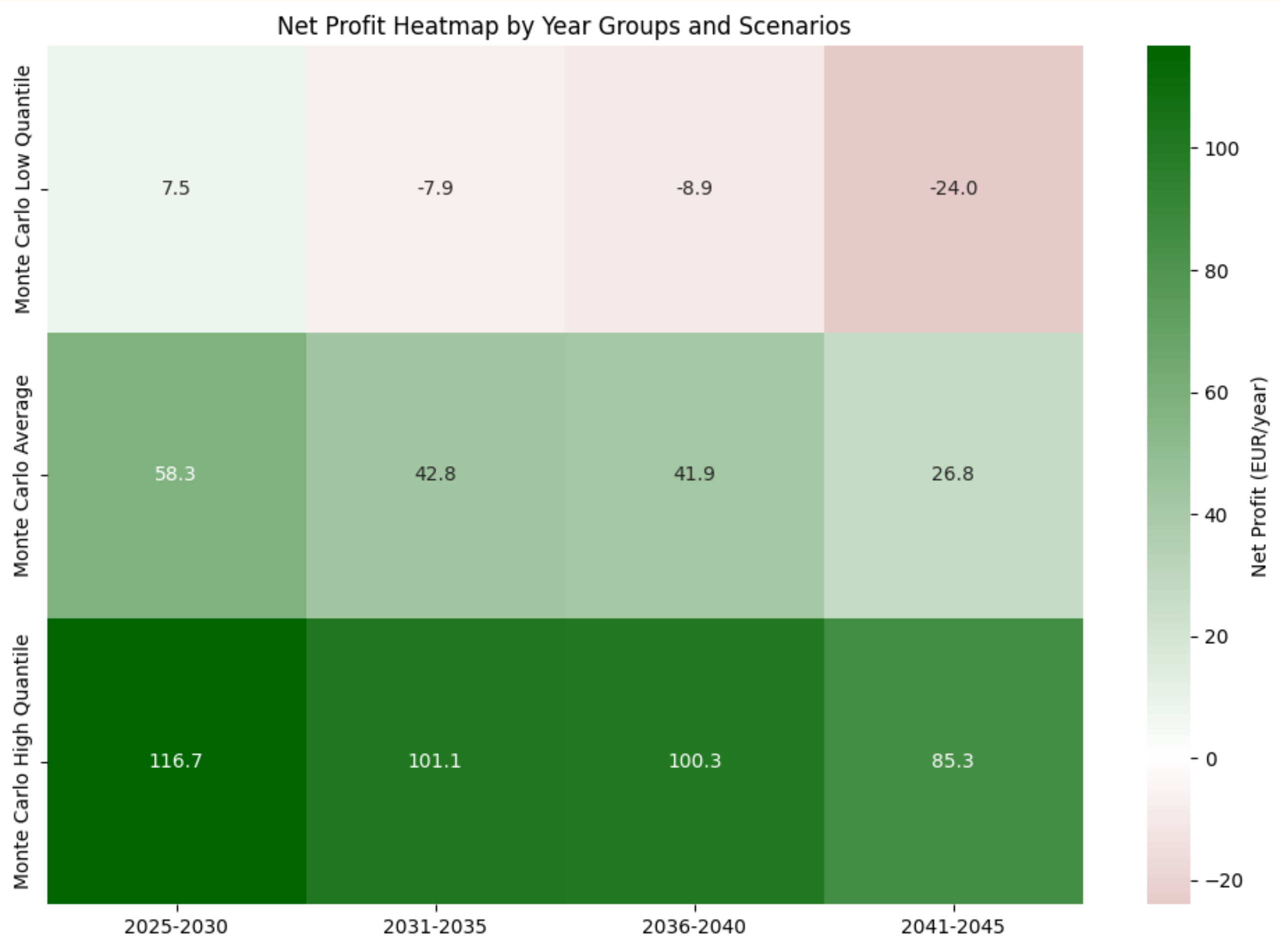
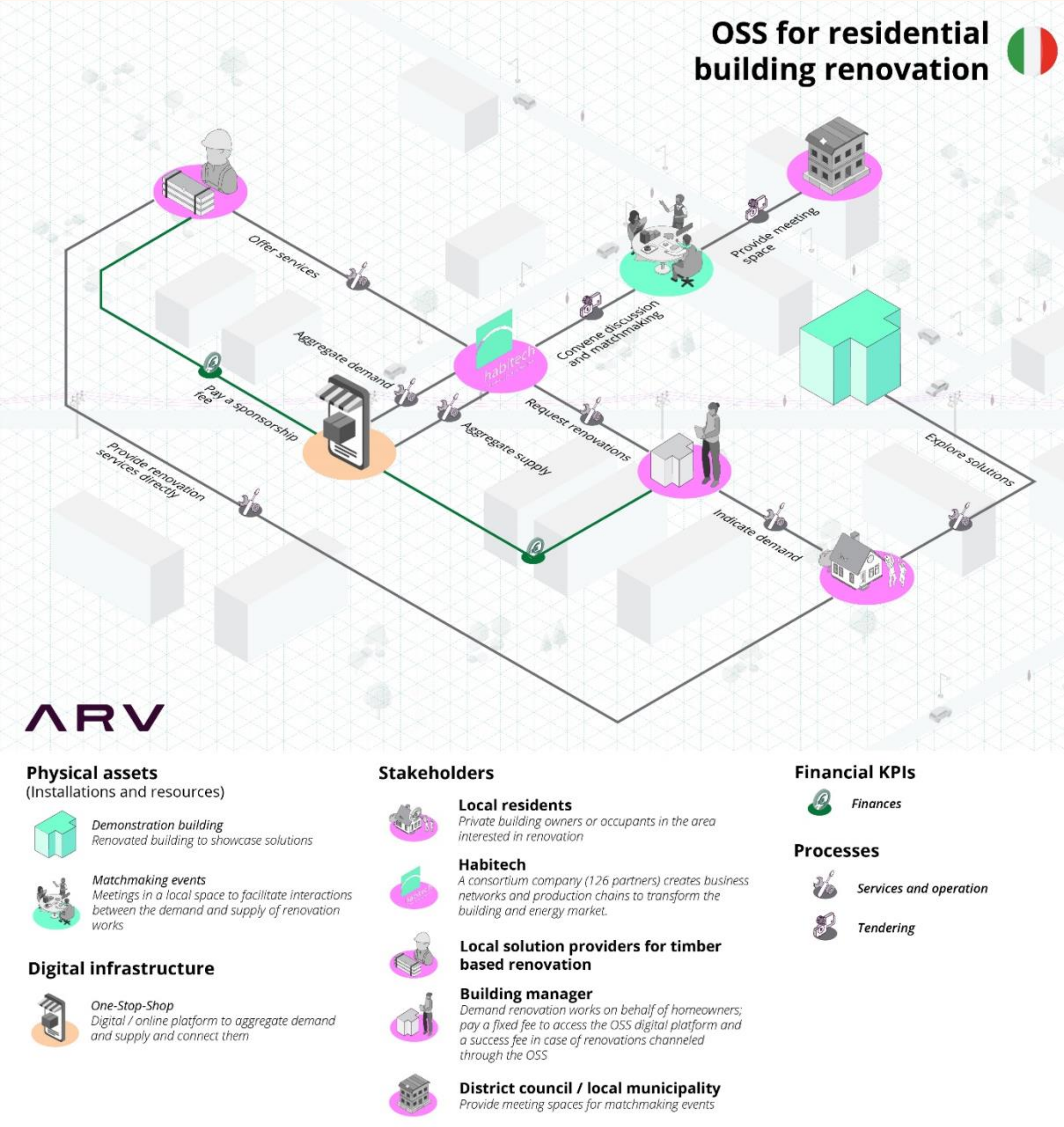


Figure 11. *Heatmap of net profit by year group and price scenario*

However, these calculations assume 100% self-consumption—meaning all energy produced by the PV panels is consumed by the community, offsetting the equivalent amount that would otherwise be bought from the grid at the PVPC price. Energy production often exceeds consumption at certain times (e.g., during midday), which would lead to excess energy being either stored, if storage is available, or exported back to the grid if allowed by regulations. In typical conditions, self-consumption rates can vary significantly, often falling between 60% and 80% depending on the size of the PV system and the energy demand pattern. In addition, there are some few more important limitations in this final analysis. First, the calculations do not include additional taxes such as VAT and electricity taxes, which are part of the final consumer price and can influence total energy savings. Including these taxes could potentially increase the savings and profits, but they also add uncertainty due to potential changes in tax policies.

ONE-STOP-SHOP FOR RESIDENTIAL BUILDING RENOVATION



BUSINESS CHALLENGE

One-stop-shops (OSSs) are vital tool to accomplish the goals of the Energy Performance of Buildings Directive (EPBD), aimed at curbing emissions and energy consumption in EU buildings. OSSs offer homeowners a centralised pathway for tailored assistance, guidance and financing for energy renovations. A comprehensive solution involves the creation and matching of supply and demand, i.e. renovators and homeowners. The concept is not new, and various solutions already exist. Yet, the failure in the initial phase of demand creation, "attracting customers", can negatively impact the value chain actors' ability to engage their potential customers. On the other hand, building a supply of innovative and more sustainable solutions in a largely SME dominated market is challenging.

The table 17 below describes the challenges of each key stakeholder.

Table 17. *Stakeholders and roles and their challenges related to the OSS Platform for building renovation*

Stakeholders and roles	Stakeholder challenge(s)
DTTN (Distretto Tecnologico Trentino): Construction value chain aggregator, OSS facilitator, assistance to match demand and supply. Provides initial capital investment to set up and manage the OSS platform.	Fragmentation of the demand/supply chain; overcome business as usual renovation processes towards more advanced sustainable solutions
DTTN LTP in ARV, timber-based panels manufacturer and construction firm	Lifting/reducing market barriers for prefabricated retrofit kits (more expensive than ETICS)
Homeowners: OSS target group for the demand of renovation works	Informative gaps of a renovation process; uncertain customer journey; lack of trust in construction firms; uncertain renovation time/costs; poor quality of renovations; uncertain financial schemes for renovations (i.e., public subsidies, tax credit, etc.)
Building manager: Demand renovation works on behalf of homeowners; pay a fixed fee to access the OSS digital platform and a success fee in case of renovations channelled through the OSS	Administrative burden from collecting bids from different providers; difficulties to navigate through a fragmented supply chain when managing multiple buildings
APRIE, Energy Agency of the Autonomous Province of Trento: (Potential) policy and technical advisor to finetune the OSS	Low renovation rate (against EU targets); emissions and energy consumption of the residential buildings
Piedicastello District Council: Liaise between the homeowners and the OSS team, raise awareness on the service	Outdated residential buildings in the area (from the '70s)
DTTN cluster members (= firms): OSS supply side; Provide design services and renovation works (facade, envelope, systems, etc.). Pay a fee to access digital platform and physical matchmaking events.	Fragmentation of the construction value chain; low visibility of innovative products (vs. BaU solutions); leverage on upskilling and qualitative works (to be accredited as OSS members)

VALUE PROPOSITION

A one-stop-shop (OSS) is an innovative refurbishment approach which intends to match both sides of the market (demand/supply of renovations) by facilitating and providing support at all (or selected) stages of the design and construction works.

The aim of one-stop-shops is to scale-up renovations from single buildings to district and large-scale in a cost-efficient way for building and homeowners. In ARV, it is mostly based on the replicability of prefabricated and circular renovation solutions which could benefit from economies of scale when applied to a district level and create a win-win scenario for the reduction of both manufacturing costs and the final price.

The table 18 below describes the value proposition in detail for each key stakeholder.

Table 18. *Value proposition of the OSS Platform for building renovation for key stakeholders*

Stakeholders	Stakeholder benefit
DTTN	Development of a new corporate service; visibility as a regional cluster organization; enlarge the cluster membership; promotion of sustainability for the built environment (corporate mission); local value chains
DTTN LTP in ARV	Market uptake of the "Renew Wall" retrofit kit; industrialization of the manufacturing process; (potential) workforce increase
Building manager	Streamlined process for the collection of bids; improved information on the available suppliers/technologies and their added value for single or multiple renovation projects; accredited and skilled firms; higher quality and more sustainable renovation (i.e., RES, biomaterials)
Homeowners	Improved customer journey and knowledge; accredited and skilled firms; streamlined renovation process; higher quality and more sustainable renovation (i.e., RES, biomaterials); time and noise reduction (i.e. prefab. systems)
APRIE, Energy Agency of the Autonomous Province of Trento	First OSS testing site in the region; policy development; private-public cooperation; scale-up and replication at the city-regional level
Piedicastello District Council	Integrate the OSS in the local urban regeneration plan; political benefit
DTTN cluster members (= firms)	Value chain cooperation vs. competition; planned and coordinated renovation works at the district level; market positioning and new clients

UNIQUE SELLING POINT (USP)

The Trento one-stop-shop presents a hybrid setup, including a digital platform to showcase renovation services/technologies and some local matchmaking events to facilitate interactions between the demand and supply of renovation works. It also benefits from a demonstration building that has been renovated using the prefabricated and circular renovation solutions in the Povo District. This allows a unique opportunity for potential future customers to visualise the available solutions in real life – albeit be it only from the outside of the building.

ECONOMIC ANALYSIS

The reference case for this economic analysis focuses on the One-Stop-Shop (OSS) hybrid model, designed to streamline the renovation process for buildings. The business model has a lifespan of three years, and the data presented in the accompanying tables 20 and 21 refer to the total costs and revenues generated over this period.

The personnel costs for DTTN (the organization responsible for managing the OSS) will be covered by the ARV project and therefore by EU funding. During this initial phase, fees for users—specifically DTTN cluster members and building managers—will not be charged. This waiver of fees is intended to make it easier to engage participants on the platform early on. It is further specified that certain assumptions, such as those related to building renovation costs, are derived from average values based on previous renovation projects. These are typically for medium-rise apartment buildings, offering a general guide for projected costs.

DTTN's perspective

DTTN takes on the responsibility of the initial investment needed to set up and manage the OSS. These investment costs include creating the digital platform, organizing the matchmaking events, and covering the necessary personnel, such as helpdesk staff, who assist with user inquiries and manage the interaction between supply and demand for renovation services. DTTN’s long-term sustainability plan relies on generating revenue from several sources, the primary one being a sponsorship package. This package is designed for cluster members (suppliers of renovation services), who will pay an annual fee of 100€. Building managers will also contribute, with a fixed annual fee of 200€ to access the digital platform and matchmaking service. Additionally, building managers will pay a success fee if renovation projects are implemented as a result of the OSS service.

DTTN also obtains other indirect benefits, such as expanding their membership service by attracting new cluster members and positioning themselves as a prominent regional actor in the sustainable construction market. The self-promotion opportunities offered by this OSS project are substantial, especially as it positions DTTN at the forefront of innovation and collaboration in the sector.

DTTN cluster members' perspective

Cluster members represent the suppliers of renovation services and pay a fee to gain access to the digital platform and the local matchmaking events, which are bundled into a sponsorship package. The annual cost for them to access the platform is 100€, and they will also incur additional costs related to the personnel needed to interact with the platform and participate in the matchmaking events. These events are an opportunity for cluster members to meet building managers and homeowners, creating new business leads. It is worth noting that the additional costs incurred by cluster members could be already planned in their cost structure for marketing and commercial purposes.

If a match is made, cluster members stand to generate significant revenues from the renovation works. It is estimated that each renovation of a medium-rise apartment building could result in around 90,000€ in profit over three years, assuming a 30% profit margin. Besides the direct financial gains, cluster members benefit from reduced administrative burdens, as the platform streamlines much of the coordination required for renovation projects. Other advantages include the potential for collaboration with other members, the opportunity to penetrate the market with innovative solutions like prefabricated kits, and increased visibility and self-promotion through their participation in the digital platform and events.

Homeowners' perspective

Homeowners form the demand side of the renovation market, as they will ultimately pay for the renovation of their properties. For a medium-rise condominium, the average renovation cost is expected to be around 600,000€. Homeowners can recover part of these investment costs through national tax deductions available for energy efficiency renovation projects. In the business model, the applied tax deduction reflects the current national rate (50%) and a deduction timeframe of 10 years, though this factor may change in the future. Additionally, homeowners are likely to achieve energy bill savings thanks to renovation actions, however these savings were not quantified in this report as homeowners represent indirect stakeholders of the business model, not direct customers.

Building managers' perspective

Building managers, who act on behalf of homeowners, also play a critical role in this process. They are responsible for organizing and managing the renovation work. To access the OSS platform, they pay an annual fee of 200€ and an additional success fee if a renovation project is matched through the platform. This success fee is proportional to the total renovation costs, calculated as 1/1000 of the total renovation cost. Building managers earn revenue from the services they provide to homeowners, which usually amounts to 1.5% of the total value of the renovation project.

Both homeowners and building managers enjoy benefits beyond the financial savings. For building managers, the OSS platform reduces the administrative burden, making it easier to search for and connect with local companies. Additionally, the possibility of receiving integrated bids from OSS-participating companies may result in lower overall renovation costs. Homeowners and building managers alike can benefit from the Business-to-Consumer (B2C) interactions and the face-to-face meetings offered at the matchmaking events, which help build trust and facilitate smoother project implementation.

Table 19. *Stakeholder disaggregated costs and returns of OSS Platform for building renovation (estimated at the end of 2024)*

		Habitech DTTN			Cluster members			Building managers		
		Unit	Value	Notes	Unit	Value	Notes		Value	Notes
Costs	Fixed	€/year	3 000	Helpdesk personnel	€/year	330	OSS coordination personnel (exchanges with the platform, preparation of technical bids)	€/ year	200	OSS digital platform subscription
		€/year	1 920	Personnel for matchmaking events (2 staff members/2 events/year)	€/year	330	OSS Corporate matchmaking personnel (2 events per year for self-promotion)	€	600	Success fee for renovations implemented through the OSS (1/1000 on the cost of renovation works)
		€/year	115	Travel costs for matchmaking events	€/year	100	Sponsorship package (visibility in the OSS platform)			
					€/year	400	Corporate communication kit			
					€/year	115	Event travel costs			
	Variable	€/year	1 000	Rental of meeting rooms for the matchmaking events (2 events/year)				€	7 500	Building manager`s allowance for renovation works (1,5% value on the renovation works)
		€/year	200	Matchmaking equipment (2 events/year)						
		€/year	160	Communication materials						
	Direct	€	1 500	Setup of the OSS digital platform						
Revenues/Savings	Direct/ Indirect	€/year	2 500	Sponsorship package (fees paid by the cluster members, 25 members)	€	90 000	Selling of renovation services (1 renovation, based on 30% profit)			
		€/year	600	Success fee for building renovations (Hp 1 building/year)						
		€/year	5 000	OSS platform subscription from the building managers (Hp. 25 building managers)						
	Subsidies									
	Net yearly	€/ year	1 197		€/ year	30 000		€/year	2 100	
	Net in the lifespan	€	3 590	3 years of lifespan	€	86 150	3 years of lifespan	€	6 300	3 years of lifespan

__Table 20.__ Investment / Return contribution calculation of OSS Platform for building renovation (estimated at the end of 2024)

		Habitech DTTN			
		unit	value	EUR one-off	EUR p.a.
Costs	Helpdesk personnel	EUR p.a.			3,000
	Personnel for matchmaking events	EUR p.a.			1,920
	Travel costs for matchmaking events	EUR p.a.			115
	Rental of meeting rooms for the events	EUR p.a.			1,000
	Matchmaking equipment	EUR p.a.			200
	Communication materials	EUR p.a.			160
	Setup of the OSS digital platform	EUR		1,500	
	Total	EUR		1,500	6,395
Return	Sponsorship package	EUR p.a.	100.00		2,500
	Success fee for building renovations	EUR p.a.	600.00		600
	Subscription to the OSS platform	EUR p.a.	200.00		5000
	Total	EUR		-	8,100
	Investment / Return Contribution	EUR		-1,500	1,705
	Payback Period	Years	0.9		

	Per cluster member			
	unit	value	EUR one-off	EUR p.a.
OSS coordination personnel	EUR p.a.			330
OSS Corporate matchmaking personnel	EUR p.a.			330
Sponsorship package	EUR p.a.			100
Corporate communication kit	EUR p.a.			400
Travel costs for matchmaking events	EUR p.a.			115
Total	EUR		-	1,275.00
Selling of renovation services	EUR p. building		90,000.00	
Total	EUR		90000.00	-
Investment / Return Contribution	EUR		90,000	-1,275
Payback Period	Years	0.014		
Number of Members (building managers	25			
Number of buildings	1			

Color Legend

(turquoise)	Value referenced in D9.3
(orange)	Assumption
(purple)	Key Indicator

MAIN CHALLENGES OR RISKS AND THEIR MITIGATION

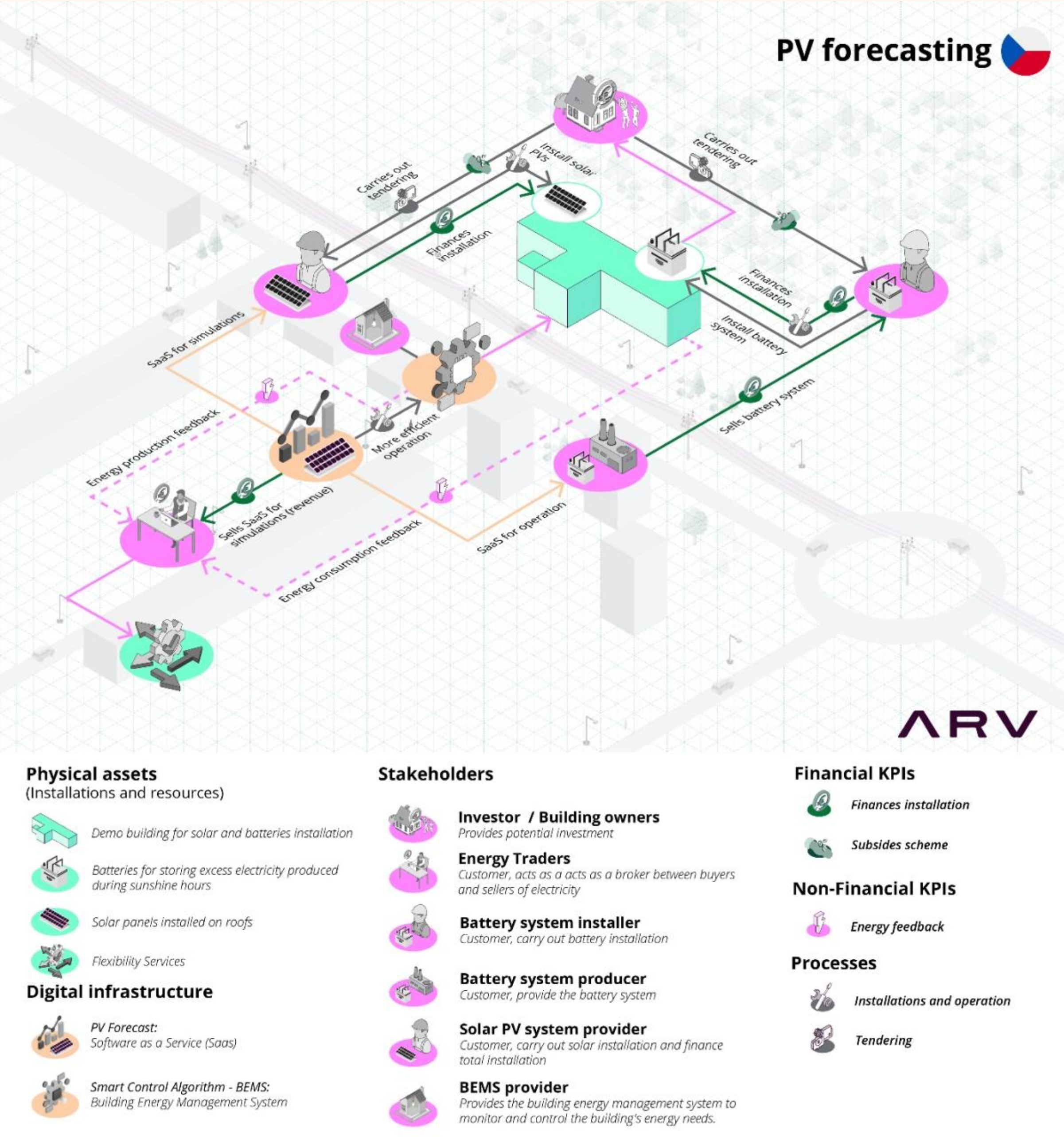
Lack of knowledge and information

General homeowners lack of awareness and fear of high costs for building renovation process can be an obstacle. Communication and awareness raising campaigns on the available technical solutions may mitigate this attitude and foster direct contacts with the construction value chain. Tangible examples of cost savings and technology deployment are an added value. Good communication on fiscal benefit for renovation at the regional and national level can help.

Business as usual and competition

Market competition often inhibits cooperation of firms (i.e. to deliver integrated bids). Demand aggregation can lead to economies of scale, especially with regards to prefabricated and industrialized manufacturing process (i.e. wood facades), potentially reducing production and final costs.

FORECASTING-AS-A-SERVICE: PV FORECASTING



BUSINESS CHALLENGE

The rise in renewable energy sources creates new challenges for efficient operation and management of renewable energy sources, storage, and demand and predictive energy management systems combining photovoltaic resources with energy storage and consumption planning. There are issues with energy waste, missed tradable potential and inaccurate energy production and consumption estimations. Furthermore, insufficient data for effective energy buffering complicates the ability to accurately simulate PV production and minimise forecast errors, and the lack of hyper-local data leads to errors in financial modelling and inaccurate payback estimations for solar PV installations.

Table 21 below describes the challenges of each key stakeholder.

Table 21. Stakeholders and roles and their challenges related to the PV Forecasting solution SaaS

Stakeholders and roles	Stakeholder challenge(s)
Building energy management system provider	Inefficient energy use resulting from suboptimal energy management, gaps in self-sufficiency, unwanted excess fed into the grid, and untapped flexibility potential for providing additional services.
Energy trader: Customer who pays a monthly fee for the service	Lack of high time resolution data available on energy flexibility from buildings > loss of tradable potential, incorrect energy production estimation.
Battery system provider: Customer who pays a monthly fee for the service; provide the battery system connected to the building and solar PV.	Lack of data for qualified energy buffering.
Battery system installer: Customer who pays a monthly fee for the service; provide the battery system connected to the building and solar PV.	Estimating dimension of battery and system parameters using simulations on PV production. In detail can also simulate errors of forecasting to minimize consequences of forecast error.
Solar PV system provider: Customer who pays a monthly fee for the service; provide the battery system connected to the building and solar PV.	Accurate hyper-local data often not available on building's solar PV potential and battery system, which can lead to errors in financial modelling (when considering solar production potential and installation payback time)

VALUE PROPOSITION

The solar forecasting service leverages advanced meteorological data, satellite imagery, and machine learning algorithms and helps clients predict and optimize energy generation, reduce operational costs, increasing potential for energy flexibility services and enhance grid stability by providing timely insights into solar irradiance variations. It is offered on a subscription-basis to solar power plants and utilities, offering real-time and accurate predictions of solar energy production and it can increase extra revenues from energy trading. This model ensures a steady revenue stream for the forecasting service while delivering tangible value to its customers in the renewable energy sector.

Table 22 below describes the value proposition in detail for each key stakeholder.

Table 22. PV Forecasting solution SaaS value proposition for key stakeholders

Stakeholder	Stakeholder benefit
Building energy management system provider	Savings from using PV production more efficiently and offering additional energy flexibility services.
Energy trader	Better profitability, lower fines for incorrect energy delivery estimation and extra revenues from balancing services.
Battery system provider	Simulations can provide better information on adequate battery system dimensions, cost and operational optimisation and competitive advantages over other products/solutions.
Battery system installer	Competition advantage via providing more beneficial and optimal system, cost optimisation and better ROI.

Solar PV system provider	Simulations can provide better information on adequate PV and battery system dimensions - cost optimisation and the PV system reliability.

UNIQUE SELLING POINT (USP)

The software aims to provide a highly accurate prediction of PV resource production thanks to a network of feedback sensors. The correction of the forecast is instantaneous due to the sensor interconnection and nowcast can be implemented at regional level. The forecast is further refined for selected locations by ground-based imaging in a 10-second period. The goal is to use computer vision to detect clouds and predict the instantaneous evolution of illumination for the observed area, provided by sky scanner service. The long-term operation of the ground-based imaging provides us with a data base for learning specialized neural networks, enhancing accuracy for the future design and operation of PV and battery systems.

ECONOMIC ANALYSIS

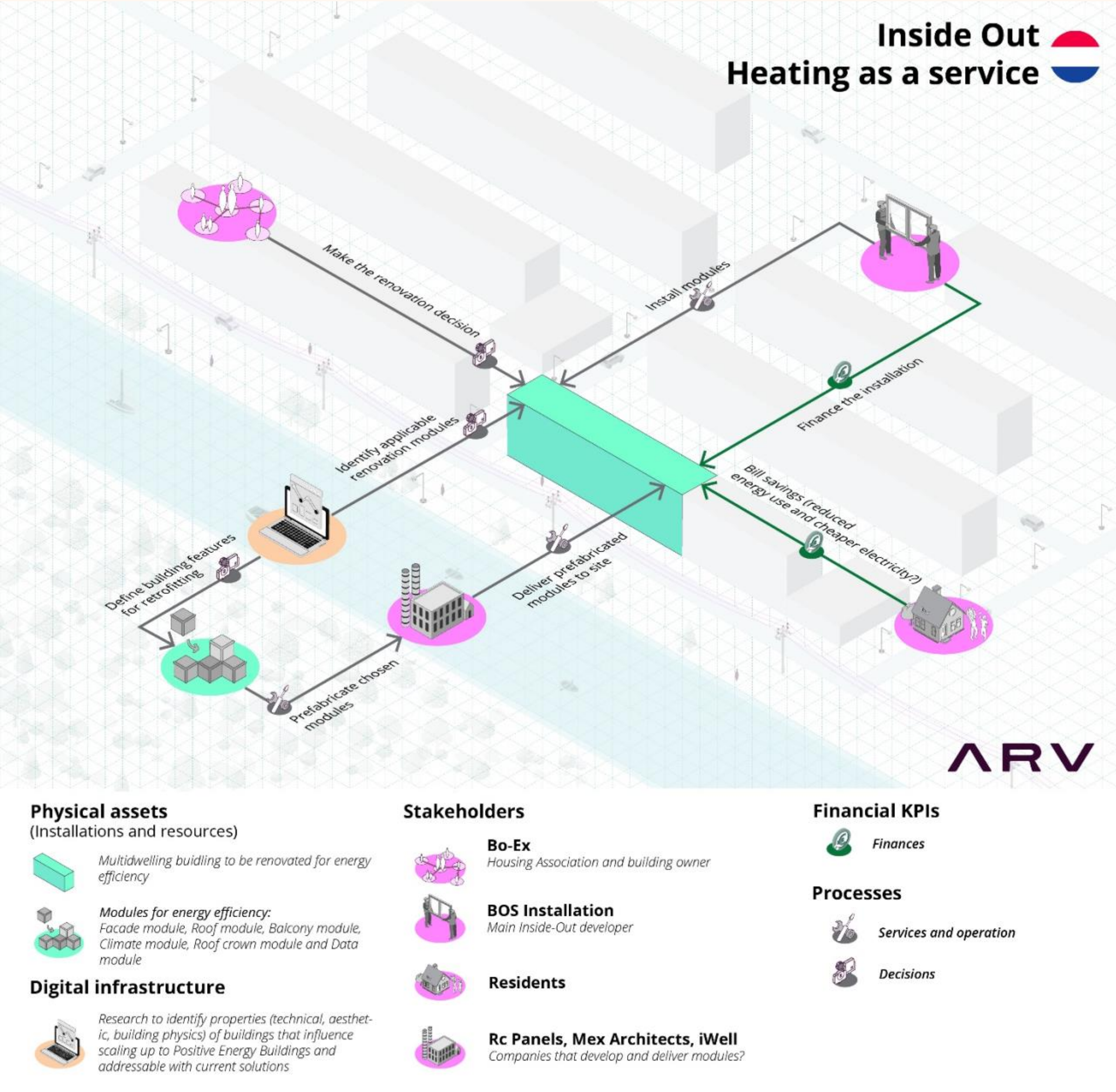
Specific figures for the economic analysis of this business model were not available at the time of writing.

MAIN CHALLENGES OR RISKS AND THEIR MITIGATION

The PV Forecast team excels in technical development but would benefit from additional expertise in marketing and business development. Some capacity for business administration, such as drafting SaaS agreements, is also needed to support the uptake and scaling up of the PV Forecasting solution.

Limited progress has been made on these aspects within the tasks and efforts leading to this report, and greater collaboration with business mentors, accelerators, or commercialisation experts could add significant value. During the remainer of the project, this work can continue within the exploitation focused tasks, particularly through the regional scale-up advisory groups, with potential to involve accelerators that specialise in early-stage business development and idea validation.

INSIDE OUT – HEATING-AS-A-SERVICE



BUSINESS CHALLENGE

The social housing corporations of Utrecht are faced with the challenge of renovating their social housing units in the coming years, while at the same time increasing the public space, quality of life, safety, mobility and culture in the area. Most of these homes are 1960s and 1970s system-build high-rise flats, of which there are approximately 15 000 to 20 000 in North-Western Europe offering a huge market potential for a systematic approach. It is a major challenge to renovate these apartment buildings to Zero or Positive Energy Buildings in a cost-efficient way. Important obstacles are the lack of integrated, generically applicable, affordable solutions, the limited possibilities for renewable energy generation in and around the high-rise flats, the extra space required in the homes and public space, the organization of innovation and collaboration with the construction value chain partners, the required renovation time, inconvenience for residents and limited confidence of residents in long-term (energy) performance.

Table 23 below describes the challenges of each key stakeholder.

Table 23. Stakeholders and roles and their challenges related to the Inside Out solution

Stakeholders and roles	Stakeholder challenge(s)
Social housing corporation: Owner of the apartment building	Needs to provide housing with sufficient heating solution. Does not have knowledge of HVAC installations, rising costs of the installations with the rising costs of maintenance costs.
Tenants of private homeowners: customers of the social housing corporation and the ESCO. The tenants will pay for the heating services and ventilation services	Lack financial means for new installation systems
Energy Service Company: Providers the heating and ventilation to tenants of Social Housing Corporation	Finding financial loans for the investment. Legislation is also a challenge when wanting to create an ESCO for just one apartment building
HVAC installation company: to place and maintain the installations	Complex systems every building is different

VALUE PROPOSITION

The Inside-Out is a system design for retrofitting of mid/high-rise social housing to Positive Energy Buildings. The Inside Out business model is exploring Energy-as-a-service (EaaS) as an Energy Service Company (ESCO) for HVAC installation for retrofitted buildings. This lowers the investment costs for the building owner. The installations that provide the heating and domestic hot water are owned by the ESCO. The ESCO is responsible for maintenance costs. The dwellings only pay for the energy used.

Table 24 describes the value proposition in detail for each key stakeholder.

Table 24. Inside Out solution value proposition for key stakeholders

Stakeholders	Stakeholder benefit
Social housing corporation	Outsource the installations and ownership. Clear life cycle costs for their building portfolio
Tenants of private homeowners	Access to clean energy, lower energy prices (regulated under the Heat Act, ensuring greater protection and clear rights for homeowners)
Energy Service Company	Steady & long-term revenue, access to a wider customer base
HVAC installation company	Standardization of installations which makes it easier to place and maintain the installation. Lower costs with better returns

UNIQUE SELLING POINT (USP)

The innovative design elements of the integrated and modular building components are:

- Rooftop: integrates the collective heat pumps, buffer vessels, (BA/BIPV) panels, insulation system.
- Facades: integrates heat recovery for LT heating and ventilation, DC-ready cabling and (BA/BIPV) panel
- Panels will be modular and adaptable to different building typologies, connecting to different façade and balcony sections
- Identifying the needed diversity of the renovation concept to create the architectural appearance which can be adapted and applied to the context.

- Standardization and flexibility of the interface connecting above modules that offer a higher adaptation potential in full life cycle and create less waste trough net assembly.
- Collective systems require fewer installations per home, reducing material usage. This contributes positively to circularity by minimizing resource consumption and waste, supporting a more sustainable lifecycle for materials.

ECONOMIC ANALYSIS

Due to some aspects of the innovation being confidential in nature, economic analysis data is not publicly available.

CASE STUDY: DECISION-MAKING PROCESS TOWARDS PEB RENOVATION IN UTRECHT

The Inside Out renovation product system was first demonstrated at the Henriettedreef in Utrecht. This ten-story building from the 1970s was transformed into a Positive Energy Building (PEB). The building is owned by the housing association Bo-Ex. In ARV, Bo-Ex aimed to renovate four more buildings to become PEBs. Once again, the Inside Out approach would be central in the renovation. This case study describes the decision-making process at Bo-Ex that resulted in the choice for a different route. The case study demonstrates some of the challenges in the process towards a CPCC and highlights the main factors that influenced the process.

Bo-Ex

Bo-Ex is a project partner in ARV. They offer over 9000 homes for rent in the city of Utrecht. They present their course in sustainability in their yearly reports as follows:

"We are continuously working on improving the average energy label for our entire housing stock (in 2022 average label A)[21]*. Sustainable energy must be available and affordable for our residents. Making our homes more sustainable must not lead to higher housing costs. We strive for as much CO_2 reduction per euro as possible, without this leading to higher housing costs for our residents. We achieve CO_2 reduction by, among other things, making more and more homes natural-gas free, insulating them and installing solar panels*[22]*."*

As part of this mission, they renovate their homes to label A or better, by insulation and the transition towards renewable energy. Their tenants typically live on a small budget, which is reflected by the repeated mention of affordability and housing cost in Bo-Ex' sustainability policy.

Timeline

2018 – 2021 Bo-Ex realizes to first PEB renovated building

The first apartment building renovated to a PEB was realized at the Henriettedreef. The project gains national and international attention, with visit from the Dutch king, visits from other housing associations inside and outside the Netherlands and a special broadcast on the German television channel ZDF. On a yearly basis the building generates 10% more energy than it uses[23]. The innovative

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[21] *Dutch Energy Labels* https://www.rvo.nl/onderwerpen/wetten-en-regels-gebouwen/energielabel-woningen
[22] *Bo-Ex. Financial statements*
https://boex.nl/media/30584B35-3012-4BE0-8423-C11B67096FEE/Jaarstukken%202023%20(Bestuursverslag%20en%20Jaarrekening).pdf
[23] https://www.inside-out.tech/projecten/henriettedreef

character of the project did take a lot of time from the project manager responsible at Bo-Ex and the investment and maintenance costs are significantly higher than for average buildings.

***Figure 12**. Henriettedreef PEB with the Inside Out concept*

August 2021 – ARV grant agreement

Bo-Ex enters the ARV consortium committing to aiming the realization of four more apartment buildings to be renovated to the PEB-level. The buildings are part of Bo-Ex' investment budget plan as buildings to be renovated between 2023 and 2025, but the allocated budget covers only a standard renovation.

April 2022: Start of the internal process towards renovation at Bo-Ex

The Board of Directors agrees to the elaboration of future scenarios for the four buildings. These scenarios include a 'basic' renovation, a 'renovation+' scenario (Inside Out) and 'demolition/rebuild'. Part of each of the scenarios is not to commit beforehand to specific partners. Bo-Ex adheres to their standard practice of having a procurement process to get the best value for money.

January 2024 Project decision for 'renovation+' scenario

The Board of Directors agrees on the 'renovation+' scenario with a maximum budget. This scenario offers the buildings the level of insulation that makes them fit for the future (Insulation Standard) and a natural-gas free heating source. The choice for the energy concept itself is still open: all-electric or district heating. The investment budgets for the complexes are double the budget from the initial investment budget plan. This scenario is the best option as:

- Renovation+ makes the building Paris proof and has a better business case than the basic renovation as the basic scenario requires an additional renovation before 2050 to become Paris Proof.
- The demolition/new build has a high-risk profile due to the required support of renters, required changes to infrastructure and municipal policy.
- The high investment cost can be earned back partly by charging the tenants an EPV *(Energie Prestatie Vergoeding:* energy performance fee) which improves the business case.

April 2024 Decision for district heating

The Bredero buildings will be retrofitted to the Insulation Standard with district heating for space heating and domestic hot water. The Insulation Standard states the maximum heat demand a building may have to be prepared for the transition to fossil-free heating. This standard was published by the National Government in 2021. Insulation to the standard ensures a future-proof investment.

Bo-Ex decided not to go for the PEB scenario, based on an assessment of the business case considering the budget management of Bo-Ex, end-user costs, and risks. This assessment took into account the costs and subsidies involved with the ARV project. The DSO advised against all-electric, as the local electricity grid has severe net congestion, and the grid could not accommodate heat pumps. Also, the business case was uncertain as the EPV-rules for collective heat pumps are under development.

Decision-making framework

Along with the decision making for desired energy concept for these four apartment buildings, Bo-Ex developed a decision support system (DSS) for the selection of a renovation option. The DSS will be used for buildings listed on the investment agenda for renovation in the coming years. The DSS allows for several renovation scenarios to be scored on Bo-Ex' main factors in decision making and attached a weighing factor to them. This results in a combined score for each of the renovation scenarios. The highest scoring scenario is then the preferred option. These factors are, in order of weight:

- Affordability for tenant
- Affordability for Bo-Ex
- Robustness solution/proven concept
- Ease of use/comfort for tenants
- Risk of net congestion issues
- Environmental impact (MPG score)
- Prevention of overheating
- Independence of third parties
- Municipal heat planning
- Risk of unavailability district heating
- Risk of issues during instalment in apartments
- Risk of price developments
- Risk of financial gains from the PV system
- Risk of required participation in the neighbourhood

It is interesting to see that support by tenants is lacking from the list, while 70% agreement is legally required before a renovation can start. That said, the affordability and ease of use / comfort for the tenants are two criteria which directly affect the support of tenants on the renovation plan.

External factors in the decision making

EPV

EPV (*Energieprestatievergoeding*) is a fee paid by social housing tenants to the housing corporation as compensation for the investments to renovate the building to be energy positive. This fee may never be higher than their reduction in energy costs. The national government dictates energy performance criteria for the EPV. The basic level is equivalent to an energy label A++++.
The current version of the EPV is applicable for individual heating installations only. Each home is to have their own installation. In the Inside Out solution, a collective heat pump is applied. Therefore, Bo-Ex would not be able to ask a fee for the retrofit to PEB using the Inside Out solution, thus compromising Bo-Ex' business case for the renovation. A new version of the EPV is under development. There is a strong lobby to include collective heat sources in the EPV. However, this is uncertain as well as the timing of this change. The risk for a poor business case was an important factor in Bo-Ex' decision.

Net congestion

The Netherlands experience net congestion on all power levels of the electricity grid. The Inside Out design for the building complexes includes a large number of PV-cells to provide the energy for heating, ventilation and household usage. A battery would store the energy to align production and consumption over the day. The feasibility study showed that the grid connection would have to be enlarged to accommodate this electric installation. The local District System Operator (DSO) Stedin indicated that the neighbourhood's grid had to spare capacity so applying for an enlarged grid connection might result in a denial or delay. Inside Out's models showed that the current connection would suffice, using the battery. Still, the risk of delay by the need for a bigger grid connection weighed highly in the decision making.

Heating transition

The complexes are located in the neighbourhood Kanaleneiland. In 2022, the municipality of Utrecht appointed Kanaleneiland as one of the first neighbourhoods to move away from national gas in their vision on the city's heat transition[24]. The neighbourhood is to phase out natural gas by 2030 and the most logical solution is district heating.

September 2024 Renewal of the project decision as district heating is unfeasible

The decision to connect the complexes to district heating has proven unfeasible. The locally active district heating company has not been able to form an acceptable offer to Bo-Ex. The costs for connecting to the district heating and monthly fees will cause the housing costs of the tenants to rise unacceptably. As stated in Bo-Ex' course in sustainability, Bo-Ex does not allow the housing costs to rise due to steps in sustainability. The fallback scenario is to retain the connection to the national gas grid and take the step towards phasing out natural gas at a later time.

Recommendations to Inside Out

Based on this case study, three recommendations towards Inside Out can be made:

1. Investigate whether the investment costs can be lowered. Due to inflation over the past years, investment costs have become even more important to housing associations.

[24] *Heat Transition Vision Part II.* https://utrecht.bestuurlijkeinformatie.nl/Agenda/Document/3a2786ca-2d0e-4f6f-9ea1-44910d7cacb9?documentId=c0cb8b88-47e3-4cb3-b094-7f428e030fb4&agendaItemId=ac50ce1e-ddb2-49cb-b4d3-40de429f40b1

2. Find convincing evidence that the current electricity grid connection of the building suffices to become all-electric.
3. Move the government to adopt collective heat pumps in the EPV systematic.

7. ECONOMIC ANALYSES REFLECTIONS

This chapter reflects on the results of the economic analyses described for each business model in the previous chapter. The economic analyses aimed to quantify revenues, cost-benefits and long-term viability of business models to guide the exploitation and commercialisation of climate positive circular communities related business models.

At the time of writing, some key financial and scalability-relevant information from the business models were not yet available, were estimates, or had not been fully quantified (e.g. economies of scale, cost degradation, residual value of certain infrastructure such as batteries or solar panels). In some instances, these gaps reflect the models' innovative and emerging nature, but this may have impacted the robustness of the analysis. All project business models are in active development, and this chapter attempts to provide valuable insights into future development needs and tasks

ECONOMIC ADVANTAGES OF LOCAL OR DECENTRALISED ELECTRICITY MODELS

Local or decentralised electricity business models, such as those combining solar PV and battery systems, demonstrate a clear economic advantage through on-site energy consumption. For example, in Sønderborg, the value of self-consumed electricity is estimated at €0.40 per kWh, compared to just €0.07 per kWh for electricity sold back to the grid, highlighting the financial incentive to prioritise self-consumption. Furthermore, the increasing integration of renewables into the energy system has led to critical issues with grid congestion, particularly in regions like the Netherlands and Utrecht demo. By maximising on-site energy use, these models can help alleviate grid pressure while enhancing local energy resilience. Although batteries represent an additional upfront investment, their payback period can be determined and optimised, as demonstrated in Sønderborg, where a specific break-even point was calculated. However, as the analysis of future energy prices in Spain illustrates, fluctuating electricity prices may influence the long-term economic viability of these models. Conducting sensitivity analyses or using advanced market modelling to predict future price trends offer a more reliable approach to understanding economic outcomes.

SIGNIFICANT RELIANCE ON PUBLIC MONEY OR SUBSIDIES

Many of the business models, particularly those targeting households as end customers, rely strongly on public subsidies. This leaves them vulnerable to shifts in political priorities and public budgets, be it on a national or the EU level. Without subsidies, the current customer base’s limited purchasing power or the prohibitive cost of the product or service does not support a viable business case, potentially creating significant challenges for widespread adoption. Given the increasing strain on public finances, it is essential to prioritise subsidies for low-income households while exploring ways to blend public funding with private investment to scale up renovation efforts. This approach can help attract private capital or alternative sources of funding and create more sustainable financing structures. For instance, the retrofitting management entity was funded by the city of Palma, and it plays a key role in enabling the retrofitting works. This enables the generation and sale of Energy Savings Certificates (CAE in Spanish) as a complementary financing source. These certificates are generated for each kWh saved and paid by energy companies, wholesale petroleum operators, and wholesale liquefied petroleum gas operators.

Additionally, such models would benefit from more holistic assessments of the multiple benefits of renovation, energy savings, or renewable energy production. This might include reduced healthcare costs, fewer sick days, carbon savings, and energy cost reductions—costs that might otherwise require subsidies. Highlighting these broader societal gains can strengthen the case for continued public and private support and foster long-term scalability.

QUANTIFYING IMPACTS FOR A STRONGER BUSINESS CASE

The ARV project is designed around a robust set of environmental, social, and economic KPIs, aligned with the EU's overarching policy ambitions, such as the Green Deal. KPIs have also been defined for each demonstration case and business model to reflect their contributions towards impact goals. However, the complexities and diversity of the innovation portfolio make it even more essential to identify early the KPIs that are being quantified, monitored and validated to allow better comparability and assessment by third parties as to the relevance and transferability of findings. Therefore, the next step should be a quantitative assessment of how each business model and its underlying innovations contribute to these KPIs under various scalability scenarios. This analysis can help demonstrate the broader impact and replicability of these models and their ability maximising climate positive benefits of a CPCC. Without such a framework, identifying and effectively exploiting innovations with high potential becomes significantly more challenging.

Certain business models, such as the aftercooling solution developed in Sønderborg, offer highly attractive investment returns, with average payback times of less than three years, however as a standalone solution, the impact potential is limited. In that regard, a "package of solutions" approach can be particularly effective, combining smaller, less impactful innovations to achieve substantial overall reductions. This approach is also reflected in the project's ambition towards integration, where several aspects and solutions are deployed as a combination. Additionally, it is important to consider the timelines for development and market entry. Smaller, ready-to-install solutions can begin delivering measurable impacts immediately, while higher-impact innovations may require longer for their uptake. By integrating both near-term and long-term opportunities, the combined approach can maximise both immediate and sustained progress toward climate positive goals.

NEED FOR MORE BUSINESS EXPERTISE

The analyses underscore the importance of embedding business expertise within technical project teams from the outset. Many demonstration sites revealed a gap in business capacity, with project teams focusing heavily on technical innovation while lacking capacity or resources for the demands of market development and stakeholder engagement. This has been addressed to some extent within the tasks leading up to outcomes described in this report, however a closer collaboration with business mentors, accelerators, or commercialisation experts would be beneficial.

Similarly, there needs to be a strong understanding of the difference between a pilot set-up and a mass roll-out, and what steps are needed to engage with potential off takers and scalability and replication partners. Work towards that goal has begun and will continue in the context of project's exploitation related tasks, specifically with the ARV Exploitation Board, and engagement with ARV Innovation Clusters and regional scale-up advisory groups to identifying key partners for the offtake. This could include startup or business accelerators, who often are designed and resourced to support teams in idea validation and business development and are particularly active at early stages of a company or business idea.

8. ANALYSIS OF BARRIERS AND ENABLERS FOR UPTAKE AND SCALABILITY

Beyond financial or economic factors that impact the uptake and potential scalability of the business models, there are other factors that play a role. This chapter reflects on business model innovation drivers described in chapter 4 and summarises the main enablers and challenges described for each business model in chapter 6.

IDENTIFYING BARRIERS

Several barriers have been identified that can hinder the development and adoption of the business models developed in the ARV project.

Perhaps the most often recurring theme relates to the human factor. Low engagement levels, lack of knowledge, and limited trust in new and often very technical solutions are compounded by concerns over data privacy and security. Governance challenges, such as complex decision-making within housing associations or communities of owners, further impede progress. Mitigation measures include targeted communication and awareness campaigns to inform stakeholders of technical solutions and build confidence through tangible examples of cost savings and successful technology deployment. Highlighting fiscal incentives for renovation at regional and national levels can also encourage uptake. Employing dedicated personnel, such as municipal staff, to facilitate these processes and speak human to human has proven effective.

Permitting delays and restrictions, which can hinder project timelines, can be addressed through streamlined and municipality-facilitated permitting processes, as was done by the City of Palma in facilitating the retrofitting management entity. On the other hand, as the Inside Out case study in Utrecht shows, this is not always possible due to local conditions - in that case the net congestion of the electricity grid.

Many business models described in this report represent a disruption to the business as usual, and conflicts of interests between established market players and newcomers sometimes appear. This is the case for instance in the Spanish publicly funded energy community model, where the boom of energy communities is not in the business interests of the local energy distributor, whose market monopoly is threatened by them. The energy distributor can cause delays and other procedural problems that may try to delay new installations to maintain their existing business. Another example can be seen in the Italian OSS model, according to which construction and renovation firms might sometimes cooperate on an integrated bid for a building renovation. In reality, this may be inhibited by market competition, and at present firms lack the culture for such cooperation.

The challenge of the "split incentive problem” remains pertinent in business models for buildings and the built environment. Lastly, solutions tailored to and emerging from regional contexts, such as using locally sourced timber in building renovations in Trento can foster local support while delivering environmental benefits. They can, however, be more difficult to replicate in other geographic regions or places where the industrial fabric of the place is noticeably different.

UNDERSTANDING ENABLERS FOR UPTAKE AND SCALABILITY

Active community engagement is a cornerstone of successful implementation of models like Trento’s One-Stop-Shop (OSS), where physical matchmaking events and workshops foster trust and participation together with a digital platform. While being an enabler, this personal and physical approach is more difficult to scale. Making sure that all project communications and materials are available in local languages and are accessible to non-technical audiences is very important. Furthermore, digital tools such as videos, social media, and online communication offer opportunities to complement and broaden community outreach efforts.

Digital tools, such as the solution platform in the Trento's OSS model or the energy community app in Spain letting users better understand their energy consumption, complement the active community engagement. While not inherently groundbreaking, these tools are often underutilised in the building and energy sectors, particularly among households, therefore the cross-sectoral innovation transfer presents untapped opportunities that require little to no new technological development or innovation.

Focusing on standardised or system-built building stock, as seen in the Inside Out case, and supported by data-driven decision-making tools like those developed by IREC and used by the retrofitting management entity, helps prioritise renovation needs effectively. Both the Trento OSS and the Inside Out model leverage prefabrication and intelligent industrialisation to further streamline this process, enabling faster and more cost-effective solutions while avoiding inefficiencies tied to customisation.

Regulatory incentives may directly drive only one of the business models, as seen in the Aftercooling model. In that case, a mandated bonus paid by district heating utilities creates the economic incentive to reduce the DH return temperature, which creates the business case from an economic perspective. It demonstrates how well-designed policies and regulation can create favourable conditions for new business models as well as for their adoption and scale-up.

Through their operation, the business models deliver multiple benefits beyond economics, including social, quality of life, and wellbeing improvements. Highlighting these positive impacts—such as health cost savings, reduced sick days, and avoided energy subsidies—clearly in the value proposition of each business model strengthens their appeal to the target customers, which again may lead to faster or more wide-spread uptake. This "customer education" and changing perceptions of the role of business can also be seen as part of business model innovation that is needed for the success of climate positive business models of the future.

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APPENDIX A – GLOSSARY OF TERMS

Table A.1 *Abbreviations and terms used in the report.*

Abbreviation	Description	References
4GDH	4th generation district heating	https://www.sciencedirect.com/science/article/pii/S036054422400522X?via%3Dihub
B2C	Business-to-Consumer	https://www.investopedia.com/terms/b/btoc.asp
BAU	Business As Usual	https://en.wikipedia.org/wiki/Business_as_usual_(business
BEMS	Building Energy Management System	https://www.cim.io/blog/building-energy-management-systems-bems
CPCC	Climate Positive Circular Communities.	See ARV Deliverable D2.1 for a detailed definition of CPCC
DH	District heating	https://en.wikipedia.org/wiki/District_heating
DSO	District system operator	https://www.gridx.ai/knowledge/what-is-a-grid-operator#:~:text=What%20is%20Distribution%20System%20Operator,(6%2D50%20kV
ESCO	Energy service company	https://e3p.jrc.ec.europa.eu/node/190
GHG	Greenhouse gases	https://wmo.int/topics/greenhouse-gases#:~:text=Greenhouse%20gases%20(GHGs)%20in%20the,warming%20of%201.1%20%C2%B0C.&text=Carbon%20dioxide%20(CO2)%20in%202023,%25%20of%20pre%2Dindustrial%20levels.
KPI	Key Performance Indicator	https://www.investopedia.com/terms/k/kpi.asp
PPP	Public-private-partnership	https://www.investopedia.com/terms/p/public-private-partnerships.asp
PVPC	Precio Voluntario para el Pequeño Consumidor (in Spanish; a variable tariff in Spain that consumers can opt for a variable rate, updated on an hourly basis and tied to the wholesale cost of electricity)	https://www.ree.es/en/operation/electricity-system/pvpc
SaaS	Software as a Service	https://en.wikipedia.org/wiki/Software_as_a_service
USP	Unique Selling Point	https://en.wikipedia.org/wiki/Unique_selling_proposition

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