D 4.3: Living lab monographs

Based on discussions with the inhabitants, stakeholders, observations and other data

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2. Executive summary

This report presents the four living labs explored in the Citizens4PED project. Two living labs are located in Brussels (La Roue and Usquare), one in Vienna (Kahlenbergerdorf), and the fourth in Bari (San Paolo).

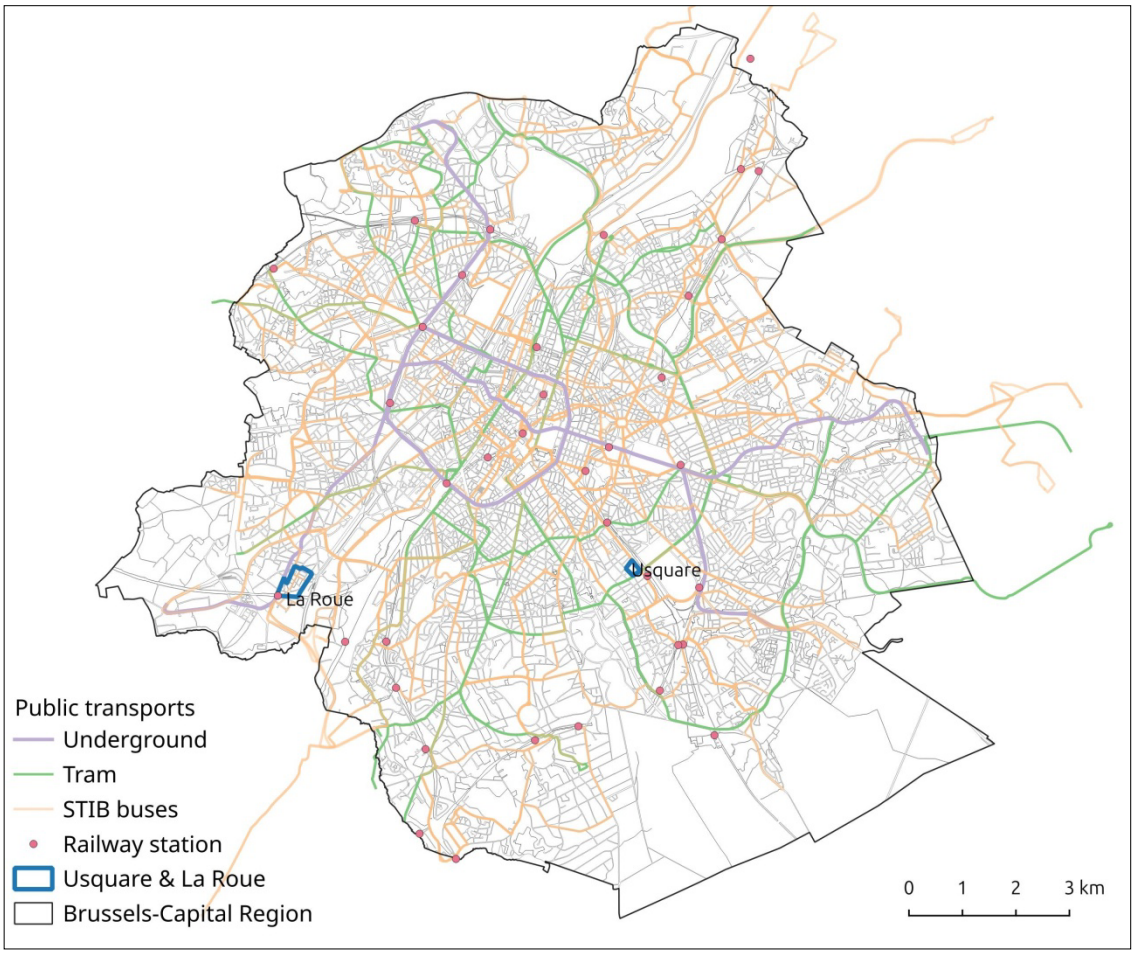
The objective of this document is to present what has taken place in the four living labs and to derive lessons that may be useful for other Positive Energy District (PED) pilot sites. The content of this report has been collected through various methodologies: interviews and focus groups with the main actors, including inhabitants, informal discussions, observation, and desktop research. For each site, the following structure is used: recent history, description and context; ongoing and/or planned projects; challenges encountered; and replicability—assessment and issues.

Across the experiences conducted in the four living labs, several common themes emerge. Among these, the high cost of renovation stands out as a significant barrier, even for relatively affluent households. Additionally, in environments where buildings have heritage value, urban planning regulations often limit the scope for undertaking energy efficiency renovations and/or installing solar panels to increase energy production.

In two living labs (La Roue and Kahlenbergerdorf), neighbourhood associations motivated by ecological concerns are attempting to overcome the cost barrier of decarbonisation by adopting collective approaches, such as group renovations and shared heating infrastructure. So far, however, these efforts have yielded limited results.

3. La Roue (Brussels)

Figure 1: Contextual map of La Roue & Usquare



3.1. Recent history, description, and context

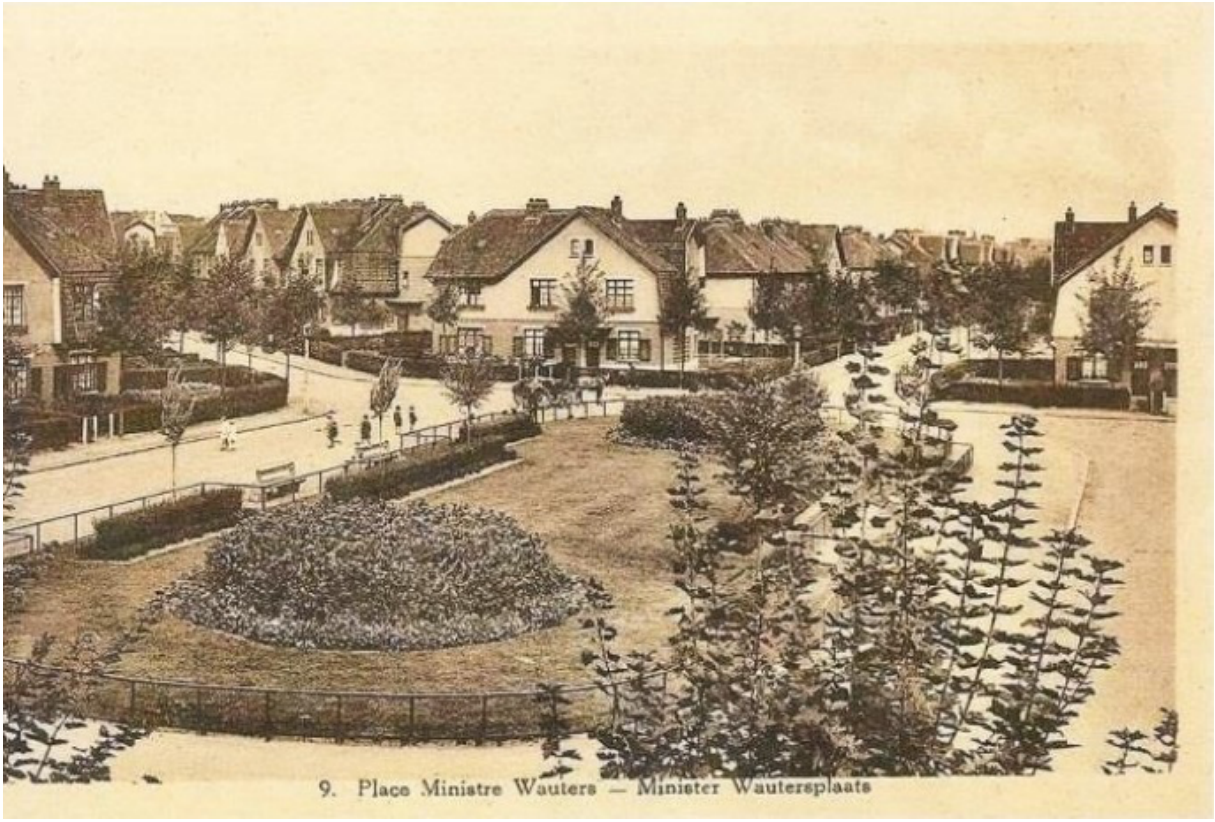
The La Roue neighbourhood is a garden city situated in the western sector of Brussels, within the municipality of Anderlecht. Construction commenced shortly before the First World War, with the majority of dwellings completed during the 1920s. The garden city was developed under the initiative of Foyer Anderlechtois, a social housing organization established to address the acute shortage and substandard conditions of working-class housing. The original masterplan envisioned the construction of 688 single-family homes.

The homogeneous architectural ensemble consists of 20 primary house types, each featuring a standardized layout: a common living area, a laundry space, two storage rooms, three bedrooms, an attic, and a small garden of approximately 50 square meters. At the time of their construction, these dwellings provided favorable living conditions for often large working-class families, offering notable comfort and spatial adequacy. The single-family units, designed with either two or three façades,

provided living spaces ranging between 100 and 150 square meters, averaging 130 square meters per dwelling.

During the early 20th century, these social houses were considered architecturally progressive, representing a substantial improvement in living standards for the working class. However, by contemporary measures, they no longer comply with modern housing quality expectations or energy efficiency requirements.

12. Avenue G. Melckmans — W. Melckmanslaan



Over time, a significant portion of the homes originally owned by *Foyer Anderlechtois* were sold to residents. However, many of these homeowners lacked the financial means to properly maintain or modernize the properties in line with contemporary standards. Additionally, subsequent modifications often failed to preserve the neighbourhood's original architectural character.

As of today, *Foyer Anderlechtois* retains ownership of 244 single-family homes (indicated in blue on figure 2). Notably, the sale of social housing has since been prohibited across Brussels. A considerable number of the remaining *Foyer Anderlechtois* properties are in need of renovation. Due to a combination of factors—including the renovation process being triggered only upon tenant turnover, as well as delays stemming from urban planning permits and public procurement procedures—a portion of these homes currently remain unoccupied.

Figure 2: Map of La Roue and location of the houses owned by the Foyer Anderlechtois

As shown in Figure 1, the neighbourhood is well-served by public transportation. A metro line and a train station are located at the edge of the neighbourhood, and several bus lines pass through or run along the area.

The houses are heated by individual gas boilers, and hot water is provided either by gas or electricity.

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Although the garden city has no shops, it features several community facilities, including two preschools, an elementary school, a social restaurant, and a youth centre. Adjacent to the neighbourhood—south of the railway line—lies the Ceria-Coovi campus, a large educational complex housing multiple schools and a publicly accessible swimming pool. Notably, this campus represents a major energy consumer and is strategically positioned along the Charleroi-Brussels Canal.

Administratively, the neighbourhood predominantly falls within a single statistical sector (Belgium's smallest administrative unit). Only a small residential cluster located south of the railway line, between the tracks and the Ceria campus, lies outside this sector.

Indicator	Year to which data refer	La Roue (Cité jardin)	Brussels-Capital Region
Area (m²)	2024	206 849	162 423 680
Number of households	2021	782	559 260
Population	2021	2 215	1 219 970
Income (average per capita income after tax, €)	2019	10 452	11 738
Employment rate	2020	51 %	52 %
Number of social housing units	2021	238	40 232
Share of tenants	2011	74 %	62 %
Share of households with one car or more	2019	62 %	52 %
Share of population aged 0-17	2021	26 %	23 %
Share of population aged 65 and over	2021	13 %	13 %
Average private household size	2021	2,75	2,16
Average age of inhabitants	2021	37,49	37,65
Average rent for social housing	2021	317 €	328 €
Dwelling units built before 1919		101	184 265
Dwelling units built between 1919 and 1945		636	116 411
Dwelling units built between 1946 and 1960		46	77 374
Dwelling units built between 1961 and 1970		20	75 791
Dwelling units built between 1971 and 1980		6	61 549
Dwelling units built between 1981 and 1990		0	16 357
Dwelling units built between 1991 and 2000		59	25 186
Dwelling units built between 2001 and 2011		5	23 732
Total number of dwelling units	2011	873	580 665
Gas price (per kwh)	2023-S2		0,0994
Electricity price (per kwh)	2023-S2		0,4111
Heating oil price (1500 l/year)	26/11/24		1361
Tertiary education	2011	17 %	36 %
Heating degree days	2019-2023		2311,154
Cooling degree days	2019-2023		29,562

The garden city accommodates approximately 800 households, with a median income slightly below the Brussels regional average. Unemployment rates align closely with the citywide average. Notably, the neighbourhood exhibits a distinct housing tenure pattern: 74% of residents are renters—significantly higher than the Brussels average of 62%—reflecting the substantial concentration of social housing units. Educational attainment levels among inhabitants are relatively low, with fewer residents holding higher education qualifications compared to broader urban benchmarks.

Despite good public transit connectivity and lower-than-average incomes, car ownership rates in La Roue exceed the urban average. This can likely be explained, in part, by the relatively high number of families with children and the ease of parking in an environment made up of small, detached houses.

In climatic terms, Brussels experiences higher heating degree days and lower cooling degree days compared to Bari and Vienna. This means that more heating is required in winter, but less cooling is needed in summer in Brussels compared to the other two cities involved in this project.

3.2. Actors

3.2.1. Collectif La Roue

The La Roue neighbourhood is served by an active community organization, Collectif La Roue, established in 2012 under Brussels' Sustainable Neighbourhood Contract program (funded by Bruxelles Environnement). The Collecif's main objectives are to renovate homes to make them more energy-efficient, the establishment of district heating networks, and, more broadly, any actions aimed at decarbonizing the lifestyles of the residents.

The group is spearheaded by three owner-occupiers who previously undertook individual home energy retrofits, and found this process to be particularly challenging. They faced difficulties in finding qualified contractors—since small-scale projects are often less attractive to professionals—in obtaining planning permits, and in coordinating the various contractors and specializations involved. As a result, they decided to organize a group renovation of the neighbourhood. The goal was to make the project more accessible to a wider group of residents by simplifying the process, reducing costs, and surrounding themselves with skilled professionals. They therefore set out to bring together and motivate other ***homeowners*** to undertake renovations collectively, organized in two successive waves.

From the perspective of the Collectif La Roue, the garden city has already lost its architectural unity due to the resale of houses to private owners, who have gradually modified them to suit their personal tastes and to improve comfort. In their view, changes to urban planning regulations—combined with widespread non-compliance by residents—have led to an irreversible situation, making it unrealistic to aim for the preservation of uniformity at all costs. Any sense of coherence or stylistic consistency has been lost amidst a patchwork of varied colours and materials.

The Collectif and all residents interested in participating in a group renovation project wish to insulate their front façades externally, as internal insulation is particularly challenging in small, occupied homes. They are well aware that it is currently nearly impossible to renovate a front façade individually, due to the strict urban planning restrictions imposed by the municipality. Rear façade insulation is also of interest to the majority of residents involved in the group renovation. Half of the participants intend to insulate their roofs, while the other half already have insulated roofing in place.

After numerous meetings with various authorities, the collective believed they had received an informal agreement that external insulation of the front façades would be permitted, and that planning permit applications would be considered independently of existing urban planning violations. Historically, the municipality has not always strictly enforced urban planning rules—for example, it once allowed some residents to convert their front gardens into parking spaces.

In practice, however, this is not the case: the municipal urban planning office continues to take past infractions into account.

The participating households generally have a strong repayment capacity (around €450 per month). This highlights the challenge of making the initiative accessible and attractive to households with lower incomes or limited capital. Nevertheless, most interviewees express the desire—or the necessity—for a financing solution, such as a loan, to support their renovation efforts.

There is interest among participants in installing heat pumps and photovoltaic panels. Nearly all of those interviewed (all but one) are open to shared heating solutions. A significant portion of residents also report issues such as humidity, mold, or leaks, which will need to be addressed during the renovation process.

One obstacle raised by participants is the Brussels requirement to install a mechanical ventilation system when undertaking major renovations that require a planning permit. Many residents are opposed to this requirement, considering it expensive, bulky, and unnecessary.

In the end, only eight households are participating in the first wave of renovations. A second wave is being prepared, with recruitment efforts led by Habitat et Participation and the Collectif La Roue.

The collective has struggled to engage residents of foreign origin, despite their strong presence in the neighbourhood. They do not understand why this group remains difficult to reach.

While the collective has political support, the municipal urban planning office remains opposed to external insulation of front façades.

3.2.2. Foyer Anderlechtois

The Foyer Anderlechtois is the social housing company that currently owns 244 single-family homes in the garden city of La Roue. It has been present since the foundation of the garden city in the early 20th century. Over time, the Foyer Anderlechtois sold part of the housing stock it owned. However, it is no longer permitted to do so, as the supervisory authority (Brussels Housing Corporation [SLRB]) now prohibits social housing companies from selling their real estate assets.

A large number of houses owned by the Foyer Anderlechtois are in need of complete renovation. Renovations are carried out when tenants move out, which results in a scattered and uncoordinated process. This often forces the organization to board up the houses, as there can be a significant delay between a tenant's departure and the start of renovation work. In 2015, they submitted a collective urban planning permit application to renovate 52 houses in the La Roue garden city.

The Foyer Anderlechtois was consulted regarding the collective permit application submitted by the Collectif La Roue. They understood the rationale for applying external insulation to the façades, particularly since the homes in question are occupied during the renovation process. For some houses, the façades held limited heritage value, and external insulation was not problematic. However, in areas of the garden city with greater architectural significance, it proved more difficult to adhere to the original character of the buildings. In these cases, the Foyer Anderlechtois raised concerns about the solutions proposed by the applicants involved in the group renovation project.

3.2.3. Ceria Campus

The CERIA campus is a large educational complex comprising several schools and a swimming pool (open to the public). It is a major energy consumer. The campus is already equipped with a site-wide district heating network powered by four gas boilers.

These gas boilers will need to be replaced in the coming years. One has already been replaced, and a medium-term decision must be made regarding the remaining three. The institution is currently considering a paradigm shift toward decarbonizing its energy consumption. Specifically, they are exploring two main options: either optimizing the existing heating network and the site's overall energy use and production, or expanding the network to serve the surrounding neighbourhood—as examined within the framework of the Renov-Roue-Rad project—provided key local stakeholders, primarily the Foyer Anderlechtois, are involved.

For CERIA, developing a district heating network at the scale of the La Roue neighbourhood would represent a pilot project for the Brussels-Capital Region. This would require thorough technical and financial feasibility assessments. CERIA lacks the internal technical and financial expertise to design and operate such a network, and would therefore need to rely on a public-private partnership to design, build, maintain, and finance the project. To proceed, CERIA would also need approval from its supervisory authority (the COCOF) as well as financial support.

If a decarbonized district heating network were to be developed at the neighbourhood level, the CERIA official responsible for the project believes it should be a low-temperature network (as

opposed to a high-temperature one). In that case, only one of the four gas boilers—the one recently replaced—would be retained, while the rest of the heating needs would be met through heat pumps combined with geothermal energy. Biomass is not considered a viable solution, as it would involve an unmanageable flow of fuel in an urban setting.

Under Brussels' energy reduction plan for large building portfolios (PLAGE), CERIA is required to set specific targets for reducing its energy consumption. The primary goal is to reduce energy use. In a second phase, the campus also plans to install solar panels to produce electricity.

One of the energy-saving measures already implemented is shutting down the current district heating network during the summer months and using more localized heating solutions (especially for the swimming pool). However, they have identified fewer options for reducing electricity consumption, which remains high—hence their consideration of installing a cogeneration boiler.

In newer buildings, occupants have expressed discomfort due to excessive indoor temperatures during the summer and have requested air conditioning.

3.2.4. The Urban Planning Department of the Municipality of Anderlecht

The Urban Planning Department of the Municipality of Anderlecht is the authority responsible for issuing urban planning permits required for major insulation and renovation works. In the case of the group renovation project in La Roue, the department conducts a preliminary review of the application, after which the file is examined by the Consultation Commission and submitted to a public inquiry. Based on these elements, the municipality formulates an official opinion on the permit application. The Consultation Commission is composed of six members: three municipal representatives, two from Urban.Brussels, and one representative from Brussels Environment.

From the perspective of Anderlecht's Urban Planning Department, a group renovation permit application should aim for coherence at the neighbourhood level. Such an application makes sense when the houses are adjacent, there are no existing planning violations, and the renovation works are uniform across all properties involved. In their view, there is no genuine group renovation effort in La Roue, as each applicant has pursued different renovation strategies and made varied choices—such as differing insulation thicknesses for front façades.

The Urban Planning Department is committed to preserving the architectural heritage of the garden city. As such, it discourages external insulation on front façades. Instead, it recommends insulating the elements responsible for the greatest heat loss—namely, the roof, windows, rear façade, and only lastly the front façade. In this context, they have criticized the La Roue Collective, which they claim is prioritizing external insulation of front façades without a clear technical justification.

They cite the Foyer Anderlechtois as a positive example, having submitted a coherent group permit application that includes interior façade insulation and the construction of small extensions to compensate for the resulting loss of interior space. The houses included in that application were relatively homogeneous, the planned renovations were uniform, and there were no planning violations. However, the municipality does not appear to take into account that interior insulation requires the homes to be vacant—raising the question of where residents will stay during the works—and that it reduces the living space. Moreover, the renovation cost per house for the Foyer Anderlechtois project is estimated at €240,000, a sum far beyond the means of most La Roue residents.

The Urban Planning Department also seeks to use permit applications as an opportunity to address existing planning infringements. In the case of the group renovation application submitted by the Collectif La Roue, some of the houses included had outstanding urban planning violations.

As a result, the Urban Planning Department has been reluctant to approve the permit and imposed several conditions on its issuance. They report having experienced significant political pressure from regional and local elected officials, as well as from their own superiors, to approve the permit application. In such situations, their strategy has been to slow down the review process.

3.2.5. Urban.Brussels

Urban.Brussels is the public administration responsible for implementing the regional policies on urban planning, cultural heritage, and urban revitalization across the Brussels-Capital Region.

Urban.Brussels has a real expertise in the preservation of urban heritage, and a right of control regarding the granting of environmental permits. In addition, together with Bruxelles Environnment, Urban.Brussels awards "Renolution" bonuses, which concern elements relating to the conservation of heritage. In the case of la Roue, Urban.Brussels plays a central role that could slow down the momentum carried by citizens.

However, Urban.Brussels has an important braking force in two axes: the renovation and the renewable energy production. Indeed, as the Municipality of Anderlecht, Urban.Brussels gives the authorization for the environmental permit for houses renovation in la Roue and for the installation of PV panels. Urban.Brussels regulate strictly it through many criteria.

3.2.6. Bruxelles Environnement

Brussels Environment is the environmental and energy administration of the Brussels-Capital Region. This public agency is responsible for developing and implementing the region’s environmental and energy policies.

Bruxelles Environnement manages regional and European funding intended for:

- Pilot projects led by citizens aimed at removing the obstacles to sustainable and circular renovation of buildings, such as that of the group of neighbours at La Roue through the Renolab.ID programme.
- Subsidies for the renovation of buildings and the installation of new equipment for individuals and professionals or public services.
- Subsidies for the support of citizens wishing to implement a project to retrofit public space to the scale of their neighbourhoods.

3.3. Ongoing and/or planned projects

3.3.1. Renov-Roue-Rad (led by the Collectif La Roue)

In October 2021, the La Roue Collective submitted its application and received a RENOLAB.ID[1] project titled Renov-Roue-Rad, with a budget of €780,000. The Renov-Roue-Rad project is a group

1 The "RENOLAB.ID" projects provide support and regional visibility to ideas and initiatives that help overcome barriers to sustainable and circular renovation of Brussels' building stock. The supported pilot projects contribute to the implementation of the RENOLUTION strategy and have the potential for larger-

renovation initiative led by the Collectif La Roue. It aims to design and test an eco-renovation process at the neighbourhood level to demonstrate the social, economic, and environmental potential of working at this scale and benefiting from the architectural homogeneity of the garden city. The project covers part of the architectural fees (80%) and has enabled the hiring of a person to mobilize neighbours and encourage their participation in the group renovation project.

The initiative seeks to design and test a renovation process at the garden city level to demonstrate the potential of working at this scale. The project includes support for two waves of renovation. The first wave involves engaged, pioneering neighbours who want to contribute to triggering a broader energy renovation dynamic in the neighbourhood. Wave 1 has submitted a group permit application to the Municipality of Anderlecht.

The idea is to begin renovations and invite interested neighbours to visit the construction sites, discuss the experience, compare prices and results, and prepare the ground for Wave 2.

Wave 1 ultimately consists of only 8 households, rather than the 20-30 initially expected. This first wave is not representative of the neighbourhood's diversity (in short, these are "Belgians"). The main reason for dropouts is the cost of renovation and financial difficulties. Discussions with various stakeholders and Financité (which was responsible for finding an inclusive financing model for the works) confirm the lack of adequate financing solutions to enable all Brussels residents to engage in the energy renovation (whether full or partial) of their homes.

Wave 1 is mainly motivated by environmental benefits, and participants are willing to invest time and effort to contribute to the energy transition. However, several neighbours, primarily interested in financial incentives, quickly realized that the financial return was not favourable and withdrew from the project.

Wave 2 will involve carrying out a second renovation project with the neighbours who can be convinced by the results of Wave 1.

As of December 2024, the Collective has still not received the urban planning permit for the group renovation works. Despite political pressures at both the municipal and regional levels supporting the collective renovation project led by the La Roue Collective, the Urban Planning Department has not issued a definitive opinion on the application.

The Urban Planning Department argues that the 8 houses are not of the same architectural typology and that the requested interventions differ. For example, the thickness of the insulation on the front façade varies for each house. According to the Urban Planning Department, the fact that the urban planning permit application is a group renovation significantly disadvantages the applicants. They also criticize the project architect's approach, which they believe lacks flexibility and a sense of compromise, and they regret the absence of residents in the process of defending the application.

Ultimately, the scope of the project is limited since only 8 households have agreed to participate in the group renovation project. The challenges highlighted by the La Roue Collective are as follows:

- Renovation costs are extremely high. It is very unlikely that the neighbours of Wave 1 will complete all the works initially planned.

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scale deployment. Their goal is to make renovation works more affordable and accessible, offering an innovative solution and an adequate response to the energy challenges that the Brussels-Capital Region will face by 2030-2050. The funding for RENOLAB.ID projects is provided by Brussels Environment.

- It is difficult to attract contractors to the project.
- The formulation and testing of an approach based on the similarities between the houses in a garden city result in few advantages for energy renovation. From the contractors' perspective, there are too many differing details in each house.
- The requirement to install mechanical ventilation is a deterrent, as it is expensive, takes up space, and residents are not interested in it.
- The solidarity co-financing approach (for architectural fees) did not work. Due to the difficulty of finding reliable prices, many neighbours were unwilling to invest further in the project costs.

The Renov-Roue-Rad project also included two studies that provide interesting results:

- A study on the construction of a district-wide heating network, which would include the CERIA campus, a building from the Municipality of Anderlecht (the primary school), as well as the individual houses of the Foyer Anderlechtois. The goal was to determine the most economical solution to decarbonize heating in the La Roue neighbourhood buildings. Two solutions were modelled and compared: individual air-source heat pumps in each building and a district heating network powered by a collective boiler.
- High-temperature heating fuelled by biomass is not feasible for the CERIA due to the truck traffic it would generate. A medium-temperature network would be based on geothermal energy, aquathermy (heat exchange with the water of the Brussels-Charleroi Canal bordering the CERIA site), and air-source heat pumps. The study shows that the medium-temperature district heating network (55°C) is more advantageous than individual heat pump systems. A medium-temperature network is more expensive and complex to implement than a high-temperature network, as it requires replacing or adapting heat emitters in older buildings, which need high temperatures (>60°C) to maintain comfort. Installing geothermal energy involves more significant drilling and installation work compared to other energy sources. However, once operational, the supply is electricity-based, which simplifies the operation. These technologies cause less disturbance to neighbourhood residents, particularly in terms of noise, as the persistent nuisances are centralized.
- In addition to the numerous financial obstacles, many assumptions in the study appear to be unmet. Foyer Anderlechtois would only agree to connect the renovated houses to the medium-temperature heating network (and not all the houses as initially planned in the study). The Municipality of Anderlecht is not interested in connecting the school because its gas boiler has just been replaced. The land where the geothermal well is projected on the CERIA campus belongs to a third-party institution (VGC). Finally, the heating network would partially rely on aquathermy, but obtaining a permit to extract heat from the Canal seems more complicated than anticipated.
- A study including the perspectives of various stakeholders confirms the lack of adequate financing solutions to enable all Brussels residents to engage in the energy renovation (whether full or partial) of their homes. The survey clearly identifies the relative importance of the barriers. First and foremost, solvency appears to be the primary issue, namely that the cost of the works is (or could be) considered too high relative to the borrower's financial capacity. Secondly, a barrier observed mainly among those who have not yet decided to carry out works is the concern about the payback period of the investment (lack of information and guarantees regarding the financial savings on the energy bill following the proposed works).

3.3.2. The ERDF application

In June 2023, the ERDF (European Regional Development Fund) published a call for projects aimed at supporting group energy renovations. Under this call, the Brussels Region and the ERDF 2021-2027 will cover 100% of study costs and between 50% and 90% of eligible work costs (energy renovation of buildings and investments related to sustainability). This call for projects allows for the financing of approximately 80% of energy renovation work costs.

The ERDF application from the Collectif La Roue includes 38 homes to be renovated, but this time with a more representative diversity of origins within the neighbourhood (to caricature: "Belgians and foreigners"). To qualify for the application, it was necessary to gather 20% of neighbours per block of houses, estimate the costs of all the work, calculate the expected improvement in Energy Performance of Buildings (EPB), and estimate the reduction in CO_2 emissions resulting from these renovations. The average cost per home was estimated at €200,000. As there was very little time between the publication of the call and the deadline for submission, the application files were put together in a rush. Habitat and Participation helped with the preparation of the files, working with standardized prices per area to be renovated.

One difficult condition to meet for the ERDF call was that at least 20% of the houses in a block had to participate in the project. With the houses of the Foyer Anderlechtois, it was very challenging to meet this threshold. Therefore, the Collectif requested that the houses of the Foyer Anderlechtois not be counted when calculating the 20% participation threshold.

Among other conditions, an EPB certificate was required to demonstrate the energy performance difference before and after the renovation. This EPB certificate posed an initial financial barrier for some households, as it required an upfront investment of approximately €250. Furthermore, even though the Collectif hoped that 80% of the work costs would be reimbursed by ERDF if their application was accepted, this still represented a very large investment that the household would have to finance first. The household must first cover the cost of the work, and the subsidy is granted later, based on invoices, after the work is completed. Consequently, it is necessary to first secure a loan from the bank, but as banks are unfamiliar with this mechanism, they are cautious. Due to the need to borrow the amount or part of it, elderly people were effectively excluded from this call for projects, as banks refuse to lend to them.

Furthermore, since ERDF operates with a closed envelope, the more participants there are in the group renovation, the lower the amount per person.

In practice, it is the lack of financial means that primarily prevents homeowners from participating in this highly subsidized renovation effort. Moreover, participants need to be familiar with administrative procedures and applying for bank loans. Among the people who expressed interest in the ERDF project, some were more interested in the potential real estate value increase than in the environmental aspect of the project. The ERDF group, in fact, reflects the full heterogeneity of the neighbourhood in terms of origin, unlike the Renov-Roue-Rad project.

Ultimately, in December 2024, the ERDF project submitted by the Collectif de La Roue was approved and subsidized for €3.78 million, which was less than originally expected. Two applicants also withdrew from the project since the submission of the application (36 energy renovations will be undertaken). They now have an average budget of approximately €100,000 per home. The Collectif

La Roue asked the participants to revise their projects to retain only the most energy-efficient aspects and to maintain 80% of the subsidy for the work that remains.

3.3.3. Renovations undertaken by the Foyer Anderlechtois

In 2015, the Foyer Anderlechtois submitted a group planning permit application to renovate 52 houses in the garden city of La Roue. They are still in the process of completing the renovations in batches, as only a portion of the 52 houses have been finalized. At the time of submission, the building regulations were particularly stringent, requiring them to request exemptions. Since then, insulation standards have been somewhat relaxed.

They chose to insulate the front façades internally in order to preserve the distinctive architectural character of the garden city. In contrast, the rear and side façades were insulated externally.

Initially, the Foyer Anderlechtois awarded a single public contract to renovate 86 houses—52 of which were in La Roue and 34 in another garden city in Anderlecht—but they soon realized that the scope of the contract was too large. As a result, the tender was cancelled, and they now proceed with renovations in smaller batches. Based on their experience, the optimal size for such batches is around ten houses.

Similar to the group renovation initiatives launched as part of the Renov-Roue-Rad project, the Foyer Anderlechtois has concluded that, although garden city houses are relatively similar, each renovation site presents its own unique challenges.

The organization is currently reflecting on the relevance of renovating houses that are geographically dispersed. Presently, they carry out renovations when tenants vacate the properties. However, they are considering whether it would be more strategic to coordinate tenant relocations in order to enable more coherent renovations within specific areas of the garden city. If they were able to focus on housing units within the same block, they believe it would be possible to renovate batches larger than ten houses, thereby accelerating the overall renovation process.

The Foyer Anderlechtois has expressed preliminary interest in the construction of a district heating network. Although they commissioned a preliminary feasibility study in 2017, they ultimately abandoned the project, as it falls outside the core mission of providing housing. Nevertheless, they issued a letter of interest in support of the feasibility study conducted by Resolia as part of the Renov-Roue-Rad project. However, they envisage connecting only renovated houses to the district heating network, as the cost of connection is high and the heat supply may not be sufficient for non-renovated dwellings. To proceed with such a connection, financial assistance from the Brussels-Capital Region would be required.

Initially, the Foyer Anderlechtois had budgeted €150,000 per house for renovations, but actual costs have reached €230,000 per unit. For upcoming renovations and their next group planning permit application, they plan to reduce the level of energy performance ambition due to financial constraints, estimating a revised budget of €200,000 per house.

From the perspective of the Urban Planning Department of Anderlecht, the Foyer Anderlechtois is often cited as a positive example of a group planning permit application. However, the organization itself describes the application process as arduous.

3.4. Replicability: challenges encountered

Based on the experience in La Roue, the group renovation initiative has yielded rather modest results. Despite considerable efforts in awareness-raising and community mobilization, only 8 households (out of approximately 450 privately owned single-family homes) committed to participating in the first group renovation. Among the main reasons for this low participation rate are the limited financial means of residents and a poor cost-benefit ratio: renovation costs are likely to significantly exceed the expected energy savings. The Renov-Roue-Rad project ultimately concludes that inclusive financing of renovations is not feasible—energy renovation remains largely inaccessible to households without sufficient financial resources. As a result, the project only engaged a handful of relatively affluent homeowners—those who could afford the investment and were motivated by environmental concerns.

Experiences from both the Collectif La Roue and the Foyer Anderlechtois further confirm that, even in a garden city where homes are architecturally similar, each renovation project is unique and presents specific challenges. Contractors treat each house as an individual construction site, limiting potential economies of scale. The Foyer Anderlechtois's renovation efforts suggest that physical proximity between renovation sites is a major advantage, and that in order to benefit from it, one must be able to renovate a large number of homes within the same housing block. Achieving this, however, is difficult—it requires either a high rate of voluntary participation from homeowners (rarely feasible) or a high concentration of property ownership, as is the case for the Foyer Anderlechtois.

The availability of ERDF (European Regional Development Fund) support significantly altered the dynamics compared to the initial collective renovation project. Since the ERDF covers approximately 80% of renovation costs, participation became financially attractive, and homeowners could anticipate a substantial increase in property value. Consequently, the number and diversity of participants expanded from 8 to 36 households. However, even with the prospect of 80% public funding, less than 10% of privately owned homes in the neighbourhood opted in.

Moreover, it is likely that the homes that will ultimately be renovated through public subsidies are not those in greatest need of improvement. In Brussels, property owners typically enjoy better socioeconomic conditions than tenants—who account for over 60% of the city's households. The ERDF mechanism requires homeowners to pre-finance the renovation, implying that only those with sufficient financial means (and the capacity to navigate complex administrative procedures) can participate. These participants likely already live in relatively well-maintained properties.

This paradoxically illustrates the inefficiency of voluntary, incentive-based group renovation policies. Despite extremely favourable financial conditions—public subsidies covering up to 80% of renovation costs—only a small fraction of the private housing stock is affected, and public funds primarily benefit those already better off. Furthermore, the homes renovated are often not the ones in most urgent need of energy efficiency upgrades. This model appears highly inefficient.

In any case, the ERDF mechanism is not replicable. The financial burden it places on the public sector in order to subsidize private homeowners is immense and renders the approach unsuitable as a foundation for the widespread development of low-energy districts.

Other solutions have been explored in La Roue in an effort to move toward a Positive Energy District (PED). Installing photovoltaic panels on rooftops has proven difficult due to the architectural complexity of the roofs, which are typically composed of multiple small surfaces. Individual heat

pumps generate noise pollution and are only viable in homes that have already undergone full renovation and radiator replacement (e.g., with fan coil units), resulting in prohibitively high costs.

The possibility of establishing a decarbonised district heating network was also explored under the Renov-Roue-Rad project. However, a high-temperature biomass-based network was deemed unfeasible due to the truck traffic it would generate. A medium-temperature network, as proposed by a consultant, is also unlikely to be viable. Several key assumptions no longer hold: the Foyer Anderlechtois now intends to connect only renovated homes (i.e., very few units); the municipal school is not interested, having recently installed a new gas boiler; and the aquathermal solution that would draw heat from the adjacent canal appears to face significant regulatory barriers.

These challenges raise broader questions about whether La Roue is the right location for such infrastructure investments. Aside from the CERIA campus, which already has its own district heating network, the overall heat demand density in a neighbourhood composed of small single-family homes is low. Furthermore, the poor insulation of most houses is poorly suited to a medium-temperature network. From a strategic perspective, it would likely be more effective to deploy a district heating system in a denser urban area elsewhere in the Brussels-Capital Region.

3.5. Assessment and issues

There exists a clear trade-off between heritage conservation and building energy performance. In the case of La Roue, homeowners encountered urban planning obstacles when attempting to renovate their homes. Similarly, regulatory requirements—such as the obligation to install centralized mechanical ventilation systems during major renovations—discourage many homeowners from undertaking renovation works.

More broadly, it is urgent to re-evaluate the logic and objectives behind renovation subsidies in Brussels. What are these subsidies intended to achieve? Who are they designed to benefit?

Renolution, the Brussels-Capital Region's building renovation strategy, publicly states the objective of achieving "*an average energy performance of 100 kWh/m²/year for all Brussels dwellings by 2050, which represents a threefold reduction in average energy consumption compared to today*." However, beyond the practical feasibility of reaching an average energy performance of 100 kWh/m²/year across the entire housing stock, this target raises concerns due to a conflation of two distinct concepts: theoretical energy performance (as measured by EPB ratings) and actual energy consumption. Fieldwork[2] and scientific literature[3] (see, for example, Van Hove *et al.*) clearly show a gap between projected and real energy use in dwellings.

Moreover, renovation subsidies primarily benefit homeowners—despite the fact that more than 60% of Brussels households are tenants. These subsidies require upfront payment of renovation costs, making them accessible mostly to financially secure households. It follows that subsidies rarely target the poorest or most inadequately housed segments of the population. In fact, homes in poor condition typically require more heating to prevent humidity and mould issues, yet they are the least likely to receive funding.

2 See for example: https://bonnevie40.be/?p=2113&lang=fr

3 M. Y. C. Van Hove, M. Deurinck, W. Lameire, J. Laverge, A. Janssens & M. Delghust (2023) Large-scale statistical analysis and modelling of real and regulatory total energy use in existing single-family houses in Flanders, Building Research & Information, 51:2, 203-222, DOI: 10.1080/09613218.2022.2113023

It is also questionable whether the current subsidy system is the most effective way to reduce energy consumption in Brussels. In many cases, it primarily serves to improve the comfort of already well-off households, without substantially reducing emissions or energy use.

In the context of the La Roue neighbourhood, ERDF funding appears to be a misallocation of public resources. It results in substantial capital gains for private owners, with minimal impact in terms of decarbonization or energy consumption reduction. Thirty-six homes owned by relatively affluent individuals will be renovated and better insulated, enhancing their comfort. The Collectif La Roue is fully aware that such a project is not replicable, as it depends on massive public subsidies to function.

From both an equity and environmental efficiency perspective, it would have been far preferable to invest these funds in the most degraded housing stock, particularly in the rental market. This could include properties owned by social housing companies or private landlords, provided that appropriate mechanisms—such as post-renovation rent controls and resale restrictions—are implemented to prevent owners from capturing disproportionate financial gains.

In conclusion, group renovation based on renovation subsidies and the goodwill of homeowners (whether occupants or landlords) is not a viable strategy. It does not represent a realistic or replicable solution for improving the energy performance of buildings at the regional level.

3.6. Focus groups

3.6.1. Summary of discussions with tenants (Foyer Anderlechtois)

- Dependency and Challenges as Tenants: Participants feel dependent on their social landlord (Foyer Anderlechtois) and perceive themselves as having limited choice regarding their heating systems and dwelling improvements. They report significant difficulties in getting necessary repairs or improvements done by the landlord. Tenants express frustration with long waiting times for repairs and the need to push hard for action from the landlord. There is a strong perception that the landlord prioritizes renovating empty units over units occupied by current residents.
- Problems with Existing Heating Systems and Comfort: Many tenants find their current heating systems insufficient or uncomfortable. Issues mentioned include slow heating [implied by need for quick warm-ups], uneven heating (e.g., heating working only downstairs or upstairs but not both), systems that are ineffective at heating the entire room or structure, and systems that produce bad smells, noise, or irritate eyes [implied by desired system features]. Some express concern about boiler location, specifically in bathrooms, which they perceive as potentially dangerous.
- Critical Issue of Poor Insulation: Lack of proper insulation is identified as a major problem contributing to cold, drafts, and ineffective heating. Tenants describe feeling cold air coming from walls and needing to find their own systems to prevent cold from entering. Good insulation is seen as fundamental for both comfort and energy efficiency. Without it, reducing heating can lead to problems like humidity and mould. The difficulty of insulating externally due to urban planning regulations and the disadvantages of internal insulation (cost, losing space, complexity) are highlighted as barriers.

- Rising Costs and Financial Burden: Participants report a significant increase in energy bills. Even tenants who previously had fixed-price contracts have seen bills rise. The cost of energy is a major concern. Some bills are described as "impossible" or "very high".
- Cost as the Primary Behaviour Driver: The financial impact of energy consumption is the most significant factor influencing tenants' behaviour. The current system for some, where heating costs might be included in a fixed rent ("forfait"), is seen as removing the incentive to reduce consumption [implied by contrast with cost sensitivity and direct discussion of cost impact]. Conversely, paying for consumption and seeing the financial benefit (or cost) is a strong motivator for reducing usage.
- Energy Consumption Habits and "Sobriety": Tenants commonly limit their heating use due to cost, discomfort, or habit. They often heat rooms to lower temperatures (e.g., 18-20°C). Personal warmth strategies like wearing extra layers, using blankets, or hot water bottles are frequently used alternatives to high heating. "Sobriety" (reducing temperature, smart clothing) is recognized as a way to save energy. The idea of using small, localized electric heaters like heated blankets or pads is discussed as a highly efficient option for personal warmth.
- Environmental Awareness vs. Feeling Powerless: Tenants are aware of climate change and related issues like floods, fires, and earthquakes. They acknowledge the importance of addressing these issues for future generations. However, they often feel that primary responsibility rests with the state, large corporations, and the wealthy. They feel they are simply consumers with limited choices in the market.
- Financial Barriers to Green Transition: While supportive of environmental goals in principle, the high cost of green energy solutions (like solar panels, heat pumps) is seen as a major barrier, making them inaccessible for low-income tenants. They emphasize that they already struggle to afford basic needs. The question of who should bear the cost of the energy transition is raised, with suggestions that the wealthy or the state should contribute more.
- Scepticism Towards Landlord and Collective Initiatives: There is deep scepticism and distrust regarding the landlord's willingness or ability to invest in renovations and system improvements. Discussions about energy communities (installing solar panels collectively) highlight challenges like perceived lack of cooperation among neighbours, practical difficulties (differing schedules, vacant units), the complexity of the system (multiple bills), and the small financial gain compared to the effort and perceived hassle. Some see the initiative as potentially more beneficial to the cooperative or landlord than to the tenants.
- Desire for Transparency and Better Information: Tenants express a lack of clear information about their energy consumption and bills. Some are unsure who their supplier is or how their bills are structured. They would benefit from clearer feedback mechanisms to understand their usage and its impact [implied by the need to "find the flaw" in high bills and discussions about meters in other contexts].
- Ideal Heating System Attributes: Based on complaints, the ideal system would provide comfortable, uniform heat, be regulable per room (preferably with a thermostat), be discreet, quiet, and without bad smells. Good insulation is seen as essential for the system to work effectively.
- Call for Systemic Change and State Action: Many feel that real change requires action at a higher level, specifically from the state and the landlord. They call for the state to address issues like high energy taxes, ensure equal access to subsidies (which currently favour

owners), and mandate landlord investment in infrastructure and insulation. They suggest that politicians and public institutions should set an example by reducing their own energy consumption (e.g., in TV studios, schools, administrations).

- Prioritizing Basic Needs Over Environmental Investment: Facing financial hardship and struggling to meet basic needs ("can't make it to the end of the month," "don't have enough to eat"), tenants understandably prioritize these over investing in energy efficiency or environmental initiatives. The idea of paying more for less pollution is met with resistance due to current financial strain.
- Frustration with Perceived Mismanagement by Landlord: Tenants express frustration over what they see as the landlord's misallocation of funds, citing large expenses on security systems that don't work while essential repairs and insulation are neglected. They also point to the issue of empty, dilapidated houses contributing to insecurity (squatters, theft) while people wait for housing.
- Perceived Lack of Respect and Trust from Landlord: The mandatory ventilation systems installed by the landlord are seen by some as a sign of distrust in tenants' ability or willingness to ventilate their homes naturally. This contributes to a feeling of being controlled and not respected. Landlord responses to tenant complaints are sometimes perceived as dismissive or offering "excuses".

3.6.2. Summary of discussions with home owners

- Active Engagement in Renovation, but Facing Barriers: Some owners have already taken steps to improve their homes' energy efficiency, including insulating floors and roofs, installing high-performance boilers, adding solar panels with batteries, and replacing windows with high-performance glazing. These measures have significantly improved comfort. However, they face substantial challenges and "exorbitant prices" for further necessary renovations like façade insulation or window replacement.

- Major Financial Strain and Lack of Affordability: The cost of energy transition is a primary and often insurmountable barrier for owners, particularly older ones or those with more modest incomes. They find the costs of renovations (like €100,000 for insulation) prohibitively high. For retired individuals, taking on new long-term loans is undesirable or impossible. There is a strong sentiment that the cost burden should not fall disproportionately on individuals, especially those already struggling to afford basic needs like food or rent.

- Urban Planning Regulations are Significant Obstacles: Owners are severely hindered by urban planning and heritage preservation regulations, specifically concerning facade modifications and the visibility of solar panels from the street. These regulations are perceived as *blocking* essential insulation work, forcing some owners to undertake renovations *clandestinely*. The process for obtaining permits is seen as difficult, arbitrary, and sometimes "impossible" with the local commune. This discourages efforts towards energy efficiency.

- Prioritization of Insulation: There's a consensus that improving building insulation (raising the PEB classification) is the absolute priority and the *necessary first step* before considering advanced heating systems like heat pumps or district heating. Without proper insulation, heat is wasted ("going out the window"), systems are inefficient or ineffective, and problems like humidity and mould can occur at lower temperatures. Proposing collective systems

without addressing insulation first is seen as trying to add the "cherry on the cake" without the basic ingredients.

- Scepticism Towards Large, Collective Energy Systems:
    - District Heating: While acknowledging the potential for CO_2 reduction and price stability, owners are highly sceptical about the feasibility, cost, and governance of district heating networks. Concerns include the potential for monopolies to raise prices, the transparency of cost calculation, and the perceived slow pace of public works. The requirement for *everyone* to connect for it to be profitable is noted.
    - Individual Heat Pumps: These are seen as expensive investments that perform well only in already well-insulated homes (PEB A/B), making them financially prohibitive or ineffective for many owners.
    - Energy Communities: The *idea* of local energy sharing is appealing as a way to avoid large corporations, support local solar investment, and potentially offer preferential rates (e.g., for pensioners during the day). However, perceived small financial gains relative to the effort, complexity, and lack of clear information make it less attractive for some.
- Attitudes Towards Sobriety and Comfort Temperatures: Owners have diverse personal comfort levels, with some already living comfortably at lower temperatures (15-17°C). Many already practice energy saving habits by wearing extra layers or using localized heating like heated blankets or pads, which are seen as very efficient for personal warmth. The "Slow Heat" concept (acclimatizing to lower temperatures) resonates with some but is also met with scepticism when framed as a *new* obligation or deprivation, as many feel they are already forced to reduce heating due to high costs. It's suggested that "sobriety" should be presented with practical tips and support, not as a demand to "live without heating".
- Need for Social Equity and Progressive Cost Sharing: There is a strong call for a more socially just distribution of the energy transition costs. Ideas include pricing based on income or requiring wealthy individuals and large corporations to bear a larger share. The current financial situation of many, even working individuals or pensioners, makes grand environmental projects feel inaccessible or unfair.
- Frustration with Institutional Inaction and Bureaucracy: Owners express frustration with the perceived lack of concrete action and support from local authorities like the commune. Regulations (especially urban planning) are seen as prioritizing heritage over necessary energy renovations. There's a feeling that while abstract support might exist, real investment and policy changes to facilitate renovations are lacking. The commune's own buildings (like the school) are cited as examples where energy initiatives are blocked or delayed.
- Information and Transparency Issues: The presentation of complex energy data (graphs comparing systems, costs, and CO_2) is found to be difficult to fully grasp or interpret, particularly regarding included costs like infrastructure (embodied energy). There's a need for clearer, more understandable information about the technical options and their real-world implications and costs for individuals.
- Tension Between Environmental Ideals and Economic Reality: Participants are generally aware of environmental challenges and the need to reduce CO_2 emissions. For some, this

ecological consciousness is a driving force for renovation, even if not financially optimal. However, the overwhelming financial burden means that for many, cost remains the primary driver of behaviour, and environmental goals are difficult to prioritize over immediate economic survival. There's a debate about whether environmental benefits should be pursued "at any price" or within the financial capacity of the population.

- Perceived Sales Pitch for Collective Systems: Some owners perceive the presentation of collective solutions like district heating, particularly by study bureaus or associated constructors, as a commercial effort ("trying to sell us a part of it") rather than a neutral exploration of the best options for the residents. There is scepticism about who truly benefits from such projects.
- Focus on Collective Benefit and Stability: Despite scepticism, the potential for collective, stable, and cleaner energy solutions is appealing. The idea of a community-managed system that is stable in price and not subject to market fluctuations is seen as beneficial, particularly for a precarious public. Trust in local, potentially cooperative, initiatives is higher than in large, distant companies.
- Frustration with the Pace of Change: There is deep frustration that progress on energy efficiency and transition is slow and hindered by numerous obstacles (regulations, costs, bureaucracy). There's a feeling of giving a lot of energy to the process without seeing sufficient results.

In summary, the property owners are often motivated to improve their homes and reduce environmental impact but are severely constrained by high costs, lack of affordable financing, and restrictive urban planning regulations. They view fundamental insulation as the critical first step for any energy transition to be effective and financially viable for them. While open in principle to collective solutions, they are sceptical about their cost, governance, transparency, and whether they will truly benefit residents given the perceived failures of current energy systems. They strongly advocate for the energy transition to be socially equitable, with a fairer distribution of costs that does not penalize those with limited means, and for authorities to remove regulatory barriers and provide meaningful support.

4. Usquare (Brussels)

4.1. Recent history, description, and context

Usquare is located on the site of a former gendarmerie barracks in Ixelles. The site lies at the intersection of Boulevard Général Jacques and Avenue de la Couronne, adjacent to the Etterbeek train station, a major multimodal public transport hub that includes a railway station, two tram lines, and a high-frequency bus service.

The site is shaped like a quadrangle and spans an area of 3.9 hectares. Originally built in the early 20th century, it included 27 buildings with a total floor area of 56,000 square meters.

The site previously belonged to the Federal State. It was purchased by the Brussels-Capital Region in 2018 and transferred to the Société d'Aménagement Urbain (SAU) to implement an ambitious and exemplary project. The SAU is a public limited company under public law, responsible for the operational development of strategic areas in Brussels. It currently oversees the development of the Usquare site. Urban planning matters were addressed through a *Plan d'Aménagement Directeur* (Master Development Plan – PAD), specifically drafted for the site by Perspective.brussels, the regional centre of expertise for regional and territorial development.

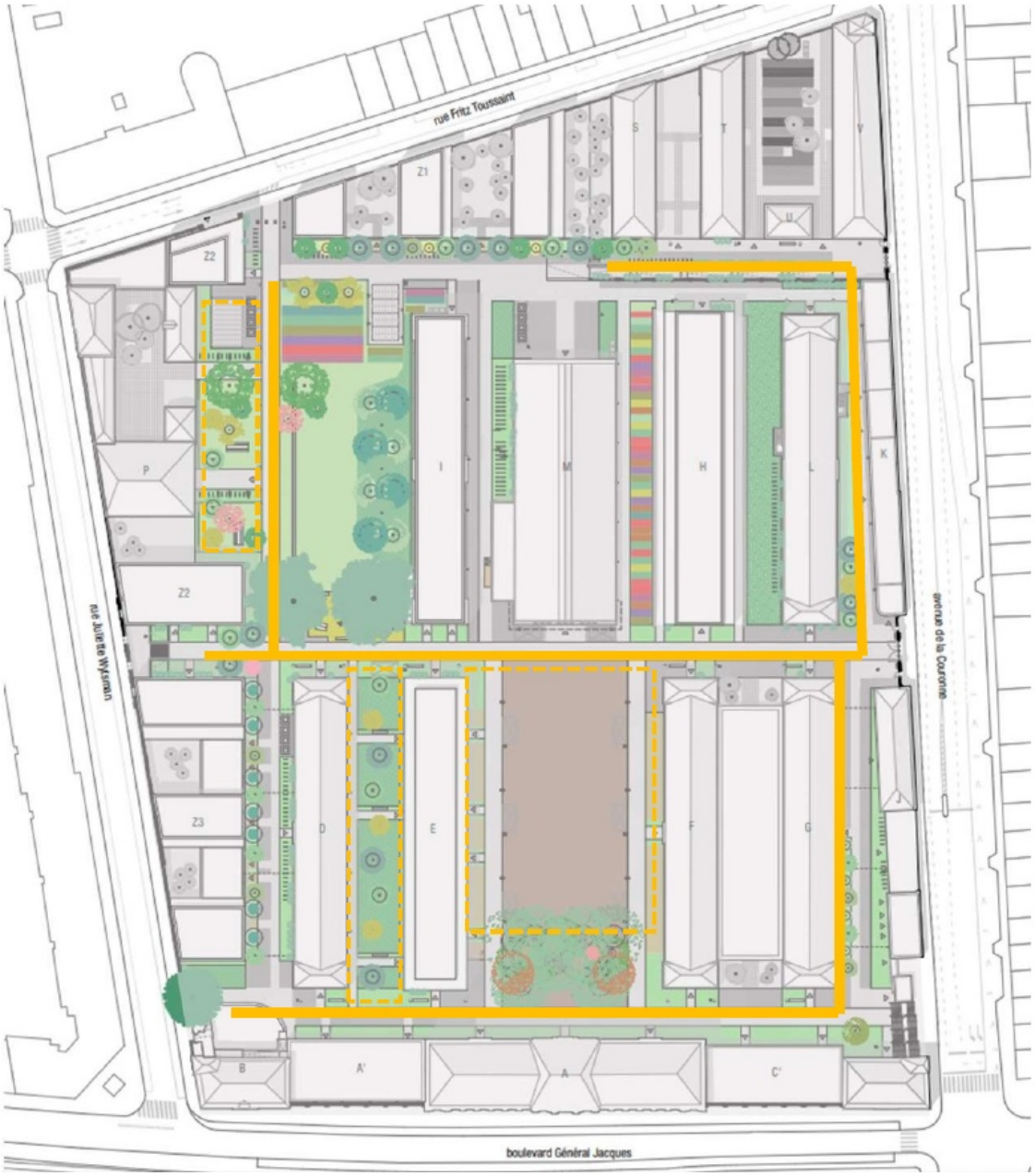
In the future, the site will host a university hub bringing together Brussels' two universities (Université libre de Bruxelles and Vrije Universiteit Brussel), 460 student rooms, and 120 public housing units (70% social housing and 30% subsidized ownership for middle-income households), an autism resource centre, a food hall, and extensive public spaces (18,000 m²). The site will also feature a neighbourhood cinema, a fablab, and a business incubator.

Usquare aims to be a pilot project with high ambitions in terms of circular economy (reusing existing buildings and materials), minimizing energy imports, and promoting active mobility. Active transport will focus on cycling and public transport; car traffic will be prohibited on-site, and no parking spaces are planned.

To reduce energy consumption, three types of renovation strategies have been applied: light renovations for buildings A, B, and C (located along Boulevard Général Jacques), major renovations equivalent to new construction, and the erection of several new buildings.

Currently, the site is uninhabited, although the universities have begun occupying office spaces in some buildings. Most of the site is still under development.

The Brussels-Capital Region has required all partners involved in the project to operate under a 50-year emphyteutic lease.



4.2. Actors

Three major actors are already present on the site: the universities (Université Libre de Bruxelles and Vrije Universiteit Brussel), the Société d'Aménagement Urbain (SAU), and the social housing companies (Binhôme and SLRB).

Other actors will join the project at a later stage, including the Maison de l'autisme, Citydev, which will offer subsidized homeownership units for middle-income households, and the operator of the food hall.

4.2.1. The Société d'Aménagement Urbain (SAU)

The SAU is a public limited company under public law responsible for the operational development of strategic areas in Brussels. It owns the Usquare site and is directly responsible for the district heating network and the development of public spaces. The SAU has received funds from the European Regional Development Fund (ERDF) for the construction of the heating network.

According to the universities, the SAU's goal is to inaugurate a renovated site that is clean and well done as quickly as possible. However, this could lead to differences in perspective with other acotrs who have different priorities, such as the universities, which may not share the same urgency to complete the project as quickly.

4.2.2. The universities (ULB et VUB)

The universities (Université libre de Bruxelles and Vrije Universiteit Brussel) are the driving forces behind the project and generally have aligned objectives. They received ERDF funds for the renovation of buildings A, B, and C.

These buildings were almost given to them for free, but the sustainability and circular economy requirements represent significant costs for the universities.

The decisions they had to make, or that were imposed on them, are not always entirely coherent. For example, while they are recovering construction materials, they were forced to demolish an entire building because it was stipulated in the Plan d'Aménagement Directeur (Master Development Plan – PAD). As a result, a building of 8,000 m² is being replaced with a building of 3,000 m², which leads to a loss of 5,000 m² of living space in a dense urban area. Modifying the PAD would have been too complicated.

In the first buildings renovated by the universities, there was no reflection on the heating system. Now, for student housing, the universities want to lower the temperature to 18°C in the student rooms and 16°C in the hallways. They are questioning the heating norms and the mechanical ventilation systems. According to them, there was too much automation in the heating equipment in recent student housing: everything is automated, and the students don't understand how it works (for instance, when the window is opened, the ventilation system automatically switches off). This level of automation doesn't help students understand or control their energy consumption.

For the next stages of the project, the universities aim to provide affordable student housing on the site, whereas the SAU wants to construct the student housing as quickly as possible.

For the renovation of buildings A, B, and C along Boulevard Jacques, the universities received 9 million from the ERDF.

4.2.3. Social housing companies (SLRB et Binhôme)

For the new social housing units to be developed on the Usquare site, two main actors are involved: the Brussels Housing Corporation (SLRB) and Binhôme. The SLRB is the regional authority responsible for the development and promotion of social housing in the Brussels-Capital Region, overseeing 16 social housing companies, including Binhôme, which will manage the social housing on the Usquare site on a daily basis. The social housing units on the Usquare site will be built by SLRB (which is the project owner) for Binhôme.

Both Binhôme and SLRB are highly interested in the circularity aspect and material reuse, but they were notably more hesitant regarding the connection to the district heating network. This will be one of the first instances in Brussels where social housing will be connected to such a network. This has raised significant concerns for Binhôme, mainly for three reasons. First, social housing tenants benefit from a social energy tariff, which is significantly lower than the regular commercial tariff. From this perspective, Binhôme has been reassured and tenants will still be able to access cheaper energy even with a district heating system, where only a portion of the users benefit from the social tariff. Second, Binhôme will no longer have exclusive control over the heating installation. The heating network will likely be managed by a private operator, and there are concerns that the system might not take their specific constraints into account. Third, Binhôme observes that the more energy-efficient the installations are (solar panels, double-flow ventilation, district heating, heat pumps, etc.), the higher the maintenance costs. For example, with a very basic condensation boiler system versus buildings equipped with solar panels, double-flow ventilation, and more, maintenance charges can be multiplied by five. While energy costs are reduced, it is important to find a balance. With the most efficient heating system, there is a risk that social tenants may not benefit from the savings and may ultimately end up paying more for energy.

Binhôme will install solar slates on the roofs of the buildings it renovates. This solution was chosen for its compatibility with the existing heritage, even though it is much more expensive than traditional solar panels. The energy produced will initially be used exclusively for the rental units managed by Binhôme. If there is a surplus, they will assess the feasibility of creating an energy community. Green certificates will benefit Binhôme.

Binhôme also does not want to install double-flow ventilation, as it poses practical issues for tenants, and prefers accepting lower energy performance (Energy Performance of Buildings - PEB) rather than implementing double-flow ventilation. They also believe that regulations encourage the over-sizing of heating installations.

The possibility of extending the district heating network and connecting the social housing located on the other side of Juliette Wytsman Street (outside of Usquare) will be considered in the future. Initially, the system's performance will need to be assessed once all the buildings on the Usquare site are constructed and in use. If there is still available heat production capacity, the district heating network will be extended. Currently, this set of social housing will be heated by an existing gas boiler, which is relatively new.

4.3. Ongoing and/or planned projects

In the future, the Usquare site will host a university hub bringing together the two Brussels universities (Université Libre de Bruxelles and Vrije Universiteit Brussel), 460 student rooms, 120 public housing units (70% social housing and 30% subsidized ownership housing for medium-income households), an autism centre, a food hall, and large public spaces (18,000 m²).

The SAU, the site's owner, aims for Usquare to serve as a model in terms of sustainability and circular construction. This will be achieved by preserving as many existing buildings as possible, reusing materials found on the site, using materials with a low environmental impact, and managing the waste generated during the construction process in an exemplary manner.

In total, the Usquare project represents an investment of around 200 million euros. 20 million euros have been spent on the works for buildings A, B, and C. The works for buildings F and G also amount to 20 million euros. Building L will cost 10 million euros, and the student housing will cost between 45 and 50 million euros. These amounts are solely related to the construction works and do not include the final total costs.

The project has received funds from the ERDF, amounting to 9 million euros for buildings A, B, and C, located along Boulevard Général Jacques. These funds were initially intended to cover 70-80% of the costs. However, with the rise in prices due to the war in Ukraine, the ERDF contribution now covers approximately 50%, with the remaining balance being the responsibility of the universities. For these heritage buildings, external insulation was not feasible, and internal insulation posed a number of practical issues: the floors needed to be raised because of the insulation, which would require raising the beautiful staircase (which also functions as an emergency exit, so the steps must all be the same height), leading to its demolition. As a result, the carbon footprint of the added materials would negate any future energy consumption gains. For this reason (and not for financial reasons), the universities have opted to carry out simple renovations to these buildings rather than major renovations that would be considered new (by insulating from the inside). In hindsight, the universities regret not having better insulated and having struggled to recycle elements present in the buildings in the light of rising energy prices.

The 460 student housing units will be distributed across 4 buildings (with a gross surface area of approximately 20,000 m²), with only one building needing to be demolished and reconstructed. For part of the student housing, there was a choice between internal or external insulation. Internal insulation would have reduced the available space and impacted the cost of the student housing (and thus the rent charged). On the other hand, external insulation was not initially planned in the Master Plan (PAD), and the permit could have been rejected on these grounds. As the SAU wants to inaugurate a well-renovated site as soon as possible, they preferred external insulation. In contrast, the universities want the student housing to be as affordable as possible and therefore preferred external insulation.

In terms of energy, one of the unique aspects of the site is the construction of a district heating system, which includes a medium-temperature loop (for new or heavily renovated buildings) and a high-temperature loop (for simply renovated buildings). The cost of the heating network is estimated at 7-8 million euros, with 700,000 euros allocated for the heat pump. The SAU received ERDF funds (1.33 million euros) to cover part of this investment. Without these funds, the heating system would have to be amortized over 30 years, and renewable energy would likely have been more expensive than gas. Indeed, the universities, Citydev, and SLRB are major energy consumers and benefit from preferential rates, which makes gas more attractive, and the investment in renewable energy more difficult to recoup (30 years for the universities, compared to the usual 15-20 years).

The heating network will be powered by a large CO_2 water-to-water heat pump of 3300 kW for heating and 650 kW for cooling, combined with 131 geothermal probes at a depth of 115 meters. Additionally, there will be 3 gas boilers to meet high heating demands during the winter. The geothermal potential is significant, but since it is a closed-loop geothermal system, the cooling of the premises in summer will be required to prevent long-term cooling of the underground. Without the geothermal system, cooling would not have been installed in the buildings. The cooling will work

either via geocooling or in combination with the heat pump. It is likely that no air conditioning would have been installed without the geothermal probes and heat pump, thus also leading to a potentially higher energy use in the summer due to this technology.

Furthermore, solar panels will be installed to cover 20% of the site's electricity needs. However, heritage constraints prevent the installation of solar panels on buildings A, B, and C along Boulevard Général Jacques.

Initially, combined heat and power (CHP) was planned, but this was abandoned due to the discontinuation of green certificate systems for installations using fossil fuels (gas in this case). Without this subsidy, CHP became financially unfeasible. Wastewater energy recovery (recovering heat/coldness from sewage water) was also considered but the project did not come to fruition due to a lack of follow-up.

When the gas boilers cease operation, a gas-free alternative will be found whenever possible.

4.4. Replicability: challenges encountered

The various stakeholders did not have to purchase the land. It was made available to them through a 50-year emphyteutic lease, either free of charge (for buildings A, B, and C) or at a cost of €250/m²—a modest price compared to market rates. This provision of land and buildings at a reduced cost enables investments in energy and sustainability that would otherwise be considered financially unviable.

Without support from the European Regional Development Fund (ERDF), a district heating network powered by geothermal probes and a heat pump would not be easily replicable, as the cost of energy would likely exceed that of a conventional gas installation. However, the financial return on this investment is hindered by the fact that universities and social housing providers are major gas consumers who benefit from preferential energy tariffs. For a conventional actor, the return on investment at Usquare would be quicker, as their energy costs would be higher.

To some extent, the geothermal system incentivizes cooling of the buildings during summer months, since maintaining the subsurface within a defined temperature range is necessary. This cooling demand will likely result in increased electricity consumption.

The renovation and insulation of heritage buildings is particularly complex. Either the buildings are simply insulated, resulting in modest improvements in energy performance and necessitating the use of a high-temperature heating loop; or they are insulated internally, which leads to a reduction in usable interior space and the replacement of a substantial part of the building's interior. Consequently, the additional materials used in such renovations may carry a carbon footprint that partially offsets the future energy savings. Therefore, the initial environmental impact of internal insulation in heritage buildings is relatively high.

Several stakeholders are also questioning the standards for sizing heating systems—specifically, the requirement to maintain an indoor temperature of 20°C when the average outdoor temperature for the day is -8°C. These standards are now considered overly stringent, particularly in light of climate change, as such cold conditions have become extremely rare in Brussels. The result is an oversizing of heating systems. Similarly, the use of high-performance technologies such as centralized double-flow mechanical ventilation in new buildings is being challenged. These systems entail high maintenance costs and present practical difficulties in daily use.

4.5. Assessment and issues

The Usquare project highlights a range of issues raised by Brussels' energy regulations.

The site does not fit into any category foreseen by the legislation governing energy communities. This recent legal framework did not anticipate a case such as this: a regional public actor seeking to facilitate energy sharing across multiple buildings. As a result, it remains unclear how energy sharing will be organized on the site.

A second gap in the legislation promoting renewable energy is the lack of support for geothermal energy. The green certificate mechanism, which is the Brussels Region's chosen incentive tool, does not apply to geothermal systems.

As observed in La Roue, heritage conservation directly impacts environmental ambitions at Usquare. For example, it is not possible to install solar panels on heritage buildings along Boulevard Général Jacques, and these buildings are particularly difficult to renovate.

Furthermore, the Master Development Plan (PAD) for Usquare, the regional planning instrument, mandates the demolition of an entire building. The universities are not in favour of this demolition, which results in a significant loss of usable space and runs counter to the sustainability and circularity goals emphasized for the site.

Finally, the renewable energy subsidy system influences technological choices more than ecological rationale. For instance, the initial intention of the Usquare energy system's designers was to install a cogeneration unit. However, following the Brussels Region's decision to withdraw green certificate support for cogeneration technologies based on fossil fuels, this option was abandoned in favour of a heat pump. Other decisions, such as the phased installation of solar panels, have also been shaped by the terms and conditions governing green certificate eligibility. As such, the design of this incentive scheme plays a crucial and far-reaching role.

4.6. Focus Groups

4.6.1. Summary of discussions with students

- Diverse Heating Experiences: Students have experienced various heating systems both in Belgium and their countries of origin. These include central heating (gas, fuel, wood), radiators, floor heating, chimneys, pellet stoves and AC functioning as heating.
- Preference for Floor Heating: Several students expressed a strong preference for floor heating. They found it effective, providing uniform heat, heating the floor and entire room well, and being discreet or invisible. Keeping their feet warm was particularly important for some.
- Issues with Current Student Accommodation Heating: Many students described problems with the heating systems in their current student accommodation. Common complaints included slow heating, not effectively heating the entire room or floor/walls, producing bad smells and noise when turned on, irritating eyes, and being poorly placed or taking up too much space. Some felt the system only worked effectively at maximum power, leading to discomfort or smell issues. Lack of proper insulation was also highlighted as a major problem contributing to cold and drafts.

- Usage Patterns and Alternatives: Many students reported using heating rarely or for short periods. Reasons for low usage included the system being uncomfortable (stifling, eye irritation), preferring warm clothes or duvets, not being at the student accommodation often, or simply being used to not having heating. Some turn the heating on briefly to warm up and then turn it off. Sleeping with heating on was generally avoided. Alternatives mentioned include wearing extra layers, using blankets/duvets, taking hot showers, or drinking hot tea. One student's family actively chose to wear sweaters and gather near a central heat source instead of heating the whole house.
- Vision of Ideal Heating: An ideal system should be regulable or personalizable per room, preferably with a thermostat to maintain a set temperature automatically. It should ideally heat from the floor, be discreet, invisible, and take up minimal space. Crucially, it should operate without noise or bad smells. Good insulation is seen as fundamental for an efficient system.
- Awareness of Consumption and Environment: While aware of climate change, initial thoughts on ideal heating focused more on personal comfort and functionality rather than environmental impact. Some felt that the primary responsibility for environmental action lies with corporations and elites, not individuals, which reduced their sense of personal urgency. There was a general lack of knowledge about their energy consumption and its environmental impact.
- Motivation for Reducing Consumption: A significant finding was that paying a fixed price (forfait) for heating, common in their current student accommodations, removed the incentive to reduce consumption. Students felt they would not change their usage habits if the cost remained the same regardless of consumption. Conversely, seeing the cost impact (losing money) was identified as a strong motivator for reducing consumption. Some were also motivated by the potential for less discomfort (smell, eye irritation, noise) from a more efficient system.
- Feedback Mechanisms: Students discussed different ways to be informed about their energy usage. Ideas included screens on the heater or near the entrance showing consumption, possibly with a simple indicator like a coloured smiley (green/yellow/red) for pollution impact, or comparing their consumption to neighbours. Some found the idea of screens showing consumption potentially "dystopian", while others welcomed feedback, particularly if it was linked to cost. One suggested showing how to reach a desired temperature rather than just raw consumption data.
- Cost and Free Heating Debate: There was a debate about whether heating should be free. Some argued that in a cold country, heating is a basic necessity like AC in hot climates and should be covered by taxes or state resources, especially if energy resources are seen as belonging to the people. Others acknowledged the costs of maintenance and materials, viewing free heating as impossible. Some feared that free heating would lead to abusive usage. Paying for energy (especially imported resources) was seen as acceptable by some. Progressive pricing or payment for consumption exceeding a reasonable limit were suggested as alternatives to the fixed forfait.
- Challenges of Group Initiatives (like Slowheat): The idea of a collective approach to energy saving on a floor or wing faced significant challenges. This included lack of social connections or even hostility between neighbours, differing schedules and presence in the student accomodation (some are rarely there), language barriers, varying levels of interest or

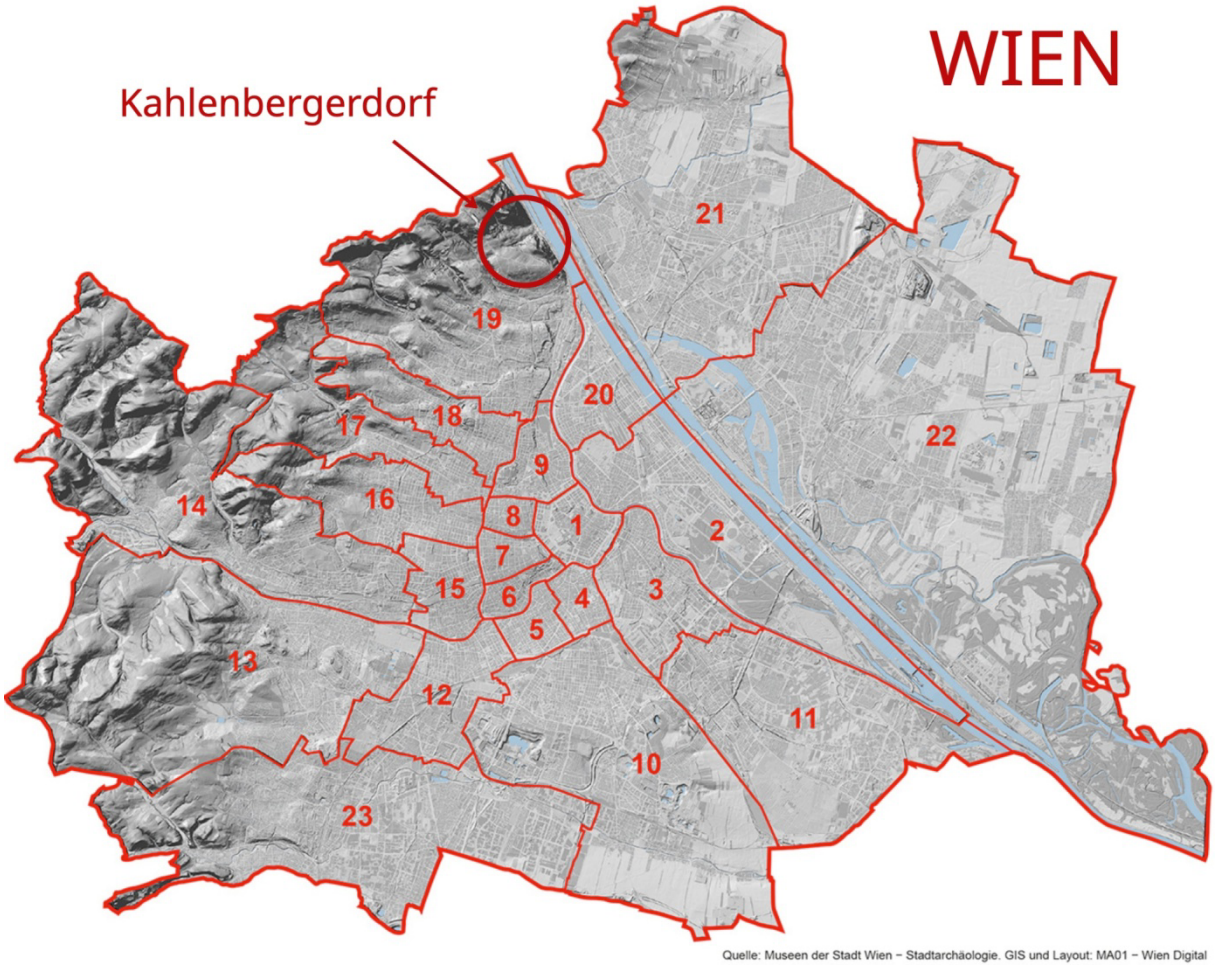
willingness to participate, and the time commitment required for meetings. Empty rooms assigned to no one also posed a practical problem for a group system based on wings. Despite the challenges, some saw the potential benefits of group discussion and dynamics. Some students expressed interest in participating on an individual level if a group approach proved too difficult.

In summary, the students prioritized comfort, functionality, and personal control in their heating experiences. While aware of environmental issues, their immediate concerns were often related to the effectiveness, comfort, and cost of heating in their daily lives. The fixed-price system in their current student accomodations is a major disincentive for energy saving, and clearer, personalized feedback on consumption, especially linked to cost or comparison with peers, could be effective motivators. Group initiatives face significant practical hurdles in the context of transient and disconnected student housing.

5. KahlenbergerDorf (Vienna)

5.1. Recent history, description and context

Kahlenbergerdorf in Vienna, a cadastral municipality in the 19th district of Döbling, is surrounded by the hills Leopoldsberg (south-west), Kahlenberg (west) and Nussberg (north-west) and lies nestled on the Danube, Vienna's most prominent river. There are no exact numbers for that area, but approximately 400 voters have been registered for the last election in this area. Today it consists mainly of residential buildings and a tavern, but until recently it was known for wineries and wine taverns. Heating is almost exclusively provided by natural gas. The centre of Kahlenberg village is located in a protected cultural heritage zone, which makes thermal renovation and the use of renewable energy very difficult.



Quelle: Museen der Stadt Wien – Stadtarchäologie. GIS und Layout: MA01 – Wien Digital

With the exception of one building, all are occupied and therefore in relatively good condition. Where renovations have been carried out, modern 2 or 3 glassed windows have been installed, the external façade has been restored and former functions such as school, restaurant, etc. have been converted into living space. In many cases renovations have not been carried out due to cultural heritage protection. In general, there are 2-3 external façades in the densely built village centre, otherwise there are 4 external façades per building. Residential buildings are privately owned, some are leasehold (owned by Klosterneuburg Abbey), and some belong to the City of Vienna (municipal social housing buildings).

Figure 3: Kahlenbergerdorf.view from the air. Source: google earth pro

Figure 4: Photo from Kahlenbergerdörfl with Danube in Background (Source: https://klimadoerfl.org/)

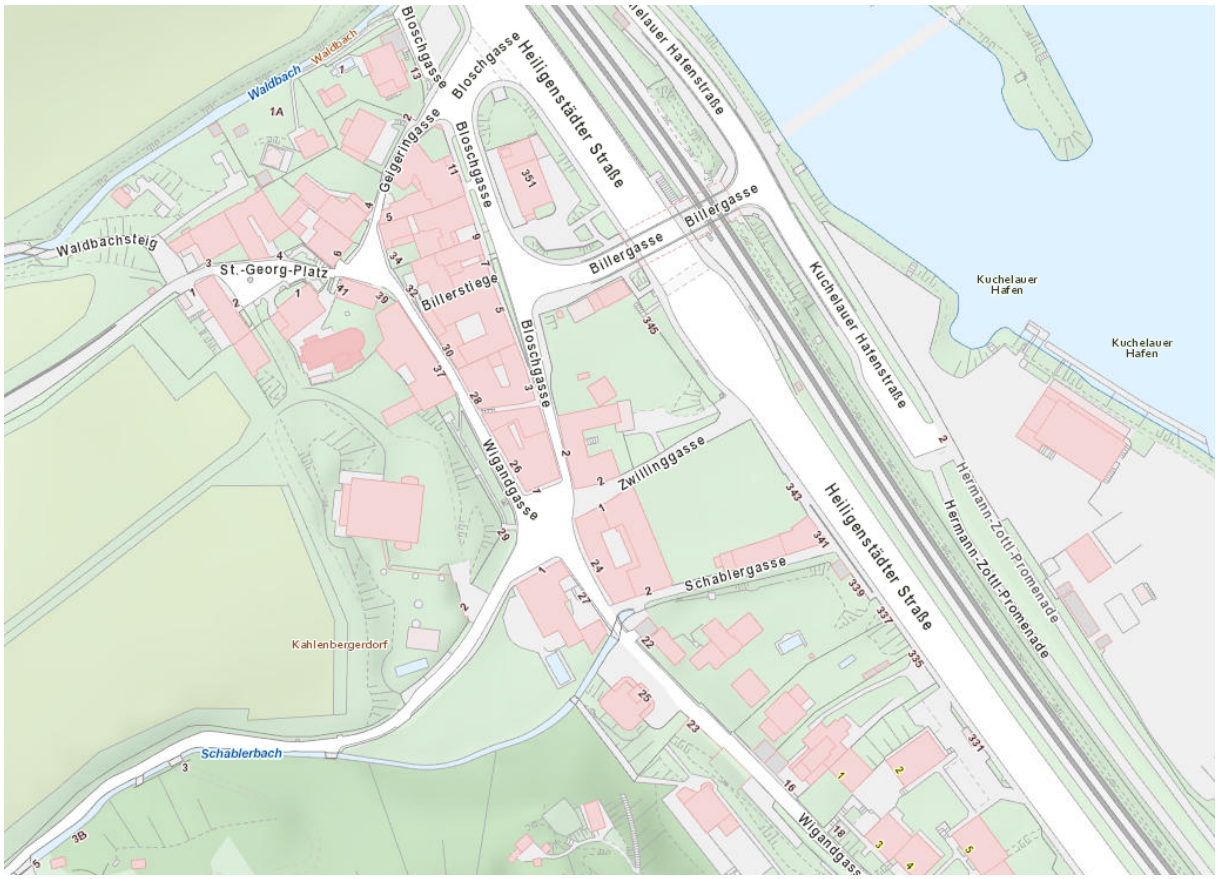


Figure 5 Source: City Map by the City of Vienna

Residents tend to have higher incomes, higher educational background and professionally situated in higher income situations or being already retired from it – an exception to that is the Gemeindebau, a social housing complex by the city of Vienna with only 38 apartments. There are very few children or young people.

The residents have formed an association called "Klimadörfl" (Climate Village – see below) with the aim of promoting possible solutions for decarbonisation, informing neighbours and promoting informative and cultural events around the vision of a climate-neutral Kahlenbergerdörfl.

Access to public transport is currently provided exclusively by regional buses, which run every 15-30 minutes to the nearest Vienna railway station (“Heiligenstadt”, with connections to the underground, city buses and regional trains - a small shopping centre with a supermarket can also be reached. These regional buses also go to Klosterneuburg, a small town on the outskirts of Vienna with a railway station for regional trains, shopping and cultural facilities such as a museum, cinema, swimming pool and the Klosterneuburg Abbey. Kahlenbergerdorf lies on a busy main road connecting Vienna with Klosterneuburg. There is a popular cycle path along the Danube, which runs parallel to the main road connecting Vienna with Klosterneuburg. No e-mobility charging stations are known.

On the one hand, there is considerable interest among numerous residents in enabling and promoting the decarbonisation of Kahlenbergerdorf. Conversely, there is a strong emotional attachment to the historic core and character of the area. The residents of Kahlenbergerdorf have

previously demonstrated their capacity for active resistance to significant changes, as evidenced by their opposition to the construction of a cable car over their community. Therefore, major alterations are similarly to be discouraged. The topography of the hilly terrain in the south, west and north of Kahlenbergerdorf indicates a minimal potential for photovoltaic (PV) installations. Zoning regulations such as those pertaining to heritage, nature conservation or agricultural use also serve to restrict the scope for change.

5.2. Actors

Of the actors and stakeholders listed below, the “Association Klimadörfl” and the external experts “e7”, “realitylab” and “reenag” are by far the most important for the current PED activities in Kahlenbergerdorf. The others are also mentioned, as they could potentially have a huge impact on decarbonising the neighbourhood, but so far have not contributed much to progress there.

5.2.1. Association Klimadörfl

The residents of Kahlenbergerdorf have been engaged in civic activities for more than 15 years, notably opposing the construction of a cable car traversing their neighbourhood. As a result of the dissolution of the association (“Freunde des Kahlenbergerdörfls”) that had been established with the objective of preserving the neighbourhood and its history, which encompasses buildings dating back to the 16th century, a new association was established. This new association, known as the "Association for the Promotion of Climate Neutrality in the Kahlenberg Village" (or "Klimadörfl" in short), was created with the intention of continuing the work of the dissolved association.

Despite Klimadörfl's continued opposition to the planned cable car, which has attracted the attention of national media outlets, the village's primary objective today is to pursue a sustainable energy supply that is environmentally and economically viable. The objective is to facilitate communication and foster a positive social climate in the village, despite the presence of socio-political differences.

Klimadörfl has the objective of securing funding for initiatives that would benefit the wider community (see “projects” below. It organises events, such as workshops and seminars, on topics related to energy, nutrition and mobility. Additionally, it serves as a point of contact for matters that are of concern to the residents of the village. To this end, the organisation has already obtained the written consent of over 40 property owners to participate in a collective effort to decarbonise their respective heating systems.

Furthermore, the association has positioned itself as a neighbourhood initiative that aims to support good cooperation in the village and also provides impetus for mobility, nutrition, culture and village renewal.

Figure 6 showing "Forum Klimadörfl" a meeting format that is held by the associaton every second month to inform about progress and activities of the working groups, to learn from each other and to invite more residents to become member.

Resources and Capabilities: The members of the Klimadörfl association contribute a wealth of resources to PED development. Many possess a robust technical and academic background, coupled with extensive professional experience, enabling them to excel in a multitude of domains. These include electrical engineering, medicine, property management, physics, law, and economics, among others. It is probable that deficiencies in expertise will be identified in the field of 'architecture and construction'. The Klimadörfl is able to compensate for existing deficiencies in expertise by collaborating with research partners such as e7, realitylab and reenag (see below). Furthermore, eminent specialists are invited to participate in the association's events, such as the Klimadörfl forum, a sort of agora for the residents of Kahlenbergerdorf.

Many residents of Kahlenbergerdörfl are financially affluent. They are frequently also (co-) owners of the residences in which they reside and thus have a vested interest in maintaining their property and potentially enhancing its value by supplying the house with cost-effective and sustainable energy.

Level of Engagement: The association is actively engaged in the developmental process. The association currently comprises approximately 50 members and aspires to expand further in order to assume a more prominent role in the future and exert greater influence on the decarbonisation of the Kahlenberg village. The association's initial objective was to develop a joint local heating network. However, this solution was ultimately dismissed on economic grounds. Subsequently, the association has sought to identify novel and creative strategies to garner support from property owners for the transition to heating solutions.

Potential Role in PED development: The association was established at the beginning of 2022 and has since assumed a variety of roles. The association assumed the role of a manager or conductor of

an orchestrated refurbishment and decarbonisation process on individual properties in the area. This was done with the aim of achieving synergy effects in the planning and implementation of construction measures and in the operation of systems, despite the fact that these are individual projects.

To date, the Association “Klimadörfl” has secured funding from the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology in Austria, as well as participating in two international research projects (see below). These have been made possible due to close cooperation with **following external professional experts**.

5.2.2. Professional experts: e7

e7 is a research, consulting and planning office specialising in energy efficiency, the energy industry and energy and climate policy. It disseminates expertise and provides technical orientation on the transformation of heat.

Resources and Capabilities: The interdisciplinary team is equipped to assess all potential decarbonisation pathways, comprehend the prospective products on the market, and provide the Klimadörfl with its expertise in decarbonising the village.

Level of Engagement: In collaboration with Klimadörfl, reenag and realitylab, e7 has successfully obtained a number of funding opportunities for research projects in this field. Moreover, they provide support and participate in networking events with the Klimadörfl association, offering feedback on new technological ideas and developments.

Potential Role in PED development: The provision of consultancy, planning and research services on all matters pertaining to the technological feasibility of decarbonisation efforts in the context of heating or the potential establishment of an energy community, together with the preparation of the requisite planning tools for the effective realisation of such efforts. This encompasses the provision of consultancy services pertaining to prospective or requisite renovations to the affected edifices, with the exception of architectural planning.

5.2.3. Professional experts: realitylab

realitylab is a leading expert in the organisation of social processes in the fields of housing and urban development. Through a commitment to fostering self-organisation within communities, realitylab is enabling these communities to assume a pioneering role in the transformation of their own futures and to become increasingly independent from fossil fuels.

Resources and Capabilities: realitylab has consulted with numerous organisations of varying sizes that have assumed a pioneering role in housing or local communities. This has enabled the company to gain a comprehensive understanding of the processes involved in establishing a group of individuals who are prepared to assume the necessary responsibilities. realitylab's approach involves the design and promotion of social cohesion and self-organisation at the group and neighbourhood levels. This is intended to facilitate the co-creation of engaging and sustainable developments that are responsive to the needs of the people involved. realitylab's work also encompasses the promotion of urban commoning at the local level.

Level of Engagement: realitylab maintains a close working relationship with the board of the association Klimadörfl, participating in nearly all meetings and contributing to the association's ongoing development.

Potential Role in PED development: The objective is to facilitate the organisational and social processes for residents of Kahlenbergerdorf in cooperation with Klimadörfl, through the provision of consulting, training and mediation services.

5.2.4. Professional experts: REENAG

REENAG is a competence centre for the development, financing, construction and operation of plants for the generation of energy from renewable energy sources.

Resources and Capabilities: reenag is a leading specialist in the field of renewable energy finance. Consequently, should the Klimadörfl association either commence this endeavour independently or establish a new organisation with the objective of constructing a future local heating network or analogous infrastructure, reenag will be available to provide support and assistance with the formulation of a viable business plan and the development of appropriate financing or potential technological solutions available on the market at present time.

Level of Engagement: To date, reenag has participated in relevant workshops and presented its best practice examples. They are available, if needed.

Potential Role in PED development: As financial experts and developers, they will play an instrumental role as key partners in the construction of the actual infrastructure in Kahlenbergerdorf.

5.2.5. City of Vienna

The City of Vienna has high social and ecological ambitions which is also reflected in the fact that the city often achieves high positions in quality-of-life rankings. It has a dense urban heat network with a supply rate of 50% of all households (460,000 households). There are city-wide strategies such as "Raus aus Gas" (“escape from gas”). The reason for this, in addition to ecological considerations, is not least that most of the heat in the network comes from Russian gas.

Resources and capabilities: City of Vienna and its entities have many employees. In addition to human resources, such as consulting, the City of Vienna has resources in the areas of finance (subsidies, favorable loans) and legal standards (e.g. building standards, building regulations, subsidies for the installation of PV systems). It set out strategies and made it law that the city and all its entities will decarbonise it’s heating infrastructure by 2040. The City of Vienna has a high potential and is actually rolling out services, support and subsidies, see below. However, it is dependent on regulations and funding from the federal government and the EU. (see Policy Canvas)

Level of commitment: The City of Vienna set out strategies, roadmaps and made it a law that the city and all its entities will decarbonise it’s heating infrastructure by 2040. It challenged itself to create PEDs in various testing areas, creating a single agency, WieNeu+, for that. However, WieNeu+ is not operational in the Kahlenbergerdorf at all. The city wants to become an important player in decarbonization and feels responsible for the issue. All it’s administrative body and entities set up “working groups” addressing decarbonization efforts – so it is relatively easy to identify someone responsible and with knowledge on the respective matter or potentially participating in creating PEDs.

Potential role in PED development: In summary, it can be said that the City of Vienna plays a major role in the development of PED. To this end, it has already created the following offices:

1. The wohnfonds_wien, a limited-profit organization run by the City of Vienna for fostering affordable (social) housing, has set up an information centre on how to start decarbonisation called "Hauskunft". It enables owners to finance a “Future Check” and advises owners and housing administrations on possible renovation technologies, approaches or alternatives. This agency does not sell anything, it only advises. About 10 houses already used the possibility of a “Future Check”, so to have a list of recommendations for refurbishment of their buildings at Kahlenbergerdorf.
2. A wide range of funding and subsidy schemes for innovative green buildings and quality assurance, such as Sockelsanierung, Thewosanierung, Huckepacksanierung or the Grundstücksbeirat (property advisory board), which is available to every owner, including in Kahlenbergerdorf.
3. Policy plans for carbon-free heat supply and climate protection, such as the Heat Plan 2040, provide relevant and helpful information, e.g. on whether to wait for the expansion of the Cities local heat network in one's own neighbourhood, or to look for local individual solutions, etc.

The City of Vienna provided a “Future Check” for about 10 houses in the area. The “Future Check” contains recommendations for the refurbishment of a building. “Hauskunft” of the City of Vienna is also subsidizing (by 50%) a more elaborated “Refurbishment Concept” that is also containing cost estimates for recommended refurbishment measures. The “Refurbishment Concept” must be authored by a technical expert or company.

5.2.6. Gemeindebau Wien / Wiener Wohnen

The company "Stadt Wien - Wiener Wohnen" manages, renovates and administers Vienna's municipal housing estates. This includes around 220,000 council flats. Wiener Wohnen wants to decarbonize all its buildings according to Viennese standards and at the same time provide affordable housing.

Resources and capabilities: With 220,000 apartments, Wiener Wohnen is a traditionally large and influential player in the Viennese housing market, which is 100% owned by the City of Vienna. The properties are professionally managed by Wiener Wohnen's own property management company. The staff (a total of 4500 employees) is well trained and experienced and could contribute its know-how in the field of dem, although there is still a lot to learn in the field of decarbonisation at Wiener Wohnen.

Level of commitment: Wiener Wohnen is still in the process of defining its decarbonisation strategy. However, the housing complex in Kahlenbergedörfl does not seem to be a priority in the decarbonisation strategy. At least there is no information available at the moment. Discussions have taken place with Wiener Wohnen in which the company has expressed interest in the activities of the Klimadörfl and the research projects, but no concrete commitment has yet been made.

Potential role in PED development: It would be desirable for Wiener Wohnen to design the heating systems (potentially geothermal and heat pumps) in the decarbonisation of its municipal building in Kahlenbergerdörfl in such a way that neighbours could easily connect, or that the system could

become part, or possibly even the core, of a larger local heating network. Wiener Wohnen could devote considerable human, financial and physical resources to such a project.

5.2.7. Catholic Parish

The Catholic Parish, in collaboration with their priest, aims to provide support to Catholics in the Kahlenbergerdorf community. They seek to maintain contact with these individuals and prevent them from becoming inactive members. The organisation operates a number of properties, including the local church, which are all owned by the Klosterneuburg Abbey. The parish hall building comprises the parish offices, the priest's residence, and a multitude of additional rooms, including a smaller stage with a bar and a considerably sized courtyard, which is arguably the largest flat area in the Kahlenbergerdorf area. The Asssociation Klimadörfl is allowed to use the premises for it's assemblys, workshops or cultural events.

Resources and Capabilities: The priest serving the parish is appointed and remunerated by Klosterneuburg Abbey. The parish is responsible for the administration of the property belonging to Klosterneuburg Abbey. These comprise the church and the vicarage. The vicarage comprises a historic ensemble of structures situated on a spacious site in the centre of Kahlenberg village, which would be highly conducive to geothermal utilisation. The Georgssaal in the vicarage is available for use by the Klimadörfl association for the purpose of holding meetings. In inclement weather, various festivals held by Klimadörfl are conducted within the vicarage and its cellar. The social network of the parish and the network of the association are mutually reinforcing, with the potential to enhance each other's capabilities. The church continues to exert a significant degree of influence. Additionally, the parish council is a locally influential body that includes members of the association.

Level of Engagement: Notwithstanding the considerable resources at the disposal of the parish and the social networks that have been established, the level of commitment on the part of the parish and its priest is disappointingly low. This may be attributed, at least in part, to the fact that a range of decarbonisation options have been discussed without a concrete request being made to the parish or the foundation. As the parish is dependent on the abbey in numerous respects, it would be necessary to conclude more far-reaching agreements and contracts with the abbey. It is to be hoped that the priests will be able to assist in this process, although this has yet to be seen.

Potential Role in PED development: The parish could play a significant role in the management of resources belonging to the abbey, given the suitability of its buildings and the size of the vicarage courtyard, which could be utilised for geothermal probing. It is also possible that the Parish Council may make decisions that would encourage commitment when dealing with Klosterneuburg Abbey. (also see "Klosterneuburg Abbey".)

5.2.8. Abbey Klosterneuburg

Abbey Klosterneuburg – a member of the Augustinian order since 1133, is currently the most prominent landowner in the village and the surrounding area. The region is renowned for its historical viticulture, with the earliest known winery dating back to the 12th century. The Abbey of Klosterneuburg continues to own and lease some of the buildings in the area, including those in Kahlenbergdörfl. The Abbey's agricultural land presents an opportunity for the utilisation of geothermal energy, particularly for heating and cooling.

Klosterneuburg Abbey has an administrative structure that has grown over the centuries. No fewer than 28 parishes belong to the monastery, most of which are located in Vienna and Lower Austria,

but some are even in Norway and the USA. This is the result of the organisation of the Augustinian canons. The monastery's business operations have an annual turnover of 40 million euros. In addition to one of the largest vineyards in Austria, the monastery also has extensive forests. The biomass from the forests is used to operate an underground heating plant in the town of Klosterneuburg, which supplies communal buildings with heat. There are 40 Fathers in the convent. The business enterprises have around 180 employees.

The Abbey is the proprietor of a number of vineyards and historic residences in Kahlenbergedörfl. The Abbey's objective is to maintain the property as a unified entity, while simultaneously reducing operational and energy-related expenditure. The Abbey owns a sizeable proportion of the village's real estate and delegates the pastoral care of its parishioners to the Catholic Parish.

Some properties owned by the Abbey are let for extended periods, with leases of up to 99 years. Although the Abbey is involved in a district heating network based on biomass in Klosterneuburg, it has not expressed an interest in contributing to a heat network in Kahlenbergerdörfl, even though many of its buildings would benefit from it. However, as these buildings are leased in the long term and the residents pay the energy bills, there is no direct incentive for the Abbey to invest unless the project is intended to generate profit.

Resources and Capabilities: In addition to the vicarage and the church, the monastery also has other significant buildings in the centre of Kahlenbergerdorf. These buildings, which are centuries old and listed, are still in use as residential properties. Furthermore, the monastery possesses vineyards in the vicinity of Kahlenbergerdorf. It can be reasonably deduced that the vineyards would be suitable for the installation of photovoltaic (PV) or geothermal energy generation systems. (Similar trials conducted in vineyards owned by other parties have yielded positive results.) The monastery has expertise and operational experience in a local heating network in Klosterneuburg and is in a financially advantageous position to provide substantial support to Klimadörfl's efforts to decarbonise Kahlenbergerdorf, whether through financial contributions or as a contractor.

Level of Engagement: Notwithstanding the considerable resources at the monastery's disposal, there is currently no discernible engagement with the local community of Kahlenbergerdorf. It would appear that the monastery is not developing any activities of its own accord. The Klimadörfl association is currently exploring potential avenues for activating the monastery. It is likely that a concrete proposal, comprising a technically sound and economically viable plan, will be required in order to initiate discussions with the monastery. Members of the Klimadörfl board who are also engaged in the Kahlenbergerdorf parish council consider the matter to be of great delicacy, as a negative response from certain decision-makers may result in unforeseen challenges to the decarbonisation of Kahlenbergerdorf in the long rund.

Potential Role in PED development: Given its extensive real estate holdings in Kahlenbergerdorf, the monastery is well-positioned to spearhead innovation in the area. As an ecclesiastical institution, it is able to plan for the long term and evaluate the profitability of investments over an extended period. From an economic standpoint, the monastery's investment in a local district heating network may prove advantageous in the long term, particularly if the network is capable of supplying heating and cooling to the monastery's owned properties. Should the monastery opt to decarbonise its building stock, it is possible that neighbouring buildings may also participate. The monastery could therefore act as a catalyst for the decarbonisation of Kahlenbergerdorf, disseminating its experience to other properties and parishes within its sphere of influence.

5.2.9. Via Donau – Österreichische Wasserstraßen-Gesellschaft m.b.H.

Via Donau is the leading international waterway operator in the Danube region. By utilising the knowledge of our experts in infrastructure management, shipping and logistics, along with electronic information and navigational systems, flood control and environmental hydraulic engineering, it provides services for the public sector, businesses, holidaymakers and residents along the Danube. Via Donau owns the land and the building that is rented out to the Restaurant Flamingo or the yacht-club Kuchelauer Hafen, located at the shore of Kahlenbergerdorf.

Resources and Capabilities: The ViaDonau company has considerable holdings along the Danube river and in the Kuchelau harbour area. In contrast to the majority of Kahlenbergerdorf, the area benefits from an abundance of sunlight, a flat terrain and an abundance of suitable roof space for the installation of photovoltaic (PV) modules. Additionally, the area is not located within a protected cultural heritage zone. The Klimdörfl Association contemplated utilising the expansive parking facilities on the premises for the installation of surface collectors (asphalt collectors). As a substantial state-owned enterprise, viadonau possesses a workforce with the requisite expertise and qualifications to engage in decarbonisation initiatives along the Danube. However, this would entail a considerable workload for the employees:

"The core task of our real estate team is the competent and environmentally friendly management of around 127 million m² of land and shore areas in the Republic of Austria. In addition, viadonau manages around 2.3 million m² of company-owned building and land areas, which corresponds to around 320 football pitches... Every year, about 500 permits are issued along the Danube for stairways and about 300 one-day events and about 200 contracts are drafted and concluded. Currently, the real estate team manages over 2,000 contracts." Source: https://www.viadonau.org/infrastruktur/liegenschaften

Level of Engagement: Given the extensive nature of the areas in question and the numerous tasks currently being undertaken by Via Donau, it appears that there is a dearth of resources available for the allocation to comparatively minor, yet innovative, tasks in the Kahlenbergerdorf. Consequently, Via Donau's commitment to these tasks is currently minimal. Furthermore, the land in question is leased to a tenant (the restaurant "Flamingo Marina"), who has demonstrated only a modicum of interest in the efforts made by Klimadörfl.

Potential Role in PED development: In accordance with the terms of the lease agreement with the restaurant "Flamingo Marina", ViaDonau is unable to act directly as an actor in this matter. It is imperative that all requests and concepts be discussed with Flamingo Marina prior to any action being taken. Nevertheless, it is conceivable that ViaDonau could assume a long-term responsibility for contributing to the decarbonisation of areas along the Danube. It seems reasonable to posit that this task can also be identified, at least in general terms, within the company's task descriptions. In order to operationalise the form of ViaDonau's contribution to the national climate plan, it may be beneficial to extend an invitation to ViaDonau to participate in a research project.

Klimadörfl wanted to install a large PV system on the roof of the restaurant, as the rest of the Kahlenbergerdörfl is poorly suited to PV. The yield from the PV system was to be distributed among the members as part of a local energy community. Here, too, the ownership structure was unfavourable. It could not be completely clarified who has the right of disposal over the roof areas.

5.3. Ongoing and/or planned projects

To date, the primary focus of decarbonisation efforts in the village has been on heating systems. The association 'Klimadörfl' has taken part in, and is still taking part in, several research projects that have concentrated on generating decarbonised heating and cooling in combination with refurbishment. None of the funded projects below have contributed financially to the refurbishment of a building or the construction of a local heat network. All projects were dedicated to developing technical, financial and organisational PED development scenarios to transition away from gas.

5.3.1. Citizens4PED

Kahlenbergerdörfl serves as a Living Lab for Citizens4PED. This Monography is a deliverable of Citizens4PED.

5.3.2. TheHeatPioneers

Project Title: *TheHeatPioneers – Participatory Climate Transformation Roadmap as a Basis for a Demonstration District in Gas-Supplied Kahlenbergerdorf*

Programme / Call:
Energy of the Future – SdZ (Flagship Region Energy), 9th Call 2021

Status: completed
Project Duration: 1 September 2022 – 30 September 2023 (13 months)
Timeframe: 2022–2023

Keywords: neighbourhood renovation, climate-neutral district, gas-supplied building stock, participatory transformation process

DieWärmePioniere is a community-led initiative in Kahlenbergerdorf aiming to pioneer the local heat transition and transform the neighbourhood into a climate-neutral district by 2040. Building on a tradition of civic engagement, residents have come together in a newly formed association to collectively phase out fossil gas and adopt renewable energy sources for heating. The project's starting point is the development of an integrated, climate-neutral energy concept covering heating, cooling, electricity, and e-mobility needs.

The core objective is to create a detailed transformation roadmap for the entire district, outlining concrete technical measures, an implementation timeline, a CO_2 reduction path, and all relevant stakeholders. A key component is ensuring acceptance and participation among building owners and residents through an inclusive, participatory process. Additionally, the project develops a forward-looking business and governance model called *Energiegemeinschaft Plus*, which goes beyond PV communities to include renewable heating, cooling, and EV charging infrastructure.

The outcome of the project includes both a strategic roadmap for full neighbourhood decarbonisation and the preparatory work for a demonstration project in a selected subarea. The transformation plan is co-created by residents with expert support, ensuring both technical

innovation and social ownership, and establishing clear roles between property owners and future energy service providers.

5.3.3. DekarboGen

Project Title: DekarboGen – Heat Transition Cooperatives to Accelerate Urban Decarbonisation

Programme / Call:
Smart Cities – Lighthouse Projects for Resilient Cities 2040
Call 2022

Status: ongoing
Project Duration: 15 February 2023 – 14 February 2026 (37 months)
Timeframe: 2023–2026

Keywords: decarbonisation, heat transition, gas, cooperative

Around 23% of Austrian households are heated with natural gas, and in Vienna, natural gas covers as much as 43% of the final energy demand for heating and hot water. Switching to climate-friendly heating systems is particularly complex in multi-family urban buildings. Due to limited district heating capacities, locally available renewable sources such as geothermal energy, photovoltaics, or solar thermal energy are essential. Their use, however, requires central and often cross-building systems that must be jointly organized and financed. This is where the *DekarboGen* project comes in: It develops and tests innovative, cooperative-based models for decarbonising urban neighbourhoods ("heat transition cooperatives"). The project focuses on overcoming legal, financial, and organisational barriers so that centralised energy systems can be jointly planned, implemented, and operated. Three demonstration projects with different urban contexts (condominium buildings, cooperative row housing, suburban structures) serve as real-world test cases. From these, transferable tools and strategies are derived, including standardised community-building processes, templates for cooperative formation, technical and legal analysis methods, and replicable financing models. The goal is to empower property owners, tenants, and property managers to independently implement decarbonisation projects. This should enable 90–95% CO_2 reductions and complete independence from gas in urban neighbourhoods—making a key contribution to achieving Austria's 2040 climate goals.

During the project it has been found that the legal organizational form of a cooperative is best suited for jointly financing investments in the renewable energy grid. Residents of a neighbourhood form a resource community that establishes, uses, and operates a shared resource system, which essentially consists of a shared anergy network (= geothermal drilling and/or wells and a pipe system), which requires relatively large investments but is technically uncomplicated, requires very little maintenance, and has a long service life.

The shared anergy network should end at the property or apartment boundary. The anergy network is the common basis for heat supply, on which a wide variety of individual solutions can be built. The anergy network is scalable, i.e., it can be expanded to include additional participating properties. Each participating building owner or apartment owner is responsible for the specific design of their

individual heat supply. Heat pumps are generally used. However, their dimensions and technical solution will vary considerably depending on the building or apartment.

Cooperative governance is based on self-organization and self-management. This means that people who were previously used to consuming energy services become producers of heat themselves. Cooperatives enable people to take responsibility for the sustainable energy supply of their neighbourhood. In summary, it can be said that communal heat supply within a cooperative can ensure a sustainable energy supply, independent of market developments and geopolitical crises. A cooperative organization results in lower investment costs, running costs, and transaction costs. In addition, a cooperative organization has a socially activating and transformative effect and offers spillover effects for other community solutions, such as shared mobility and joint neighbourhood design.

5.3.4. Planned projects: TheHeatPioneers DEMO

Joint Decarbonisation Management (JDM)

The HeatPioneers DEMO project was developed in response to the obstacles encountered during the initial HeatPioneers project. The local heat network proposed by the association 'Klimadörfl' was evaluated by it's external experts e7 and realitylab unfeasible for technical and economic reasons. (see below 3.6 Technical solutions and scenarios)

Therefor a completely other approach was chosen: The objective is now to develop a joint decarbonisation management (JDM):

The aim is to utilise synergies, increase acceptance and attract additional participants through a coordinated approach for at least 12 buildings. The innovative approach strengthens the community of building owners, who jointly implement construction measures and select innovative energy solutions in a competitive process. The aim is not only to successfully decarbonise the pilot buildings, but also to further develop and disseminate the JDM model. Financing models should take individual needs into account in order to ensure broad accessibility. The project aims to create a model for the climate-neutral transformation of other neighbourhoods.

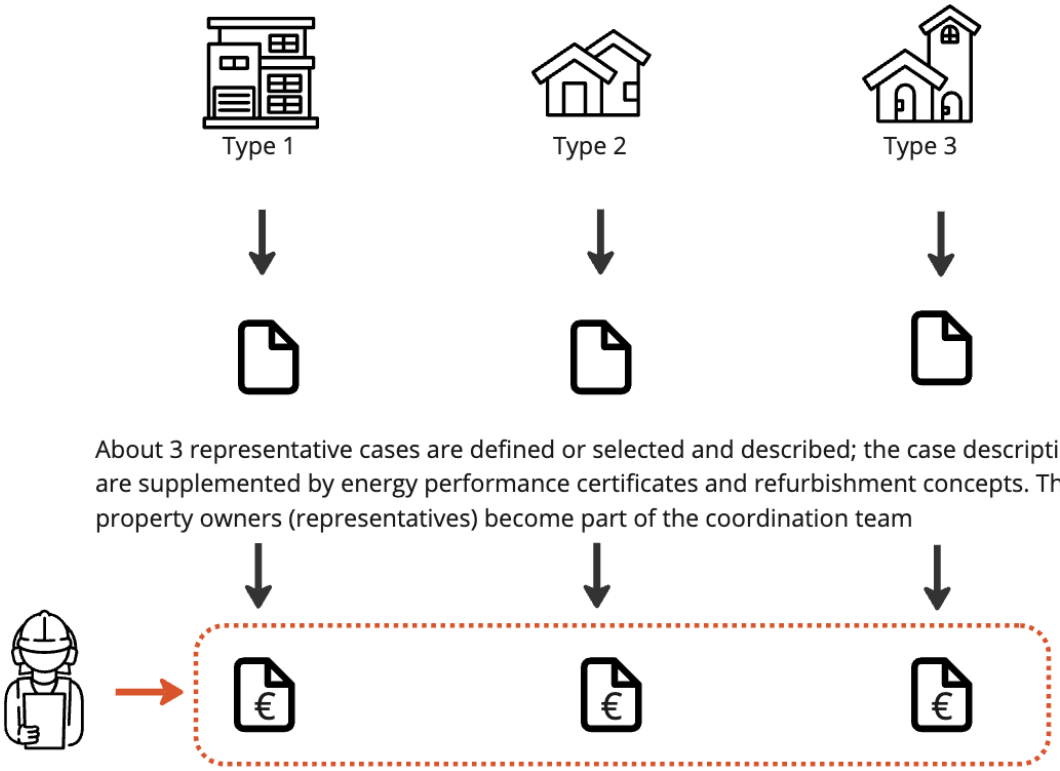
The JDM approach:

Although the refurbishment of buildings and the generation of sustainable energy takes place on individual properties or small clusters of properties, it still makes sense to proceed together. We call this approach « Joint Decarbonisation Management », which can be characterised by the following features:

1. Collaborative research and fact checks; **common knowledge** is generated **that fits the specific conditions of the village**: protection zone, solar radiation, building types and condition,...
2. **A joint overview** of possible **technical solutions** and consultation with **experts**. Some people now feel empowered to start a project on their property.
3. **Community building**: People see each other again and enjoy socialising. The social contacts offer many benefits and are good for well-being and health.

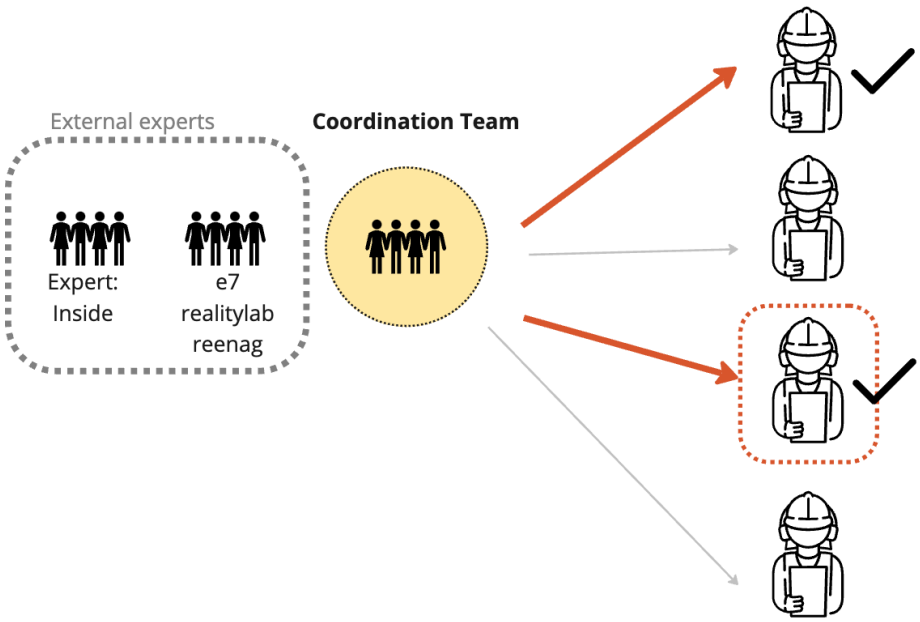
These effects have already materialised through the founding of the "Klimadörfl" association and the "Die Wärmepioniere" project. The next joint steps will build on this:

1. **Founding the Energy Community** - for the time being only for the joint procurement of sustainable electricity and thereby learning to become economically active together (this is currently taking place as of May 2025)
2. **Joint tendering of refurbishment and energy services** on the basis of 2 to 3 sample cases that are as representative as possible.



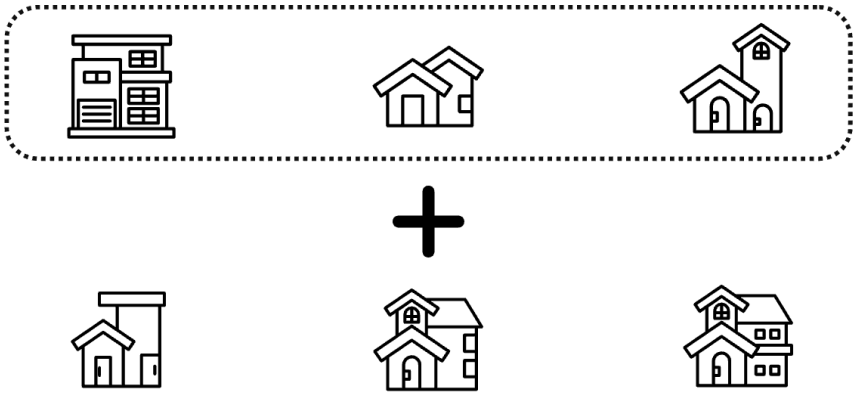
Energy service providers and builders are invited to look at all three cases and prepare offers.

3. **Different financing offers,** e.g.Purchase of equipment before commissioning or leasing it



The coordination team negotiates the offers with the support of the expert team and makes the decision in favour of 2 providers.

4. **Joint commissioning of services, to achieve volume advantages.**



More properties can join in the next round. The aim is to achieve volume advantages through the larger order amount. Each of the two remaining energy service providers will submit bids.

5. **Jointly coordinated and commissioned project management** that supervises and quality-assures the execution of construction work.
6. **Coordinated maintenance and operation** of the constructed facilities
7. **Expanding the energy community**
    - to consume locally generated electricity locally and utilise synergies
    - to jointly supply themselves with sustainable residual electricity (citizen energy community)
    - possibly even to jointly invest in sustainable energy supply
    - in order to jointly commission services in the area of operation (maintenance, energy cost billing, etc.)

Unfortunately, the Heat Pioneer Demo project has failed twice to secure government research funding. Consequently, most building owners have put their individual decarbonisation projects on hold. Nevertheless, the Klimadörfl association is still encouraging and informing the public about the potential of a community-wide decarbonisation initiative. Furthermore, the establishment of an energy community is now underway. However, this will only cover electricity and not heat.

e7, Realitylab and Reenag continue to support Klimadörfl's research activities and help them acquire new funding sources to sustain their efforts towards carbon neutrality in Kahlenbergerdorf.

„side“ projects:

Furthermore, initiatives have been undertaken to improve mobility, such as the provision of a free bicycle cargo trailer for rental and collaboration with local small-scale farming and gardening initiatives to facilitate a more coordinated delivery of vegetables. The potential for additional funding opportunities could enable the integration of topics related to mobility and nutrition into the vision for a decarbonised Kahlenbergerdorf.

Technical solutions and scenarios

In the first HeatPioneer Project described above - Several heat supply scenarios as pictured in Figure 7 have been developed and evaluated:

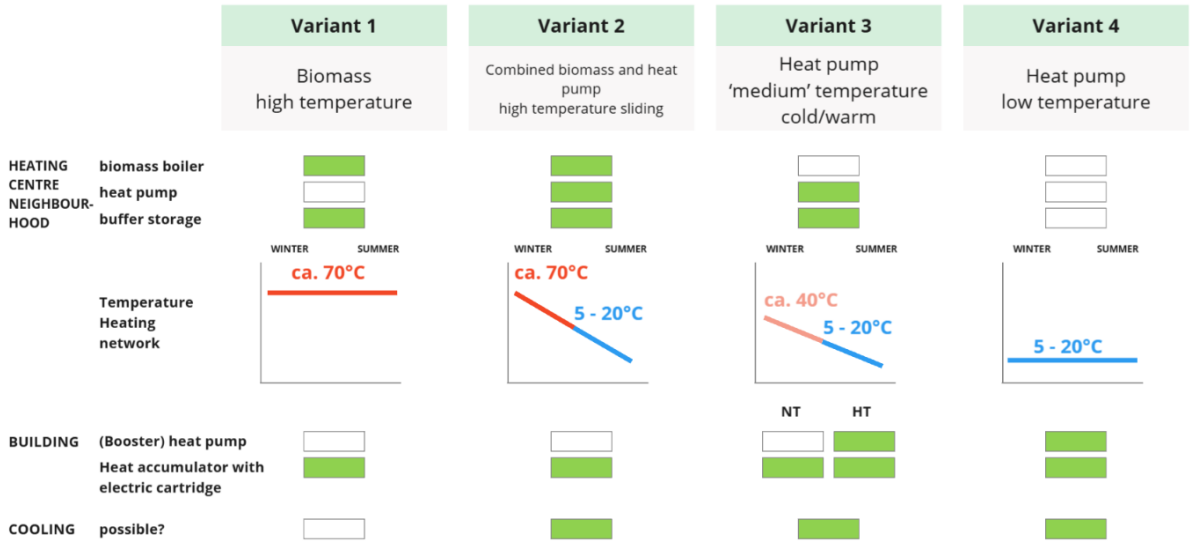


Figure 7: Overview of the technical solutions

1. **No change:** Current heat supply remains unchanged. To enable a comparison of the scenarios, this variant was included as business as usual, which is why maintenance, servicing and necessary reinvestment costs are considered in the cost analysis.
2. **Biomass district heating network**: Use of a central biomass boiler with buffer storage to provide high flow temperatures.
3. **High temperature heat pumps**: Combination of central biomass and central high-temperature heat pump. The network is supplied with high flow temperatures in winter and low flow temperatures in summer to enable heating and cooling. The buildings require their own heat storage tank with an electric cartridge to provide hot water in summer.
4. **High/low temperature heating network**: The 'medium' temperature heat supply in winter (approx. 40°C) is provided by a central heat pump. In summer, the flow temperature is lowered to enable cooling via the heating network. Heat at higher temperature levels for small radiators and hot water is provided by hot water storage tanks with electric cartridges.
5. **Anergy network**: The heat is transported from a geothermal probe field directly via the anergy network to the individual buildings, where each has its own heat pump that raises the heat to the required temperature level. In summer, the network can also be used as a heat sink for cooling, which also thermally regenerates the soil of the geothermal probe field.

The scenarios were assessed in terms of cost, technical feasibility and environmental impact. The construction costs in Figure 8 were divided according to the location where they occur into the following categories:

- **Heating plant:** Includes all technical components that connect the heat source to the heating network. Depending on the type of the network, separate heat generators may also be integrated here.
- **Geothermal energy**: Covers the construction costs for the geothermal probe field and the associated equipment.

- **Heat network:** Includes costs for laying pipes and the associated civil engineering work.
- **Buildings:** Covers components installed within the buildings that are necessary for the generation and distribution of heat.
- **Planning:** Includes expenses for the technical and organisational planning of the project.

construction costs	Option 0	Option 1	Option 2	Option 3	Option 4
Minimum	€ 0	€ 431 000	€ 389 000	€ 314 000	€ 97 000
Heating plant	€ 0	€ 479 000	€ 432 000	€ 349 000	€ 108 000
Maximum	€ 0	€ 527 000	€ 475 000	€ 384 000	€ 119 000
Minimum	€ 0	€ 0	€ 362 000	€ 428 000	€ 428 000
Geothermal energy	€ 0	€ 0	€ 402 000	€ 475 000	€ 475 000
Maximum	€ 0	€ 0	€ 442 000	€ 523 000	€ 523 000
Minimum	€ 0	€ 400 000	€ 400 000	€ 400 000	€ 400 000
Heat network	€ 0	€ 444 000	€ 444 000	€ 444 000	€ 444 000
Maximum	€ 0	€ 488 000	€ 488 000	€ 488 000	€ 488 000
Minimum	€ 2367 000	€ 733 000	€ 773 000	€ 1197 000	€ 1490 000
Buildings	€ 2630 000	€ 814 000	€ 859 000	€ 1330 000	€ 1655 000
Maximum	€ 2893 000	€ 895 000	€ 945 000	€ 1463 000	€ 1821 000
Planning	€ 95 000	€ 122 000	€ 150 000	€ 182 000	€ 188 000
Total	**€ 2725 000**	**€ 1859 000**	**€ 2287 000**	**€ 2780 000**	**€ 2870 000**

Figure 8: Overview of construction costs per variant

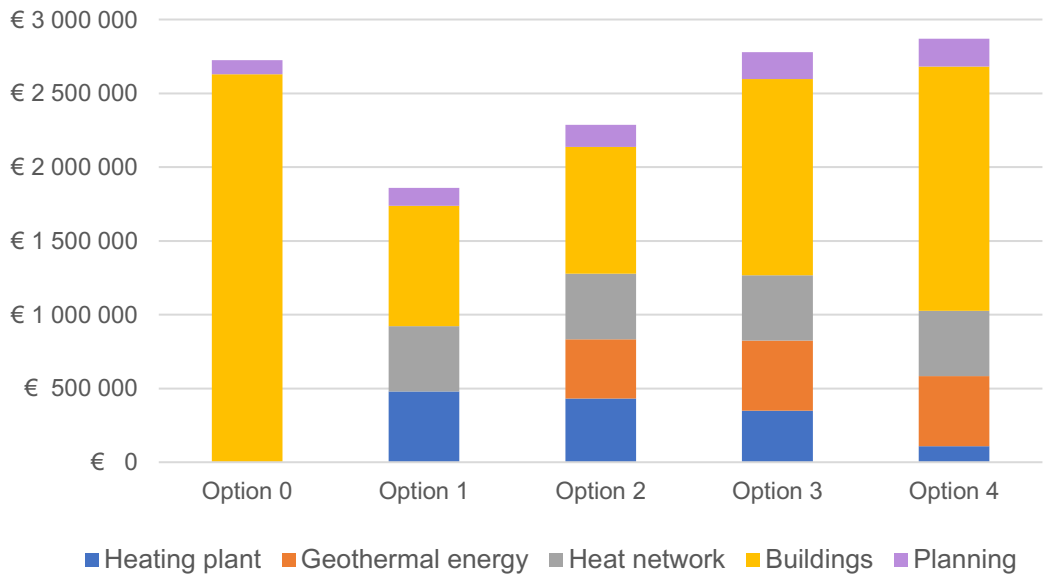


Figure 9: Proportion of total costs accounted for by each cost category per Variant

Annual operating costs	Option 0	Option 1	Option 2	Option 3	Option 4
Energy costs	€ 219 000	€ 189 000	€ 190 000	€ 81 000	€ 81 000
Maintenance, repair	€ 94 000	€ 26 000	€ 24 000	€ 37 000	€ 51 000
Total	**€ 313 000**	**€ 215 000**	**€ 214 000**	**€ 118 000**	**€ 132 000**

Figure 10: Annual operating costs. Assumptions: Gas 10 cents/kWh; biomass 6.6 cents/kWh; electricity 18 cents/kWh

Option 3 (high/low temperature heating network) proved to be the most cost-effective solution, while option 4 (anergy network) is also economically and environmentally advantageous, but would have the highest individual cost impact due to the renovation work required in each building connected to the network.

5.4. Replicability: challenges encountered

The main barriers to renovation are the considerable financial outlay require. A significant proportion of residents are not in a position to finance the necessary structural and technical work. The cost of renovating the buildings in order to make a local energy network feasible varies greatly from building to building. Here, a group effort could be to hire a single contractor to carry out the work and thus achieve a higher level of cost efficiency thanks to synergies in terms of labour and materials. (as described above as “Join Decarbonisation Management”

From an economic point of view, it does not make sense to install a common heating network in the centre of Kahlenbergerdorf. It is more cost-effective to implement solutions in individual buildings or in the vicinity of buildings that are very close to each other. In addition, the legal framework and monument protection requirements pose additional challenges.

A potential replicability for a local heating network might be feasible if there weren't so many obstacles related to monument protection or presented by the owners of the individual buildings. However, organising local retrofitting efforts together could always be potentially more cost effective, even if it is challenging in terms of potential neighbourhood disputes.

In order to deal with the extremely heterogeneous structure of users and owners of the properties in Kahlenbergerdorf, this voluntary association provides the necessary framework for building the structures of a local community capable of making decisions. The association provides the opportunity to work together as a neighbourhood, to hold meetings, to make fundamental decisions and to gain knowledge about the possibilities and interests of the neighbours. The association plays a central role in activating residents and also fulfils an important educational role by disseminating relevant knowledge.

5.5. Assessment and Issues

The decision not to proceed with the planned district heating network marks the end of a promising approach. Coordinated decarbonisation will continue, but now at the level of individual buildings, as the Heat-Energy Community could play a central role in coordinating and supporting the decarbonisation process. Therefore, a new Joint Decarbonisation Management (JDM) system will be developed, including technical analysis, planning and implementation of measures, and support for

building owners in their efforts to adopt their buildings where necessary. (for more info on JDM see above section “Ongoing and/or planned projects”)

5.6. Results and conclusions

A Heat Energy Community is being established as the central organisation for decarbonisation. Shared decarbonisation will now continue at individual building level, with cross-building solutions being considered where appropriate. Technical and organisational support from external experts remains an important part of the process. Decarbonisation will be implemented gradually, starting with the most motivated building owners.

5.7. Outlook

The Concept of Energy Community will continue to play a central role in coordinating and supporting decarbonisation measures. The concept of a joint decarbonisation management (JDM) as describe above is ready to be implemented as soon as the necessary funding will be made available by the City of Vienna and/or the Federal Government of Austria.

Both are currently struggling with heavily deficit budgets. Austria is threatened with deficit proceedings by the EU Commission and is forced to cut spending. The previous government had distributed generous subsidies for refurbishment and decarbonisation. In the current federal budget for the years 2025 and 2026, these subsidies have been drastically reduced, although the EU climate targets to which Austria has also committed itself would require decisive and swift action. Experts believe that the targets will have to be achieved less through financial incentives and more through legal regulations and standards. This means that the residents of Kahlenbergerdorf could sooner or later be forced by legislation - which will stipulate binding dates for phasing out oil and gas - to carry out refurbishment measures and change their heating systems. By then at the latest, the concepts developed so far by Klimadörfl, e7 and realitylab will have to be reactivated and implemented.

6. San Paolo (Bari)

San Paolo, a neighbourhood in the city of Bari, tells a tale of transformation and resilience. Originally developed in the mid-20th century to address housing shortages, it was marked by rapid urbanization but limited resources, leaving many residents to contend with inadequate infrastructure and social challenges. Over the years, San Paolo has evolved into a residential district, characterized by its public housing blocks and a vibrant, tight-knit community. Its streets echo with the stories of working families, immigrants, and long-time residents who call this place home.

The neighbourhood's journey of regeneration is as inspiring as it is complex. Projects aimed at revitalizing San Paolo have blended art, culture, and community engagement. One notable initiative involved using street art to breathe new life into forgotten corners, creating murals that became symbols of pride and identity. These colourful expressions have not just beautify the area; they brought neighbours together, fostering a sense of shared purpose.

Architectural efforts have also played a role, with renewed public spaces designed to encourage interaction and inclusivity. These projects have faced their share of difficulties, breaking through decades of neglect and scepticism was not easy. Yet, through persistence, the neighbourhood has seen glimpses of success: vibrant public areas, a growing sense of belonging among residents, and increased visibility for San Paolo's potential as a sustainable urban hub.

The road to transforming San Paolo into a Positive Energy District (PED) is paved with both lessons and hope. Efforts around renewable energy, smarter infrastructure, and community-cantered planning are gaining traction, though challenges like funding and consistent resident involvement remain. The neighbourhood's story is a testament to the power of collaboration, the resilience of its people, and the belief that even the most overlooked places can become models of innovation and community spirit.

6.1. Recent history, description and context

San Paolo is a neighbourhood of approximately 30,000 residents located on the outskirts of Bari. The community is relatively young, with a significant portion of the population under 40 years old. Specifically, there are 1,351 children aged 0-4, 1,650 aged 5-9, 1,760 aged 10-14, and 1,780 aged 15-19. The working-age population (15 years and older) comprises 10,336 individuals, of whom 7,973 are employed, resulting in an employment rate of approximately 77%. However, 1,200 individuals are unemployed and actively seeking employment, indicating an unemployment rate of about 11.6%.

San Polo shows a mix of problems resulting from physical degradation, low accessibility, socio-economic marginalization. In the last decade, it has been targeted by several rehabilitation projects, focused on either urban design, slow mobility or cultural revitalization.

The residential character of San Paolo is complemented by a strong sense of community among its inhabitants. The population is notably diverse, encompassing families who have lived in the area for generations alongside more recent arrivals, including immigrants seeking opportunities in Bari.

The demographic profile skews younger compared to other parts of the city, with a large number of children and young adults living in the area. However, the elderly also form a significant portion of the community, many of whom have deep ties to San Paolo's history and culture.

Economically, the neighbourhood reflects its working-class roots, with incomes often below the city average. Many residents work in service industries, local trades, or commute to the city centre for employment. While unemployment is a concern, there is also a growing entrepreneurial spirit, with small businesses and initiatives emerging to revitalize the local economy.

San Paolo's connection to the broader city of Bari is facilitated by a combination of public and private transportation. Public buses provide essential links to the city centre and surrounding districts, yet many residents rely heavily on personal vehicles, contributing to congestion, noise, and pollution. This car dependency highlights a critical challenge in San Paolo's urban planning. The narrow streets, designed decades ago, are ill-equipped to handle modern traffic volumes. Efforts are underway to improve mobility through sustainable transport options, including better public transit and proposals to create pedestrian-friendly zones.

The neighbourhood consists of public housing and housing cooperatives. Below is a map excerpt of the relevant target area:

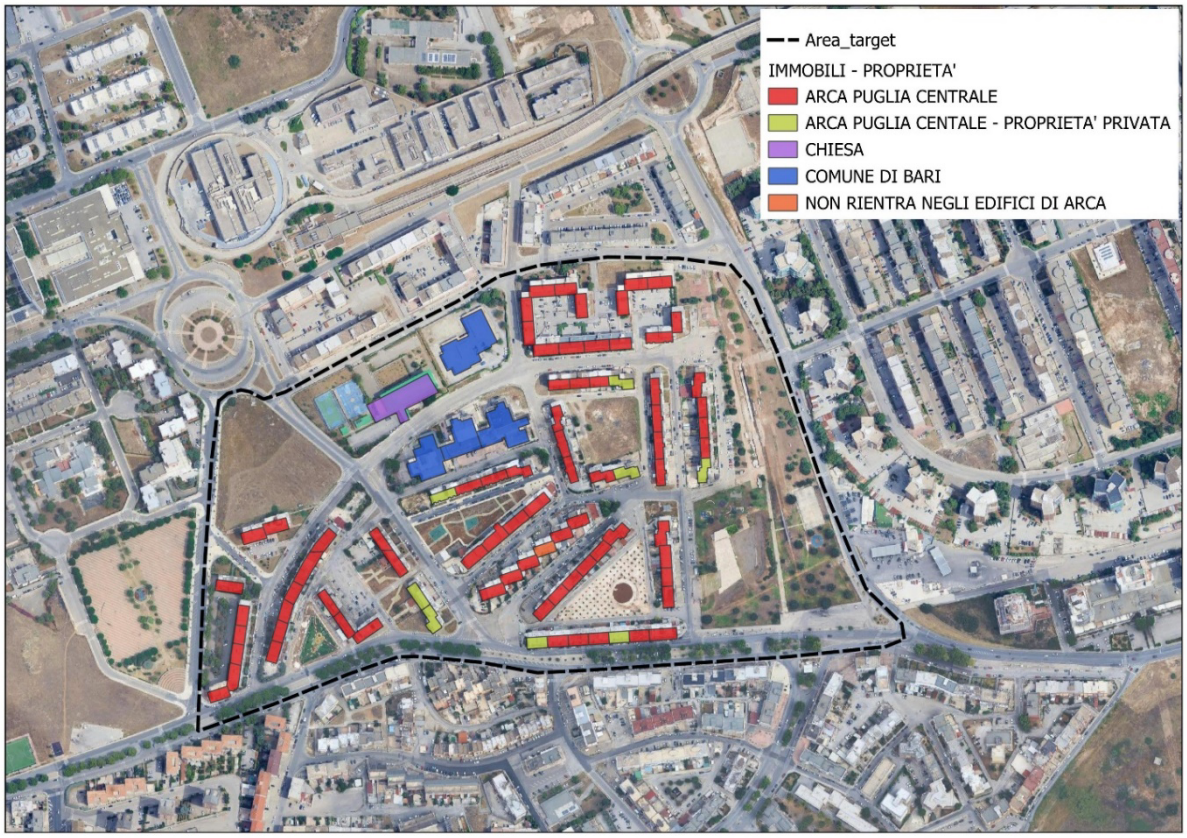
The target area is home to approximately 2,000 residents and consists of public housing and a few multi-purpose buildings. Specifically, the target area includes:

- 84 residential buildings, of which:
    - 75 are owned by ARCA Puglia Centrale;
    - 9 are ARCA Puglia Centrale buildings containing apartments purchased by private owners.
- 1 church (Church of San Giovanni Bosco);
- 1 multi-purpose building that hosts three different associations:
    - Casa delle Culture,
    - InContra,
    - ALA Azzurra;
- 1 building that houses CAPS (Therapeutic Community “Tonio Signorile”).

Within this area, the properties can be classified based on ownership:

- red (exclusively owned by ARCA Puglia Centrale),
- orange (owned by the Municipality of Bari),

- green (mixed ownership between ARCA Puglia Centrale and private individuals following the purchase of some apartments).



Key challenges for PED transition include the involvement of the low-income community and the link to broader urban strategies for urban regeneration and just energy transitions.

The target area under study, like the vast majority of housing within the San Paolo neighbourhood, features a widespread and standardized housing typology that follows the model of Public Housing (Case di Edilizia Popolare). Most of the buildings were constructed between the late 1960s and the 1970s. These residences were originally intended to meet the housing and economic needs of working-class populations, within a newly designed urban context that included public spaces and services. The characteristics of the housing in the target area are largely similar: modular block buildings with 3 to 5 floors, medium-small in size, generally between 60 and 80 square meters. The modular structures were designed to be quick to build and, above all, cost-effective.

Over time, signs of physical and social decay have emerged, making redevelopment interventions necessary in order to meet modern energy standards and the evolving needs of their residents.

In San Paolo's neighbourhood there are buildings subject to specific urban planning regulations (PIRU – Integrated Urban Regeneration Plans and/or Zoning Plans) that may influence the feasibility of interventions such as external thermal insulation.

Moreover, in San Paolo, it is quite common to find split air-to-water heat pumps used exclusively for cooling, alongside gas boilers for heating. Not all homes are equipped with air conditioning.

Generally, in the City of Bari, and hence in San Paolo neighbourhood, cooling in summer is more expensive than heating in winter, especially for those using electric air conditioners. It is worth noting that summers have become long, very hot, and humid, extending from June to September, with temperatures often exceeding 30–35°C and high humidity levels, which significantly increase discomfort.

Moreover, Solar water heaters are not used in San Paolo.

In the target area, photovoltaic panels have not yet been installed. However, there are several incentives available for installation, listed below:

- National Energy Income Scheme: At the national level, a contribution of up to €11,000 is available for the installation of 6 kW photovoltaic systems, for certain income brackets.
- Regional Energy Income Scheme: This is an initiative by the Puglia Region aimed at supporting families in socio-economic hardship with the installation of photovoltaic systems for self-consumption, thereby helping to reduce energy bills and promote clean energy.
- 50% Renovation Bonus: In this case, there are no income limits for eligibility.

As far as initiatives and projects undertaken in San Paolo regarding energy, not much has been done in the residential sector. ARCA, that is responsible for managing public housing in the target area, facing a dramatic financial situation (connected to a high rate of tenant arrears and a significant number of evictions) which does not enable any energy rnovations on the houses.

However, the Three-Year Public Works Plan provided by the Municipality shows:

- Redevelopment and Energy Efficiency Works at the San Paolo Market on Viale Lazio – €600,000.00;
- other interventions concern the redevelopment of areas or are strictly public works projects.

As far as building renovation projects, instead, which are currently underway, the only building renovation project provided by the Municipality, is the 'Casa delle Culture' on Via Barisano da Trani, currently nearing completion and managed with PNRR funding. The project is titled:

- Mission 5 'Inclusion and Cohesion', Component 2 'Social infrastructure, families, communities, and the third sector', Subcomponent 1 'Social services, disability, and social marginalization', Investment 1.3 – Temporary housing and reception centres, funded by the European Union – Next Generation EU. Project code PN22020_Framework agreement concerning the 'Energy refurbishment of the building envelope and redevelopment of external areas of the Multifunctional Centre – Casa delle Culture', with a total budget of €910,000.00 and a duration of 2 years."

Amongst the funds for renovation works, it is possible to mention the municipal funds:

- PON METRO 2014–2020, now PON METRO 2021–2027
- PNRR across its various missions
- PNRR – 'Safe, Green and Social' Program: The Municipality of Bari has obtained over €24 million for the redevelopment of 623 public housing units (ERP) in the neighbourhoods of San Paolo, Santa Rita, and Torre a Mare. The interventions include energy efficiency improvements, boiler replacements, thermal insulation, renovation of roof terraces, and verification of the seismic safety of the buildings.
- POC Funds for metropolitan cities
- CDP (Cassa Depositi e Prestiti)

- Conto Termico 2.0: Incentivizes the replacement of outdated heating systems with more efficient solutions such as condensing boilers, heat pumps, and photovoltaic systems.

6.2. Actors

The transformation of San Paolo into a Positive Energy District (PED) has required the development and implementation of a community that involves a diverse set of actors, each playing a crucial role in shaping the neighbourhood's transformation and its energy and social revitalization.

These include local authorities, energy providers, community enterprises, and residents, whose interactions have been analysed by using the Actor Linkage Matrix (ALM) and Social Network Analysis (SNA) as explained in D5.1. The Stakeholder analysis, which has mapped interactions, highlighting degrees of cooperation or conflict, and the SNA, used to measure and enhance the web of connections among stakeholders, have reflected the importance of sharing resources, building collective capabilities, and fostering mutual engagement.

The Citizens4PED project in San Paolo has adopted a stakeholder-centric approach to foster equitable local energy transition partnerships. Key participants include local government entities, from local institutions to business actors, from academic institutions to non-profit and voluntary organizations, from energy providers to residents organized in newly formed associations.

Local authorities are key facilitators, often serving as intermediaries between funding sources and community-led projects. They have received public funding for urban renewal and energy efficiency improvements, focusing on creating sustainable public spaces and supporting community initiatives.

- **Municipality of Bari** and **San Paolo Municipal District (Municipio III)**: These bodies provide administrative and financial resources. They manage public spaces and buildings in the target area, ensuring that urban development aligns with sustainability and social inclusion goals. Their strong relational capabilities and high engagement make them key facilitators and funders for PED projects.
- **Apulia Region**: As a regional government, it coordinates larger-scale initiatives, offering financial and regulatory support. Its focus includes energy efficiency, decarbonization, and social inclusion, making it a strategic partner with medium engagement.

Social Housing and Building Management

- **ARCA Puglia Centrale**: This social housing management agency oversees most residential buildings in the target area, making it a pivotal actor. Its resources include administrative capacity and physical assets such as rooftops, suitable for renewable energy installations. ARCA is deeply involved in the PED initiatives as a funder, facilitator, and prosumer.
- **Building Managers**: Representing residential condominiums, these administrators handle maintenance and community engagement at a lower level, with limited influence or engagement in PED initiatives.

Energy and Utility Companies, while less directly engaged with residents, offer critical technical expertise and allocate resources for energy-related projects.

- **AMGAS SpA** and **Retegas Bari**: These utility companies manage natural gas distribution and energy services, providing critical infrastructure for PED goals. While they operate with high financial and technical resources, their engagement levels remain low, requiring strategic alignment with community-driven efforts.

Energy Providers and ESCOs

- **Enel and ESCOs**: These energy service companies bring technical expertise and financial capacity to PED development. However, their engagement is contingent on economic incentives and project feasibility.

Schools and Educational Institutions
Public and private schools, such as I.C. "Grimaldi-Lombardi" and I.C. "Don L. Milani", play dual roles as community builders and infrastructure providers. These institutions participate in environmental education initiatives and provide rooftops for potential solar energy projects. Their medium engagement reflects a growing but not yet fully developed involvement in energy transition projects.

Non-profit Organizations and Community Actors

- **Casa delle Culture**: This multipurpose center acts as a community hub for cultural and social initiatives. It offers large rooftops for potential solar energy installations and builds strong ties with the community through intercultural projects. Its high capabilities and medium engagement make it a facilitator and coalition partner in PED efforts.
- **InConTra Association** and **Tracce Verdi Cooperative**: These organizations focus on social inclusion and environmental education, respectively. Their community trust and potential access to public rooftops position them as facilitators with medium engagement levels.

Healthcare Providers

- **San Paolo Hospital** and **ASL Casa della Salute**: These public health facilities have extensive physical resources but lower engagement in PED activities. Their potential lies in aligning health services with sustainable energy practices.

Residents and Local Businesses.
Residents, as primary stakeholders, actively participate in these projects, both as contributors and beneficiaries. Approximately 30% of the neighbourhood is engaged in a newly formed residents' association that seeks to advocate for local needs, protect cultural identity, and ensure that projects remain resident-focused. Their contributions include co-organizing cultural festivals, street art initiatives, and community clean-up events, which strengthen communal ties and a sense of ownership.

- **Residents**: Approximately 2,184 individuals live in the target area, forming a critical base for energy-saving initiatives. Their high level of engagement stems from the direct benefits they seek in reduced energy costs and improved living conditions.
- **Retailers and SMEs**: Local businesses like restaurants and supermarkets are significant community connectors. Their medium engagement and resource potential hinge on the economic returns from energy efficiency measures.

Churches and Religious Institutions

- **Parish of Don Bosco**: As a trusted community institution with extensive facilities, the parish serves as a prosumer and local development partner. Its involvement in social and educational projects aligns with PED objectives.

Community enterprises represent local businesses and cooperatives that align their economic activities with the neighbourhood's goals, such as creating local employment opportunities and fostering social cohesion. These enterprises have spearheaded initiatives funded by regional and EU grants, including cultural and environmental projects that resonate with the community's needs.

This networked approach underscores the dynamic and multifaceted roles of San Paolo's stakeholders, paving the way for a more sustainable and equitable urban future.

The collaborative potential of diverse stakeholders has been expressed in other projects of San Paolo's urban renewal that have planned few years ago and are still ongoing. Amongst those, it worth to mention the following:

- The **Periphery Plan for the San Paolo Neighbourhood** focuses on urban regeneration, aiming to improve public and open spaces through better infrastructure, accessibility, and public transport. By enhancing slow mobility and redeveloping the areas between buildings as collective spaces, the plan seeks to foster community interaction and create a more connected neighbourhood under the broader "Patto con i Municipi" initiative.
- **Rigenerazioni Creative** is a participatory project that engages citizens in the regeneration of public spaces, emphasizing inclusivity and collaboration. The initiative includes the **Verde Incontro (Meeting Green)** project, which planted 400 trees and shrubs, involved local schools and day care centers in environmental education activities, and built accessible vegetable gardens for differently-abled participants, enhancing both biodiversity and community ties.
- The **Renzo Piano G124 project for Corte Don Bosco** focuses on transforming the courtyard into a green public space that acts as a social hub for residents. Featuring a garden with 110 trees, a central clearing for gatherings, and sustainable infrastructure, the project integrates nearby Giovanni Paolo II Park and urban murals to strengthen the neighbourhood's cultural and environmental identity.
- **QM - Quartiere Museo San Paolo** leverages urban art for regeneration by commissioning 10 murals created by Apulian, national, and international artists. The project involves the local community in shaping the artworks and aims to enhance the neighbourhood's aesthetic appeal and sense of belonging, supported by collaboration with Fondazione Mecenate 90, the Apulia Region, and Arca Puglia Centrale.

These projects not only have emphasised the importance of aligning technical solutions with social and environmental objectives but they have demonstrated that San Paolo's progress has occurred mostly because of practices of community engagement that have laid the groundwork for further efforts towards urban transformation initiatives, including energy-efficient building retrofits, renewable energy installations, and social inclusion programs.

As far as Citizens4PED project, the proportion of residents involved in the newly formed association is steadily growing, signaling a shift towards grassroots activism and local ownership of the PED transformation. This inclusivity is vital for the project's long-term success, as it fosters a sense of shared responsibility and commitment.

6.3. Ongoing and/or planned projects

San Paolo in Bari is undergoing a significant urban transformation as it moves also toward becoming a climate-neutral and sustainable urban area.

In this neighbourhood, several urban regeneration initiatives are ongoing, which also include some measures for energy efficiency and sustainable energy uses. Among them, it is worth mentioning the Periferie programme, which was funded under a national programme for urban regeneration in 2015 and is currently in the implementation phase. Among the actions funded under this programme it is possible to find the greening of several public spaces and streets, which would contribute to reduce the urban heat island effect and have a positive impact on energy consumption for cooling within residential units and public buildings. As a follow-up of this programme, a project for the greening of

a large square in the target area has been recently approved and is currently under implementation. The project will develop what has been names a 'climate refugee' in that square, as a place where the effect of the urban heat island will be reduced and where the local community can gather in the hot summer days to reduce indoor cooling needs while strengthening community links. A massive change in the technology for public street lighting is also currently ongoing in the San Paolo as well as in other districts of the city of Bari.

In Italy, the "Superbonus 110%" program (2020–2023) offered significant incentives for energy efficiency renovations, allowing a 110% tax deduction for interventions like thermal insulation, solar panels, and efficient heating systems, with the option to transfer deductions to contractors. In the target area, ARCA Puglia Centrale sought to leverage this incentive for renovating its buildings in 2021, but the program ended before work could begin, resulting in a missed opportunity for advancing Positive Energy District (PED) goals. No residential units have undergone renovations to date, though energy efficiency upgrades are now starting at the "Casa delle Culture" public building.

In line with the above, there is certainly the development of an integral energy concept designed to address the district's heating, cooling, and power needs through environmentally friendly and efficient solutions that is in line with Citizens4PED project.

This ambitious vision is not confined to a single initiative but encompasses a series of interconnected projects aimed at reshaping the district's energy and environmental landscape not merely by bringing in innovative approaches to de-carbonization but by fostering community involvement. The latter is necessary since it implies a series of solutions that replace conventional, carbon-intensive energy sources that go beyond the technical measures, while emphasizing active participation from the community. By doing this, local residents are not just passive recipients but active contributors to the transformation. This participatory approach is designed to build trust, secure public acceptance, and ensure the long-term success of the district's climate-neutral goals.

Funding for Positive Energy Districts (PEDs) in Bari is expected to align with the regional approach that has been used for urban regeneration. Puglia has historically relied on European Structural Funds, starting from the 2007–2013 funding period. Currently, Bari's financial resources come from the National Plan for Recovery and Resilience (PNRR), supported by Next Generation EU funds, the Complementary National Programme, the National Operational Programme Metro Plus (focused on metro and medium-sized cities in Southern Italy), and the ERDF-ESF Regional Operational Programme for 2021–2027. PEDs are anticipated to follow this funding trend. Therefore, San Paolo will benefit from a mix of financial and technical support to bring these ambitious projects to life.

Funding streams will include regional and national grants, often aligned with broader European Union incentives for Positive Energy Districts (PEDs). These financial mechanisms are crucial for offsetting the costs associated with deploying advanced energy systems and retrofitting older infrastructure.

Local associations, non-profits, and small businesses working on renewable energy projects often receive direct financial support, helping to catalyze action on the ground.

A pivotal actor in these initiatives is the Polytechnic of Bari, whose role has been instrumental, for a decade now, in fostering collaboration and driving projects carried out by university students forward. It has acted as a bridge between technical experts, local authorities, and the community, facilitating participatory processes in university and research students' thesis and dissertations.

Their work includes organizing workshops, mediating discussions, and providing technical expertise to co-create project goals and strategies.

This collaborative approach has been particularly vital in addressing the complexities of urban regeneration and not, it is particularly useful to conduct activities regarding the Citizens4PED project.

Despite these efforts, some technical challenges may emerge and may be critical for the implementation of the projects whereas aligning local policies with national and European standards takes time.

The projects unfolding in San Paolo at the moment and those that will develop regarding PED represent a bold vision for the future of urban sustainability since they will not only putting in place cutting-edge technologies but also transform the way energy is conceived, managed, and consumed at a neighbourhood level.

Thanks to Citizens4PED project and by combining technical innovation with grassroots participation, San Paolo is setting a precedent for how urban areas can transition to climate neutrality while addressing social equity and fostering a strong sense of community ownership

6.4. Replicability: challenges encountered

The energy transition in San Paolo faces multiple interconnected challenges, from socioeconomic barriers and financial constraints to regulatory complexities and market dynamics. Addressing these challenges requires a multifaceted approach, combining robust financial support, community engagement, skill development, and infrastructure innovation.

6.4.1. Socioeconomic Disparities

The energy transition presents significant challenges for low-income and marginalized populations, who face systemic barriers to accessing affordable and reliable energy. Poorly maintained and energy-inefficient facilities in low-income neighbourhoods exacerbate these disparities. Without targeted policy measures, energy transitions risk deepening inequalities, as benefits might disproportionately favour wealthier populations. Rising energy costs further marginalize vulnerable groups, potentially excluding them from efficient energy solutions while imposing indirect costs, thereby hindering equitable socioeconomic development. Community-led energy transition initiatives can help address these imbalances by empowering local stakeholders and fostering cooperation. Such approaches counteract power asymmetries and the commodification of energy, while also creating opportunities for local socioeconomic development. These initiatives enhance energy security, combat energy poverty, and contribute to ensuring vulnerable groups' right to energy.

6.4.2. Financial Support and Subsidies

To address these disparities, Italy has implemented measures such as the "Social Bonus," providing financial relief for electricity and gas bills to low-income households.

In Italy, some policy measures have been taken to contrast energy poverty and to secure a sufficient access to energy for basic needs from vulnerable groups. The main one is the Social Bonus (Social Bonus for Energy and Social Bonus for Gas). These measures are specifically designed to reduce energy and gas bills for low-income households. Eligible families can receive a discount on their electricity and gas bills based on their income and household composition. Statistics from ARERA

show that in 2023 7,6 million household received social bonuses for electricity and gas, with an estimated amount of more than 2.4 Billion Eur.

Given the socio-economic conditions of the household living in the San Paolo area – the residential units are for the largest majority public houses assigned to households on the basis of socio-economic vulnerability, while only a few of them has been redeemed by previous tenants – it is likely that almost all residents receive those bonuses.

In the San Paolo neighbourhood, where most residents live in public housing assigned based on socioeconomic vulnerability, these subsidies are critical. Additionally, special tariffs for vulnerable populations shield them from market fluctuations. Despite these measures, there remain opportunities to enhance financial support mechanisms and improve accessibility.

Awareness, Education, and Market Complexity

Energy market liberalization has introduced a variety of tariffs and contracts, which are often difficult for consumers to navigate. Vulnerable groups face additional challenges due to limited awareness and literacy regarding energy options. Initiatives like the “Centro Assistenza Bollette” (CAB) in San Paolo play a vital role in guiding families through these complexities, helping them select suitable tariffs and better understand energy contracts. These services are complemented by educational campaigns and training to empower consumers and promote energy-saving practices.

6.4.3. Innovation and Skills Development

The transition to a modern energy system necessitates specialized skills, creating opportunities for employment in energy production, management, and installation. In San Paolo, educational initiatives such as the three-year “electric operator” training program for young residents address both skill shortages and local unemployment. Funded by regional programs, these initiatives foster economic resilience while supporting the energy transition.

6.4.4. Infrastructure and Policy Framework.

Innovations in energy infrastructure in Bari align with national and EU-level policies. Investments in renewable energy, supported by feed-in tariffs, net metering, and funding from regional programs, aim to increase local renewable capacity. However, market concentration among a few dominant players in distribution and production poses challenges to competition and equity. Additionally, regulatory uncertainties and zoning restrictions hinder large-scale renewable installations.

6.4.5. Need for Local Coordination and Self-Initiative

Policies promoting prosumerism and Renewable Energy Communities (RECs) rely on active local engagement and coordination among community members, local authorities, and private stakeholders. These programs not only empower communities but also address energy poverty by enabling shared energy production and consumption. Hence, these require strong local leadership and organizational capacity, which may not be readily available in other regions. Scaling these models to areas with weaker institutional frameworks or less engaged communities could be challenging.

6.4.6. Dependency on Large-Scale Infrastructure

Bari's energy system innovations heavily depend on large-scale infrastructure projects driven by national Transmission System Operators (TSOs) and substantial public investments, such as those outlined in the National Transmission Network Development Plan. These projects, including high-voltage lines and grid enhancements, require significant financial resources and long timelines, posing challenges for replication in regions lacking similar access to funding or established TSOs.

6.4.7. Regulatory and Design Challenges

The dynamic regulatory landscape, characterized by frequent amendments to subsidy schemes and zoning laws, creates uncertainties for renewable energy projects. Design criteria outlined in regional plans must balance socioecological processes and heritage considerations, adding complexity to project implementation. Clearer guidelines and consistent policies are needed to streamline the transition.

7. Conclusions and recommendations

The four living labs present diverse local contexts. In Vienna, the Kahlenbergerdorf neighbourhood is a relatively affluent area with some houses dating back to the 16th century. The La Roue district in Brussels is a garden city from the early 20th century. Originally designed as social housing, a large number of units have since been sold to individual residents. The neighbourhood is currently poorer than the Brussels average. Always in Brussels, Usquare is located on the site of a former gendarmerie barracks, which belongs to a public body. In the future, it will house a university hub, student accommodation, social housing, an autism resource centre, a food hall and extensive public spaces. The San Paolo neighbourhood in Bari was built in the mid-20th century. It consists of public housing buildings inhabited by low-income households.

Only Usquare, which is publicly owned and has benefited from significant financial resources, has undergone major renovation. To reduce energy consumption, three types of renovation strategies have been applied: light renovations, renovations equivalent to new construction, and the erection of several new buildings that comply with the most recent standards. Solar panels are to be installed on the roofs of several buildings. A site-wide heating network has been created. This heating network will be powered by a large CO_2 water-to-water heat pump for heating and cooling, combined with geothermal probes. Ultimately, the Usquare site is expected to consume relatively little energy, with a significant share coming from decarbonised sources.

In La Roue, the group renovation initiative has yielded rather modest results. Despite considerable efforts in awareness-raising and community mobilization, only 8 households (out of approximately 450 privately owned single-family homes) committed to participating in the first group renovation. Among the main reasons for this low participation rate are the limited financial means of residents and a poor cost-benefit ratio: renovation costs are likely to significantly exceed the expected energy savings. Inclusive financing of renovations is not feasible, as energy renovation remains largely inaccessible to households without sufficient financial resources. As a result, the project only engaged a handful of relatively affluent homeowners—those who could afford the investment and were motivated by environmental concerns.

At a later stage, an opportunity arose to benefit from ERDF (European Regional Development Fund) support, allowing highly subsidized renovation work. The potential for significant property value increases and energy savings through public funding was more appealing. Nevertheless, even under such favourable conditions, only 36 households committed to the group renovation project.

In Kahlenbergerdorf, the local association Klimadörfl has taken part in, and continues to participate in, several research projects focused on developing decarbonised heating and cooling solutions in conjunction with building refurbishment. However, none of these funded projects have contributed financially to the implementation of actual construction work.

In San Paolo, the decarbonisation initiative is at a much earlier stage, making it difficult to draw conclusions. Although the area has strong solar potential, no solar panels have yet been installed due to lack of financial resources. The only building renovation carried out by the municipality is the House of Cultures (Casa delle Culture). To date, no residential buildings have been renovated.

Despite the different contexts of the four living labs, common patterns and shared challenges emerge. Across the case studies, financial barriers repeatedly emerged as a major constraint.

In both Kahlenbergerdorf and La Roue, heritage conservation regulations are a major obstacle to housing renovation (as they often require internal insulation) and to the installation of solar panels on the street side. In Kahlenbergerdorf, solar potential is further limited by its location in a valley.

In Kahlenbergerdorf, a district heating network was deemed unfeasible due to both economic and technical reasons. Similarly, in La Roue, the extension of the heating network from the nearby CERIA campus to the neighbourhood appears unlikely due to a lack of interested users willing to connect.

In both La Roue and Kahlenbergerdorf, local associations are attempting to organize group renovations in order to lower costs and support homeowners in undertaking energy-efficient retrofits. However, in La Roue, the group renovation initiative has so far yielded limited results. In addition to regulatory and financial barriers, the expected economies of scale from group renovations appear limited.

Consequently, even in environments with highly motivated actors—such as La Roue or Kahlenbergerdorf—the cost of decarbonisation is such that it cannot be achieved solely through voluntary and incentive-based measures, even when substantial subsidies are offered to property owners. On this basis, it is unrealistic to expect the large-scale renovation of entire cities, as financial constraints, shortages of materials, and lack of skilled labour remain insurmountable obstacles.

A paradigm shift is therefore needed: subsidies should be redirected where their impact is greatest—toward the worst-performing housing, which is often rented by low-income tenants—with safeguards such as rent caps or resale restrictions to prevent speculative gains from public investment. These dwellings offer the highest potential for energy savings.

Currently, in Brussels, the opposite is observed: renovation subsidies tend to benefit homeowners — typically the most affluent and best-housed segment of the population. As a result, renovation subsidies are exacerbating housing inequalities.

In Brussels, we have also identified that certain heating regulations—such as boiler sizing requirements—are inappropriate, as they mandate the installation of oversized and more expensive systems. Similarly, certain renovation standards, such as the obligation to install centralized mechanical ventilation systems during major renovation works, discourage some homeowners from undertaking energy retrofits.

To conclude, it is evident that if we are to meet our carbon reduction goals, we must change our heating habits (sufficiency) and consume less energy overall.

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