LOCATEE

LOCAL AUTHORITIES TACKLING ENERGY POVERTY
IN PRIVATE MULTI-APARTMENT BUILDINGS

Varieties of domestic energy deprivation in private multi-apartment buildings. Insights from Poland, Portugal and Greece.

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About LOCATEE

LOCATEE aims to support local municipalities in addressing energy poverty through the renovation of private multi-apartment buildings for vulnerable residents. LOCATEE will achieve this goal by providing a toolkit for identifying energy-vulnerable households, matching tailored interventions to their needs, and integrating energy poverty alleviation activities into long-term strategies of municipalities such as Sustainable Energy and Climate Action Plans. LOCATEE will use administrative data to create household and building typologies to identify priority intervention locations. This process will help authorities and social partners address local energy poverty through coordinated solutions, including contact points and focus groups with housing entities, to facilitate knowledge exchange on renovation programs and targeted solutions. The evidence based and collaborative approach will be implemented in three pilot municipalities in Central, Southern and Southeastern Europe: Piraeus (Greece), Rumia (Poland), and Torres Vedras (Portugal) and, while ensuring scaling up the LOCATEE framework to more municipalities and regions across Europe.

WHO WE ARE

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5	Gmina Miejska Rumia	COR	PL	
6	Municipality of Piraeus	MOP	EL	
7	Municipio De Torres Vedras	COTV	PT	
8	Austrian Energy Agency	AEA	AT	
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Executive Summary

This report presents a framework for measuring local exposure to energy poverty in municipalities and tests it using administrative data from different national contexts. It responds to a clear gap: local authorities often lack the tools to identify which neighbourhoods or buildings – and which residents within them – face the highest risk of energy deprivation. The report, as well as the wider LOCATEE project, focuses on private multi-apartment buildings, where collective decision-making, market failures, and institutional constraints frequently complicate renovation efforts.

The report introduces micro-level indicators derived from administrative data as proxies for energy poverty. It combines them with a microsimulation model that integrates Household Budget Survey data at the building or small-area level. This approach is tested in three municipalities: Rumia (Poland), Torres Vedras (Portugal), and Piraeus (Greece), each characterised by different climates, housing conditions, and ownership patterns. These contrasting contexts demonstrate the flexibility of the methodology, while also revealing the limitations posed by uneven data availability. Building-level analysis is possible in Poland, whereas only aggregated spatial units (neighbourhoods, parishes, postal codes) are available in Portugal and Greece, reducing the resolution of the assessment.

Across the three cases, similar patterns emerge. Certain types of multi-apartment buildings consistently exhibit higher exposure to energy poverty, although vulnerability is also influenced by geography, socio-demographic composition, and structural factors. Municipalities, however, have only limited and indirect influence over privately owned multi-apartment buildings, with their role largely restricted to advising, coordinating, providing information, and mediating among stakeholders. This limited mandate underscores the need for new forms of support that can more effectively promote energy renovations and reach households experiencing energy poverty at the very local level.

The report highlights one such overarching recommendation: initiating or strengthening a housing intermediary, such as a homeowners' association or a professional building manager, in private multi-apartment buildings. Such an intermediary can support collective decision-making, facilitate regular saving, and improve access to financial or technical assistance. It would also help municipalities engage more effectively with building owners and residents, receive information about the housing stock and renovation processes, and, therefore, translate local energy and housing strategies into tangible improvements in living conditions, especially for households facing domestic energy deprivation.

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List of abbreviations and acronyms

Full name	Abbreviation/ Acronym
Carbon dioxide	CO_2
Energy efficiency	EE
Energy performance certificate	EPC
Energy Performance of Buildings Directive	EPBD
Energy Poverty Advisory Hub	EPAH
Energy Poverty Monitoring System	EPMS
European Commission	EC
European Union	EU
Face-to-face	F2F
General Data Protection Regulation [Regulation (EU) 2016/679]	GDPR
Household Budget Survey	HBS
Integrated Territorial Investment	ITI
Low Income – High Costs Indicator	LIHC
Multidimensional Energy Poverty Index	MEPI
Organisation for Economic Co-operation and Development	OECD
One-stop-shop	OSS
Private rented sector	PRS
Renewable energy sources	RES
Sustainable Energy and Climate Action Plan	SECAP

1. Introduction

Nearly half of Europe's population lives in multi-apartment buildings (Eurostat, 2024). The European multi-apartment housing stock is highly diverse, including historic urban tenements, large post-war housing estates constructed in response to the demographic pressures of the mid-20th century, and contemporary residential developments designed in line with current energy-efficiency standards. Another key differentiating factor is the structure of ownership, which ranges from predominantly private ownership and rental markets to intermediate forms, such as housing cooperatives or cohousing schemes. Access to energy services, particularly heating, is equally varied: district heating systems prevail in Northern and Central Europe, while Western and Southern regions rely more heavily on decentralised heating based on gas, oil, and electricity (Bertelsen & Vad Mathiesen, 2020). At the same time, there remain heterogeneous buildings where different floors utilise different heating sources, possess different flat ownership, and have various social structures.

A defining characteristic of multi-apartment buildings is the collective nature of decision-making. Residents are required to reach an agreement on issues such as the renovation fund, service fees, and particular investments (Manias et al., 2025), such as external insulation and solar photovoltaic systems. However, the depth of cooperation and the degree of autonomy of individuals residing in multi-apartment building units vary between countries. Furthermore, various market failures and institutional constraints complicate these processes, including split incentives, legal barriers to joint decision-making, and insufficient technical or financial support mechanisms (Gerőházi et al., 2023). As a result, residents in multi-apartment buildings can be particularly exposed to energy poverty. This vulnerability is not uniform: findings from the project suggest that some types of multi-apartment buildings are more exposed than others, and that these differences may stem not only from the buildings themselves but also from local geographies, tenure structures, and socio-demographic composition. These challenges have gained further relevance in light of EU policy developments, including EPBD and the Social Climate Fund, which place increasing responsibility on municipalities to understand and address energy poverty at a granular level. Against this background, scientific and practical initiatives addressing the gaps at the intersection of social policy, housing, and energy systems are gaining importance (Papantonis et al., 2022). The LOCATEE project, within which this document was prepared, is one such initiative. It brings together evidence from three European regions with high exposure to energy poverty (EPAH, 2025) and provides municipal-based solutions to tackle domestic energy deprivation.

This report presents a framework for measuring local exposure to energy poverty in municipalities and tests it using administrative data from different national contexts. Our analysis focuses on multi-apartment buildings in three medium-sized local authorities: Rumia (Poland), Torres Vedras (Portugal) and Piraeus (Greece). We employed a similar research design but adopted slightly different approaches across, varying in the data, indicators used, and stakeholder feedback provided, due to geographical and institutional constraints. These differences reflect the reality that data availability and institutional arrangements vary widely between countries, necessitating tailored methodological procedures.

A key innovation of the report is the introduction of micro-level indicators based on administrative data as a proxy for energy poverty, combined with a microsimulation model that utilises Household Budget Survey data at the building or small-scale area level. Using the Rumia case, we demonstrate the feasibility of a combined top-down and bottom-up approach to identifying energy poverty exposure at the microscale. The methodology developed for Poland will be expanded and refined over the coming months within the LOCATEE project to replicate it in other pilot municipalities, where the first quantification of energy poverty exposure was also calculated using collected administrative data and various spatial units (buildings, apartments, and subsections). These quantitative methods are complemented and compared with a qualitative assessment of stakeholders' perceptions on energy vulnerability in their local contexts, for a more robust approach. This mixed-methods structure reflects the reality that quantitative indicators alone cannot fully capture the social dynamics and governance constraints that shape energy vulnerability in private multi-apartment buildings.

Although this is a novel analytical exercise, we highlight the challenges inherent in a predominantly technocratic approach to energy-poverty measurement, particularly when the lack of available data and data protection regulations prevents analyses at the household level. Moreover, because the scope of accessible data varied between countries, each case required a tailored and different methodological procedure in terms of the analysed unit, applied datasets and indicators (Palma et al., 2025). Consequently, the context, methods and results are presented separately for each national context. For readers seeking a broader perspective, we provide a discussion that compares findings across all countries and draws conclusions relevant to measuring energy poverty at the intersection of social, energy, and housing domains.

2. Pilot areas

In this section, we present the general characteristics of the three pilot municipalities, with a special focus on the multi-apartment building landscape, as well as ongoing energy policies and initiatives undertaken. The LOCATEE project involves three small and medium-sized municipalities: Rumia (Poland), Torres Vedras (Portugal), and Piraeus (Greece). While Torres Vedras and Piraeus are located near their national capitals, Rumia lies at a considerable distance from Warsaw, situated instead near the Baltic Sea coast (Figure 1). All three cities, however, are situated directly on or in close proximity to the sea or ocean, which also influences their local climatic conditions.

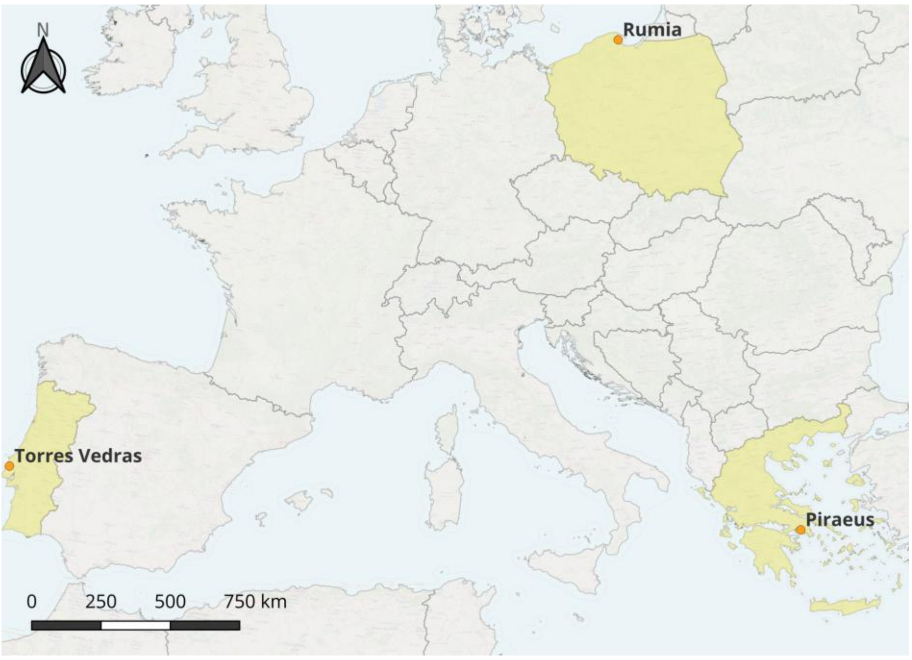

Figure 1: Location of the three pilot municipalities in the LOCATEE project

Source: IBS elaboration based on the OpenStreetView layer.

Each pilot municipality differs in terms of area, built environment, density, building stock structure, as well as competencies and experience related to residential housing policies that intersect with energy and climate goals. The choice of municipalities was made to enable the implementation of the LOCATEE project in diverse geographical conditions (Table 1), offering flexibility for adaptation to the specific needs of municipalities and local authorities.

Table 1: Basic information about pilot municipalities in LOCATEE

Municipality	Rumia (PL)	Torres Vedras (PT)	Piraeus (EL)
Population	53,316	83,072	163,572
Area [sq km]	30	62	11
Settlement type	Urban/suburban	Urban/rural	Urban
Climate	Transitional	Mediterranean	Mediterranean
Dominant economic functions of the municipality	Housing, logistics, retail services	Agriculture, manufacturing, tourism	Marine shipping, logistics

Source: own elaboration based on dispersed data.

2.1. Rumia

2.1.1. Short characteristics of the municipality

Rumia is a small city in northern Poland, located in the Gdańsk-Gdynia-Sopot Metropolitan Area. During the present decade, the city's population exceeded 53,000 residents and continues to experience demographic growth (Statistics Poland, 2024), fueled by urban sprawl (migration from the metropolitan core to areas with attractive land and buildings that are released for new residential development). While Rumia is primarily a residential community, it also functions as an important retail and logistics node, particularly for the northern part of the metropolitan area. A dispersed, fragmented pattern characterises the city's spatial layout (Milewska-Wilk et al., 2025). Since Rumia was consolidated into its present administrative boundaries, a clearly defined urban centre has not emerged. A situation further complicated by the city's location along a major road and rail transport corridor between Gdańsk and Szczecin that physically divides its territory (Figure 2).

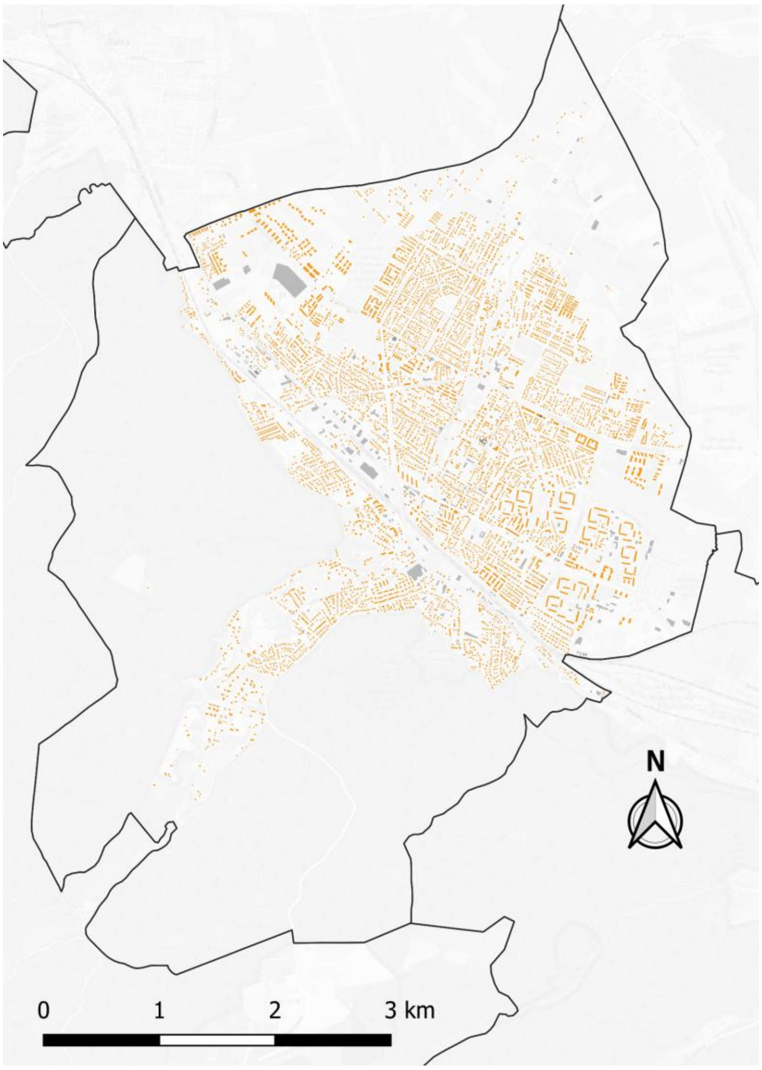

Figure 2: Map of Rumia municipality

Note: residential housing stock marked in orange.

Source: Own elaboration based on the OpenStreetView layer.

Real estate prices in Rumia have risen sharply since the beginning of the decade. By the end of 2024, the average price had reached 9,700 PLN per square meter for apartments on both the primary and secondary markets (Milewska-Wilk et al., 2025). The trend is explained not only by overall real estate price growth and high inflation at the beginning of the decade, but also by intensive developer activity on the city's borders, where somewhat higher-quality multi-apartment buildings are being built. The influx of new residential projects has attracted newcomers from other municipalities – mainly from the Tricity – among them many younger residents, which helps maintain a relatively favourable demographic structure compared with other Polish cities.

Housing is the dominant function in Rumia. The city has over 11,100 buildings, of which 1,072 are multi-apartment (Head Office of Geodesy and Cartography, 2024). Altogether, these contain about 22,100 residential apartments (Statistics Poland, 2022). The number of multi-apartment buildings and apartments continues to rise. Over the past five years, the housing stock has increased by 18% (Statistics Poland, 2024), primarily due to new developer-led projects on the city's periphery. Most multi-apartment buildings are owned by individuals (69%), then homeowner associations (18%) and cooperatives (11%). The size and other characteristics of the private multi-apartment housing stock are presented in detail in Section 4.1. The municipality also owns just 416 apartments, mostly in multi-apartment buildings, which are home to 1,289 people (Statistics Poland, 2022), representing a relatively small share of the city's total population compared to other cities in Poland.

2.1.2. Ongoing energy policy and undertaken initiatives

The City of Rumia pursues an active climate and energy policy. This is based on strategic documents and a clear vision statement in the Strategy for the Development of the City of Rumia for 2023–2032, adopted in 2023:

> *"By 2032, Rumia will offer the best living conditions in the northern part of the Pomeranian metropolitan area. It will be a dynamically developing, green, and resilient city that builds its future while minimising its negative impact on the natural environment"* (City of Rumia, 2023)

Issues at the intersection of energy and housing in the local policy are defined as one of four strategic objectives of the city, named "Climate neutrality and a developed green-blue infrastructure". The city has identified two milestones on the path toward climate neutrality: by 2032 (through investments in both public and private housing stock) and by 2050 (through the implementation of innovative solutions based on renewable energy sources, local low-temperature heating networks, and decentralised, community-led energy systems). The city explicitly emphasises its ambition to develop model solutions in this area and expects this process to generate new jobs, objectives that align well with the LOCATEE project. The general development strategy outlines 11 actions to achieve energy neutrality, distinguishing key actions that include improving the technical condition of public infrastructure and transitioning toward energy self-sufficiency, as well as measures for climate change mitigation and adaptation. Moreover, two key indicators have been assigned to these directions, consistent with the LOCATEE project:

- The number of energy efficiency investments in existing public buildings, including renewable energy installations, in 2023–2032 (target: 20 by 2032).
- The number of solid-fuel heating sources replaced in private residential buildings with the support of the municipal advisory centre in 2023–2032 (target: 2,000 by 2032).
- The number of municipal housing units (including those under SIM) (2022: 513; 2032: 613).

Complementary documents refining the strategy and relevant to the LOCATEE project include:

- **Assumptions for the heat, electricity, and gas supply plan, and the whole supply plan itself** [Projekt założeń do planu zaopatrzenia w ciepło, energię elektryczną i paliwa gazowe] – approved in 2014 (update), the document sets out the projected energy needs of the municipality and the development of the necessary heat, electricity, and gas infrastructure. It outlines investment priorities, system modernisation, and measures to ensure a secure and efficient energy supply.
- **The municipal environmental protection program** [Program Ochrony Środowiska dla gminy Rumia na lata 2023-2026 z uwzględnieniem perspektywy na lata 2027-2030] – approved in 2022, defines the municipality's environmental goals and actions aimed at improving air, water and waste management, and soil quality. It contains an extensive diagnostic section and outlines measures to reduce pollution, protect natural resources, and support sustainability.
- **The low-emission economy plan** [Plan Gospodarki Niskoemisyjnej dla Gminy Miejskiej Rumia na lata 2015-2020] – approved in 2016, presents the municipal approach to reducing greenhouse-gas emissions through energy efficiency, renewable energy, and cleaner transport. It identifies priority actions and investment pathways supporting the transition to a low-carbon economy.
- **The municipal social problem-solving strategy** [Strategia Rozwiązywania Problemów Społecznych dla Gminy Miejskiej Rumia na lata 2021 – 2024] – approved in 2021, obligatory municipal strategic document which identifies key social challenges within the municipality and sets priorities for improving residents' well-being. It proposes targeted interventions, support mechanisms, and cooperation frameworks to address social needs.
- **The municipal revitalisation program** [Gminny Program Rewitalizacji Gminy Miejskiej Rumia na lata 2017-2030] – approved in 2019, updated in 2021 and 2023, focuses on restoring degraded urban areas and enhancing their social, economic, technical, environmental, and spatial conditions. It defines the revitalisation area, key interventions, and mechanisms for community participation and long-term development.

During the LOCATEE project implementation period, the city began preparing Sustainable Energy and Climate Action Plan (SECAP), providing a framework for further practical steps in the energy transition.

The Air and Climate Protection Department at Rumia City Hall is primarily responsible for developing and implementing local climate and energy documents. Established in 2020/2021, the department mainly focused on air quality policy. Over the past decade, the City of Rumia has made significant progress in this field, including the installation of air quality monitoring stations, securing funding for the renovation of municipal buildings, and launching an advisory centre for heating source replacement. The department employs four staff members, whose competences cover handling matters related to climate and air protection, coordination of urban policy in the field of climate and air protection, including the provisions of strategic documents, management of a system supporting residents in replacing heat sources and implementing other requirements arising from national and local legal acts in force in the city in the field of climate and air protection including supervision of managing matters related to the granting of funding for projects related to climate and air protection, coordination and control of the implementation of requirements arising from national and local legal acts in force in the city regarding climate and air protection. Interestingly, the department is also responsible for managing housing allowances, a practice not commonly observed in Poland, but which provides the city with a possibly effective tool in tackling energy poverty.

Within the department, there is a division for energy affairs. Its activities include supervising the implementation of energy policy in the municipality, planning, conducting, and promoting actions related to low-emission and energy policy in the municipality, and developing annual and long-term investment and repair plans for energy infrastructure. Lastly, but not least, the City of Rumia is a co-owner of the metropolitan company [OPEC Gdynia], which supplies district heating. In 2023, OPEC Gdynia adopted a development strategy for the years 2023–2040, which was positively endorsed by the co-owners and defines the company's development directions with a strong emphasis on green transformation.

2.2. Torres Vedras

2.3.1. Short characteristics of the municipality

Torres Vedras is located in the West sub-region of mainland Portugal, within the Lisbon District, forming an important territorial link between the West Region and the Lisbon Metropolitan Area. The municipality covers approximately 407 km² and exhibits a diverse territorial structure, ranging from densely populated urban areas in the city centre to coastal settlements and low-density rural areas further inland. This spatial diversity gives rise to distinct demographic, social and environmental patterns relevant to understanding local energy needs and housing vulnerabilities. According to the 2021 Census (Instituto Nacional de Estatistica, 2021b), Torres Vedras has a population of about 83,072 inhabitants, making it the most populous municipality in the West Region. A map of the Torres Vedras municipality is displayed in Figure 3.

Figure 3: Map of Torres Vedras Municipality

Source: Own elaboration.

There's a clear differentiation between the coastal–urban axis and the rural hinterland. The city of Torres Vedras acts as the main administrative and service centre, while Santa Cruz, located on the Atlantic coast, is shaped by tourism, seasonal residency and a strong coastal identity. Beyond these poles, the municipality is characterised by scattered settlements and small villages, many of which display demographic stagnation and a pronounced ageing trend. Age dependency ratios are particularly high in several interior parishes, reflecting a growing proportion of elderly residents. This demographic profile has direct implications for energy poverty. Older populations often experience greater thermal discomfort, limited financial resources for renovation, and greater vulnerability to fluctuations in energy prices.

Climatically, Torres Vedras is shaped by a temperate Atlantic regime with mild, humid winters and warm, dry summers. The coast is more exposed to strong winds and high humidity, while inland areas experience more pronounced temperature fluctuations. These conditions affect building-level energy performance, particularly in older and uninsulated structures. Many dwellings require heating during winter and increasingly cooling during summer.

The municipality's urban system is polycentric, structured around the city of Torres Vedras, the coastal settlement of Santa Cruz and a network of compact parish centres and dispersed rural localities. The city centre is a historic core comprising both older buildings and expansion areas that developed throughout the second half of the 20th century. These zones concentrate most of the municipality's multi-apartment buildings, which are largely absent in the more rural parishes dominated by single-family homes.

According to the Municipal Housing Charter (MHC), approximately 95% of residential buildings in Torres Vedras contain only one or two dwellings. These predominantly correspond to detached, semi-detached or terraced houses. Only about 5% of buildings qualify as multi-apartment structures with three or more dwellings. This proportion rises significantly in the central parish, where more than 15% of buildings are multi-apartment.

In total, the housing stock comprises 46,406 dwellings. It exhibits a high degree of ageing, considering that around half of all residential buildings are more than 40 years old and were constructed before modern energy-performance standards were introduced. The MHC identifies that approximately 32.5% of dwellings require repair, and around 1,160 dwellings require deep renovation. A further 1,612 dwellings are classified as inadequate due to degradation, insalubrity or unsafe living conditions. Some residents also inhabit precarious or non-standard structures, underscoring the existence of severe housing deficiencies. These conditions are most evident in the historic centre, older, consolidated areas, and certain rural parishes, where ageing buildings intersect with socio-economic vulnerability.

2.3.2. Ongoing energy policy and undertaken initiatives

The Municipal Climate Action Plan (MCAP) reinforces the municipality's commitment to aligning climate mitigation, adaptation and social equity. It sets ambitious goals, including a 41% reduction in energy consumption and a 56% reduction in emissions by 2030 relative to 2009 levels. It includes measures dedicated to the housing sector, such as energy efficiency improvements in social housing, technical support for vulnerable households, and incentives for the adoption of renewable energy.

Complementing the MCAP, since mid-2025, the municipality operates an Energy One-Stop-Shop (OSS) integrated within the national network of OSS – Rede Espaço Energia, supported by the national energy agency (ADENE). This service provides guidance on energy bills, renovation options, financing schemes, and renewable solutions, playing an essential role in assisting vulnerable households and supporting community-level engagement to address energy poverty.

In addition to these climate-oriented measures, several municipal initiatives further reinforce the local governance landscape, addressing both housing needs and socio-economic vulnerabilities with direct implications for energy poverty:

- **Local Housing Strategy [Estratégia Local de Habitação]** – Approved in 2021, it establishes a comprehensive 10-year strategy to address structural housing needs in Torres Vedras. The plan envisions a total investment of €962 million and aims to deliver approximately 10,800 housing solutions through the construction, rehabilitation, and reactivation of vacant dwellings.
- **1st Right Program [1.º Direito]** – National program that supports households living in precarious, inadequate or overcrowded housing situations who lack the financial capacity to secure adequate accommodation. This programme funds rehabilitation and construction solutions, many of which involve improving thermal performance and overall living conditions.
- **Co-financing Program for Conservation, Repair or Improvement of Degraded Housing** [Programa para a Comparticipação em Obras de Conservação, Reparação ou Beneficiação de Habitações Degradadas (PCOCRBHD)] – Provides financial support for rehabilitation works in degraded dwellings occupied by residents in socio-economic vulnerability since 2003. Supported interventions frequently address dampness, insulation deficits, structural degradation and other issues directly relevant to household energy performance.
- **Municipal Social Housing Program [Habitação Social]** – Expands and manages the municipal housing stock under supported rental schemes, targeting households with substantial socio-economic constraints. Social housing units are often among those most in need of energy-efficiency upgrades.
- **Rental Support Program** [Programa de Apoio ao Arrendamento] – Offers financial assistance to low-income residents renting in the private market since 2009, including unemployed individuals, single-parent families, persons with chronic illnesses or disabilities, and isolated elderly residents. By alleviating financial stress among vulnerable households, the programme indirectly reduces exposure to energy poverty and facilitates engagement with renovation and advisory services.

Together, these initiatives form a cohesive and multi-layered policy framework highly relevant to the LOCATEE project. They support renovation efforts, assist vulnerable populations, and enable the integration of energy-efficiency considerations into housing interventions.

2.3. Piraeus

2.3.1. Short characteristics of the municipality

Piraeus is a dense coastal municipality in the Attica Region and is part of the wider Athens metropolitan area. The city hosts Greece’s main port, which is recognised as the country's primary maritime gateway and one of the largest passenger ports in Europe, concentrating port-related logistics, services, and cruise activities alongside a compact urban core (Figure 4). According to data from the Hellenic Statistical Authority for 2023, the municipality has approximately 164,000 residents, ranking among the five most populous municipalities in the country and one of the most densely populated.

Administratively, Piraeus is divided into five municipal districts that host distinct neighbourhoods, from the historic centre and port-adjacent areas, to hillier residential areas, such as Kastella. Housing in Piraeus is primarily composed of multi-apartment blocks. The local multi-apartment building stock is dominated by mid-rise, reinforced-concrete "polykatoikia" constructed mainly between the early 1960s and mid-1980s, before the introduction of national thermal regulations for buildings. Almost three-quarters of the municipality's buildings (72%) were built before 1985, and only about 27% afterwards (with a negligible share of buildings of unknown construction period), indicating a predominantly ageing building stock.

Figure 4: Map of Piraeus Municipality

Source: Climate Piraeus.

A significant presence of both middle-aged working households and older residents characterises the socio-demographic structure of Piraeus. Approximately 27% of residents are under 30 years old, 44% are between 30 and 59, while almost 29% are 60 years or older, and women represent a slight majority of the population (around 52%). These patterns are particularly relevant for addressing energy poverty, as older residents may face barriers in undertaking complex renovation schemes and navigating digital procedures. In contrast, younger and mid-age residents concentrate much of the human capital required to coordinate building-level decisions. More detailed socio-economic and energy data are presented in Section 4.2.

Combined with the socio-demographic profile and the highly urbanised environment, these characteristics create a significant potential for addressing domestic energy poverty in private multi-apartment buildings, making Piraeus a particularly relevant pilot municipality for the LOCATEE project.

2.3.2. Ongoing energy policy and undertaken initiatives

In Piraeus, the main funding source for implementing local climate, energy and social policies is the Integrated Territorial Investment (ITI) / Sustainable Urban Development strategy, co-financed by the EU within the current programming period 2021-2027. ITI provides a coherent framework and dedicated funding for projects that promote, among other priorities, urban regeneration, energy efficiency, sustainable mobility, environmental upgrading and social cohesion. Its objectives include improving the quality of the urban environment, enhancing resilience to climate change, upgrading public infrastructure and services, supporting vulnerable groups and strengthening the city's overall attractiveness and competitiveness.

Within this framework, ITI finances flagship initiatives such as "Climate Piraeus" and "Social Innovation Piraeus". "Climate Piraeus" represents the implementation framework of the city's Sustainable Energy and Climate Action Plan (SECAP), providing a horizontal structure within the municipal administration to coordinate mitigation and adaptation actions, monitor emissions, manage climate-related projects, and support awareness-raising efforts. "Social Innovation Piraeus" (Social Innovation Hub) brings together a network of social services and initiatives that aim to prevent exclusion, support vulnerable groups, and pilot new tools and methods for outreach, participation, and community-based solutions.

SECAP was first adopted in 2018, in the framework of the EU Covenant of Mayors, where the municipality participates as a member. It defines mitigation and adaptation measures up to 2030, focusing on energy efficiency in buildings and infrastructure, promoting renewable energy sources, sustainable mobility, and enhancing climate resilience throughout the city. The plan integrates climate and energy objectives into local development planning and guides interventions such as energy audits and retrofits in the municipal building stock (schools, administrative and cultural buildings), upgrades to public lighting, improvements to heating and cooling systems, and complementary actions on awareness and behaviour change. SECAP is currently under revision, and this update intends to take into account the findings and tools developed in the LOCATEE project.

The implementation of these policies relies on specialised municipal structures. The Directorate of Programming plays a central role in strategic planning, coordination and integration of ITI and SECAP into the local development strategies. The Directorate of Technical Services and Environment**,** through its dedicated "Climate Piraeus" structure, manages the technical aspects of the climate and energy agenda, including emissions monitoring, design, and supervision of energy-efficiency projects, and participates in relevant European and national programmes.

On the social side, the Municipal Public Benefit Enterprise of Piraeus (KODEP) and the Community Centre serve as the main pillars for designing and delivering social policies, mapping needs, supporting vulnerable households, and connecting them to available schemes, including those related to housing and energy costs. KODEP also coordinates the Social Innovation Hub, which embodies a social innovation approach by testing new forms of service delivery, partnerships and local actions to reach people at risk of poverty, exclusion or energy poverty.

In parallel, the Municipality of Piraeus actively participates in a series of European projects that reinforce this policy framework, covering themes such as energy management in public buildings, integrated urban interventions, sustainable mobility, social innovation and the fight against poverty and discrimination. These projects – including LOCATEE – provide technical tools, pilot actions and additional resources that complement the investments of ITI and the strategic orientation of the SECAP. Overall, the combination of ITI with "Climate Piraeus" and Social Innovation Piraeus, SECAP and the Municipality's infrastructures, KODEP and the Directorate of Programming, creates a robust ecosystem in which climate, energy and social policies are increasingly integrated, and where LOCATEE can be effectively embedded to address energy poverty in private multi-apartment buildings in a structured, long-term way.

3. Data and methods

The following section presents the analytical strategy for each municipality, including the characteristics of key variables that increase the risk of energy poverty used in further modelling, and the resulting multidimensional energy poverty index (MEPI) – a single indicator that accounts for the multi-faceted nature of energy poverty, useful for poverty mapping and policy planning, developed for each pilot case. It combines various partial proxy indicators, setting a threshold that enables tackling more than one form of deprivation and, through that, estimating the incidence of energy poverty in a given area (Sokołowski et al., 2020).

We adopted differentiated analytical strategies, datasets, and levels of data aggregation for each of the three pilot municipalities. This approach was determined by the varying availability of data across the three countries, GDPR-related constraints, and the specific characteristics of energy poverty in each context. In measuring energy poverty, we applied a pragmatic approach. Due to the lack of data for commonly used energy poverty indicators, and in line with our aim to utilise available administrative data, we defined energy poverty through characteristics that increase the risk of this phenomenon at the national level. In each municipality, we achieved the lowest feasible level of data aggregation in our analysis.

3.1. Rumia

Herein, we present a summary of administrative data collected for Rumia, including data from publicly available sources and data obtained directly from or by the city. For Rumia and Poland, we were able to gather administrative data from various databases at the multi-apartment building level. This enables highly accurate aggregation, allowing the municipality to work directly with the data — for example, to target specific buildings based on available renovation funding opportunities. The variables used and ideas for measuring energy poverty were consulted with the municipality and stakeholders during the workshop in June 2025. Moreover, part of the datasets comes from open data sources, which makes it possible to replicate the approach used in Rumia in other municipalities at no additional cost and to calibrate the energy poverty measurement model based on HBS using precise variables.

Here are the variables used in operationalising energy vulnerability to create a multidimensional index (Table 2). All weights in this approach remained the same. A multi-apartment building was considered eligible for the multidimensional energy poverty index (MEPI) if at least 40% of the evaluated indicators exceeded the established threshold values of qualification criteria, based on a similar approach applied at the national level with more typical energy poverty indicators (Sokołowski et al., 2020).

Table 2: Variables used to calculate MEPI for multi-apartment buildings in Rumia

Variable	Source	Ownership	Years	Qualification criteria (which increase vulnerability)
Age of the building	Historical topographic maps of Poland (Szubert et al., 2024)	Publicly available	2025	exists in the 1980s
Annual non-renewable primary energy demand indicator	Central Register of Building Energy Performance (Ministry of Economic Development and Technology, 2025)	Publicly available	2025	building class “C” and lower
Heat source	Central Register of Building Energy Performance (General Office of Building Control, 2025)	Partially confidential	2025	only such sources of heating from among: solid fuel, electric, and oil
Registered people living in a building in particular age cohorts	State Register System (Ministry of Digital Affairs, 2025)	Partially confidential / Collected upon request	2024	2/3 and higher percentage of people under 30 years and people 60 years and older
Number of received social security (housing allowances, energy allowances + social security allowances)	Local Social Welfare Centre, City of Rumia (Local Social Welfare Centre, 2025)	Sensitive	2024	using at least two various types of social security under a particular building (divided into the total number of people registered – must be 10% or more)

Source: own elaboration.

We pilot-test an Energy Poverty Microsimulation Model in Rumia. We take local and regional household data to recover the shapes of income and energy-expenditure distributions, then for every residential building we generate synthetic households that match that building’s context (age structure of residents, heating system, construction period/type, and size). For each synthetic household, we draw the household size, infer the dwelling area, and then draw income, along with a split of energy costs into electricity (per person) and space heating (per square meter), using parameters calibrated from HBS and adjusted by age/technology multipliers when available. We equate both income and energy using the modified OECD scale, ensuring that outcomes are directly comparable to national benchmarks. We then assess each simulated household against the LIHC indicator and aggregate results across simulations to obtain building-level probabilities and summary statistics. We obtain a map-ready table that shows, for each building, the predicted risk of energy poverty.

To balance our findings from bottom-up (MEPI) and top-down (Energy Poverty Microsimulation Model) quantitative calculations, we conducted a series of interviews and consultations on energy poverty within municipalities in June 2025. We spoke with the Mayor’s Representative for NGO Affairs, as well as with representatives of local NGOs in Rumia and residents of multi-apartment buildings (→Appendix 2). The interviews provided a deeper understanding of the local context and specific challenges related to energy poverty. An additional and valuable source of qualitative insights was a meeting ("Roundtable dedicated to energy efficiency in multi-family buildings") with city officers, managers, and residents of single-family buildings, which brought together 25 participants representing various professions (Figure 5) as well as the city mayor. During the meeting, participants discussed the local energy poverty mapping approach in the project, energy audits of buildings as a tool for effective modernisation and the practical aspects of energy billing, using the example of the largest housing cooperative in Rumia. These activities will also continue in the subsequent years of the project.

Figure 5: Stakeholder workshop in Rumia (25/06/2025)

Source: City of Rumia/IBS.

3.2. Torres Vedras

Following the guidance on indicators that can be used to assess energy poverty vulnerability from the LOCATEE report "Analysis of indicators and datasets for energy poverty assessment: The case of private multi-family buildings" Palma et al. (2025), as well as on previous work on regional energy poverty assessment in the country (Gouveia et al., 2019, 2021), several datasets were collected from the housing unit of the Torres Vedras municipality and also from publicly available national statistics and other sources. The administrative data from the municipality is available at the most granular level – street and postcode. Other statistics were obtained at the parish and subsection levels, which are larger territorial units within the municipality. The stakeholder consultation described below also contributed to identifying additional and relevant data sources. As with Rumia, since some of the utilised datasets are publicly available for territorial units (e.g. civil parish, municipality) across the entire national territory, the developed methodology will be at least partially replicable in other Portuguese municipalities.

As the collected variables, described in Table 3, are mostly available at the civil parish and sub-section unit, an area-based multidimensional index was developed, in which a subsection is considered vulnerable to energy poverty if it exceeds the vulnerability threshold of at least 5 of the 8 defined indicators, as depicted in Table 3. A higher number of indicators was selected to assess vulnerability in Torres Vedras compared to Rumia and Piraeus, as not every indicator is available at the sub-section/district level; some are only available at the civil parish level. It is relevant to note that each case-tidy has different datasets at its disposal, which shape the configuration of the assessment method. Therefore, a threshold with more indicators guarantees a more robust proxy of overall energy poverty vulnerability. The threshold for each indicator is defined as the 75% percentile value.

Table 3: Variables used to calculate MEPI for multi-apartment buildings in Torres Vedras

Variable	Source	Ownership	Years	Qualification criteria (which increase vulnerability)
Age of buildings	BGRI (Instituto Nacional de Estatistica, 2021b); Building cadasters (Department of Housing. Torres Vedras Municipal Council, 2025a)	Public	2021	Over 67% of buildings before the 1980s
Buildings with repairing needs	BGRI (INE, 2021a)	Public	2021	Over 50% of buildings
Building Energy Performance class	National Energy Agency (ADENE, 2025)	Sensitive	2025	Over 88.7% of dwellings with class “C” or below
Individuals older than 64 years old	BGRI (Instituto Nacional de Estatistica, 2021b)	Public	2021	Over 17%
Individuals younger than 15 years old	BGRI (Instituto Nacional de Estatistica, 2021b)	Public	2021	Over 32%
Dwelling rented	BGRI (Instituto Nacional de Estatistica, 2021b)	Public	2021	Over 70%
Education level (none or primary education)	Censos (Instituto Nacional de Estatistica, 2021a)	Public	2021	Over 74.1%
Social support beneficiaries (rent, building rehabilitation programs)	Beneficiaries database (Department of Housing. Torres Vedras Municipal Council, 2025b)	Sensitive	2025	Over 34 beneficiaries of the three support programs

Source: own elaboration.

Concurrently, a process of stakeholder auscultation was conducted to gather and analyse insights into the municipal and city context regarding energy poverty vulnerability faced by the population residing in private multi-apartment buildings. It engaged local, regional, and national stakeholders to draw a comprehensive picture of the current situation, linking central governance and planning with local policy and knowledge. A total of 15 face-to-face (F2F) meetings in the form of semi-structured interviews (→Appendix 1) have been conducted in the 1st semester of 2025 (→Appendix 2) with the presidents of several civil parishes (regional unit smaller than municipality), one local association, a representative of the Housing and Urban Regeneration Unit of the municipality, a representative of the Housing and Urban Rehabilitation Institute, and the Intermunicipal Community of Oeste (association of municipalities including Torres Vedras). Each interview and the respective questions were tailored to the entity being interviewed. The meetings touched on topics such as the entity’s role in building renovation, the progress observed in the past 5 years, the main obstacles for homes renovation, the integration of energy poverty in their activities, urban regeneration and housing policies, energy poverty mitigation projects and initiatives at the local scale, energy poverty expressions across the territory, the importance of stakeholder participation and their future role and impact. Questions and the exchange were flexible and adapted to each entity. Further meetings will be held in the coming months, with an increased focus on targeting and engaging local building managers and owners, who have been a challenging segment of stakeholders to reach.

On June 26, 2025, Torres Vedras Municipality and NOVA FCT organised the first local stakeholders meeting (Figure 6), to present the LIFE LOCATEE project, share technical and scientific knowledge about energy poverty and building energy efficiency and discuss these critical challenges with a diverse group of 17 local, regional, and national stakeholders, including NGOs, local councils, consumer organisation, national energy agency, local association and a local foundation which is a building owner. The meeting started with presentations on the participation of the municipality in the project and related ongoing works and policies, an overview of energy poverty, focusing on definition, indicators and policies in the EU and Portugal and a presentation of the LOCATEE project, focusing on goals and tasks with a specific emphasis on energy poverty diagnosis. The current context of residential buildings in the city, focusing on their current state, challenges, and the instruments and programs currently implemented to address the identified issues, was also presented. In the second part of the meeting, a group exercise was conducted to discuss the determinants of energy poverty, building stock issues, available data and indicators, and vulnerable groups in Torres Vedras. Finally, a participatory mapping exercise enabled the identification of energy poverty hotspot locations and neighbourhoods in the city and municipality, revealing different profiles of vulnerability and their respective geographical, infrastructural, and economic determinants.

Figure 6: Stakeholder workshop in Torres Vedras (26/06/2025)

Source: Municipality of Torres Vedras/NOVA.

3.3. Piraeus

In this section, we present a concise depiction of the administrative data collected for the case of the Municipality of Piraeus (Table 4), combining publicly available sources with data provided directly by several Greek administrative service providers (e.g., "Climate Piraeus" office of the Municipality of Piraeus, Inspectorate of the Ministry of Environment and Energy). For the Greek pilot case, administrative and statistical data were collected at different levels (e.g., building, address, zip code level), allowing for the tailored calibration of the LOCATEE EPMS, thereby using more precise, locally relevant variables.

In this preliminary analysis and based on the data collected so far, the operationalisation of energy vulnerability into a composite, bottom-up index draws on variables such as building construction period, building status (i.e., good/fair/poor condition), energy class/ Energy Performance Certificate (EPC), and primary energy source.

Table 4: Variables per dataset provided that will be utilised for preparing EPMS in Piraeus

Variables	Sources	Ownership	Years	Qualification criteria (which increase vulnerability)
Building construction period	Municipality of Piraeus, Ministry of Environment and Energy	Publicly available/ collected upon request	2017 – 2022	Buildings constructed before 1981 (no thermal regulation in place)
Building/floor status	Municipality of Piraeus	Publicly available	2017 – 2022	Derelicts, shacks, and buildings with “poor condition” status
Heating source	Ministry of Environment and Energy	Collected upon request	2025	Buildings that use fuel oil or solid fuels (biomass) as a heating source
EPC class	Ministry of Environment and Energy	Collected upon request	2025	Units with EPC class “C” or lower

Source: own elaboration.

To expand and validate our findings for the Municipality of Piraeus, a series of face-to-face (F2F) meetings and structured stakeholder consultations on energy poverty have been conducted, with activities planned to continue in subsequent project years. As of the date this report is written, 12 F2F meetings (→Appendix 2) have taken place in total with stakeholders from the Municipality (e.g., district ambassadors, Piraeus Municipality Development Organisation, Deputy Mayor of building services and urban mater planning, municipal councillor in charge of public health and social services, etc.), and other relevant stakeholders, like the Greek association of property owners (POMIDA), and the "Sustainable City" Network of Municipalities across Greece.

In June 2025, the Municipality of Piraeus, in collaboration with TEESlab-UPRC, held a local stakeholder workshop at the municipal city council to introduce the LOCATEE project, discuss local energy poverty issues, and explore the co-creation of targeted solutions (Figure 7). Stakeholders were briefed on the project’s objectives, consortium, and the forthcoming LOCATEE activities.

Figure 7: Stakeholder workshop in Piraeus (30/06/2025)

Source: Municipality of Piraeus/UPRC.

4. Results: Domestic energy deprivation in the pilot areas

Here, we present the initial results of domestic energy deprivation measurements conducted in the pilot areas. Each pilot case is structured into three subsections, encompassing:

- A bottom-up assessment, based on proxy indicators derived from administrative data, used later to summarise within the MEPI index or a similar approach (described in the Methods section);
- A top-down assessment, drawing on administrative data combined with a microsimulation model developed by IBS and also fed by Household Budget Survey data to estimate the Low-Income High-Costs indicator – at this stage prepared only for Rumia, where all required data, including the national HBS, were available; and
- A qualitative assessment, informed by feedback gathered from local energy-poverty stakeholders during workshops and face-to-face consultations.

4.1. Rumia

4.1.1. Local energy poverty (bottom-up approach)

In Rumia, the multi-apartment building stock comprises almost 1,072 buildings with a combined estimated total floor area of over 1.1 million m². On average, a single multi-apartment building has an estimated usable floor area of approximately 1,1 thousand m² and a mean of 3 floors. Ownership of multi-apartment buildings is diversified. The largest share of the stock is owned by individual owners (69% of buildings, 40% of usable floor area), followed by homeowners' associations (16% of buildings, 22% of usable floor area) and housing cooperatives (11% of buildings, 31% of usable floor area). These are five housing cooperatives operating in Rumia: Janowo (the largest, covering the vast majority of cooperative stock in the municipality), Maluch, Informatyk, and two cooperatives with their headquarters in neighbouring cities (Wejherowska Spółdzielnia Mieszkaniowa and "Własny Dach"). The average building size varies considerably by ownership form, with cooperative buildings being the largest on average (3,200 m² per building), and municipal buildings the smallest (1,150 m² per building). The privately owned multi-apartment buildings are very diverse (Figure 8), and many of them do not meet the rigorous definition of a multi-apartment building (i.e., they are just oversized single-family buildings); however, we used the official state classification (Head Office of Geodesy and Cartography (GUGiK), 2024), which also allows them to be counted in this category.

Across all multi-apartment buildings, the average annual primary energy consumption is 112 kWh/m². The estimated share of multi-apartment buildings using renewable energy sources (RES) is 7%, indicating a moderate penetration of renewable solutions within the housing stock (slightly higher than the national average for this kind of building, primarily in housing cooperative stock). Disaggregated by ownership, housing cooperatives exhibit the highest average energy consumption (130 kWh/m²), indicating relatively large yet well-performing buildings (a bit better on average in the largest housing cooperative – Janowo). Most cooperative buildings are supplied from group heat-exchange stations owned by the district heating operator. Heat is distributed to individual buildings through a four-pipe underground network built in the 1970s and 1980s. This network has high transmission losses, reaching approximately 17 kWh/m² for domestic hot water alone. In 2025, the district heating operator began implementing a new building-supply system, which will significantly reduce these distribution losses. Homeowners association-managed cooperatives display the lowest average consumption (87 kWh/m²), likely due to smaller scale or brand-new housing stock. Multi-apartment buildings owned by individual private owners exhibit relatively efficient performance (average: 104 kWh/m²), consistent with moderate adoption of energy-saving measures. There are a few examples of buildings above (projected range of) Class C, due to the high gasification level and the relatively young age of the housing stock. For the buildings with energy certificates in the municipality, we counted only 3% of such energy vampires; however, it should be assumed that there is a much higher number of such buildings in the group without an EPC. Compared to private multi-apartment buildings, publicly owned municipal buildings have the weakest energy performance, with an average consumption of 190 kWh/m², reflecting the ageing and lower retrofit rate of the municipal stock.

Figure 8: Urban context of Rumia

Source: City of Rumia

Overall, a quarter of multi-apartment buildings in Rumia were constructed before 1980, indicating that roughly one-quarter of the stock consists of older structures likely requiring energy renovation. This is a relatively minor value, resulting from the city's socio-economic history and the presence of only two primary housing cooperatives in the area. Cooperatives and homeowners' associations show low shares (40% and 21%, respectively) in terms of building age, while privately owned buildings are significantly newer (only 22% pre-1980). The segment of associations managed by housing cooperatives consists entirely of newer buildings, with all the buildings constructed after 2000. In contrast, the municipal multi-apartment housing stock is overwhelmingly old — 96% of municipal buildings date back to before 1980; they are primarily located in the Szmelta district and constitute the oldest cohesive residential estate in the city, built for workers even before World War II, and partly renovated in 2010s from KAWKA municipal programme (i.e. replacing all the coal stoves in the area by district heating).

The population residing in multi-apartment buildings is older than in the entire city. There are 28% under 30 years old, 42% between 30 and 59 years old, and 30% aged 60 or older (compared to 31%, 45%, and 24%, respectively, for the entire municipality). However, differences by ownership indicate varying socio-demographic profiles. Housing cooperatives exhibit the highest share of older residents

(39% aged 60 and above), while privately owned buildings show a younger demographic structure (34% under 30, 47% aged 30-59, and 19% aged 60 and above). Homeowners' associations have a balanced age mix, although it is still skewed toward middle-aged residents (48% aged 30-59). Municipal buildings have the oldest resident population, with 26% aged 60 and above, and 33% below 30, reflecting the concentration of elderly residents in publicly owned housing. Multi-apartment buildings are also characterised by a slightly higher share of women than men compared to the city as a whole. The share of women amounts to 54%, which is 2.5 percentage points higher than the overall figure for Rumia. The highest proportion of women is also found in bigger housing cooperatives (Janowo, Wejherowska Spółdzielnia Mieszkaniowa) as well as in municipal housing.

The dominant heating source in Rumia is gas heating, used in 2 out of 3 multi-apartment buildings. Other significant sources include solid fuel heating (20%) and district heating (31%), with partial overlap where hybrid systems are present. Renewable heating solutions remain rare: heat pumps are present in less than 1% of buildings, and solar collectors in only 0.5%. Electric heating accounts for 7%, and oil heating below 1% of the stock. The highest reliance on district heating is observed in municipal and housing cooperative buildings (95% and 84%, respectively), while individual private owners of multi-apartment buildings rely mostly on gas (78%) and solid fuels (26%). Homeowners' associations managed by cooperatives are almost entirely connected to the district heating system, without gas, which is typical of new investments.

Social support in 2024 was concentrated in a relatively small share of multi-apartment buildings. The most widespread benefit was the energy voucher [*bon energetyczny*], granted in 24% of buildings, followed by the social security allowance [*zasiłek z pomocy społecznej*] (7%) and the housing benefit (6%) [*dodatek mieszkaniowy*]. In most cases, these benefits were assigned more than once per building, suggesting repeated or multiple household needs within the same address. Only 2% of multi-apartment buildings (mostly large buildings located in two housing cooperatives) received all three forms of support. Overall, 74% of multi-apartment buildings (791 out of 1,072) did not receive any benefit or allowance.

The 127 multi-apartment buildings in Rumia (12% of all) are being affected by more than one of the factors (from Table 2) that increase exposure to energy poverty (measured by MEPI index). Among these, more than half belong to private owners (without any established housing entity form). The next largest group comprises municipal buildings; within the municipal stock, the share of buildings captured by the index was the highest (21 out of 24). This indicates that it is not the private, but rather the public housing stock that is among the most exposed to energy poverty in the city – a trend consistent not only in Rumia but also across the whole of Poland (Muzioł-Węcławowicz & Nowak, 2018). Housing cooperative and homeowners' association buildings follow in the ranking; the higher share of cooperative buildings within the index primarily results from the older age of residents. Privately owned multi-apartment buildings affected by energy poverty are spatially dispersed and do not form coherent areas (Figure 9). Only a few hotspots can be distinguished, suggesting the need for individual outreach and targeted interventions.

4.1.2. Local energy poverty (top-down modelling approach)

The top-down approach, based on microsimulation of the estimated probability of the LIHC index, suggested an average level of around 15% for multi-apartment buildings in Rumia, with a range from 2% to 32%. The likelihood of experiencing energy poverty is higher among municipal buildings (17%), homeowners' associations (16%), and — slightly above average — privately owned buildings (15%); in contrast, housing cooperatives show lower values (12%). This finding is supported by both complementary survey data collected in Rumia within the Janowo Housing Cooperative, where the incidence of energy poverty is approximately 8% across various indicators, smaller than the national average (Frankowski et al., 2025). In Rumia, more than one-third of multi-apartment buildings with a high probability score also met the criteria of the MEPI index[1], indicating that the applied modelling approach can support local-level diagnostics of energy poverty (Figure 9).

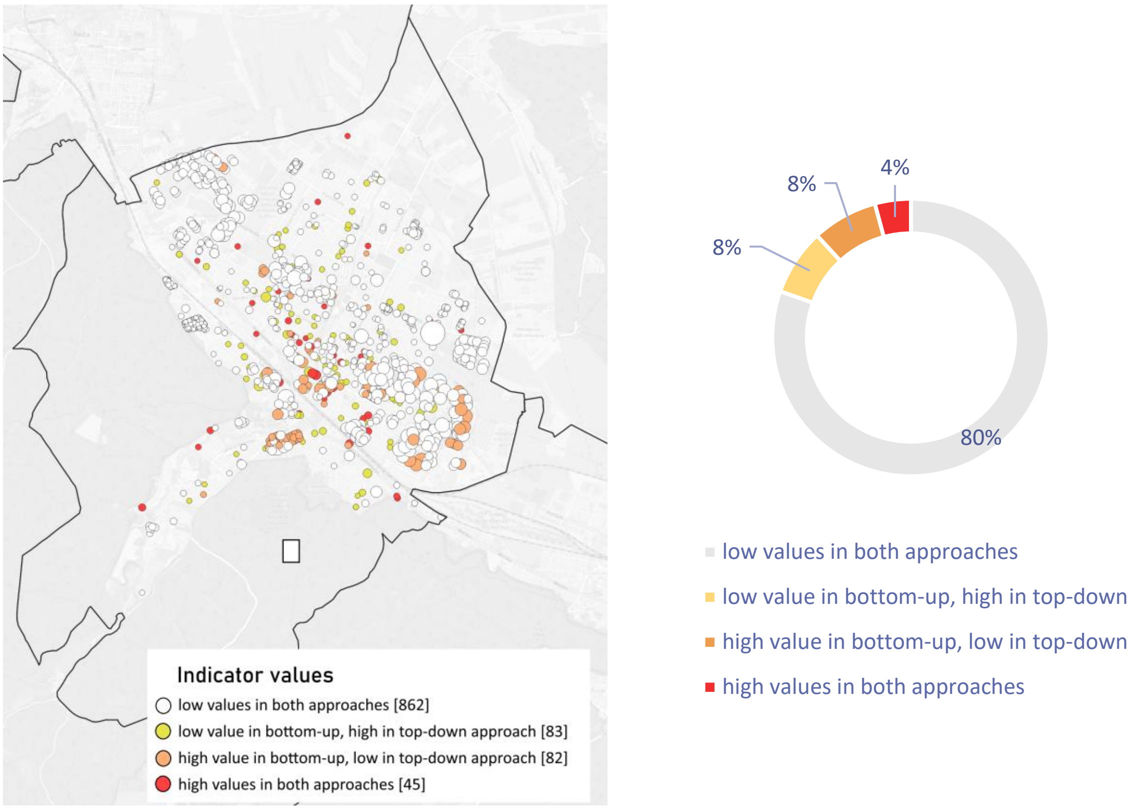

Figure 9: Vulnerability hotspot buildings in Rumia

Note: The size of the circle is an estimated usable area of the building.
Source: Elaborated by IBS.

Compared to the bottom-up classification, the top-down classification identified more small multi-apartment buildings, including those owned by private individuals[2]. The use of both approaches enables the precise identification of buildings on which local authorities should focus their attention and interventions. This exercise limited the number of buildings requiring specific attention to 20% of

[1] We obtained 127 multi-apartment buildings that met the criteria of at least 2 out of 5 partial indicators (Table 2). We compared the number of these multi-apartment buildings that fall within the sequence of buildings arranged in descending order by their LIHC value. We identified 45 such buildings (Figure 9).

[2] We set the same threshold of buildings as in the case of MEPI; using this approach, we classified buildings with at least 27% estimated probability as high-value, requiring specific intervention.

the multi-apartment housing stock in Rumia, with 4% (present in both measuring approaches) receiving the highest priority.

4.1.3. Energy poverty perceived by local stakeholders (qualitative approach)

Energy poverty in the city of Rumia is perceived as a multifaceted challenge, particularly affecting the elderly population. Especially older women living alone struggle with high energy costs, rent, and healthcare expenses. Many occupy old, large, gas-heated single-family or semi-detached multi-apartment houses (Figure 10) that are expensive to maintain and poorly adapted to their current needs. However, the municipality has implemented stove replacement programs (which have significantly reduced the problem of individual coal heating compared to what it was 10 years ago; only single multi-apartment buildings still use this heating mode); these measures have not been sufficient to address the issue entirely.

Conversely, energy vulnerability among residents of multi-apartment buildings is often overlooked. Energy and housing intermediaries (such as heating companies, homeowners' associations, and housing cooperatives) engage with energy poverty-related issues to varying extents, and there is a notable lack of cooperation among them at the city level, which is also typical for other Polish municipalities. However, this group plays a crucial role in addressing energy poverty, informing residents about available support options (especially housing allowance), and improving their housing conditions.

Figure 10: Examples of multi-apartment buildings with poor energy efficiency in Rumia

Source: City of Rumia.

The landscape of social and non-governmental organisations in Rumia demonstrates a well-established but fragmented network of actors addressing general social needs. The key stakeholders include the local government, Kashubian cultural associations, several charitable and scouting organisations, and the University of the Third Age. Their efforts are primarily directed toward immediate forms of assistance, such as food distribution, clothing drives, and holiday support. However, there is a noticeable lack of organisations or initiatives that are explicitly focused on energy poverty or connecting environmental topics with the needs of vulnerable groups. Collaboration between social welfare actors and ecological groups is practically nonexistent, which limits the city's capacity to develop integrated responses to energy vulnerability.

Several barriers hinder the provision of adequate support for residents affected by energy poverty. The most pressing issue is the limited information available regarding assistance programs managed by institutions such as the Municipal Social Welfare Centre (MOPS), the Social Insurance Institution (ZUS), and the County Centre for Family Support (PCPR). Many older adults remain unaware of their entitlements, including, e.g. widow's pensions or disability benefits. Furthermore, communication channels between institutions and residents could be strengthened, and NGOs often lack the necessary expertise to guide beneficiaries through energy-related assistance programs.

4.2. Torres Vedras

4.2.1. Local energy poverty (bottom-up approach)

In Torres Vedras, there are 3,182 multi-apartment buildings, accounting for approximately 9% of the total building stock. They are identified by the number of floors, with every residential building with three or more floors considered a multi-apartment building (Figure 11). According to municipal building cadasters, these buildings have an average of 3.7 floors, and each dwelling has an average useful area of 103 m², as per energy performance certificates data (SCE, 2025).

Figure 11: Urban context of Torres Vedras

Source: Municipality of Torres Vedras

Most residential multi-apartment buildings are private and organised in horizontal property (per dwelling). A considerable proportion of buildings (49%) were built before 1980, before any energy performance regulations were implemented in the country, rendering this stock more likely to have poor energy performance despite potential renovations that have occurred since then. The parish of *Carvoeira e Carmões*, located in the eastern part of the municipality, has the highest rate of older buildings (69%). In contrast, A dos Cunhados e Maceira, in the northwest, has the lowest (37%). This conclusion is corroborated by the energy performance certificate data for all dwellings, as 92% and 81% of buildings have an energy performance class of C or lower, which is below the regulation requirements for renovated buildings (B+). The municipality has an average of 83%. The parish of *Dois Portos e Runa* presents the lowest performing building stock (94% C or below). However, when we examine dwellings only in multi-apartment buildings (a small sample from several parishes), *Dois Portos* e *Runa* continues to be the lowest performing (95%). Still, Freiria places as the one with the highest percentage of homes with an EPC above C (63% C or lower). The thermal comfort ratio is an indicator that reflects the difference between the heating or cooling reference energy needs and actual values. The municipality has a two-to-one ratio for space heating and 0.74 for cooling. As 1 represents a situation in which the reference needs are the same as for the average building, these results indicate a case of low space heating energy efficiency. In contrast, no problem is identified for cooling. The average dwelling in a multi-apartment building has primary energy needs of about 165 kWh, the highest in *Dois Portos e Runa* and lowest in *Turcifal*. Electricity is the dominant heating energy source. Another relevant building indicator, which complements the energy performance analysis and introduces the conservation dimension, is the share of buildings with repair needs. According to this indicator, the *Dois Portos e Runa* parishes have the highest share of buildings with repair needs, whereas *Ponte de Rol* has the lowest, 8%. Buildings repair needs can range from minor to more significant interventions, and therefore do not necessarily reflect automatically substantial problems related to their energy efficiency. The indicator can also point to economic difficulties within the household, preventing renovation work from being commissioned. Approximately 32% of buildings in the municipality require repairs (Instituto Nacional de Estatistica, 2021b). Regarding the population's demographic and socioeconomic situation, 62% of the population has only primary education or none, which is frequently correlated with lower incomes. Moreover, it may indicate that these citizens are likely to be less knowledgeable about energy issues, resulting in lower adaptive capacity. *Ventosa*, located in the southwest part of the territory, has the highest rate of residents with lower educational levels. In contrast, westernmost *Silveira* has the highest percentage of citizens (42%) with at least a secondary education (Instituto Nacional de Estatistica, 2021b).

The condition of tenancy can also be seen as one of less power and higher vulnerability (Riva et al., 2021), as decisions regarding the home belong to the landlord, and split incentives often pose a considerable barrier to home renovation and increased energy efficiency. Moreover, the housing rental market is considerably inflated due to growing demand and a lack of regulation, as renters often face burdensome rents to secure a comfortable living space. Approximately 52% of dwellings in Torres Vedras are rented. The highest share (62%) is found in both *Ventosa* and *Ponte de Rol* (in the centre of the municipality) (Instituto Nacional de Estatistica, 2021b). In *Silveira*, it is more common for people to own their homes (40% of dwellings are rented). There are no private housing entities (homeowners' associations, housing cooperatives, housing management companies, or other housing entities).

Age is considered a significant factor increasing exposure to energy poverty (Middlemiss, 2022). Children and individuals over 65 are considered more vulnerable to thermal comfort distress due to their lower adaptive capacity (Gouveia *et al*., 2019). In the municipality, there are 13% of children 14 or younger and about 23% of elderly citizens. The *Campelos e Outeiro da Cabeça* (in the north area) has the youngest share of young children (14%), whereas *UDois Portos e Runa* (in the south-east area) has the highest percentage of elderly population (31%). The results for these indicators are displayed in Table 5.

Another relevant indicator to assess local vulnerability is the number of people who received support from the council. There are three programs providing support related to housing and energy poverty: Programa de Apoio ao Arrendamento, which offers rent support; the PCOCRBHD (Rehabilitation of degraded homes Support), which provides support for the rehabilitation of degraded homes; and *1º Direito*, which supports subletting, home renovation, and the purchase of new homes. The number of beneficiaries per parish (448 in total) is displayed in Table 5. The civil parish in which the city is located naturally has a higher number of beneficiaries, reflecting the city's larger population. The civil parishes of *Dois Portos e Runa, Maxial e Monte Redondo*, and *A dos Cunhados e Maceira* also present a significant number of household beneficiaries (63, 34 and 44), reflecting the overall higher vulnerability in the population of these territories.

Table 5: Number of beneficiaries of the three municipal support programs

Number of people supported	Programa de apoio ao arrendamento (Rent support)	PCOCRBHD – Rehabilitation of degraded homes Support	1º Direito – Subletting, Renovation, Purchase of homes
Freiria	0	8	4
Ponte do Rol	0	12	1
Ramalhal	0	11	7
São Pedro da Cadeira	0	14	7
Silveira	0	9	17
Turcifal	0	3	8
A dos Cunhados e Maceira	0	30	14
Campelos e Outeiro da Cabeça	0	12	3
Carvoeira e Carmões	1	12	2
Dois Portos e Runa	0	25	38
Maxial e Monte Redondo	0	27	7
Torres Vedras e Matacães	77	42	85
Ventosa	0	4	4

Source: Municipality of Torres Vedras.

Finally, testing the MEPI for Torres Vedras, using data at the subsection and civil parish levels to characterise the vulnerability of each subsection, identified a total of 133 vulnerable subsections out of 2085, spread across all 13 parishes. The map of the vulnerable subsections is displayed in Figure 12. The map shows a considerably higher density of vulnerable subsections in the interior of the municipal territory, linked to joint low energy efficiency and socioeconomic vulnerability. The population of these 133 subsections amounts to 1,281 people, who are in more vulnerable conditions.

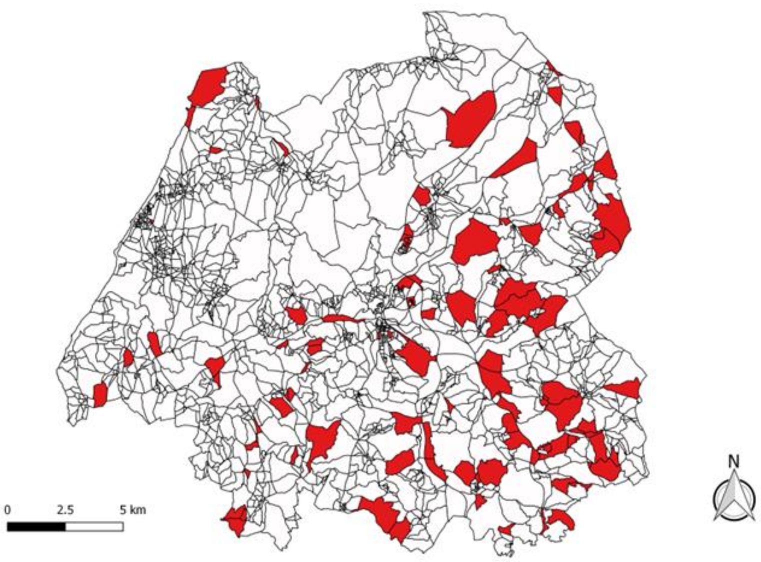

Figure 12: Vulnerability hotspot subsections in Torres Vedras

Source: Elaborated by NOVA.

4.3.2. Local energy poverty (top-down modelling approach)

The collection of national-level household data is finalised, and the last administrative datasets are being collected, which will enable a more robust top-down simulation model currently in development, following the approach implemented in Poland (section 4.1.2).

4.3.3. Energy poverty perceived by local stakeholders (qualitative approach)

Both in face-to-face (F2F) and group meetings, local stakeholders identify older people as a particularly vulnerable group to energy poverty. Old building stock, which is often poorly constructed and has low energy efficiency, is also identified as a significant factor contributing to higher vulnerability. Both factors are underscored by economic deprivation, creating compound vulnerability.

Socioeconomic vulnerability intersects with specific technical conditions that can increase vulnerability. The use of low-efficiency stoves and fireplaces is more common among older adults, which may have consequences for indoor air quality (Stojilovska et al., 2023). In fact, poor ventilation and security were mentioned as everyday issues. Lack of ventilation is often also a coping mechanism for facing cold temperatures. Security is related to inadequate and unsanitary housing conditions, which are present across the municipality. The condition of tenancy is also seen as a factor of vulnerability, specifically in multi-apartment buildings. The lack of knowledge regarding energy issues, as well as the cultural engraining of coping practices perceived as typical, are also identified as relevant factors characterising households in energy poverty, preventing self-recognition of this issue and acceptance of support. Using blankets and turning off the heating when temperatures are cold are recurrent behaviours, as corroborated by Horta et al. (2019). Often, thermal comfort is not a priority. Torres Vedras is regarded as a very humid region, with consequences for home deterioration. The migrant population in illegal housing/rental are a growing, vulnerable group.

There is a growing trend in renovation, with a high demand for properties to invest in. There is also an increased demand for housing and renovation from young people seeking affordable housing in the outskirts, driven by economic factors (lower costs) and social factors (such as traffic, quality of life, and school conditions for children). Nevertheless, several barriers to building renovation for energy poverty mitigation have been identified, including high material costs, scarcity of labour/workforce, slow renovation processes, administrative processes and bureaucracy, economic deprivation, heirs' inheritances and difficulties in dividing property, and land registration issues (such as tracing owners). Lack of trust among the population regarding support actions and local governments, outdated property registries, and technical difficulties in renovation works are also seen as substantial barriers. Very demanding standards for new buildings pose challenges regarding their cost and accessibility to lower-income households. New homes have better energy performance, but prices are unsustainably high for the average family, let alone the most economically vulnerable. The fact that citizens have to incur upfront costs in some national renovation programs is also seen as a deterrent to building renovation.

Fragmented ownership within multi-apartment buildings presents a challenge, as residents often disagree over priorities. However, there are cases of mixed property buildings (public and private), which can present an opportunity, as public entities can push for and organise renovation works that benefit the private dwellings.

Some tax incentives (such as reducing VAT to 6%) require an improved energy performance class, which is a good practice, but quality control of renovation works remains an issue. The municipality does not monitor common renovation works; only bigger projects require licensing. The increasing ease of licensing has had negative consequences for home quality, comfort, lighting, and air quality. Informal interventions can compromise fundamental issues (e.g., security). A new municipal regulation is currently being developed, presenting an opportunity to introduce positive changes. Social housing can be used as an example of good renovation practices.

The primary role of the municipality identified by the stakeholders is to manage support programs such as Municipal Program for Subsidising Works for the Conservation, Repair, or Improvement of Degraded Dwellings; Dissemination and support in the national ones like the environmental Fund renovation program (already finished) and the "Bilha Solidária" (Solidarity Gas Bottle) program. They also have a relevant role in disseminating existing and/or future support/aid, ensuring access to information, increasing literacy on energy poverty, providing technical support, and defining a mitigation strategy.

On the other hand, local parishes primarily serve as mediators in implementing various support programs. They are facilitators in the application of programs, but only at the informational level. They play a part in the dissemination of programs. They can also play a role in identifying or signalling social support or vulnerable families. Some stakeholders also mention their role as inspectors for the municipal programs. The possibility of creating a support office for renovation/licensing in coordination with the municipality to streamline the bureaucratic procedure, a greater effort to engage with locals/parishioners, and the power to incentivise associativism/community involvement were mentioned as potential roles to further pursue by these local authorities.

Several local actors have been identified as potential stakeholders, including associations (religious, recreational, and social support), condominium management entities, social support services, local support centres for migrants, and social integration services. No homeowners' associations were identified. Collaboration between local governments and associations has proven fruitful, e.g. Just a Change for the renovation of homes. Partnerships with other local partners and associations can also contribute to a more accurate and effective identification of vulnerable families. The coordination between different actors (authorities, associations, universities, and companies) can bring synergies and complementarity of diverse knowledge and actions. It was noted that there are significant connections between national programs promoting building renovation and municipalities, such as the deployment of Recovery and Resilience Plan funding and collaboration in household signalling, marking an important alignment and cooperation between central and local governments.

The identification of hotspots of vulnerability within the municipality and city, as revealed in the mapping exercise, presents different perspectives, as shown in Figures 13-16. Coastal areas are often highlighted as more economically affluent and with more efficient housing, thus presenting lower vulnerability. The inland areas are perceived as more vulnerable than the coastal areas, while the region of *Macieira* is identified as particularly vulnerable. Urban areas near the road links to Lisbon are seen as less vulnerable and more expensive. During face-to-face meetings with civil parish presidents and representatives, they were asked to assess the energy poverty vulnerability of their parish on a scale of 1, indicating potential energy poverty, to 4, indicating severe energy poverty. The hot spot parishes are similar to those identified by the majority of participants in the group sessions, as shown in Figures 13-16. The inland, more rural civil parishes of *Maxial, Redondo, Carvoeira,* and *Carmões* are the most vulnerable. In contrast, Turcifal, where mostly high middle-class inhabitants reside, is identified as the least vulnerable. Within the city centre, there is also some disparity of opinion. Still, there is a consensus that the surrounding neighbourhoods to the castle are the most vulnerable, due to an old building stock and ageing population.

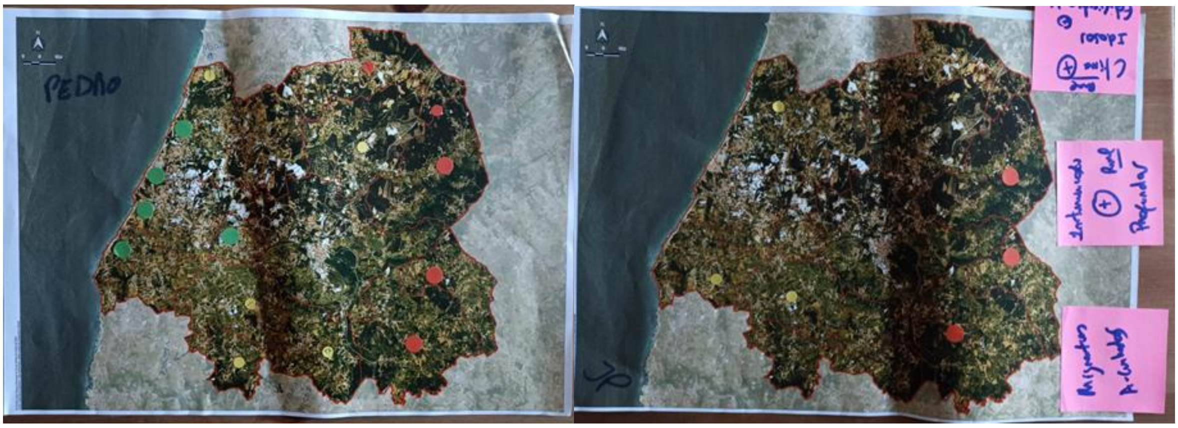

Figure 13: Mapped hotspots of vulnerability in the Torres Vedras Municipality by three stakeholder groups at the stakeholder group meeting (A and B).

Source: NOVA/Municipality of Torres Vedras.

Figure 14: Mapped hotspots of vulnerability in the Torres Vedras Municipality by the three stakeholder groups at the stakeholder group meeting (C)

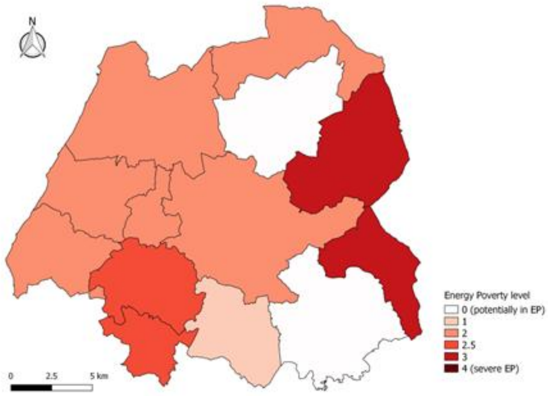

Figure 15: Mapping of civil parish representatives' self-attributed Energy poverty rate

Source: NOVA/Municipality of Torres Vedras.

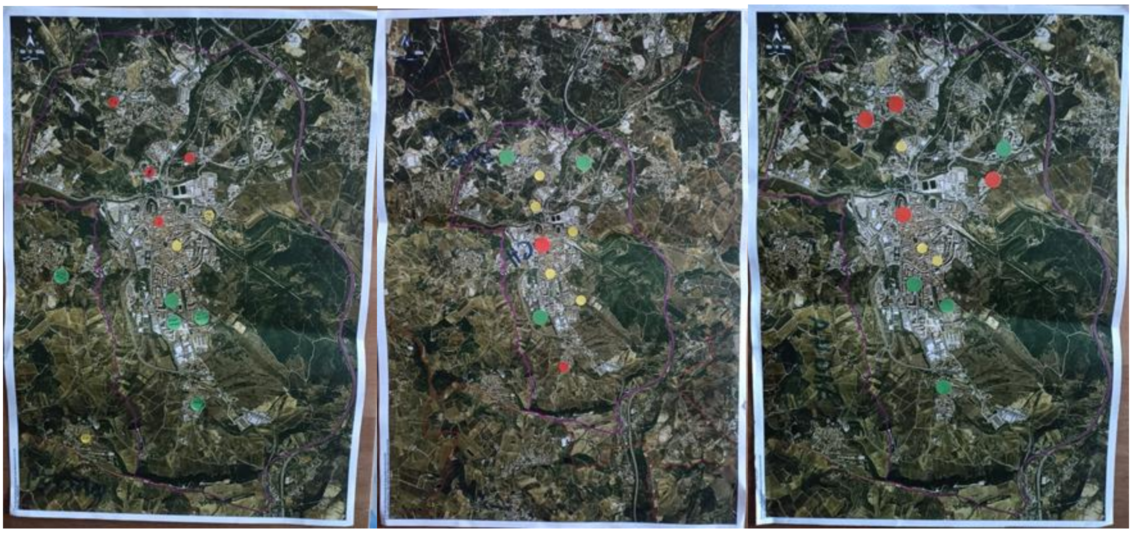

Figure 16: Mapped hotspots of vulnerability in the Torres Vedras city by the three stakeholder groups at the stakeholder group meeting (A, B, C)

Source: NOVA/Municipality of Torres Vedras.

4.3. Piraeus

4.3.1. Local energy poverty (bottom-up approach)

In Piraeus, the multi-apartment building stock comprises almost 16,514 buildings with a combined estimated total floor area of over 5.36 million m^2 (Hellenic Statistical Authority, 2021). The multi-apartment building stock in the Municipality of Piraeus is characterised by mid-century multi-apartment blocks, which form a dense, mixed-use urban fabric (Figure 17). Most of the buildings were constructed between 1961 and 1985 (8,954 buildings, 54%), before the establishment of the national thermal regulation for buildings (Statistics Greece, 2025). More accurately, 72% of the Municipality's buildings have been built before 1985, while approximately 27% have been built after 1985 (1% of buildings' construction period is not available), thereby indicating an ageing building stock. Typical buildings are mid-rise (with a mean of 3 floors) and feature compact dwelling units, most commonly with a usable area of approximately 60 to 90 m^2 (mean of roughly 76 m^2), reflecting the Municipality's constrained plots and high land values. Moreover, 59% of the dwellings in the Municipality are privately owned by individuals, while 36% of the dwellings are rented by tenants (Statistics Greece, 2021). A smaller share of the stock is owned by legal entities (e.g., companies and institutions) and by the Municipality, with municipal buildings generally being smaller on average than privately managed condominium blocks (a share of 5%, categorised as "other types of ownership"). Finally, in contrast to the Polish context, housing cooperatives are comparatively rare in the Greek context.

Figure 17: Urban context of Piraeus.

Source: Municipality of Piraeus

Across Piraeus' multi-apartment building stock, the annual primary energy intensity typically averages 237 kWh/m², which, based on the average usable area, equals 18,012 kWh annually, reflecting an intense energy consumption building stock. The estimated share of apartments that belong to multi-apartment buildings using RES is around 22% (*including solar energy for hot water through solar water heaters*). EPC evidence suggests that only a minority of Piraeus households in multi-apartment buildings currently attain energy class of A+, A, B and B+ – specifically only 4% of them – while the rest, 96%, of them are characterised by an energy class of C or lower, thereby indicating a low energy performance building stock in the Municipality.

Across Piraeus, 27% of the residents are under 30 years old, while 44% are between 30 and 59 years old (the remaining 29% are aged 60 years or older) (Statistics Greece, 2021). The gender distribution of the municipality's residents is 48% male and 52% female, consistent with national urban patterns. Taking into account the abovementioned sociodemographic characteristics, these signals suggest that older cohorts – substantial in size – may face higher barriers to navigating administrative, financial, and digital processes linked to housing renovation and energy upgrades, while mid-aged and younger cohorts concentrate the human capital needed to lead or coordinate collective action also in multi-apartment building settings.

In Piraeus, space heating in apartments of multi-apartment buildings is dominated by oil boilers (62% of the apartments), accounting for almost two out of three apartments. District heating is not a common practice in most Greek urban settings; thus, it is absent, and solid-fuel use is limited to a small share of individual dwellings (only 0.3% use solid fuels like biomass for heating and hot water). Electrified heating has expanded, primarily through air conditioning, since 25% of space heating is achieved through electricity, while almost three out of four apartments (76%) use electricity for space cooling. It is noted that only 10% of the apartments use natural gas boilers for space heating, cooling, and hot water, while 0.2% use alternative fuels, such as liquid gas, for their space heating. Renewable heat is primarily present through the widespread use of solar-thermal collectors for domestic hot water on rooftops, as 21% of the municipality's apartments in multi-apartment buildings utilise solar water heaters.

In conclusion, a similar approach to the case of Rumia (a methodological framework similar to MEPI) is employed for estimating the percentage of households in Piraeus that are likely to be affected by energy poverty. More accurately, by considering the number of building units (apartments that belong to multi-apartment buildings): (i). been constructed before 1981, (ii) have an EPC class of "C" or lower grade and (iii). Use fuel oil or solid fuels (biomass) as a heating source. The condition for characterising a unit as "affected by energy poverty" presupposes that at least two out of these three criteria are met. However, the case of having an apartment with an EPC class of "C" or lower grade and using fuel oil or solid fuels as a heating source is not taken into account due to the interconnection of these two parameters (e.g., an apartment that uses fuel oil as a heating source is very likely to have a lower EPC class). As a result, the probability of being in energy poverty is calculated for the following three cases:

- Been constructed before 1981 AND have an EPC class of "C" or lower.
- Been constructed before 1981 AND use fuel oil or solid fuels (biomass) for heating.
- Been constructed before 1981 AND use fuel oil or solid fuels for heating AND have an EPC class of "C" or lower.

From the calculations above, three indices are exported, and the greatest of these is retained for inclusion in the most building units. Following this methodology, 28% of apartments of multi-apartment buildings in Piraeus are likely to be affected by energy poverty (13,552 apartments out of 48,405 in total). The analysis is applied at the apartment level based on the availability of relevant data (e.g., EPCs and heating source) at this level of granularity. Finally, it should be noted that this preliminary analysis will be further populated once we more (sociodemographic) parameters are collected (data collection process is ongoing) for the calculations of the vulnerability index (e.g., income, gender and residents' age), thereby making the estimation more accurate and providing even more robust estimations of local energy poverty in private multi-apartment buildings.

4.3.2. Local energy poverty (top-down modelling approach)

Once data collection for the Municipality of Piraeus is finalised, including national-level variables on income, gender, age, and household size, a comparison of bottom-up and top-down energy poverty calculations will take place, following the approach implemented in the case of Poland (section 4.1.2).

4.3.3. Energy poverty perceived by local stakeholders (qualitative approach)

Energy poverty in the Municipality of Piraeus is a complex urban issue, primarily affecting older residents and lone female households in multi-apartment buildings with energy-inefficient envelopes. Summer overheating further exacerbates vulnerability in top-floor flats (Koukoufikis et al., 2024; European Commission et al., 2025). In this context, at the national level, Greece is among the Member States (along with Romania and Bulgaria) that have the highest number of individuals facing arrears on utility bills, thereby reflecting broader socioeconomic disparities (Koukoufikis et al., 2024). While national measures, such as the Social Residential Tariff and targeted bill supports, and building renovation schemes like "Exoikonomo 2025" offer partial relief, uptake in dense central municipalities, including Piraeus, has historically lagged behind relative to need and the age of the building stock (Energypress: Greek energy news portal, 2025; *Exoikonomo 2025*). At the local level, social assistance delivered via the Public Benefit Municipal Enterprise (KODEP) and the municipal Community Centre provides casework, referrals to benefits, and basic needs support, but structural barriers in multi-apartment buildings governance and split incentives slow energy upgrades.(Municipality of Piraeus, 2024) In this regard, the LOCATEE project – anchored also in the Municipality of Piraeus – seeks to mobilise data, tools, and tailored interventions for private multi-apartment buildings, in line with EU guidance that prioritises the alleviation of energy poverty (Municipality of Piraeus, 2024).

During the pilot engagement activities, initial discussions were held to strengthen LOCATEE's outreach and provide input for shaping its actions. These discussions addressed key local challenges identified to date, the current situation regarding energy poverty and energy efficiency, as well as barriers to renovation in multi-apartment buildings. During the workshop, the structured questionnaire (→ Appendix 1), translated and adapted to the Greek context, was also distributed to citizen representatives for wider dissemination within their networks. The results of this process indicate that over 90% of respondents reside in apartment buildings or housing complexes, while more than 80% are property owners. Furthermore, more than half (58%) consider themselves "energy poor". The key challenges mentioned in relation to energy poverty and energy efficiency include: (i) *the combination of high renovation costs and low household income*; (ii) *the burden of elevated energy prices*; (iii) *difficulties in finding qualified technicians and coordinating renovation works- particularly in apartment buildings*; and (iv) *high material costs, along with practical issues affecting daily life during renovations (e.g., storage constraints, disruption to household routines)*. In addition to identifying challenges, participants were asked to suggest ways the Municipality could enhance its efforts to alleviate energy poverty. Key proposals include:

- Improved information and guidance: providing regular updates on available and upcoming energy renovation programmes, along with clearer practical support.
- Financial support mechanisms: offering incentives, reduced municipal fees, zero-interest loans, or direct subsidies for energy renovations.
- Enhanced coordination and technical support: simplifying permitting procedures, ensuring faster approvals, and facilitating cooperation with relevant organisations for collective actions (e.g., rooftop solar installations).
- Promotion of new technologies and bundled solutions: supporting the adoption of energy-efficient technologies and offering coordinated renovation packages for entire apartment buildings.
- Large-scale funding initiatives: establishing schemes that enable comprehensive upgrades, particularly benefiting low-income households.

5. Discussion

We structured the discussion around three complementary strands. We begin by outlining the process of administrative data collection across the project countries, highlighting both shared challenges and country-specific pathways. We then compare the three pilot municipalities to illustrate commonalities and differences that shape exposure to energy poverty. Finally, we examine the role of housing intermediaries in multi-apartment buildings – an emerging theme that points toward one of the project's key policy recommendations.

5.1. Administrative data in analysed countries

Our work in three pilot municipalities shows that, with growing access to building- and neighbourhood-level administrative data, it is now feasible to estimate local exposure to energy poverty. However, initial data collection efforts also revealed essential differences in access to administrative data across the partner countries, which are necessary for constructing energy poverty indicators.

For Rumia, building-level data are readily available, often through national open-data repositories. While such data remain useful for municipalities planning energy-poverty mitigation strategies and renovation scenarios, they primarily capture the energy efficiency dimension, offering limited insight into the broader socioeconomic dimensions of energy poverty. A partial way to mitigate this risk is to combine different measurement approaches, integrating both bottom-up and top-down methods. Using the Rumia pilot case, the top-down method proved more effective at capturing the dimension of low energy performance. In contrast, the bottom-up method, due to the structure of the available data, more clearly reflected the income-related aspects of energy poverty. The two perspectives are complementary, allowing us to narrow the scope and pinpoint buildings where residents are likely to require support. Importantly, both approaches are replicable under Polish conditions and require relatively modest data from municipalities and state institutions, without compromising access to sensitive personal information.

For Torres Vedras, no data are available at the building level, which prevents the identification of energy poverty probabilities or levels at this scale. However, indicators depicting building energy performance and socioeconomic and demographic conditions at the postcode, subsection, and civil parish levels could be combined to identify the most vulnerable subsections across the municipality and the respective drivers of vulnerability. It represents a step forward in local energy poverty assessments in the country, as the most granular analysis available to date was developed at the parish level. It combines the quantitative approach with qualitative analysis and mapping based on stakeholder auscultations, for comparison, validation, and added robustness. There are limitations associated with the redundancy of the chosen indicators and their different spatial units of analysis. However, decisions regarding the method design aim to add nuance and strength to the representation of each dimension (buildings and socioeconomic), considering that no direct energy poverty indicators are being used, but rather proxy ones. With the additional datasets still being collected, the top-down approach currently under development will address several of these shortcomings, potentially providing a more targeted and direct assessment.

For Piraeus, data collection efforts have progressed effectively, yet they similarly highlighted important constraints in accessing granular administrative data. As in the Portuguese case, most operational datasets relevant to energy poverty – including building condition, heating systems, and EPC information – are available only at aggregated spatial levels, typically the zip code scale. This limits the ability to produce building-level vulnerability assessments and requires methodological adjustments to ensure meaningful diagnostics for multi-apartment buildings. Throughout the process, several institutional and technical barriers were identified, particularly regarding access to socioeconomic variables, which are crucial for capturing the social dimension of energy vulnerability but are either unavailable or not systematically collected at fine spatial scales. To overcome these gaps, the project has collaborated closely with the Municipality of Piraeus and the Greek Ministry of Environment and Energy, enabling the retrieval of key datasets from municipal repositories and national services. These local indicators will be coupled with national-level data, especially income, demographics, and household composition, to support the development of the top-down modelling approach. Although current datasets emphasise the energy performance dimension, their integration with national data will strengthen the forthcoming diagnostic tools and allow for a more robust representation of local energy poverty risks.

5.2. Pilot municipality similarities and differences

The three pilot municipalities represent distinct urban development trajectories that give rise to different varieties of domestic energy deprivation, shaped by building age, ownership structures, climatic conditions and socio-demographic profiles. Rumia is a dynamically expanding urban area where new residential developments coexist with older multi-apartment blocks and municipal stock; Torres Vedras presents a more balanced and incremental pattern of urban growth, while Piraeus is a compact and dense urban fabric with almost no remaining space for expansion. These structural differences underpin a broad range of vulnerabilities. In Rumia, with only one-quarter of buildings constructed before 1980, domestic energy deprivation is strongly linked to the condition of ageing municipal housing and small private multi-apartment buildings without established housing intermediaries. Torres Vedras, with nearly half of its buildings predating modern thermal requirements, exhibits more pervasive inefficiencies dispersed across inland neighbourhoods but embedded in a predominantly private housing market (Table 6). Piraeus, in contrast, is characterised by an aged stock of multi-apartment buildings, where poor thermal envelopes, insufficient ventilation, and ageing installations amplify both winter and summer energy stress.

Differences in building age and associated technical conditions further reinforce these contrasts. Rumia’s mixed-age stock includes both post-2000 developments with relatively efficient envelopes and older municipal and small private multi-apartment buildings with outdated infrastructure and minimally developed renewable energy infrastructures. Torres Vedras, despite its moderate climate, faces disproportionately high energy use due to older fabric and low-efficiency electrical heating devices, particularly among lower-income households. Meanwhile, Piraeus exhibits the structurally highest concentration of old buildings, resulting in extensive thermal losses, system inefficiencies, and pronounced vulnerability to overheating – an increasingly critical dimension of domestic energy deprivation (Thomson et al., 2019). Climate conditions play a dual role across the cases: although all three cities lie in coastal zones with generally milder winters than their inland counterparts, their climatic profiles diverge significantly. Especially Piraeus faces severe summer heat, making cooling needs and exposure to overheating a core component of energy vulnerability. Conversely, in Rumia and Torres Vedras, winter heating remains the primary driver of energy stress. However, results of research findings in Rumia's housing cooperatives indicate that summer heat is becoming increasingly relevant, even in northern Poland, with a growing tendency toward the installation of air conditioners and cooling appliances (Frankowski et al., 2025). This signals an important transition: domestic energy deprivation is no longer primarily driven by cold-related hardship, even in countries such as Poland, but increasingly by an evolving dual burden of inadequate heating and cooling.

Table 6: Comparison of three pilot municipalities

Dimension	Rumia	Torres Vedras	Piraeus
Number of multi-apartment buildings	1,072	3,182	16,514
Dominant heating sources in multi-apartment buildings	Gas and district heating	Electric	Electric and oil
Ownership modes	Diversified ownership structure (cooperatives, homeowners' associations, individual ownership)	Individual private ownership with a more developed rental market	
Vulnerability hotspots	Social housing buildings, small multi-apartment buildings without established housing intermediaries	Inland parishes with older housing stock	Ageing centrally-located multi-store buildings, especially on top floors
Quantification of energy poverty exposure	20% of multi-apartment buildings	6% of subsections	28% of the apartments
Specificity of the support policies	Social assistance and housing support in two departments	Mostly housing instruments, including support for rents and renovations	Social support provided by a separate unit, also responsible for social innovations (KODEP)

Source: own elaboration.

These structural and climatic factors interact with distinct ownership regimes. Rumia exhibits a diversified ownership structure, combining private units, cooperatives, homeowners' associations, and a non-negligible share of municipal housing – each with different governance capacities and access to renovation funding. Torres Vedras and Piraeus, by contrast, are characterised by private ownership and exhibit a more developed rental market, which gives rise to issues of split incentives and fragmented decision-making. In Piraeus, the high density of small private apartments particularly complicates coordinated renovation efforts, with governance arrangements and co-ownership rules emerging as significant barriers to collective action. These ownership distinctions shape both the feasibility and pace of energy retrofit interventions. While Rumia's cooperatives can mobilise collective decision-making relatively efficiently, private and fragmented ownership in Piraeus and Torres Vedras introduces higher transaction costs and reduces the effectiveness of standard incentive schemes.

The social structure of the three municipalities reveals important similarities and differences. All are ageing, with older residents increasingly living alone, often in oversized or inadequately adapted dwellings. Especially, women – particularly those 60 years or older, living alone – appear disproportionately among those experiencing domestic energy deprivation, as confirmed by both administrative data and qualitative accounts. Yet, each city shows different spatial patterns of vulnerability: in Rumia, the highest concentrations of households in energy poverty are found in municipal buildings, ageing cooperatives, and small multi-apartment buildings without established housing intermediatory; in Torres Vedras, vulnerability hotspots are located predominantly in inland municipal subareas with older building stock; and in Piraeus, the most vulnerable households reside in ageing central multi-storey buildings, especially on top floors where exposure to extreme summer temperatures is most pronounced. These differences reflect localised varieties of domestic energy deprivation – ranging from heating cost burdens and insufficient insulation to cooling deficits and thermal discomfort – reinforced by demographic pressures and household composition.

Across all cases, municipalities hold only an indirect and limited mandate regarding private multi-apartment buildings, primarily limiting their role to providing advisory services, coordination, information, and mediation. Social assistance institutions operate separately from energy efficiency schemes, resulting in fragmented governance and weak institutional anchoring of domestic energy deprivation. Moreover, none of the municipalities explicitly places energy poverty at the core of their local policy agenda; rather, the issue is addressed implicitly as an expected co-benefit of broader and external retrofit programmes or energy transition in general. This institutional fragmentation, typical for small and medium-sized understaffed municipalities across Europe, which have limited financial resources, presents a structural challenge for scaling up targeted and coordinated interventions in the area of energy poverty.

Given these constraints, municipalities frequently lack the financial, technical and legal capacity to support direct renovation activities in private multi-apartment buildings; they are also obliged to prioritise investment in their municipal housing stock. Moreover, larger entities – such as regional funds, national/regional energy agencies, and building management bodies – possess more substantial competencies and resources to provide dedicated technical services to multi-apartment building residents, particularly in preparing detailed energy audits or coordinating specific and complicated renovation activities. Nevertheless, the role of municipalities in the field of private multi-apartment buildings remains significant, particularly in ensuring policy coordination, knowledge transfer, stakeholder engagement, and targeted interventions. Projects such as LOCATEE provide municipalities with additional capacities and resources for these activities, which, without LIFE+ support, would likely have no chance of being implemented.

5.3. Housing intermediaries in multi-apartment buildings

An essential yet often overlooked factor influencing exposure to energy poverty is building ownership. Ownership structures differ significantly between Central European countries, such as Poland, the Czech Republic, and Germany, and those in Southern and Southeastern Europe, like Portugal and Greece (Kováts & Kohl, 2025). This variation has important implications for vulnerability to energy poverty. The presence of an institutional intermediary within the private housing stock – such as a cooperative, a homeowners' association, or a professional property manager – can substantially reduce the likelihood of energy poverty conditions.

Across all three cases, the pilot identified important opportunities for strengthening municipal coordination, including one notable insight emerging especially from Rumia: the positive and strategic role of housing intermediaries, who facilitate communication between households, building administrators, and service providers. In Torres Vedras and Piraeus, a common individual horizontal property regime exists within multi-apartment buildings, which can lead to difficulties in engaging with homeowners. Moreover, there is a high percentage of home tenancy, where households do not have agency over the property in which they reside. On-the-ground projects (Gouveia et al., 2024) have shown that engaging with the citizens in energy poverty who own or rent an apartment is even more challenging. Still, local governments and stakeholders can have an important role in increasing support adoption among these segments. Introducing or strengthening an intermediary – such as a professional manager or a homeowners' association – could significantly support renovation processes and better assist households facing energy poverty. Enhancing such mechanisms could strengthen the municipal mandate, improve the uptake of renovation programmes, and help place the needs of energy-poor households at the core of local policy design. In Rumia, this could mean starting discussion on establishing small homeowners' association and/or considering offering the services of the municipal housing company to the small private multi-apartment buildings; in Torres Vedras, this could mean engaging condominium companies, which are entities responsible for managing building properties; in Piraeus, it could involve strengthening or formalising building administrators so they can act as a coordination point and better inform individual homeowners. Such institutions can facilitate regular saving, access to financial support, and stable collective decision-making regarding the construction of infrastructure and common areas. In the case of private managing companies, it might require the implementation of specific incentives targeting these entities to trigger their action in prompting homeowners towards collective and individual EE work and support request/application.

Addressing split incentives between landlords and tenants is also essential, as many rented apartments cannot be renovated without owner consent. Creating structured dialogue spaces and support mechanisms could help align interests and find a balance between enabling renovations, allowing landlords to secure their benefits, and safeguarding tenant rights (Papantonis et al., 2022). For these reasons, one of the project's key recommendations for municipalities is to foster the establishment and activation of local housing intermediaries capable of supporting renovation efforts and providing structured assistance to residents affected by energy poverty. The outcomes of this report and the LOCATEE toolkit will precisely help identify the districts and buildings where residents in energy poverty reside, enabling effective territorial targeting of efforts and instruments to promote engagement and collaboration, and ultimately achieving a higher impact on the ground for energy poverty mitigation. These energy poverty analysis approaches are particularly relevant as they can serve as blueprints for replication across regions and cities within the case-study countries, potentially contributing to the scaling of energy poverty diagnosis and action nationally and across the EU.

6. Conclusions

This report demonstrates that addressing energy poverty in European municipalities requires combining building and neighbourhood-level evidence, spatial diagnostics, and an in-depth understanding of domestic energy deprivation. The three pilot cities – Rumia, Torres Vedras, and Piraeus – illustrate how built environment, climatic conditions, and structural factors shape different expressions of energy poverty, even when municipalities share similar general challenges.

The methodological work carried out in the pilots shows that measuring energy poverty risk at local and building levels is feasible. By integrating top-down and bottom-up approaches, the project helps surface complementary aspects of vulnerability – from building performance constraints to household resources and renovation barriers. The Rumia case demonstrates that such tools can be implemented with relatively modest data requirements. At the same time, the work in Torres Vedras and Piraeus indicates the need to adapt approaches to contexts where building-level datasets are more limited. These differences in data availability will remain important for the next methodological steps in the project, especially in developing the Energy Poverty Monitoring System (EPMS), a key component of the LOCATEE toolkit.

The results also relate to the broader policy landscape in which municipalities operate, particularly the implementation of the Social Climate Fund at the local level and the revised Energy Performance of Buildings Directive. All three municipalities have limited mandates regarding privately owned multi-apartment buildings. Still, the analyses produced here may support their advisory roles – for example, by identifying priority buildings, mapping vulnerabilities, or aligning local actions with EPBD-related planning requirements.

An essential aspect of the project has been the effort to engage stakeholders around the overlooked segment of privately owned multi-apartment buildings. Although still in its early stages, the emerging contact points within municipalities, the initial sharing of data and guidance, and the attention given to housing intermediaries represent steps toward improving coordination between local actors and facilitating renovation processes in buildings where collective decision-making is often challenging. These elements provide a foundation on which more systematic local monitoring and engagement can gradually be built.

Looking forward, the subsequent phases of the LOCATEE project will further develop the analytical framework, extend the top-down approach across all pilot municipalities, and explore how the combined insights can inform practical recommendations at the intersection of energy, housing and social policy. The project aims to support municipalities in gradually strengthening their capacity to identify vulnerable buildings, reach residents more effectively, and embed energy poverty considerations more directly within their strategic planning.

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Appendix 1: The basic interview script

Institution	………………………………………………………………………………………	
Date and location	………………………………………………………………………………………	
Statistical information	……. Number of buildings	……. Number of apartments
Moderator	………………………………………………………………………………………	

1. What major renovations have you carried out in the last 5 years? From which sources?

………

………

2. What renovation activities are the most important for your housing stock in the next 5 years? From which sources do you plan to obtain financing?

………

………

………

3. What are the main barriers to renovating multi-family buildings? Name at least 3 and rank.

………

………

………

4. How is energy poverty manifested in your housing stock?

………

………

………

5. What actions on renovation and combating energy poverty do you expect from the municipality?

………

………

Appendix 2: F2F meetings with stakeholders

No	Interviewee institution	Case study	Month
#01	Housing cooperative	Rumia	October 2024
#02	Housing cooperative	Rumia	October 2024
#03	District ambassador	Piraeus	March 2025
#04	District ambassador	Piraeus	March 2025
#05	District ambassador	Piraeus	March 2025
#06	District ambassador	Piraeus	March 2025
#07	District ambassador	Piraeus	April 2025
#08	Housing cooperative	Rumia	May 2025
#09	Institute of Housing and Urban Rehabilitation	Torres Vedras	May 2025
#10	Housing and Urban Regeneration Unit	Torres Vedras	May 2025
#11	Intermunicipal community	Torres Vedras	May 2025
#12	Parish representative	Torres Vedras	May 2025
#13	Somos Comunicade	Torres Vedras	June 2025
#14	Parish representative	Torres Vedras	June 2025
#15	Parish representative	Torres Vedras	June 2025
#16	Parish representative	Torres Vedras	June 2025
#17	Parish representative	Torres Vedras	June 2025
#18	Parish representative	Torres Vedras	June 2025
#19	Parish representative	Torres Vedras	June 2025
#20	Parish representative	Torres Vedras	June 2025
#21	Parish representative	Torres Vedras	June 2025
#22	Parish representative	Torres Vedras	June 2025
#23	Programming Deputy Mayor	Piraeus	June 2025
#24	Municipality Development Organisation	Piraeus	June 2025
#25	Parish representative	Torres Vedras	June 2025
#26	Social NGO focused on poverty alleviation	Rumia	June 2025
#27	Plenipotentiary responsible for NGOs	Rumia	June 2025
#28	City Network Representative	Piraeus	June 2025
#29	Public Benefit Municipal Enterprise of Piraeus	Piraeus	June 2025
#30	Deputy Mayor of Building Services	Piraeus	June 2025
#31	Municipal Councillor	Piraeus	June 2025
#32	Greek association of property owners	Piraeus	June 2025

#LIFELOCATEE

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