

**Assessing the impact of energy poverty on vulnerable communities:
Case study on social housing neighborhoods in Montijo**

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ASSESSING THE IMPACT OF ENERGY POVERTY ON VULNERABLE COMMUNITIES:

CASE STUDY ON SOCIAL HOUSING NEIGHBOURHOODS IN MONTIJO

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Para os meus avós, e para a minha estrelinha

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Abstract

Energy Poverty is a significant concern affecting millions of households across Europe, with a disproportionate impact on vulnerable communities such as those living in social housing neighborhoods. This study centers on Montijo, Portugal, where the population faces challenges in maintaining adequate domestic heating at a rate significantly above the European Union average. The research aims to understand the structural factors of energy poverty in Montijo, followed by a verification of this fragility in social housing neighborhoods, and to evaluate the effectiveness of current mitigation strategies, with the aim of offering specific solutions. The case study was chosen based on an analysis of the four municipalities that were part of the *Ponto de Transição +PRÓXIMO* project - an energy efficiency One-Stop-Shop: Alcochete, Barreiro, Moita and Montijo. Montijo stood out due to its particular social housing challenges and the availability of relevant data, such as the Energy Poverty Vulnerability Index and energy performance certificates of social housing units in Bairro Novo do Esteval (Montijo), referring to multi-family housing, to assess housing conditions. Qualitative data was collected through interviews with local stakeholders and surveys of residents derived from the One-Stop-Shop initiative, highlighting their experiences and coping strategies. The Energy Poverty Vulnerability Index revealed high vulnerability scores in certain civil parishes of the municipality, associated with inadequate housing and low incomes - factors associated with social housing residents. The energy performance certificates indicated widespread inefficiency, while interviews with local stakeholders and citizen surveys identified obstacles in implementing energy-saving measures and the adverse health effects of reducing heating use. The results highlight the prevalent nature of energy poverty in Montijo's social housing neighborhoods and suggest that integrated solutions are needed. These include technical upgrades - such as better insulation and improved heating systems - along with social policies such as financial aid, community awareness-raising, and greater coordination between local authorities, social services, and community organizations. National funding programs such as the Efficiency Vouchers can play a crucial role in supporting these efforts, especially in the most vulnerable areas of the social housing. Better collaboration between local authorities, social services, and community organizations is essential for an effective response to energy poverty in these communities. This dissertation provides a detailed framework for targeted interventions to improve the energy efficiency and living conditions of social housing residents in Montijo, contributing to a more sustainable and equitable future.

KEYWORDS: Energy Poverty, Social Housing, Vulnerability, Energy Efficiency, Montijo

Resumo

A Pobreza Energética é uma preocupação significativa que afeta milhões de agregados familiares em toda a Europa, com um impacto desproporcional nas comunidades vulneráveis, como as que vivem em bairros de habitação social. Este estudo centra-se no Montijo, Portugal, onde a população enfrenta desafios para manter um aquecimento doméstico adequado com uma taxa significativamente acima da média da União Europeia. A investigação visa compreender os fatores estruturais da pobreza energética no Montijo, seguido de uma verificação desta fragilidade nos bairros de habitação social e avaliar a eficácia das atuais estratégias de mitigação, com o objetivo de oferecer soluções específicas. O caso de estudo foi escolhido com base numa análise dos quatro municípios que fizeram parte do projeto Ponto de Transição +PRÓXIMO - uma *One-Stop-Shop* de eficiência energética: Alcochete, Barreiro, Moita e Montijo. O Montijo destacou-se devido aos desafios específicos em habitação social e à disponibilidade de dados relevantes, como o Índice de Vulnerabilidade à Pobreza Energética e certificados de desempenho energético de unidades de habitação social no Bairro Novo do Esteval (Montijo), referentes a habitações multifamiliares, para avaliar as condições de habitação. Os dados qualitativos foram recolhidos através de entrevistas com as partes interessadas locais e de inquéritos aos residentes derivados do Ponto de Transição +PRÓXIMO, destacando as suas experiências e estratégias de sobrevivência. O Índice de Vulnerabilidade à Pobreza Energética revelou elevadas pontuações de vulnerabilidade em certas freguesias do município, associadas a habitações inadequadas e baixos rendimentos – fatores associados a residentes em habitação social. Os certificados de desempenho energético indicaram uma ineficiência generalizada, enquanto as entrevistas com as partes interessadas locais e os inquéritos aos cidadãos identificaram obstáculos na implementação de medidas de poupança de energia e os efeitos adversos para a saúde da redução do uso de aquecimento. Os resultados destacam a natureza generalizada da pobreza energética nos bairros de habitação social do Montijo e sugerem que são necessárias soluções integradas. Estas incluem atualizações técnicas - tais como melhor isolamento e sistemas de aquecimento melhorados - juntamente com políticas sociais como ajuda financeira, sensibilização da comunidade e uma maior coordenação entre as autoridades locais, serviços sociais e organizações comunitárias. Programas como o Vale Eficiência podem desempenhar um papel crucial no apoio a estes esforços, especialmente nas áreas mais vulneráveis da habitação social. Uma melhor colaboração entre as autoridades locais, os serviços sociais e as organizações comunitárias são essenciais para uma resposta eficaz à pobreza energética nestas comunidades. Esta dissertação fornece um quadro detalhado para intervenções direcionadas para melhorar a eficiência energética e as condições de vida dos residentes de habitação social no Montijo, contribuindo para um futuro mais sustentável e equitativo.

PALAVRAS-CHAVE: Pobreza Energética, Habitação Social, Vulnerabilidade, Eficiência Energética, Montijo

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LIST OF ABBREVIATIONS

EDI – Energy Development Index

EP – Energy Poverty

EPAH – Energy Poverty Advisory Hub

EPC – Energy Performance Certificate

EPG – Energy Performance Gap

EPVI -Energy Poverty Vulnerability Index

EU – European Union

HTR – Hard-to-Reach

MS – Member States

NECP – National Energy and Climate Plans

NOVA FCT – Nova School of Science and Technology, NOVA University of Lisbon

OSS – One Stop Shop

SH – Social Housing

UNDP – United Nations Development Programs

ENA – Arrábida Energy and Environment Agency

CENSE – Center for Environmental and Sustainability Research

RNAE - Association of Energy and Environment Agencies

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1. Introduction

Energy Poverty (EP) is an escalating issue globally, particularly affecting vulnerable communities, such as the social housing (SH) estates. Recent statistics underscore the urgency of this issue, as 10.6% of the European Union's (EU) population reported an inability to maintain adequate warmth in their homes in 2023 (Eurostat, 2023a). The rate is even more troubling in Portugal, used to explore a case study in this work, with around 20.8% of the population facing similar conditions (Eurostat, 2024a), a rate remaining above the EU average, illustrating the persistent challenge of energy affordability for low-income households (Horta *et al.*, 2019). EP is a complex issue shaped by a variety of factors such as income, housing characteristics, energy installations, and consumption habits (Llera-Sastresa *et al.*, 2017). These factors contribute to higher energy burdens and increased vulnerability in SH neighborhoods (Bouzarovski & Thomson, 2018; Mashhoodi *et al.*, 2019), and make understanding EP's drivers and consequences crucial for developing effective interventions to mitigate this issue.

SH neighborhoods, often inhabited by impoverished households, are particularly vulnerable to EP due to lower incomes and inadequate housing conditions (Aranda *et al.*, 2017; Bouzarovski & Thomson, 2018; Chen & Feng, 2022a; Llera-Sastresa *et al.*, 2017), such as older buildings, lack of insulation, and inadequate energy installations, tending to restrict their energy use, worsening their situation (Chen & Feng, 2022b; Seabra *et al.*, 2021). In Portugal, SH communities are particularly susceptible to EP due to aging housing stock, poor energy efficiency, and low incomes (Horta *et al.*, 2019). Combining each set of vulnerabilities, EP and SH drive the concern about inequality and marginalization, where disparities associated with more disadvantaged populations are stereotypically exacerbated. Additionally, there is a lack of coordinated policies and funding to address EP effectively. Integrated approaches that combine housing and energy policies are needed to mitigate the issue (Hernández & Bird, 2010; Teschner *et al.*, 2020).

This thesis seeks to analyze how EP affects vulnerable populations, particularly in SH neighborhoods, using a Portuguese region as a case study. By deconstructing the layers of vulnerability in these communities, the research aims to better understand

how EP impacts their everyday lives, health, and well-being. The pressing need to address the multi-faceted vulnerabilities faced by SH residents who are disproportionately affected by EP was the main motivation. Through this research, a deeper understanding of the structural issues contributing to EP will emerge, offering a pathway to more targeted and sustainable solutions.

This will be done in detail through a critical analysis of EP's implications for residents living in SH. The studies aim to examine vulnerabilities that contribute to EP and suggest strategies that could help mitigate these problems. To answer this, the study evaluates the current energy efficiency of social housing units through the analysis of buildings' energy performance certificates (EPCs) to understand how inadequate housing infrastructure directly impacts the energy consumption of residents and contributes to their heightened vulnerability. In addition, by exploring surveys on the living conditions and energy use patterns of residents, insight is provided into how EP manifests daily. Interviews with key stakeholders also shed light on the role of local organizations and municipal initiatives in addressing EP. Interviews and surveys together reveal bureaucratic obstacles, financial constraints, and the difficulties in securing resident consent for both external and internal renovations.

The dissertation is structured into six main chapters, each addressing distinct aspects of the research on energy poverty in social housing. Below is an outline of how it will be organized:

- Chapter one: Presents the background and motivation for the research and introduces the key research question.
- Chapter two: Defines EP, focusing on hard-to-reach (HTR) energy users, analyzes the EU's policy framework and its interrelations with social equity, financial mechanisms, and governance, discusses the policy context specific to Portugal, including alignment, inclusivity, and challenges in implementation.
- Chapter three: Examines the SH context at the European and Portuguese levels.
- Chapter four: Reviews the role of One-Stop Shops (OSSs) in addressing EP, particularly their importance in providing support to vulnerable populations, and

highlights the role of stakeholders and their involvement in the transition toward energy efficiency.

- Chapter five: Describes the case study approach, focusing on Portugal and four municipalities (Alcochete, Barreiro, Moita, Montijo), detailing the methods used, including interviews and surveys to assess EP impacts.
- Chapter six: Provides an in-depth analysis of the findings from the case study, compares it with existing literature, and discusses policy recommendations and future research directions.
- Chapter seven: Summarizes key findings regarding the impact of EP on vulnerable communities within SH neighborhoods. Acknowledges the structural inadequacies and policy challenges contributing to EP in Montijo. Reviews the methodologies utilized in the research and identifies limitations of the study. Proposes future research directions and outlines next steps.

2. Energy Poverty

Energy poverty (EP), a globally recognized challenge, refers to more than the mere privation of energy access. EP is referred to as the absence of a household's access or affordability to fundamental energy services, encompassing essential standards for dignified living and health in Directive 2023/1791 of the European Parliament and of the Council of 13 September on energy efficiency. These services include heating, hot water, cooling, lighting, and the energy required for household appliances. This definition emphasizes the consideration of the national context, prevailing social policies, and other pertinent national frameworks. EP is often linked to poor housing quality, including older, poorly insulated houses, and lack of basic energy service equipment (Chen & Feng, 2022b; Taltavull de La Paz *et al.*, 2022). Implementing energy efficiency measures and retrofitting social housing can significantly reduce EP. These measures include improving insulation, upgrading energy installations, and adopting renewable energy sources (Aranda *et al.*, 2017; Seabra *et al.*, 2021).

EP stems from a convergence of various factors, encompassing, but not confined to, financial constraints, limited disposable income, disproportional energy expenses regarding income, and inadequate energy efficiency within residential spaces. This all-encompassing characterization highlights the diverse aspects constituting EP, as elucidated in the referenced directive.

Bouzarovski and Petrova (2015) shed light on the widespread societal challenge of inadequately heated homes in developed-world households. They argue that fuel poverty (FP), also termed EP, poses challenges in developing countries. The European Union's Third Energy Package incorporates the term EP, emphasizing the need to explore the conceptual relationship between energy and FP paradigms. However, the absence of a comprehensive EP definition is still an obstacle, stressing the need for a systematic, quantifiable method to measure and monitor EP across EU member states (MSs) (Kyprianou *et al.*, 2019).

Li *et al.* (2014) discuss the multifaceted nature of EP, often defined as a lack of access to modern energy services. The Energy Development Index (EDI) is highlighted to compare EP situations in developing countries. The authors note that about 1.3 billion

people lack access to electricity in developing regions, explaining that EP is crucial for development, impacting employment, education, health, and sustainable development.

Pachauri and Spreng (2011) emphasize the growing concern about EP reduction in the public policy agenda. They identify complex factors contributing to EP, including the lack of physical energy availability, income constraints, and high energy costs. In the context of Pan-European initiatives, Sareen *et al.* (2020) highlight the prioritization of EP alleviation, addressing the measurement challenge and emphasizing practical barriers such as limited databases, coverage, and disaggregated resolution.

Various definitions in the literature encompass limited access to electricity and fuel, impacting basic human needs and varying due to climate, technology, and socio-cultural factors. Ulucak *et al.* (2021) research delves into the nuanced dimensions of EP. The concept covers diverse needs such as information technologies, entertainment, education, and transportation. Affordability challenges, rooted in low energy efficiency, income levels, and high energy prices, are pivotal factors contributing to EP. The study underscores that EP transcends mere social and economic challenges constituting an environmental and health problem accentuated by economic crises, climate change, and technological advances, prompting a shift in production and household energy consumption dynamics. The post-pandemic era introduces novel challenges related to socialization and online education in the context of EP.

EP intersects with the United Nations Development Programme's (UNDP) sustainable development goals, hindering sustainable development. Governments and international agendas need to prioritize addressing this issue, prompting research to bridge the knowledge gap regarding EP drivers and formulate effective energy policies (Ulucak *et al.*, 2021).

The lack of consensus on defining EP may pose some challenges in tracking and monitoring, hindering the development of impactful policies. Only a handful of European countries have official definitions and strategies to mitigate EP. Different definitions lead to different measurement methods which can result in varying identification outcomes for energy-poor households. This inconsistency complicates the targeting and implementation of EP alleviation actions (Faiella & Lavecchia, 2021; Halkos

& Gkampoura, 2021; Villalobos *et al.*, 2021). A clear definition is essential for the development of effective policies. Without it, policies may fail to address the specific needs of different regions and populations, leading to ineffective or misdirected interventions (Urquiza *et al.*, 2019; Villalobos *et al.*, 2021; Zainudin *et al.*, 2023). The lack of clear definitions, measurement standards, and systematic data collection on EP hinders effective policy responses (Teschner *et al.*, 2020). There is a need for coordinated policies that integrate housing and energy assistance programs to address EP comprehensively (Hernández & Bird, 2010).

The significance of addressing EP as a global challenge has been underscored, considering its far-reaching implications on social, economic, environmental, and health dimensions. The chapter has delved into the complexities of measuring and monitoring EP, emphasizing the need for internationally consistent measures and a functional definition to guide effective policy development. The literature reviewed has highlighted the intersectionality of EP with broader sustainable development goals, emphasizing its critical role in hindering overall development progress.

A coherent and flexible definition that can be applied across different settings is necessary to understand the relationship between energy and well-being comprehensively. This coherence is currently lacking, which limits the effectiveness of interventions (Day *et al.*, 2016; Li *et al.*, 2014). Moving ahead, it is crucial to recognize EP's dynamic nature, influenced by both subjective and objective metrics, and the changing challenges posed by economic downturns, climate shifts, and technological progress.

2.1. Hard-to-Reach energy users

Exploring a demographic that often stands at the periphery of conventional policy frameworks, such as Hard-to-Reach (HTR) users, is of the uppermost importance to fostering inclusivity and ensuring that the benefits of energy policies reach every corner of society. In energy efficiency and demand response initiatives, the focus on HTR energy users has become increasingly pronounced (Mundaca *et al.*, 2023).

According to Rotmann *et al.* (2020), the term HTR includes audiences resistant to engagement, motivation, or intervention, especially in the context of top-down

initiatives, programs, or services. This encompasses a diverse group, including low-income, energy-poor, and vulnerable households, such as the elderly, young, rural, and minority populations (Rotmann *et al.*, 2020). Low-income households and small businesses often lack the financial resources to invest in energy-efficient technologies and practices (Ambrose *et al.*, 2020; Ashby *et al.*, 2021). Vulnerable and marginalized consumers, such as those living in chaotic conditions, face additional difficulties in accessing and benefiting from energy advice and support services (Ambrose *et al.*, 2020).

Presented by Ashby *et al.* (2020), their work provides an overview of various HTR audience segments, definitions, goals, and intended outcomes of HTR efforts. One key objective was to clarify the often-ambiguous term HTR by better defining the audiences included within it. Underserved audiences encompass individuals, groups, or organizations that are marginalized or not served equitably in society (Ashby *et al.*, 2020). ; while the literature surrounding HTR energy users has expanded, exploring facets like EP, housing, remote communities, small businesses, low-income households, and the rental property market (Mundaca *et al.*, 2023), it is still important to emphasize the need for equity and energy justice for these vulnerable groups, pointing to structural inequalities and racism as key factors, further exacerbated by the COVID-19 pandemic (Rotmann *et al.*, 2020). Vulnerable households and tenants are often underrepresented in energy policies, leading to unfair outcomes. Barriers such as insufficient access to information and decision bias contribute to this issue, making it difficult for these groups to engage effectively in energy transitions (Sequeira *et al.*, 2024). This includes those who do not receive commensurate benefits for their ratepayer funding due to factors such as a lack of suitable program offerings or the inability to participate in existing programs (Rotmann *et al.*, 2020).

Common barriers across various HTR audiences include competing priorities, financial considerations, trust issues, market failures like split incentives, and informational barriers (Rotmann *et al.*, 2020). Specific barriers exist for distinct groups, such as disabled individuals who may rely on others to represent their interests. This dependency can hinder their participation in energy-related decision-making processes (Sequeira *et al.*, 2024). Many HTR energy users also experience anxiety and stress when

dealing with energy-related issues, which can deter them from seeking help or participating in programs (Ambrose *et al.*, 2020). There is often a lack of trust in energy providers and advisors, stemming from past negative experiences and poor treatment (Ambrose *et al.*, 2020). However, there is a notable gap in understanding the specific needs of HTR energy users compared to the extensive exploration of barriers (Rotmann *et al.*, 2020). HTR users frequently lack awareness of available energy efficiency programs and the benefits they offer (Ashby *et al.*, 2021). Vulnerable households often face multiple intersecting vulnerabilities (e.g., being elderly, disabled, or migrants), which complicates their engagement, and the effectiveness of policies aimed at supporting them. A poorly targeted intervention can be ineffective and waste resources (Sequeira *et al.*, 2024). There is a need for more effective communication strategies to reach these users and inform them about energy-saving opportunities (Ashby *et al.*, 2021; Broto *et al.*, 2017).

Estimating the size of the HTR audience is complex, with potential sizes exceeding 50% of the population, depending on definitions and metrics. Most research attention is directed towards the residential sector, with a notable emphasis on multi-family apartments, creating a research void in the non-residential (commercial) sector. The diverse HTR audiences in varied contexts compound the conceptual complexity of delineating the category of 'hard-to-reach' individuals. This underscores the necessity for nuanced approaches tailored to tackle the distinct barriers and requirements they present.

Equity considerations, while acknowledged, remain understudied, requiring further exploration of underlying causes. The reliance on generic policies that target the average consumer is criticized. Instead, structural, and targeted approaches that recognize the specific needs of hard-to-reach groups are called, ensuring that energy transitions are just and equitable (Sequeira *et al.*, 2024). These gaps and complexities are outlined, emphasizing the need for a more comprehensive understanding of HTR energy users to inform effective strategies and policies (Rotmann *et al.*, 2020).

Addressing the challenges posed by HTR energy users is not only a necessity but a moral imperative. The frameworks presented by Ashby *et al.* (2020), Rotmann *et al.*

(2020), and Mundaca *et al.* (2023) provide a valuable starting point, offering a nuanced understanding of HTR audiences and the barriers they face in accessing energy efficiency and demand response programs. The implications suggest that energy policy development must be more inclusive, nuanced, and responsive to the diverse realities of different household types to effectively support energy transitions in the EU (Sequeira *et al.*, 2024). As we navigate the complexities of defining target behaviors, estimating audience sizes, and acknowledging systemic inequities, it becomes clear that a holistic and empathetic approach is required, underscoring the importance of ongoing research, policy development, and collaborative efforts to bridge the existing gaps and ensure that energy programs are accessible to all.

2.2. Policy context in the European Union

Exploring the main energy and energy poverty-related policies within the European Union (EU) provides a nuanced understanding of the strategies employed to mitigate the challenges faced by diverse populations.

The EU's EP and energy efficiency approach represents a complex and evolving policy landscape. Despite the absence of a dedicated EP body and a structured EU-wide strategy, there has been an increasing interest in tackling EP and protecting vulnerable consumers (Kyprianou *et al.*, 2019). The EU has secondarily approached EP through provisions within directives on matters like energy efficiency and market regulation (Kyprianou *et al.*, 2019). Initiatives stemming from directives regarding market regulation for natural gas and electricity have highlighted the necessity of protecting citizens against electricity disconnection and inability to pay bills (Kyprianou *et al.*, 2019).

These policies are interlinked with broader objectives such as climate action, energy efficiency, and social equity, reflecting the EU's commitment to ensuring that all citizens have access to affordable and sustainable energy through an integrated approach that leverages energy market liberalization and renovation initiatives, ensuring that vulnerable populations are not left behind. However, the ambitious goals laid out in various initiatives and directives raise significant questions about the effectiveness of implementation, the coherence of the policies, and their actual impact on vulnerable populations.

2.2.1. Interrelation of policies

In the context of efforts toward full achievement of electricity market harmonization within the European Union, the Commission Recommendation (EU) 2020/1563, issued in October 2020, acts as a guide for Member States (MS) on EP to develop integrated policies that address the needs of vulnerable populations within the context of the liberalization of energy markets (European Commission, 2020b). This recommendation emphasizes the use of indicators to assess EP and highlights the importance of cooperation between various stakeholders and an open and participatory public procedure for the elaboration of policies. It lays the groundwork for a more focused effort of EP by directing MS to incorporate these considerations into their broader energy and climate plans, as stipulated by the Governance Regulation (EU) 2018/1999 (European Commission, 2020b).

The “Clean Energy for All Europeans” Package further builds on this foundation by integrating EP considerations into National Energy and Climate Plans (NECPs). This package aligns with the “European Green Deal” which sets the long-term goal of achieving climate neutrality by 2050 (European Commission, 2019). The Renovation Wave, a key component of the Green Deal, directly addresses EP by promoting energy-efficient building renovations. By prioritizing energy efficiency in building renovations, the EU targets one of the main drivers of high energy costs for vulnerable households (Figure 1). The policy is ambitious in its scope, aiming to not only reduce carbon emissions but also improve living conditions and create new economic opportunities, especially for low-income populations (European Commission, 2020a).



Figure 1: Why does the Renovation Wave matter? (European Union, 2021).

This is where the policies start to interconnect: the Commission’s focus on energy efficiency as a priority – especially within the housing sector - forms the basis for

a strategy that reduces energy consumption and alleviates EP by lowering energy costs for vulnerable households.

Thus, the Renovation Wave and the Commission Recommendation (EU) 2020/1563 complement each other. While the Renovation Wave provides the technical and financial tools to improve the energy efficiency of buildings, the Commission's recommendation ensures that the most vulnerable households benefit from these renovations, particularly by urging MS to prioritize low-income households in the allocation of funds.

Moreover, the Directive (EU) 2023/1791 on energy efficiency solidifies energy savings as a primary tool for combating EP. This directive prioritizes energy efficiency across all sectors, extending beyond energy systems to encompass social policies that protect vulnerable consumers. It mandates MS to incorporate social objectives into energy efficiency measures, thus ensuring that public funding is effectively used to alleviate EP. This directive highlights the potential of energy efficiency to provide long-term, sustainable relief from EP by reducing household energy consumption and lowering bills (European Parliament and Council, 2023).

The alignment of financial mechanisms across these policies is a notable strength. The Renovation Wave's focus on increasing access to grants and technical assistance, for low-income households, alongside the financial provisions outlined in the Fit for 55 Package, demonstrates the EU's commitment to ensuring that vulnerable populations have the resources needed to participate in the energy transition.

2.2.2. The role of financial mechanisms

A critical link between these policies lies in their focus on financial mechanisms designed to support vulnerable populations in the energy transition. Financial mechanisms such as subsidies, grants, and targeted investments are crucial for mitigating EP. These mechanisms help lower the cost of energy for vulnerable households and support energy efficiency improvements (Bouzarovski *et al.*, 2021; Dobbins *et al.*, 2019; Streimikiene *et al.*, 2020). The Renovation Wave's emphasis on accessibility to grants and technical assistance has been echoed by the Commission Recommendation (EU) 2020/1563, which calls for the use of public funds to help low-

income households with energy-efficient renovations (European Commission, 2020a; European Commission, 2020b). The same is perpetuated by Directive (EU) 2023/1791, the requirement that public funds for energy efficiency improvements be channeled toward households at risk of EP (European Parliament and Council, 2023).

The Fit for 55 Package expands on this by ensuring that the EU's climate policies include social considerations, creating a supportive framework for innovation and competitiveness while safeguarding the most vulnerable populations (European Commission, 2024). By aligning financial mechanisms across various policy instruments, the EU aims to ensure that the transition to a low-carbon economy is just and socially inclusive, providing financial support and market mechanisms for those most affected by EP.

This focus on financial inclusion is crucial for achieving the EU's climate goals. The European Green Deal calls for substantial investments in energy efficiency, particularly through the Renovation Wave, which seeks to make energy-efficient homes accessible to all Europeans (European Commission, 2019). However, this can only be realized if financial barriers are removed, especially for low-income households. The interconnected policies provide a robust financial architecture that makes it possible for vulnerable populations to participate in and benefit from the green transition.

2.2.3. Governance and Accountability

Recent research highlights the complex relationship between EP and democratic governance in the European Union. Improving voice and accountability correlates with reduced EP, especially in flawed democracies (Kwilinski *et al.*, 2024). The EU's energy efficiency governance requires strengthening institutional capacities and addressing disparities between member states (Pereira & da Silva, 2017).

The governance framework established by Regulation (EU) 2018/1999 in the Governance of the Energy Union and Climate Action provides a mechanism for tracking and reporting progress on EP, ensuring that MS are accountable for their progress in addressing this challenge. This regulation requires MS to assess EP at the household level and to integrate specific measures into their NECPs (European Parliament and Council, 2018a). It also mandates regular reporting and progress monitoring (European

Parliament and Council, 2018a), which is crucial for maintaining momentum and ensuring that policies are effectively implemented. However, the success of this framework depends on the quality and transparency of data provided by MS, as well as the effectiveness of EU oversight.

The EU has developed a more coherent EP agenda through regulatory provisions like the Clean Energy for all Europeans Package. These efforts aim to enhance governance and accountability in addressing EP (Bouzarovski, 2018; Bouzarovski *et al.*, 2021).

The Energy Poverty Advisory Hub (EPAH)¹ is a leading European initiative dedicated to combating EP at the local level, run by the European Commission at the request of the European Parliament. Established in 2021, EPAH serves as a knowledge and recourse platform, aiming to eradicate EP and accelerate the just energy transition of European local governments, providing support to cities and regions in developing and implementing effective strategies (European Commission, 2024). The platform offers a range of services, including technical assistance, capacity-building activities, and the dissemination of research and best practices. By fostering collaboration, sharing best practices, and promoting evidence-based approaches, EPAH plays a crucial role in driving progress toward a more just and equitable energy transition.

EPAH is working closely with local governments to become the central platform to discover local actions and measures for inspiring socially inclusive energy transition efforts, understand about EP and how to tackle it by exploring national and local indicators, enhance skills through online courses, and get direct support for developing local projects (European Commission, 2024). By providing comprehensive support, EPAH enables cities and regions to develop tailored strategies that address the specific needs and challenges of their vulnerable populations, while contributing to the broader EU objectives of promoting social inclusion.

This governance framework is complemented by the Directive (EU) 2018/844, which focuses on the energy performance of buildings. By requiring MS to develop

¹ This tool is available at: <https://energy-poverty.ec.europa.eu/>

forward-looking renovation strategies that address the least energy-efficient parts of their building stock, this directive ensures that EP is integrated into national policies on building renovations. It further strengthens the EU's commitment to a long-term, cost-effective transformation of the building sector, aligning with the broader goals of the European Green Deal (European Parliament and Council, 2018b).

The EU's EP approach primarily focuses on long-term structural changes, such as building renovations and energy market reforms. While these measures are essential for addressing the root causes of EP, they may not provide immediate relief to households currently struggling to pay their energy bills. Future research and policy should focus on enhancing transparency, public participation, and accountability in energy decision-making to effectively address EP across the EU (Bouzarovski *et al.*, 2021; Kwilinski *et al.*, 2024).

2.2.4. Social Equity as a Core Principle

Social equity is a fundamental principle in EP policies. Policies must ensure that all societal groups, especially the most vulnerable, benefit from energy initiatives. This includes addressing social inequalities and ensuring fair access to affordable energy (van Bommel & Höffken, 2021). The principle of social equity is at the heart of all the mentioned interconnected policies. The energy and climate policies of the EU repeatedly highlight the protection of vulnerable consumers and ensure no one is left behind in the energy transition. It is reflected in the Directive (EU) 2023/1791, when it calls for the inclusion of social objectives in energy efficiency measures (European Parliament and Council, 2023), and in the Fit for 55 Package, underlining the importance of a just and socially inclusive transition (European Council, 2024).

The European Green Deal and the Renovation Wave further reinforce this commitment by ensuring that energy efficiency improvements benefit all citizens, regardless of income (European Commission, 2019; European Commission, 2020a). By making energy efficiency a right rather than a privilege, these policies aim to reduce the social disparities often exacerbated by EP. In any event, such focus on vulnerable groups—low-income households, the elderly, and people living in poorly insulated homes—further

strengthens the EU's commitment to social equity as one core underpinning in developing its energy and climate policy.

The integration of social policy with energy policy is essential for effectively reducing EP. Member States with prominent levels of EP often face challenges due to the high cost of implementing social policies, which can hinder the transition to a sustainable energy society (Primc & Slabe-Erker, 2020).

Community energy initiatives are promoted to achieve energy justice. However, not all societal groups are equally positioned to benefit from these initiatives, highlighting the need for a broader understanding of energy justice that includes social equity considerations (van Bommel & Höffken, 2021).

2.2.5. Synergies and Challenges in Implementation

The interrelation between these policies creates synergies that enhance the effectiveness of the European Union's approach to combating EP. By integrating energy efficiency with social policies, financial mechanisms, and governance frameworks, the EU has developed a comprehensive strategy that addresses the symptoms and the root causes of EP. The Renovation Wave and Fit for 55 Package illustrate how environmental and social policies can be aligned to create a more sustainable and equitable energy system (European Commission, 2020a; European Council, 2024).

The EU has expanded its EP policies through various initiatives like the Clean Energy for all Europeans Package. However, there is a need for better coordination and implementation at both the EU and national level (Bouzarovski, 2018; Bouzarovski *et al.*, 2012, 2021) and in ensuring these policies are effectively implemented across all MS. Member states are responsible for addressing EP within their territories, but the effectiveness of these policies varies. While some countries have developed comprehensive strategies, others lag behind, which may lead to inconsistent outcomes across the EU (Bouzarovski *et al.*, 2012, 2024; Kyrianiou *et al.*, 2019). The decentralized nature of the EU's approach, which allows MS to tailor their strategies to their national contexts, can lead to inconsistencies in policy implementation. Policies aimed at household energy consumption for climate change mitigation can also have the potential to reduce EP. However, these measures have not fully realized their potential

due to barriers like the energy efficiency paradox and other implementation challenges (Chen & Feng, 2022a; Streimikiene *et al.*, 2020) like the absence of a standardized definition of EP which complicates the measurement and comparison of progress across MS.

Poor coordination, a low level of awareness by national policy-makers, and a lack of integration with broader social policies have weakened the actual impact of a range of policies that exist on paper (Bouzarovski *et al.*, 2012; Dobbins *et al.*, 2019; Primc & Slabe-Erker, 2020). This places a further burden on another challenge: the need to coordinate policy efforts at successive layers of governance from the EU to national, regional, and local levels. Translating into concrete action on the ground the ambitious targets included in the European Green Deal, Renovation Wave, and Fit for 55 Package will require continuous political will and at least sufficient funding, together with close monitoring mechanisms.

Policies and initiatives are interconnected within the overall EU strategy on EP. From the Commission Recommendation EU 2020/1563 to the Renovation Wave, European Green Deal, and Fit for 55 Package, the EU has developed a complex framework that interacts with energy efficiency, social equity, and climate action. While the EU has made considerable progress in integrating EP into its broader energy and climate policies, challenges remain in ensuring that vulnerable populations are adequately protected and that the benefits of the energy transition are shared equitably across all MS. The EU's future success in combating EP will hinge on its ability to refine its policies, enforce accountability, and continuously adapt to the evolving needs of its citizens.

2.3. Policy context in Portugal

Portugal has effectively transposed existing or new legislation for energy efficiency, providing specific additional benefits for the low-income population and vulnerable consumers (Kyprianou *et al.*, 2019). The country's strategy to combat EP is embedded in a multifaceted framework of strategic plans, regulations, and funding schemes that align with broader European Union directives. These initiatives aim to create a sustainable and equitable energy landscape while addressing the specific needs

of vulnerable populations. However, while Portugal's policies are ambitious and comprehensive, their success relies heavily on effective implementation, coordination between various levels of governance, and addressing gaps and repercussions.

2.3.1. Alignment across policies

Portugal's policy framework for addressing EP is notable for its high level of coherence and integration across multiple strategic plans complementing each other. Energy efficiency regulations have been implemented to reduce EP, but their effectiveness is limited due to economic, institutional, and behavioral barriers (Koengkan *et al.*, 2023; Matos *et al.*, 2022). The Long-Term Strategy to Combat Energy Poverty 2023 2050 (ELPPE) serves as the central pillar, for continuing to increase the quality of living for all families and continuing to raise living standards, while offering a more sustainable and equitable energy scenario for Portugal (Presidência do Conselho de Ministros, 2024). The strategy follows the definition of EP outlined in Directive (EU) 2023/1791 (European Parliament and Council, 2023), reflecting Portugal's commitment to broader European goals. In general, ELPPE aims to eradicate EP in Portugal until 2050, considering the protection and inclusion of vulnerable consumers into a fair, democratic, and cohesive energy and climate transition.

At the operational level, the strategy itself is expected to follow four strategic lines of action: promoting sustainable energy and environmental housing, acting on the leverage of housing enhancement for energy efficiency, and decarbonization of consumption through the following: promoting universal access to essential energy services; reducing the number of households struggling to afford essential energy services and protect vulnerable consumers facing EP; promoting integrated territorial action; seeking to strengthening local structures in the combating EP and supplying public housing with high energy performance through coordinated efforts between state and municipal supply entities; promoting knowledge and informed action, aiming to increase the capacity to identify households with EP, enhance energy literacy, stimulate research and innovation, and encourage professional training for rehabilitation, energy efficiency, and renewable energy interventions in housing (Presidência do Conselho de Ministros, 2024).

This strategy is intricately linked to the Roadmap for Carbon Neutrality by 2050 (RNC2050), which outlines the country's long-term decarbonization goals. By integrating EP reduction with climate action, Portugal ensures its energy transition is sustainable and socially equitable. This strategic vision entails a comprehensive strategy that includes initiatives such as urban regeneration, enhanced energy efficiency in buildings, encouraging gradual electrification, and adopting more efficient equipment. Furthermore, the roadmap underscores the significance of sustained emphasis on urban rehabilitation efforts. This ongoing focus creates an avenue for integrating enhancements in energy and water efficiency, the integration of low-carbon materials, and the integration of renewable energy sources (República Portuguesa, 2019).

In particular, the ELPPE is well-integrated with the NECP 2021-2030, emphasizing this transition through urban regeneration, energy efficiency, and renewable energy development. It aims to ensure a level playing field for all, with a particular emphasis on addressing EP. All this is underlined by the active involvement of citizens in decarbonization and energy transition. The plan also includes establishing instruments that safeguard vulnerable individuals, protect them, and further develop active participation in territorial valorization (Presidência do Conselho de Ministros, 2020b).

Further integration in urban regeneration efforts is seen in the Long-Term Strategy for the Renovation of Buildings (ELPRE), which targets improving the thermal efficiency of residential buildings—a critical factor in reducing energy costs for vulnerable households (Presidência do Conselho de Ministros, 2021a), and bolstered by the Financial Instrument for Urban Rehabilitation and Revitalization (IFRRU 2020), which combines European Union funds with national public and private investment to finance energy efficiency improvements in buildings (IRHU, 2017).

The two primary goals of ELPRE are to ensure that acceptable comfort levels are achieved without exacerbating energy consumption for heating in such a way as to contribute to the eradication of EP. This strategic action will take place in two important steps: First, by 2030, the focus is on residential buildings with the lowest energy performance, specifically those constructed before 1990. This initial phase is meant to

create the groundwork for substantial improvements. Then, by 2040, the scope extends to all the other dwelling structures built until 2016. This is an all-inclusive approach because the program's benefit permeates most of the residential building landscape (Presidência do Conselho de Ministros, 2021a).

IFRRU 2020 is designed to promote sustainable urban development with a focus on improving energy performance in residential and commercial buildings. This aligns with both the ELPPE's goals of reducing EP and the RNC2050's objectives of decarbonizing the building sector (IRHU, 2017).

The National Strategy to Combat Poverty 2021-2030 complements these energy-focused policies by addressing broader social vulnerabilities, ensuring that efforts to reduce poverty and enhance social inclusion are mutually reinforced. The resolution underlines the commitment to facilitating access, through support programs, to basic energy services for economically vulnerable families, aimed at alleviating the energy burden. It also advocates building renovation programs aimed at improving energy efficiency, environmental performance, thermal comfort, and overall living conditions of dwellings. This would contribute to less energy expense and a lower ecological impact, benefiting families (Presidência do Conselho de Ministros, 2021b).

The coherence of these policies is further supported by the Energy Efficiency Fund (FEE), IFRRU 2020/2030, and other financial mechanisms that provide essential support for energy-efficient renovations and technology adoption, critical for long-term EP reduction. Additionally, specific programs like the Social Tariff and the Extraordinary Social Support for Energy Consumers (ESSEC) provide immediate relief by reducing energy costs for low-income households, aligning with EU directives to protect vulnerable consumers from escalating energy prices (Presidência do Conselho de Ministros, 2011a; Presidência do Conselho de Ministros, 2011b).

2.3.2. Policy design and inclusivity

Portugal's policy framework is characterized by a comprehensive and inclusive approach to addressing EP. Policies targeting EP in Portugal focus on improving the thermal performance of buildings and increasing energy efficiency, which is crucial for enhancing living conditions, especially for vulnerable households (Kyprianou *et al.*, 2019;

Matos *et al.*, 2022). The ELPPE, in conjunction with the RNC2050, underscores the ambition to decarbonize the economy while ensuring that vulnerable populations are not left behind (Presidência do Conselho de Ministros, 2024; República Portuguesa, 2019). By integrating EP strategies with climate goals, Portugal ensures that efforts to reduce carbon emissions are coupled with measures to protect and empower economically disadvantaged communities.

A notable aspect of this inclusive design is the emphasis on social safeguards, such as the Social Tariff and ESSEC, which provide immediate financial relief to low-income households (Presidência do Conselho de Ministros, 2011a; Presidência do Conselho de Ministros, 2011b). The implementation of this social tariff rate for electricity and natural gas aims to establish protective mechanisms in respect to economically vulnerable end consumers who are burdened with higher and unpredictable energy costs (Presidência do Conselho de Ministros, 2011a). The ESSEC supports individuals benefiting from the social tariff regime for electricity or natural gas, by allowing a combination of the social tariff with a reduced rate on electricity and natural gas supplies (Presidência do Conselho de Ministros, 2011b). These measures are complemented by other measures targeted at specific schemes, such as the “Efficiency Voucher” and the Support Program for More Sustainable Buildings, which aim to reduce energy costs through efficiency improvements. The “Efficiency Voucher”, with a primary focus on improving the energy and environmental performance of structures, enhancing thermal comfort, and promoting overall health and well-being, the program serves as a crucial instrument in the broader mission to reduce energy bills and ecological footprints (República Portuguesa, 2023a). One of the conditions for applying for the “Efficiency Voucher” is to be a beneficiary of the social electricity tariff (Presidência do Conselho de Ministros, 2020b). The range of interventions spans from environmental enhancements in the surroundings to the replacement or acquisition of energy-efficient equipment (República Portuguesa, 2023).

Additionally, the Housing Component (C2) of the Recovery and Resilience Plan (PRR) plays a vital role in addressing the housing needs of low-income families, thereby indirectly combating EP. The Investment RE-C02-i01, through the *Programa 1.º Direito*, supports the promotion of housing solutions for people living in inadequate conditions

and who cannot afford suitable housing. It relies on local authorities to design Local Housing Strategies (ELH) that diagnose existing situations and outline investments. The PRR allocates €1.211 billion to support 26,000 families by 2026, directly addressing one of the core contributors to EP—substandard housing (Portal da Habitação, 2019).

Moreover, the *Bolsa Nacional de Alojamento Urgente e Temporário* (RE-C02-i02) creates a structured response for urgent housing needs, allocating €176 million under the PRR to establish emergency and transitional housing units for individuals in vulnerable situations. Similarly, the *Parque Público de Habitação a Custos Acessíveis* (RE-C02-i05) provides financial support via loans to increase public housing stock, guaranteeing affordable rents for low-income groups. With €774.8 million invested, this initiative aims to build or rehabilitate 6,800 affordable housing units, significantly impacting EP by offering accessible housing for households unable to meet traditional market prices (Portal da Habitação, 2019).

The fundamental objective of the Support Program for Residential Condominiums is to financially support energy efficiency measures that enhance thermal comfort of residential (República Portuguesa, 2023b). This initiative, complementing existing programs such as the Support Program for More Sustainable Buildings and the "Efficiency Voucher" Program, signifies a concerted effort to enhance energy efficiency in the residential sector. These interventions contribute significantly to reducing energy bills, revitalizing existing housing stock, and aligning with Portugal's broader sustainability and climate goals. In particular, the program prioritizes measures that reinforce thermal insulation for facades, roofs, and floors, recognizing their paramount importance in realizing substantial gains in energy efficiency and resultant energy savings (República Portuguesa, 2023b). However, there is a need for policies that link energy efficiency with clean energy generation and provide clear guidance for materializing energy strategies (Matos *et al.*, 2022).

These housing initiatives, combined with energy-efficiency measures, form a solid strategy for tackling energy poverty in Portugal. By improving both the quality of housing and its energy performance, the government aims to ensure that vulnerable populations have access to affordable and energy-efficient homes. This approach helps

lower energy costs while enhancing overall living conditions. By aligning housing and energy policies, Portugal shows a strong commitment to social equity, ensuring the energy transition benefits everyone, particularly those most impacted by energy poverty.

2.3.3. Implementation challenges

Despite Portugal's ambitious design of its EP strategy, significant challenges remain in its implementation. The ineffectiveness of current regulations in mitigating EP is partly due to economic, institutional, and behavioral barriers that impede policy goals (Koengkan *et al.*, 2023). One key challenge is the administrative complexity associated with accessing benefits like the Support Program for More Sustainable Buildings. Delays in processing applications can create frustration for households waiting for financial support. The demand for these programs often exceeds available funding, leading to a slow allocation of grants (Lusa, 2024). Simplifying these processes and ensuring that information is accessible will be crucial to maximizing the impact of these initiatives. Additionally, households often consider it normal to feel cold or hot at home, which can hinder the social recognition of EP and the need to address its negative consequences (Horta *et al.*, 2019). Without this recognition, efforts to improve energy efficiency and living conditions often face resistance or indifference, further entrenching the problem.

2.3.4. Social equity and a just transition

Social equity is a central pillar of Portugal's EP strategy, with a strong emphasis on ensuring that the energy transition benefits all citizens, particularly those most at risk of EP. Reducing EP by improving residential building stock can significantly enhance living conditions and promote a smarter, sustainable, and inclusive society (Matos *et al.*, 2022). The PNEC 2030 and ELPPE explicitly focus on a just transition, emphasizing the need to protect vulnerable consumers and promote inclusive participation in the energy market. This approach aligns with the goals of the RNC2050, which seeks to decarbonize the economy while ensuring that the benefits of the energy transition are distributed equitably.

However, achieving social equity in practice is challenging. EP policies need to consider the multidimensionality of the issue and address specific factors contributing

to it in different contexts (Gouveia *et al.*, 2019; Horta *et al.*, 2019). While programs like the Support Program for More Sustainable Buildings and policies like the Long-Term Strategy for the Renovation of Buildings aim to reduce energy consumption and costs, there is a risk that the upfront costs of energy-efficient technologies and renovations could be prohibitive for some households, even with subsidies.

2.3.5. Governance and future challenges

Effective governance systems are crucial for addressing EP, but there is a need for better coordination and awareness among national policymakers regarding EU-level initiatives (Bouzarovski *et al.*, 2012, 2021). Sustaining political commitment over the long term also poses a significant challenge. With strategies like the ELPPE spanning several decades, maintaining momentum, and ensuring that EP remains a priority across successive governments will be critical. The periodic revision of action plans under the ELPPE provides an opportunity to adapt and refine strategies based on evolving needs and challenges. Still, this process must be robust and responsive to real-world conditions.

Emerging initiatives like the Reduction of Network Access Tariffs and efforts to promote access to the regulated market reflect Portugal's ongoing efforts to adapt its policy framework to current market conditions and ensure financial stability for regulated activities. Regulated electricity tariffs and prices are set annually by the Energy Services Regulatory Entity (ERSE) for a calendar year period, running from January to December. The commitment to regular reviews ensures that consumers can make informed choices and promotes transparency and stability in the energy market, aligning with Portugal's goal of mitigating EP (ERSE, n.d.). However, these measures must be continuously refined to address the complexities of the energy market and ensure that they benefit all citizens, particularly those most vulnerable to EP.

Portugal's policy framework for addressing EP is ambitious and comprehensive, aligning closely with European Union directives while addressing the challenges faced by vulnerable populations. The integration of long-term strategies like the ELPPE with broader energy and climate plans such as the PNEC 2030 and ELPRE reflects a well-coordinated approach that prioritizes sustainability, social equity, and inclusivity.

Nevertheless, the success of these policies depends on effective implementation, the ability to address potential gaps and barriers, and a sustained commitment to ensuring that the energy transition benefits all citizens, particularly the most vulnerable.

Future challenges include the need for a balanced approach that integrates both energy and social policies to avoid an energy-poverty trap and ensure a sustainable transition (Primc & Slabe-Erker, 2020). As Portugal moves forward, it will need to continuously refine its strategies, strengthen governance and accountability mechanisms, and ensure that the benefits of its energy policies are distributed equitably across all regions and social groups.

3. Social Housing and Energy Poverty

Social housing (SH) is a government-regulated tenure that provides affordable rental dwellings based on need with a traditional aim to improve the overall living conditions of workers and low-income residents. Developed by government agencies or non-profit organizations with state support, SH remains affordable through housing allowance programs and favorable financing from public banks (Croon *et al.*, 2024). SH is often inhabited by low-income households, making them particularly vulnerable to EP (Llera-Sastresa *et al.*, 2017). The rise of energy demands has intertwined a set of complications at the very core of EP, environmental degradation, and increased vulnerability in society, pressing on urban infrastructures and social well-being, hence the need to shift investments urgently to refurbishment and maintenance of the building stock, in order to make it more environmentally, economically, and socially efficient for the improvement of quality of life (Seabra *et al.*, 2021).

Among the main characteristics recognized, it should be outlined that exceptionally low energy consumption for heating and cooling in SH are said to be conditioned by decentralized systems, EP, and poor energy efficiency (Seabra *et al.*, 2021). However, the legislative framework in force frequently does not meet the demands of this sector and needs considerable investment in building performance and social cohesion (Seabra *et al.*, 2021).

Social housing providers (SHPs) are non-profit organizations and thus undertake several social commitments with regulatory frameworks. Their main goals include ensuring the adequate supply of new-built dwellings made available, its fair allocation, rents should be affordable, buildings' quality maintained and upgraded to meet standards of sustainability and energy efficiency (Croon *et al.*, 2024).

SHPs are taking several steps to address EP among their tenants. One key intervention is offering personalized energy advice to vulnerable tenants, which helps them better understand their energy usage and identify ways to reduce costs (Croon *et al.*, 2024). Customizing renovation plans for SH must consider the demands of its inhabitants (Seabra *et al.*, 2021). Another major focus is retrofitting homes to improve energy efficiency, though this can be challenging due to long preparation times and the

risk of tenants relocating before the work is finished (Croon *et al.*, 2024). Research shows that passive strategies should be prioritized to reduce energy demand, with remaining needs met by renewable sources (Seabra *et al.*, 2021). By improving the energy efficiency of homes, mitigating reliance on fluctuating energy prices through renewable energy sources, and setting affordable rental rates, SHPs play a crucial role in alleviating EP among their tenants (Croon *et al.*, 2024).

Occupant comfort should be of greater concern than just a reduction in energy consumption, especially when heating and cooling provisions are scant or non-existent in the SH context (Seabra *et al.*, 2021). However, studies indicate that passive measures alone are often insufficient to achieve adequate indoor comfort, especially for vulnerable groups like the elderly (Brandão & Lanzinha, 2021). Future renovation strategies should balance energy efficiency with occupant comfort, considering the unique challenges of SH contexts (Rocha *et al.*, 2023). Supplemented by renewables, reduced energy demands will reduce EP and lead to an improved quality of life for vulnerable demographics (Seabra *et al.*, 2021).

3.1. European social housing context

Housing is recognized as a critical factor for social safety, equity, and long-term economic growth, with the EU emphasizing its importance in social policy (Kleinman, 2002; Kucharska-stasiak *et al.*, 2022). The EU's actions in housing policy are seen as part of broader efforts to support social and territorial cohesion and combat social exclusion (Juan Toset, 2012; Kucharska-stasiak *et al.*, 2022).

Housing conditions are fundamental for a decent life and social equity. The economic dimension of housing is crucial for ensuring long-term economic growth (Kucharska-stasiak *et al.*, 2022). A single EU housing policy for all member states is challenging to implement, and a more effective approach would be to seek general solutions for countries with similar conditions through a European housing program supported by EU law (Kucharska-stasiak *et al.*, 2022). This approach would require active involvement to include housing in EU competencies, as well as political, social, economic, environmental, and legal initiatives to support common values (Kucharska-stasiak *et al.*, 2022).

SH in Europe exhibits considerable diversity across European countries in terms of definitions, size, providers, beneficiaries, and financing models (Pittini, 2012). Research indicates that EP is more prevalent among SH tenants in Europe compared to other housing tenures (Croon *et al.*, 2024). The issue is exacerbated by obsolete housing stocks and widespread EP situations, leading to a "prebound effect" where residents consume less energy than projected (Desvallées, 2022). To address this issue, SHPs are focusing on retrofitting building envelopes rather than renewable energy installations, which may overlook the multidimensional nature of EP (Desvallées, 2022). Effective policies should improve access to low-cost retrofit options, engage residents, emphasize co-benefits, and implement government requirements, particularly for publicly owned housing (Tozer *et al.*, 2023).

This concentration of EP within the SH sector is expected, as SHPs are institutionally tasked with supporting low-income groups and vulnerable residents. Despite this responsibility, there is a notable lack of research dedicated to the unique role of SHPs in addressing EP (Croon *et al.*, 2024). SHPs face challenges in addressing both energy efficiency and social inclusion, often focusing on passive measures like building envelope retrofitting (Desvallées, 2022).

The European Union (EU) plays a significant role in shaping SH policy across its member states, despite housing policy being primarily the responsibility of national governments. However, the EU influences national housing policies through competition policy and state support regulations, impacting how member states manage their housing sectors (Gruis & Priemus, 2008; Priemus, 2006). SH is viewed within the broader framework of EU goals related to social inclusion, poverty reduction, and sustainable urban development. The European Pillar of Social Rights, introduced in 2017, is a significant initiative reaffirming twenty social rights and principles, highlighting access to affordable housing and essential services as a fundamental right (Garben, 2019; Miriřan & Miriřan, 2021), underscoring the EU's commitment to addressing housing affordability and homelessness.

In recent years, the social rental sector in Europe has undergone significant changes, often due to government policies that reduce public funding and impose

stricter eligibility criteria. This has led to a “residualization” of SH, where it is increasingly allocated to people with extremely low incomes and marginalized societal groups such as refugees and individuals with mental health issues. This clustering of vulnerable groups high-density SH neighborhoods exacerbates EP and highlights the need for SHPs to address this issue effectively (Croon *et al.*, 2024).

3.2. Portugal’s social housing context

Portugal faces significant challenges in EP, particularly in SH, due to poor building conditions and socio-economic vulnerabilities (Horta *et al.*, 2019). In Portugal, SH represents 5% of the total stock and is occupied by low-income residents because of national policies that favor private homeownership (Desvallées, 2022). A substantial portion of the population still lives in inadequate housing, mainly in the metropolitan areas of Porto and Lisbon, where housing shortages are acute (Seabra *et al.*, 2021).

While EU directives have highlighted EP, Portugal still experiences elevated levels of thermal discomfort, reflecting poor building performance and economic factors (Desvallées, 2022). Despite its mild climate, the country exhibits high vulnerability to EP, with many households considering thermal discomfort normal (Horta *et al.*, 2019). EP is notably higher in inland regions and islands, with rural civil parishes being particularly affected. Heating is a significant issue in terms of energy demand and health hazards (Gouveia *et al.*, 2019; Horta *et al.*, 2019).

Poor thermal performance of building stock, combined with low family incomes and high energy prices, contributes to prominent levels of thermal discomfort, especially during winter (Horta *et al.*, 2019; Matos *et al.*, 2022; Seabra *et al.*, 2021). A striking 29% of the population lives in dwellings that are affected by leaks, dampness, or rot, highlighting the structural inefficiencies of the building stock (European Commission, 2024). These issues are especially prevalent in older buildings, which dominate the SH landscape, and they significantly impact energy efficiency. Most of the SH in Portugal was built before strict legislation on the use of energy was enacted (Desvallées, 2022). This makes residents turn to biomass and electrical heating, which becomes inadequate to satisfy the energy needs of such poorly insulated properties (Desvallées, 2022). Homes with poor insulation and deteriorating structures are not capable of retaining

heat effectively, leading to increased energy consumption, higher utility bills, and greater financial strain on already vulnerable populations.

In addition to the high percentage of homes with structural issues, about 8.1% of the population considers their dwellings to be too dark (European Commission, 2024), which points to poor design or lack of adequate natural lighting in these buildings. While this may not seem related to EP, it implies a greater reliance on artificial lighting, further driving up electricity consumption, particularly in low-income households that may already struggle with high utility costs. Approximately 3.8% of the population is in arrears on their utility bills, indicating that these households are struggling to keep up with rising energy costs (European Commission, 2024). Compounding these difficulties is the fact that 20.1% of the population is at risk of poverty or social exclusion (European Commission, 2024), a figure that reveals the widespread economic vulnerability across the country. The situation is further worsened by the housing cost overburden rate, which, while low at 4.9% (European Commission, 2024), conceals significant disparities.

As Portugal continues to navigate the challenges of EP, especially as energy prices fluctuate and the impacts of climate change become more pronounced, addressing the inefficiencies of the housing stock and the socio-economic vulnerabilities of its population must remain a priority. Without substantial interventions, the cycle of EP will persist, particularly among those living in SH, further entrenching inequality and limiting opportunities for upward mobility in a society already grappling with significant economic challenges (Desvallées, 2022).

EP in Portugal is, therefore, a multi-faceted issue that stems from both poor housing conditions and the broader socio-economic struggles of a sizable portion of the population. The country's aging building stock, particularly in the SH sector, is ill-equipped to meet current energy efficiency standards, which exacerbates the financial strain on low-income families. Addressing this issue requires not only improving the physical state of homes through retrofitting and renovation but also providing financial support to households struggling with high energy costs.

4. Energy efficiency One-Stop-Shops

In the face of rising energy costs and the urgent need to combat climate change, improving energy efficiency has become a critical priority for policymaking, households, and communities. Enhancing home energy efficiency is essential to achieving the carbon neutrality goals outlined in the European Green Deal (Pardalis *et al.*, 2022). A significant proportion of the EU's building stock predates modern energy standards, presenting substantial potential for energy savings through renovations. Upgrading buildings can reduce energy costs for households in need, addressing EP (Bertoldi *et al.*, 2021).

The slow rate of energy renovations is due to several factors (Pardalis *et al.*, 2022). Traditional renovation schemes often focus narrowly on technical and economic aspects, which has led to low levels of homeowners (Sequeira & Gouveia, 2022). Despite the potential benefits, these models often place the burden on homeowners to manage projects, navigate technical details, and secure financing (Bertoldi *et al.*, 2021), with energy renovation offerings often fragmented (Pardalis *et al.*, 2022). The lack of accessible incentives and suitable financial products is a significant barrier, making it difficult for homeowners to find suitable financial options to support their renovation projects (Sequeira & Gouveia, 2022). This "atomized model" often results in suboptimal outcomes and deferred projects (Bertoldi *et al.*, 2021), as homeowners struggle navigating the energy renovation market due to perceived complexity, transaction costs, and a lack of clear warranties for the effectiveness of these solutions (Pardalis *et al.*, 2022). Traditional renovation efforts face significant hurdles (Bertoldi *et al.*, 2021), resulting in these investments in energy efficiency measures often being overlooked due to limited capital, unreliable information, a shortage of skilled workers, and doubts about the benefits (Pardalis *et al.*, 2022).

One-Stop-Shops (OSSs) have emerged as a promising approach in the construction industry, offering integrated renovation solutions that guide homeowners through the entire process (Donati & Copiello, 2023; Bertoldi *et al.*, 2021). This model consolidates fragmented information into a single, accessible platform, simplifying the gathering of relevant data for specific projects (Mendes, 2022). OSSs assist homeowners from initial assessment to financing and implementation (Bertoldi *et al.*, 2021), with

energy consultants and market facilitators also helping customers with the financial aspects of energy refurbishment projects (Donati & Copiello, 2023).

By bringing centralized access points for a range of services, OSSs reduce the complexity and mental load involved while ensuring better project outcomes and more informed decisions (Bertoldi *et al.*, 2021; Mendes, 2022; Boza-Kiss *et al.*, 2021), the hassle of managing multiple contractors and services and making it easier for consumers to navigate the renovation journey (Boza-Kiss *et al.*, 2021). The revised Energy Performance of Buildings Directive underscores the importance of OSSs as a reliable advisory tool for overcoming renovation barriers (Pardalis *et al.*, 2022).

OSSs, whether virtual or physical, offer property owners comprehensive information, services, and support to implement energy efficiency measures (Mendes, 2022). They can also assist in identifying and securing funding opportunities from both public and private sources, such as low-interest loans, grants, and subsidies (Bertoldi *et al.*, 2021), making renovations more accessible for those at risk of being left behind in the energy transition (Sequeira & Gouveia, 2022).

The role of OSSs varies depending on their target audience and available resources, serving consumers at national, regional, or local levels (Mendes, 2022). They provide technical support, ongoing advice, feasibility studies, and project management—all of which aim to ensure high-quality results (Bertoldi *et al.*, 2021). Although the concept of OSS is still emerging in many European countries, it is gaining traction as a crucial strategy for promoting energy efficiency and sustainability (Gouveia *et al.*, 2024). By facilitating energy renovations, OSS contributes to broader energy efficiency goals, helping to reduce overall energy consumption and greenhouse gas emissions. This aligns with policy objectives aimed at combating climate change and promoting sustainable practices (Boza-Kiss *et al.*, 2021).

OSSs have immense potential to increase energy renovations by addressing fundamental barriers such as information gaps and decision-making challenges (Bertoldi *et al.*, 2021). They can coordinate the renovation works and streamline processes for homeowners who may find it complex to manage multiple actors and responsibilities involved in renovations (Sequeira & Gouveia, 2022). Close collaboration among supply-

side actors improves renovation projects' time and price efficiency (Bertoldi *et al.*, 2021). By acting as a trusted intermediary, OSS can help build consumer confidence in the renovation process. They can provide verified information and connect homeowners with reputable contractors, reducing the risk of poor-quality work (Boza-Kiss *et al.*, 2021). Besides, they guarantee qualified renovations, looking into the whole renovation process from the reliability of the contractor. Moreover, OSSs support energy culture by fostering participation in energy efficiency among communities. This approach helps overcome barriers such as a lack of knowledge and technological capabilities (Gouveia *et al.*, 2024).

To be effective, OSSs need strong policy frameworks and financial incentives at both the national and regional levels. Local governments, especially municipalities, play a vital role in establishing OSSs, offering local grants, and extending tax alleviations. Consistent energy policy and financial frameworks are essential to promote homeowner engagement and support OSS operations (Bertoldi *et al.*, 2021).

OSSs can be managed by various entities, including municipalities, energy agencies, cooperatives, or private organizations, demonstrating diverse ownership models (Bertoldi *et al.*, 2021). This approach bridges the gap between fragmented supply and demand, reducing the complexities and non-monetary costs homeowners face during the renovation process. Providing tailored information from a sole source can overcome informational barriers, but the reliability of such advice should be verified by an independent party (Pardalis *et al.*, 2022).

While having immense potential, the challenge lies in securing continuous financing. Learning from successful examples and transferring best practices across regions is crucial to ensure the long-term viability of OSSs (Boza-Kiss *et al.*, 2021). Stable national and regional energy policies are necessary to create favorable conditions for OSS development (Bertoldi *et al.*, 2021).

The general objective of the OSS concept is to replace the fragmented renovation process with an integrated and holistic approach. (Pardalis *et al.*, 2022). By simplifying the renovation process, OSSs support vulnerable populations, reduce EP, and contribute to the EU's climate goals (Bertoldi *et al.*, 2021). Successful projects, such as

“Transition Point” in Portugal, demonstrate the positive impact of OSSs in local communities by providing tailored support and engaging residents in sustainable energy solutions (Gouveia *et al.*, 2024). Educational campaigns to inform potential customers about available options and the advantages of energy renovations can help reduce uncertainty and encourage participation (Boza-Kiss *et al.*, 2021).

Overall, OSSs enhance the effectiveness of energy renovation efforts by providing a user-friendly, integrated approach that supports consumers more sensitive to EP (Boza-Kiss *et al.*, 2021). Developing robust information and support systems is essential to help people access sustainable energy solutions, regardless of their location or socio-economic status.

4.1. Ponto de Transição project

Promoted by the Calouste Gulbenkian Foundation, a pilot project in Portugal, the *Ponto de Transição* allows for a creative and pragmatic contribution to combating EP from the perspective of a repurposed shipping container. This converted container is an OSS, offering a range of community services under one roof: advice on electricity and gas, support for home energy efficiency improvements, and free energy assessments (Gouveia *et al.*, 2024).

The project was launched in the Setúbal district between 2022 and 2023, later expanded to Alcochete, Barreiro, Moita and Montijo (*Ponto de Transição +PRÓXIMO*, the second edition under EPAH technical assistance (EPAH, 2024)), and partnered with three other Portuguese organizations: the Energy and Environment Agency of Arrábida (ENA), FCT-NOVA University of Lisbon’s Center for Environmental and Sustainability Research (CENSE), and the Association of Energy and Environment Agencies (RNAE). This collaboration received strong backing at various levels with support to local residents (Gouveia *et al.*, 2024).

The OSS model offers a comprehensive framework from problem diagnosis to direct assistance which can be very effective in the holistic approach to enhance energy efficiency and literacy among local populations (Gouveia *et al.*, 2019). *Ponto de Transição* emphasizes the viable means of mobile OSSs for enhancing the living standards of vulnerable households. These shops ensure that no one is left behind through bringing

services directly to the community level, especially in terms of climate change. The success this has witnessed in the district of Setúbal demonstrates the potential of this model to alleviate EP through local, integrated responses (Gouveia *et al.*, 2024).

Ponto de Transição provides general advice on energy efficiency, energy-saving opportunities, assistance with home renovations, and free home energy audits. The project is supposed to target energy-poor families but is widely available to all citizens, who can find valuable information and support, and also in the design of the container with detailed information about the project in infographics (Figure 2), along with practical tips for boosting home energy efficiency and savings (Gouveia *et al.*, 2024).

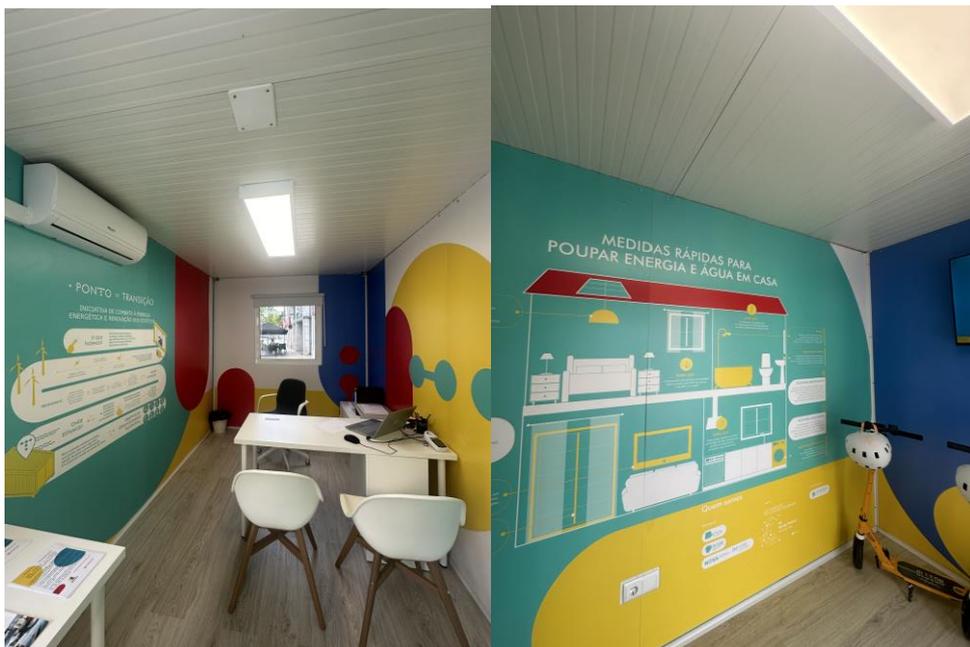


Figure 2: Inside view of the container

Ponto de Transição has effectively displayed how OSSs can effectively address EP and, in doing so, contribute toward a just energy transition. By repurposing a shipping container into a community hub, the project offers a comprehensive approach that bridges national energy policies and local needs. The insights that came out underlined the potential for further energy efficiency, greater sustainability, and scalability in actions undertaken by such initiatives.

4.2. The significant role of stakeholders

A stakeholder is considered any group or individual who can affect or is affected by the achievement of the organization's objectives (Mitchell *et al.*, 1997). The active involvement of local stakeholders is a critical ingredient in the success of OSSs for addressing EP (Gouveia *et al.*, 2024), as local approaches to diagnosing the issue should actively engage stakeholders from diverse backgrounds (Croon *et al.*, 2024). Stakeholder involvement methodologies and community engagement processes are essential for delivering innovations and investments in energy efficiency programs (Attolico *et al.*, 2017).

A local partnership is important for several reasons. Without partnerships with institutions of social support, community groups, sports clubs, and arts associations, it would be hard to extend the reach and impact of energy efficiency initiatives. These organizations already have built up relations with vulnerable families in their areas, which can be used to build trust and engage on energy issues (Gouveia *et al.*, 2024). Local actors, such as non-governmental organizations, make substantial contributions to bridging the gap between top-down policies and the energy poor, representing an adaptive response to the limitations of state and supra-national action (Creutzfeldt *et al.*, 2020). These partnerships also contribute different things to the OSS regarding its capacity to offer integrated support. For instance, logistical support from the local governments is achieved, and assistance in spreading the information by opening public spaces for promotional activities is made possible (Gouveia *et al.*, 2024).

Already, engaging players at the local level in various activities has been found to multiply pilot project effects. Sharing such information with a bigger audience of project stakeholders on issues pertinent to the project would increase its outreach and, at the same time, become more effective (Gouveia *et al.*, 2024). However, many local actors lack technical knowledge, resources, and capacity for deep involvement (Quadrat-Ullah *et al.*, 2020a) in project tasks, such as direct support or coordination of a project. Nevertheless, local energy agencies and governments can more easily fill these gaps, acting as leaders in one-stop shop initiatives (Gouveia *et al.*, 2024).

Local authorities face significant obstacles in implementing energy policies due to limited resources and freedoms under the localism agenda (Morris *et al.*, 2017). National governments should provide enabling policy frameworks with stable funding for household energy-efficiency improvements. Still, to accelerate progress, energy planning functions should be devolved to local governments (Qudrat-Ullah *et al.*, 2020b). In energy policy development, it will be proper for energy support services to map and approach probable stakeholders, proceed with those who express interest, and connect with organizations that are already in contact with target audiences. Identifying and mapping stakeholders early in the process helps ensure equitable outcomes and anticipate potential conflicts (Mathur *et al.*, 2007).

Successful projects will have to be sustained, scaled up, and replicated through collaboration among one-stop shop initiatives, local governments, and other stakeholders. Public-private partnerships and mixed bottom-up and top-down approaches can help overcome barriers like technical knowledge and financing constraints, and engage communities effectively (Fecondo & Moca, 2015). Enough funding, resources, and time should be invested in the mapping, engagement, and working with such local partners if the same are to be fruitful (Gouveia *et al.*, 2024).

5. Methodology

The methodology used in this research explores the effects of EP within SH neighborhoods. A multimethod approach was followed integrating both quantitative and qualitative research methods, offering a comprehensive understanding of the challenges posed by EP and the effectiveness of interventions. By combining statistical data with firsthand experiences, this methodology provides a nuanced analysis of how EP manifests and how it can be addressed through targeted actions. The approach can be simplified in eight steps, as Figure 3 shows.

STEP 1 – Define the research scope and approach. The study begins with an extensive literature review focusing on EP and the broader policy environment, including European and national initiatives and funding schemes. This review helps establish the research framework by situating it within the existing discourse on EP and identifying knowledge gaps, particularly concerning SH. This step is crucial for selecting the municipalities to be analyzed, defining the scope and direction of the research, and ensuring it applies and addresses relevant issues.

STEP 2 – Collect data and analyze context. Data and information are gathered from various sources, including government reports, census statistical data, and municipal records, focusing on four municipalities: Montijo, Alcochete, Barreiro, and Moita. These municipalities, located in the Setúbal Peninsula, were selected due to their participation in replication of Ponto de Transição OSS - the *Ponto de Transição +PRÓXIMO* project (EPAH, 2024).

This step involves analyzing the state of preservation of SH units, ownership regimes, construction periods, and the existence of non-traditional housing arrangements within these municipalities. The socio-economic conditions of the region, including high unemployment rates, economic disparities, and aging infrastructure, contribute to varying levels of EP, particularly in vulnerable SH populations.

By focusing on factors like income levels, the physical condition of housing units, and energy efficiency ratings, this analysis provides a detailed understanding of EP intensity across these regions. This data aids in estimating the severity of EP and

informs targeted interventions. Montijo was ultimately selected for in-depth analysis due to its proactive stance on EP and the availability of detailed data, especially from its most recent participation in the *Ponto de Transição +PRÓXIMO* project.

Step 3 – Select the municipality and analyze the EPVI for civil parishes. Based on the initial data analysis, Montijo was selected as the specific municipality for a detailed study due to its high levels of housing challenges and vulnerabilities. The next step involves analyzing data from the Energy Poverty Vulnerability Index (EPVI) (Gouveia *et al.*, 2019). The EPVI is designed to map EP at a high-resolution spatial scale, considering both space heating and cooling needs. This is particularly relevant in Portugal, where both winter and summer conditions can pose significant energy challenges despite the country's Mediterranean climate. The EPVI is a measure of current conditions and a tool for guiding policy and interventions by identifying regions with higher probabilities of EP. This makes it possible to implement targeted actions that address specific vulnerabilities at the local level (Gouveia *et al.*, 2019).

The EPVI provides a numerical representation of the risk faced by municipalities and parishes regarding EP, particularly during extreme heating and cooling seasons. With scores ranging from 0 to 20, a higher score indicates greater vulnerability, integrating a range of factors such as income levels, housing conditions, energy efficiency, and climate data into a single score, which not only quantifies vulnerability but also ranks municipalities and parishes at both national and local levels. (Gouveia *et al.*, 2019)

Step 4 – Analyze Buildings' EPCs. EPCs play a critical role in promoting energy efficiency across the European Union. EPCs influence renovation decisions and property choices, but their effectiveness varies significantly between countries and age groups (Charalambides *et al.*, 2019). Analysis of EPC data reveals that residential buildings in some European countries have low energy performance, with windows and roofs being the most inefficient elements. Retrofitting, particularly of roofs, shows high potential for reducing energy needs (Gouveia & Palma, 2019).

In Portugal, established as part of the *Sistema de Certificação Energética dos Edifícios* (SCE), the EPC system is grounded in EU directives and implemented at the

national level by Portugal's Directorate General for Energy and Geology (DGEG). EPCs have been mandatory for all residential and service buildings in Portugal since 2009 (Vaquero, 2019). EPCs provide valuable data for analyzing the energy performance of residential buildings, identifying retrofit opportunities, and estimating potential CO₂ emissions reductions (Gouveia & Palma, 2019), serving as a standardized tool to evaluate and communicate the energy performance of buildings, which is crucial for advancing sustainability goals, reducing carbon emissions, and improving public health.

Energy performance certificates gather quantitative data on the energy efficiency of SH units before and after renovation. These certificates of 100 social housing units located in the *Bairro Novo do Esteval*, a multi-family residential area, serve as a critical tool in measuring the impact of energy efficiency interventions on reducing EP. The energy certification process was conducted by S. Energia, the Regional Energy Agency for the municipalities of Alcochete, Barreiro, Moita and Montijo, responsible for evaluating and certifying the energy efficiency of these homes. By comparing pre- and post-renovation data, this step provides a clear picture of how energy efficiency improvements can alleviate EP in the targeted areas.

Step 5 – Conduct semi-structured interviews. A series of semi-structured interviews are conducted with key stakeholders, including local authorities and community organizations. After identifying the key stakeholders in the Montijo municipality, interviews are conducted with representatives from various local organizations to assess challenges, opportunities for collaboration, and their roles associated with SH and EP. The identification of stakeholders to be interviewed was based on their active involvement in SH management, provision for community support services, and energy efficiency initiatives in the Montijo municipality.

This structured table organizes interviews with key organizations and people involved and operating in Montijo, detailing their self-reported goals and activities (Table 1). This structured representation highlights the diverse range of stakeholders involved in addressing social, housing, and energy issues within the municipality. The table categorized the interviewees into social support, local government, and energy agency types (Soc1 and Soc2, Gov1 and Gov2, Ener1 and Ener2, respectively), attributing

those different codes to maintain the interviewee’s privacy, illustrating their varying approaches to tackling local challenges.

Table 1: Table of mapped stakeholders and self-reported goals and activities.

Type of Organization	Code	Self-Reported Goals	Self-Reported Activities
Social Support and Health – <i>Bairro do Esteval</i>	Soc1	Support vulnerable populations, including the elderly and low-income families; address housing and social issues.	<ul style="list-style-type: none"> - Provide social support services to low-income families and the elderly. - Address housing issues, including affordability and access to adequate living conditions. - Aid with health and social welfare.
Social Support and Health – <i>Escola</i>	Soc2	Facilitate the socio-professional integration of families receiving Social Insertion Income (RSI); address issues of inadequate housing and living conditions.	<ul style="list-style-type: none"> - Coordinate a team to support families receiving RSI. - Conduct home visits to assess living conditions, including energy efficiency issues in SH. - Assist families with accessing financial aid for heating, energy bills, and necessary equipment. - Advocate for urban regeneration and better housing insulation.
Local Government – <i>Câmara Municipal do Montijo</i>	Gov1	Improve housing infrastructure and energy efficiency in the municipality.	<ul style="list-style-type: none"> - Assess housing conditions, especially in SH. - Propose energy efficiency improvements and infrastructure upgrades. - Collaborate with other agencies to address community needs related to housing and urban services.

<p>Local Government – <i>Câmara Municipal do Montijo</i></p>	<p>Gov2</p>	<p>Address social issues within the community and support resident needs.</p>	<ul style="list-style-type: none"> - Provide direct support and resources for residents facing housing issues. - Facilitate communication between residents and the municipality for maintenance requests. - Implement redevelopment projects in problematic SH buildings. - Educate tenants on their responsibilities and promote accountability in maintaining housing conditions.
<p>Energy Agency – <i>Ponto de Transição +PRÓXIMO</i> Project</p>	<p>Ener1</p>	<p>Mitigate EP through practical interventions and community outreach.</p>	<ul style="list-style-type: none"> - Provide advice on energy efficiency improvements. - Assist households in applying for energy efficiency funding and making home improvements. - Identify and implement energy-saving measures tailored to specific households.
<p>Energy Agency – <i>S. Energia</i></p>	<p>Ener2</p>	<p>Promote energy efficiency, environmental sustainability, and address EP in collaboration with local authorities.</p>	<ul style="list-style-type: none"> - Collaborate with municipalities to develop and implement energy and climate action plans. - Run projects like “Megawatt” (education in schools), “Caderneta Energética” (energy management in municipal buildings), and “EduLUX 2,3+” (lighting improvements in schools). - Support energy efficiency in SH.

These organizations are key players in addressing these issues that disproportionately affect low-income residents. Their diverse roles allow for valuable insights about the difficulties and opportunities related to EP alleviation and renovation in SH stock. The sample selection of the interviewees does not seek to represent the studied population, and the findings do not aim to achieve statistical significance, rather it seeks to emphasize the careful testing of the possibility of involving local organizations in energy aid, applying a collaborative approach, and assessing the outcomes in an empirical case study. Note that the organizations and representatives that agreed to be interviewed already demonstrated some willingness to engage.

Data on the organization's name, e-mail address, and mobile number were collected; the six mapped stakeholders were contacted by e-mail with a general presentation of the research theme and invited to participate in the research activity consisting of a single one-on-one interview. This invite was sent to all organizations in June, conducted all five from June through August, all performed online. The interviews followed a semi-structured format, covering topics such as organizational goals, their experience with SH, knowledge about energy efficiency, and potential collaboration in energy-related initiatives. As it was a small sample of stakeholders, besides some frequent questions, the script of the interview had some specific ones based on the stakeholder's organization sphere (The full interview scripts can be found in ANNEX I – INTERVIEW SCRIPTS). This approach has enabled an in-depth understanding of the current activities of each organization and their capacity to engage in efforts related to energy efficiency.

The interview transcripts were manually processed, and their qualitative outputs were analyzed for potential collaborative roles in energy support and choice of drivers, barriers, and solutions to collaboration. Direct citations from the interviewees were extracted to illustrate their perspectives (translated from Portuguese to English by the authors).

These interviews aim to gather insights into the current state of SH, the role of various projects in addressing EP, and potential solutions for improving energy efficiency and living conditions. This step adds depth to the quantitative findings by capturing personal insights and lived experiences.

Step 6 – Analyze survey data. Survey data is analyzed from the residents as part of an energy advisory initiative. The *Ponto de Transição +PRÓXIMO* project in Montijo used a comprehensive survey to evaluate the impact of its energy advisory services and assess the needs of residents. While the container was in Montijo, a total of 57 participants filled out the surveys from April until June.

This survey was designed by CENSE, FCT-NOVA team in collaboration with ENA, informed by recent studies and EP indicators under the EU EPAH guidelines (Mendes, 2022). The survey was structured into three main sections: general demographic

information (name, age, nationality, etc.), data collection for domestic visits, and monitoring the impact of implemented solutions. This structure facilitated a thorough understanding of both the residents' needs and the project's effectiveness. The final survey version, developed with ENA's input, included automatic features for database management, consent forms, and adherence to Portuguese data protection regulations (Mendes, 2022).

The practical implementation of the survey involved home energy audits conducted by trained "Transition Agents." These agents provided detailed assessments of energy use and offered tailored advice on potential improvements. This approach not only addressed immediate concerns regarding energy efficiency but also contributed to broader goals of reducing energy and water consumption, lowering costs, decreasing greenhouse gas emissions, and enhancing thermal comfort (Gouveia *et al.*, 2024). The project emphasized community engagement through meetings with residents' associations, social solidarity organizations, and local governments, which facilitated trust-building and encouraged local involvement.

This step provides valuable insights into residents' energy consumption patterns, their awareness of energy-saving measures, and the financial and technical challenges they face in reducing energy use. The survey data complements the quantitative data from the EPVI and energy certificates, offering a holistic view of the residents' experiences.

Step 7 – Synthesize insights. The data collected from all sources – EPVI, energy certificates, interviews, and surveys – are analyzed using both thematic and statistical methods. Thematic analysis is applied to qualitative data to identify key patterns and themes, while statistical analysis is used to examine the quantitative data in detail. This integrated analysis provides a comprehensive understanding of EP in SH neighborhoods, highlighting both the statistical realities and the human experiences of energy vulnerability.

Step 8 – Develop recommendations. Based on the findings, targeted interventions are developed to address the immediate and long-term needs of vulnerable communities. These interventions include recommendations for improving

housing infrastructure, increasing energy efficiency, and providing financial support for residents. This step aims to translate the research findings into actionable strategies that can effectively alleviate EP in the study regions.

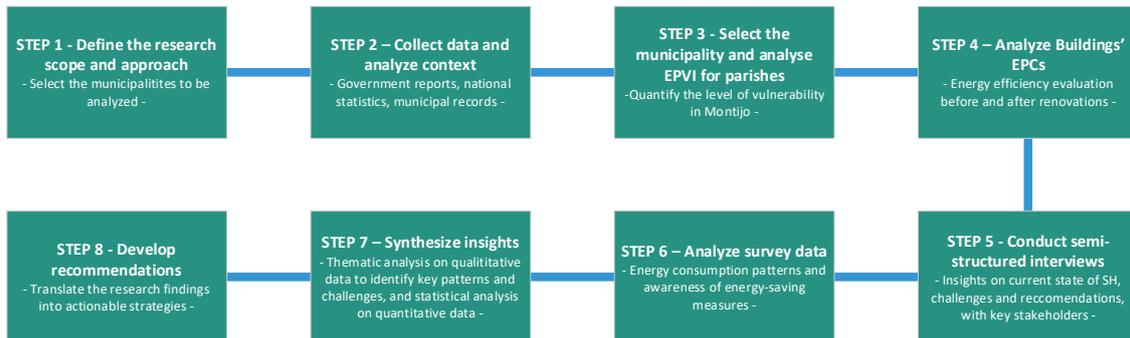


Figure 3: Methodological approach sequence.

5.1. Case Study

The selection of four municipalities — Montijo, Alcochete, Barreiro, and Moita—set the base for the case study on EP in SH neighborhoods. These municipalities, belonging to the Setúbal Peninsula region, were chosen due to their participation in the *Ponto de Transição +PRÓXIMO* project, as part of technical assistance from the EPAH, which included the creation of a second container (EPAH, 2024).

The selection of these municipalities was informed by their socio-economic conditions, characterized by economic disparities, high unemployment, and aging infrastructure. These factors combined to create a landscape of energy vulnerability, where residents of SH were at a higher risk of EP. While each municipality had its unique characteristics, they shared a common challenge: the need to address the energy needs of their most vulnerable populations. This context underscored the importance of targeted interventions and municipal strategies that could mitigate the effects of EP.

Among the four municipalities, Montijo stood out as a focal point for a more in-depth assessment. Montijo was chosen for its initiative-taking approach to EP and the availability of detailed data on its SH neighborhoods (Bairro da Lançada, in Sarilhos Grandes, and Bairro Novo do Esteval, in Montijo e Afonsoeiro). The municipality's active participation in the *Ponto de Transição +PRÓXIMO* project provided a wealth of information on the impact of energy efficiency interventions, making it an ideal candidate for a more in-depth analysis.

5.1.1. Alcochete

According to the 2021 Census, the resident population in the municipality of Alcochete was 19,143 residents, with a balanced age distribution, with the active working-age category predominant with 65.8%, 17.8% elderly and 16.4% youth. (PORDATA, 2021a).

Turning to education, Alcochete depicts a very heterogeneous profile. 386 individuals with no formal education, 15.4% of which have completed the fourth grade, 7.4% the 6th, 17.8% the ninth, and 28% the 12th grade. Only 1.4% have higher education degrees, whereas 25.9% have undertaken post-secondary education (PORDATA, 2021a).

Alcochete's SH stock remained stable from 2009 to 2015, with a slight decline in the total number of units. In 2009, there were 69 SH units, and by 2015, this number had decreased to seventy-three. However, the distribution of units across different typologies (T0-T4) remained consistent (INE, 2023a; Figure 4).

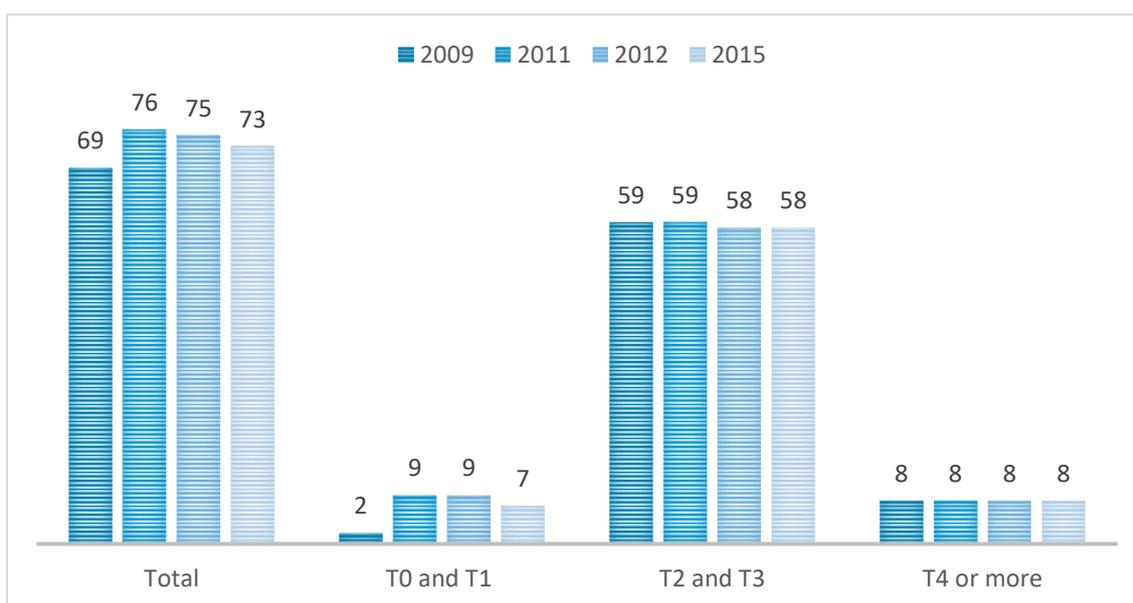


Figure 4: Social housing dwellings (No.) by geographical location (NUTS-2002) e Typology; Annual (INE, 2023a).

The number of SH buildings in Alcochete fluctuated slightly during the same period. In 2009, there were 22 SH buildings, and by 2015, this number had decreased to twenty-three. While the total number of buildings varied, the ownership regime (total or partial municipal/entity ownership) remained stable. The data demonstrates that during the years under consideration, Alcochete's SH stock was under total or partial municipal/entity ownership (INE, 2023b; Figure 5).

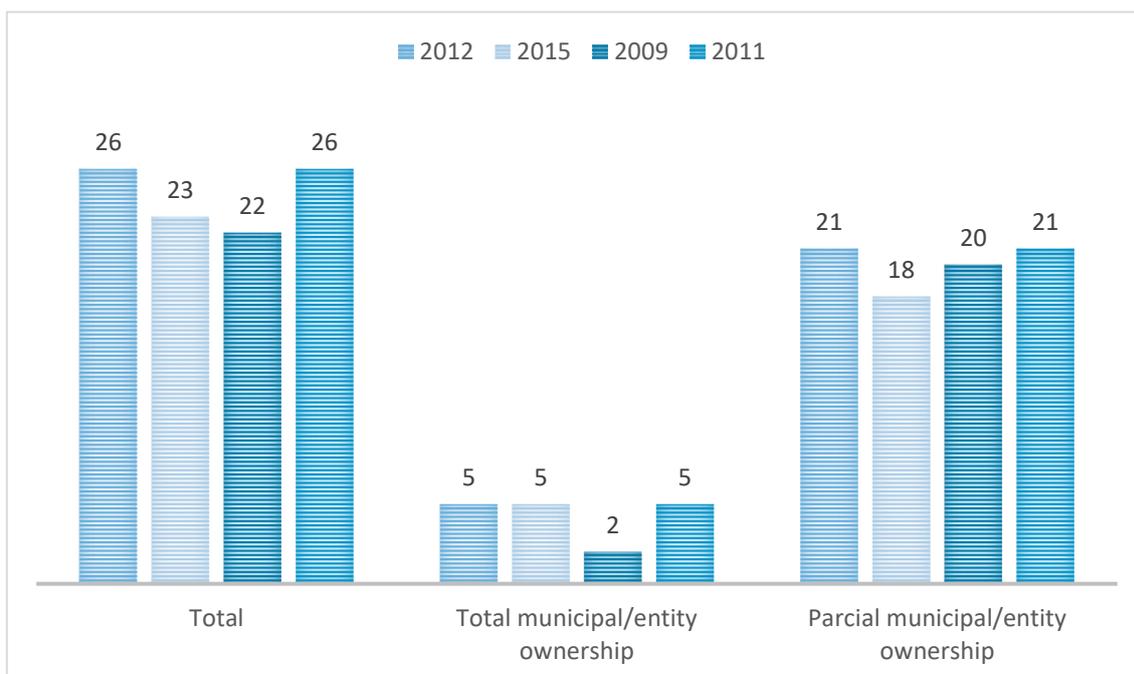


Figure 5: Social housing buildings (No.) by geographical location (NUTS - 2013) and ownership regime; Annual (INE, 2023b).

In 2012, there were 26 SH buildings; among these, two buildings had only one accommodation unit, while most of the buildings, 24, had two or more accommodation units. As of 2015, the number of buildings in SH was twenty-three. The distribution by size of accommodations remained the same, at 2 buildings only one unit and twenty-one buildings two accommodation units or more. A slight decrease in the overall number of SH buildings from 2012 to 2015 may indicate some changes in housing infrastructure or even in the way that SH development was approached back then. However, the existence of buildings with many accommodation units underlines an approach toward the meeting of housing demand more generally (INE, 2023c; Figure 6).

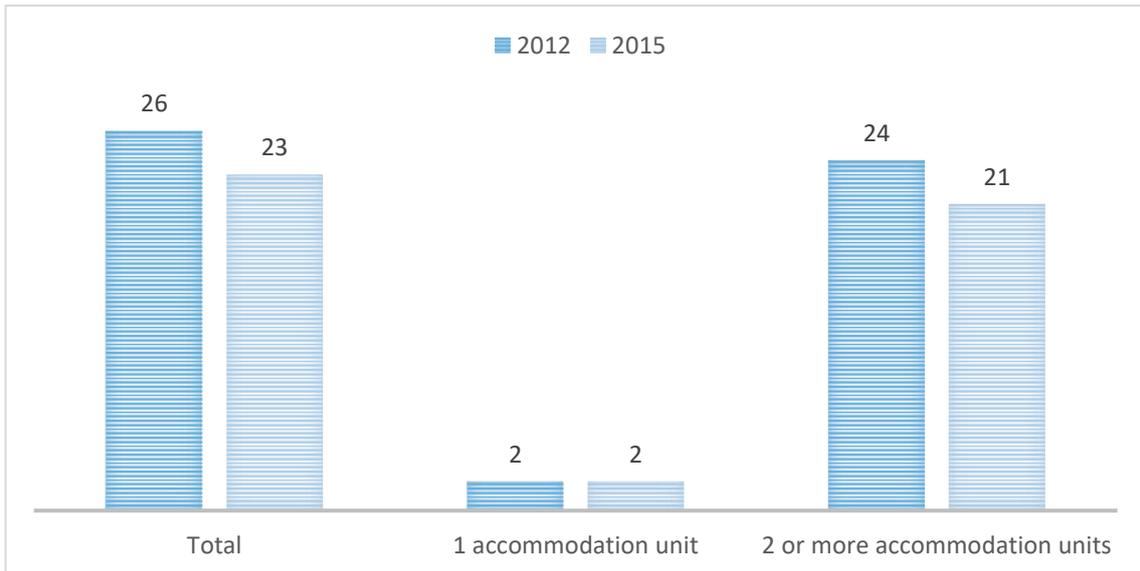


Figure 6: Social housing buildings (No.) by geographical location (NUTS - 2013) and housing size class; Annual (INE, 2023c).

Alcochete's SH infrastructure benefited from ongoing rehabilitation and conservation efforts. While the number of rehabilitated units and buildings undergoing conservation fluctuated over the years, these initiatives demonstrate a commitment to maintaining and improving the existing SH stock. For example, in 2009, 11 SH units were rehabilitated, and in 2015, 13 more units. (INE, 2023d; INE, 2023e; Figure 7).

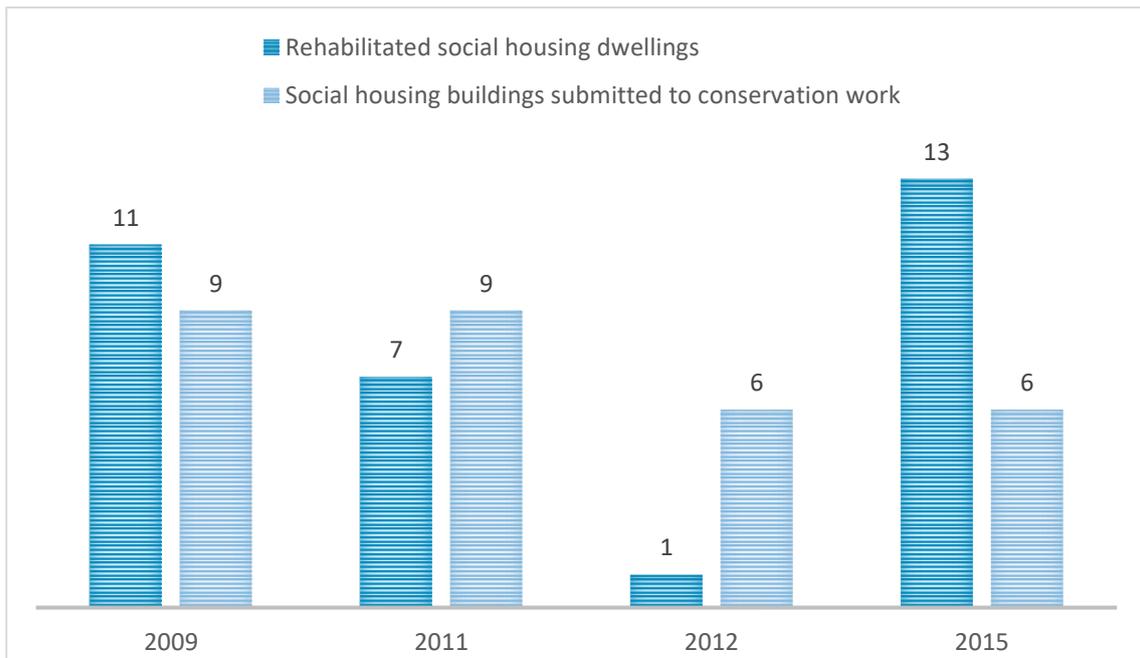


Figure 7: Rehabilitated social housing dwellings (No.) and social housing buildings undergoing conservation work (No.) by geographical location (NUTS - 2013); Annual (INE, 2023d; INE, 2023e).

Now, analyzing the construction time frames, the construction of SH buildings in Alcochete spanned several decades. Eleven buildings were constructed between 1946 and 1974, while six were constructed between 1991 and 1995 (INE, 2023f; Figure 8).

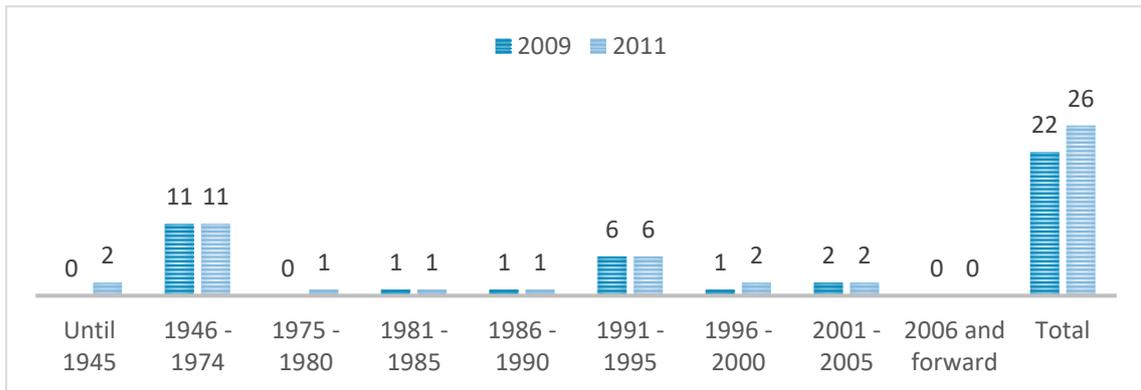


Figure 8: Social housing buildings (No.) by geographical location (NUTS - 2002) and season of construction; Annual (INE, 2023f).

In 2009, the municipality had 44 SH rental contracts, which slightly increased to 45 in 2011. All SH lease agreements in Alcochete during the years 2009 and 2011 were categorized as "Social or supported rent," indicating a consistent approach to SH policies (INE, 2023g; Figure 9).

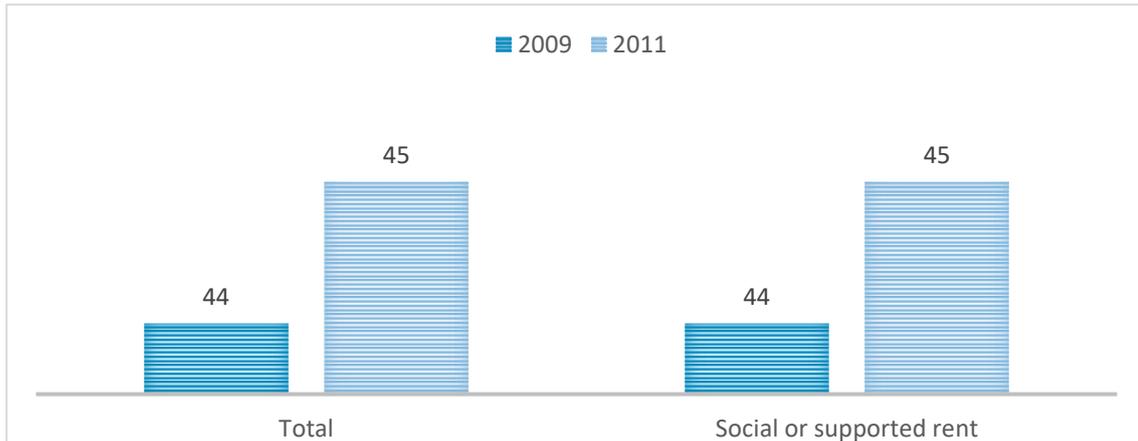


Figure 9: Existing social housing rental contracts (No.) by geographical location (NUTS - 2002) and type of rental contract (2009, 2011); Annual (INE, 2023g).

Whereas in 2009 there was already huge diversification in the number of units, this does not so much appear to be the case in 2015. On the other hand, despite an overall slight decline of units, Alcochete has kept a wide diversification of housing types. The new municipal regulation for the allocation of SH, approved in 2018, is testimony to a renewed will toward transparency and efficiency in the management of housing to meet the citizen's needs better (Câmara Municipal de Alcochete, 2018). It is the scarcity

of housing stock, coupled with an increased social demand, which underlines the real need for strong public policies and a greater investment by the state to guarantee that all inhabitants can live in decent and adequate housing conditions.

5.1.2. Barreiro

Barreiro, another Portuguese municipality, had a larger resident population of 78,345 in 2021. From the analysis by age bracket, 13.2% fall into the youth category, 61.3% belong to the active working-age group, and 25.6% are classified as elderly (PORDATA, 2021a).

The educational landscape of Barreiro is characterized by 1,548 individuals with no formal education, 20.3% have completed the fourth grade, 7.7% the sixth grade, 19.6% the ninth grade, and 27.7% the 12th grade. Only 1.3% have achieved higher education, while 19% have pursued post-secondary education. (PORDATA, 2021a)

The number of SH in Barreiro has fluctuated between 2009 and 2015, both in terms of the overall units and distribution by typologies. Whereas in 2009 there were 351 SH units, by 2015 this had increased to 416 (INE, 2023a; Figure 10).

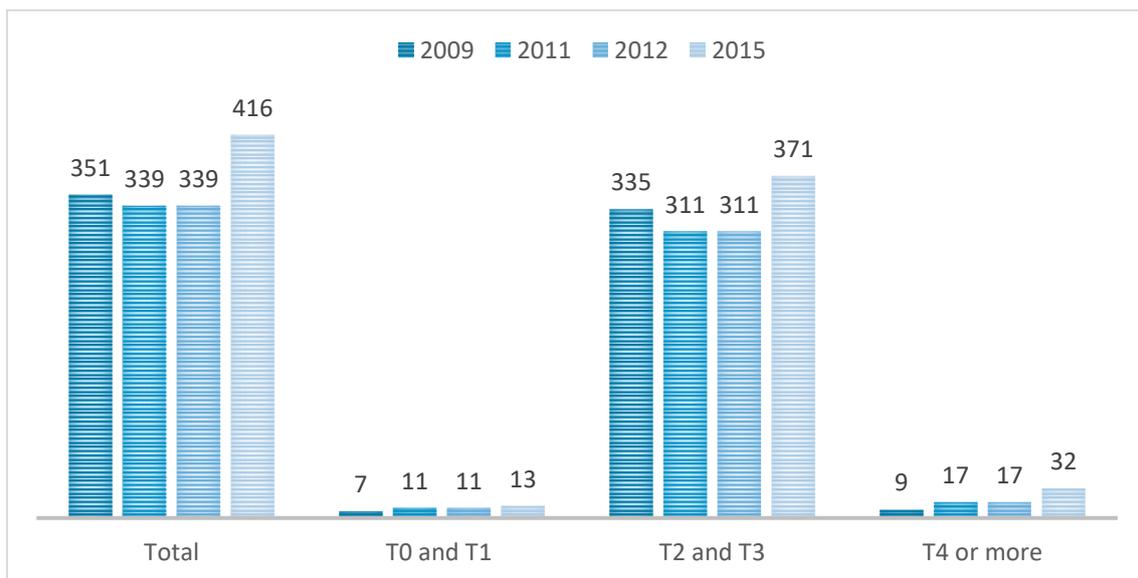


Figure 10: Social housing dwellings (No.) by geographical location (NUTS-2002) and type of dwelling; Annual. (INE, 2023a)

In total, Barreiro reached 136 SH buildings in 2009. Of those, twenty-three entirely belonged to the municipality/entity, and 113 were partially owned. By 2011, the total number of SH buildings remained the same at 136. The number of SH buildings

overall was still 136 in 2011. In the reshuffle of ownership distribution, thirty-six were under total municipal/entity ownership, with ninety-nine under partial municipal/entity ownership. In the following year of 2012, the Municipality of Barreiro recorded a rise in total SH buildings at 154. Of these, 104 were under total municipal/entity ownership, and fifty were under partial municipal/entity ownership. During the same period in 2015, the total number of SHs buildings decreased, to 135. The ownership distribution was 104 wholly municipally/entity-owned and thirty-one partially municipally/entity owned (INE, 2023b; Figure 11).

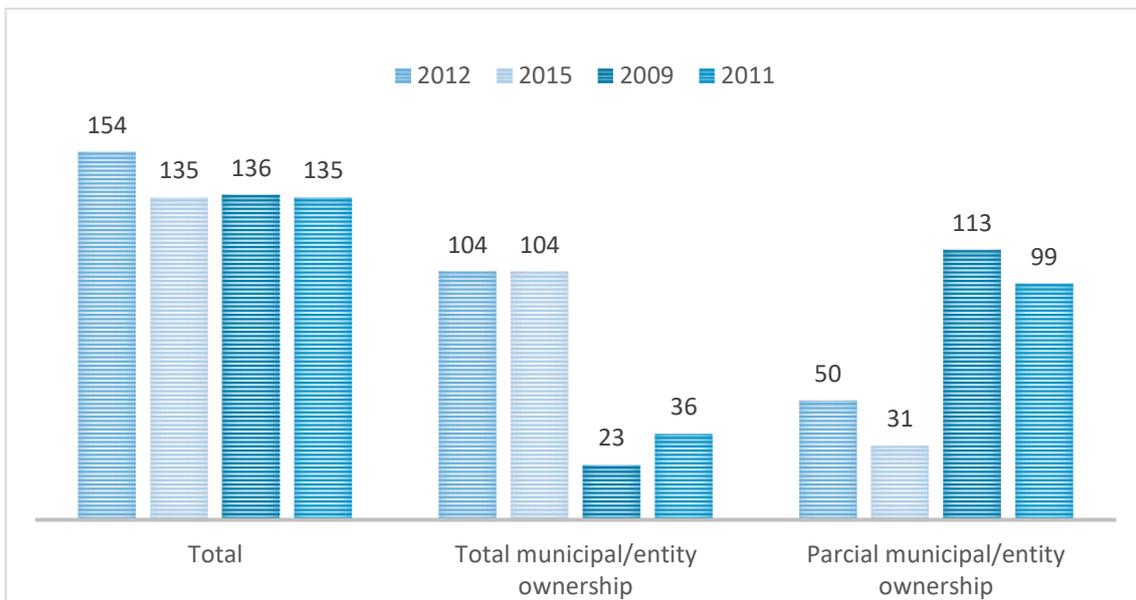


Figure 11: Social housing buildings (No.) by geographical location (NUTS - 2013) and ownership regime; Annual (INE, 2023b).

In Barreiro, similar to Alcochete, the majority of the SHS buildings had two or more accommodation units. In 2012, 86 buildings had two or more accommodation units. This dropped to 67 buildings that were reported to have two or more accommodation units in 2015. The changes in the distribution by size range of the accommodation units in SH buildings indicate that there is dynamism in Barreiro's approach to managing its house stock. By 2015, the decline in the total number of buildings could indicate an adjustment considering new challenges and demands regarding the housing market or strategic opportunities (INE, 2023c; Figure 12).

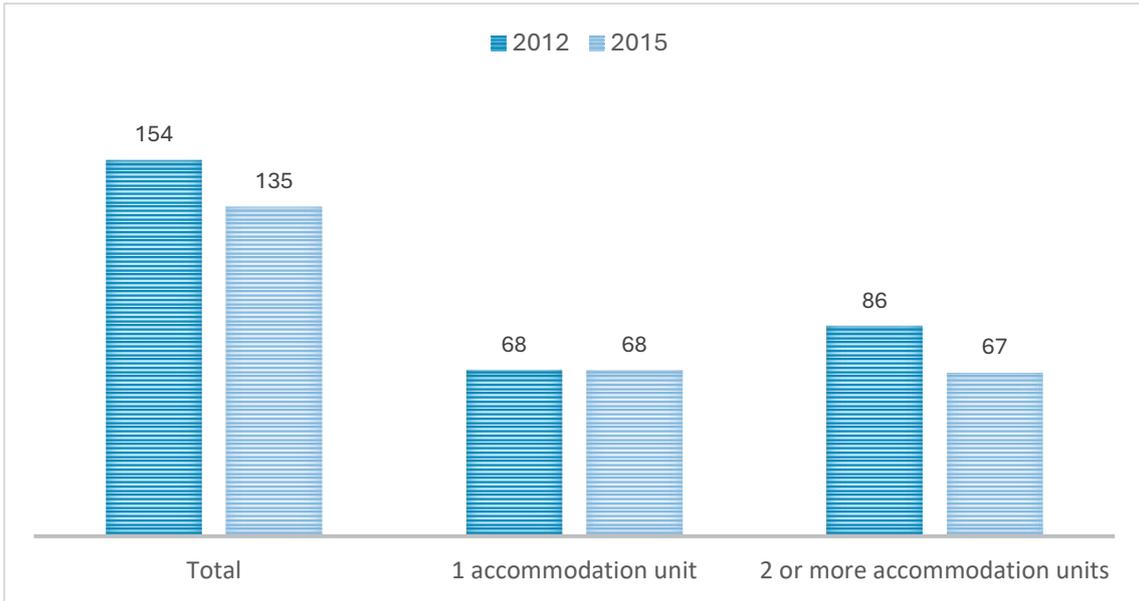


Figure 12: Social housing buildings (No.) by geographical location (NUTS - 2013) and housing size class; Annual (INE, 2023c).

The rehabilitation and conservation of the SH infrastructure in Barreiro has been developed with different intensities throughout the years. In 2009, the rehabilitation of 37 dwellings of SH was carried out, whereas in 2015, the number of rehabilitated dwellings reached 35. These figures evidence the continuous effort of Barreiro regarding the quality in the conservation and maintenance of the SH infrastructure, as expressed by the periodic conservation campaigns developed during this period (INE, 2023d; INE, 2023e; Figure 13).

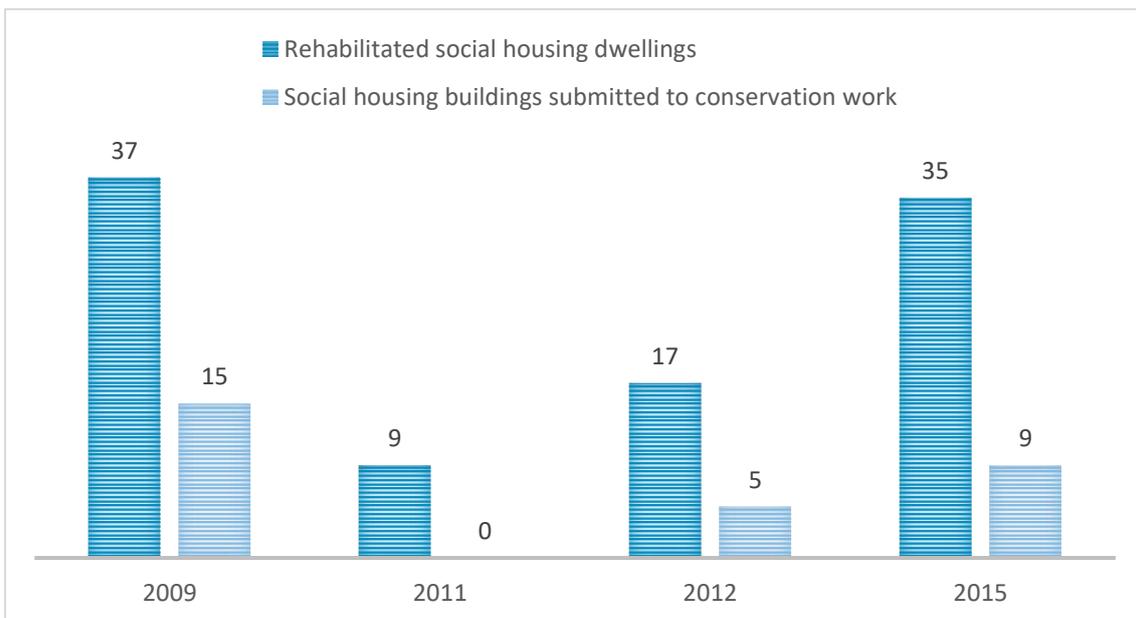


Figure 13: Rehabilitated social housing dwellings (No.) and social housing buildings undergoing conservation work (No.) by geographical location (NUTS - 2013); Annual (INE 2023d; INE, 2023e).

Between 1946 and 1974, 78 buildings in SH were constructed, followed between 1991 and 1995 by 4 buildings. In 2009, there were 136 SH buildings. The trend in 2011 was the same, with 135 SH buildings. (INE, 2023f; Figure 14).

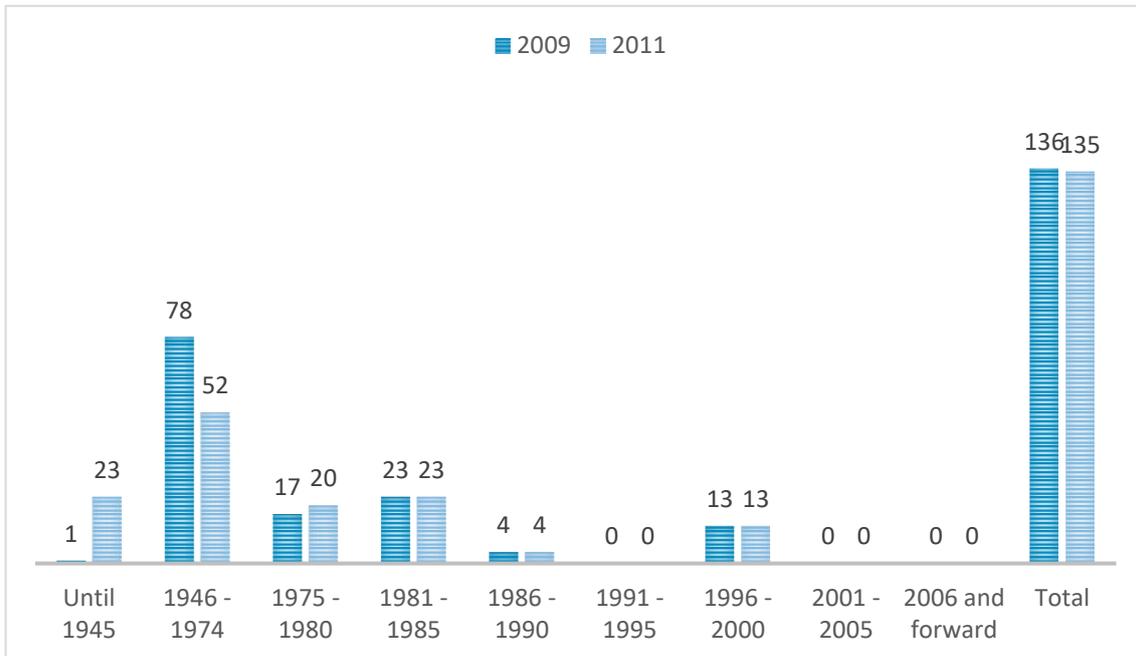


Figure 14: Social housing buildings (No.) by geographical location (NUTS - 2013) and Season of construction; Annual (INE, 2023f).

The data regarding existing SH lease agreements in Barreiro for the years 2009 and 2011 offers insights into the distribution of housing arrangements during these periods. In 2009, the total number of lease agreements for SH was 357. Out of these, 263 were categorized under social or supported rent, while ninety-four fell under the category of "Outro" (Other). There were no reported lease agreements for the type of resolvable property. In 2011, the total number of SH lease agreements decreased to 344. Within this, 261 were classified as social or supported rent, and eighty-three were under the category "Outro." Like 2009, there were no reported lease agreements for resolvable property during 2011 (INE, 2023g; Figure 15).

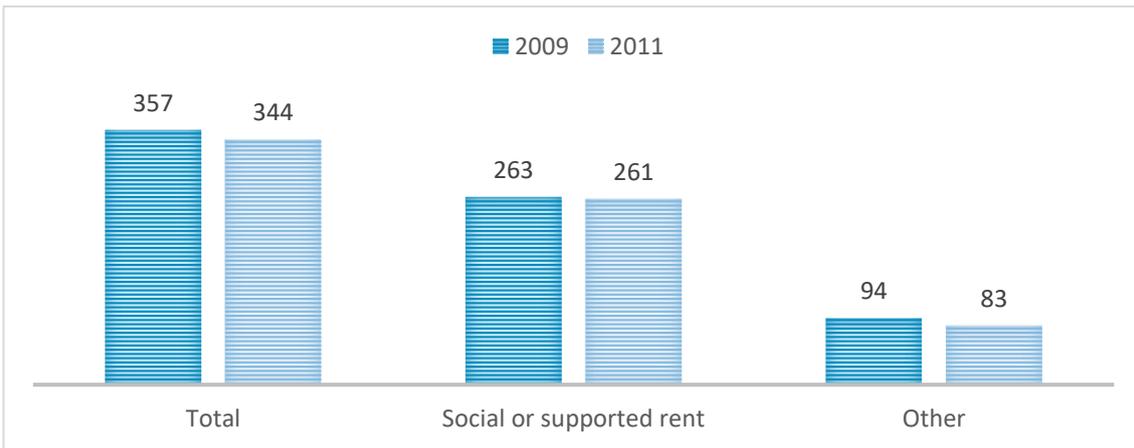


Figure 15: Existing social housing rental contracts (No.) by geographical location (NUTS - 2002) and type of rental contract (2009, 2011); Annual (INE, 2023g).

5.1.3. Moita

Moita, with a resident population of 66,255 in 2021, exhibits a demographic structure where 14.8% are young individuals, 63.3% fall within the active working-age segment, and 21.9% are categorized as elderly. (PORDATA, 2021a)

The educational profile of Moita includes 1,633 individuals with no formal education. It follows with 20.8% completing the fourth grade, 9.2% the sixth grade, 22% the ninth grade, and 28.1% the 12th grade. Just 1.4% have reached higher education, while 13.2% have pursued post-secondary education. (PORDATA, 2021a)

From 2009 to 2015, Moita did not show significant changes in SH stock, passing from 875 units in 2009 to 870 in 2015. This data provides a detailed breakdown of the distribution of SH units in Moita, offering a glimpse into the composition based on different dwelling typologies over the specified years (INE, 2023a; Figure 16).

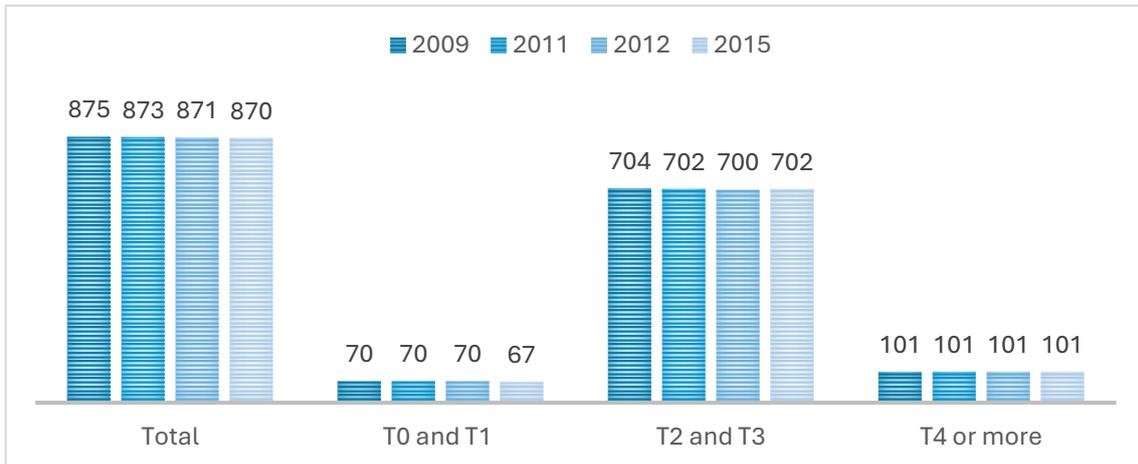


Figure 16: Social housing dwellings (No.) by geographical location (NUTS - 2002) and type of dwelling; Annual (INE, 2023a).

Moita is a municipality whose number of SH buildings varied between the total number of buildings and ownership regime. At the end of the year 2009, it counted 324 SH buildings, but in the year 2015, this number increased to 265. This brings out the share of SH buildings across the Moita municipality, the percentage variation of the ownership regimes in the years targeted. The difference in the values provides some evidence of SH dynamics related to the ownership structure. (INE, 2023b; Figure 17)

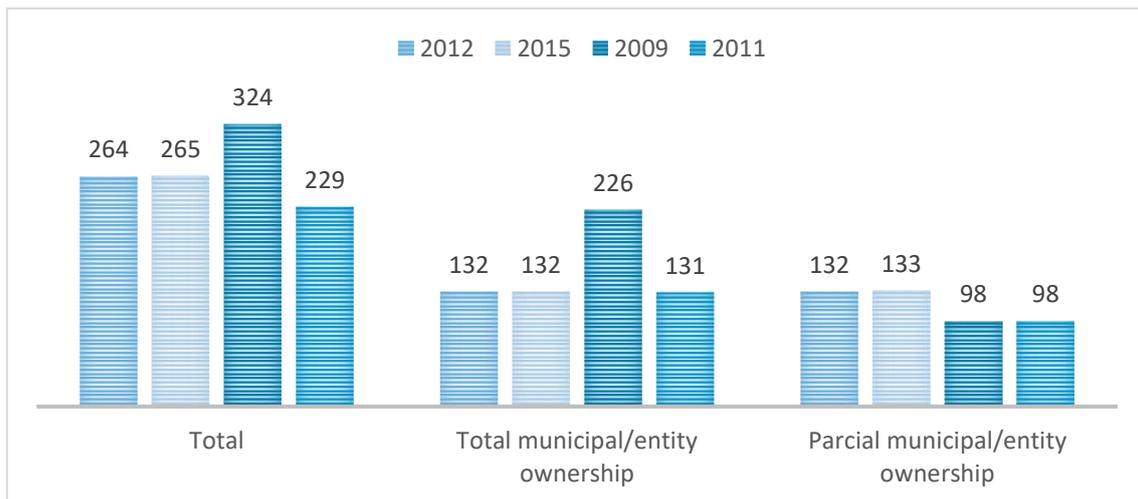


Figure 17: Social housing buildings (No.) by geographical location (NUTS - 2013) and ownership regime; Annual (INE, 2023b).

Like what happened with all the municipalities analyzed, the majority of the SH buildings stock in Moita corresponded to buildings with more than two accommodation units. In 2012, there were 184 buildings and, in 2015, 185 buildings. This data gives an indication of the composition of the SH structures in Moita, underlining the preponderance of buildings with more than one accommodation unit. It follows from this that, for the years taken into consideration, there is a stable distribution according to the scale of the accommodation units (INE, 2023c; Figure 18).



Figure 18: Social housing buildings (No.) by geographical location (NUTS - 2013) and housing size class; Annual (INE, 2023c).

Moita's SH infrastructure benefited from significant rehabilitation and conservation efforts, particularly in the early 2010s. However, the intensity of these initiatives decreased in the later years. For example, in 2009, 14 SH dwellings were rehabilitated, while in 2011, 124 dwellings were rehabilitated. These fluctuations in the rehabilitation of SH dwellings and conservation work on buildings suggest dynamic trends in housing policies or initiatives during this period in Moita (INE, 2023d; INE, 2023e; Figure 19).

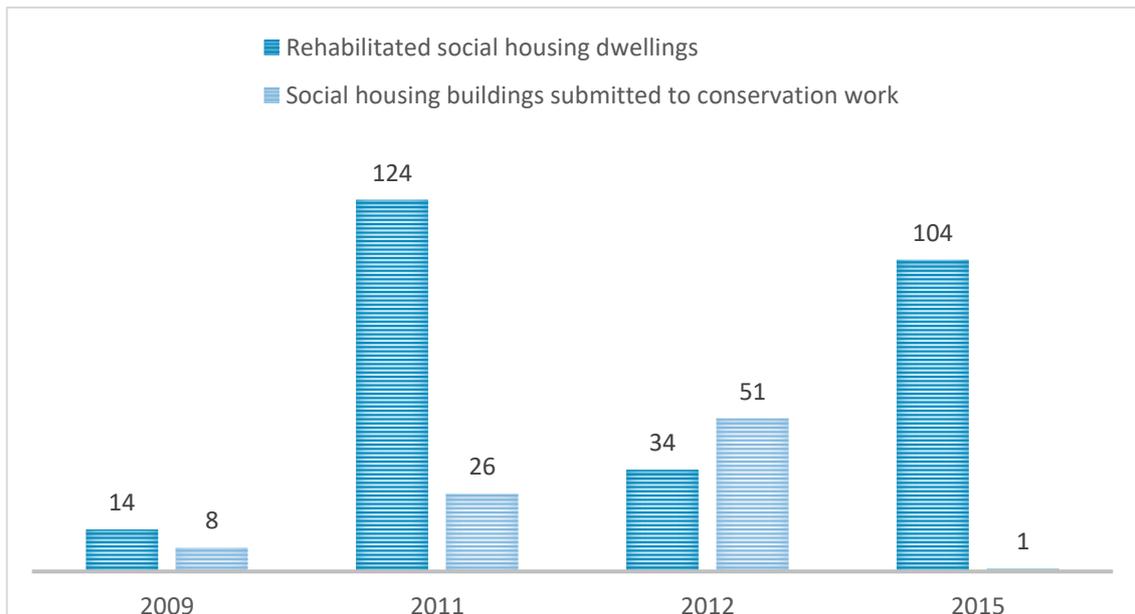


Figure 19: Rehabilitated social housing dwellings (No.) and social housing buildings undergoing conservation work (No.) by geographical location (NUTS - 2013); Annual (INE, 2023d; INE, 2023e)

The data on SH buildings in Moita, categorized by the period of construction and reported annually for the years 2009 and 2011, reveals insights into the housing landscape during these periods. In 2009, there were no reported SH buildings constructed until 1945, while the majority were built in the period from 1975 to 2000, with a substantial number of 116. The years 2001 to 2005 also saw notable construction activity with thirty-five buildings. No new constructions were reported for the years 1986-1990 and 2006 onwards. In 2011, the trend remained similar, with no buildings reported for the period until 1945. Many SH buildings were constructed between 1975 and 2000, with eighty-eight buildings. The years 1996-2000 and 2001-2005 also saw construction activity with 21 and 30 buildings, respectively. There was a decrease in the number of buildings constructed in the later years, with twenty-two buildings reported for the period 2006 onwards. Overall, these figures indicate the distribution of SH construction in Moita during the specified periods, highlighting a concentration in the late 20th century and a decline in the subsequent years (INE, 2023f; Figure 21).

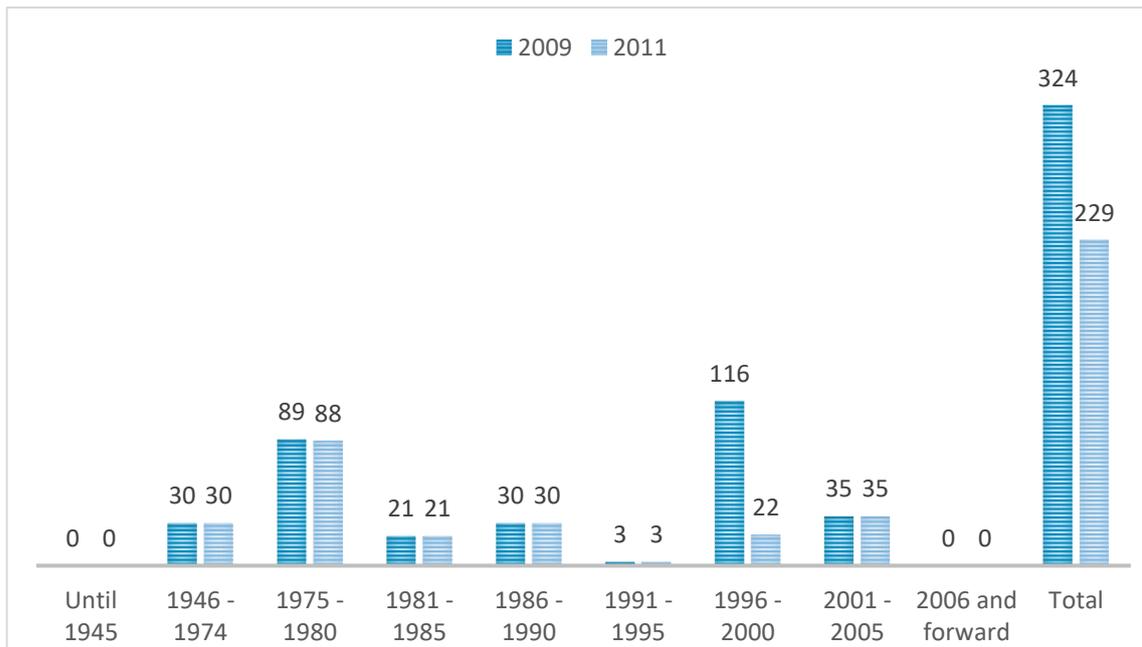


Figure 21: Social housing buildings (No.) by geographical location (NUTS - 2002) and season of construction; Annual (INE, 2023f).

The data from 2009 and 2011 regarding existing SH lease agreements in different geographical locations (NUTS - 2002) and contract types reveals insightful information. Most SH lease agreements in Moita were categorized as "Social or supported rent," similar to the other municipalities. In 2009, there were 847 housing lease contracts, and in 2011, there were 811 housing lease contracts. This data provides an overview of the distribution of SH lease agreements based on different contract types in the specified geographical locations during these years (INE, 2023g; Figure 20).

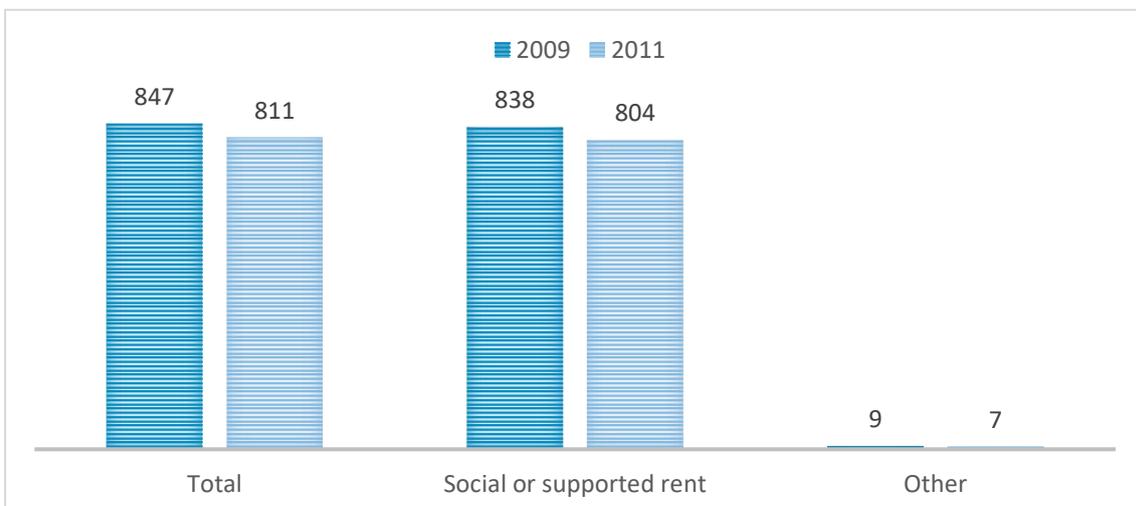


Figure 20: Existing social housing rental contracts (No.) by geographical location (NUTS - 2002) and type of rental contract (2009, 2011); Annual (INE, 2023g).

5.1.4. Montijo

Montijo, hosting a resident population of 55,682 in 2021, has a demographic distribution comprising 16.2% young individuals, 65.1% in the active working-age cohort, and 18.8% classified as elderly. (PORDATA, 2021a)

In education, Montijo has 1,437 individuals with no formal education. The educational landscape includes 17.3% completing the fourth grade, 7.8% the sixth grade, 18.8% the ninth grade, and 28.1% the 12th grade. A modest 1.5% have achieved higher education, and 21.2% have pursued post-secondary education. (PORDATA, 2021a)

Montijo, has implemented various SH initiatives and urban development projects. The data below sheds light on the SH landscape, encompassing the number of buildings, types of construction, rehabilitation efforts, and other relevant aspects.

Montijo's SH stock experienced minor fluctuations in both the total number of units and the distribution across typologies. In 2009, there were 542 SH units; by 2015, this number had increased to 551. This data provides a comprehensive overview of the distribution of SH units in Montijo over the specified years, shedding light on the various typologies within the region (INE, 2023a; Figure 22).

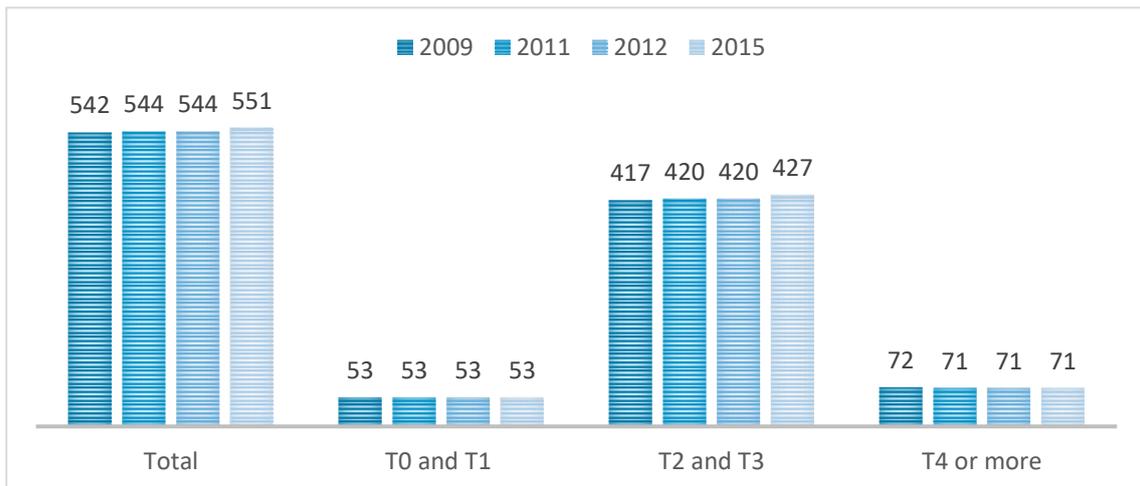


Figure 22: Social housing dwellings (No.) by geographical location (NUTS - 2002) and typology; Annual (INE, 2023a).

The number of SH buildings in Montijo fluctuated slightly, with changes in both the total number of buildings and the ownership regime. In 2009, there were 96 SH buildings, and by 2015, this number had decreased to ninety-four. This information

provides a comprehensive overview of the ownership distribution of SH buildings in Montijo over the specified years, highlighting the role of both municipal and partial ownership in the region (INE, 2023b; Figure 23).

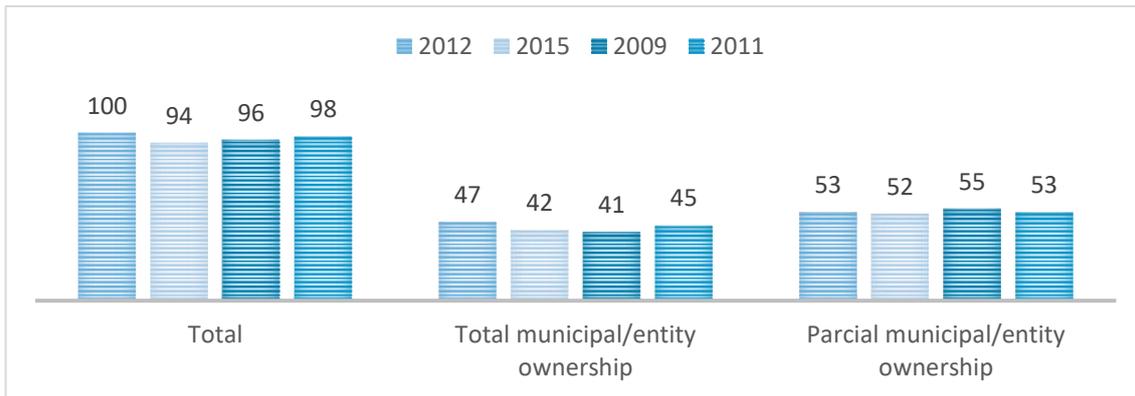


Figure 23: Social housing buildings (No.) by geographical location (NUTS - 2013) and ownership regime; Annual (INE, 2023b).

Many SH buildings in Montijo had two or more accommodation units, like the other municipalities. In 2012, 4 buildings had only one accommodation unit, while in 2015, all ninety-four buildings had two or more accommodation units. This data indicates a shift in the composition of SH buildings in Montijo during the specified years, with a reduction in the number of buildings with a single accommodation unit and an emphasis on those with two or more units. Understanding these changes can be crucial for housing planning and policy considerations in the region (INE, 2023c; Figure 24).



Figure 24: Social housing buildings (No.) by geographical location (NUTS - 2013) and housing size class; Annual (INE, 2023c).

Analyzing the data on SH in Montijo regarding rehabilitated dwellings and buildings subjected to conservation work provides insights into the region's housing trends over the specified years. Montijo's SH infrastructure benefited from rehabilitation and conservation efforts, although the intensity of these initiatives varied

over the years. For example, in 2009, 11 SH dwellings were rehabilitated, while in 2015, 106 dwellings were rehabilitated. These findings suggest a considerable effort towards the rehabilitation of SH dwellings in Montijo, with a fluctuating trend in buildings subjected to conservation work, emphasizing the dynamic nature of housing policies and interventions in the region (INE, 2023d; INE, 2023e; Figure 25).

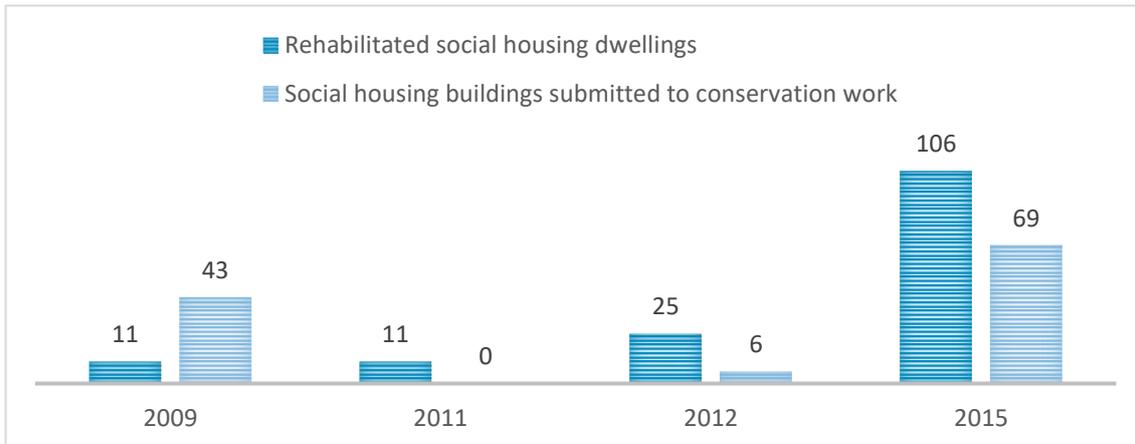


Figure 25: Rehabilitated social housing dwellings (No.) and social housing buildings undergoing conservation work (No.) by geographical location (NUTS - 2013); Annual (INE, 2023d; INE, 2023e).

Examining the data on SH buildings in Montijo, most buildings were constructed between 1991 and 1995, suggesting a concentration of SH construction in Montijo in these decades. The absence of construction in certain periods may reflect specific housing policies or demographic trends during those times (INE, 2023f; Figure 26).

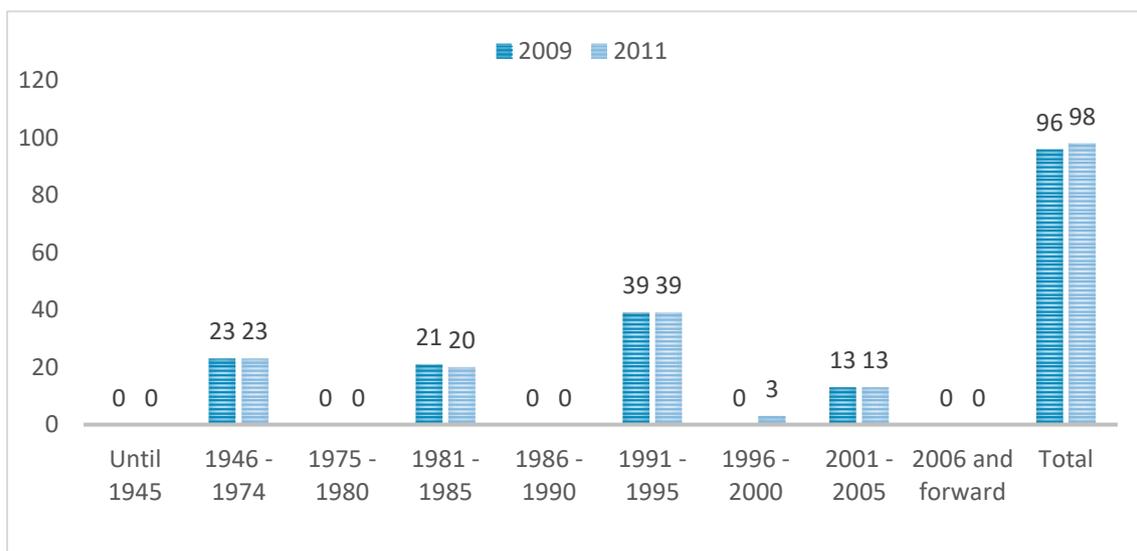


Figure 26: Social housing buildings (No.) by geographical location (NUTS - 2002) and season of construction; Annual (INE, 2023f)

The majority of SH lease agreements in Montijo were categorized as "Social or supported rent," similar to the other municipalities. In 2009, there were 535 housing lease contracts, and in 2011, there were 514 housing lease contracts. This information provides a detailed breakdown of the types of lease contracts, emphasizing the prevalence of social or supported rent agreements in Montijo during the specified years (INE, 2023g; Figure 27).

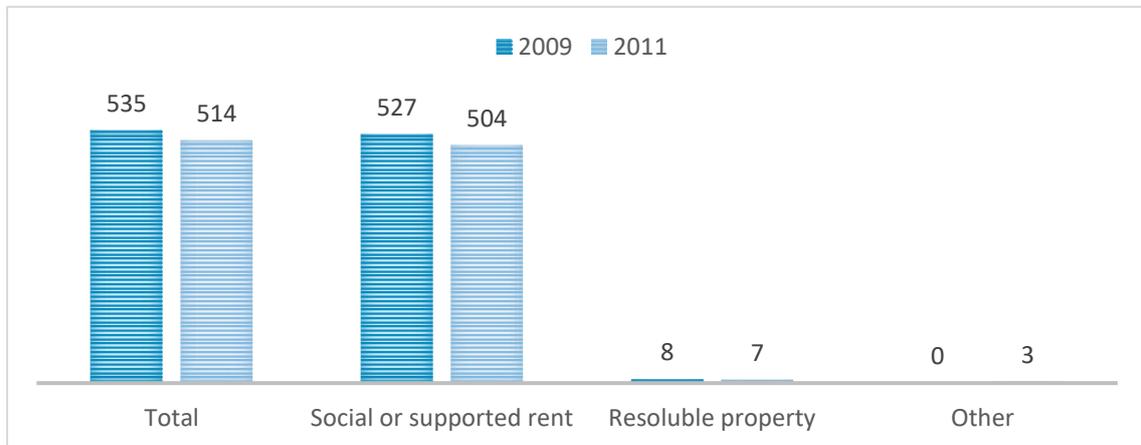


Figure 27: Existing social housing rental contracts (No.) by geographical location (NUTS - 2002) and Type of rental contract (2009, 2011); Annual (INE, 2023g).

6. Results and Discussion

The research will present findings based on the analysis of four key components: the Energy Poverty Vulnerability Index, Energy Performance Certificates, interviews with stakeholders, and survey results from *Ponto de Transição +PRÓXIMO* during its stay in Montijo.

6.1. Energy Poverty Vulnerability Index

Understanding and measuring EP is essential to identify vulnerable populations, assess the impact of policy interventions, and guide targeted measures to alleviate the problem. EP has been widely studied from various perspectives, including social, economic, geographic, and technical dimensions. These multidimensional approaches highlight the need for complex and integrative methodologies to effectively map and address EP at local and regional levels. One such methodology is the Energy Poverty Vulnerability Index (EPVI), which combines socioeconomic factors, climate variables, energy consumption, and building characteristics to identify hotspots of EP. (Gouveia *et al.*, 2019)

The vulnerability of Montijo to EP during the heating season is a critical concern. In the context of the EPVI, Montijo's parishes exhibit varying degrees of vulnerability, influenced by factors such as building stock quality, household income, and the efficiency of heating systems. The vulnerability score for each parish ranges from 0 to 20, with higher scores indicating greater vulnerability.

Montijo's overall vulnerability to EP is reflected in its rankings during both the heating and cooling seasons (Figure 28). The municipality faces significant challenges in ensuring that all residents can maintain adequate indoor temperatures, both in winter and summer. Montijo's vulnerability during the heating season, for instance, is a pressing issue. Winter temperatures can drop, and the need for effective heating is essential for maintaining not just comfort but health. Montijo's vulnerability score for the heating season ranks it at #308 nationally, placing the municipality among those with moderate to high vulnerability to EP during the winter. This high ranking signals the

difficulties faced by many residents in affording adequate heating, particularly in older, less energy-efficient homes.

The situation is even more pronounced at the civil parish level. Sarilhos Grandes, for example, has the highest vulnerability score in Montijo during the heating season, with a score of 9.8. This places Sarilhos Grandes among the most vulnerable parishes in the country, ranking #3092 nationally. The high score suggests that residents of this parish face significant challenges in staying warm during the winter, due to a combination of lower household incomes and older housing with poor insulation. This vulnerability is a clear indicator of the need for targeted energy efficiency measures in this parish, such as upgrading heating systems, improving insulation, and supporting low-income households with financial assistance.

While the vulnerability during the heating season is concerning, EP during the cooling season is also a significant challenge in Montijo. Portugal's summers have become increasingly hot due to climate change, making it essential for residents to maintain cool indoor environments, especially for vulnerable populations like the elderly and those with pre-existing health conditions. Montijo's vulnerability score during the cooling season places it similarly at #308 in the national ranking, indicating that residents struggle to manage indoor temperatures during the summer, particularly in homes that lack adequate cooling systems or insulation.

Once again, Sarilhos Grandes emerges as the most vulnerable parish in Montijo, with a cooling season vulnerability score of 11.8. This score ranks it among the highest in the country, underscoring the parish's susceptibility to EP during both winter and summer. The extreme vulnerability during the cooling season highlights the urgent need for interventions that not only address winter heating issues but also focus on ensuring that residents can stay cool during the increasingly hot summers. The challenges in Sarilhos Grandes, as well as other vulnerable parishes in Montijo, reflect a broader issue that requires a comprehensive, year-round approach to EP.

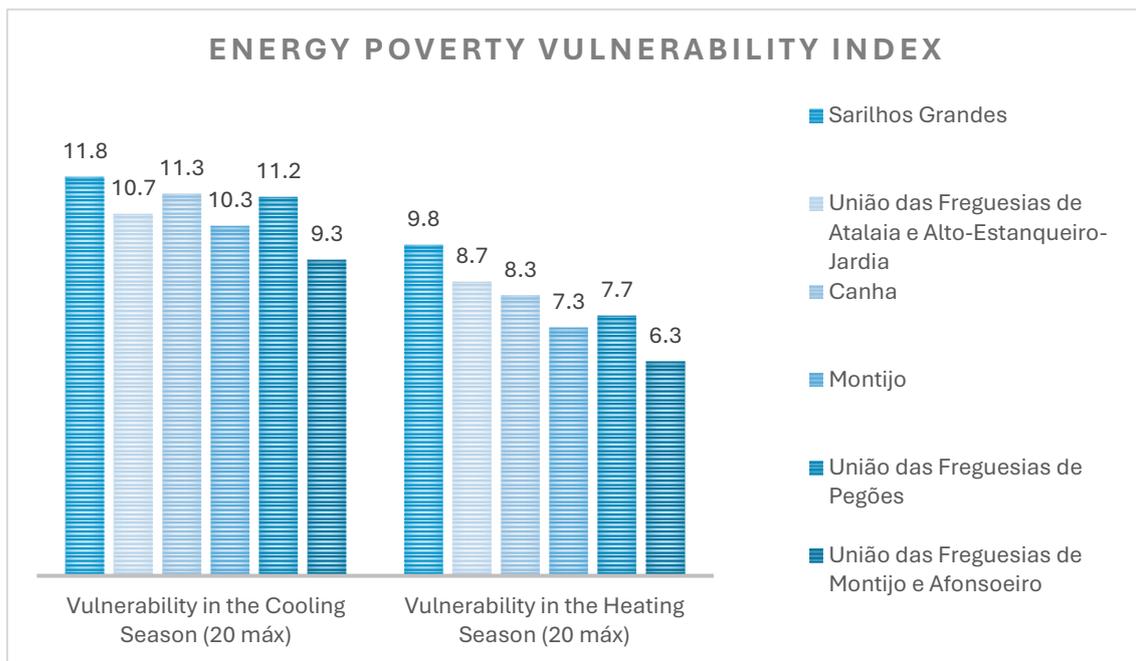


Figure 28: EP Vulnerability in the cooling and heating season values in Montijo (Adapted from Gouveia et al., 2019)

The implications of these findings are significant for Montijo's EP strategy. The high vulnerability scores suggest that a combination of energy efficiency improvements, financial assistance, and social support will be necessary to reduce EP and improve residents' resilience to extreme weather conditions. Energy efficiency upgrades, for instance, are essential in Montijo's housing stock, particularly in the most vulnerable parishes. This could involve retrofitting homes with better insulation, upgrading both heating and cooling systems, and promoting the use of renewable energy sources. Existing programs like the Efficiency Voucher offer potential funding sources for these upgrades, especially in low-income areas. In addition to energy efficiency measures, expanding access to financial assistance programs is crucial for helping vulnerable households manage their energy costs. Programs such as the ESSEC can provide immediate relief to residents struggling with high energy bills, particularly during periods of extreme weather. Social and health institutions in Montijo should also play a key role in addressing the intersection of EP and health. Vulnerable populations, such as the elderly and those with chronic health conditions, require targeted support, which could include home visits, health monitoring, and emergency assistance during extreme weather events.

Moreover, addressing EP in Montijo requires strong community engagement. Awareness campaigns and educational initiatives can promote energy-saving behaviors and inform residents about the support programs available to them. Collaborating with stakeholders and community organizations will be essential to ensure that vulnerable populations are reached and that they receive the necessary assistance.

Long-term strategic planning is also necessary to address the root causes of EP in Montijo. Beyond the immediate challenges, local authorities should invest in sustainable energy solutions, improve housing conditions, and foster economic development. By doing so, Montijo can reduce EP and create a more equitable and sustainable energy future for all residents.

The EP Vulnerability Index reveals critical insights into Montijo's challenges in managing EP. High vulnerability scores in the civil parishes of Sarilhos Grandes underscore the need for targeted interventions that address both heating and cooling issues. By utilizing the insights provided by the index and leveraging support from governmental bodies, and other stakeholders, Montijo can develop a comprehensive strategy that reduces EP, supports vulnerable populations in social housing neighborhoods such as Bairro da Lançada, and promotes a sustainable energy future.

6.2. Energy Performance Certificates

The importance of EPCs stems from their comprehensive assessment of a building's energy consumption, thermal performance, and greenhouse gas emissions. The EPC system in Portugal is designed to encourage energy-efficient practices both during the construction of new buildings and the renovation of existing ones. Article 17 of the law highlights that EPCs aim to provide an evaluation of a building's current energy performance while also suggesting measures for improvement, which is critical for achieving long-term energy savings and reducing environmental impacts (Presidência do Conselho de Ministros, 2020a) Moreover, EPCs are a prerequisite for obtaining certain financial incentives, such as tax benefits, making them essential for property owners interested in upgrading their buildings. Additionally, Portuguese consumers demonstrate a high willingness to pay for dwellings with better energy

ratings, indicating the effectiveness of EPCs as an informational instrument (Ramos *et al.*, 2015).

But while EPCs project the estimated energy use of a building, there often exists a significant gap between these predictions and the actual energy consumption observed after a building is inhabited. This discrepancy, known as the Energy Performance Gap (EPG), poses challenges for achieving accurate assessments and efficient energy renovations. (Hernandez-Cruz *et al.*, 2024)

This gap is influenced by numerous factors, including occupant behavior, building characteristics, and socioeconomic conditions (van den Brom *et al.*, 2018). In many cases, actual energy use can be two to five times higher than the predictions made by EPCs, leading to inefficiencies in energy-saving measures and building renovations. Hernandez-Cruz *et al.* (2024) emphasize that this gap highlights the need for more precise methodologies in EPC calculations and a better understanding of how occupants interact with buildings.

When considering the renovation of SH buildings, especially those aimed at reducing EP, the EPG becomes a critical issue. Studies show significant discrepancies between actual and simulated energy consumption in SH, with actual consumption often 40-140% lower than simulated values (Aranda *et al.*, 2018). However, as Hernandez-Cruz *et al.* (2024) point out, relying solely on predicted energy performance can lead to underestimating the actual energy needs of residents, especially in vulnerable populations. Low-income households in SH often consume less energy than predicted, living below average thermal comfort levels (Aranda *et al.*, 2018; Hernandez-Cruz *et al.*, 2023).

To address this issue, it is essential to incorporate real consumption data into the renovation strategies for SH buildings. Monitoring campaigns and social surveys are essential for understanding actual occupancy patterns and indoor conditions, which can inform more effective renovation strategies (Seabra *et al.*, 2021). By considering actual energy use, local authorities can better tailor their interventions to meet the real needs of residents, ensuring that renovations effectively reduce energy consumption and improve living conditions. Passive strategies and renewable energy sources should be

prioritized in SH renovations to reduce energy demand and alleviate EP (Seabra *et al.*, 2021). This approach is particularly relevant in SH, where occupants may have less control over their energy use due to economic constraints, making it even more crucial to optimize energy efficiency.

In Montijo, the commitment to energy efficiency is reflected in the recent issuance of one hundred energy certificates for SH buildings in Bairro Novo do Esteval, divided into 3 blocks of apartments: *Bloco D*, *Bloco A* and *Bloco C*. These certificates, provided by S. Energia and emitted in February 2023, were prepared as part of the municipality's submission process for the PRR, focused on rehabilitating SH, and provide a detailed evaluation of the energy performance of these buildings, highlighting areas where improvements are needed. The provided documents included a summary of the values comparing the before and after the applied energy measures, an overview of the sample used, and detailed recommendations for improvements to be adopted in the rehabilitation process. This information highlights potential upgrades in energy performance and serves as the foundation for the funding application to the PRR. The focus of these certificates has been on enhancing the heating index, reflecting the municipality's efforts to address EP and ensure that residents can maintain comfortable indoor temperatures during colder months.

The application of energy-saving measures, specifically the use of external thermal insulation (MM1) and the insulation of inclined roofs (MM2), has resulted in a significant reduction in cooling energy requirements across the one hundred analyzed buildings in Montijo (Figure 29). On average, there was a 26.3% decrease in cooling needs, indicating a substantial improvement in the buildings' thermal performance. The reduction varied across different properties, with some buildings experiencing minimal changes, while others saw reductions of up to 63.3%. This variation suggests that the initial conditions, such as the pre-existing insulation quality and building design, play a crucial role in determining the effectiveness of these measures. The overall decrease in cooling demand not only highlights the potential of targeted retrofitting to enhance energy efficiency but also emphasizes the importance of customizing solutions to individual building characteristics.

The application of these measures also significantly improved the heating efficiency (Figure 30). On average, heating needs were reduced by 43.3%, reflecting the effectiveness of the interventions in minimizing heat loss through building envelopes. The reductions were most pronounced in buildings with initially poor insulation, such as those with high pre-intervention heating demands, where improvements of over 70% were observed. This indicates that the addition of external wall insulation and roof insulation was particularly beneficial for these properties, drastically reducing the amount of energy required to maintain comfortable indoor temperatures during colder months. The overall trend demonstrates the potential of targeted retrofitting measures to contribute to substantial energy savings and improved thermal comfort.

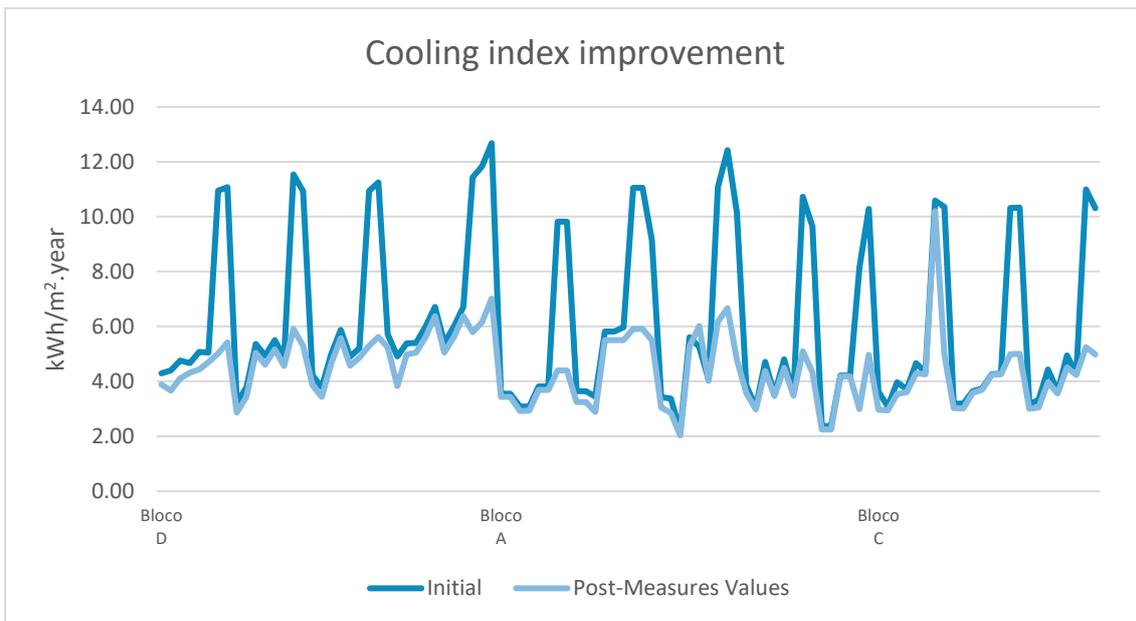


Figure 29: Comparing initial vs post implementation of measure values in terms of cooling.

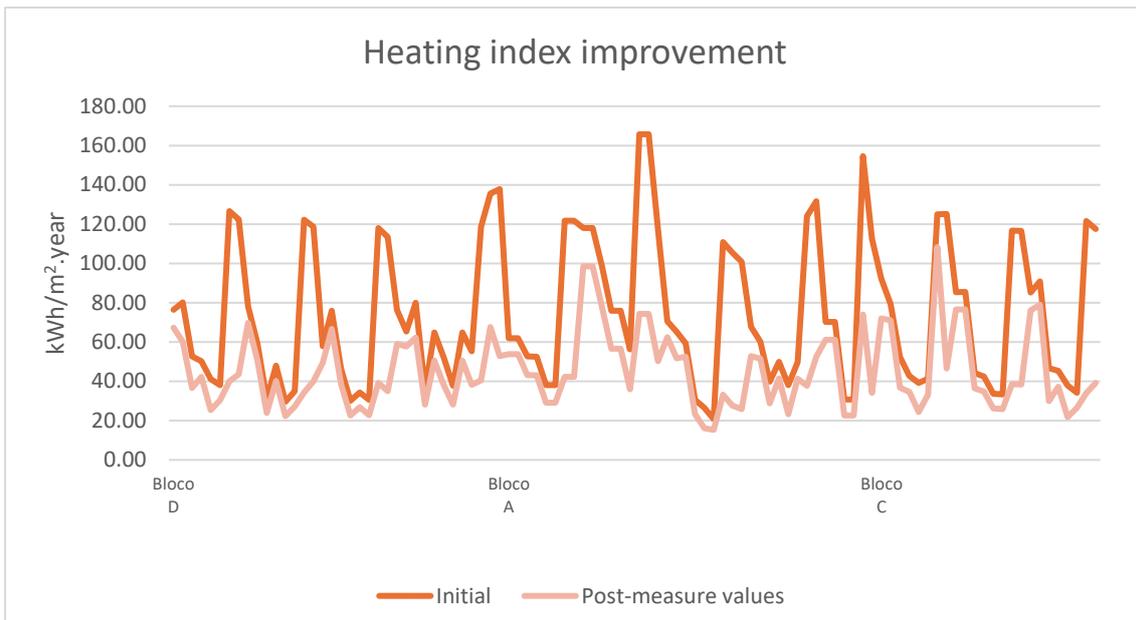


Figure 30: Comparing initial vs post implementation of measure values in terms of heating.

Furthermore, the data from these energy certificates provide a valuable resource for local authorities in Montijo as they develop long-term renovation strategies. By identifying the specific needs of each building, the municipality can target its resources more effectively, ensuring that the most impactful energy-saving measures are implemented. This approach not only contributes to Montijo's sustainability goals but also supports the broader objectives of the EU's Renovation Wave initiative, which seeks to double the rate of building renovations across Europe by 2030. By incorporating real consumption data into these assessments, the municipality can identify specific areas where interventions are needed, such as upgrading insulation, replacing windows, or improving heating systems, as suggested by Hernandez-Cruz *et al.* (2024)

In summary, EPCs are a crucial tool for advancing energy efficiency and sustainability in Montijo. Addressing the EGP and incorporating actual use data can lead to more accurate assessments, more efficient renovations, and better living conditions for residents (Hernandez-Cruz *et al.*, 2024). The recent issuance of one hundred energy certificates for SH buildings demonstrates the municipality's commitment to improving energy performance and addressing EP. Incorporating these insights into renovation planning can lead to more accurate predictions and better outcomes for SH residents. By leveraging the insights provided by these certificates, Montijo can continue to

enhance the energy efficiency of its buildings, reduce carbon emissions, and create a more resilient and sustainable community.

6.3. Montijo's social housing neighborhoods

After the analysis made to the EPVI and to the EPCs, we move the focus to two critical social housing neighborhoods in Montijo: Bairro da Lançada and Bairro Novo do Esteval. The EPVI presents a higher vulnerability in the parish of Sarilhos Grandes, where the Bairro da Lançada neighborhood is located, outlining that the residents from this area suffer extremely, especially during the heating season. Against this backdrop, Bairro Novo do Esteval was granted a hundred EPCs; it has been the epicenter in discussions regarding energy performance improvement and retrofitting needs toward attempts at mitigating energy poverty.

These two neighborhoods could give a better look into the broader struggles with energy poverty issues in Montijo because Bairro da Lançada has 12 social housing units, while Bairro Novo do Esteval has a hundred units developed under the Programa Especial de Realojamento PER. The Energy Performance Certificates provided from Bairro Novo do Esteval present the most important recommendations for energy efficiency upgrades, especially for heating and cooling, to take away part of the vulnerabilities of this community. Further, the map (Figure 31) situates the position of the two neighborhoods within the urban fabric of Montijo and underlines the need for a specific intervention to reduce EP in these social housing areas.

Bairro da Lançada

In the neighborhood of Bairro da Lançada, specifically in Sarilhos Grandes in Montijo, there are 12 social housing dwellings accommodating 11 families. The housing infrastructure includes two buildings, each with three floors. These buildings consist of a combination of two-bedroom (T2) and three-bedroom (T3) apartments, with six units of each type. The average rent for these social housing units is reported to be €19.60 (Câmara Municipal do Montijo, 2021).

Bairro Novo do Esteval

Bairro Novo do Esteval, in the parish Montijo e Afonsoeiro, with 100 social housing units, was constructed in the early 2000s as part of the *Programa Especial de Realojamento* (PER) (Município do Montijo, 2021). This neighborhood, housing 97 families, consists of the following typologies: 14 T0 units, 24 T1 units, 36 T2 units, 18 T3 units, and 8 T4 units (Município do Montijo, 2021; Câmara Municipal do Montijo, 2021). The average rent for these social housing units is reported to be €44,63 (Câmara Municipal do Montijo, 2021). While the overall condition of the estate is considered average, largely due to its relatively recent construction, some issues persist. The use of lighter internal and external walls, as part of the metal construction system, makes it prone to wear, particularly from impacts, which is already visible in common areas.

The strategic design of Bairro Novo do Esteval, located within a developing urban area alongside social, commercial, and private housing projects, has helped reduce stigmatization risks. This integration fosters better maintenance of the buildings due to the shared sense of responsibility and social control in the community. However, improvements are still needed in areas such as accessibility (Município do Montijo, 2021).



Figure 31: Map of Montijo's social housing neighborhoods, including Bairro da Lançada in Sarilhos Grandes and Bairro Novo do Esteval (Câmara Municipal do Montijo, 2021).

6.4. Interviews

The interviews began with a brief introduction, in which the purpose of the research was explained. It was important to set a collaborative tone and so the objectives of the interviews were outlined, emphasizing that the goal was to better understand the local landscape of EP and identify potential pathways for improvement. The interviewees were reassured that their responses would be treated with confidentiality and used solely for the analysis and reporting required by the research.

Initially, interviewees were asked to provide an overview of their perception of EP in Montijo, particularly within SH neighborhoods. This allowed the discussion to begin with a broad context, inviting respondents to share their views on how they or their organizations approached the challenge and what they saw as the scale and impact of the issue. Both Gov1 and Ener2 highlighted the need to improve energy efficiency within SH. Gov1 focused on external improvements, such as roof insulation and making improvements to building facades, due to the difficulty of obtaining resident consent to improve dwellings inside their homes. Ener2 also found it was necessary to make improvements at structural levels, but equal importance must be placed on internal energy efficiency projects and resident participation and education.

Soc2 offered a closer look at the socio-economic struggles faced by residents, emphasizing that many families live in poorly insulated homes that are prone to dampness. Soc2 observations echo those of Gov1 and Ener2 but add the crucial insight that beyond construction quality, residents are often more concerned with the immediate challenge of paying bills rather than long-term energy efficiency. This highlights a gap between the technological progress of the municipality and the day-to-day realities faced by residents living in precarious housing conditions. As Soc2 pointed out, while external interventions like roof insulation are critical, they are insufficient if they do not address the internal living conditions that directly affect energy consumption and health.

The challenges Gov1 experienced in getting unanimous agreements on internal improvements, particularly in mixed-ownership blocks, point to the contrast between the technological progress of the municipality and the concrete barriers that exist for residents. This is further illustrated by the insights given by Soc1 and Soc2, who observed

poor housing conditions, with homes suffering from damp and poor insulation. *“Houses that have poor energy utilization, often with damp... even though most of them or almost all of them, have access to the social tariff, they end up not being able to have the house with conditions for better energy insulation,”* Soc 2 pointed out. However, they emphasized that these issues often go unmentioned by the residents themselves, who are more concerned and in *“survival mode, which is to have the money to pay,”* and affording basic needs like paying their energy bills.

In discussing the main challenges faced by residents living in SH, Gov2 noted, *“In terms of social problems, we have a lot in social housing. And, as you realize, as they say, there are children of many mothers. There are buildings where nothing happens, absolutely nothing. There is a 30-year-old building that is spotless from top to bottom. And then there is one next door where there is not a light switch. So, all of this is the result of people's behavior. It's the people who make the buildings; it's the people who make the environment.”* This statement underscores the interplay between social behavior and the physical conditions of housing.

Regarding whether the issues are more social or technical, they stated, *“It's more from a cultural perspective. And sometimes what happens is a result of this.”* This emphasizes that the diversity of the tenant population also influences their living conditions and responses to interventions. Gov2 further elaborated on their direct interactions with residents, explaining, *“I go there if I have to. In fact, I go when it's necessary and when it's not, and when I have time.”* Their perspective illustrates the importance of ongoing engagement with residents to understand and address their needs effectively.

Discussing the specific factors contributing to residents' discomfort at home, Gov2 pointed out that many residents lack the resources for necessities: *“They don't pay rent, they don't pay for water, they don't have money to eat, they live on RSI (Rendimento Social de Inserção)”*. This highlights the broader socio-economic context that complicates the issue of EP.

Gov2 emphasized the importance of understanding tenant responsibilities, stating, *“The council is the landlord. Sometimes there's an understanding that the council*

has to do everything." This reflects a common misconception that can hinder resident engagement and accountability. They also noted challenges related to rehabilitation programs, mentioning that while there are redevelopment projects for the most problematic buildings, not all can be addressed due to resource limitations.

EP is not just a technical issue but a deeply social one, where improving energy efficiency must go hand in hand with addressing broader living conditions and ensuring effective resident engagement. This interaction shows that, as important as external interventions may be, they remain insufficient if not attuned to internal living conditions that directly affect energy consumption and health.

The grassroots activities of Ener1 shed a different light on this understanding. According to Ener1, who worked very close to the residents, *"many of them need more than consultation—in terms of replacing windows and enhancing internal insulation, they require hands-on support."* This observation speaks to a flaw in the current approach, which has focused overwhelmingly on comprehensive external works, overlooking the more pressing yet less extensive needs in individual homes. Soc2's perspective supports this view, stressing that residents require more practical, tailored guidance and education to improve their energy efficiency. *"The residents don't just need information – they need direct support and guidance to make changes that will make a real difference in their lives."* However, like Ener1, Soc2 acknowledged that without the necessary funding and structural support, the impact of these educational efforts remains limited.

Following this, the conversation shifted towards existing initiatives and strategies aimed at addressing EP. Questions in this section were designed to gather specific information about the types of programs or measures that had been implemented, such as energy efficiency improvements in SH or financial support for residents facing energy costs. This section provided a clear picture of the current landscape of interventions and any gaps that might exist in addressing EP effectively. A meaningful confluence of feedback from these stakeholders concerns the issue of financing. Both Ener2 and Ener1 highlighted the gap between the funding available and the real needs of the inhabitants. *"The current funding programs are more suited for*

large-scale, external renovations rather than the smaller, internal upgrades that many residents desperately need" explained one representative from Ener2. On the same lines, Ener1 said, "there's a gap between what the funding covers and what these homes actually need."

This concern was echoed by Soc1, where they noted that *"the residents who need the most help often fall through the cracks of these funding schemes. They can't afford to cover the cost of the improvements themselves, but the programs don't cover enough of the necessary work."* Soc2 emphasized the lack of adequate policy to address these structural issues in SH: *"There has been no care in the construction of these houses, so that they are not too cold in winter and too hot in summer. And although there was a campaign a while ago to help with the costs of putting in windows that insulate better, not everyone was covered."* Soc2 underscored the disconnection between the needs of these homes and available support: *"The houses aren't theirs, so they couldn't do it... there is still no policy to promote SH with energy insulation capacity."*

Another critical aspect of the interview script focused on the challenges and barriers that both organizations and residents encounter when dealing with EP. These questions aimed to uncover the practical difficulties faced in implementing policies, securing resources, or dealing with the everyday realities of maintaining affordable access to energy. Bureaucratic barriers were a powerful theme arising from the interviews which many face. GOV1 cited their frustrations in navigating all the approval processes necessary for external and internal SH improvements. Indeed, they stated, *"The layers of bureaucracy slow down the process, sometimes to the point where it becomes impossible to execute the needed changes"* when funds were available.

The problem is further compounded by the skepticism of the residents regarding these processes. According to Soc1, *"Many residents feel disconnected from the decisions that are being made about their homes. They don't always see the benefits of these improvements, especially if they're not involved in the process."* This shows the need for effective communication and engagement strategies to ensure residents are informed and in support of the proposed upgrading.

Soc2 elaborated on the severity of the challenges faced by residents when it comes to paying their bills. *"They clearly don't have the conditions that we're used... they can't heat their homes the way we do, or they spend a lot more money on heaters, which sometimes they don't have,"* he explained. He also highlighted that some residents lack even basic heating equipment and may need external support to acquire necessary appliances, remembering *"a family that only had one heater and needed to by another... there was no money, they asked for financial support for that."*

Ener1 seeks to address this disparity by offering tailored guidance and assistance regarding energy efficiency. ***"Our goal is to empower residents by giving them the knowledge they need to make informed decisions about their energy use. But without the necessary funding and structural support, there is only so much we can do,"*** argues Ener1. This points out how crucial it is to couple resident education with concrete financial and technical support that might translate guidance into practice. The responses often revealed the complexities of addressing such a multifaceted problem, leading to deeper discussions about the obstacles that hinder progress.

The interviews were guided further to examine the role of different actors in relation to the issue of EP. Understanding this work should be done by many sectors, the respondents were asked about the roles and responsibilities of the local government, social organizations, and the community in addressing the problems, tasking them to reflect on how the stakeholders coordinated, what challenges in coordination were faced, and how effective were their joint efforts. Soc2 mentioned that while some collaborations exist, there is room for improvement, especially when it comes to mobilizing more resources. *"In terms of social mobilization, it would be interesting to have... companies that could make these partnerships, not directly with us, but with the local councils... there could be urban regeneration along these lines."*

The input from the different stakeholders consulted evidence the need to unify the approach toward EP in Montijo. As important as these external initiatives are, it should also entail internal improvements and higher contributions from residents. *"We need to find a way to streamline these processes and get everyone on board—residents, building owners, and the municipal authorities."* GOV1 explains. Moreover, it will be

required to match financial resources with community needs. Ener2 commented, *"flexible funding mechanisms that allow for both large-scale renovations and smaller, more immediate upgrades"* are paramount. Sustainable improvement in energy efficiency and alleviation of EP in Montijo will succeed only with a holistic approach that addresses technical interventions together with resident participation.

The scripts were meant to create focused but flexible interviews, enabling the interviewees to give their opinions on several salient themes, yet giving ample space for thorough discourse on issues. This flexibility ensured that each interview was relevant and meaningful, tailored to the unique perspective of each stakeholder.

Overall, the interviews provide a detailed understanding of the challenges faced by local organizations in Montijo as they work to address EP and improve SH. Such views from stakeholders call for comprehensive, integrated strategies that, besides technical solutions, are resident based with financing mechanisms that are flexible and an effective means of communication. To effectively fight EP in Montijo is necessary to strengthen infrastructures and, at the same time, empower the local population and activate sector collaboration. Additionally, policy support at the municipal and national levels is essential to ensure that SH units are retrofitted to meet modern energy standards, reducing the burden of EP on vulnerable residents.

Moving forward, collaboration between these organizations and government initiatives could play a crucial role in improving energy efficiency and supporting vulnerable populations in Montijo. Effective solutions require coordinated efforts across various sectors, improved community engagement, and sustained support systems. A multistakeholder strategy of this nature is essential for implementing sustainable improvements both in energy efficiency and social welfare in the municipality. By addressing the interconnected issues and leveraging the strengths of these local organizations and the community outreach of social support centers, there is potential to create more impactful and sustainable solutions for the community.

6.5. Surveys – Ponto de Transição +PRÓXIMO

The survey results from the time that the container was in Montijo from 19th of April until 31st of May 2024 (Figure 33), revealed several significant trends and issues concerning EP and household discomfort. Of the 57 participants, a notable proportion were aged between 55-64 and 65+ (Figure 32), indicating that older demographics were particularly represented.



Figure 33: Ponto de Transição +PRÓXIMO container at Praça da República, Montijo

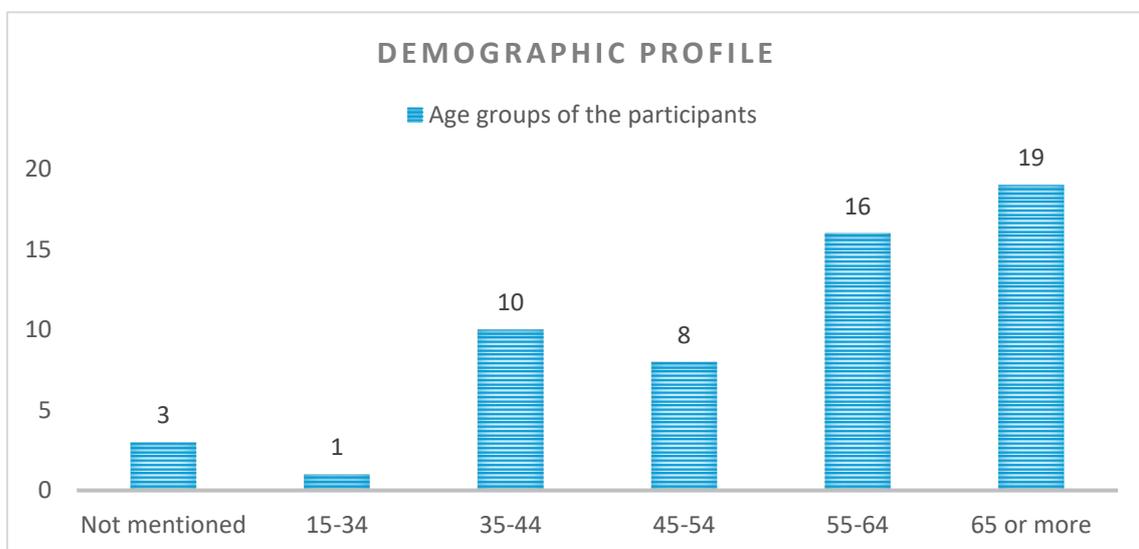


Figure 32: Demographic profile of participants in the surveys

A recurring theme is thermal discomfort, as most respondents frequently reported feeling cold in winter (mostly scoring four, "frequently"), with many also facing excessive heat in summer (Figure 34). This underscores the poor insulation and inadequate temperature regulation in homes surveyed. Moreover, a substantial number of respondents reported frequently suffering from external noise, though this concern was less consistently reported compared to thermal discomfort.

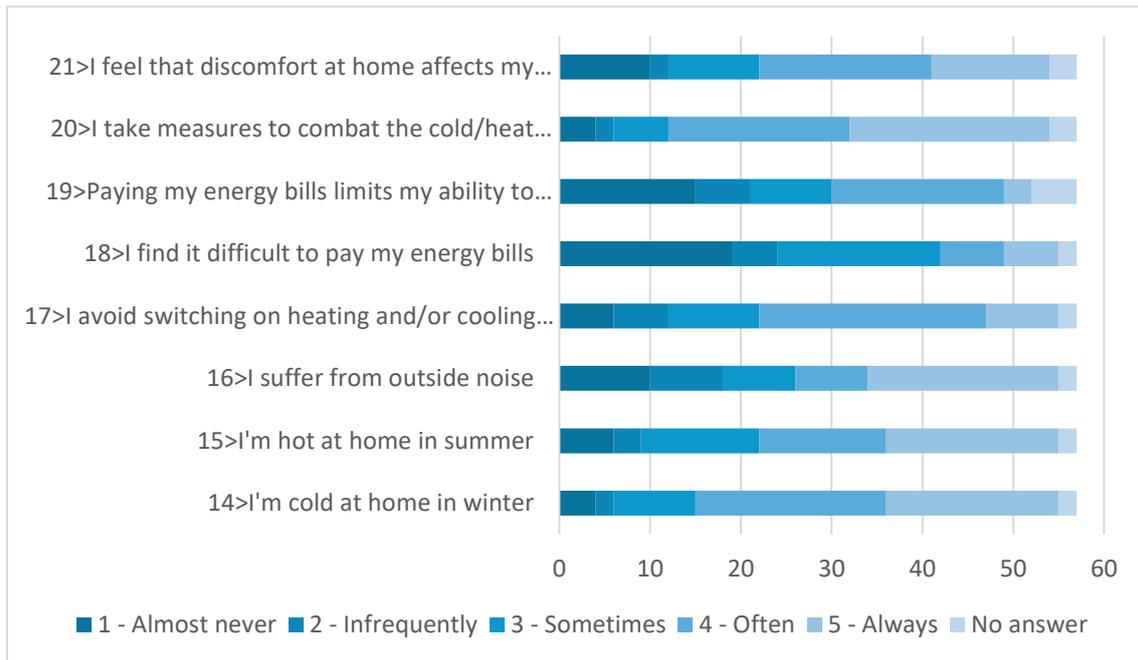


Figure 34: Survey answers related to house discomfort.

A prominent issue is the economic impact of energy costs (Figure 35). Many respondents noted that they avoid using heating or cooling systems to prevent high bills, and several also struggle to pay their energy bills. The economic burden extends beyond just energy bills, with respondents indicating that paying for energy limits their ability to afford other essential services, such as medication or internet access.

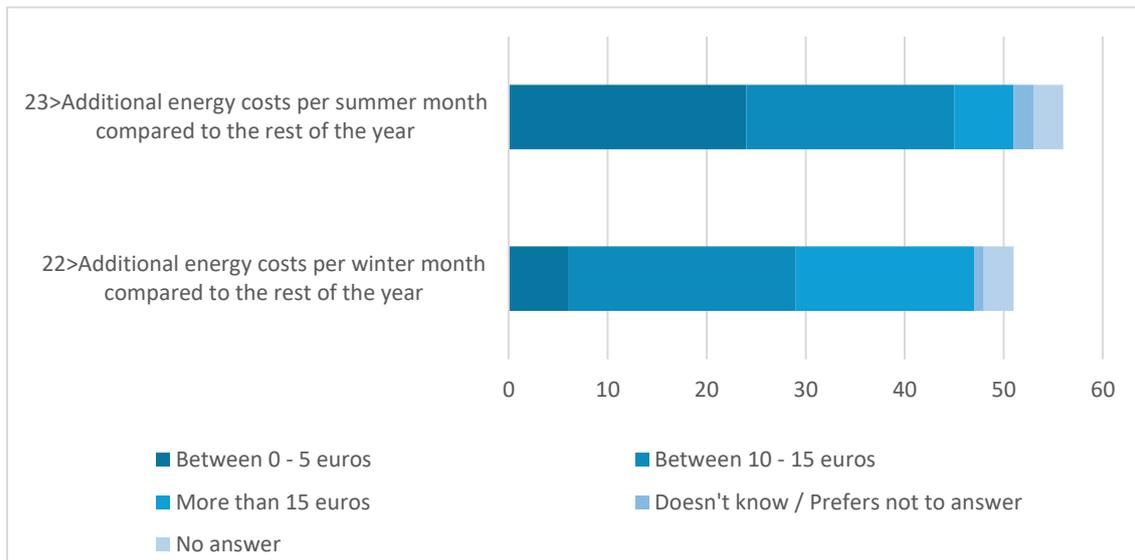


Figure 35: Survey answers related to energy expenditures.

Furthermore, adaptive behaviors such as wearing extra clothing or leaving the house to avoid discomfort were reported frequently, signaling a tendency to resort to coping mechanisms rather than utilizing energy-consuming appliances. Many respondents also noted that the discomfort directly affects their health, leading to conditions such as frequent colds in winter or respiratory problems.

Lastly, additional energy expenditures were common in both winter and summer, with most households reporting higher monthly energy costs. This reflects the ongoing financial strain and EP faced by these communities.

The data from the home audits conducted during the *Ponto de Transição +PRÓXIMO* project offers an insightful glimpse into the housing conditions experienced by residents in Montijo, particularly those likely to be experiencing EP (Figure 36). By analyzing the results, several patterns and issues become evident, shedding light on the challenges these residents face in maintaining comfortable and safe living environments.

A key finding is the prevalence of degraded window frames or glass, with 31.6% of respondents indicating this issue in their homes. Windows play a crucial role in building energy efficiency and occupant comfort. They significantly impact heat loss and gain, affecting heating and cooling demands (Selkowitz, 1985). The design of building envelopes, including windows, plays a crucial role in energy efficiency and thermal

comfort (Altan *et al.*, 2009). Poorly insulated windows allow cold air to enter during the winter and heat to seep in during the summer, forcing residents to use more energy for heating and cooling. This contributes to both higher energy bills and significant thermal discomfort. 36.8% of households that reported no window degradation are experiencing better insulation and energy efficiency.

Another housing issue highlighted by the survey is damaged covering, with 17.5% of households reporting this problem. While this is a smaller proportion compared to other issues, it still represents a considerable challenge for those affected. Older homes, particularly those occupied by low-income and minority families, are more likely to have structural deficiencies and outdated systems, resulting in energy insecurity and adverse health outcomes (Lewis *et al.*, 2020). However, with 50.9% of respondents reporting no damage to coverings, many homes are still structurally sound in this regard.

One of the most alarming results is the widespread presence of mold on the walls, reported by 47.4% of respondents. Building envelope condition, ventilation, and insulation show strong dose-response relationships with mold presence, with poor conditions increasing mold odds by 2.4-15.9 times across surveys (Taptiklis *et al.*, 2020). Environmental problems, including mold, are prevalent in low-income housing, with more than half of homes having three or more exposure-related issues. These cumulative exposures are associated with higher odds of reporting fair-poor health (Adamkiewicz *et al.*, 2014). This is a particularly troubling finding as mold growth is not just a symptom of poor housing conditions but also a significant health hazard, especially for vulnerable populations such as children, the elderly, and those with respiratory conditions. A study by Sharpe *et al.* in 2015, points out that fuel poverty significantly increases the risk of mold contamination, regardless of occupants' risk perception or ventilation practices (Sharpe *et al.*, 2015). This could be exacerbated by the fact that many residents may avoid using heating systems to save on energy costs, as indicated by other parts of the survey that reflect on energy usage behaviors. Inadequate ventilation or poor construction practices can trap moisture in homes, promoting mold growth and leading to long-term health complications.

Conversely, cracks in the walls are less of an issue, with only 21.1% of respondents reporting this problem. While less common than mold, cracks in walls can be indicative of structural weakness or foundational issues in a home. These cracks lead to air infiltration, which affects energy loads, indoor air quality, and moisture accumulation in building envelopes (Younes *et al.*, 2012). However, with half of the households (47.4%) reporting no cracks, this issue is less widespread than others, like mold or degraded windows.

In the data approximately 31.6% of respondents left questions unanswered, meaning that there was no home audit scheduled for that group.

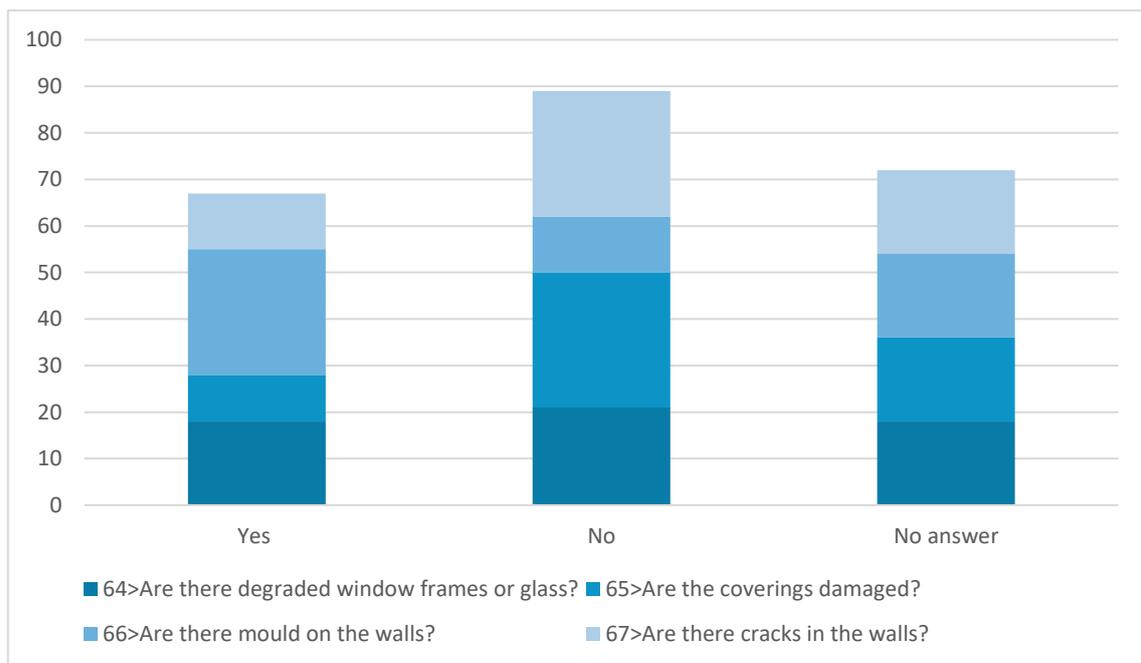


Figure 36: Survey answers related to housing conditions from the energy home audits.

This data highlights the urgent need for energy efficiency interventions and economic support for vulnerable households in Montijo. Additionally, the study revealed that many residents were adopting energy-saving behaviors, such as reducing heating usage, due to concerns about high energy costs. This behavior, while understandable, can lead to health issues like respiratory problems and mold growth, which were also prevalent in the surveyed homes. To address these challenges, there is a need for targeted interventions, such as energy efficiency upgrades, financial assistance, and community outreach. These measures can help

reduce energy consumption, improve indoor air quality, and alleviate the financial burden on households.

6.6. Results Overview

These findings shed light on the complexities of energy poverty (EP) at the local level in Montijo, emphasizing the need for a holistic approach that integrates energy efficiency improvements with financial assistance and active community engagement. The analysis of the EPVI and EPCs highlights two key neighborhoods—Bairro da Lançada and Bairro Novo do Esteval—as priority areas for intervention due to their significant vulnerability.

In this regard, EPVI attests that in the parish of Sarilhos Grandes, the Bairro da Lançada presents a very high vulnerability. It follows that the exposure to hardship of residents is maximum in this area, when indoor temperatures are in extreme conditions; thus, insulation and heating systems must be improved urgently. In parallel, the EPC analysis from Bairro Novo do Esteval underlines that retrofitting social housing may contribute to quite significant reductions of heating and cooling demands, showing the potential role of energy efficiency in the alleviation of EP.

The research further underlines the relevance of social problems that are at the root of EP. The stakeholder interviews, on the other hand, illustrated the inclusion of the community perspective to policy planning, especially regarding flexible financing options, and the need to better communicate in order to enable residents. This reflects the results of the survey led by Ponto de Transição +PRÓXIMO, where economic support became an urgent need among residents and energy-saving measures were being practiced in ways reported as harmful to themselves.

7. CONCLUSION

This dissertation aims to contribute to the ongoing investigation into EP by bringing greater focus to its impact on vulnerable communities, specifically within SH neighborhoods. The case study was centered on the municipality of Montijo, Portugal, where the significant impact of EP on these communities was examined through the perspective of stakeholders in active contact with residents. The findings indicate that EP in Montijo is not merely a matter of insufficient financial means to meet energy needs but is deeply rooted in structural inadequacies of the housing stock, inadequate policy support, and a lack of integrated approaches to energy and social welfare. These factors collectively contribute to a cycle of deprivation, where residents of SH neighborhoods face compounded challenges that extend beyond energy affordability, affecting their health, well-being, and social inclusion.

The research utilized several methodologies to assess EP in Montijo, including the Energy Poverty Vulnerability Index (EPVI), energy performance certificates, interviews, and surveys. The EPVI revealed high vulnerability scores in specific civil parishes, indicating the need for targeted interventions to improve both heating and cooling energy needs. The analysis of EPCs showed widespread deficiencies in the energy efficiency of SH units, highlighting the urgent need for retrofitting and modernization of building infrastructure. Interviews with local stakeholders provided insights into the challenges faced by organizations in implementing effective strategies to combat EP, while surveys of residents shed light on the daily struggles and coping mechanisms adopted by those affected. These results underscore the need for comprehensive strategies that integrate energy efficiency, financial support, and community engagement.

A few limitations of this study should be acknowledged. First, the research was limited to Montijo, which may restrict the broader applicability of its findings to other regions. Additionally, the sample size for interviews and surveys was relatively small due to time and resource constraints. Future research should expand to other municipalities and include a larger sample to provide a more comprehensive understanding of EP across diverse contexts. Next steps should focus on assessing the impact of national and

EU-level policies on local EP dynamics and piloting integrated intervention programs that connect housing improvements with social and energy policies. Such initiatives could offer valuable insights into creating more sustainable and resilient communities.

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ANNEX I – INTERVIEW SCRIPTS

This is the interview scrip used for Soc1:

- Which are the main demographic groups that you provide support for, and in which areas?

- Do you have a community group structure where you can meet, and the various inhabitants can go and ask their questions or express their problems?

- What are the main challenges or problems that they expose to you?

- Do many people come to you with housing problems? And do you have any idea if these people live in social housing?

- These problems of energy poverty, of not being able to heat or cool their homes properly, or failing to pay their energy bills, do they come up quite regularly, do you ever talk about it?

- And are there any problems of access to energy services for people in social housing compared to other communities?

- Is there any opportunity that has not been explored or any potential partnership to support these communities or any specific area, in this case of these economic factors, where it would be interesting or necessary to intervene, but has been unexplored?

- What would you say are the main obstacles or challenges to the implementation of these types of solutions or these types of interventions, by the actors involved, for the population living in these types of homes?

This is the interview scrip used for Soc2:

- I would start by asking you to describe your role and the main responsibilities you have.

- What are the main challenges or problems that are reported to you through this direct contact, and whether the conditions of social housing are also a problem?

- So, this problem is not mentioned that often? Is it more by just observation?

- And do you have any specific situations that illustrate how the lack of ability to pay bills impacts people's lives?

- Are you aware of any other programs or initiatives that aim to help?

- What is your approach when you receive this type of complaint?

- Do you collaborate with other organizations, or in this case just the Montijo council, the town hall?

- Would you say that there was the capacity or opportunity to expand into this type of other partnership or to create new initiatives or new programs?

- What would you say would be the improvements or additional resources that would be beneficial to better support the residents of these neighborhoods?

This is the interview scrip used for Gov1:

- How do you address the issues of access to essential energy services in social housing neighborhoods, such as electricity and heating?

- Have you had any specific initiatives to improve energy efficiency in these infrastructures?

- Do you usually have initiatives to educate residents about efficient energy consumption practices or the importance of energy conservation?

- In addition to this awareness-raising program, are there other programs or partnerships that help with financial assistance or technical support for residents

- You've already told me about having difficulty intervening inside residents' homes, but apart from that, can you identify any other obstacles or challenges to implementing effective solutions to these problems?

- What would you say are the key characteristics for ensuring the success of this type of intervention?

- And based on your experience, what would you say are the most effective approaches to mitigating this problem? Should it be a more direct approach to the population?

This is the interview scrip used for Gov2:

- What are the main challenges or problems faced by residents living in social housing?
- Do you have direct contact with the residents? And do you have an open space for it?
- How does this interaction take place? Do people contact you directly, or do you have a platform?
- Are there any specific factors that might contribute to not being comfortable at home, and other economic difficulties?
- Are rehabilitation programs and projects planned?
- And when you go to the field, what is the interaction like? How do you usually interact? Do you provide solutions? Are there certain aspects that you can resolve at the time? If not, how do you usually interact?
- And in different seasons, do they usually complain more about the housing structure?
- And in those cases, do try to talk to people, raise awareness, how does that approach usually go? Do you just replace it and that is it, or do you usually try to talk to people, explain that it can't be like that and that it shouldn't be?
- So that is one of the main challenges, the lack of resources, would you say?

This is the interview scrip used for Ener1:

- I would start by asking you to briefly describe your role in the project and what you set out to achieve.
- And in general, what was the profile of the people who visited the container? Their socio-economic situation?
- What were the main concerns or problems that made them go there to consult the project?

- And what kind of information about routines they adopted to get around these problems was most often mentioned?

- Would you say that compared to other areas and other types of housing you have seen a greater incidence of this problem in these neighborhoods, if not in other areas?

- Based on your experience, what would you say are the most effective approaches to mitigating energy poverty in these communities?

This is the interview scrip used for Ener2:

- How do you collaborate with local authorities, including the City Council, in formulating or collaborating in formulating and implementing energy and environmental policies?

- And apart from providing this support, are there any other projects or initiatives that you have in collaboration with local authorities to promote energy efficiency or the use of renewable energies?

- Are there initiatives or programs aimed at mitigating energy poverty?

- What would you say are the key characteristics that are most important in a partnership, to have a successful partnership to address energy poverty? That is, aligning objectives or sharing resources.

- And in terms of these barriers, in terms of support, especially for partnerships and initiatives, who would you say are the main relevant actors to include, to tackle these difficulties and above all difficulties, more specific, for the partnerships involved in energy poverty in social neighborhoods?

- Based on your experience, what would you say are the most effective approaches for trying to help and mitigate energy vulnerability in these communities? Whether through support programs or energy efficiency measures.

