Guidelines on funding mechanisms and business models of PEDs/RECs

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Project Executive Summary

Energy4All: Energy as a common pool resource

Energy can be conceived as a public resource that should be accessible to all. The human dimension therefore plays an important role in the design and implementation of Positive Energy Districts (PEDs) and Energy Communities (ECs). In the ENERGY4ALL project, energy communities include not only a set of households producing and consuming energy, but also common users of a public resource, such as the industrial and civic sectors. By exploring different ECs elements through four pilot studies in Stavanger (Norway), Styria (Austria), Budapest (Hungary) and Rome (Italy), the project strives to provide insights into how participatory energy governance practices affect the success of PEDs/ECs.

D1.2 Executive Summary

This report presents a systematic overview of the challenges, plans, and collaboration opportunities for funding mechanisms and business models related to pilot cases of Positive Energy Districts (PEDs) and Renewable Energy Communities (RECs) in four innovation contexts within the ENERGY4ALL project, ranging from households to industrial actors, and partnered by urban authorities and business enterprises. The cases featured map on to pilots in Stavanger in Norway (Felleskjøpet and Skretting in the PED Hillevåg case), Budapest in Hungary (Kazán and Megyeri PED cases), the Styria region in Austria (RECs Hengist+ and Graz-Umgebung-Süd), and in Rome in Italy (Quarticciolo REC).

In each context, we provide relevant contextual background in a concise, fit-for-purpose manner to help readers make sense of the diverse actors and incentives at stake to drive pilot development in each emergent case of PED/REC. We then build upon this with an emphasis on present actions and strategic activities from 2024 onwards up to early 2025, to draw out the range of possibilities, barriers and opportunities, as diverse stakeholders strategise in order to align their activities and PED development to create action spaces. This analysis foregrounds the economic, social, technical, and other practical considerations that need to be considered for business models to be feasible, including a helpful overview of relevant funding mechanisms that can be brought into play to support desirable activities. Thereafter, we offer a forward-looking prognosis for each pilot, indicating potential PED pathways while also flagging obstacles that need to be overcome to realise these.

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Introduction

This report provides the contextual background, status overview and future pathways related to funding mechanisms and business models for the Positive Energy District (PED) and Renewable Energy Community (REC) pilot cases in the ENERGY4ALL project, namely:

- Felleskjøpet and Skretting in the PED Hillevåg case in Stavanger, Norway
- Kazán and Megyeri PED cases in Budapest, Hungary
- RECs Hengist+ and Graz-Umgebung-Süd in Styria, Austria
- Quarticciolo REC in Rome, Italy

We purposely do not over-emphasise distinctions between PEDs and RECs, in recognition of the potentially overlapping nature of these initiatives especially at emergent stages when applicable legislation and incentive structures make definitional flexibility of strategic value. We are also mindful that their future development is conditional on political economic dynamics, the complex considerations of diverse actors, and broader geopolitical considerations in the evolving European energy landscape.

This report aims to offer timely, valuable insight on the background contextual conditions, initial actions and current status (from 2024 onwards and as of early 2025), and potential future pathways of cases across these four pilots. Each holds the potential to evolve into a replicable model of a PED/REC, but for this to happen, contingencies related to policies and politics, as well as the industrial and economic considerations of specific actors, must be aligned in a manner that enables innovation and investment towards this ambitious goal. Additionally, diverse specific structural challenges must be overcome in ways that our overview analysis draws out.

By offering this systematic overview for each of the pilot contexts in the ENERGY4ALL project, we are thus able to present guidelines – and important considerations with regard to funding mechanisms and business models of a range of PEDs and RECs. Mindful of the very contingencies that give rise to these versatile approaches, we opt not to propose a rigid framework, but rather, to draw out the contextual particularities applicable to each pilot. This means that the central contribution of this report is to showcase a type of approach, namely contextual analysis of funding mechanisms and business models for PED pilots.

The guidelines we present are summarised in terms of challenges, plans and collaboration opportunities identified for each context. Other aspiring PED pilots can emulate such an approach to map scope for action, challenges to be addressed and mitigated, and opportunities that can be exploited to develop RECs and PEDs in a variety of circumstances.

Stavanger pilot

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1 Case overview of Felleskjøpet and Skretting

We provide brief background about the basic manufacturing industry operations of the two cases in the Hillevåg neighbourhood of the Stavanger pilot in ENERGY4ALL, with emphasis on the scope for re-use of their process waste heat (Section 1). Next, we offer background on progress made to date (Section 2). Thereafter, we present an overview of potential funding mechanisms and business models related to energy transitions for these actors in PED Hillevåg (Section 3), concluding with an overview of challenges, plans, and opportunities for collaboration (Table 1). Part of this text features in an article under review.

1.1 Felleskjøpet

Felleskøpet is a farmers' cooperative feed-manufacturing industry with its regional operations for Rogaland and Agder counties based in Stavanger, established in 1899. It was formed through the merger of small farmers' cooperatives and is now owned by 8,000 farmers. Felleskøpet is a leader in the development of agriculture and a prominent market leader in several business areas, specializing in the production and sale of animal and pet feed and seed products. Their production facility is the largest animal feed production plant in Norway and one of the largest in Europe, producing close to 400,000 tons of feed annually. Consequently, Felleskøpet is a significant company within the well-known feed production and gastronomy cluster in southwestern Norway. Felleskjøpet has recently switched to using natural gas and propane to produce steam for the manufacturing of animal feed pellets due to the high cost of electric energy. Approximately half of the total energy consumption is dedicated to steam production. There is an intent to move towards systematic clarity on energy targets related to consumption and emissions reduction, especially with Felleskjøpet being signatory to the City of Stavanger's climate contract.

Felleskjøpet has come a long way to become a carbon-neutral industry and energy-efficient company, contributing to a low-carbon city and neighbourhood. Despite a decrease in energy consumption, total CO2 emissions have not been reduced due to the company's reliance on natural gas to produce steam. This has been necessary to cope with the increase in energy prices and to remain competitive in the market. Decades ago, Felleskjøpet's energy consumption was around 100 kilowatts (KW) per ton produced. Now, it has been reduced to nearly 75 KW per ton, reflecting a significant 25% reduction over the years mostly due to building more efficient production lines. As part of Felleskjøpet's sustainability strategy for 2023–2026, the company aims to maintain international social and ethical responsibility standards, including environmental sustainability. It plans to achieve a climate agreement to reduce manufacturing's GHG emissions by 55 percent from 1990 levels by 2030 to meet national and global demands, contributing to climate-friendly and sustainable feed production.

1.2 Skretting

Located adjacent to Felleskjøpet, Skretting was also established in 1899, specializing in fish feed production. Skretting uses natural gas and electricity, like Felleskjøpet. For instance, in 2022, the total energy consumption was 17.2 gigawatt hours (GWh) equivalent of natural gas and 8.94 GWh of electricity use. Around 7.6 gigawatt hours per year are used to produce steam, which accounts for about 44 percent of the total natural gas demand by Skretting. While Felleskjøpet uses propane and natural gas to produce steam, Skretting largely depends on natural gas to increase the hot water temperature required to produce the feed. The natural gas is supplied by Lyse, which has a distribution line in the area. It is delivered via a pipeline located close to the factory.

The fish feed production process in Skretting is similar to Felleskjøpet’s with slight differences. The raw materials needed to produce fish feed usually arrive by boat and stored in big silos. This could be wheat, fishmeal, sunflower, maize, and so on, or a mix, which consists of different ingredients that help to produce fishfeed. After grinding these grains into tiny particles, they are blended with different vitamins, minerals and colour agents before transferring them to an extrusion process. In the extrusion process, the product is mixed with steam and hot water to achieve spaghetti resembling gelatinization, which is cut up into pieces and then becomes a fish feed pellet. Because of the addition of moisture and heat, the moisture content is increased by at least 25% to achieve this gelatinization. The next step is to evaporate the water using a drying process. Moreover, around 70 to 80% of the energy demand is related to extrusion and drying. Due to the drying process, considerable excess heat with a lot of moisture is lost without further utility. Skretting operates two production lines with dryers, which during 2022 consumed 4.7 GWh in line 1 and 4.5 GWh in line 2. Additionally, the factory has installed an electrode boiler that could potentially replace fossil energy used for steam and hot water production, but it’s not in use due to high energy costs.

To achieve a climate-neutral Stavanger and promote a low-carbon neighbourhood in Hillevåg, Felleskjøpet and Skretting need to transition away from fossil fuels in compliance with national and international sustainability regulations. This transition involves focusing on energy efficiency and developing strategies to recycle excess heat lost in the form of steam. Both industries are looking for solutions to replace their natural gas and recover the waste heat from steam production. Felleskjøpet aims to move away from natural gas and energy efficiency problems by operating a biofuel boiler, under construction and due to be in operation in late 2025.

2 Action towards energy transition and sustainability targets

2.1 Felleskjøpet

According to Norway's Climate Action Plan (2021-2030), the manufacturing sector must produce low-emission goods and products and consider climate risks and green transitions in their planning and investment (NMCE, 2021). In line with this, Felleskjøpet has integrated sustainability practices into the company's main strategy. That means each division or department must make its own plans and action plans to achieve that overall strategy. Accordingly, Felleskjøpet devised sustainability goals and strategies, including sustainable agriculture, sustainable energy consumption, and sustainable waste management, in order to align itself with the United Nations Sustainable Development Goals (UN SDGs), such as SDG 9 (industry, innovation and infrastructure), SDG 12 (responsible consumption and production) and SDG 13 (climate action). To ensure sustainability in the agriculture and supply chains, Felleskjøpet tries to ensure that grains such as soy which they buy from Asia and Latin America are produced in a deforestation-free manner and without the use of genetically modified organisms. This is not always feasible, however, as tracing small farmers in source countries runs up against limits.

To achieve SDG 9, Felleskjøpet tries to use technology that makes its operations more sustainable. For instance, the company has decided to use electrically powered new forklifts on the industrial estate. Obviously, it is not sustainable to throw out functional machines and devices, but when they need to be replaced, they procure electric forklifts. For *responsible consumption and production*, Felleskjøpet has set some targets for feed production that will reduce waste in general, including energy to reduce CO2 emission from the production, contributing to SDG 13 on *climate action*. The giant leap for Felleskjøpet towards realizing net zero is a substantial investment of many million Norwegian kroner in building a biofuel boiler that will use biomass to produce steam and is expected to reduce the company's CO2 emissions by 70 to 90 percent. The biofuel boiler is expected to produce 3.5 megawatts per hour (MW/h) and will be fuelled by 900 kg of oat husk per hour, with an annual output of 30.7 GWh using 7,884 tons of oat husk. The biofuel boiler will de-hull oats and use the hulls as fuel to produce steam, significantly reducing energy consumption from fossil fuels and contributing to energy efficiency. Investing in new technologies, such as the biofuel boiler, to replace fossil fuels with renewable energy sources is critical in reducing GHG emissions.

Felleskjøpet thus demonstrates a comprehensive and effective strategy for achieving energy efficiency and reducing environmental impact by aligning with global sustainability targets, investing in advanced technologies, and optimizing resources. These best practices enhance sustainability and contribute to long-term operational efficiency and cost savings. Industries looking to improve their sustainability efforts can learn from Felleskjøpet's experiences and implement similar strategies tailored to their specific contexts.

2.2 Skretting

Skretting has implemented an energy management system within the last decade. According to the IEA in 2012, "Energy management involves the systematic tracking, analysis and planning of energy use. Energy management systems include energy management activities, practices and processes" (quoted in Sola & Mota, 2020:248). Energy management aims to increase energy performance and reduce GHG emissions in industries worldwide (Sola & Mota, 2020). Industries consume a large amount of energy globally, and if they work to improve energy efficiency, it will reduce emissions and costs. Skretting's continuous efforts to reduce energy consumption and improve operational efficiency resulted in a significant 25-26% reduction in energy usage over the past decade by implementing and maintaining ISO 50001 energy management systems since 2014, leading to systematic improvements in energy efficiency. Implementing ISO 50001 is an effective way to use energy and cost savings and minimize GHG (Sola & Mota, 2020).

Literature across different regions shows that the ISO 50001 energy management system improves energy efficiency and saves costs. For instance, studies in China (Chiu et al., 2012), in the U.S (Therkelsen et al., 2013) and in Germany (Bottcher & Müller, 2016) manufacturing firms show that the implementation of ISO 50001 contributes to significant energy consumption and costs reduction (Trianni et al., 2013). This, in turn, significantly contributes to curbing global GHG emissions in industrial sectors and promoting low-carbon city neighbourhoods (Rosenow & Eyre, 2022; McKane et al., 2017). Moreover, implementing ISO 50001 helped Skretting to measure and evaluate the energy system and performance.

In addition, Skretting is committed to incorporating science-based targets into its sustainability strategy. By 2030, the company aims to reduce greenhouse gas (GHG) emissions by at least 30% for both Scope 1 (direct emissions) and Scope 2 (indirect emissions). Implementing energy management systems to improve efficiency and adhering to science-based sustainability targets are viewed as exemplary practices by Skretting. Nonetheless, the problem of reutilizing its waste heat, and shifting away from natural gas as a fossil fuel energy source for its considerable industrial manufacturing process emissions, is not one that Skretting had found an easy and cost-effective solution to at the time of study.

3 Challenges and plans

The Norwegian Environment Agency has recently drawn up a proposal for a regulation that prohibits the direct and indirect use of fossil fuels by 2030, aiming to reduce emissions of GHG by approximately 300,000 tons of CO2 per year. Energy-intensive industries, primarily relying on natural gases and propane, are obliged to phase these out by this deadline. Being at the forefront of the largest feed-producing industries in Norway and beyond, Felleskjøpet and Skretting need to replace gas usage for steam production. Since switching to electricity costs them twice the gas price, looking for an innovative energy consumption and waste energy recovery solution becomes a daunting task.

Animal and fishfeed manufacturing industries (i.e., Felleskjøpet and Skretting) are some of the most energy-intensive industries, so efficient waste heat capture and reutilization have naturally great potential for decarbonization. Decarbonizing the industry does not just depend on the use of clean energy for everything; it also requires innovative changes in heat-intensive manufacturing processes. Felleskjøpet and Skretting encounter limitations in reducing the amount of energy they use to produce animal and fishfeed pellets, given that transforming raw materials into products requires energy commensurate with sanitization regulations (heat levels) and grain quality to meet stringent production specifications. This necessitates a high standard of steam production to shape and form good-quality feed pellets. Therefore, onsite energy consumption reduction measures are difficult to achieve; which makes partnering with Stavanger municipality and energy-providing companies to re-use the excess heat a potentially attractive proposition. Waste energy in Felleskjøpet and Skretting can be recovered by heat exchanger and can be transferred into the district heating system. Thematic literature frequently cites heat recovery as a viable option for enhancing energy efficiency (Kim et al., 2024) and recovering waste energy from animal and fish feed manufacturing industries can be a feasible method for reducing emissions (Fleiter et al., 2020).

Felleskjøpet's most significant source of waste energy is the steam production that can be captured. Their sister company in Trondheim, for instance, has a project where they attempted to capture the heat out of their coolers and recycle it into steam through a cascade of advanced heat exchangers. Felleskjøpet's excess heat is estimated to reach between 150 and 195 degrees centigrade, which can heat buildings and swimming pools as well as be integrated into the district heating system. Therefore, the demand to make the industry energy-efficient and decarbonized, and interest from the municipality and Lyse to use the waste energy, make Felleskjøpet interested in this possibility. District heating and cooling requires a suitable temperature, within 100 degrees centigrade (Guelpa et al., 2023). So technically speaking, waste heat from Felleskjøpet is recoverable and reusable. Felleskjøpet has made headway in integrating a sustainability approach in the production and supply chains, with substituting in electric trucks being a future step. A saying in the company is "the most sustainable approach is not packaging", meaning Felleskjøpet convinces its customers to buy in bulk, not in bags, to reduce waste. However, this requires multiple trucks to load the animal feed every day, leaving Felleskjøpet to unload it at their destinations. The use of a fossil fuel truck fleet does not align with the city's approach to future mobility.

The drying operations are the primary sources of waste heat in Skretting. Efforts to reduce energy consumption in this industry have, in part, improved through the implementation of energy management systems. However, the remaining challenge is to develop a future roadmap to decarbonize the factory. According to an operations engineering expert at Skretting:

> *The first step is to phase out the indirect energy from fossil fuels by 2030, as proposed by the government. The next step is how we can utilize the excess energy in the best way for internal or potentially external use and find a solution for funding such a project. It cannot be funded internally because normally, we ask for a payback period of two to three years.*

In order to use the waste energy, Skretting needs to invest in advanced technology. The payback requirement for such major future-oriented investment would likely be more relaxed than the short typical period indicated in the quote. To keep up with national climate targets, Skretting is considering investing in Mechanical Vapor Recompression (MVR) heat pumps aiming to increase the temperature of the steam while reducing fossil energy usage. It is believed that MVR could reduce both the energy used for the dryers and the energy used for heat or steam production. A feasibility study to invest in MVR is underway to assess the potential of MVR as an alternative for future clean and efficient energy usage. However, it is known that such an investment requires high investment costs to recover heat (Wahlroosa et al., 2018), which can cause financial challenges. Skretting officials noted that the industry has a low margin and that investing in heat recovery projects will cost a lot with a low rate of return.

By and large, Felleskjøpet and Skretting require two things: moving away from fossil fuels reliance by 2030 as per government regulations and realizing energy efficiency by reutilizing the dissipated energy through heat. Advanced surplus heat integration to existing district heating networks is an effective option for improving energy efficiency in the industry, and expanding the use of waste energy can significantly improve the overall energy efficiency of manufacturing processes (Kim et al., 2024). The location of Felleskjøpet and Skretting is strategic to integrate the excess heat into the existing district heating network because the district heating provider, Lyse, has a hot water pipeline in the area that could be advantageous to minimize the cost of building new infrastructures. This strategic proximity can accelerate just energy system transitions by bringing energy production and consumption closer together on a local scale (Sareen et al., 2024). Integrating the waste heat from Felleskjøpet and Skretting with Lyse will help create a more competitive district heating system.

3.1 Felleskjøpet, Skretting and Lyse: Opportunities for collaboration?

An operations engineering expert at Skretting reflected that “We cannot work alone. We have to work together and find a solution collectively”. It emphasizes the significance of collaboration among different stakeholders in achieving a common goal. Both Felleskjøpet and Skretting produce significant amounts of waste heat, which could be captured and reused through collaborative projects depending on technical scope which they are keen to identify through study. Engaging with potential partners, like Lyse, to integrate excess heat into its district heating systems and waste energy utilization can open new avenues for energy reuse and increase profitability. While energy policymakers strive to narrow the gap between energy supply and demand, they usually overlook the smarter use of the already supplied energy— utilizing waste energy (Sørensen, 2023).

As identified by Fleiter et al. (2020), excess heat from heavy industries is an untapped source of energy. Excess heat dissipated in the EU alone is close to 2,860 terawatt-hours per year (Sørensen, 2023). This, arguably, amounts to the EU’s energy demands for heat and hot water in residential and service sector buildings (Sørensen, 2023). The excess heat could be used for district heating systems, especially in cities where hot water is widely used for heating purposes. Felleskjøpet and Skretting are in Stavanger’s relatively central Hillevåg district, easing the possibilities of capturing the waste energy and transferring it to Lyse's district heating system and buildings with energy demand in the vicinity. This strategic location reduces transmission and infrastructure costs. In turn, this could accelerate the transition towards net zero, realizing energy efficiency in the industrial sector. According to the EU (2016) report, barriers to reutilizing surplus heat or waste energy from industries include lack of awareness and information, inadequate business models and incentives, insufficient nearby heat networks, and lack of cooperation between industries and energy-producing companies. Our study goes some way to overcome such barriers.

3.2 Future collaboration pathways with Lyse

Lyse is a district heating-providing energy company. It supplies energy in hot water pipes from its production facility at Forus, where it has a waste incineration plant that produces hot water from the waste's incineration. The company then distributes that energy to consumers in both the cities of Stavanger and Sandnes, using about 20 kilometres of pipelines. Lyse has an interest in matching its district heating capacity, heat generation and local heat demand towards future market development, which is contingent upon technical solutions, including in relation to reuse of currently wasted locally produced industrial heat.
Felleskjøpet and Lyse are working together to reutilize the waste energy from Felleskjøpet's steam production. Lyse aims to include Felleskjøpet's waste energy in its district heating network by 2025. Lyse will use Felleskjøpet's available surplus energy in its district heating network only during the winter, those peak hours when Lyse does not have enough heat from the incineration plant. "We will connect Felleskjøpet to our network, and we can increase the usage of the existing plant instead of building another one just next to it. So, we think this is a good resource to use better what is already there instead of building something new", stated a business development expert at Lyse. Lyse plans to build a hot water accumulator tank near Felleskjøpet so that it can store waste energy from Felleskjøpet over several hours, such that Lyse can exchange energy from Felleskjøpet's system to its system without Felleskjøpet having to build anything new, and provide it to end users.

Skretting mainly produces steam to heat and gelatinize the semi-finished fishfeed product. To manufacture the fish feed, Skretting mixes different raw materials with flours, water and steam in the extrusion process, which cuts it into small pellets with approximately 25% moisture. Water is thereafter evaporated to the atmosphere by reducing product moisture content to approximately 10% in the drying process. However, according to an official from Lyse, if Lyse could recondense the water, then some of the energy put into the process could be recovered. And then, instead of using biogas to produce hot water and steam, Lyse can recover the energy by using heat pumps and putting it back into its system. This requires Lyse to install heat pumps because Skretting's waste heat is not hot enough to use directly. Heat pumps can recover low-temperature waste heat and boost the temperatures. Skretting investing in MRV heat pumps can potentially enable the reuse of waste heat.

Table 1 sums up the challenges, plans and collaboration opportunities identified.

Table 1: Overview of challenges, plans and collaboration opportunities

	Challenges	Plans	Opportunities for collaboration
Felleskjøpet	• Uses natural gas predominantly for steam production. • Energy waste (excess heat from steam production and machinery operations). • High cost of transitioning to new technologies and economic feasibility	• Investment in biofuel technology (e.g., biorefinery) to cut CO2 emissions. • Reducing waste and improving operational efficiency. • Aiming for better waste management and recycling practices.	• *joint heat recovery projects:* -Both Felleskjøpet and Skretting produce significant amounts of waste heat, which could be captured and reused through collaborative projects -Potential to integrate excess heat into district heating systems operated by Lyse • *Shared investment in new technologies*: -Co-investing in technologies such as MVR heat pumps or biofuel systems can reduce individual firms' financial burdens and accelerate implementation. • *Knowledge Sharing:* -Regular exchanges of best practices and technological advancements can help both Felleskjøpet and Skretting improve their energy efficiency and sustainability efforts
Skretting	• Uses natural gas for extrusion and drying processes. • Energy waste heat from drying processes • High cost of transitioning to new technologies and economic feasibility	Based on Skretting (2025): • Implementing MVR heat pumps to recover and reuse waste heat • Purchasing electricity origin certificates eliminating scope 2 emissions (implemented 2024) • Implementing heat recovery from extrusion process, reducing CO2 and energy consumption (Q1 2025) • Insulating process equipment reducing CO2 and energy consumption (Q1 2025)	Based on Skretting (2025): • Setting and utilizing science-based targets and working towards CO2 neutrality • Developing a CO2 reduction roadmap for Stavanger plant (Q2 2025) • Studying if Averøy plant waste heat recovery pilot project can be implemented in Stavanger plant (Q4 2025)

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Budapest pilot

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1 Case overview of Kazán and Megyeri

The Budapest pilot cases, comprising Kazán and Megyeri, represent two distinct yet complementary approaches towards establishing PEDs, each uniquely defined by its actors, contexts, and challenges.

1.1 Kazán

In the Kazán pilot, the primary objective centers on drastically reducing fossil fuel reliance and energy costs while fostering a fully integrated energy community characterized by cooperative ownership and sustainable operational practices. The Kazán Community House, a facility marked by historical resilience against displacement and economic precariousness, is currently confronted with technical deficiencies such as outdated mechanical systems, inadequate insulation, and water leakages, contributing significantly to elevated energy consumption. Despite these challenges, Kazán thrives socially, housing dynamic organizations such as the Gólya Cooperative and the Alliance for Collaborative Real Estate Development (ACRED). These groups embody a profound commitment to collective self-management, solidarity economics, and progressive social missions, making community engagement and participatory governance cornerstones of the pilot's approach. Through holistic monitoring, a robust key performance indicators (KPI) framework, and collaborative stakeholder involvement, Kazán intends to transform both its physical infrastructure and occupant behavior, effectively merging technical innovation with the community's core values of autonomy and resilience.

1.2 Megyeri

Conversely, the Megyeri case sets its sights on repurposing an underutilized school building in northern Pest into a Net Zero Energy, multifunctional co-housing complex. This ambitious transformation aims to catalyze the wider district's shift towards sustainability by introducing innovative energy solutions, particularly a novel heat exchange system utilizing the local water pipeline. The pilot area encompasses a diverse mix of institutional, residential, and industrial properties, housing predominantly lower-middle-class residents alongside a notable elderly population. A significant strength of this pilot is its robust institutional backing, with key stakeholders including the Municipality of Budapest, Budapest Waterworks, utility companies, and district authorities collaboratively shaping the project. Integral to Megyeri's methodology is comprehensive stakeholder engagement through participatory workshops, digital interactions designed to understand and influence occupant behaviors and align technical interventions with local needs. The project emphasizes advanced digital monitoring and smart energy management, intending not only to decarbonize the immediate area but also to demonstrate scalable, replicable urban sustainability models.

Both pilot cases, though distinct, share a unified vision of community-centered sustainability, resilience, and cooperative governance. Kazán leverages its strong grassroots foundation and cooperative structures, while Megyeri capitalizes on municipal support and innovative technological solutions.

2 Historical background of recent measures

Historically, recent measures undertaken within these pilot contexts have laid a strong foundation for the current initiatives. In Kazán, significant community-driven actions have previously been implemented, including grassroots renovations and cooperative management practices. The Kazán Community House emerged directly from community mobilization efforts, responding effectively to threats of gentrification and displacement. These prior renovations, although limited in scope and constrained by funding, demonstrated substantial community involvement and laid crucial groundwork for the larger-scale retrofitting envisioned in the pilot.

Similarly, the Megyeri area has already seen preliminary efforts to set the stage for broader sustainability initiatives. Initial measures included extensive documentation analyses, stakeholder mappings, and participatory workshops designed to engage the local community deeply. Preparatory actions have involved collaboration with municipal entities and utilities, establishing crucial partnerships that facilitate the ambitious technical interventions planned. These foundational steps ensure both community buy-in and technical feasibility, positioning Megyeri to successfully execute its transformative vision.

3 Current challenges and pathways for funding mechanism and business model

3.1 Kazán

In Kazán case, the primary challenges stem from the facility's technical deficits, such as inadequate insulation, outdated heating systems, and lack of comprehensive monitoring equipment. Despite these barriers, the project benefits substantially from strong community engagement, volunteer efforts, and an established cooperative management framework. Moving forward, Kazán's business model leverages cooperative financing strategies, phased retrofitting investments, and detailed energy models for forecasting and validating energy performance. These tools are critical to achieving financial sustainability, with long-term cost savings envisioned through smart energy management and flexible rent structures reflective of the community's cooperative roots.

3.2 Megyeri

In contrast, the Megyeri pilot faces different resource constraints, primarily related to the absence of real-time energy data and advanced digital monitoring systems. Additional field surveys are required to capture precise occupant behavior, which is crucial for optimizing intervention scenarios. Megyeri's funding and business model is designed to balance upfront retrofit investments against long-term operational savings. Revenue sources include reduced energy costs, European Union (EU) funds, European Investment Bank (EIB) loans, public subsidies, and potential surplus renewable energy production. Advanced predictive analytics and comprehensive monitoring systems are planned to ensure financial sustainability and optimize system performance, integrating financial instruments that support citizen-centric co-creation aligned with urban development strategies.

Styrian pilot

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1 Renewable energy communities Hengist+ and Graz-Umgebung-Süd

In Austria, we are engaged in two renewable energy community (REC) cases in the Styrian region: Hengist+ and Graz-Umgebung-Süd (GU-Süd). Both cases aim to promote regional energy autonomy through RECs.

1.1 REC Hengist+

The REC Hengist+ is managed as an association and relies on volunteers for its operation. The central figure behind the initiative is Stefan Sturm, the chairman and founder of the community, who is also a representative of the municipality. He is supported by other members of the executive board. So-Strom GmbH has played a key role in supporting the planning and founding phases, and continues to provide essential services such as member management and tax-compliant billing through its digital platform, So-Strom-Digital. Other relevant stakeholders are the municipalities Lebring, Lang and Hengsberg, who joined the energy community recently, as well as household producers and consumers.

1.2 Graz-Umgebung-Süd

In contrast, the "Erneuerbare Energiegemeinschaft GU Süd eGen" in the GU-Süd region operates as a cooperative, with the mayors of the six participating municipalities forming the cooperative's board. These mayors—Robert Tulnik (Fernitz-Mellach), Gerald Wonner (Gössendorf), Jakob Frey (Hart bei Graz), Patrick Dorner (Hausmannstätten), Karl Mayrhold (Raaba-Grambach), and Johann Wolf-Maier (Vasoldsberg)—have long pursued shared goals in areas such as transport, mobility, and energy. The GU-Süd cooperative, which was formally established in July 2024, focuses on enhancing regional energy autonomy, reducing energy costs, and combating energy poverty. This initiative also aims to foster social cohesion by providing energy solutions to both municipalities and their residents . At the moment, the main stakeholders are the respective mayors. In the future, small and medium-sized enterprises, household consumers and producers will be invited to join as members. These two REC cases demonstrate different approaches to building PEDs, highlighting the significance of local leadership, community engagement, and the role of expert support in achieving regional energy autonomy and fostering social cohesion.

2 Development and progress of RECs towards PEDs

2.1 REC Hengist+

In September 2023, the regional REC "Erneuerbare Energiegemeinschaft (EEG) Lebring-St. Margarethen" was established in the form of an association. In September 2024, the municipalities of Lebring-St. Margarethen, Lang, and Hengsberg joined the initiative, leading to the renaming of the REC to "Erneuerbare Energiegemeinschaft Hengist+" to reflect the expanded membership. The primary goal of this association is to promote energy derived from renewable sources, offering environmental, economic, and social benefits to the region and its partners. This includes the regional production, storage, use, and sale of renewable energy, as well as facilitating the purchase of renewable energy from members of the association (EEG 2023, 2–3). The REC has experienced rapid growth, thanks to effective citizen engagement. In December 2024, there were around 120 members, in April 2025 there are already around 200 members who are part of the REC.

Looking ahead, the project team is now focused on developing a concept for a children's workshop in Lebring St. Margarethen to encourage active participation and promote knowledge about energy transition among young residents. The workshop will provide children with an opportunity to learn about the energy transition. Through these steps, we aim to build lasting relationships within the community, inspire the next generation to take an active role in shaping their future, and spread knowledge within families.

2.2 Graz-Umgebung-Süd

The planning process for the GU-Süd REC began in May 2023, with expert support from So-Strom GmbH and 4ward Energy Solutions GmbH in technical, organizational, and financial matters. The energy exchange is expected to begin in December 2024, following a 2-3 month pilot phase, with the goal of extending membership to SMEs and private households. GU-Süd has a multi-stage approach: the first goal is to produce cheap electricity on municipal buildings and to use this energy for all municipal buildings to reduce costs. The second goal is to involve local SMEs and household consumers and producers. Low-income households are supposed to benefit from cheap(er) energy costs. The GU-Süd REC initiative, which is municipality-driven, contrasts with the citizen-driven model of the REC Hengist+. It will be interesting to compare the success factors of these two approaches after a longer evaluation phase.

Next steps in the GU-Süd region include re-establishing contact with community representatives, participating in an upcoming public event for local residents, and organising and preparing a workshop with key community leaders to develop clearer future scenarios.

3 Funding mechanisms and business model challenges for RECs in Austria

In Austria, RECs are regulated by the Renewable Energy Expansion Act (EAG) and the Complete Legislation for Electricity Markets and Organization Law (ElWOG 2010). These regulations provide a robust legal framework for RECs, enabling citizens, small and medium-sized enterprises (SMEs), and local authorities to collaboratively produce, consume, store, and trade renewable energy within a defined geographical area. The strong regulatory foundation supports the creation of sustainable, community-driven energy solutions, though ongoing clarification of the permissible business model will be crucial for the continued success and growth of RECs.

There are three main types of energy communities in Austria, each with different structures, geographical coverage and economic benefits. These models facilitate the joint production, consumption and trading of renewable energy and also offer specific benefits, such as reduced fees and exemptions from grid fees. An overview of each model is provided below (Klima- und Energiefonds 2025):

- **Community Generation Facilities (GEA – Gemeinschaftliche Erzeugungsanlagen)**: This model is designed for localised energy production, typically within buildings. It allows participants to produce renewable electricity and there is no limit to the number of production facilities that can be included. Participants can be both natural persons (individuals) and legal persons (companies), and there is no requirement to set up a specific legal entity. This model is particularly suitable for small-scale, community-based energy production. One of the advantages of this structure is that participants benefit from the elimination of grid fees and charges for the electricity, which is generated and used within the community.
- **Renewable Energy Communities (EEG – Erneuerbare-Energiegemeinschaften)**: Renewable Energy Communities are regionally focused and enable participants to generate, store, consume and sell renewable heat or electricity within their local (grid levels 6 - 7) or regional (grid levels 4 - 7) area. Participants can include individuals, small businesses and municipalities. This model requires the establishment of a legal entity, such as a cooperative, association or partnership. One of the main advantages of an EEG is that participants benefit from reductions in grid charges, with local energy communities benefiting more than regional ones.
  Both pilot cases are regional renewable energy communities.
- **Citizen Energy Communities (BEG – Bürgerenergiegemeinschaften)**: Citizen Energy Communities allow for wider geographical participation, with no specific geographical restrictions within Austria. This model allows participants to generate, store, consume and trade renewable electricity over a wider area. BEGs do not offer reduced grid fees.

The members of a REC play different roles, depending on whether they are "pure consumers" or "prosumers".

Consumers in a REC primarily purchase their electricity or heat from the community's network, mainly using surplus energy generated by shared renewable energy installations. Surplus energy occurs when more energy is generated than a member can consume. This surplus is distributed within the community, often at more favorable rates than standard electricity contracts with conventional providers. The distribution of energy within the REC follows a predefined model, which can be based on various factors such as the amount of surplus energy produced or the individual needs of the members. The prices for energy purchased from the REC are typically lower than those from traditional providers because grid fees are reduced. If the energy demand cannot be covered within the REC, energy is supplied by the external electricity provider. In addition to the basic energy costs, consumers may face additional charges. These could include membership fees to cover the general operational costs of the community, contributions for maintenance and repair of the generation facilities, or financial investments in new generation projects. These costs are defined by agreements between the members and the operating structures of the REC, and can vary depending on the specific community setup (Klima- und Energiefonds n.d.c).

Prosumers are members who own their own generation facilities, which remain in private ownership. These generation facilities are planned, financed and realised by individual members. Regardless of the RECs, there are federal, state and sometimes municipal subsidies for their installation. In an REC the operational and disposal rights over the facility are transferred to the REC, allowing the community to utilize the self-produced energy. Prosumers generate electricity or heat for their own consumption, and any surplus energy is fed into the community's network. The excess energy is made available for sale to other members of the community who have an energy need (Klima- und Energiefonds n.d.a).

The role of the prosumer is dual: they are both producers of energy and consumers when their own generation capacity is insufficient, requiring additional power from the REC or an external provider. The distribution of energy costs within the REC is based on a model that accounts for both the energy produced and the energy fed into the network. The price for both the energy consumed from the REC and the energy injected into the network is typically negotiated and depends on factors such as the amount of energy generated, market conditions, and the operational costs of the community (Klima- und Energiefonds n.d.a).

Members gain economic benefits by selling or buying their own electricity or heat within the community. This is done on largely independent terms and at prices that can remain constant over several years, which is particularly advantageous in times of volatile energy prices. Like private households, municipalities and SMEs can be consumers or prosumers and thus benefit from these advantages (Klima- und Energiefonds n.d.b).

Common problems are the geographical limitations of local and regional renewable energy communities. The area of GU Süd is supplied by two grid operators. So there is a need to set up two different regional renewable energy communities. Otherwise they would have to create a Citizen's Energy Community, but then the financial benefits would be significantly reduced.

There are also concerns about the increased time required for administrative tasks, which could offset any financial or social benefits that members may receive. Additionally concern about the impact of municipal oversight, which could introduce more complexity and regulation, leading to additional administrative work and higher costs. Taken together, these concerns suggest that membership may be perceived as less beneficial than before, potentially deterring new members and raising doubts among current members.

Table 2 provides an overview of challenges and plans related to these two RECs.

Table 2: Overview of challenges and plans

	Challenges	Plans
Hengist+	• Membership of municipalities • Energy balance consumer vs producers • Involvement of whole region	• Grow membership of Energy Community • Regular community engagement
GU-Süd	• Chain of communication • Ongoing management - who is in charge and who takes the initiative? • Dependence on political interests	• Involvement of local citizens and SMEs

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Rome pilot

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1 Key stakeholders in the Quarticciolo neighborhood

Several stakeholders can be included in the Italian pilot case of the Quarticciolo REC. Some of these could benefit directly from the REC, not only directly from the reduction of energy costs but also from being part of a community that aims to foster social cohesion among its members. Going into detail, the key stakeholders that would benefit from being part of the energy community can be grouped into two main categories: civilian population and private sector actors.

The civilian population are directly interested in their wellbeing and the future of Quarticciolo neighbourhood. Within this group there are the inhabitants of Quarticciolo that mainly live in social housing buildings thus are more fragile from an economic and social point of view. But also the Quarticciolo Ribelle association that aims to connect the population and could benefit from an even stronger connection between its inhabitants linked by the energy community.

The private sector actors that have developed in Quarticciolo neighbourhood have an interest in long-term stability of their activities. It is difficult to assess how many commercial activities have been opening or closing in recent years with a desk analysis of census data. There is no recent data available at census areas, a lower level than the municipality one that is crucial to form the perimeter of Quarticciolo neighbourhood. But from a direct observation of the area made by Quarticciolo ribelle there have been several closures in recent years. It is difficult to understand the specific reasons but economic instability led by the global pandemic and the consequent rise of the prices, including the ones for electricity, had an impact on these closures. Nonetheless, there are some activities that are still open. The ones that have been identified are: the public gym, the people’s health clinic, local small entrepreneurs such as the bakery, the brewery, the print shop and the theatre-library.

All of these activities have a strong social impact on the community. For example, the brewery offers vocational training to former inmates who typically have more difficulty re-entering the job market. A vocational training programme in catering for women in the neighbourhood has recently been set up so that they can establish a catering service. Currently the training has used the professional kitchens of the Mistica Park.

Currently, the main stakeholders that have been considered by the neighbourhood committee are the private sector actors and the associations. The main challenge with these stakeholders is that they have quite different necessities and consumption patterns. This can be a challenge when considering energy flows. Analyzing consumption patterns for the area is one of the main things that the pilot's partners are currently tackling.

2 Identified critical issues and recent measures

2.1 Identified critical issues

The main aim is to develop an energy community that is coherent with the Sustainable Development Goals (SDGs). In particular, the SDG 11 "Make cities and human settlements inclusive, safe, resilient and sustainable" and the SDG 13 "Take urgent action to combat climate change and its impacts". In order to do that, it is crucial to identify critical issues among the neighborhood.

First, there are problems related to the presence of illicit economic activities. This impacts the inhabitants that live in social housing situations and have very low incomes. Recently, the Quarticciolo situation has been investigated by the national and local authorities. This has led to a higher visibility of the neighborhood at a national level since it has been covered by several media. But it is also leading to possible stricter regulation and actions towards the neighborhood, known in Italy as the implementation of the Caivano model. It is still unclear whether the activities of the energy community would be impacted by these actions but the partners are keeping in touch with local authorities.

Second, it is crucial to make further analysis on financing. As it will be shown in further sections, there are several financing measures that are currently being considered. Other than that, it is possible to cooperate by implementing new partnerships among public bodies, firms and NGOs.

Third, it is fundamental to foster positive communication with the public body that is in charge of social housing. It is crucial also because it is directly linked to the Italian energy service operator, GSE (*Gestore dei servizi elettrici*). As will be explored further, GSE has some incentives that could be quite useful to implement.

Fourth and last, it is important to raise awareness among the inhabitants about the energy community. It is quite difficult at the moment but it is an important step towards building a strong participative model among the local population.

2.2 Recent measures

Recently, two very important steps have been taken to go forward with the development of the energy community business model and funding mechanism. First, there had been a public event related to energy communities in Rome. It was held on the 10th of February 2025 in the Campidoglio building, where the mayor's office is located. There were several public actors alongside the mayor of Rome, Roberto Gualtieri. But there were also private stakeholders and representatives of the energy communities of Rome. Also the Quarticciolo energy community was present, with a speech curated by Pietro Vicari (Quarticciolo Ribelle) that showed the complexity of the current situation in Quarticciolo area.

This was a great opportunity for the Italian partners to understand the current state of art and see other good practices that had been implemented in other areas of the city. This was also an important opportunity to see other economic actors that could help improve further the funding base and the stability in the long term of the energy community. This meeting was also important for improving the partner’s knowledge about the implementation of energy communities. In particular, the Italian partnership had the opportunity to speak with Luca Raffaele, general director of the NeXt project. He coordinated the first Italian open source platform related to ECs. He gave specific insights on how to develop a resilient business model, as well as tailoring the EC coherently with the current legislative context and necessities from a technological and social point of view.

Second, Quarticciolo Ribelle has organized a public meeting in the theatre-library to discuss among the civic population and other stakeholders the development strategies for the energy community. This round-table discussion has been held in a bigger event regarding the economic activities of the neighborhood. This occasion was important to further proceed with the creation of an innovative model of local economy that merges urban regeneration with social and solidarity aspects. Several stakeholders have participated at the energy community table. There was a representative of the Climate Office of the Municipality of Rome, Edoardo Zanchini, that renewed his availability to help in case of need. But there were also other stakeholders such as representatives of AzzeroCO2, a consulting firm with a specific expertise in sustainability and energy. All the Italian partners had the opportunity to show the specific areas that they are working on and had significant inputs from the people that took part in the event.

3 Current challenges and pathways forward

There are some viable solutions that have been analyzed in order to finance the energy community located in Quarticciolo. Some of these are related to public funds whereas others are linked to private foundations. Here is a brief overview of the possible funding methods, followed by an analysis of the next steps.

3.1 Public funding

When considering possible funding mechanisms and business models for the Italian energy community of Quarticciolo, it is crucial to analyze which public incentives are put in place. As a general overview, the Italian government adopted the Directive (EU) 2018/2001 with the legislative decree 199/2021. The new incentives for the energy communities have been integrated through the decree 414/2023, published by the ministry of environment and energy security (translated in Italian: *Ministero dell’Ambiente e della Sicurezza Energetica*, MASE). With this decree, public incentives can be implemented to every renewable energy plant comprehended inside the EC that has been built as a new construction or has been enhanced with specific intervention. Thus, these incentives do not interests those These incentives are applied to the plants that register a nominal power lower than 1MW. The overall power of the installed plants can be higher. In order to gain access to these incentives, the plants must not enter into operation before the regular constitution of the EC.

Going into detail, MASE decree defines two main measures, namely pricing investing and non-refundable aid:

- **Pricing investing** is given as a tip on the energy shared from the plants of the EC. This tip is given by the energy service operator GSE and is assured for a period of 20 years. It is made by a fixed part that is linked to the dimension of the plant and a variable part, related to energy market prices. Furthermore, when talking about photovoltaic panels, a correction is put in place linked to the geographical area where the plant is located. This is related to the lower production that a solar plant can have in northern areas of the country instead of the southern ones. If the amount of the tip exceeds a specific threshold, the excess part must be directed to consumers different from firms or be used for social projects linked to the areas included in the energy community. This incentive can be quite useful for the Quarticciolo area: the solar panels that will be installed are going to be new and never been used before the formalization of the energy community. The crucial challenge is to understand consumption patterns, an aspect that is currently under investigation.
- **Non-refundable aid** is related to the Recovery and Resilience Facility (RRF), a financial instrument that aims to boost European economies with a common debt dynamic. For the Italian case, there is a measure contained in the respective National Plan of Recovery and Resilience (NRRP) that aims to boost energy communities. It is contained in the second mission of the Italian NRRP. The EC of Quarticciolo cannot apply to these funds because they are related to ECs that have been formalized in municipalities with under 5.000 residents.

3.2 Private foundations

Another stakeholder that could be included in the funding mechanism of the Quarticciolo energy community is Charlemagne Foundation. It is a non-profit organisation that operates with the aim of preventing, supporting and providing practical help to situations characterized by strong social exclusion, health difficulties, isolation or poverty. The activities are held, both at national and international level, to promote the development of the human person and human dignity. Currently, in addition to actively supporting individual projects, the foundation works to create sustainable non-profit ecosystems and a system of strategic partnerships with Italian and foreign foundations that share common values. The neighborhood committee has already met the representatives of Charlemagne foundation. This seems a viable option for financing the solar panels.

3.3 Further steps

Currently, the meetings between Charlemagne and the neighborhood committee are going in the right direction. Charlemagne foundation agreed to put solar panels on the rooftop of the community health clinic. There has also been a meeting with the central administration of Rome to understand if it is possible to actually install the panels on that specific roof. All the administrative work is going to be held by the neighbourhood committee before summer. Whereas all the installation works are going to be held during summer. Table 3 provides an overview of challenges, plans, and collaboration opportunities.

Table 3: Overview of challenges, plans, and collaboration opportunities

Challenges	Plans	Opportunities for collaboration
• Tensions and possible difficulties for the possible implementation of "Caivano" model • Analysis on financing models • Foster better communication with "ATER" • Raise awareness among citizens	• Keep strong connection with the local authorities • Further investigate public opportunities even for public funds	• *Private funds*: "Charlemagne Foundation" has specific funding opportunities • *Other ECs of Rome:* it is crucial at this stage to exchange best practices with other energy communities that have been developing in the municipality of Rome

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